Hubert John
Peter Wiklund *Editors*

Robotic Urology

Second Edition

Springer

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Hubert John • Peter Wiklund
Editors

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Foreword I

With the introduction of the robot-assisted minimally invasive surgery a new era started for urologic surgery. Robotic-assisted surgery allowed a more precise removal of tumourous organs in the pelvis. It was important at the very beginning to differentiate robotic-assistance using intelligent assistance systems, which modify and improve the surgeons' movements from the actual use of robots with a predefined working schedule (where the surgeon does not actually operate), which has been used and abandoned by other disciplines such as orthopaedic surgery. In urology, robotic surgery has been a success and the current second edition bears an excellent testimony to that. Initially mainly used for radical prostatectomy, indications have successfully been expanded to other oncological surgeries such as cystectomy, partial nephrectomy, adrenalectomy as well as reconstructive surgery such as urinary diversion and upper urinary tract reconstruction.

What have we learned since the first reports erupted more than a decade ago in urology?

We have seen that an intelligent assistance system does whatever the surgeon wants it to do; however it must be remembered that even the best vision, highest precision and smooth movements of the hands do not make a perfect surgeon. A comparison of robotic, laparoscopic and open surgeons doing the same procedure is dependent on their respective experience with each surgical technique. In other words: There is plenty of literature where an experienced open surgeon will out-perform a mediocre robotic surgeon and vice versa. Only randomized series with surgeons with a defined minimum case load might be more informative as to whether one or the other technique (and for which type of cases) is better both in the short and long-term outcome.

Robot-assisted surgery increases the price of each procedure considerably using the currently available technology. Health authorities on the other hand are increasingly only willing to pay this price if there is evidence for a decrease in the overall costs of a hospital stay and a measurable improvement of the long-term oncological and functional outcome. But in some countries none of the current literature fulfils the requirements necessary for the authorities to be convinced to fully compensate the additional costs. We therefore as urologists need to create prospective and – if possible – randomized data to better delineate the benefits.

There are signs such as from the Canadian Health Technology Association that they are willing to pay the additional costs for subsets of prostate cancer patients [1].

With more than a decade of experience in robotic assisted surgery in the pelvis as well as in the retroperitoneum and in disciplines other than urology it is clear that this type of surgery will stay and will not be a “fashion fad”. Future developments will now focus on a simplification of the current technology. These could include bringing the surgeon back to the OR-table, having a better posture of the surgeon and introduction of vision-based navigation, intraoperative fluorescence guidance and precision destruction systems such as laser into the intervention [2–4]. Several research groups have been working on haptics in order to overcome one of the often-cited disadvantages when compared to open surgery: the feeling of tumors, organs and structures. All these developments are based on intelligent assistance systems and do not make any sense for open surgery and will not really improve it. Thus the more these developments find their way into routine clinical applications, the more robotic-assisted surgery will become indispensable.

Tübingen, Germany Prof. Arnulf Stenzl, M.D.

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Preface

Hubert John and Peter Wiklund in the Swiss Alps, 7th March 2010, when they decided to re-edit this book

Urology has traditionally been a technically driven specialty. Minimally invasive surgical procedures aim to reduce collateral surgical damage while optimizing functional and oncological results.

Ten years ago, when both editors began robotic urology in 2002, it was unexpected that this technology would revolutionize surgical approaches in urology. In the last decade, no other operative technology has had a stronger influence in urology than the master–slave robotic system "DaVinci" (Intuitive Surgical, Sunnyvale, Calif.) Robotic technology has overcome the limitations of conventional laparoscopy and brought challenging laparoscopic interventions from a few experts' hands to a broad spectrum of urologists and patients who can profit worldwide.

The second edition of this book in 2012 is therefore very timely. The authors have invested great effort and personal experience in order to support other robotic teams around the world. The book highlights the standards of robotic urology today of the kidney and adrenals, the ureter, bladder and prostate and also reviews some possible future indications and techniques that are today still in clinical evaluation. We are happy that the second edition has come to a fruitful conclusion after 2 years of hard work. Our thanks go especially to Dörthe Mennecke-Bühler from Springer (Heidelberg) and to Kevin Horton (Winterthur), who helped to advance this project in a significant way. We are especially grateful to our families for their support and tolerance of our high professional workload.

Winterthur, Switzerland
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Part I

Kidneys

Surgical Anatomy of Kidneys and Adrenals

1

Ibrahim M. Karam, Alexandre Oliver, and Jacques Hubert

1.1 Introduction

In this chapter, surgical anatomy of kidneys and adrenals is described in detail. Their anatomical relationships and preoperative evaluation of retroperitoneal anatomy are illustrated for providing anatomic information necessary to plan the surgical procedure. This evaluation is crucial, in robotic surgery, for detecting vascular anomalies and helps the surgeon to easier dissect atypical renal or adrenal vessels. We also describe the practical surgical options of dissection to give to the operator the capacity to anticipate difficulties and overcome them.

1.2 Description and Anatomical Relationships

1.2.1 Retroperitoneum and Gerota's Fascia

The retroperitoneum is divided into the anterior pararenal space, the perirenal space, and the posterior pararenal space. The perirenal space is defined by the anterior and posterior layers of the perirenal fascia (Gerota). This fascial layer encloses the kidney and adrenal in their covering of perirenal fat (Fig. 1.1). It was originally described as being made up of two separate entities, the posterior fascia of Zuckerkandl and the anterior fascia of Gerota [1].

1.2.2 The Adrenal Glands

The adrenal glands are paired structures medially located to the upper poles of the kidneys. They are covered by the perirenal (Gerota's) fascia and are surrounded by an adipose and connective tissue that forms a pseudocapsula, facilitating surgical dissection [2]. The *right adrenal* is usually lower than the left. It lies above the upper pole of the right kidney, between the liver and the diaphragm, and forms the

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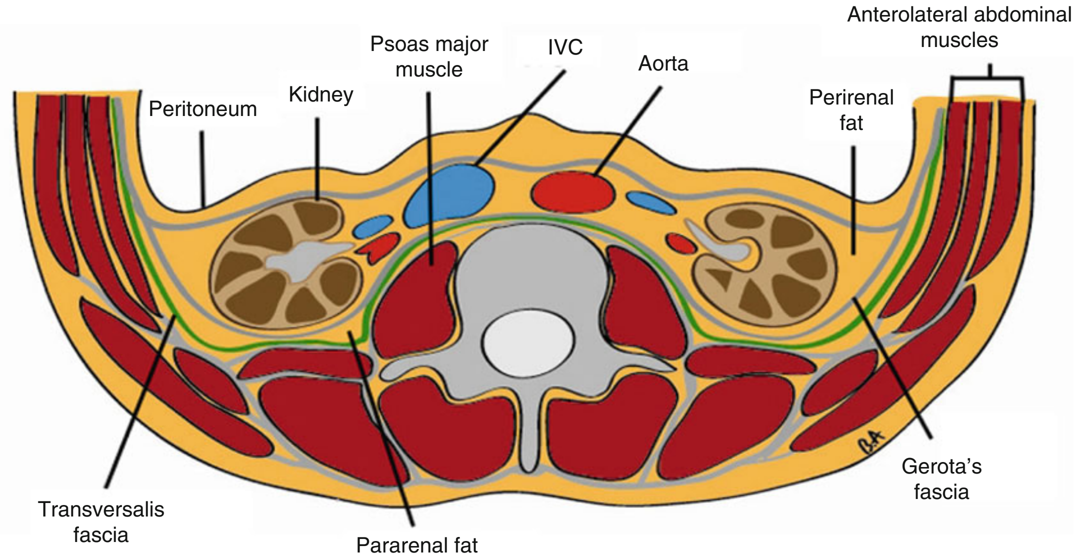

Fig. 1.1 Organization of the perirenal space and fascia

impressio suprarenalis on the liver surface, just to the right of the inferior vena cava. Surrounding structures include the liver anterolaterally, the duodenum anteromedially, and the inferior vena cava (IVC) medially. The *left adrenal* lies within the perirenal fat along the medial or superomedial border of the left kidney. It is more closely related to the kidney than is the right one, and it is more easily drawn down with the kidney because its central vein drains into the midpoint of the left renal vein, while on the right the central vein fixes the gland high on the inferior vena cava. It is more crescent-shaped and medial to the upper pole of the left kidney. The upper and anterior aspects are related to the stomach, tail of the pancreas, and splenic vessels.

The adrenal arterial supply originates from three sources: The inferior branches are issued from the ipsilateral renal artery, while the middle branches originate directly from the aorta, and finally the superior adrenal pole is irrigated by branches from the inferior phrenic artery (Fig. 1.2). The venous drainage varies by side, the left principal adrenal vein joins the inferior phrenic vein, and the other enters the cranial aspect of the left renal vein. On the right side, the adrenal vein enters the IVC directly on its posterolateral aspect.

1.2.3 The Kidneys

The kidneys are paired retroperitoneal organs that parallel the psoas muscle on either side of the lumbar spine. The left kidney is usually slightly higher than the right one and is slightly more medially located. Posteriorly, the diaphragm covers the upper third of each kidney. Medially the lower two-thirds of the kidney lie against the psoas muscle, and laterally the quadratus lumborum and aponeurosis of the transversus abdominis muscle are encountered. Anteriorly, the right kidney is bordered by the liver and attached to it by the hepatorenal ligament. On the medial aspect, the descending duodenum is intimately related to the hilar renal structures. The left kidney is bordered superiorly by the tail of the pancreas and the splenic vessels adjacent to its upper pole. The splenorenal ligament attaches the left kidney to the spleen. It can lead to splenic capsular lesions if excessive downward pressure is applied on the left kidney. Superior to the pancreatic tail, the posterior gastric wall can overlie the kidney.

The renal arteries typically arise from the aorta slightly below the origin of the superior mesenteric artery. The right renal artery has a long downward course to the relatively inferior right kidney, traversing behind the inferior vena cava.

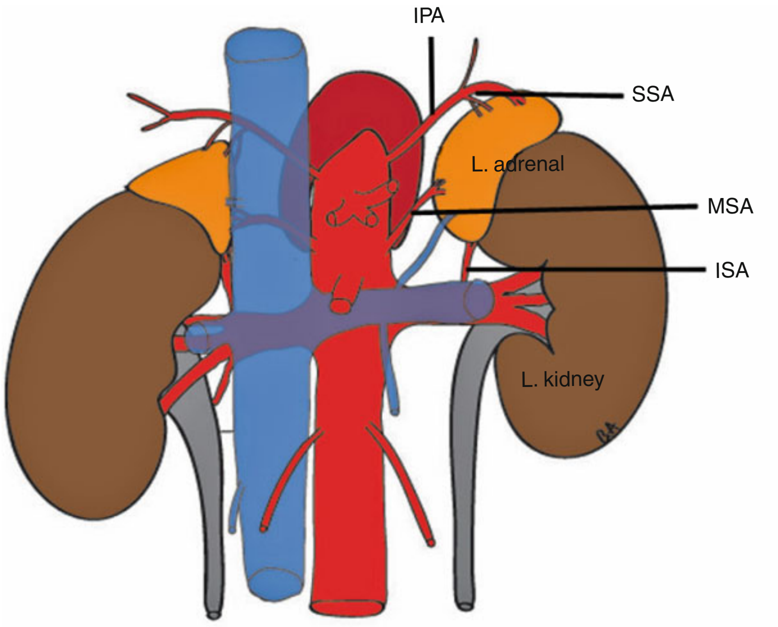

Fig. 1.2 The arterial supply to the adrenal gland originates from three sources: Superior suprarenal arteries (*SSA*) from the inferior phrenic artery (*IPA*), middle suprarenal arteries (*MSA*) originate directly from the aorta and inferior suprarenal arteries (*ISA*) issue from the ipsilateral renal artery

However, the left renal artery, which arises below the right renal artery and has a more horizontal orientation, has a rather direct upward course to the superiorly positioned left kidney. The renal vein usually lies anterior to the renal artery at the renal hilum. The left renal vein is almost three times longer than the right renal vein. It runs anteriorly between the superior mesenteric artery and the aorta before emptying into the medial aspect of the IVC. Unlike the right renal vein, the left renal vein receives several tributaries before joining the inferior vena cava. It receives the left adrenal vein superiorly, the left gonadal vein inferiorly, and a lumbar azygos vein posteriorly (Fig. 1.3).

1.3 Radiological Anatomy

CT angiography, performed with volume rendering and multiplanar reconstructions, is extremely accurate in the preoperative evaluation of renal vascular anatomy. It has replaced conventional angiography in most institutions. Comprehensive preoperative evaluation of retroperitoneal anatomy is crucial for detecting vascular anomalies and for providing anatomic information necessary to plan the surgical procedure [3]. The multidetector computed tomographic (*MDCT*) angiography presents a noninvasive imaging modality for the evaluation of adrenal and renal vascular anatomy. In addition to assessing the vessels, anatomic definition of the collecting system is important [4]. The number, size, branching pattern, course, and relationship of the renal arteries and veins are easily demonstrated by MDCT angiography [5]. The 3D imaging provides high-quality images that make intraoperative anatomic analyzes more accessible to those nonspecialized in imaging mainly urologists. Preoperative knowledge of minor venous variants such as a lumbar or gonadal vein may facilitate the dissection of these veins and help to avoid hemorrhagic complications during surgery. Dual-phase MDCT combined with maximum intensity projection (*MIP*) reconstruction can provide a minimally invasive, accurate preoperative evaluation of kidney donor candidates in a single study (Fig. 1.4).

The accuracy of MDCT angiography in detecting accessory arteries, early branching, and renal vein anomalies are 95, 90–95, and 95–100 %, respectively [6]. The most common venous anomaly is a circumaortic left renal vein. The larger veins can be evaluated with the volume-rendering technique (*VRT*); however, to find all smaller

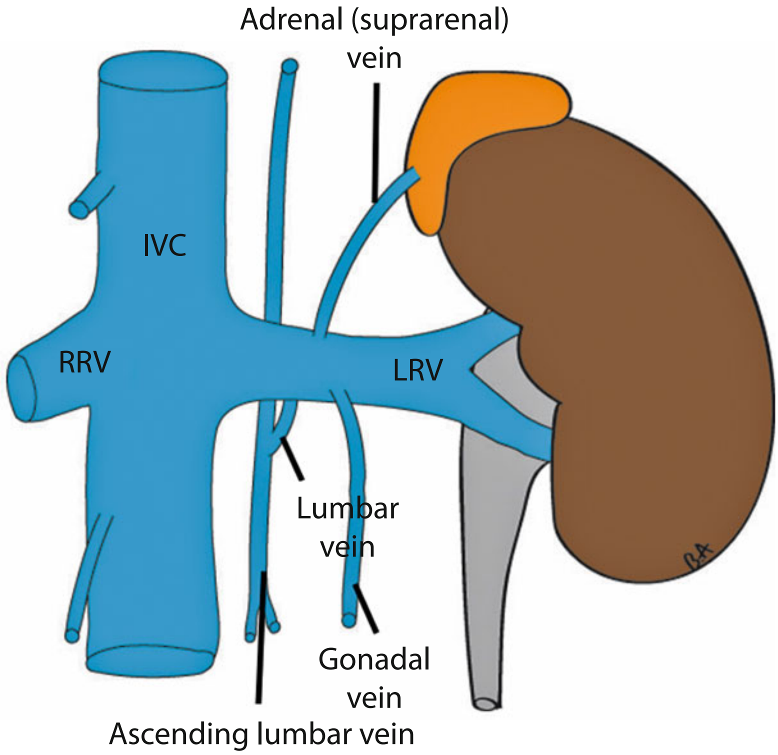

Fig. 1.3 Before joining the inferior vena cava (*IVC*), the left renal vein (*LRV*) receives the left adrenal vein superiorly, lumbar vein posteriorly, and left gonadal vein inferiorly. The right renal vein (*RRV*) typically does not receive any branches

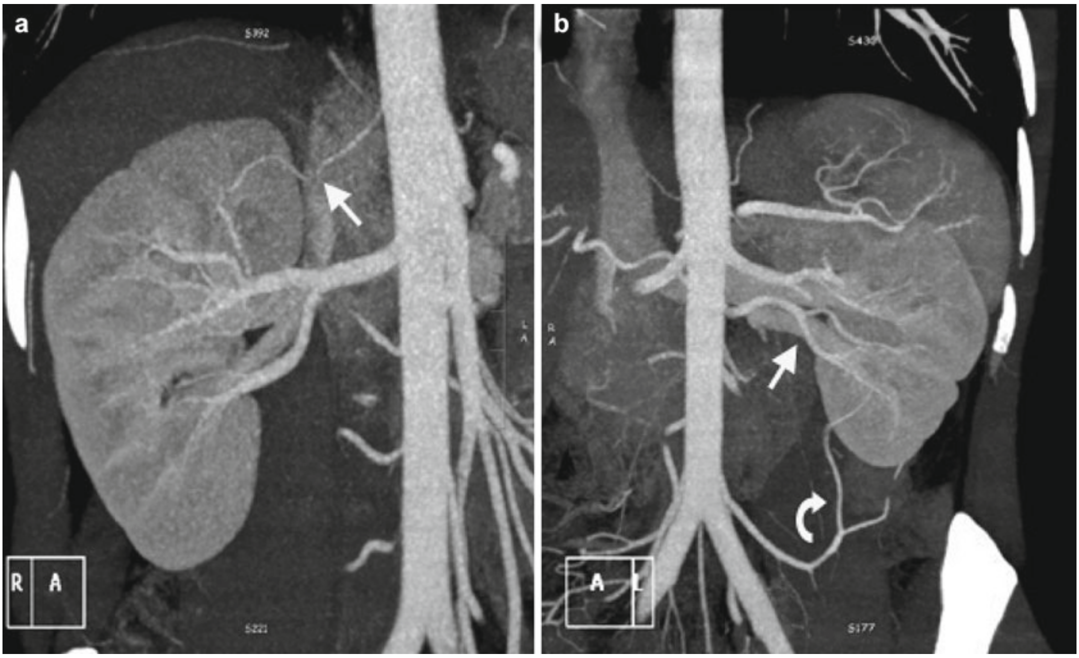

Fig. 1.4 Oblique maximum intensity projection images, of a man undergoing preoperative renal donor evaluation, show accessory polar renal arteries to the right and left kidneys (*arrows*). The superior branch of the inferior mesenteric artery (*curved arrow*), which courses toward the left kidney, mimic the appearance of an accessory renal artery

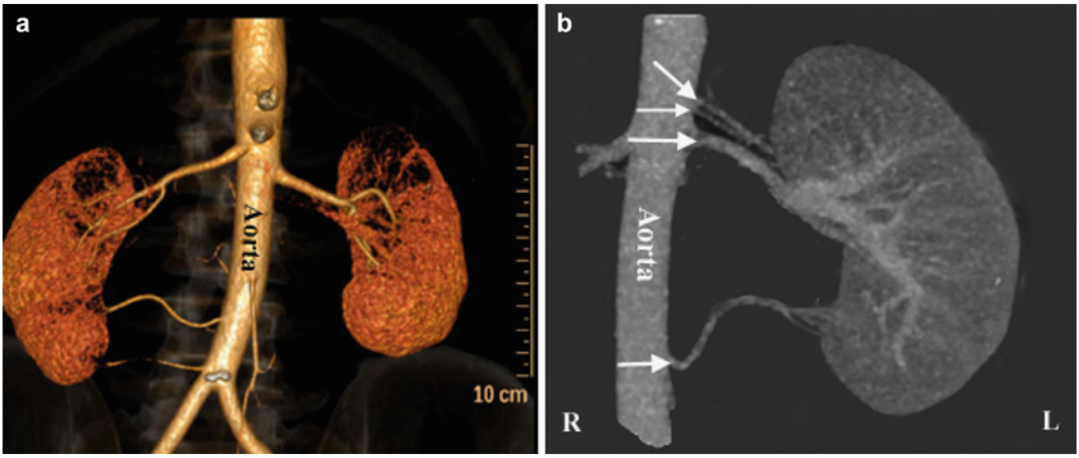

Fig. 1.5 (**a**) Coronal VR image shows two accessory polar renal arteries to the right kidney. (**b**) Coronal MIP image shows two upper polar arteries of the left kidney, the main left renal artery and a left inferior renal polar artery (*arrows*)

veins, the multiplanar reformatting technique (*MPR*) is better and should employ axial, coronal, sagittal, and oblique planes. Retroperitoneal varices can be detected with this technique [7]. Recent studies have demonstrated that the best nephron-sparing approach can be based in reconstructed 3D renal arteriogram, fused with 3D image of surface-rendered renal tumor and semitransparent kidney to facilitate selective microdissection of tumor-specific arterial branches, even for intrarenal or central tumors [8].

The multiphasic acquisition with multislice CT scan 3D reconstruction permitted the establishment of an intraoperative cartography of the vessels number and situation resulting in an easier dissection in a reduced operative field. The 3D CT scan images and 3D robotic coupling lead operator to conduct a selective dissection of renal and adrenal vessels and overcome difficulties represented by the atypical anatomic configuration [9]. The identification of renal vascular variants is important in the preoperative evaluation, especially before donor or partial nephrectomy. Renovascular variations are common, occurring in 25–40 % of cases.

1.3.1 Renal Arteries Variants

Accessory arteries are seen in about one-third of the population, while about 70 % of the population have a single renal artery that originates from the abdominal aorta on each side [10]. They usually arise from the aorta or iliac arteries. Most commonly, the accessory arteries originate from the abdominal aorta and supply the inferior pole of the kidney (Fig. 1.5a).

In rare cases, they can arise from the lower thoracic aorta or from lumbar or mesenteric arteries. Bilateral multiple renal arteries occur in 10 % of the population [11]. Double renal arteries are detected in 25 % of cases, triple renal arteries in 4 %, and quadruple renal arteries in 1 % of the population (Fig. 1.5b). Accessory renal arteries are considered to be persistent embryonic lateral splanchnic arteries. Rarely, they can arise from the coeliac, mesenteric, lumbar, middle colic, or middle sacral artery [12]. The polar accessory renal arteries are usually smaller, but hilar accessory renal arteries are not always smaller than the principal renal arteries. Early branching of the renal artery is a variant in which any branch diverge from the lateral wall of the aorta in the left kidney or in their retrocaval segment in the right kidney.

1.3.2 Renal Vein Variants

The most common anomaly of the left renal venous system is the circumaortic renal vein, seen in approximately 2–17 % of the population. Here, the gonadal vein will typically join the retroaortic limb and the adrenal vein will join the preaortic limb (Fig. 1.6). The completely retroaortic renal

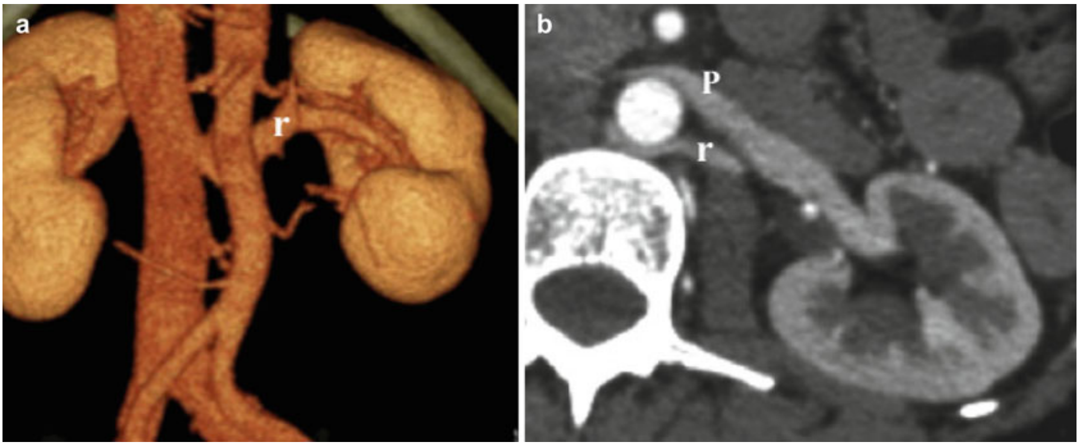

Fig. 1.6 (**a**) Coronal VR image shows triple right renal arteries and circumaortic left renal vein. (**b**) Axial MIP image demonstrates a "circumaortic left" renal vein with retroaortic (*r*) and preaortic (*p*) components

Fig. 1.7 (**a**) Coronal volume-rendering image, of a preoperative renal donor evaluation, shows the right renal arteries. The last pierces the lower pole of the kidney directly. (**b**) Axial slice shows a retroaortic left renal vein (*arrow*)

vein, is seen in 2–3 % of patients. In this case, the single left renal vein courses posterior to the aorta and drains into the lower portion of the IVC (Fig. 1.7).

The left adrenal vein and gonadal vein enter into the left renal vein in almost all cases. However, on the right side, the gonadal vein and adrenal vein enter the right renal vein in only 7 and 30 % of cases, respectively. Two left gonadal veins may be seen in about 15 % of cases. In about 60–85 % of the population, the retroperitoneal veins, including the lumbar, ascending lumbar, and hemiazygos veins, drain into the left renal vein [13].

1.4 Anatomical Landmarks and Surgical Dissection

The robotic-assisted laparoscopic surgery can be performed via a transperitoneal or retroperitoneal approach. The transperitoneal approach is a familiar one with quicker access to the renal hilum, easily recognizable anatomy and a much larger working space [14]. In this approach, the peritoneum is incised along the line of Toldt, and the bowel is mobilized medially, developing the plane between the anterior Gerota's fascia and the posterior mesocolon. Dissection is continued along the upper pole of the kidney to mobilize the spleen or liver:

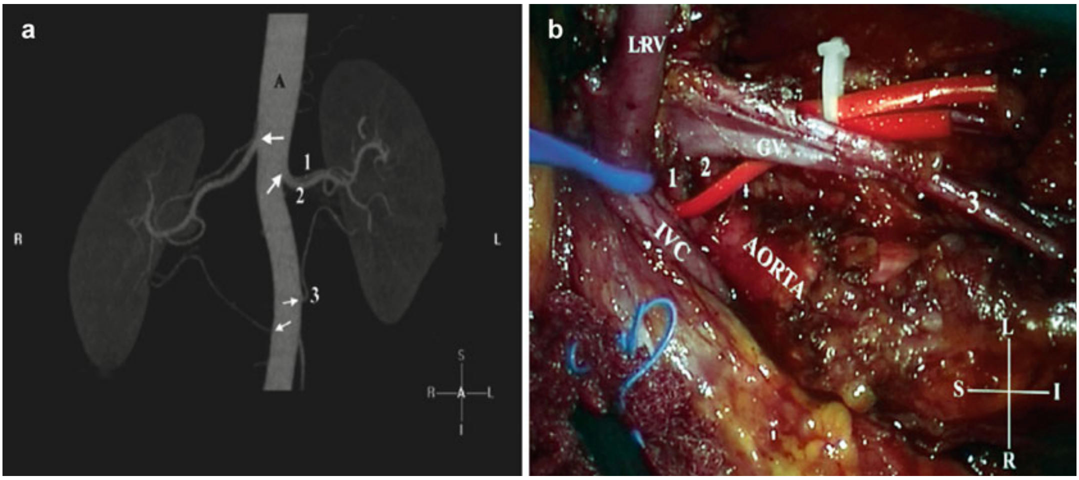

Fig. 1.8 (**a**) Oblique maximum intensity projection image shows an accessory renal artery to the lower pole of the right and left kidneys (*arrows*). (**b**) Intraoperative photography shows an early branching of the main left renal artery (*1*, *2*) and a left inferior renal polar artery (*3*)

On the right, dividing the right triangular ligament is usually necessary to gain access to the Gerota's fascia and visualize the upper pole. *On the left*, the upper pole is well visualized after division of the phrenicocolic, splenocolic, and the splenorenal ligaments at the splenic flexure. The ureter and gonadal vein must be identified, and they can be followed superiorly to aid in hilar identification and dissection. At the level of the lower pole of the kidney and proximal ureter, the gonadal vessels are medial to the ureter, and a slight anterior elevation of the ureter and lower pole may be useful to identify the renal hilum and its vessels, including the anteroposterior lumbar vein. After the hilum is identified, it is dissected, and the artery and vein are controlled separately [15]. The 3D robotic vision and articulation lead operator to conduct a selective and meticulous dissection of renal vessels and overcome difficulties represented by the atypical anatomic configuration (Fig 1.8).

If a retroperitoneal approach is used for nephrectomy, Gerota's fascia is identified and the renal pedicle exposed. The renal artery and vein are identified and individually dissected. The remainder of the kidney is mobilized using sharp and blunt dissection. The ureter is identified inferiorly, clipped, and divided. Although adopted by some trained teams, the retroperitoneal approach offers only a reduced operative field, which complicates the robotic instrument's movements [16].

Partial nephrectomy requires complex dissection and intracorporeal reconstruction. There are technical challenges which include adequate intraoperative visualization and control of the vascular supply to realize a nephron-sparing procedure. Precise identification of all renal arteries is mandatory in order not to miss to clamp one collateral branch during renal excision. Knowledge of arteries and veins respective positions helps to the surgical strategy (such as finding the artery at the superior or inferior aspect of the vein, dissection of the interaorticocaval space for getting access to the right renal artery) (Fig. 1.9).

For adrenalectomy, it is important to recognize the lateroconal fascia (extending from Gerota's fascia to the lateral peritoneum). This fascia covers the space that contains the adrenal gland, and it must be opened to expose the adrenal gland and its vessels. Circumferential separation of adrenal after careful dissection of the gland from its adhesions is done by holding the fat overlying the adrenal. This avoids direct handling of the gland and facilitates the precise dissection of the adrenal arterial supply. The advantage of the retroperitoneal approach is that mobilization of other organs is unnecessary because the adrenal gland is approached in its

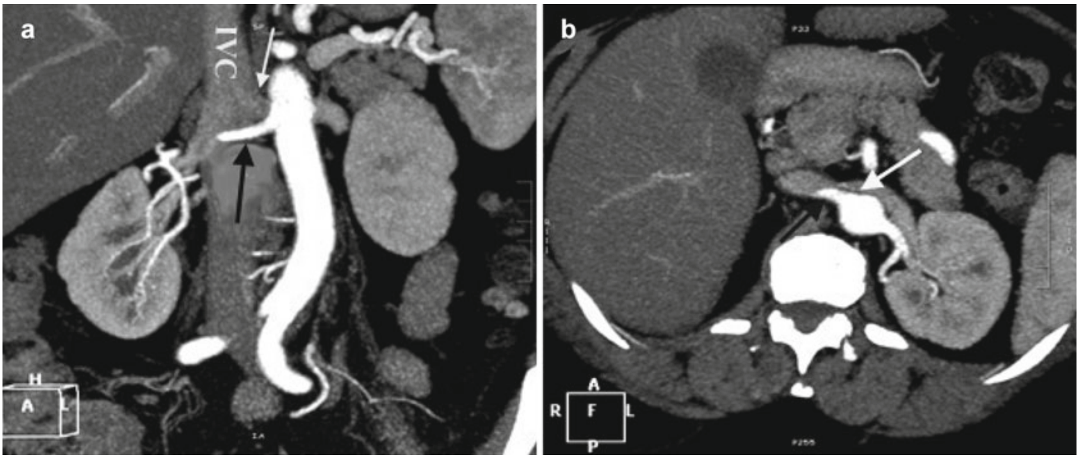

Fig. 1.9 Coronal MIP image (**a**) and axial MIP image (**b**) show renal vessels of a patient undergoing right partial nephrectomy. "In this anatomical situation: left renal vein (*white arrow*) is above the right renal artery (*black arrow*), interaortocaval clamping of the right renal artery is made possible"

proper anatomic plane [17]. A disadvantage of retroperitoneal adrenalectomy is the limited maneuvering space for the endoscopic instruments. Adrenalectomy involves delicate dissection alongside major vascular structures and viscera:

For left side, the mobilization of the left colon flexure is sometimes necessary; the plane of dissection is developed laterally and dorsally to expose the superior aspect of the kidney and the adrenal gland. Identification of the left adrenal vein and its confluence with the renal vein is essential to secure the left adrenal vein. It is followed by clipping and dividing the adrenal vein. The same is done with the suprarenal arteries. Thereafter the adrenal gland is completely dissected from its bed.

In the right side, after incising the precaval peritoneum, the upper pole of the kidney, the right adrenal, and the inferior vena cava (IVC) are visualized. The adreno-caval junction can be located by dissecting along the lateral border of the inferior vena cava. Following this lateral caval plane cranially, the adrenal vein or veins and arteries are identified, clipped, and divided. Although the right adrenal gland is readily accessible when the transperitoneal approach is used, exposure of the left adrenal gland can be difficult because it requires mobilization of the spleen, the splenic flexure of the colon, or the pancreatic tail [18].

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Robotic Kidney Surgery

2

Jorn H. Witt and Christian Wagner

2.1 Introduction

Over the last 15 years, laparoscopic procedures in urology have become a widely used approach for many surgical indications [9]. In many specialized centers, laparoscopy is an integral part of daily practice [68]. The well-known difficult learning curve in laparoscopic procedures has lead to the developments of alternatives that shorten the learning curve and improve surgical outcomes. In kidney surgery, the popularity of hand-assisted nephrectomy, especially in the USA, is a good example for a pragmatic approach to improve the learning process [31]. Since the introduction of telemanipulatory devices in the beginning of the last decade, robot-assisted procedures for many indications have become the preferred approach of many urologists. Notably, in complex reconstructive and advanced ablative surgical procedures, the robot offers advances to the surgeon providing 3D vision and seven degrees of freedom of motion in the hand-wristed instruments, scaling of motion, and reducing of tremor [48].

The proven benefits for laparoscopic kidney surgery, compared with open procedures, such as less pain, shorter hospital stay, and faster return to normal activity and favorable cosmetic results, could be also demonstrated for robotic renal surgery [40, 42, 47].

This chapter describes current ablative and reconstructive robotic procedures, considerations for the choice of different approaches, and the management of possible complications.

2.2 Patient Evaluation and Preparation

Evaluation and preparation for robotic kidney procedures follow the same principles as comparable standard laparoscopic or open surgery [4, 9, 12]. Prior to surgery, possible complications including injuries of the bowel, vascular structures, nerves, spleen, pancreas, liver, diaphragm, and collecting system (in nephron-sparing cases) must be discussed with the patients; also conversion to open surgery in consequence of surgical or technical reasons should also be specified [34, 76] to obtain informed consent. Furthermore, OR technicians/nurses should be always prepared for conversion.

There are no robot-specific contraindications in renal surgery, but, for example, multiple prior abdominal surgeries or status post-peritonitis may influence the choice of a transperitoneal robotic approach, particularly for beginners. Obese patients in general have a lower risk of postoperative wound infection or pulmonary complications in laparoscopic procedures; however, the identification of anatomical structures could be more delicate; working space may be reduced, so the possibility for conversion to open surgery is higher in obese patients [88].

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General laboratory and imaging studies depend on patient history and indication. Bowel preparation is usually not mandatory but could be considered subject to the approach, prior peritoneal surgery and the preference of the surgeon. In dilated bowel loops, the presumption of adhesions and anticipated complex procedures, we consider bowel preparation with purgative the day before surgery [68].

Depending on the disease and the procedure, special imaging and examination includes ultrasound, i.v. pyelogram, CT or MRI scan, and dynamic renal scan. Stenting of the ureter prior to the procedure can be helpful in selected cases.

2.3 General Considerations for Robotic Kidney Surgery

In addition to open and standard laparoscopic procedures, two main aspects should be focused in robotic kidney surgery: (1) robot installation and (2) selection of the robotic instruments [54].

The patient cart is usually placed on the side of the patient's back, mainly with the camera arm at the level of the targeted lesion. Right-angle positioning of the robot to the patient's back is used in most cases [58]. Since newer versions of the robot are available that offer more flexibility of the robotic arms, also oblique positioning of the arms is possible and could be helpful in selected cases.

A possible OR setting is shown in Fig. 2.1.

Robotic procedures can mostly be performed with a limited number of instruments. For most procedures, three or four robotic instruments are adequate. Table 2.1 indicates a list of instruments used in our institution and possible alternatives. For suturing, one or two needle drivers can be used due to the preference of the surgeon. Since one additional instrument adds some 250–300€/US$ to the procedure, well-considered instrument selection is economically worthwhile.

Typical useful instruments are listed in Table 2.1.

2.4 Surgical Approaches

As in standard laparoscopy, both transperitoneal and retroperitoneal approaches are possible for robotic kidney surgery. Randomized trials have shown no significant differences in standard laparoscopy between transperitoneal and retroperitoneal access regarding operative time, results, and complications, but did report a significant faster resumption of oral intake for the transperitoneal group [68]. The transperitoneal approach allows an optimal working space and more possibilities for different trocar placement. The orientation by anatomical landmarks is also easier in the transperitoneal approach [45]; thus the transperitoneal approach should be considered easier for beginners.

Retroperitoneal access requires an adequate working space in the retroperitoneum before trocar placement; this can be either achieved by special dilating balloons or blunt dissection with the surgeon's finger. Identification of anatomical structures may be unfamiliar especially for surgeons who are not accustomed to this approach. For patients with a history of peritonitis, multiple prior abdominal surgery, and abnormalities of the posterior surface of the kidney, the retroperitoneal access could be superior to the traditional transperitoneal approach [15].

There are some reports of hand-assisted approaches combined with robotic surgery [70]. Due to handling advantages in robot technology, procedures are easier also for less experienced surgeons so that possible benefits of the hand-assisted technique are without doubt less important than in standard laparoscopy [49].

2.4.1 Transperitoneal Approach

2.4.1.1 Patient Positioning and Port Placement

In all laparoscopic procedures, patient positioning and port placement are major condition requirements for a trouble-free target approach and a successful accomplishment of the procedure. In robot-assisted techniques, additionally the adequate distance between robotic arms for unrestricted movements and optimal placement of the robot beside the patient is essential for straightforward docking [45, 82].

The patient is placed in a modified lateral decubitus position with a 20–30° ipsilateral rotation of shoulder and hip. For most cases, the

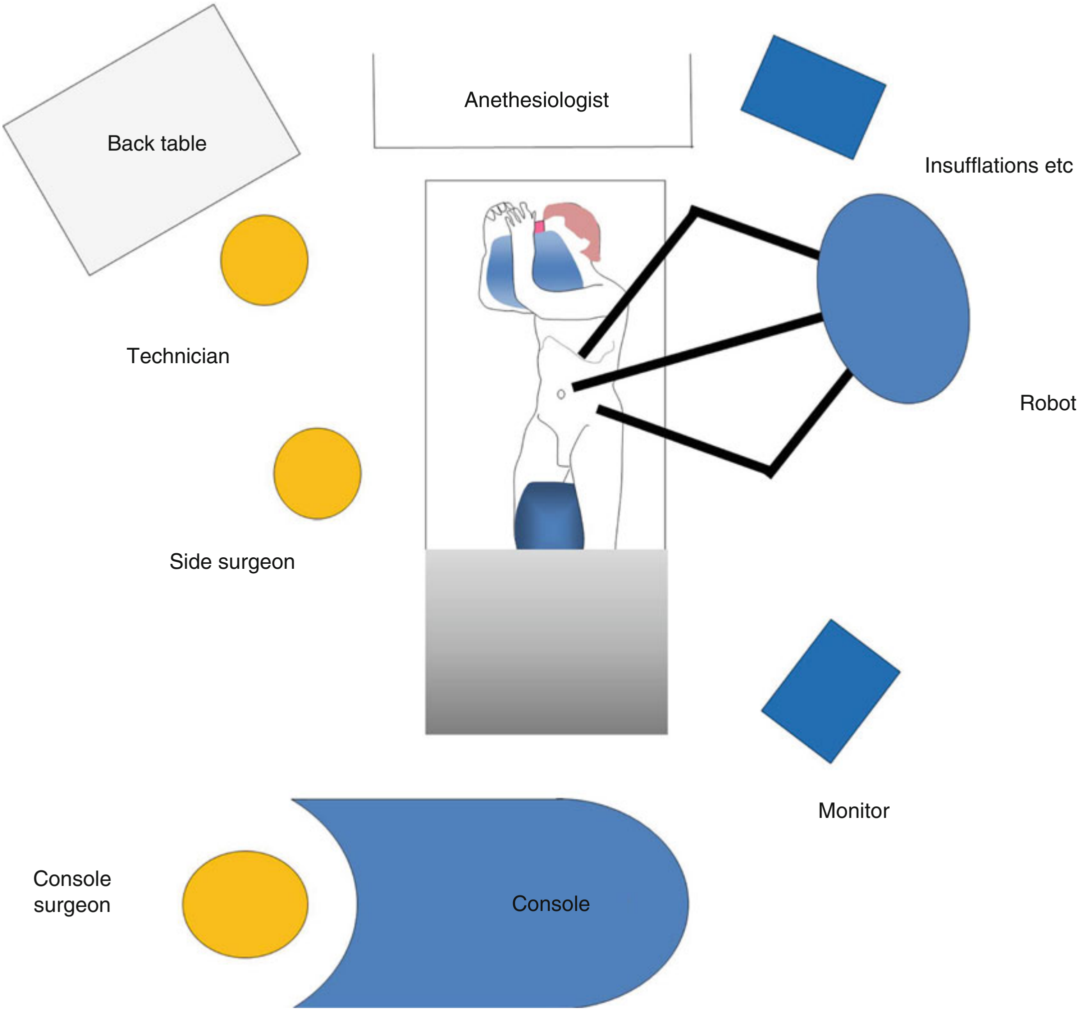

Fig. 2.1 OR setup

ipsilateral arm can also be placed close to the patient side. If desired bending of the operating table can be performed at the level of the umbilicus before securing the patient at the table, for example, with adhesive tape. We prefer a vacuum bedding device as an inexpensive, reusable, and safe tool for proper patient positioning on the table. After securing on the table, the patient can easily be rotated to the full flank position. The complete ipsilateral flank is prepared and draped, and a Foley catheter is placed in the bladder before trocar placement.

Figure 2.2 illustrates port positions; for initial insufflation, we prefer the open Hasson technique with minilaparotomy. Alternatively, a Verres needle can be used. There are generally two major approaches for transperitoneal kidney surgery: the medial and the lateral camera port placement. In the medial camera placement, the camera port is placed pararectal at the level of the umbilicus. The two robotic arms are placed in the midclavicular line in triangular fashion with the camera port. A minimum distance of 8 cm between the ports is necessary to avoid collision of the robotic arms during the procedure. The assistant port is placed pararectally between umbilicus and pubic bone. If needed, additional assistant ports can be placed below the xiphoid (often helpful for liver retraction in right-side kidney surgery) and below the costal arch if possible [81]. For medial camera port placement,

Table 2.1 EndoWrist™ Instruments for robotic renal surgery

Instrument	Alternative instrument(s)	Use	Suggested arm (sinistrals may switch position)
Typical instruments			
Monopolar curved scissors	Permanent cautery hook Curved scissors Round tip scissors	Cutting, preparation and monopolar cautery in most procedures	Right
Large needle driver	SutureCut needle driver	Suturing (two or in combination with Maryland/PK dissector)	Right or both
PK dissector	Fenestrated Maryland bipolar Precise bipolar	Preparation, dissection, grasping, bipolar cautery, and suturing	Left
Harmonic curved shears	Ultrasonic shears	Kidney/pelvic preparation	Right or left
Instruments for special situations			
ProGrasp forceps	Cadiere forceps	Holding/elevating	Left
Potts scissors		Ureter incision	Right
DeBakey forceps		Grasping of delicate structures, suturing	Left

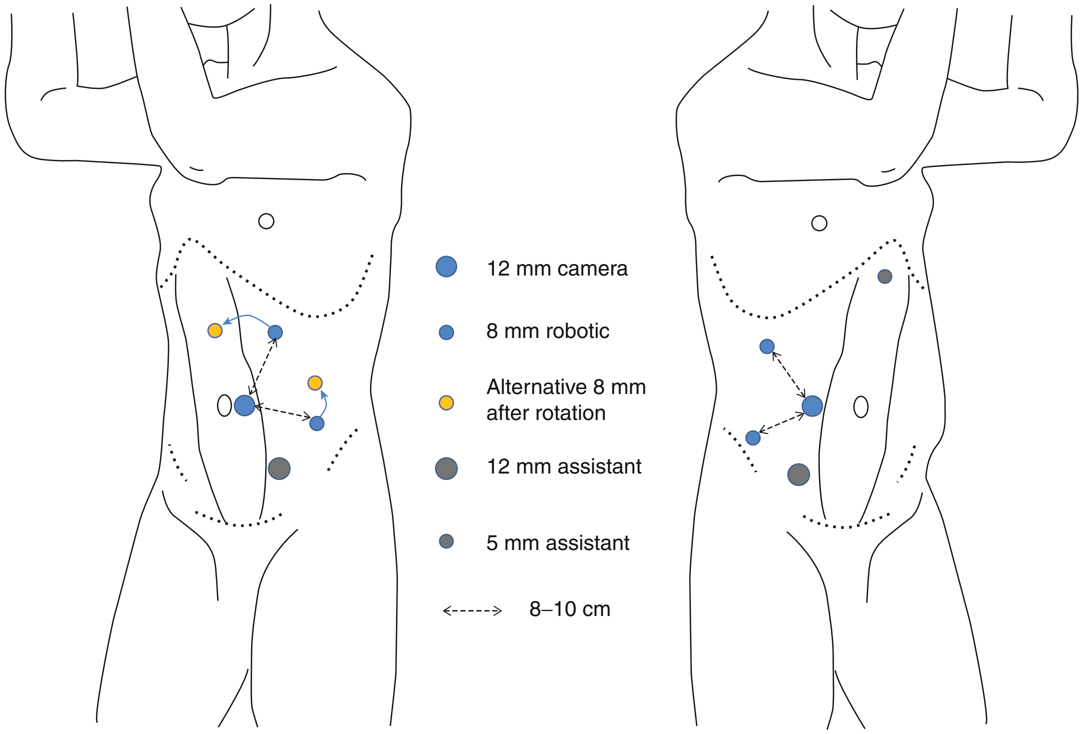

Fig. 2.2 Port placement for transperitoneal procedures. In obese patients (*right*), trocars should be shifted laterally. An additional port inferior to the xiphoid for liver retraction is often helpful

usually a 0° or a 30° down lens is used. One possible disadvantage of this approach is the limited space for the assistant, because camera arm and the robotic arms reach very far into the direction of the assistant. Also, this could lead to quite dangerous collisions with additional instruments, such as a laparoscopic Satinsky clamp, that are attached to delicate structures like the renal hilum. The advantage is a broader view over the operative field, which makes orientation easier.

For lateral camera port placement, the port is placed lateral to the midclavicular line [3]; therefore, a 30° up lens is useful. The possible disadvantage of this approach is a very close view of the operative field which could lead to a lack of overview plus slightly reduced space inside the abdominal cavity for camera movements; the table-side assistant has an easier access to his ports, which can be beneficial.

Port placement for robotic laparoscopic procedures of the kidney is less straightforward than pelvic procedures [45]. The best placement of ports depends on many variables. Especially for upper pole kidney surgery, the whole setup should be shifted upward and can be rotated. In obese patients, trocars should be placed more laterally [33, 44].

Considerations, such as location of interest (upper pole, lower pole, and hilum), interference of dissection because of large organ or tumor size, distorted renal anatomy, and the individual patient's physical features, affect the optimized port positioning. Preoperative imaging is obligatory in the proper planning of the surgical approach.

2.4.1.2 Left-Side Kidney Preparation

Using a PK dissector and monopolar scissors, dissection is started by incising the white line of Toldt lateral to left colon and bringing down the descending colon. Alternatively, a cautery hook or ultrasonic energy ("harmonic scalpel") could be used instead of the scissors. The mobilization of the colon should be at the same level throughout its length; cranially, the kidney should be made free to the level of the spleen, and caudally, the colon should be mobilized to the level of iliac vessels. In case of nephroureterectomy, the sigma also has to be mobilized to follow the ureter in the pelvis. Medial traction by the assistant helps clearing of anterior Gerota's fascia by identifying additional colorenal attachments. The lienocolic and phrenicocolic ligaments are incised to allow the left colic flexure to fall medially along with the pancreas. Care has to be taken to leave the kidney attached laterally to avoid a flipping into the operative field which could make hilar dissection difficult.

The psoas muscle is identified and followed medially to expose gonadal vessels and ureter. The gonadal vessels which are usually first encountered should be swept laterally to expose the ureter. Both structures are then followed proximally to the lower pole of the kidney. Our group also prefers in ablative procedures not to divide the ureter at this point because lateral traction on ureter and lower kidney pole can help to identify the renal hilum. The gonadal vein can be traced proximally to the renal vein.

2.4.1.3 Dissection and Securing of the Renal Hilum

Safe dissection of the renal hilum requires two conditions: (1) medial retraction of the colon and bowel by gravity or infrequently by an additional retractor and (2) lateral retraction of the kidney by lifting it out of the renal fossa. Lifting the kidney to the lateral abdominal wall will place tension on the vessels, helping identifying and controlling anticipated structures and accessory vessels. Anterior dissection is performed layer by layer with the PK dissector until the renal vein is uncovered. Gonadal, lumbar, and accessory venous branches can then be clipped and divided when identified. The inferior adrenal vein can be preserved when adrenalectomy is not required but has often to be clipped. The renal vein and artery can then be cleaned off carefully (Fig. 2.3). In most cases, the artery is best approached inferior to the vein, but access from superior is also appropriate if easier. Preoperative imaging can help identifying accessory pole arteries or an early division of the main renal artery into the major branches.

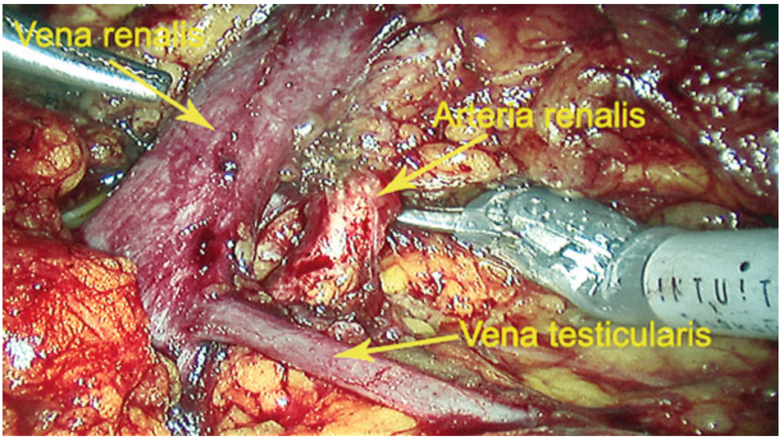

Fig. 2.3 Renal hilum (left side)

In ablative surgery, the renal artery is usually divided first. Clips, stapler (endovascular gastrointestinal anastomosis = GIA staplers), or suturing can be used in robotic surgery [57]. Clipping and stapler firing has to be done by the table-side surgeon, also a robotic clip applier can be used, the downside is the additional costs for the instrument plus the lack of one robotic arm to keep the hilum under stretch while clipping. If desired suturing of the vessels, like in open nephrectomy, is possible due to the wrist-like movements of the robotic instruments. We prefer the use of at least two Hem-o-lok clips proximally and one distally. When using GIA staplers, care must be taken not to entrap clips from smaller vessels divided before [20].

For nephron-sparing procedures, a laparoscopic bulldog or Satinsky clamp is used on the artery and on the vein, either combined artery and vein or separated; alternatively, clamping the renal artery alone has been described as a useful approach in case of aberrant vascular supply to the kidney. A vascular tourniquet with a cut drainage tube is also a safe and feasible manner to achieve a nearly bloodless field.

2.4.1.4 Right-Side Kidney Preparation

Access to the right renal hilum is more unpretentious than on the left side due to the fact that the right kidney is an organ with more contact to the peritoneum. In left flank position, the ascending colon and the right colic flexure drop down usually exposing anterior surface of the kidney. Analogous to left-side preparation, the line of Toldt is incised from coecum to colic flexure, and gonadal vein and ureter are identified at the pelvic brim. The right gonadal vein is followed proximally to the inferior vena cava and secured and divided, if desired. By tracing the vena cava, the duodenum is released, and the renal vein is located. The steps in dissecting and securing of the renal vessels are similar to those previously described for the left side.

2.4.2 Retroperitoneal Approach

2.4.2.1 Patient Positioning and Port Placement

Retroperitoneoscopic robotic renal surgery affords, similar to open surgery, a complete, bended flank position. Available space and possible positions for port placement are nevertheless restricted compared to transperitoneal approaches. A slightly anterior rotation of the operation table allows the peritoneum and its content to drop away ventrally resulting in some more working space in the retroperitoneum. Two different possibilities for retroperitoneoscopic port placements are shown in Fig. 2.4. The robot is docked again from the patient's back. For better right arm docking, the robot should be installed in a 45° position to the operation table when the camera port is placed over the iliac crest.

The first step is to create the retroperitoneal working space. A 12-mm incision is made off the tip of the twelfth rib, and the surgeon's index finger is used to penetrate bluntly through the muscular layers into the retroperitoneal space. By

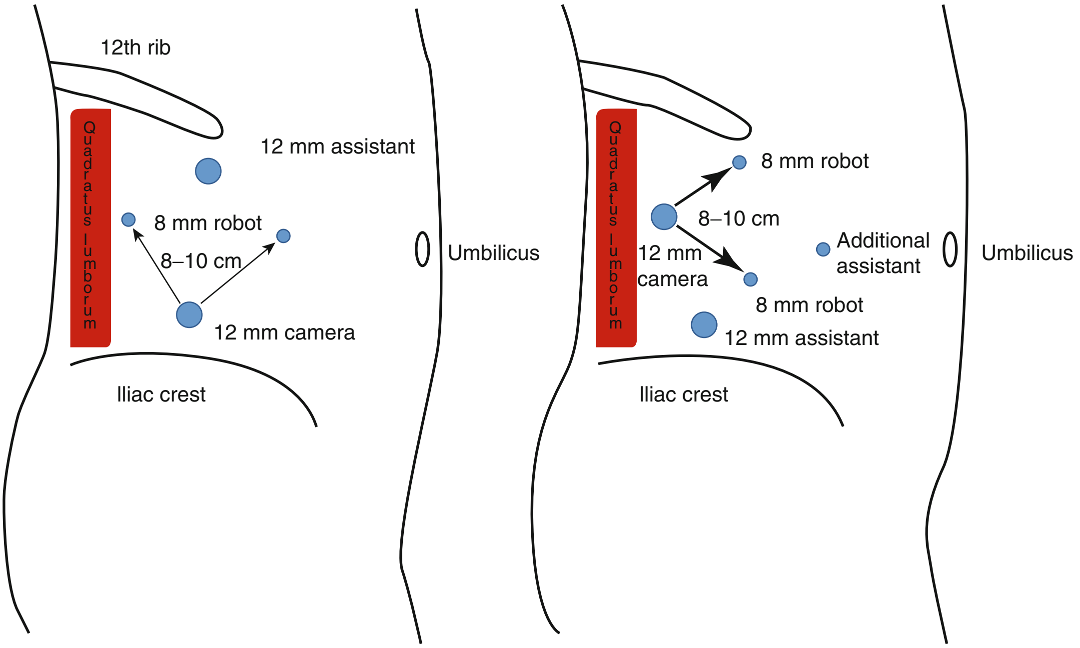

Fig. 2.4 Retroperitoneal port placement

entering the correct space, the surgeon should feel the lower pole of the kidney downward, the tip of the 12th rib upward and the smooth surface of the psoas muscle. Then the retroperitoneal space is created by using the middle finger of an 8½ glove mounted on a trocar or a catheter which is filled with 700–800 ml saline. Alternatively, commercial distension balloons are available [28, 66]; some surgeons prefer create the space with the optical camera itself.

Under direct vision, 8-mm robotic trocars and a 12-mm camera trocar are placed using blunt tips. Again an 8- to 10-cm right-angle setting of the robot trocars is required to allow for adequate robot arm movements and to avoid arm collision. Working space could then be extended if necessary. The initial incision is used as the assistant port for the table-side surgeon. In case of alternative port placement, the initial incision has to be reduced by suturing for the 8-mm robot port; hybrid technique (inserting the robot port through established 12-mm port) is also possible [82].

2.4.2.2 Kidney Preparation

The orientation in the fatty tissue may be more difficult, especially in obese patients, due to unavailable typical anatomical landmarks in the beginning of the procedure. First the psoas muscle should be identified; by dissecting medially, the ureter and the gonadal vein are encountered, a penetration of the overlying peritoneum has to be avoided. Then the dissection of the renal hilum follows the same principles as in the transperitoneal approach. Tension on the ureter and lower kidney pole helps to identify vascular structures. The surgeon must be aware of the different direction of preparation compared to the transabdominal approach. Aorta or vena cava inferior is located perpendicular below the ureter with the risk of accidental injuries. Access to the renal artery is usually more direct than in transperitoneal surgery. On the right side, camera orientation should be rechecked before clamping or securing the assumed renal vein due to reports of ividing the vena cava during standard laparoscopic nephrectomy [65].

2.5 Nephrectomy

2.5.1 Simple Nephrectomy

Robotic simple nephrectomy can be used for almost all benign renal diseases that require kidney removal. Chronic pyelonephritis, obstructive or reflux nephropathy, nephrosclerosis, and renovascular hypertension can be treated as well as symptomatic acquired renal cyst disease or symptomatic autosomal dominant polycystic kidney disease [41, 55]. Depending on the primary disease and the duration of patient's history inflammatory adhesions between the kidney and surrounding tissue and fibrosis of perirenal tissue "simple" nephrectomy may be a very delicate procedure.

Kidney preparation is described in Sect. 4.1.2 and dissection and securing of renal artery and vein in Sect. 4.1.3.

On the left side, the inferior adrenal vein can often be preserved. After controlling of renal vessels, the preparation is continued circumferentially at the upper pole by peeling of the Gerota's fascia from the kidney. The use of ultrasonic energy (ultrasonic shears or harmonic curved shears) on the left robotic arm facilitates the preparation of the upper pole and the lateral and dorsal aspect of the organ by simultaneously coagulating small vessels. The use of a LigaSure device by the table-side surgeon is also possible but requires a good cooperation between console and table-side surgeon. Preparation and dissection by bipolar PK dissector and monopolar hook or scissors (Hot Shears™) is also possible but is often more time-consuming.

At the end of the procedure, the ureter is divided after clipping at the level of the iliac vessels, or as far distally as possible. The specimen is entrapped in an endocatch bag and removed after undocking of the robot. This could be done by extending the camera trocar site at the level of the umbilicus or alternatively by widening the robot or assistant trocar site in the lower abdomen. Some surgeons prefer morcellating of the kidney inside the retrieval bag [9, 93].

A drain can be placed in the renal bed at the end of the operation if necessary or due to preferences of the surgeon.

2.5.2 Donor Nephrectomy

Donor nephrectomy follows the same principles as described for simple nephrectomy regarding some special aspects and modifying the surgical steps. Due to the length of the renal vein, the procedure is usually performed on the left side.

At the beginning, a 7-cm midline incision is made below the umbilicus. After opening the abdominal cavity, a hand-port device is inserted, and pneumoperitoneum is established [13]. After robot trocar placement (camera port pararectal, 8-mm robot arm ports midline between xiphoid and umbilicus and left lower abdomen), a 12-mm assistant port is placed in the lower abdomen or below the xiphoid [48].

Before dividing renal vessels, the kidney has to be completely mobilized and the ureter traced below the level of the iliac artery. Care has to be taken not to compromise the ureteral blood supply by leaving a sufficient amount of periurethral tissue on the ureter. After dissecting of the renal vein and dividing its tributaries (adrenal, gonadal, and if present lumbar veins) by LigaSure device or clipping, the artery (or arteries) are followed to its aortic takeoff.

Then the ureter is clipped and divided. At this time, most groups administer heparin [50]. Then artery and vein are divided by GIA stapler; the use of Hem-o-lok clips in case of living donor nephrectomy is not approved. The kidney is removed immediately through the hand port, on the back table staples are removed from the vessels, and the kidney is flushed with preservation solution [51, 78].

After inspection of the renal bed to ensure hemostasis, the robot is undocked, trocars are removed, and wounds are closed, with or without leaving a drain.

2.5.3 Radical Nephrectomy

Laparoscopic radical nephrectomy has become an established and widely used procedure by many experienced centers [38]. In the 2010 EAU Guidelines on renal cell carcinoma, it is considered as the standard of care in patients with T_2 tumors or T_1 tumors in which partial nephrectomy is not indicated. Outcome data indicate equivalent cancer-free survival rates when compared with open radical nephrectomy by reduced morbidity and less inflammatory and immunologic reaction of the organism after surgery [16, 21].

The laparoscopic approach duplicates the oncological principles from open surgery [37]. In addition, port site seeding must be avoided by using following precautions: minimizing direct tumor handling, en bloc resection of the tumor including surrounding tissue, entrapping all tissue in impermeable retrieval bag before removing, redraping of port sites at time of specimen removal, avoiding of positive margins, and change of gloves for all table site staff before wound closing [18, 30].

Robot technology allows for all described steps of laparoscopic radical nephrectomy with the additional virtue of better dexterity of the instruments and 3D vision.

Preoperative evaluation is the same as in open surgery including imaging of the tumor size, possible extension in perirenal structures, and status of the vein for possible tumor thrombus and exclusion of presentable metastasis.

Patient positioning, port placement, preparation of the kidney, and dissection of the renal hilum are described in previous chapters depending on trans- or retroperitoneal approach and side of surgery.

Before dividing the vein, it should be carefully inspected if there is any question of tumor thrombus. The dissection is then performed external to Gerota's fascia at all times. Simultaneous adrenalectomy is performed in upper pole tumors or large mass tumors. After dividing the inferior adrenal vein, the preparation is followed cephalad medial to the adrenal, and additional veins and artery supply are identified and clipped. On the left side, the tail of the pancreas should be gently pushed medially. On the right side, an additional 5-mm port for liver retraction is often necessary.

After the nephrectomy, lymphadenectomy is performed. Lymphadenectomy should be restricted to the perihilar tissue for staging purposes since extended lymphadenectomy has been shown not to improve survival. Lymphatic tissue is dissected by clips, bipolar coagulation, or ultrasonic energy. Care has to be taken of lumbar veins on the right side and of lumbar arteries on the left side to avoid bleeding complications which may be difficult to handle laparoscopically. Although lymphadenectomy is usually a limited staging procedure in renal cancer, extended robotic retroperitoneal lymphadenectomy is possible nearly without limitation [1, 26, 90].

We always remove the intact kidney by expanding the camera port incision (alternatively the assistant port in the lower abdomen). Morcellating procedures are also described [59, 60], but histopathologic examination can only lead to reliable results with an intact specimen.

2.6 Nephron-Sparing Procedures

Nephron-sparing or partial nephrectomy has become a widely used technique in tumors smaller than 4 cm or in patients with solitary kidney, suboptimal kidney function, or bilateral tumors [10, 41, 61, 86]. The largest obstacle to the widespread use of laparoscopic partial nephrectomy is its technical difficulty. Limitation of instrument dexterity makes tumor excision, hemostasis, and reconstruction of the collecting system a quite challenging procedure even for experienced laparoscopic surgeons. Warm ischemia of the kidney is restricted to approximately 30 min due to potential loss of renal function, so the procedure has to be performed in a quick and safe manner [79, 80].

The same considerations that changed the view of both surgeons and patients about radical prostatectomy over the last years are obvious in nephron-sparing surgery. Advanced instrument movements and excellent visualization facilitate the surgeon to accomplish especially the delicate steps of this procedure [17, 35, 72].

Patient evaluation, preparation, and positioning are described before. In selected cases with the expectation of an extensive repair of the collecting system, stenting of the ureter prior to surgery may be considered, but is usually not necessary. Renal outside or inside cooling is usually not necessary but could be useful in special situations (e.g., large tumor in solitary kidney, central tumors).

After identifying of the ureter and aorta/vena cava, isolation of the renal vessels and mobilization of the kidney is performed as described before. We use PK dissector, monopolar curved scissors, and needle driver for the whole procedure. The tumor is localized, and renal capsule is exposed, leaving perirenal fat on the specimen (Fig. 2.5). Intraoperative use of a laparoscopic ultrasound probe by the table-side surgeon may help identifying the tumor and defining the line of resection [79, 80] and the vascular supply of the tumor. The TilePro tool of newer robotic generation allows for a picture-in-picture technique (Fig. 2.6).

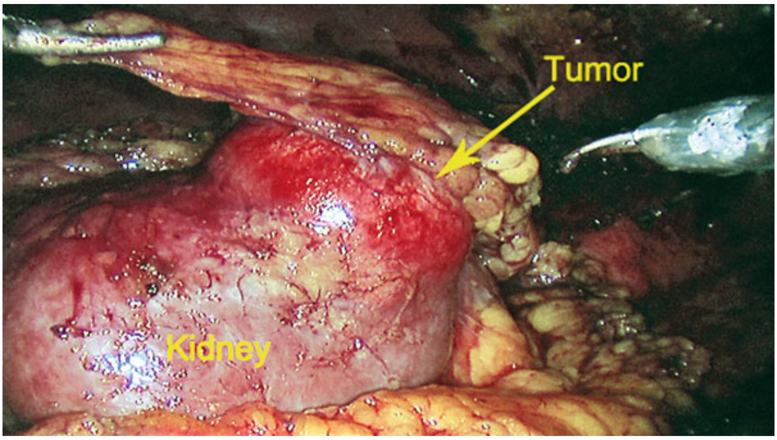

Fig. 2.5 Tumor after preparation. The perirenal fat is left on the tumor

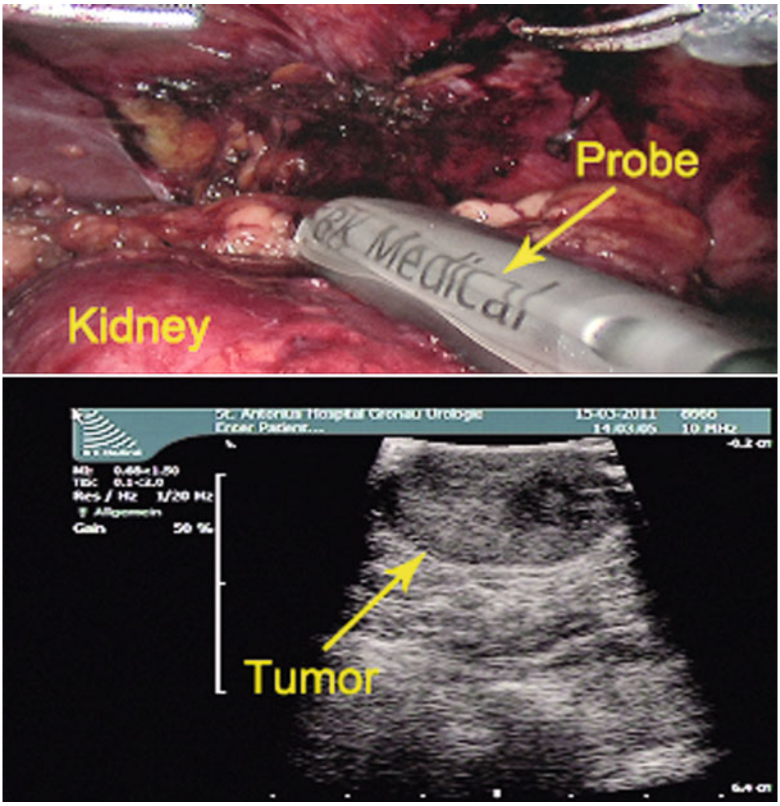

Fig. 2.6 Console view with ultrasound probe on the tumor (*above*) and ultrasound picture (*below*)

Before clamping of the renal vessels, the line of incision is superficially marked with the Hot Shears on the renal capsule. About 20 min prior to clamping, 12.5 g mannitol is administered by the anesthesiologist [72, 87].

The table-side surgeon is clamping the renal artery (and vein on right-side procedures or large tumors) with laparoscopic bulldog clamps after elevating the kidney by the console surgeon to expose and stretch the hilum [91, 94]. The use of a Satinsky clamp is also described but not our preference [72]. The "tourniquet technique" by using a vessel loop around the artery (or vein) and suspending the blood flow by traction on 3-cm 18 F drain through which the loops are guided is a good alternative (Fig. 2.7).

After marking (Fig. 2.8) and incision of the capsule, the tumor is excised using the scissors without electrocautery. The PK dissector is used for traction and exposing and coagulation of perforating arteries. Larger arteries should be clipped (Fig. 2.9). The use of ultrasound energy for coagulation is also described [98]. The suction device of the table surgeon helps by keeping the field clear of blood and exposing structures by countertraction. If a positive margin is suspected, a new, deeper plain of excision is created. Verifying the line of dissection by ultrasound probe may be helpful [53]. The excised specimen is placed beside the kidney. Biopsies for frozen section can be collected from the base of the lesion with the robotic scissors or a sharp grasper handled by the side surgeon.

The base of the lesion is checked for large perforating vessels and defects of the collecting system. After replacing the scissors by a needle driver (due to surgeon preferences two needle drivers could be used), suturing of vessels and, if necessary, defects

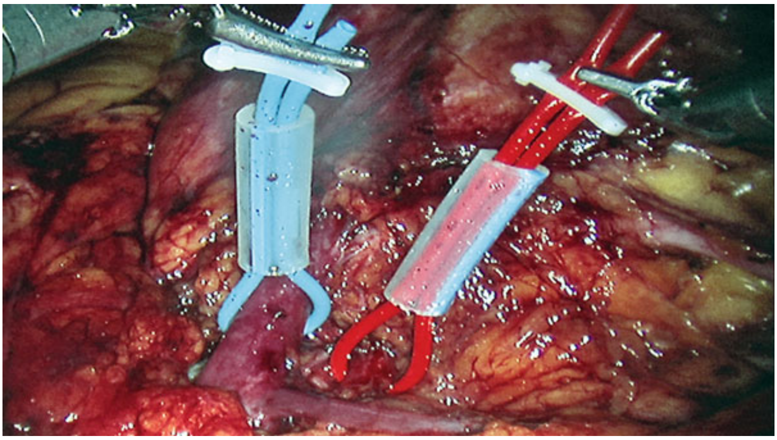

Fig. 2.7 Situs prior to clamping, loops around vein (*blue*) and artery (*red*). In most cases, clamping of the artery is not necessary

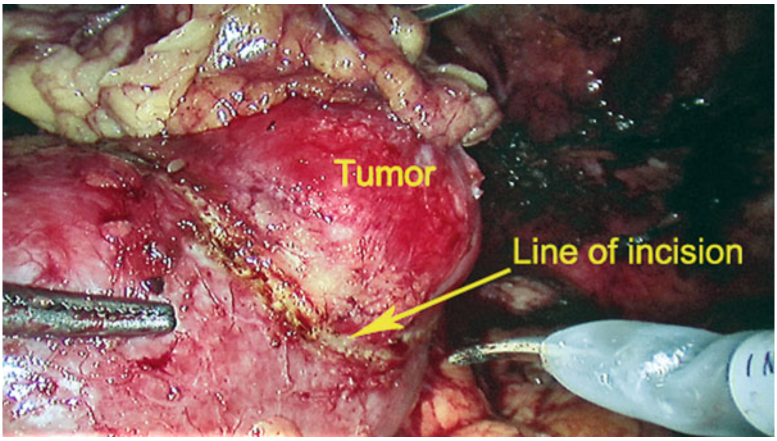

Fig. 2.8 The line of excision is marked with electrocautery

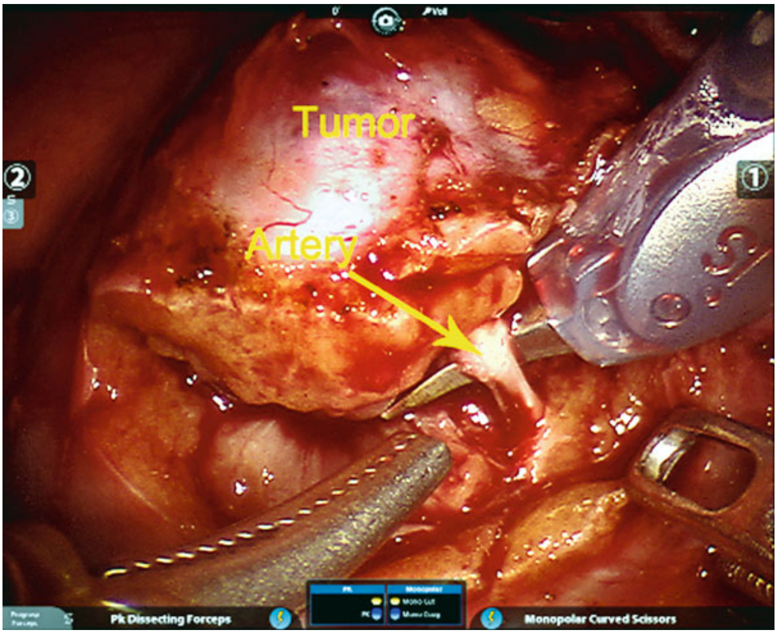

Fig. 2.9 Clipping of a larger artery during excision of the tumor

in the collecting system is performed with a 3/0 absorbable monofilic or braided suture (e.g. polyglyconate) on a small needle (e.g. RB-1 or HR 17). Also the use of a barbed suture (V-Loc™) for the deep layers is now common alternative. Additional hemostasis of the parenchyma can be achieved with an argon beam (one must be aware of the possibility of rapid increasing intraabdominal pressure caused by cautery gas) [74, 85]. Argon beam coagulation and other described additional forms of hemostasis (e.g., FlowSeal™ or TissueLink™) [73, 74, 95] are usually not necessary for adequate hemostasis in our hands. Bolstering of the defect is in most cases not necessary; in large defects, where sufficient approximation of excision rims cannot be achieved otherwise, bolsters can be helpful.

The defect is closed by renorrhaphy, utilizing a running suture on a large needle and using a sliding clip technique (Fig. 2.10); also a barbed suture can be used.

After elevating the kidney by the console surgeon, the bulldog clamps are released and retrieved. Early unclamping (after the first layer of suturing) reduces warm ischemia time and should be performed whenever possible. Hemostasis is confirmed, and perirenal fat is sutured over the defect in running technique. The tumor is placed in an endocatch bag for removing at the end of the surgery. Lateral fixation of the kidney is only performed in cases with extended kidney mobilization. We prefer to place a drain beside the defect or the hilum; in straightforward procedures or exophytic tumors, drainage could be renounced; in case of an obviously open collecting system, a drain should be put to avoid urinoma. After undocking of the robot, the specimen is removed through the site of the optic trocar or the assistant trocar in the lower abdomen.

2.7 Nephroureterectomy

Indications for nephroureterectomy are upper urinary tract transitional cell carcinoma with the need of resection of a bladder cuff and hydronephrosis caused by distal ureteral obstruction without the necessity for bladder opening [9, 14].

The surgical steps for removing of the kidney are described in previously chapters. As with other robotic renal procedures, trans- and retroperitoneal approach is possible. We prefer the transperitoneal approach due to easier access of the distal ureter and bladder wall. Especially when using the standard da Vinci system, the camera port should not be placed above the level of the umbilicus to avoid problems accessing the pelvis and the ureteral orifice [69]. The robotic arms should be placed as far away from each

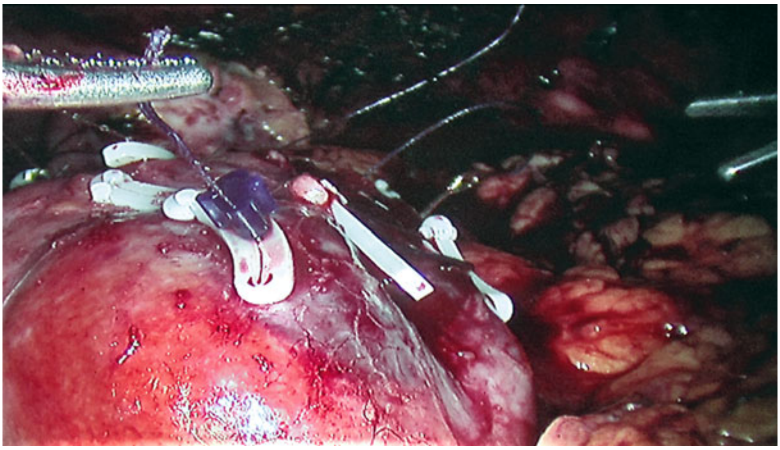

Fig. 2.10 Renorrhaphy in sliding clip technique

other as possible; this allows for a wide range of motion between robotic arms and the camera arm; access to the distal ureter can be achieved. If difficulties are encountered, redocking of the robot with adjustment of the arms can facilitate surgery: The camera trocar can be left in place, but the patient cart is driven over the shoulder of the patient, the operating table is slightly turned, and the previous right robotic arm is now attached to the previous left trocar; the right robotic arm is attached via a hybrid port-in-port technique to the previous assistant trocar.

By following the ureter in the pelvis, the peritoneum has to be incised medially or laterally to the medial umbilical ligament, and the vas deferens in males or the round ligament in female patients is clipped or coagulated and divided as encountered. After clipping of the ureter distal to the tumor, the ureter is dissected to its passage through the bladder wall.

The bladder is irrigated with 100-ml saline, and the bladder cuff is excised with the monopolar scissors [39, 52, 63]. After replacing the scissors with the needle driver, the bladder wall is subsequently closed with a 2/0 Vicryl running suture on an SH needle. This part of the procedure is easy to perform with the robotic instruments on contrary to standard laparoscopic approach [69]. The specimen is removed by a semi-Pfannenstiel incision on the side of surgery, in women, extraction of the retrieval bag through the vagina can be performed. If gaining appropriate access to the bladder wall is difficult (or if preferred by the surgeon), the procedure can also be finished in standard open technique; also a previous or even simultaneous transurethral incision of the bladder cuff can be performed , which facilitates this last step of the surgery.

2.8 Other Procedures

The experience of our group in other robotic kidney surgery is limited, just as reports in the literature. One publication demonstrated the feasibility of management of partial staghorn calculi by extended pyelolithotomy [2, 43].

In principle, renal surgery procedures such as nephropexy, cyst decortication, calyceal diverticulectomy, and pyelolithotomy that have been publicized for standard laparoscopy approaches [5, 6, 23, 29, 46, 64, 92] should be possible in robotic kidney surgery with potential advantages due to the technology.

Besides the still relatively young technology, reasons for limited experience in infrequent kidney procedures at this time may be economical aspects and the limited operation room capacity. Many centers are working to full capacity by radical prostatectomies and have only restricted robot time slots for other procedures.

2.9 Postoperative Management

As in other laparoscopic procedures, early mobilization of the patient (on the day of surgery) is recommended. Oral intake beginning on the day of procedure and return to full oral intake on day one or two is possible if tolerated. Catheter could be usually removed on the day of surgery or day one with exception of nephroureterectomy (we check for leakage on day 5–7 by cystogram). Also a possible drain could be removed in most patients on day one [77, 96].

Many patients could be discharged on day one, and hospitalization is rarely longer than a few days.

2.10 Complications and Management

Even in the hands of most experienced surgeons, complications are an unavoidable consequence of surgical practice [9]. The patient has to understand that factors related to anatomical conditions or due to the disease, operating room environment, and technical problems could lead to such undesirable conditions. Efforts at prevention should be maximized. In case of complications, early recognition and appropriate management is necessary to avoid fatal consequences [32]. Fatal robot errors are rare; procedures can often completed by standard laparoscopy, and in difficult situations, conversion to open surgery may be considered [75].

Overall (minor and major) complication rates reported in the literature for (simple and radical) nephrectomy is between 6 and 17 % [9, 56]. Complications are possible during the whole procedure, either surgeon-related as well as due to the anesthesiologist [62, 97]. Typical surgical complications include bowel injuries, solid organ injuries (mainly liver, spleen, pancreas), bleeding problems at trocar site (epigastric vessels), intra- and retroperitoneal bleeding (hilum, adrenal, mesenterial, lumbar and gonadal vessels; vena cava; aorta), urine leakage, subcutaneous emphysema, trocar hernia, and trocar site infection [27, 84].

Bleeding complications from renal vein or artery could be life threatening, and in doubt rapid conversion to open surgery may be necessary [67]. In such situations robot undocking is technically possible in less than one minute and should be trained on a regular base. Literature reports indicate that bleeding complications due to stapler or clip malfunction occur occasionally; they are conditional on technical reasons and could be avoided by the following safety measures: keep tip of stapler or clip free of tissue, no stapling over clips, no traction on applied clips, and correct stapler position with complete transaction [20].

Injuries of the diaphragm and port hernias (mostly at the site of organ removal) are less frequent, port hernias can be avoided by wound closure in layers of ports larger than 8 mm of size; useful tools against for port site hernia are, for example, the Berci needle or the Carter Thomason CloseSure device. Other complications include prolonged intestinal hypomotility, (transient) skin numbness, testalgia, deep vein thrombosis/pulmonary embolism, and pneumonia [11, 22, 71, 89].

Intravascular volume overload during surgery by the anesthesiologist should be avoided due to the fact that the laparoscopic approach has far less insensible fluid loss compared to open surgery.

In case of postoperative oliguria and hemodynamic instability, bleeding should be excluded as the cause.

In contrast to recognized bowel injury during surgery which can be sutured and usually does not lead to problems, unrecognized or delayed bowel injury may be fatal for the patient. Common causes for bowel injuries are direct or indirect electrocautery (mind that metal instruments can conduct electric current outside the surgeon's view as well), Verres needle or trocar placement [9]. We recommend not using monopolar energy when working in close proximity to the bowel; also using the Hasson technique for the primary access and placing all trocars under direct vision as a rule – and if possible in blunt technique – is an effective means to prevent bowel injury.

Patients with bowel injuries after laparoscopic procedures are often less symptomatic than after open surgery [8]. Patients with unrecognized bowel injury after laparoscopy typically present with persistent and increased trocar site pain at the site closest to the bowel injury. Increasing inflammatory blood parameters and persistent bowel sounds could lead to diagnosis. Later, signs and symptoms include nausea, diarrhea, reduced general condition, low-grade fever, and a low or normal white blood cell count. The patient's condition can rapidly deteriorate to hemodynamic instability and death if the injury is not quickly recognized and treated. Abdominal ultrasound, plain abdominal X-ray, and CT are diagnostic imaging tools, but sometimes an additional surgical intervention must be considered. A primary diagnostic laparoscopy can be useful; conversion to open exploration is usually required to evacuate bowel spillage and perform the necessary repair [8].

2.11 Future Perspectives

The still relatively young field of robotic surgery is focused currently on reconstructive and technically challenging procedures. In urology, radical prostatectomy and pyeloplasty have gained widespread use over the last years. With growing experience in many centers, there is an increasing interest in other procedures where the advantages provided by the technology could be assumed. Nephron-sparing surgery and cystectomy with urinary diversion are examples for these upcoming points of interest [7, 25].

Especially in partial nephrectomy, further developments may help to make surgery even more precise; also future indications could probably be expanded to larger tumors. These developments could include new robotic instruments, combining of techniques like cryoablation or radiofrequency ablation with robotic technology and the use of virtual imaging data acquired before or during the procedure [19, 24, 36, 83].

The rapid evolution of technical possibilities will offer urologic surgeons numerous new perspectives over the next years.

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3

Partial Resection of the Kidney for Renal Cancer

Alexander Mottrie and Vincenzo Ficarra

3.1 Introduction

Partial nephrectomy (PN) can be used in patients with bilateral tumours or with anatomic or functional solitary kidney to avoid dialysis (imperative indication) or in patients with normal contralateral kidney to prevent chronic kidney disease and to reduce non-cancer mortality (elective indication). Consistent peri-operative and oncologic data support the current role of PN as the gold standard of treatment for renal masses ≤4 cm (cT1a). Similarly, a few studies support the expanded indications for PN in selected patients with tumours ranging between 4.1 and 7 cm (T1b). Open PN (OPN) is still considered the best available approach. However, in the last decades, pure laparoscopic (LPN) and robot-assisted partial nephrectomy (RAPN) represent the main alternatives to OPN [1].

LPN is considered a technically challenging procedure requiring a long learning curve in order to reach acceptable warm ischemia time (WIT) and peri-operative complications. For this reason, the European Association of Urology (EAU) guidelines propose such a minimally invasive approach as an optional treatment for cT1a renal tumours only in experienced centres [1]. Conversely, RAPN seems to be a promising procedure, able to bridge the technical difficulties of LPN in favour of a broader diffusion of minimally invasive treatment of small renal masses. Indeed, RAPN can be considered the natural evolution and simplification of traditional LPN, and the advantages offered by the da Vinci platform could be more relevant in a very delicate organ such as the kidney, where every minute WIT lost could be detrimental to renal function. Specifically, three-dimensional (3D) vision, optical magnification up to ×12 and the patented EndoWrist (Intuitive Surgical, Sunnyvale, CA, USA) technology allow robotic surgeons to perform very precise tumour resection with an adequate margin of resection, simplifying the manoeuvres to achieve haemostasis and parenchyma reconstruction and thus reducing WIT. This makes the technique very tempting and adaptive to duplicating the oncologic outcomes of open PN, even in patients with tumours >4 cm or in very complex cases according to the anatomical and topographic characteristics. In experienced centres, RAPN can be indicated also in the treatment of cT1b and in very selected cT2 tumours.

3.2 Surgical Technique

3.2.1 Personal Technique

The majority of robotic surgeons prefer the transperitoneal approach to perform RAPN regardless

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of the anatomical and topographic characteristics of the renal tumours. Arguments in favour of transperitoneal approach are larger working space allowing better manoeuvrability of instruments and more familiar anatomic landmarks improving the orientation. However, this route requires bowel mobilization to expose the kidney, and it could facilitate bowel irritation due to the contact with blood and sometimes with urine. Moreover, posterior renal tumours may be difficult to approach, and full kidney mobilization is required to visualize the lesion. Potential benefits of a retroperitoneal approach could include a more direct access to the kidney and renal hilum without bowel mobilization and an easier approach to the lesions located at the level of the posterior face of the kidney. Conversely, the main issue can be represented by the limited retroperitoneal space making the procedure technically more challenging. No study has compared the two approaches using the robotic technology. Therefore, the choice of the best route should be based on the surgeon's preference. In our experience, we are more comfortable to use the transperitoneal approach.

3.2.2 Patient Positioning and Trocar Placement

Patients are placed on the operation table in a full flank position with the table slightly bent so that the margin between the costal and the iliac crest is enlarged in order to gain space for the robotic arms and lower the risk of collision. The positioning of the patient depends on the tumour location. In detail, a classical half flank position is used for tumours located at level of the anterior face of the kidney. Conversely, a full flank position is preferred for tumours located on the posterior face. To avoid conflict with the robotic arms, the patient arm ipsilateral to the tumour side can be positioned and fixed along the superior margin of the body. The patient is secured to the table, and all pressure points are padded.

In our experience, primary access for the pneumoperitoneum is performed using a direct open access checking with the finger the incision of the fascia and then putting directly the 12-mm camera port loaded with a blunt obturator. This manoeuvre is safe, simple and not associated with some potential risks using the Veress needle. A four-arm approach is actually preferred. We use a medial trocar configuration in which the camera is located medially near the umbilicus. In details, one 12-mm camera port is placed 2 cm cranial to the umbilicus on the pararectal line. The 8-mm cranial robotic trocar is placed subcostally on the pararectal line. Using the four-arm technique, the correct placement of the two caudal robotic trocars is of paramount importance to avoid collision of both arms on one side and to maintain their sufficient mobility on the other hand. This is done under visual control: the most posterior trocar is placed 2 cm caudal to the lower pole of the kidney and as lateral as possible. Now, the fourth robotic trocar is placed in the lower quadrant of the abdomen just 1 cm lateral to the pararectal line with sufficient distance to the former (>8 cm). Usually, only one 12-mm assistant trocar is placed between camera trocar and the cranial or medial caudal robotic arm. If necessary (fatty patients, large liver, difficult cases), an additional 5-mm or 12-mm assistant trocar can be placed on the midline between the camera port and the caudal robotic trocar. The strengths of the medial trocar configuration include a wide viewing distance and the ability to track instruments being passed into the abdomen by the assistant (Fig. 3.1)

Alternatively, other centres use a modified trocar arrangement, with the camera port placed more laterally and with two assistant ports placed medially (i.e. lateral trocar positioning).

The da Vinci robot is docked from backside of patient with an angle centred along the line defined by the camera port and the renal hilum. While docking, there are some tricks that can be particularly helpful: (1) Lift up the camera arm after docking to gain space. (2) The elbow of the lateral caudal robotic arm (nr. 2) must be turned inside towards the camera arm to improve the mobility range of this arm in the abdomen. (3) The third robotic arm is placed over the hip of the patient. Good bending of the table helps to do so without collision to the body. That is why the use of a hip holder is to be avoided as well. A 30° downward lens is used throughout the case. The working

Fig. 3.1 Patient positioning and port placement for 4-arm da Vinci Partial Nephrectomy (O.L.V. Clinic Aalst, Belgium)

arms are outfitted only with robotic monopolar scissors, ProGrasp forceps and needle drive.

3.2.3 Isolation of Renal Hilus and Tumour Identification

Primary access to the renal vessels is achieved, leaving the kidney attached to the abdominal wall. The bowel is reflected medially to expose the retroperitoneum. For right-sided tumours, the renal vein is usually identified following the inferior vena cava under the liver. Conversely, for the left-sided tumours, the renal vessel isolation is conducted starting from the lower pole of the kidney. Renal vein and artery are isolated by placing a vessel loop around them secured with a Hem-o-lok clip (Teleflex Medical, Research Triangle Park, NC, USA). Renal artery branches directed to the tumour can be isolated with the aim of selective clamping (Fig. 3.2). Then, the Gerota's fascia is incised and the peri-renal fat tissue extensively removed to visualize the tumour and to mobilize the kidney until easy access to the tumour from all sides is achieved. To allow a correct definition of the pathologic stage, the peri-renal fat is left on top of the tumour. This step of the procedure is very important to create an ideal situation to minimize the request time for tumour resection and renorrhaphy. Intra-operative ultrasound is then employed to define the gross margins of the mass and to correctly perform the lesion demarcation. Care is taken to free >1 cm of capsule around the tumour, and the parenchyma is incised few millimetres away from the tumour to demarcate the lesion before starting with warm ischaemia (Fig. 3.3). Patients are given intravenous 12.5 g of mannitol about 5–10 min before vascular clamping to reduce ischemic injury.

3.2.4 Hilar Control and Tumour Excision

Clamping is achieved using the robotic bulldog clamps (Fig. 3.4). Usually, only the main renal artery is clamped. However, in larger or centrally located tumours, both renal artery and the vein are clamped. In selected cases, it is possible to perform selective clamping of the secondary or tertiary arterial vessels going to the tumour. In this

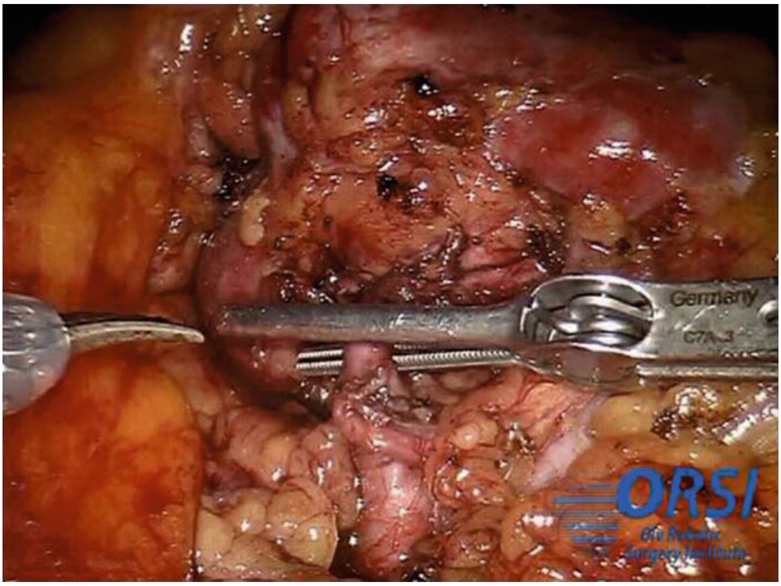

Fig. 3.2 Isolation of secondary renal artery for selective clamping (O.L.V. Robotic Surgery Institute)

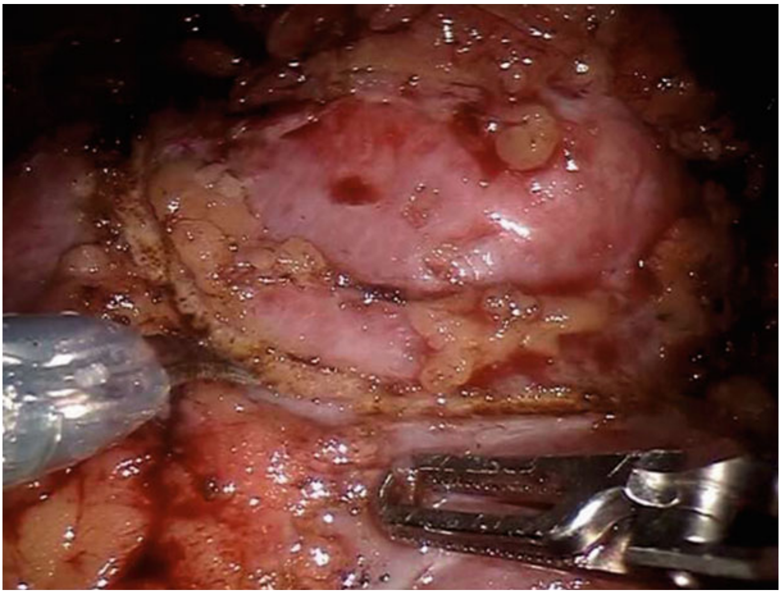

Fig. 3.3 The renal parenchyma is incised few millimetres away from the tumour to demarcate the lesion before to start with warm ischaemia

case, a perfusion assessment using the *FireFly* fluorescence imaging can be performed. In details, 1.5–2 ml of indocyanine green (ICG) is intravenously injected, and the branch of the renal artery clamped. Few seconds after the injection, the main renal artery and vein are visualized in green using the FireFly (near infrared) imaging (Fig. 3.5). Then, the normally perfused parenchyma will appear green with the exception of the area perfused by the clamped secondary or tertiary arterial vessel (Fig. 3.6a, b). If the area surrounding the tumour is not perfused, the tumour excision can be performed using the selective arterial clamping without the risk of excessive bleeding. Vice versa, the risk of bleeding will be consistent, and the best strategy will be to clamp the main artery. Good vision at the level of the bed of the tumour is essential to follow the correct plane of dissection avoiding the risk of tumour violation and local dissemination. Before starting

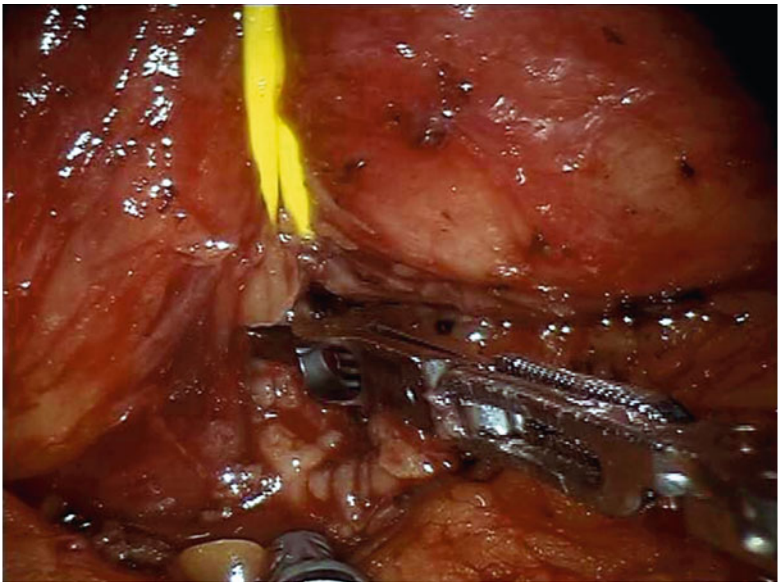

Fig. 3.4 The renal artery is clamped using the bulldog scanlan directly by the robotic surgeon

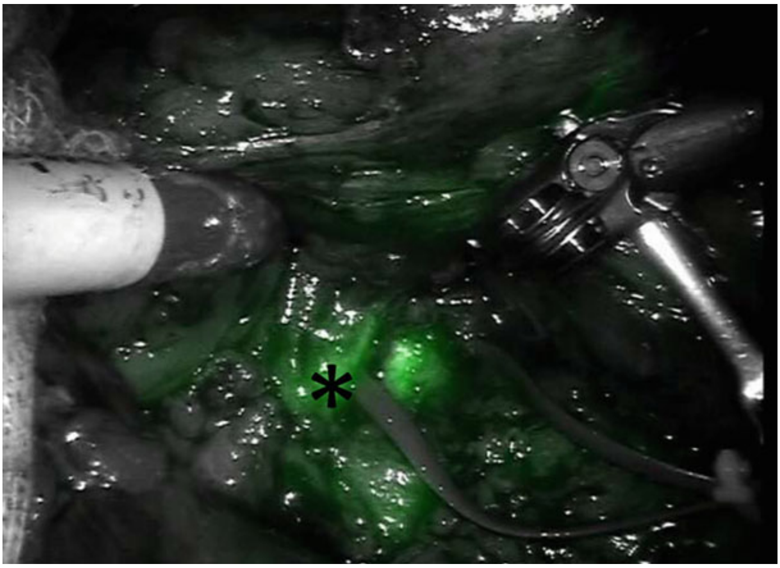

Fig. 3.5 FireFly Fluorescence Imaging showed the renal artery (isolated by placing a vessel loop around) and the renal vein (*)

with the resection, the pneumoperitoneum pressure is increased from 15 to 20 mmHg. Before clamping, the capsule is demarcated a few millimetres away from the tumour circularly. The borders of the tumour can more easily be defined using intra-operative ultrasound. The parenchyma is then entered a few millimetres, which eases blunt resection of the tumour surrounded with a few millimetres of healthy tissue ("enucleo-resection"). Clamping is usually performed with one laparoscopic bulldog on each vessel. The ProGrasp forceps can be used to gently spread the tissues to aid dissection. Cold dissection is used so that the surgeon can judge the quality of the incised tissue avoiding cutting into the tumour and thus avoiding positive surgical margins (Fig. 3.7). The role of the assistant controlling the suction device is essential as he has to facilitate the tumour excision by gently pushing the parenchyma and/or compressing little opened vessels in the tumour bed. Once dissection is complete, the specimen is placed above the liver or spleen for later retrieval.

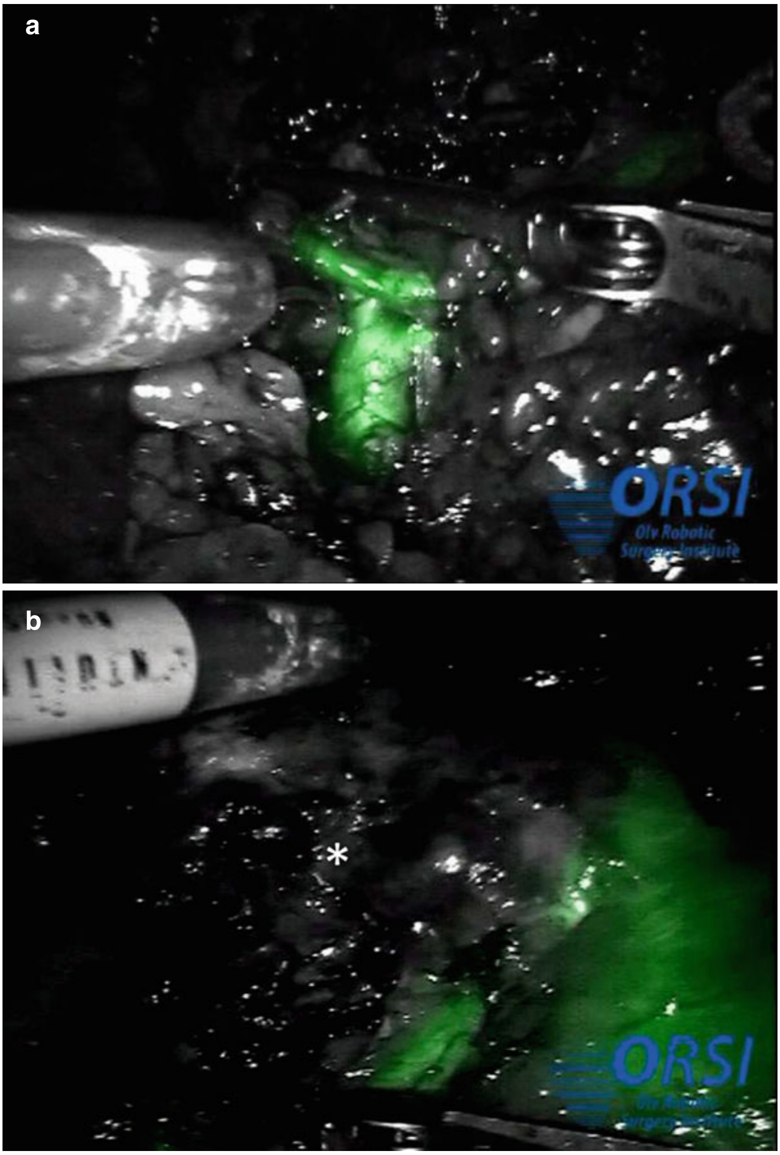

Fig. 3.6 (**a**) FireFly Fluorescence Imaging during selective clamping of secondary arterial branch. (**b**) FireFly Fluorescence Imaging showed the normal renal parenchyma in *green*. The tumour region (*) is not fluorescent because of it is not vascularized after selective clamping (O.L.V. Robotic Surgery Institute)

3.2.5 Renal Reconstruction

For the renorrhaphy, all sutures (Monocryl 3-0 SH Plus and Vicryl 1 CT Plus) are first prepared on the back table. A knot is tied at the end of an 18-cm suture. Above the knot, a Hem-o-lok clip is placed. The robotic scissors are exchanged for a robotic needle driver. The inner defect is closed with a running Monocryl 3-0 suture preloaded with a Hem-o-lok clip. The Monocryl is brought outside in, in order to have the clip outside the defect. Care is taken to take all retracted calices and vessels in the running suture. In contrast, too deep bites should be avoided in order to avoid injuries to larger vessels lying just under the defect. The Monocryl suture is then brought inside out through the parenchyma and secured with a second Hem-o-lok clip. Through the sliding clip technique, the right tension is brought on this suture. Proper tension has been applied when the surface of the kidney is slightly dimpled. After completion of the inner suture, usually the hilar clamping is removed (“early unclamping technique”), the pneumoperitoneum pressure lowered to 12 mmHg and the kidney checked for any bleeding (Fig. 3.8).

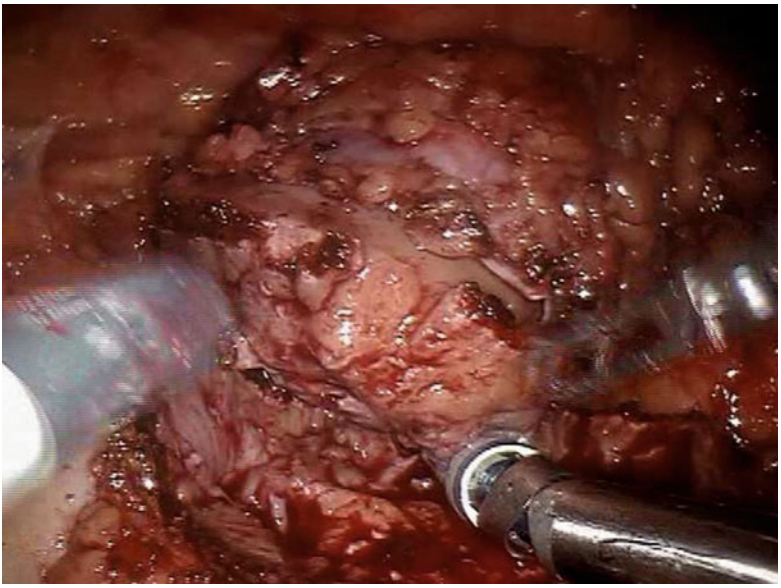

Fig. 3.7 Tumour excision was completed. In this case the procedure was performed. Using the dual console and the robotic suction device

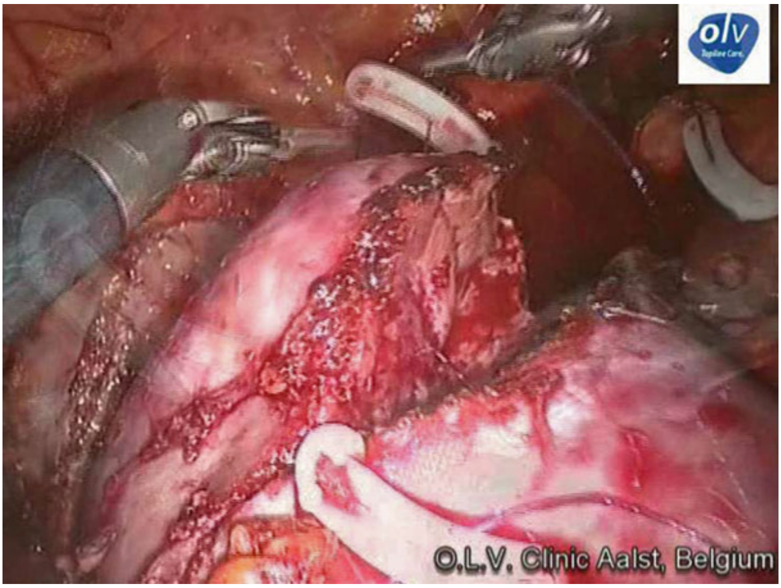

Fig. 3.8 Inner suture is performed using Monocryl 3-0 SH Plus (O.L.V. Clinic Aalst, Belgium)

The outer renorrhaphy is performed with polyfilament 1-0 sutures on CT needles using a running sliding clip technique (Fig. 3.9). The running suture is used, and at each bite, the thread is secured with a Hem-o-lok clip and proper tension given on the tissue. Then, the inner defect suture is put under tension again, because the pressure was taken away as a result of the outer closure. Then, a second Hem-o-lok clip is placed on all ends of the sutures. The use of monofilament suture and Hem-o-lok clip without LapraTy clip allows us to perform this manoeuvre, avoiding application of excessive force. If necessary, additional sutures or thrombogenic material may be used at the level of the parenchyma defect.

The specimen is placed in a retrieval bag, and the needles, bulldog clamp and vessel loop are removed. Gerota's fascia is closed, and the robot

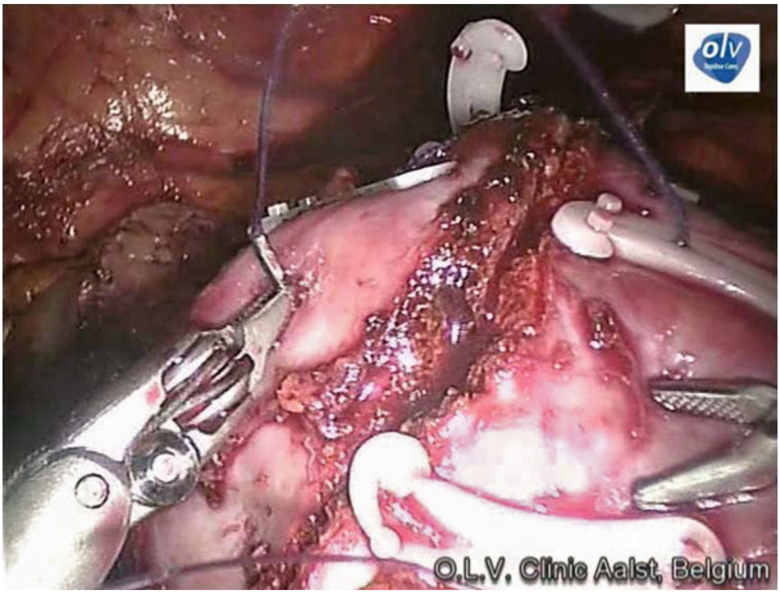

Fig. 3.9 The borders of the parenchyma defect are closed with polyfilament 1-0 sutures on CT needles using a running sliding clip technique (O.L.V. Clinic Aalst, Belgium)

undocked. A wound drain is introduced through one of the 8-mm trocars under direct vision. The specimen is usually retrieved through the camera port which may be enlarged if necessary. The fascia at the extraction site should be closed with a thick dissolvable suture. The remaining trocar sites do not require fascial closure, as the risk of herniation is low.

3.3 Other Approaches

3.3.1 Retroperitoneal Approach

This approach is described and shown by James Porter during several live surgery procedures. Patients are placed in the full flank position, and the bed is maximally flexed. The retroperitoneal space is created by placing a balloon dilator (Covidien, Mansfield, MA) in an incision in the mid-axillary line 2 cm above the iliac crest. Once the retroperitoneal space has been dilated, a 12-mm Hasson balloon trocar (Covidien, Mansfield, MA) is placed. The CO_2 pressure is maintained between 12 and 15 mmHg depending on the patient. A four-port configuration (one camera trocar, two robotic ports and one 12-mm assistant trocar) is routinely used for RP-RAPN. Once the ports are placed, the robot is docked by bringing the robot in over the patient's head, parallel to the spine. A 0° robotic laparoscope is most commonly used, but on occasion, a 30° up lens is needed to avoid camera conflict with the iliac crest. The renal vessels are then exposed, and enough artery is dissected to allow bulldog clamps to be placed on the artery. The vein is isolated, but only clamped if the tumour is large or centrally located. The renal mass is then isolated, and enough parenchyma is exposed to allow a resection margin around the tumour and closure of the defect. Laparoscopic ultrasound is used by the bedside assistant to determine the depth of tumour invasion. Prior to clamping the renal artery, 12.5 g of mannitol and 20 mg of furosemide are given intravenously to induce diuresis. One or two bulldog clamps are placed on the artery beginning warm ischaemia time. The tumour is excised with cold scissors, and cautery is avoided to prevent charring of the normal renal parenchyma and preserve visualization. Once the tumour is freed, it is placed in an endoscopic entrapment sac for later removal. The renal defect is reconstructed by first closing the collecting system, if it is entered, with 4-0 absorbable braided sutures. Individual vessels are oversewn with 4-0 sutures. The base of the defect is oversewn with 3-0 monofilament absorbable suture in a running fashion and secured on the outside of the kidney with locking clips. The renal cortex is then closed using 2-0 absorbable, braided suture using the sliding locking clip technique. Once the defect is closed, the bulldog clamps are removed ending warm ischaemia time. The renal closure is observed, and additional 2-0 absorbable sutures are placed and secured with sliding locking clips if needed. A drain is placed, and the renal mass is removed.

3.3.2 Zero Ischaemia

This technique described by Gill et al. in 2011 requires a controlled hypotension during the anaesthesia [2]. The mean arterial pressure (MAP) is maintained at approximately 60 mmHg to ensure adequate oxygenation and perfusion of vital organs and tissues. Specifically, nadir hypotension is induced only during excision of the deep part of the tumour. Upon completion of tumour excision, blood pressure is restored to preoperative levels. Briefly, the hilar vessels are prepared and clamped en bloc using the Satinsky clamp or bulldogs. In cases with a medially located hilar or polar tumour, wherein the tumour or the tumour-bearing segment of the kidney is specifically supplied by a dedicated tertiary or quaternary renal arterial branch, meticulous microdissection and clip ligation of this specific vascular branch is done. Laparoscopic ultrasound is performed to identify the tumour and score its proposed resection margin. Tumour excision is begun with J-hook electrocautery through the full-thickness renal cortex to reach the medulla and sinus fat. MAP is incrementally reduced specifically during excision of the deep part of the tumour, commensurate with the amount of bleeding in the individual case. Then, the major intra-renal vessels in the renal sinus fat are identified, individually clip ligated with Hem-o-lok clips, and transected with cold scissors. Tumour excision is completed with cold scissors, followed by an initial layer of haemostatic sutures in the partial nephrectomy bed. MAP is gradually returned to baseline, and any residual bleeding vessels are suture ligated; thus, parenchymal reconstruction is always completed under normotensive conditions to assure complete haemostasis. Biologic haemostatic agents and Surgicel (Ethicon Inc, Somerville, NJ, USA) are applied to the resection bed, and the procedure is terminated.

3.4 Peri-operative Outcomes

Since its introduction in 2004 by Gettman and colleagues, RAPN has been steadily gaining acceptance as a viable alternative to both open and laparoscopic partial nephrectomy for patients with small renal masses suitable for nephron-sparing surgery (NSS) [3]. Initial series demonstrated that RAPN is a safe, minimally invasive procedure requiring a short learning curve to reach satisfying results in terms of peri-operative outcomes. In details, looking at the most relevant single series published between 2004 and 2010, the mean operative time was 194 min, the mean blood loss was less than 200 ml and the mean warm ischaemia time (WIT) was 25 min. Previous data were confirmed by the results of the first international multicenter study published by Benway et al. in 2010. In this study, the authors analysed 183 cases reporting a mean WIT of 24 min, a mean console time of 141 min, a mean blood loss inferior to 150 ml and an overall complication rate of 9.8 % (8.2 % major and 1.6 % minor complications) [4]. However, similar to other robotic procedures, >30–40 cases are needed to master RAPN, and it is expected that further improvement of the results will be parallel to the further progression in surgical experience. In our initial experience, the WIT <30 min was reached after the first 20 cases and a WIT <20 min after the first 30 procedures. Moreover, our study demonstrated a significant decrease in the WIT, console time and percentage of pericaliceal repair according to the increase of the surgical experience. In this single-centre series influenced by the learning curve, we observed only 2 (3.2 %) grade 3 complications according to Clavien classification. In both cases, patients had postoperative bleeding due to arteriovenous fistula requiring selective percutaneous embolization [5].

Currently, in our experience, the operative time ranges between 80 and 120 min, the mean WIT using the early unclamping technique is 9 min (range 5–15 min) and estimated blood loss between 100 and 150 ml. The percentage of peri-operative complications decreased to 3.5 % in low risk cases and 15 % in more complex cases. No positive surgical margins were observed after the first 62 patients analysed to evaluate the learning curve period.

In 2011 Gill et al. proposed an anatomic targeted dissection and super selective control of tumour-specific renal arterial branches to facilitate the zero-ischaemia PN avoiding hilar clamping even for challenging medial and hilar tumours [2]. The conclusive message was that global surgical renal ischaemia appears unnecessary for the majority of cases suitable for RAPN, regardless of size or location of the tumour.

Currently, we prefer to use early unclamping technique, and when it is possible, a selective clamping of secondary arterial branches. In our opinion, the application of zero ischaemia should be reconsidered with caution. This approach is still complex (more than 4 h were required) also in the hands of very expert laparoscopic surgeons. Moreover, only preliminary data coming from a limited number of cases were available in literature. Therefore, preliminary results must be reconfirmed in prospective, single or multicenter, case series studies including a large number of patients and then further compared to the gold standard technique in the context of randomized or non-randomized studies.

More recent studies showed a further significant improvement in the peri-operative outcomes after RAPN and the feasibility of this new approach also in complex cases. Specifically, in a recent multicenter, international study of ours, we reported in patients with intermediate or high-risk tumours according to PADUA score a median WIT and console time of 20 and 120 min, respectively. Moreover, the percentages of intra-operative and postoperative complications were 4 and 17 % in the intermediate group and 6 and 15 % in the high-risk ones, respectively. Interestingly, in this multicenter experience, the authors reported grade 1 postoperative complications according to Clavien system in 10 cases (2.9 %), grade 2 in 21 (6.1 %), grade 3 in 7 (2.0 %), and grade 4 in 3 (0.9 %) [6].

Few data are available about the application of the RAPN in the treatment of cT1b tumours. In 2009 for the first time, Patel et al. showed the feasibility of the RAPN in a single-centre series including 15 renal tumours larger than 4 cm. In that study, RPN for tumours >4 cm showed comparable outcomes to RPN for smaller tumours, although with longer warm ischaemia times (25 min versus 20 min). Interestingly, in this preliminary experience, the authors reported an overall complication rate of 26 % with three major complications (19.8 %). Conversely, neither intra-operative complications nor positive surgical margins were reported [7]. More recently Gupta et al. published the results of a single-centre series analysing 19 procedures performed in 17 patients. In this series, the median WIT was 36 min, and the median blood loss 500 ml. However, no patient received blood transfusion during the peri-operative period, and the unique complication reported was a case of urine leakage and ureteropelvic junction obstruction requiring a postoperative stenting. However, three procedures required conversion to OPN due to excessive bleeding. No positive surgical margins were reported. Both previous studies did not show any significant impairment of the kidney functional comparing preoperative and postoperative (3 and 12 months) creatinine and eGFR values [8]. Only anecdotic data were reported about the feasibility of RAPN in selected T2 cases.

No study compared RAPN to OPN, and only few studies compared RAPN to LPN showing a significant shorter WIT in the RAPN groups. Moreover, some studies documented a statistically significant advantage in favour of robotic procedure also in terms of reduction of blood loss and in-hospital stay duration [9].

3.5 Functional and Oncologic Outcomes

Available functional outcomes indicated excellent preservation of renal functional reserve 3 or 6 month after RAPN. However, the majority of these studies are based on the evaluation of creatinine levels (mg/dl) and/or estimated glomerular filtration rate (GFR) values [4, 5]. Therefore, the real impact of the surgery on the renal function could be masked by the normal contralateral kidney. No study evaluated the renal function of the treated kidney after RAPN using the renal scintigraphy. Studies evaluating the factors influencing the renal function after RAPN should be performed.

Considering the short follow-up reported in the majority of available series, only early oncologic outcomes can be evaluated after RAPN. Specifically, the risk of positive surgical margins ranges between 2 and 4 % of the cases in the most recent and wide series reported in Literature. This preliminary result can be considered overlapping with the percentages previously reported after open or traditional laparoscopic partial nephrectomy. Data concerning recurrence-free or cancer-specific survival after RAPN are still immature. Therefore, longer follow-up is mandatory also to confirm the oncologic effectiveness of this procedure at an intermediate and long-term follow-up.

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Robotic Nephroureterectomy

4

Shyam Sukumar and Craig G. Rogers

4.1 Introduction

Transitional cell carcinoma (TCC) of the renal pelvis and ureter represents approximately 8 % of all tumors of the kidney and 5 % of the tumors of the entire urothelium [1–4]. Open nephroureterectomy (ONU) with excision of the ipsilateral bladder cuff has been considered the standard of care for patients with upper tract TCC. In a large multi-institutional study of outcomes after ONU for patients with upper tract TCC, Margulis et al. [3] demonstrated an extravesical disease recurrence rate of 28 % and a cancer-specific mortality rate of 23 % at a mean follow-up of 51 months. However, ONU is associated with significant perioperative morbidity.

In 1991, Clayman et al. [5]. reported the first laparoscopic nephroureterectomy (LNU). LNU has demonstrated improved short-term perioperative outcomes with equivalent short-to-intermediate-term oncologic outcomes compared to ONU, at least for organ-confined disease [6, 7]. Berger et al. [8] presented long-term oncological outcomes or LNU that is comparable to ONU, with a 5-year cancer-specific survival of 80, 70, and 68 % for pTis/Ta, pT1, and pT3 disease, respectively. LNU can be technically challenging, particularly the dissection of the distal ureter, excision of the bladder cuff, and sutured reconstruction of the bladder. With the emergence of robot-assisted partial nephrectomy (RAPN) [9–11], substantial experience has been gained with the use of robotic assistance for minimally invasive kidney surgery, and these skills may be useful in the management of patients with upper tract TCC. Robotic nephroureterectomy (RNU) may help with the technical challenges of LNU with the benefit of improved visualization and precise articulating instruments. In this chapter, we discuss the indications, preoperative evaluation, procedural steps, and complications of RNU with a brief discussion of the current literature on minimally invasive nephroureterectomy.

4.2 Indications and Contraindication

Indications for LNU and ONU are also indications for RNU for treatment of TCC of the upper urinary tract. Bleeding diathesis is a contraindication for RNU. Patients with prior abdominal surgery are a relative contraindication, especially early in the learning curve of the operating surgeon.

4.3 Preoperative Evaluation and Preparation

The diagnosis of TCC is usually established with a combination of radiographic tests and endoscopic biopsy/cytology. Tumor staging should

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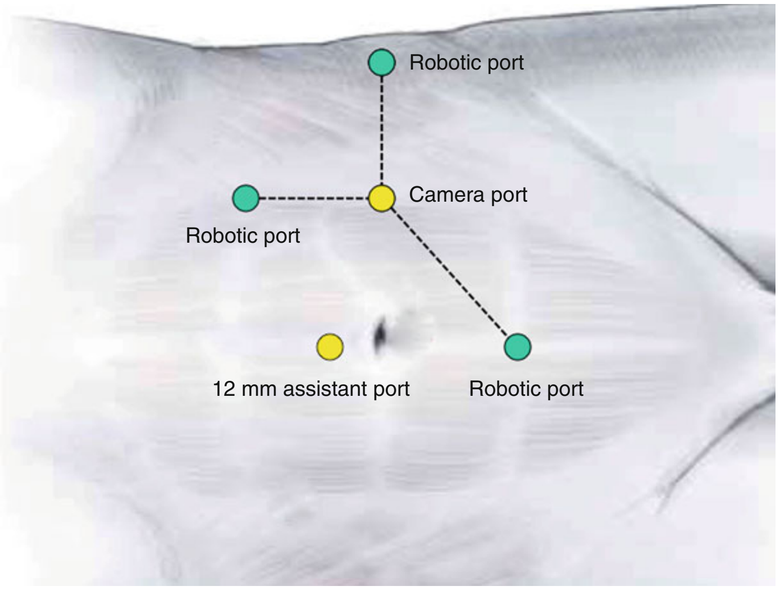

Fig. 4.1 Port placement for robotic nephroureterectomy (left)

include a chest X-ray and abdominal CT/MRI to evaluate for metastatic disease. Preoperative laboratory studies include renal function tests, liver function tests, and coagulation profile. All food and liquid intake should be stopped after midnight on the day before surgery.

4.4 Patient Positioning and Trocar Placement

The patient is positioned with the shoulders in flank position and the hips slightly leveled. We do not routinely perform intraoperative cystoscopy, but if the need for this is anticipated, the legs can be positioned to provide access to the urethra. Pressure points are carefully padded, and the patient is secured to the table. Pneumoperitoneum is obtained, and trocars are placed under direct vision. Figure 4.1 shows the placement of the various ports. We place a 12-mm camera port laterally at the level of the umbilicus. Robotic ports are placed forming two triangles centered on the camera port, with one triangle angled toward the renal hilum and the other triangle angled toward the pelvis. The robotic port for the third robotic arm is placed in a medial and caudal position. An assistant port is placed medially in a periumbilical position to allow access to both the kidney and the renal pelvis. During the pelvic portion of the case, the caudal robotic working arm is changed to the third robotic arm port. The robotic is docked perpendicular to the patient. Although it is possible to do a single docking strategy, if collisions become problematic, we suggest undocking, leveling the hips, placing the patient in reverse Trendelenburg position, and redocking at an angle over the hip.

4.5 Operative Steps

4.5.1 Colon Mobilization

An incision is made on the posterior peritoneum along the line of Toldt to displace the colon medially (Fig. 4.2). A plane between the Gerota's fascia and the posterior mesocolon is developed. The renal attachments to the liver or spleen are released.

4.5.2 Nephrectomy

Following medial reflection of the colon, the ureter and gonadal vein are identified. The ureter and

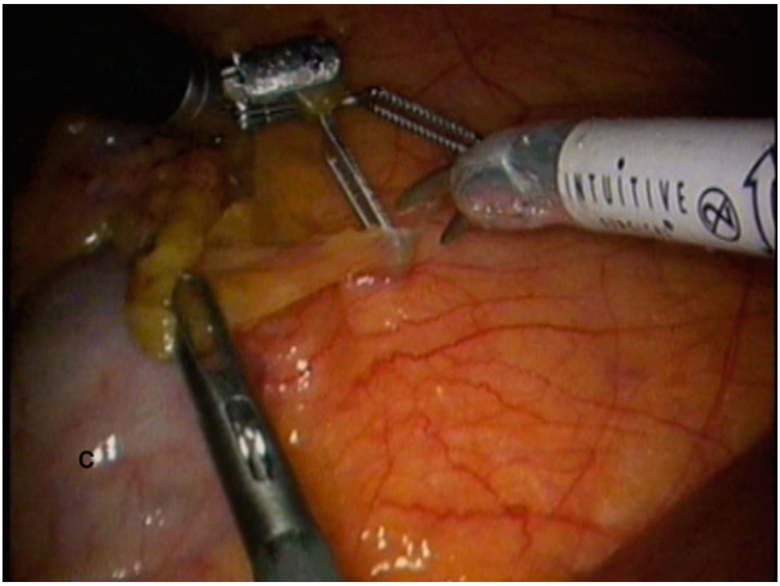

Fig. 4.2 Colon mobilization. The peritoneal reflection is incised, and the colon (*C*) is reflected medially

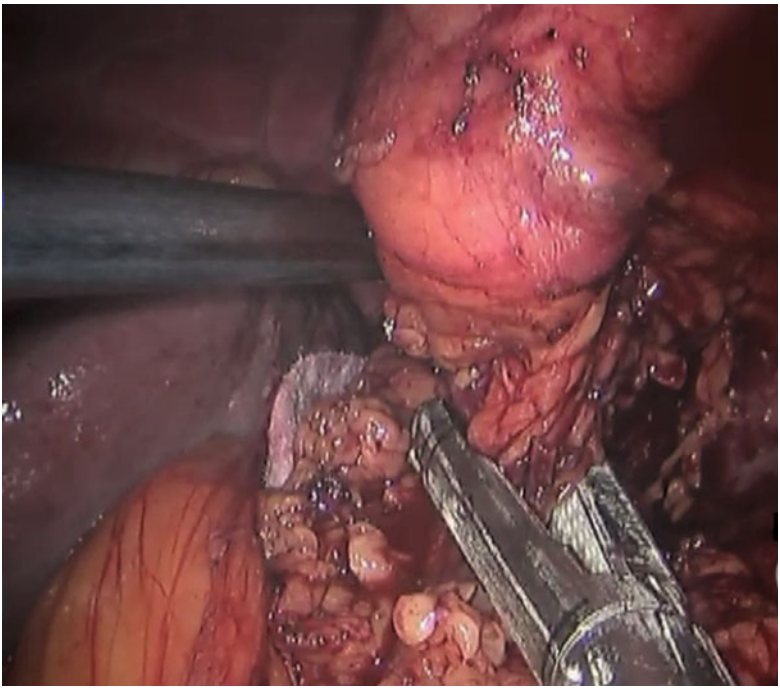

Fig. 4.3 Stapling of renal hilar vessels using an endovascular GIA stapler during left robotic nephroureterectomy

lower pole of the kidney are elevated anteriorly off the psoas muscle to place the renal hilar vessels on stretch. Dissection proceeds in a proximal direction toward the hilar vessels. The renal artery and vein are then dissected in preparation for hilar ligation. The lumbar, gonadal, and adrenal veins may be ligated as needed, and the kidney is adequately mobilized. The renal hilar vessels may be ligated using an endovascular stapler (Fig. 4.3) or Hem-o-lok clips. Following hilar ligation, all remaining renal attachments are released. The adrenal gland is spared unless it is clinically involved.

4.5.3 Distal Ureteral Dissection

The ureter is dissected caudally, and the distal ureter is clipped (Fig. 4.4). The robotic monopolar scissors can be moved to the third robotic arm port to improve access to the pelvis. Distal dissection of the ureter is continued all the way to the ureterovesical junction (Fig. 4.5). Ligation of the obliterated umbilical ligament and the superior vesicle artery may help expose the distal ureter for bladder cuff dissection.

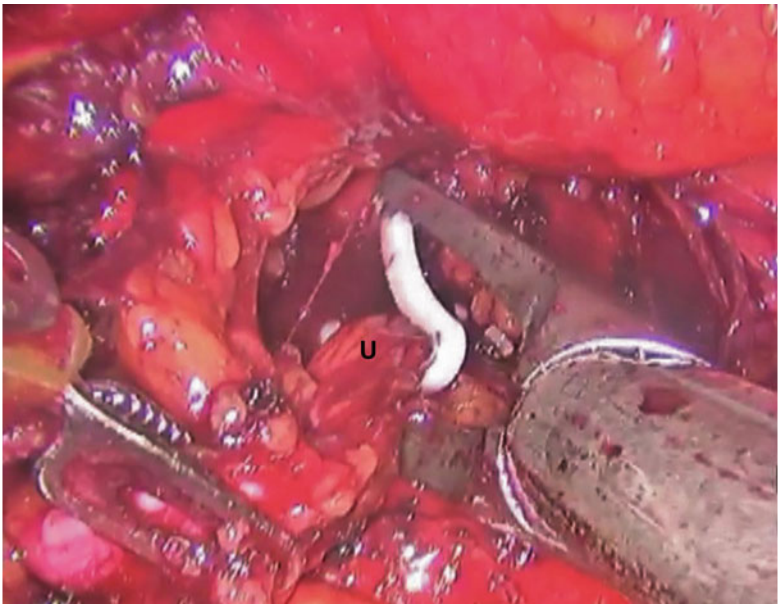

Fig. 4.4 Clipping of the ureter (*U*) using Hem-o-lok clips prior to dissection of bladder cuff in order to prevent tumor seeding or spillage

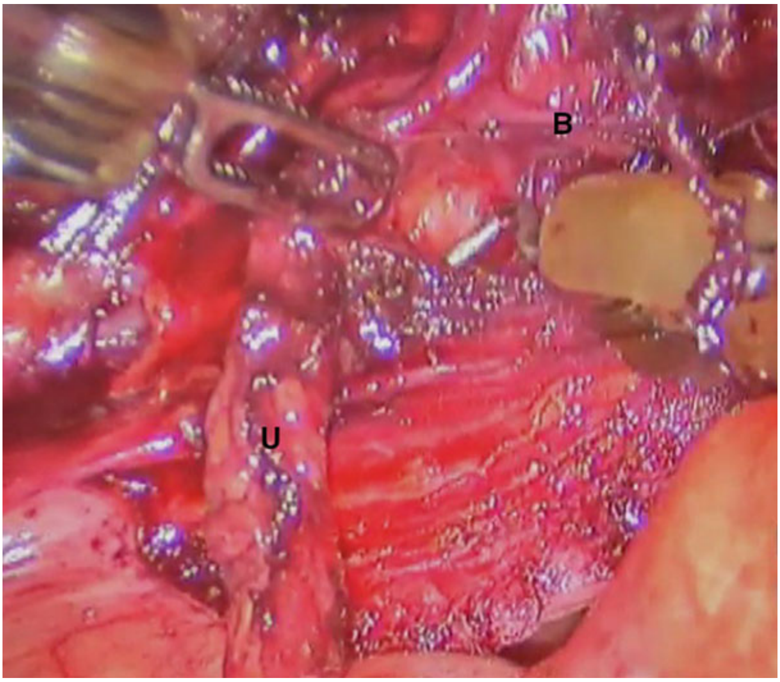

Fig. 4.5 Dissection of the distal ureter (*U*) and bladder (*B*) to expose detrusor muscle circumferentially around ureter prior to excision of bladder cuff

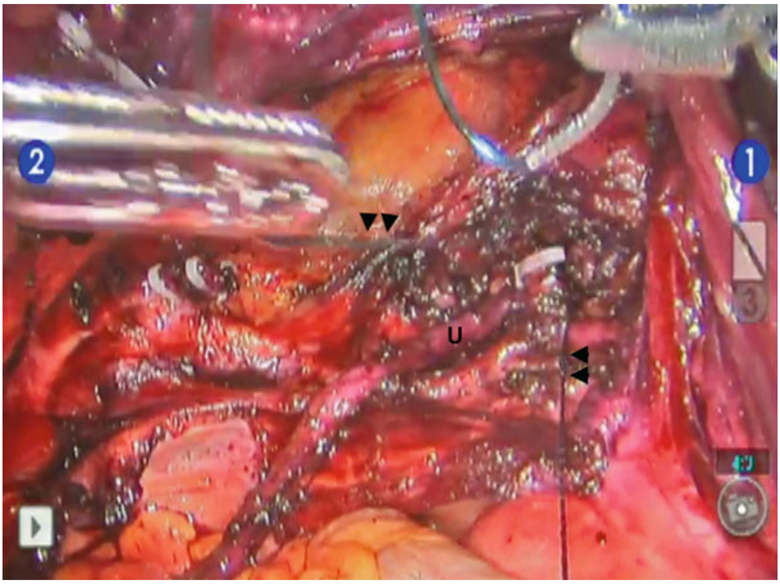

Fig. 4.6 Placement of stay sutures (*arrowheads*) on bladder outside the intended resection line of the bladder cuff using barbed suture. These sutures are used for subsequent bladder closure without the need for intracorporeal knot tying. The ureter (*U*) can be seen with a distal clip between the stay sutures

4.5.4 Excision of Distal Ureter and Bladder Cuff

The detrusor muscle is dissected circumferentially around the ureter. We place stay sutures on the bladder with barbed suture (V-loc™, Covidien, Mansfield, MA., 3-0 CV-23, 6 in.) outside the intended resection line for traction and for subsequent bladder closure (Fig. 4.6). The bladder cuff is excised (Fig. 4.7) sharply to ensure complete removal of the ureteral orifice with an adequate bladder cuff margin. Closure of the bladder defect is performed in two layers using the barbed tacking sutures. The barbed suture allows for two-handed suturing without slippage or the need to tie knots (Fig. 4.8). The bladder can be filled to test the bladder closure for leaks. The nephroureterectomy specimen is placed in a retrieval bag for extraction, and a drain and Foley catheter are left in place.

4.6 Postoperative Management

Diet is gradually advanced, and ambulation is encouraged. The average hospital stay is 2 days. The Jackson-Pratt drain is removed prior to discharge, and the Foley catheter is removed in approximately 1 week.

4.7 Complications

Potential complications associated with RNU include bleeding, bowel injury, and urine leak.

4.7.1 Hemorrhage

Inadvertent injury to the renal vasculature or other abdominal vessels can result in significant bleeding. Pressure with a sponge or laparoscopic pad and an increase in pneumoperitoneum may help tamponade and resolve venous bleeding. While electrocautery or clips may be useful for small bleeding vessels, sutured repair may be needed for injury to larger blood vessels. Conversion to open surgery is considered if there is intractable bleeding. Postoperatively, a decrease in hemoglobin values and hypovolemia signals the onset of hemorrhage, and transfusions are usually adequate. If the bleeding is not self-resolving, then explorative laparotomy may be indicated.

4.7.2 Bowel Injury

Injury to the bowels or other intra-abdominal organs can result from either inappropriate port placement or from cautery. A general surgery

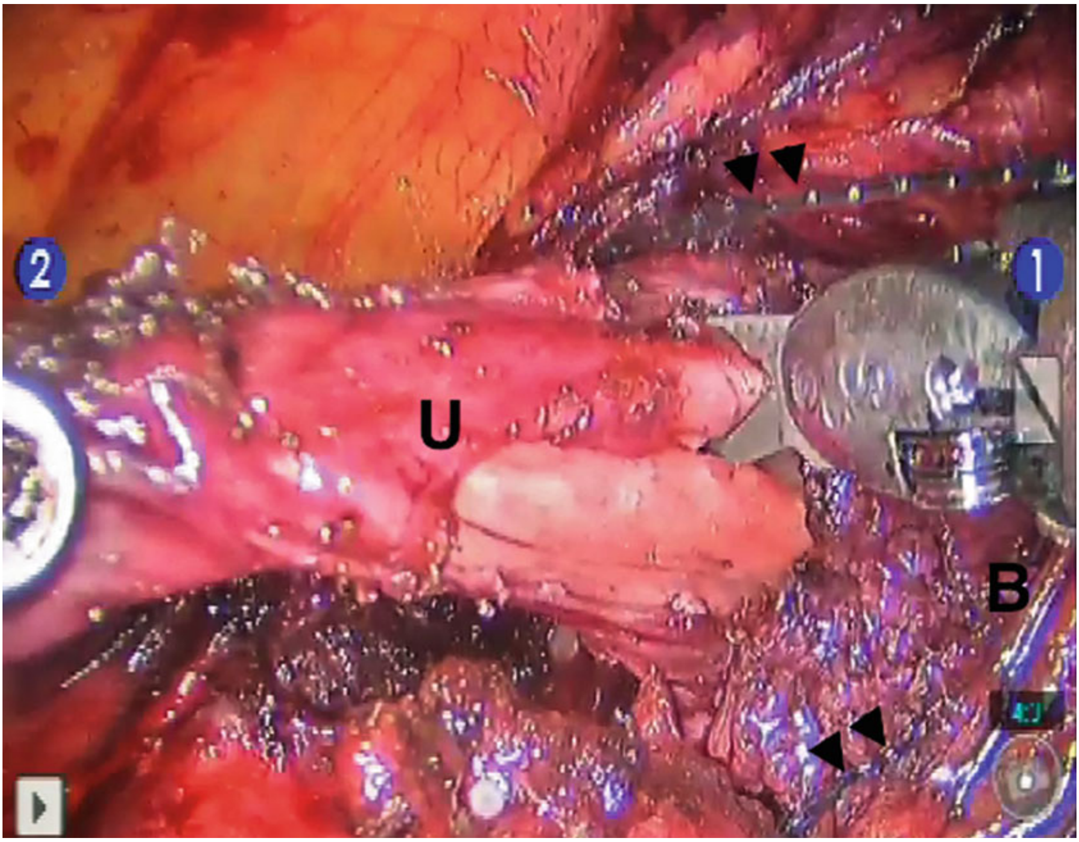

Fig. 4.7 Sharp excision of ureter (*U*) with adequate bladder cuff. Stay sutures (*arrowheads*) can be seen on the bladder (*B*)

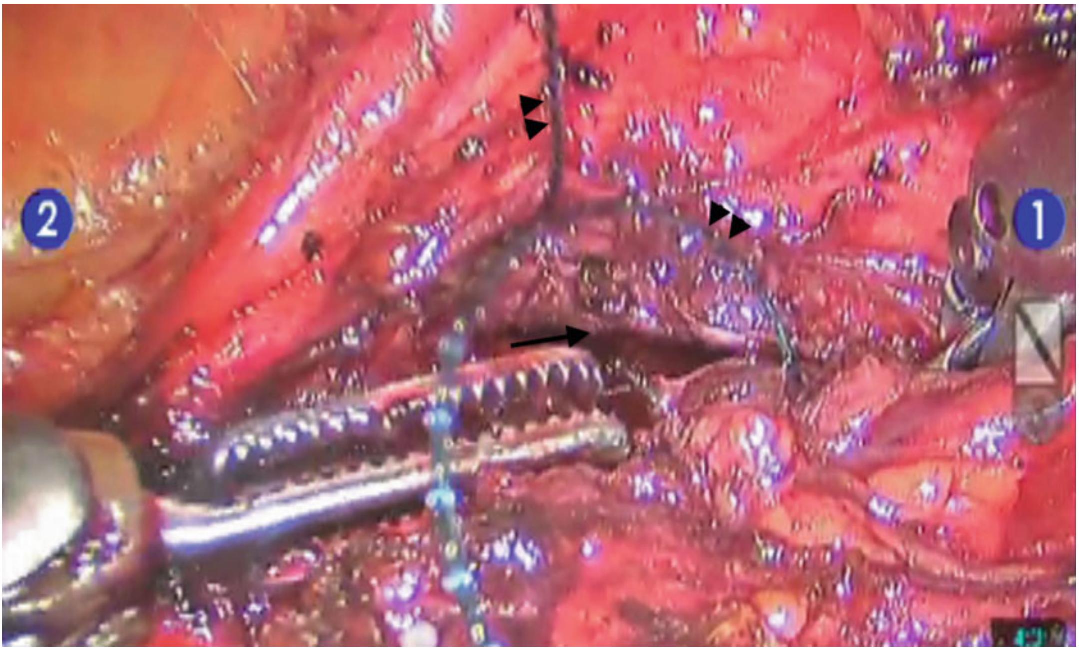

Fig. 4.8 Bladder defect (*arrow*) closed in two layers using barbed suture (*arrowheads*)

consultation is indicated for intraoperative repair of any noticed bowel injury. Nausea, fever, increased drain output, and abdominal pain in the postoperative course should raise the suspicion of a bowel injury, which may then be confirmed using a CT scan.

4.7.3 Urine Leak

If the patient has a persistent drain output and high drain creatinine values, the drain should be left in situ. Clinical suspicion of a urine leak can be confirmed with a CT urogram, particularly if an undrained collection is suspected clinically. Collections that do not spontaneously resolve need to be percutaneously drained and patients followed up to confirm resolution.

4.8 Literature Review

The various studies dealing with robotic assistance for nephroureterectomy are shown in Table 4.1. Nanigian et al. [12] used the da Vinci robot for the management of the distal ureter and bladder cuff in ten consecutive patients who underwent LNU for upper tract TCC. They reported a mean operative time of 4.4 h and length of stay of 3 days and concluded that robotic assistance minimizes the technical difficulty of this portion of the procedure during LNU. Hu et al. [13] reported a similar series of nine patients with a mean operative time of 303 min and average hospital stay of 2.3 days. At a mean follow-up of 16 months, three patients developed recurrence, and one patient had developed distant metastasis. Rose et al. [14] used robotic assistance for the performance of nephrectomy in a retroperitoneal manner but performed the ureterectomy using the open technique. Park et al. [15] reported their initial experience with nephroureterectomy performed completely robotically (RNU) using a hybrid-port technique. This precluded the need for patient repositioning and thereby reduced the operative time by about 50 min and also improved exposure during the latter part of the procedure. Eandi et al. [16] recently reported oncological outcomes for patients undergoing RNU. Mean operative time was 326 min, estimated blood loss

Table 4.1 Contemporary outcomes for robotic assistance during nephroureterectomy

	Nanigian et al.	Hu et al.	Rose et al.	Park et al.	Eandi et al.
Robotic assistance	Excision of ureter and bladder cuff only	Excision of ureter and bladder cuff only	Nephrectomy only	Completely	Completely
Approach	Transperitoneal	Transperitoneal[a]	Retroperitoneal	Transperitoneal	Transperitoneal
No. of patients	10	9	2	11	11
Clinical stage					
≤T2	–	–	–	9	–
≥T3	–	–	–	2	–
Pathological stage					
≤T2	–	4	–	4	8[c]
≥T3	–	5	1[b]	7	2
Mean operative time	264	303	183	223	326
Mean EBL		211	75	181	200
Mean hospital stay	3	2.3	5.7	7.6	4.7
Recurrence	1	–	–	–	4
Metastatic disease	–	–	–	–	2
Mean follow-up (mo)	–	16.2	3	–	15.2

[a] The first patient underwent retroperitoneoscopic radical nephrectomy

[b] The other patient had a painful nonfunctioning hydronephrotic kidney with a megaureter

[c] No cancer detected in one patient

(EBL) was 200 ml, and the mean length of stay was 4.7 days. Of the 11 patients, 4 developed recurrence, and 2 died of metastatic disease at a mean follow-up of 15 months.

Conclusion

Robotic nephroureterectomy is an emerging technique for the minimally invasive management of upper tract urothelial cancer. Robotic assistance provides three-dimensional visualization and more efficient intracorporeal suturing which is useful for the more difficult steps of the procedure, namely, dissection of distal ureter and excision of the bladder cuff. Short-term outcomes from initial series are promising, and longer-term data on oncological control and functional outcomes are needed.

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Robotic Pyeloplasty

5

Anika Winkel and Dirk Kusche

5.1 Introduction

The ureteropelvic junction obstruction (UPJO) is a well-known urologic disease. To cure this problem, a lot of different operations are available. The best long-term results are produced by the so-called dismembered Anderson/Hynes pyeloplasty which was first published in 1949 [1]; this technique is considered today as the gold standard [2].

Due to shortcomings of the access trauma of a flank incision which is traditionally used to reach the kidney, minimal invasive procedures, for example, the laparoscopic radical nephrectomy [3], were introduced in modern urology as a new standard of care [2].

In plastic reconstructive kidney surgery, Schüssler et al. performed in 1993 the first dismembered laparoscopic pyeloplasty [4]. Since then there has been an increasing number of publications and a growing adaption of the minimally invasive version of the dismembered pyeloplasty. Nowadays, we find several publications confirming the feasibility and good functional results of the laparoscopic pyeloplasty, which are comparable to the results of open procedures [5]. Unfortunately in all laparoscopic plastic reconstructive procedures, suturing and tissue handling are very difficult and lead to a long learning curve, prolonged operation times, and the effect of the procedure was not always available. To overcome these problems and still give the benefit of minimal invasive surgery to the patient (less blood loss, shorter hospital stay, less pain, and better cosmesis) while on the other hand keeping the very good long-term results, the robotic version of the pyeloplasty carried out with the da Vinci system (Intuitive Surgical, Sunnyvale, CA) came in to play [6]. Having all seven degrees of freedom for the instruments and a real three-dimensional view, this technical device can ease the learning curve for the procedure and still give excellent results to the patient.

It is possible to reach the renal pelvis with the robot via a retroperitoneal or transperitoneal route. There is no evidence that one access is superior over the other, and eventually it is the surgeon's preference [7]. Both accesses will be discussed here briefly with a special view on specific advantages and disadvantages these operations have.

In our opinion, it is not the access per se which leads to good results. We think it is more important to practice the basic principles of laparoscopic surgery: a fully standardized technique and a pedantic orientation, firmly based on the relevant anatomic landmarks, all of which we will discuss in this chapter.

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5.2 The Transperitoneal Approach Step by Step

The advantage of this access in comparison to the retroperitoneal approach is the larger operation space. This helps especially the beginner in tissue handling and suturing.

Another advantage is that the crucial landmarks are easy to identify, so orientation is easy to ensure. A disadvantage is the slightly longer operation time in comparison to the retroperitoneal version [8].

5.2.1 Patient Positioning

After the transurethral catheter is inserted, the patient is positioned in a moderate lateral position. To achieve this, he is bedded in a 30° flank position on the healthy side (Fig. 5.1).

The operating table is moderately unfolded, and supports are fastened at the level of the shoulder and the greater trochanter (Fig. 5.2).

The patient is additionally fastened to the operating table by means of adhesive plaster. As usual, the lower arm is positioned in an abducted way, whereas the upper arm is positioned as low as possible (Fig. 5.1).

The assistant stands ventrally to the patient; the OR nurse a little further caudally.

5.2.2 Port Placement and Docking of the Patient Cart

The 30° down optic is inserted by means of a mini laparotomy at the umbilicus, and the capnoperitoneum is established with a pressure of 15 mmHg. Starting from the camera access, the trocars for the robotic instruments are inserted in a straight line 10 cm caudally and cranially and about 3 cm from the costal margin and from the iliac spine (Figs. 5.3 and 5.4).

After a 12-mm trocar for the assistant has also been established 10 cm caudally from the camera port, the patient cart of the da Vinci System is

Fig. 5.1 The patient is positioned in 30° angle and secured

Fig. 5.2 The back is supported to prevent slipping of the patient if the table is moved

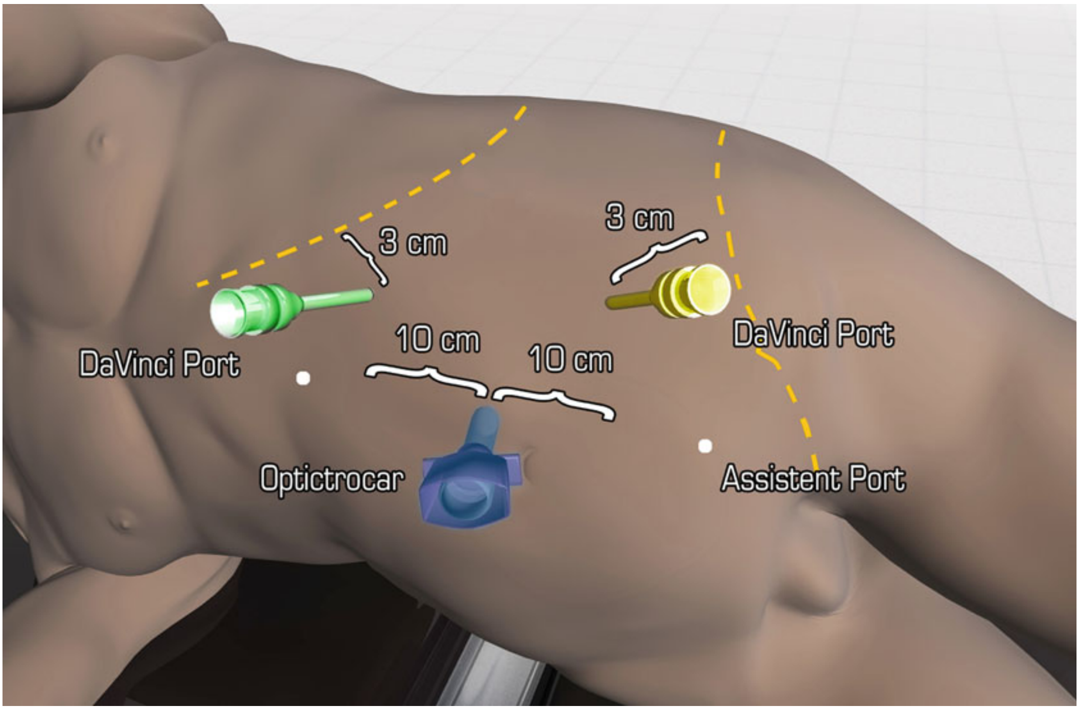

Fig. 5.3 The port placement

Fig. 5.4 The final port positions after the docking of the patient cart

moved in an angle of about 15° craniodorsally to the patient, ready for docking (Fig. 5.5).

5.2.3 Mobilization of the Descending Colon and Identification of the Ureter

In order to reach the retroperitoneum, the descending colon is detached along the line of Toldt with monopolar scissors and drawn medially. In this respect, it is important to precisely reach the avascular layer between the Gerota's fascia and the mesocolon and at the same time to dissect not too laterally between the abdominal musculature and the kidney (Fig. 5.6).

In the next dissection step, the ureter has to be found as an important landmark in front of the psoas muscle and is then traced proximally (Fig. 5.7). Directly before entering the renal pelvis attention must be paid to the accessory lower pole vessels in order to avoid vascular complications.

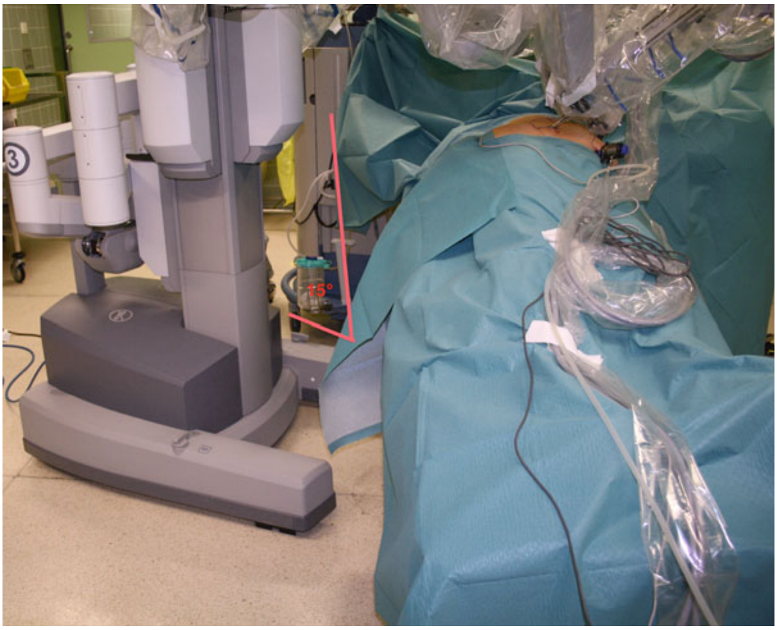

Fig. 5.5 The patient cart is moved in an angle of 15° from the back of the patient

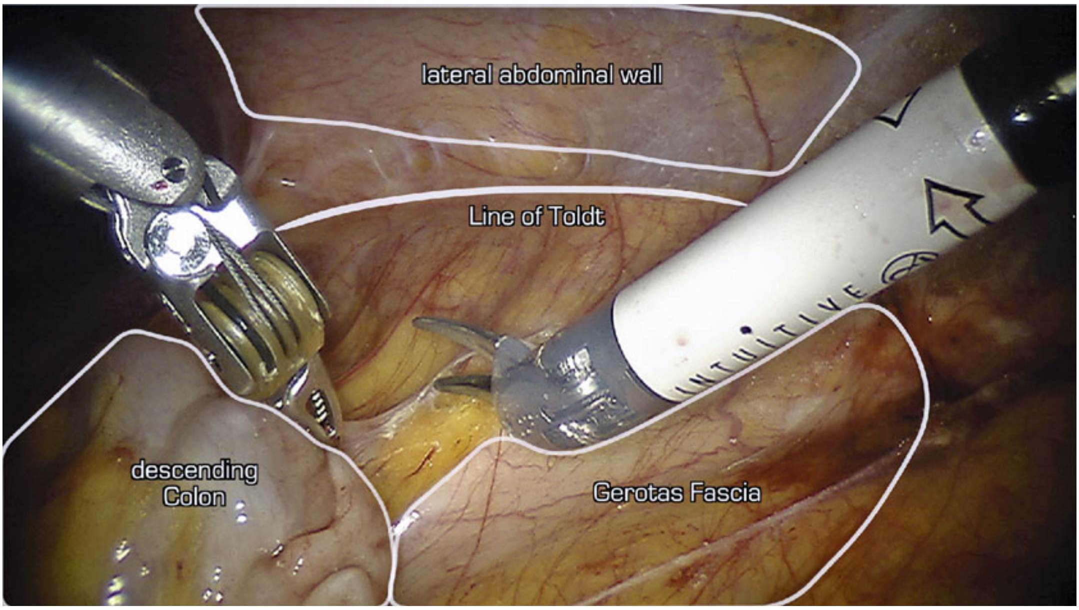

Fig. 5.6 The illustration shows the dissection line to enter the retroperitoneum on the left side

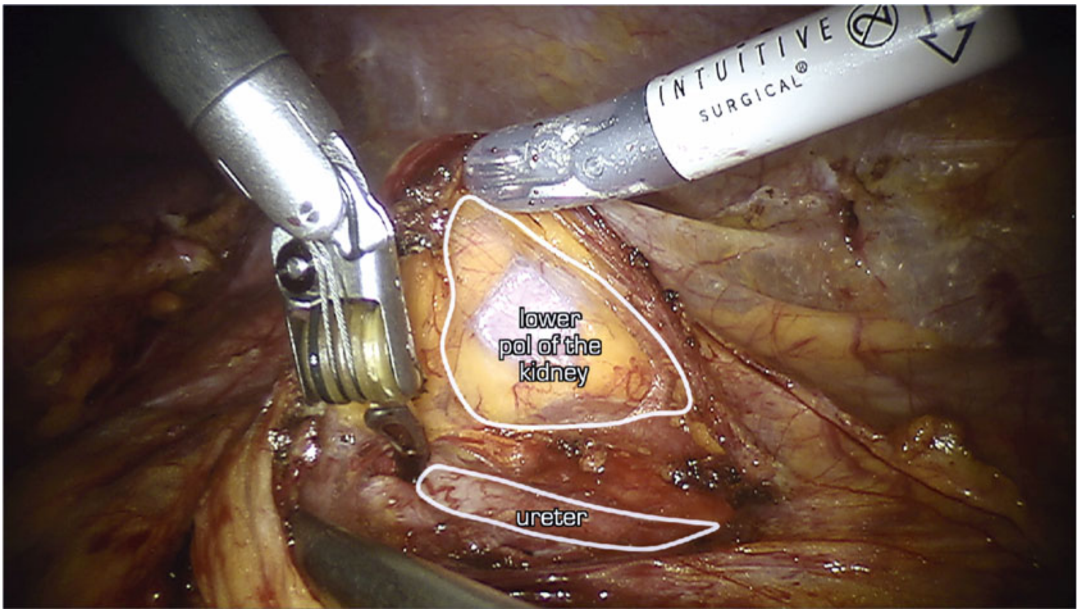

Fig. 5.7 The ureter is identified and traced proximal to the UPJ

5.2.4 Mobilization of the Renal Pelvis and Resection of the Ureteropelvic Junction (UPJ)

The renal pelvis is now circularly completely freed from the surrounding tissue and can be freely moved. This is important in order to ensure a tension-free anastomosis later on (Fig. 5.8).

The resection begins at the caudal lateral edge of the renal pelvis and is then continued medi-ocranially through the anterior wall (Fig. 5.9). The ureter is then stabilized through the still

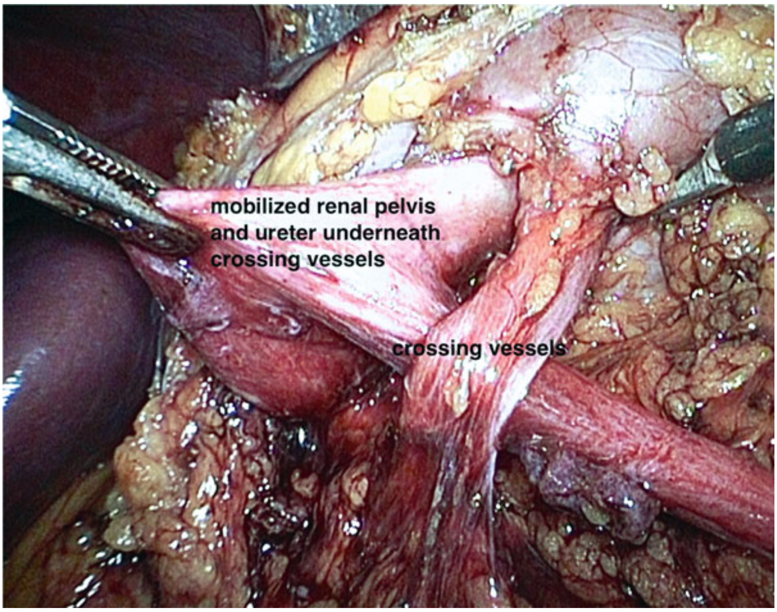

Fig. 5.8 The renal pelvis is circumferentially freed and detached from the obstructing crossing vessels. Ready to transpose them posterior to the anastomosis later on

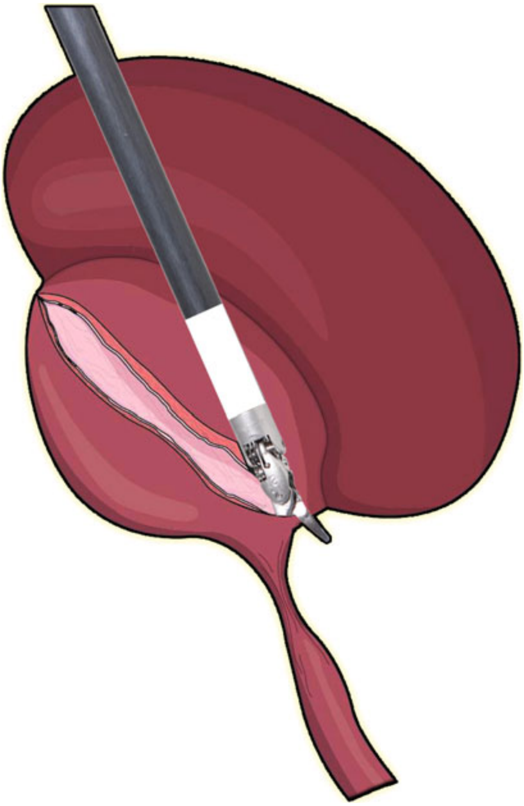

Fig. 5.9 The resection starts by only incising the ventral wall of the renal pelvis. From the caudal end of this incision, the spatulation of the ureter is done, while the posterior wall stabilizes it so that the lateral circumference of the ureter can be clearly identified

remaining posterior wall, making complex stay sutures unnecessary.

The next step is the lateral spatulation of the ureter. Therefore, an incision is made starting from the opened renal pelvis through the stenosis until far into the wide ureter. The still intact posterior wall of the renal pelvis and ureter prevents twisting, and orientation is always ensured (Fig. 5.10).

After the lateral spatulation of the ureter, the posterior wall of the renal pelvis is now transected. Only then, a little distally from the stricture is the ureter divided, and the specimen removed (Fig. 5.11). The introduction of this technique developed by us has considerably reduced the length of the operation.

5.2.5 The Posterior Anastomosis of the Renal Pelvis

The anastomosis between the renal pelvis and the ureter can be carried out with the preoperatively inserted ureteric catheter as well as having inserted the ureteric catheter intraoperatively. The anastomotic technique is not affected by this, but it should be performed ventral to accessory vessels.

The anastomosis starts with the assemblage of the ureter and renal pelvis posterior wall. In contrast

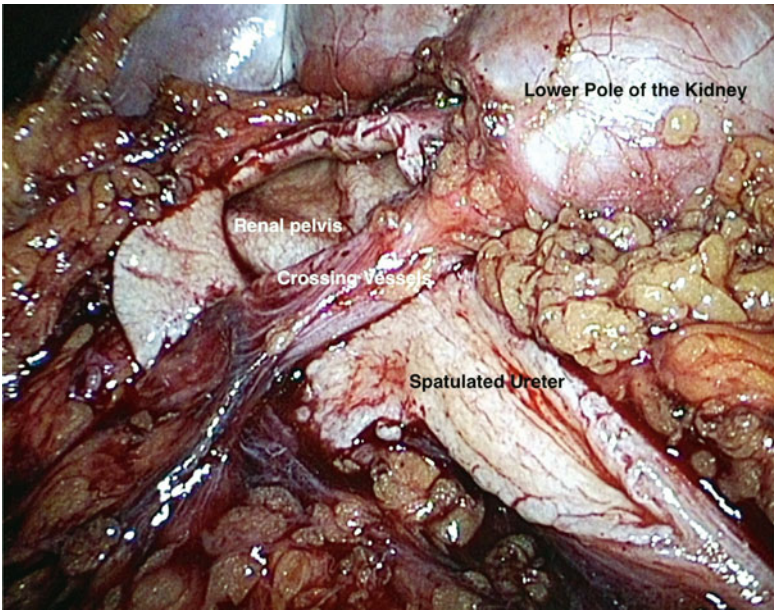

Fig. 5.10 The renal pelvis is opened, and the spatulation is done below the crossing vessels, while the posterior wall of the pelvis is still intact

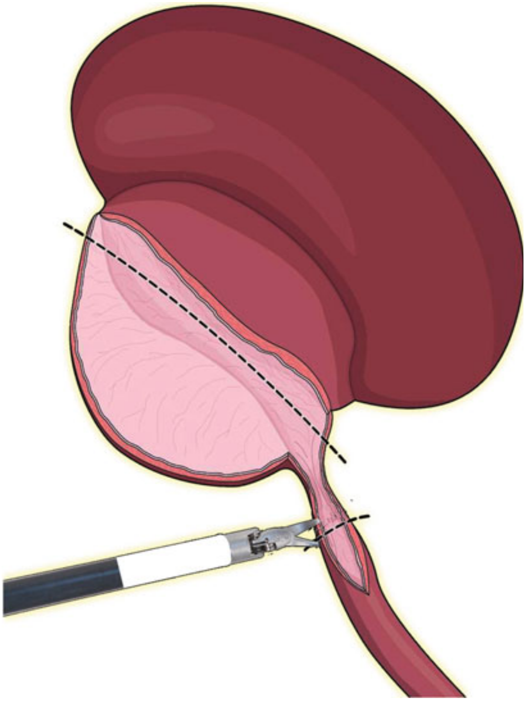

Fig. 5.11 The resection of the renal pelvis and the stenotic ureter segment is done after the spatulation

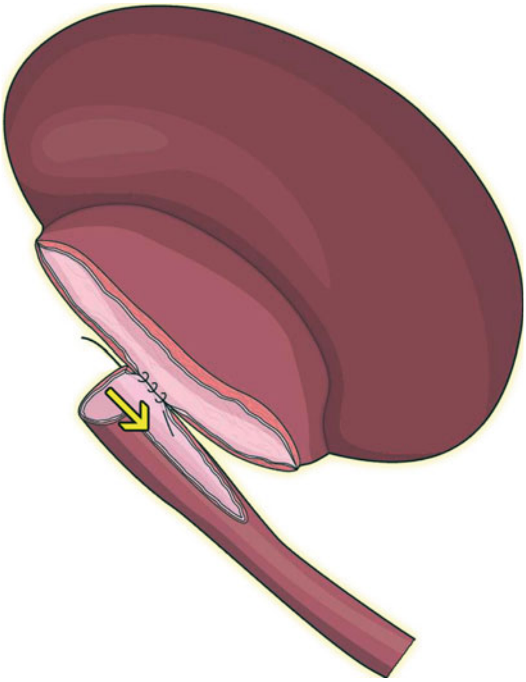

Fig. 5.12 The anastomosis starts at the cranial portion of the ureter and is directed to the tip of the spatulation

to the classical open technique, this process is not started at the caudal end of the ureter spatulation. Rather, the first stitch is done from outside inwardly at the cranial end of the ureter posterior wall and then directed outwardly at the corresponding spot of the renal pelvis posterior wall and secured with two double knots (Fig. 5.12). The result is a secured mucosa to mucosa adaptation.

The modification presented here shows the advantage of the highest point of the ureter being

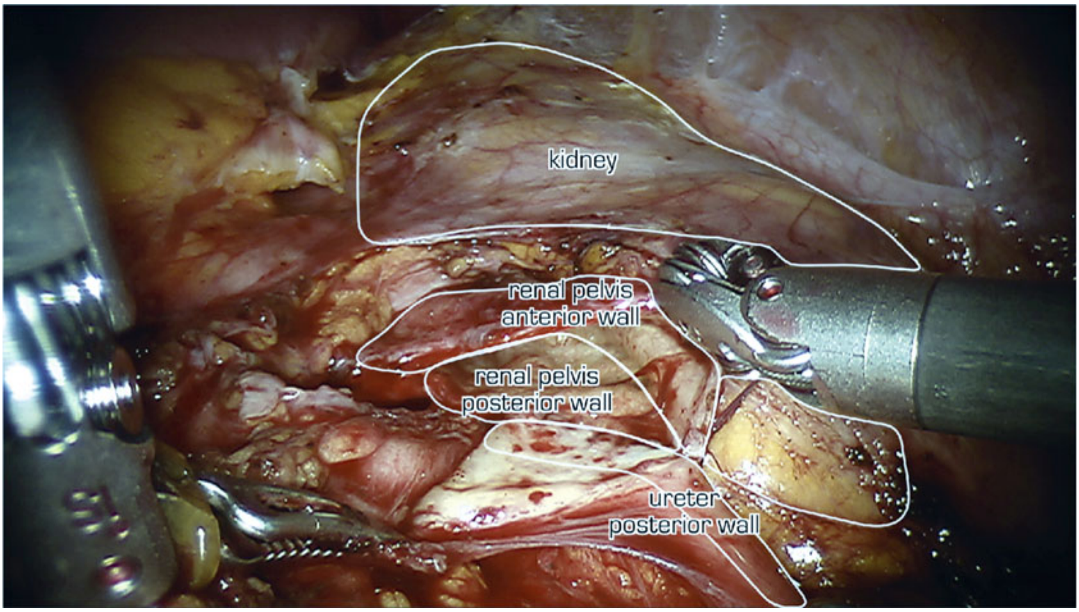

Fig. 5.13 The anastomosis of the posterior wall is completed showing an entire mucosa to mucosa adaptation

immediately fixed to the renal pelvis and preventing the otherwise mobile, cranial end from being drawn into the running suture and twisting.

The running suture (4/0 Vicryl) beginning at the proximal ureter is then continued as far as the spatulation top. The last stitch at the top of the spatulation is secured outside with two double knots (Fig. 5.13).

5.2.6 Intraoperative, Antegrade JJ Catheter Insertion, and Completion of the Anastomosis

The intraoperative antegrade ureter catheter insertion saves time and facilitates suturing the anastomosis of the posterior wall, as the suture need not be conducted around the already inserted catheter.

An indwelling vein cannula gauge 18 is percutaneously inserted cranially as far off as possible from the opened ureter. Through this, a guide wire can be intracorporeally advanced (Fig. 5.14). Here the wire is now inserted along the proximal ureter into the bladder, which means until a distinct resistance can be felt. Then the JJ catheter is placed using the typical antegrade technique, and the wire is removed (Fig. 5.15).

After the JJ catheter has been placed, the running suture of the anterior wall anastomosis is performed. To do so, we start from the caudal end of the spatulation from outside the ureter, completing the anastomosis by continuously adapting ureter and renal pelvis (Fig. 5.16). Two double knots finally secure the suture. In case of a still existing defect in the area of the upper renal pelvis, this can also be continually closed.

The result is a waterproof funnel-shaped anastomosis now lying ventrally to the accessory lower pole vessels (if existing) and hereby unobstructed (Fig. 5.17).

5.3 The Retroperitoneal Approach Step by Step

The advantage of this access in comparison to the transperitoneal approach is the faster and more direct access to the renal pelvis. The disadvantage

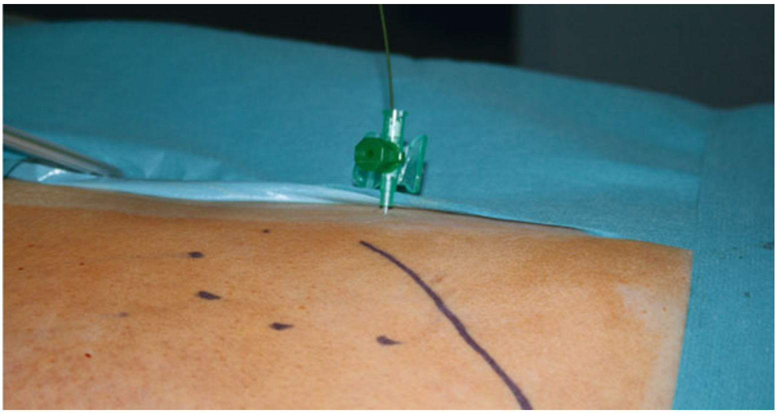

Fig. 5.14 The venous cannula is inserted percutaneously, and a guide wire is brought into the abdomen through this access

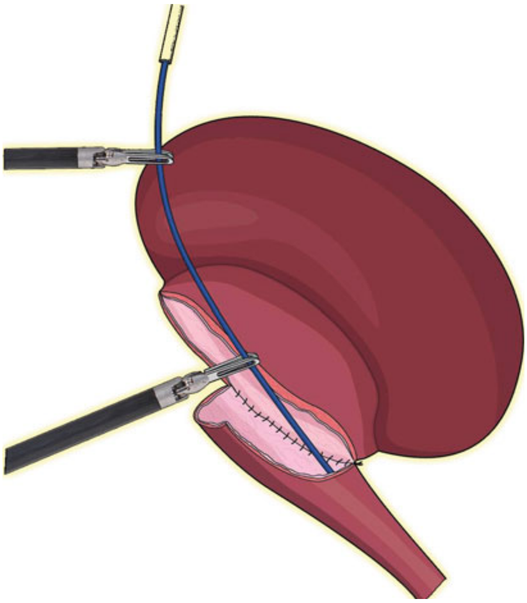

Fig. 5.15 The percutaneously inserted guide wire is directed with the robotic instruments into the proximal ureter and then further down to the bladder, followed by the JJ catheter in an antegrade fashion

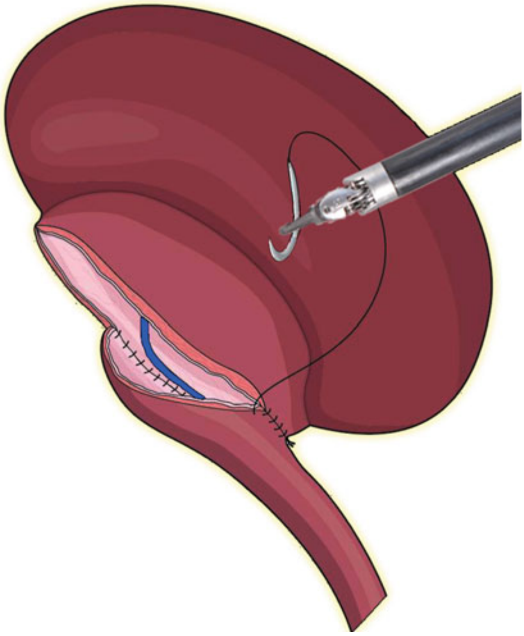

Fig. 5.16 After the JJ catheter is placed, the ventral part of the anastomosis is carried out, starting from caudal to cranial

is the narrow working space and very often clashing of the instruments and robotic arms.

5.3.1 Patient Positioning

After the transurethral catheter is inserted, the patient is placed in a proper 90° flank position padded and secured, while the operating table should be slightly flexed. Similar to the setting we described for the transperitoneal operation.

5.3.2 Port Placement and Docking of the Patient Cart

Before planning the port insertion, one needs to take two important things into account:

Firstly, the field to place the trocars stretches from the anterior axillary line to the iliac crest and secondly all robotic ports should have at least a distance of 8 cm, better 10 cm, between them to avoid clashing of the arms later on.

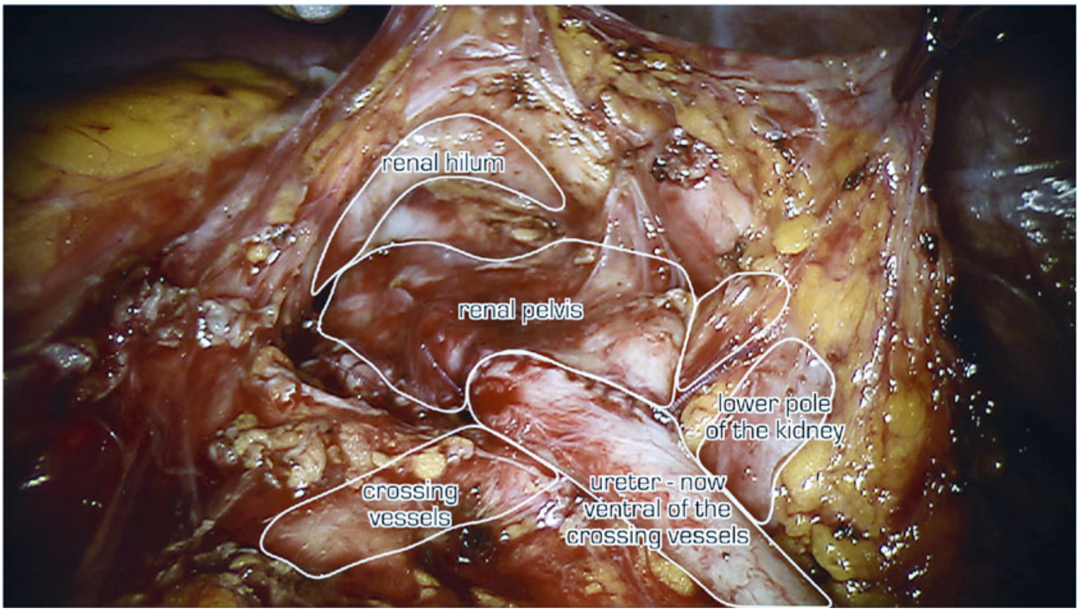

Fig. 5.17 The final anastomosis should be watertight and funnel-shaped and should be positioned ventral to the crossing vessels

- The first 1.5 cm skin incision is made for the camera port (12 mm) 1 cm above the iliac crest and 1.5 cm posterior to the anterior iliac spine.
- The muscles are split by blunt dissection, the lumbodorsal fascia is incised, and then a small tunnel is made with the index finger into the retroperitoneum ensuring not to violate the peritoneum.
- After this, one can insert the dilatation balloon trocar and blindly enlarge the space by filling the balloon with ca. 500 ml of air and leaving it for 5 min in situ.
- The next working trocar (8 mm) will be placed under digital guidance medial to the latissimus dorsi muscle and ca. 3 cm above the iliac crest.
- The other working trocar (8 mm) should be placed 1.5 cm medial to the costal margin in the anterior axillary line. It is always helpful to have an additional assistance trocar (12 mm) for suction and suture delivery, which can be placed over the iliac fossa (Fig. 5.18).
- The docking of the patient unit has to be done in an angle of 45° referring to the patients head and should come as close as possible toward the operating table.
- Then the capnoperitoneum with a pressure of 10 mmHg is established. Depending on the surgeon's choice, the operation is carried out with a bipolar forceps (Maryland) and a monopolar scissors.

5.3.3 The Procedure Step by Step

5.3.3.1 Incision of Gerota's Fascia and Identification of the Ureter

Once Gerota's fascia is clearly identified, it is incised over the whole length, making sure that the kidney falls medially. In this position, the lower pole is freed, and the ureter and pelvis are found in front of the psoas muscle.

Note: On the right side, the vena cava runs laterally.

5.3.3.2 Identification and Transection of the UPJ

Having found the UPJ, one should carefully search for crossing vessels. In this narrow working space, it is advisable to use two stay sutures (brought in from the outside by a needle). The first suture is placed in the renal pelvis cranial to the resection line. The second suture stabilizes the proximal ureter close to the stenotic region.

Fig. 5.18 Port positions for the retroperitoneal approach on the right side: *red* = camera position (12 mm), *blue* = the two da Vinci instruments (8 mm), and *yellow* = an additional assistance trocar (12 mm)

Then the renal pelvis is opened, the stenotic area transected, and the healthy ureter is spatulated over 2 cm. If crossing vessels are encountered, the ureter is brought ventral to them.

5.3.3.3 Anastomosis and Ureteric Stent Placement

The anastomosis can be performed with 4/0 Vicryl suture in a running fashion and should be started at the anterior suture line.

To avoid traumatizing the mucosa and ureter, additional stay sutures can be helpful.

If one needs to place a ureteric catheter, this can be done after the anterior part of the anastomosis is finished. It can be done in the same technique as described for the transperitoneal access (Figs. 5.14 and 5.15).

Having done this, the posterior part of the anastomosis is carried out, and the stay sutures are removed. The capnoperitoneum is exsufflated, and the cavity is checked for bleeding.

Placing a drain is optional. The 12-mm port incisions are closed by firstly suturing the fascia and then the skin.

5.4 Surgical Outcome and Complications

To measure and compare surgical outcomes after pyeloplasty is difficult due to the lack of common success criteria [9, 10].

In the literature, one can find the washout curves of the renogram, radiological findings on CT-scan or intravenous urography, or the diameter of calyces judged with ultrasound used as parameters of success [11].

While all these different parameters are compared to each other, the current literature is very heterogeneous. Despite all this, the common success rate for the robotic pyeloplasty is between 95 and 100 % [12], and the overall complication rate is between 3 and 10 % [13, 14]. We find similar data for the gold standard, the open pyeloplasty, but of course with a much longer follow-up [15].

In our series of 54 robotic dismembered pyeloplasties with a follow-up of at least 12 months, we recorded as complications only urogenital tract infections and two times a blocked ureteric stent. No serious complication occurred, and no conversion was needed. With the modification presented here, the mean operation time was 148 min including 18 min for the anastomosis.

5.5 Postoperative Management and Follow-Up

Our patients are encouraged to leave the bed on the day of surgery, and they are allowed to eat and drink the same day. Oral pain medication is given if required.

Ultrasound is performed on the first postoperative day, and the indwelling catheter is removed on day three after the anastomosis is checked with a reflux cystogram.

The JJ catheter is removed after 4 weeks without having evidence from the literature about this time span.

For follow-up, we recommend a urography after 5 weeks and a renogram with a baseline sonography at 6 months. If these are without problem, the patient can be followed and compared by ultrasound only.

5.6 Problems and Solutions

5.6.1 Severe Adipositas

In patients with a severe adipositas, the perirenal as well as the intra-abdominal fat can reach a massive size. Due to this, the view is often obstructed, and the fatty tissue makes orientation and tissue handling difficult.

It can be overcome by placing the camera port more lateral (Fig. 5.19) so that the bowel and thickened mesenterium has more space to fall medial. This helps to raise the view of the camera above the intestines.

Disturbing perirenal fat can be fixed via a marionette stitch with a straight needle from the outside against the abdominal wall. This will lead to a better overview, and the assistant can actively help during the procedure.

5.6.2 Crossing Vessels

Crossing vessels can sometimes make the entire mobilization of the renal pelvis really difficult (Fig. 5.20), especially if severe scar formation

Fig. 5.19 In obese patients, the camera trocar is moved more lateral from the umbilicus

after inflammation or previous surgery is encountered. To prevent a vessel injury and to have enough space to mobilize the pelvis, it can be helpful to encircle the vessels with a loop (Fig. 5.21) and pull them gently out of the operating field. To do this, a "Berci needle" (Karl Storz GmbH, Tuttlingen) is brought with a vessel loop from the outside into the abdomen; the vessels are encircled and lifted up, giving more working space below them by pulling on the vessel loop from outside.

5.6.3 Simultaneous Kidney Stones

If there are calyceal stones apart from the uretero-pelvic junction stenosis, these can be removed

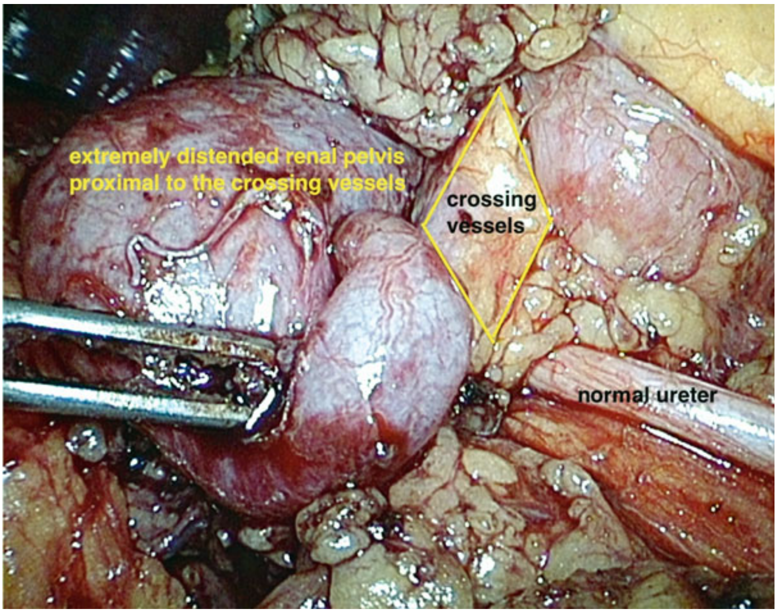

Fig. 5.20 Especially with a very distended renal pelvis, crossing vessels can be difficult to handle

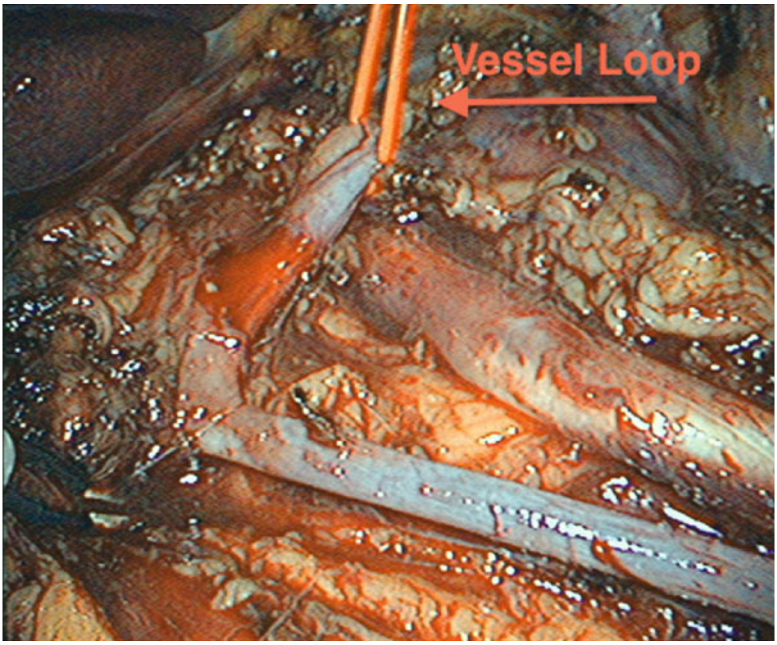

Fig. 5.21 Crossing vessels are encircled, and the ureter below is mobilized

Fig. 5.22 The flexible cystoscope is inserted through the assistance port

during the operation. In this case, a flexible cystoscope can be inserted through the assistant's port (Fig. 5.22), facilitating a good inspection of all calyces (Fig. 5.23). An existing concrement can be secured and removed on sight through a Nitinol basket inserted through the cystoscope (Fig. 5.24).

5.6.4 Difficult Guide Wire Insertion

The antegrade insertion of the guide wire or ureteric stent can be difficult at times. If one feels a resistance without having passed the guide wire deep enough to reach the bladder, this step should be aborted. Otherwise there is a high risk to tear the already done posterior anastomosis apart. In this case, we would complete the anastomosis without the JJ catheter in situ and pass it after the operation in a retrograde fashion under x-ray control.

5.6.5 The Intrarenal Pelvis

Patients with a very small or even intrarenal pelvis (Fig. 5.25) are difficult to handle with a classic dismembered pyeloplasty. Having resected the stenotic area, one can easily end up with too little tissue for an anastomosis or an opened calyx (Fig. 5.26). Another problem can be the renal hilum which is very close, making suturing extremely difficult. This is the only situation in which we perform a YV plasty instead of the dismembered version (Fig. 5.27). The continuity of the ureter helps in this particular situation to avoid the above-mentioned trouble.

5.6.6 Revision Surgery

A secondary pyeloplasty with the robot after a first operation has failed is a good and viable option because of the magnification and the precise instruments. It is not easy, but we think the best way to perform the revision. In these cases, we would pass the ureteric stent before the procedure is started and identify the ureter far down in the pelvis and then follow it through the scar formation toward the renal pelvis. Sometimes it is necessary to resect a rather

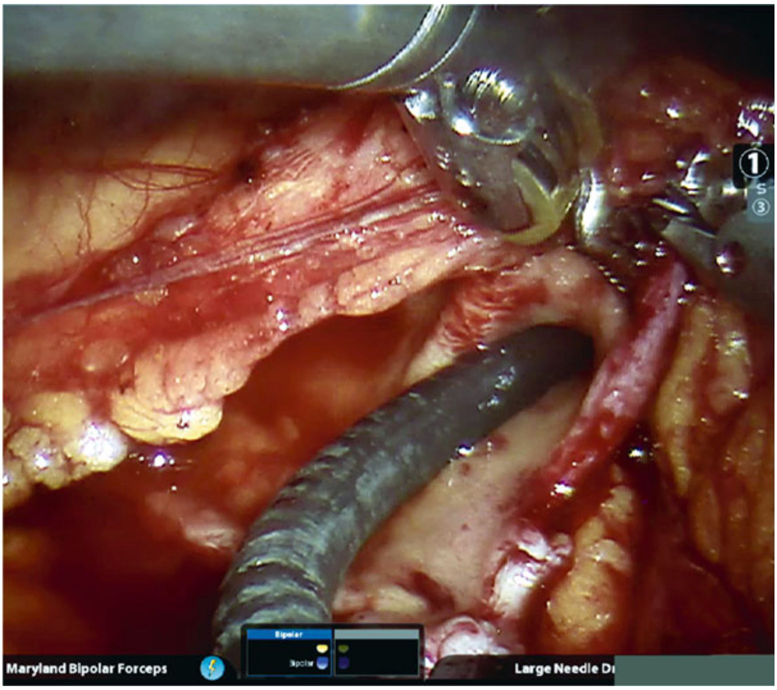

Fig. 5.23 The tip of the cystoscope is advanced into a calyx after the renal pelvis is opened

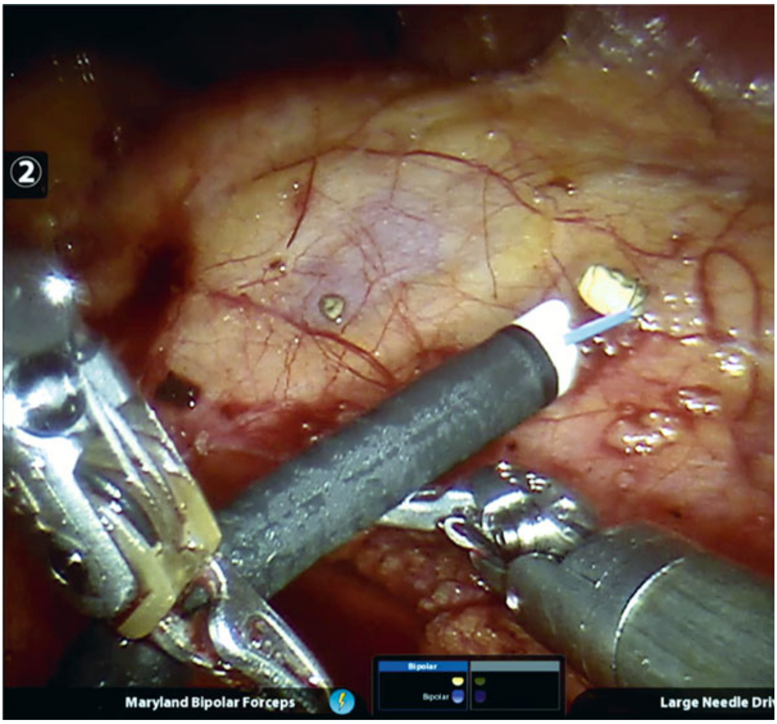

Fig. 5.24 After the stone is entrapped in the basket, it can be removed with the cystoscope

long segment of the proximal ureter because it is completely avascular, stenotic, and embedded in scar tissue. To avoid too much tension for the new anastomosis, the large distance can be bridged by mobilizing the whole kidney as it is done for partial nephrectomies. In this way, we could move the kidney 5 cm more caudally.

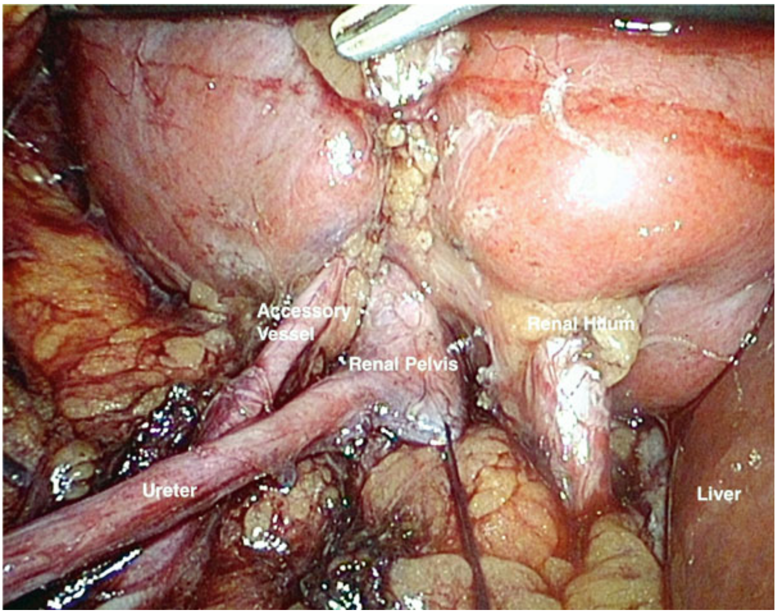

Fig. 5.25 A very small renal pelvis can lead to difficulties during the anastomosis by slipping into the hilum if a dismembered technique is chosen. A stay suture can be helpful for the exposure

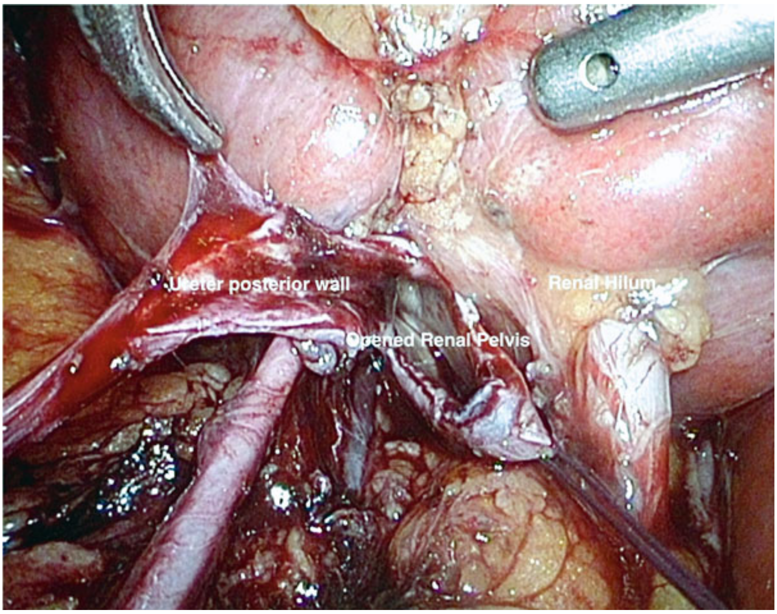

Fig. 5.26 The renal pelvis is opened in the shape of a V, and the stenotic part of the ureter is incised ready for the anastomosis

5.6.7 Obstructed Ureteric Stents

In the beginning of our laparoscopic pyeloplasty series, we had immediately after surgery the problem of impaired drainage due to obstructed DJ stents. In this case, the stent obviously needs to be replaced. To avoid this, we are now intensively irrigating the opened renal pelvis intraoperatively to wash out all blood clots.

5.7 Conclusion and Future Perspectives

According to the current literature, the RALP is a feasible operation, leading to comparable long-term results as the actual gold standard (open pyeloplasty) [16] although the follow-up of the RALP is much shorter [17]. With a very low complication rate [18], this operation is able to minimize the access trauma, the blood loss, pain,

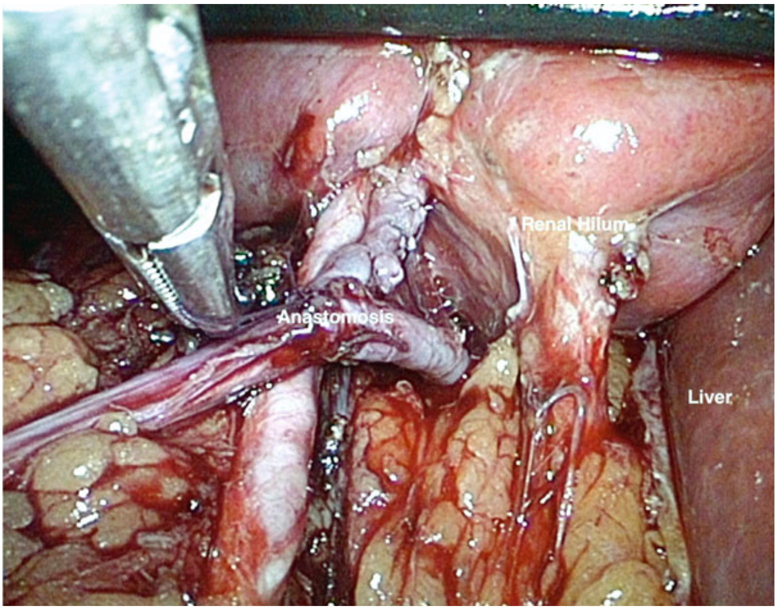

Fig. 5.27 The tip of the opened renal pelvis is sutured to the ureter below the incised stenotic part, resulting in a funnel-shaped anastomosis

and hospital stays, with the potential to replace the open procedure.

The conventional laparoscopic procedure has a much more complicated learning curve due to the laparoscopic suturing, but in experienced hands, it can produce the same outcome while being much cheaper [19].

With new options like single-port surgery, we gain more possibilities to make minimal invasive surgery even less traumatic. But with this type of access, the "old problems" of conventional laparoscopy (tissue handling and suturing) are increased because the inherently lacking degrees of freedom become even more acute. Meaning that a further development of the given conventional laparoscopy can be extremely difficult. This highly challenging technique is performed by only a small group of surgeons. Due to this, it is infrequently available for the patient care and may end in an unimportant role.

Exactly here the robotic technique with the seven degrees of freedom and the three-dimensional view is superior to the conventional laparoscopic technique [20]. It has the potential to bridge the gap between the advantages we already know from conventional laparoscopy on the one side and the less difficult learning curve on the other side.

We think that in future the necessary further development of minimal invasive surgery, that is, single-port surgery will only be widespread available if one combines it with robotic technology for the sake of our patients.

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Part II

Adrenals

Robotic Adrenal Surgery

6

Elias Hyams and Michael D. Stifelman

6.1 Introduction

In the past decade, laparoscopic adrenalectomy has been established as the standard of care for benign adrenal disease [13, 16, 17, 19, 43, 49] and increasingly considered for malignant disease [34, 44, 46]. First described in 1992 [13], laparoscopic adrenalectomy has been shown to be safe, to reduce patient morbidity, to decrease costs, and to shorten convalescence compared with open surgery [20, 26, 37, 39, 49]. Both transperitoneal and retroperitoneal approaches to laparoscopic adrenalectomy have been shown to be safe and effective [38].

Robotic-assisted laparoscopic techniques have concurrently achieved prominence in urological surgery. Robotic surgery has several potential advantages compared with laparoscopy including improved range of motion, easier instrument manipulation, stereoscopic three-dimensional vision, powerful magnification, and improved ergonomics. Robotic surgery shares many of the advantages of laparoscopy including decreased postoperative pain, shorter convalescence, and improved cosmesis. Robotic techniques have been employed in particular for urological procedures that require intracorporeal suturing and reconstruction, i.e., radical prostatectomy and pyeloplasty [30, 33]. Although adrenalectomy is an extirpative procedure that does not require reconstruction, it requires careful dissection along major vessels (i.e., aorta, renal vessels, vena cava) and intraabdominal organs (i.e., liver, spleen, kidney). By improving the speed and safety of dissection, the robot has been considered beneficial for adrenal surgery by some authors [10, 11, 45]. Also for practitioners without significant laparoscopic experience, robotic techniques may be easier to learn and more intuitive than laparoscopy and may enable more practitioners to perform advanced minimally invasive procedures such as adrenalectomy [41].

The first robotic adrenalectomy was reported in 2001 by Horgan and Vanuno [24]. Since then, robotic adrenalectomy has been shown to be safe and feasible [45] and may have advantages in certain instances over laparoscopy [4]. Robotic techniques may facilitate identification of small and often numerous adrenal vessels [18] and visualization and dissection of the short right adrenal vein [48]. While there have been no prospective randomized studies comparing laparoscopic and robotic adrenalectomy, there have been numerous case series of robotic adrenalectomy [4, 36, 47] and comparisons between the two techniques [1, 4, 36]. While robotic adrenalectomy has not been proven superior to laparoscopy by objective data, it may be a reasonable option for selected patients, particularly at high-volume robotic centers, and may assist practitioners without substantial laparoscopic experience.

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In this chapter, indications for minimally invasive adrenalectomy are reviewed, followed by a discussion of techniques for both right and left robotic adrenalectomy. Literature pertaining to robotic adrenalectomy and comparisons with the laparoscopic procedure are reviewed. Lastly, considerations for technique and training are discussed as well as the future of minimally invasive adrenal surgery.

6.2 Indications

Laparoscopic adrenalectomy has become the standard of care for benign adrenal masses and is increasingly considered for selected malignant lesions [9, 21, 34, 49]. As studies have shown that robotic adrenalectomy is safe and feasible, it may be indicated in cases where laparoscopic adrenalectomy would be performed. Indications for minimally invasive adrenalectomy are diverse and include adrenal masses >6 cm and up to 15 cm depending on surgeon skill and comfort, smaller lesions suspicious for malignancy, or in younger patients to avoid the stress of serial follow-up, lesions that increase in size on serial imaging, and hormone-secreting tumors [12, 44, 50]. Contraindications to minimally invasive adrenalectomy are controversial though typically include infiltrative adrenal masses, involvement of large vascular structures or significant involvement of adjacent organs, and tumors of large size (e.g., >10–15 cm). Disseminated metastatic disease or peritoneal carcinomatosis generally contraindicates surgical management of adrenal malignancy. There is further discussion of minimally invasive management of adrenal malignancy below.

Incidental adrenal masses are found on CT scan in up to 4 % of patients [3, 23]. Numerous algorithms for evaluation and management of adrenal incidentalomas have been published [23, 50]. Decision making regarding these lesions is based on numerous criteria including size, radiographic characteristics, and testing for secretory tumor [49].

Traditionally, adrenal masses >6 cm are considered likely to harbor malignancy and should be removed, although that size threshold has been lowered to 4 cm by some authors [49]. Adrenal tumors >6 cm have 92 % likelihood of malignancy [7]. Size is the best single indicator of malignancy, although its sensitivity and specificity are imperfect [44]. Younger patients may have a lower threshold for adrenalectomy based on higher lifetime risk of cancer, e.g., patients less than 50 years old with 3- to 5-cm mass may warrant adrenalectomy [15]. Size criteria for laparoscopy versus open surgery vary depending on the skill and experience of the laparoscopist as well as patient factors. Dissection of larger lesions is frequently more difficult based on increased vascularity and confined working space, and the risk of malignancy increases with the size of the adrenal tumor which may deter many surgeons from pursuing minimally invasive interventions [27].

Imaging characteristics on CT or MRI help to discriminate benign from malignant adrenal lesions. Adrenal adenomas are generally homogeneous with distinct margins compared with malignant lesions which are typically heterogeneous with irregular margins. Adenomas may be indicated by low attenuation (<10 HU) from lipid content as well as by rapid washout of contrast medium [29, 50]. Unfortunately, radiographic characteristics of benign and malignant lesions may overlap; thus, imaging tests by themselves may not be completely reliable [15, 29].

Hormonally active adrenal tumors necessitate adrenalectomy. In general, hormone secretion is investigated for lesions >1 cm [23] by a combination of history, physical exam, and laboratory testing including serum electrolytes, 24-h collection of urinary catecholamines or their breakdown products, and urinary free cortisol [49]. Functional tumors can be subclinical, and screening, even without clinical evidence, is warranted.

Minimally invasive adrenalectomy for primary or secondary adrenal malignancy is controversial, but recent literature indicates a growing willingness to treat selected lesions laparoscopically [27]. Infiltrative disease or other signs of malignancy have traditionally been considered absolute contraindications to minimally invasive resection based on the need for "radical adrenalectomy" [21, 27, 28, 44]. Radical adrenalectomy involves en bloc resection including periadrenal fat and potentially neighboring organs. This type of resection may be feasible for selected patients in skilled laparoscopic hands, but the patient should be counseled on the possibility of conversion to open surgery. Conversion should be performed if there is any intraoperative doubt regarding completeness of resection [35]. Not disrupting the adrenal capsule and not grasping tumor or adrenal tissue is imperative if malignancy is suspected [21, 40, 44].

There is growing literature on the minimally invasive resection of isolated adrenal metastases [6]. The adrenal may be the site for metastases from lung cancer, renal cell carcinoma, melanoma, breast, and colon cancer. Adrenal metastases are generally confined to the capsule and may require simple, rather than radical, adrenalectomy for complete resection [6, 51]. Long-term disease-free survival from metastatic disease can occur following laparoscopic resection of isolated adrenal metastases [31, 32, 49], and oncological outcomes may be equivalent to the open approach for selected populations [51]. Risk of recurrence at trocar sites is minimal with no recurrences noted in several studies of laparoscopic adrenalectomy for metastasis [46].

Primary adrenal malignancy is generally considered a contraindication to minimally invasive adrenalectomy because of the high risk of locoregional recurrence [51]. There are reports of intraperitoneal dissemination and local recurrence following laparoscopic treatment of primary adrenal malignancy. It is not clear whether these resulted from tumor selection, operative technique, or other factors [6, 44]; however, if complete resection can be performed, laparoscopic resection of adrenocortical carcinoma may be equivalent to open surgery in terms of local recurrence and survival [35]. Complete resection may be difficult to achieve because of the locoregional aggressiveness of these tumors and the requirement for regional lymphadenectomy [51]. Proper staging and selection of patients with suspected malignancy are critical. Contraindications may include extensive infiltration, caval thrombus, pheochromocytoma metastatic to periaortic nodes, bulky locoregional lymphadenopathy, and tumors >15 cm [6, 12, 35]. Survival following laparoscopic resection of malignant tumors may improve when lesions are <5 cm [35]. Regarding the risk of port-site metastases, this risk can generally be minimized by meticulous laparoscopic technique and appropriate patient selection [35]. It is critical to follow long-term these patients for recurrence, and further prospective data regarding minimally invasive therapy for adrenal malignancy is required.

Intraoperative ultrasound may assist in staging and other aspects of minimally invasive adrenalectomy. Its potential uses include helping to locate the gland, confirm pathology, identify the adrenal vein, and examine the contralateral adrenal gland [12, 15].

Needle biopsy of an adrenal mass is not generally recommended. It may be unreliable in distinguishing malignant from benign tumors [21, 28]. Additionally, it presents the risk of hemodynamic instability from an unrecognized pheochromocytoma, adhesions making future resection more difficult, and possibly tumor seeding [21, 28].

6.3 Operative Technique

Our technique for robotic adrenalectomy is based on the transperitoneal approach with the patient in the semilateral position. We utilize the Da Vinci Surgical System. Standard preoperative precautions are taken for these patients including sequential compression devices to bilateral lower extremities, generous padding to all pressure points, and prophylactic antibiotics.

6.3.1 Right Robotic Adrenalectomy

The patient is placed in the left lateral decubitus position with proper padding of the left arm and the arm board at 90°. The right arm is placed over the left arm with appropriate padding, and the table is flexed at the level of the kidneys. The abdomen and right flank are prepped and draped. Robot, side, and console surgeon positions are outlined in Fig. 6.1, and patient positioning in Fig. 6.2. Trocar placement is illustrated in Fig. 6.3.

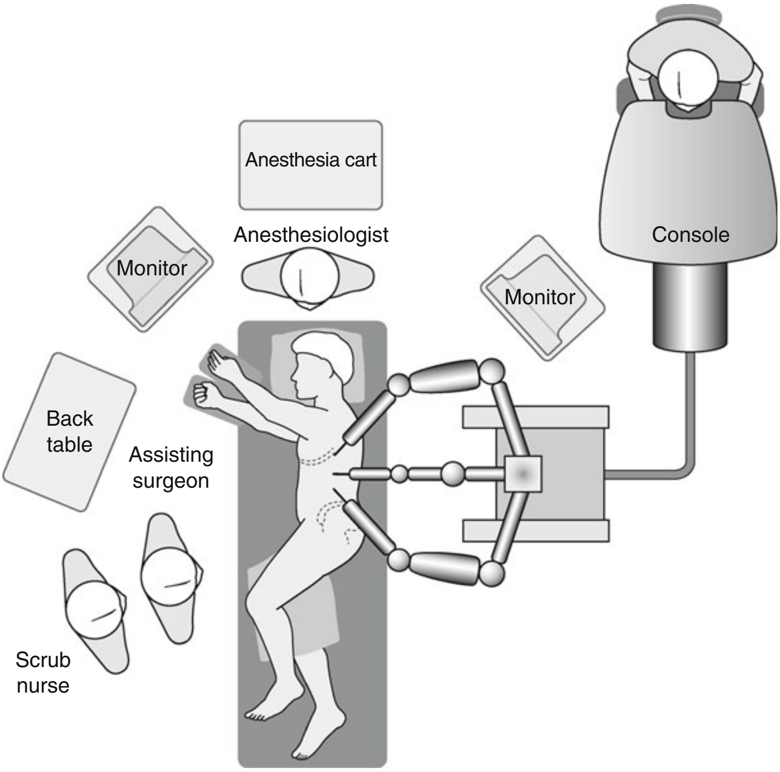


Fig. 6.1 Operating room setup for robotic adrenalectomy

We prefer to utilize the 30° down-angled camera, a Maryland bipolar dissector in the left hand, and hot shears in the right hand. The side surgeon uses a combination of suction, irrigation, and small bowel atraumatic graspers. In addition, the side surgeon is responsible for placing hemo-lock clips and firing the endovascular GIA when necessary.

The steps for this procedure parallel that of laparoscopic right transperitoneal adrenalectomy. The lateral attachments of the liver are incised with hot shears, and traction is placed superiorly on the liver by the assistant with the shaft of a wavy grasper, fan retractor, or Genzyme triangle retractor. The posterior peritoneal attachments at the inferior edge of the liver are incised from the vena cava to the lateral side wall. The liver is further mobilized superiorly until the superior edge of the adrenal gland is identified and isolated off the underlying psoas muscle. The liver is then placed on self-retained superior retraction by either grasping the side wall with a wavy grasper and utilizing the shaft of the instrument to support the right lobe of the liver or placing a fan or Genzyme retractor to support the right lobe and securing either retractor to a self-retaining arm secured to the operative bed. Next, the colon and duodenum are identified and reflected medially using a combination of blunt and sharp dissection exposing the vena cava from the liver's inferior edge to the renal vein.

With adequate exposure now obtained and the superior adrenal gland, vena cava, and renal vein isolated as landmarks, attention is directed toward securing the adrenal vein. Note that no traction has been placed on the adrenal gland. The superior angle made by the renal vein and cava is skeletonized so that a suction probe can be placed within that angle and gentle traction placed on the adrenal gland laterally. Simultaneously, either the side surgeon or console surgeon with a Cartier forceps in the right hand retracts the vena cava medially. This opens up the space between the cava and medial edge of the adrenal gland so that the adrenal vein can be identified (Fig. 6.4). Again, blunt and sharp dissections are used to open up this plane and isolate the adrenal vein. Once isolated, a Weck clip or endovascular stapler is used to secure and divide the vein.

Fig. 6.2 Patient positioning for robotic right adrenalectomy

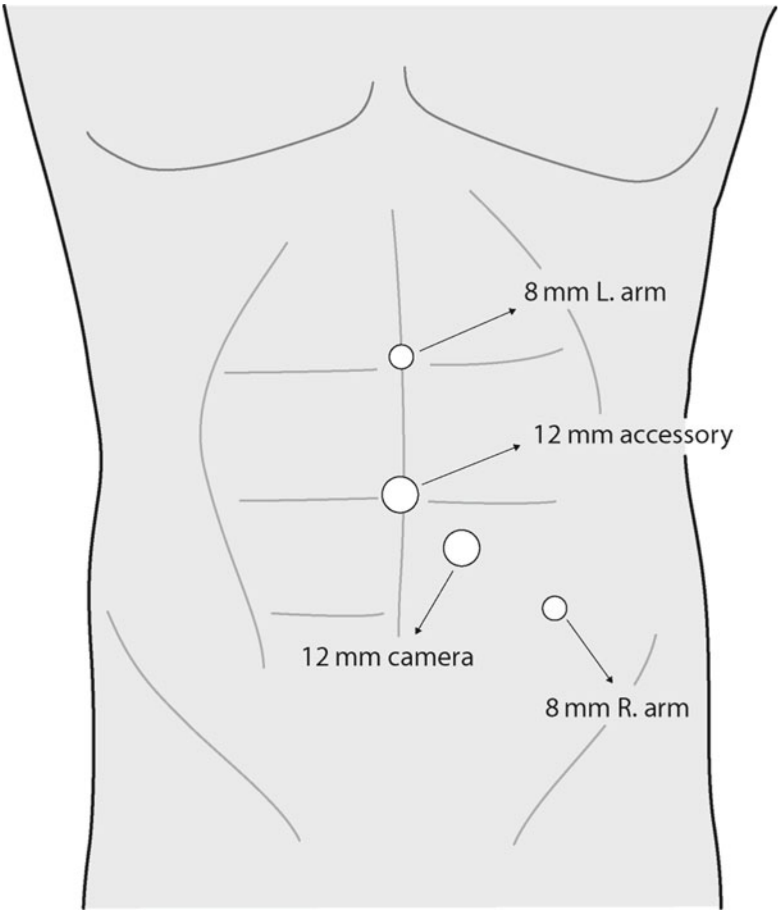
With the medial border of the adrenal now dissected off the vena cava and the superior border dissected off the liver's edge, attention is paid to releasing posterior and inferior attachments. Gerota's fascia is incised over the upper pole of the right kidney and dissected down to the psoas muscle. At this step, the side surgeon utilizes either the Ligasure or Harmonic to divide these attachments as well as all posterior attachments (Fig. 6.5) while the console surgeon provides exposure with Maryland dissector and Cartier forceps. Finally, the lateral attachments are divided with either hot shears, Harmonic, or Ligasure (Fig. 6.6). The adrenal is placed in an endocatch bag and removed from the Hassan trocar site.

Once the gland is out, the bed is reinspected for bleeding (Fig. 6.7) with pneumoperitoneum decreased to 5 mmHg, mean arterial pressure raised to 90, and 30 mmHg of positive ventilation delivered. Once hemostasis is confirmed, all ports are removed under direct vision and closed appropriately.

6.3.2 Left Adrenalectomy

Positioning, trocar placement, and instrument preference are almost identical to the right side (Fig. 6.3). The first step is to mobilize the colon and spleen widely and medial to the aorta so that

Fig. 6.3 Left trocar configuration (reverse for right)



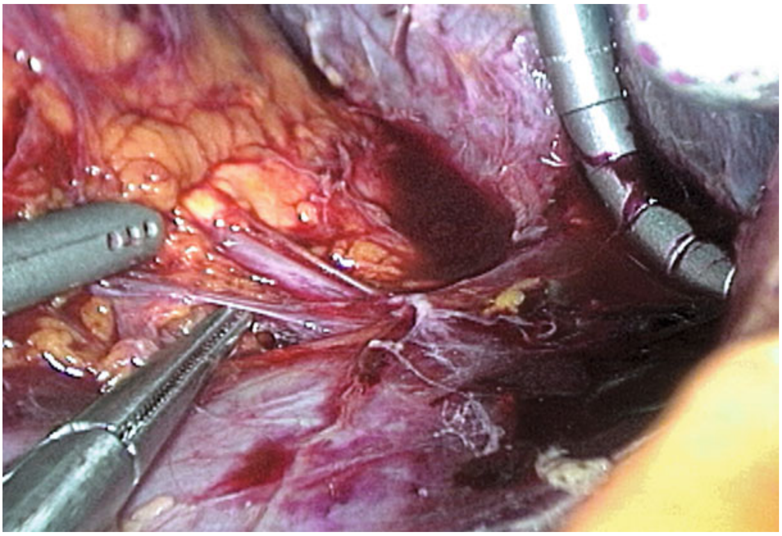


Fig. 6.4 Identification of right adrenal vein

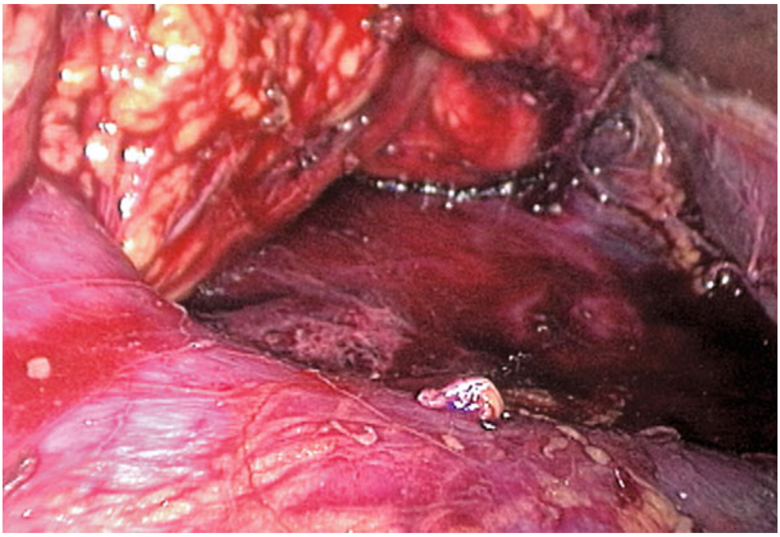


Fig. 6.5 Released superior medial and posterior attachments of right adrenal gland

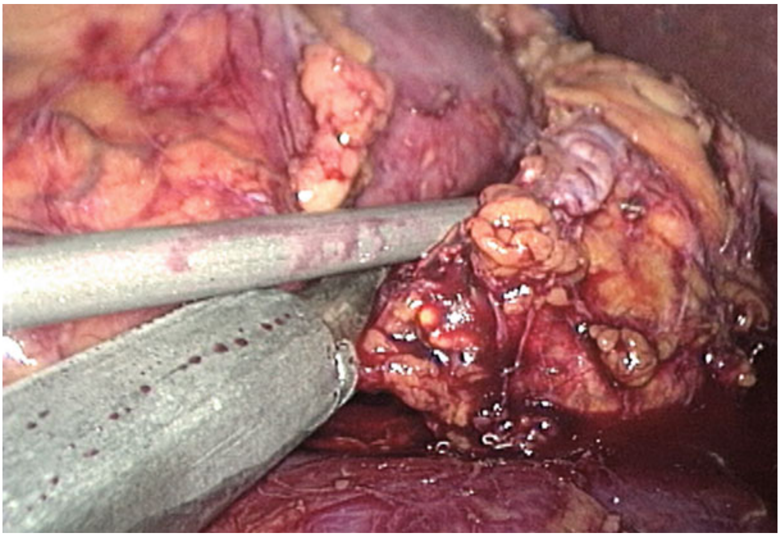


Fig. 6.6 Release of inferior attachments of right adrenal gland

the adrenal gland and renal hilum are exposed. This is accomplished by incising the lateral peritoneal attachments of the colon on the anterior surface of the kidney and exposing Gerota's fascia. The posterior peritoneal incision is carried inferiorly to the lower pole of the kidney and superiorly to the spleen, and the colon is mobilized medial to the aorta with a combination of blunt and sharp dissection. The side surgeon places gentle superior traction on the spleen, and the console surgeon retracts the kidney inferiorly, opening up and exposing the splenorenal attachments which are incised sharply including the lateral splenic attachments. The spleen is mobilized superiorly and medially with a combination of blunt and sharp dissection while the side surgeon places constant medial and superior traction. Adequate exposure is obtained when the superior edge of the adrenal gland is identified and isolated off the underlying psoas muscle. The spleen is then placed on superior retraction by either grasping the side wall with a wavy grasper and utilizing the shaft of the instrument to support the spleen or placing a fan or Genzyme retractor to support the spleen and securing either retractor to a self-retaining arm secured to the operative bed.

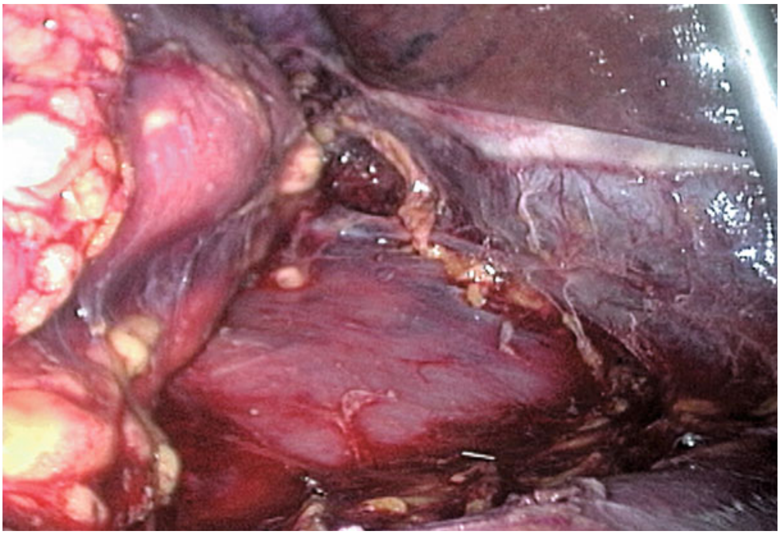


Fig. 6.7 Inspection of right adrenal bed after adrenalectomy

With adequate exposure now obtained, attention is directed toward securing the adrenal vein. The renal vein is first identified and skeletonized. Useful landmarks to identify the renal vein are the gonadal vessel and/or aorta, or a laparoscopic Doppler probe may help to isolate its signal. Once the renal vein is isolated, the adrenal vein is easily identified entering its superior border. The adrenal vein is then divided between Weck clips or with an endovascular stapler. With the vein controlled, a suction probe can be placed within the angle between the renal and adrenal vein and gentle traction placed on the adrenal gland laterally. Simultaneously, either the side surgeon or the console surgeon with a Cartier forceps in the right hand retracts the pancreas and colon medially, opening up the medial attachment of the adrenal overlying the aorta and psoas muscle. We prefer to divide these attachments with Harmonic scalpel, Ligasure, or endovascular GIA since multiple vessels run in these attachments. With the medial border now dissected free and the superior border dissected off the spleen, attention is paid to releasing posterior and inferior attachments. Gerota's fascia is incised over the upper pole of the left kidney and dissected down to the psoas muscle. At this step, the side surgeon utilizes either the Ligasure or Harmonic to divide these attachments as well as all posterior attachments while the console surgeon provides exposure with Maryland dissector and Cartier forceps. Finally, the lateral attachments are divided with hot shears, Harmonic, or Ligasure. The adrenal is placed in an endocatch bag and removed from the trocar site.

Once the gland is out, the bed is reinspected for bleeding with the pneumoperitoneum decreased to 5 mmHg, mean arterial pressure raised to 90, and 30 mmHg of positive ventilation delivered. Once hemostasis is confirmed, all ports are removed under direct vision and closed appropriately.

6.4 Results

There have been numerous small case series (Table 6.1) and several comparison studies between robotic and laparoscopic adrenalectomy (Table 6.2). The number of patients in these studies has ranged from 1 to 30. Robotic adrenalectomy has been assessed in these limited series with regard to complication rate, operative time, length of stay, cost, and other variables. Comparison studies have been particularly limited in terms of patient selection, number of patients, and methodology. These studies demonstrate that robotic adrenalectomy is safe and effective, and while laparoscopic adrenalectomy is the standard of care for benign adrenal lesions,

Table 6.1 Published series of robotic adrenalectomy

Reference	No. of patients	Operative time (min)	Morbidity	Conversion (%)	OR complications (%)	Median LOS (days)	APA	Pheo	Cush	Aden	Other	Cost (USD)
[47]	30	185	7	0	0	2	9	11	5	1	4	8,645 (OR) 12,977 (hospital)
[36]	10	169	20	40 lap[b]	20[d]	5.7	3	4	0	2	1	3,466 (total)
[4]	19		15.8		0		8	4	5	2	0	NA
[1]	9	132.8		44 lap[c]	0	5.7	0	2	6	1	0	NA
[45]	2	118	50[a]	0	0	4				2		NA
[3]	14	111	21	7 open		6.7	5	2	4	2	1	NA
[2]	4	220	0	0	0	5	1	2	0	0	1	NA
[48]	1	100	0	0	0	1	0	0	0	0	1	NA
[11]	2	138	0	0	0	2.5	0	1	0	0	1	NA
[24]	1		0	0	0							NA

APA aldosteronoma, *Pheo* pheochromocytoma, *Cush* glucocorticoid adenoma, *Aden* adenoma, *LOS* length of stay

[a] Pulmonary embolism

[b] Malposition of robotic trocars (2), difficulty obtaining hemostasis (1), and prolonged operative time (1)

[c] "Owing to technical difficulties"

[d] Severe intraoperative hypertension associated with pheochromocytoma

Table 6.2 Studies comparing robotic and laparoscopic adrenalectomy

Reference	Type	No. of patients		Mean size (cm)		LOS (days)		Operative time (min)		OR complications (%)		Morbidity (%)		Total cost (USD)[a]		Conversion (%)	
		R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
[36]	PR	10	10	3.3	3.1	5.7	5.4	169	115	20	0	20	0	3,467	2,737	40 lap[b]	0
[4]	PNR	19	14	3.0	3.3			107	86			15.8	14.3				
[1]	PNR	9						132.8	82.1	0	0					44.4	0
[5]	PNR	14	14	3.2	3.0	6.7	6.9	111	83			28	14			7 open[c]	7 open[d]

PR prospective randomized, *PNR* prospective nonrandomized

[a] OR + hospitalization

[b] Malposition of robotic trocars (2), difficulty obtaining hemostasis (1), and prolonged operative time (1)

[c] Significant bleeding from the adrenal vein

[d] Difficult dissection with a polycystic kidney

robotic techniques may provide advantages in certain settings.

Gill et al. [14] first demonstrated the feasibility of robotic adrenalectomy in an animal model. This study compared robotic adrenalectomy using AESOP and Zeus instruments in four pigs with conventional laparoscopy in three pigs. The operations were completed telerobotically from a separate room and utilized a side surgeon to change instruments and provide suction. While surgical and total operative times were significantly longer for robotic adrenalectomy, the procedure was shown to be feasible and subsequently performed in humans.

The first robotic adrenalectomy in a human subject was reported by Horgan and Vanuno in 2001 [24]. Subsequent small case series have demonstrated the safety of robotic adrenalectomy including a low intraoperative complication rate. Morino et al. [36] describe two intraoperative complications involving severe hypertension during pheochromocytoma removal. Desai et al. [11] describe an adrenal capsular tear that occurred during manipulation of the gland. Overall the complication rate between laparoscopic and robotic adrenalectomy has been approximately the same [5].

The conversion rate from robotic to open adrenalectomy has been low and comparable to the laparoscopic technique, although several robotic cases have been converted to traditional laparoscopy. Reasons for conversion have included malposition of trocars, difficulty with hemostasis, and prolonged operative time [36]. Brunaud et al. [5] noted 7 % conversion rate to open for both laparoscopic and robotic adrenalectomy, for reasons including bleeding and slow progression because of polycystic kidney disease. The conversion rate may decrease with increasing experience; in Morino et al. [36], conversion decreased from 60 % in the first five cases to 20 % in the subsequent five.

Length of hospital stay has been shown to be equivalent between robotic and laparoscopic adrenalectomy [5]. This is not surprising given that they both confer advantages of minimally invasive surgery including decreased postoperative pain and shorter convalescence.

Studies have examined both total OR time and operative time for robotic adrenalectomy. Total OR time includes setup and positioning of the robot which can be time-consuming in the early experience; however, robot positioning time may decrease as more procedures are performed [8]. Winter et al. [47] describe median robot setup time of 4 min. Brunaud et al. [5] describe similar mean duration of operating room activity for both laparoscopic and robotic procedures. Preparation and draping time will likely improve until a plateau point with increasing experience with robotic surgery.

Operative times have generally been longer for robotic versus laparoscopic adrenalectomy [1]. Morino et al. [36] attributed longer operative times to limited robotic instruments. Transition time from laparoscopic to robotic instrumentation may improve with experience [24]. Robotic adrenalectomy may confer a time advantage for obese patients. Brunaud et al. [5] noted positive correlation between patients' body mass index and duration of laparoscopic adrenalectomy, but no correlation in patients having the robotic procedure.

Evidence suggests that costs per patient for robotic adrenalectomy may exceed costs for laparoscopic adrenalectomy [1, 36]. The cost of purchasing and maintaining robotic systems should be integrated into cost analyses. Return on investment might be improved with higher volume and multidisciplinary use of the robot. Winter et al. [47] did not show a significant difference in hospital costs comparing robotic with laparoscopic and open adrenalectomy. They attributed lower hospital charges in the minimally invasive groups to shorter hospitalizations.

Quality-of-life measures have been studied regarding robotic versus laparoscopic adrenalectomy. Brunaud et al. [4] showed that there were no major differences in quality-of-life measures including postoperative pain between the two procedures.

From a training standpoint, robotic adrenalectomy may benefit from a more rapid learning curve compared with laparoscopy [2, 22, 25, 41]. Winter et al. [47] demonstrated a 3-min improvement in operative time with each robotic adrenalectomy. Morino et al. [36] demonstrated a decrease in conversion rate from 60 % in the first five cases to 20 % in the subsequent five. Brunaud et al. [5] noted decreased operative time with increasing experience with the robot for adrenalectomy. Corcione et al. [9] estimated that at least ten robotic procedures were necessary to master use of the robot. Based on these observations, robotic surgery may allow urologists to apply minimally invasive techniques to adrenalectomy more rapidly than laparoscopy [25].

Further investigation is required to identify the exact advantages of robotic adrenalectomy and which patients might benefit from these techniques. The few small studies making direct comparisons between robotic and laparoscopic adrenalectomy have generally concluded that laparoscopy is superior in terms of feasibility, length of procedure, and cost [36]. As robotic systems become utilized more commonly and cost and maintenance issues become less significant, the role of robotics in adrenalectomy will likely become clearer.

6.5 Considerations

Robotic techniques may present disadvantages regarding adrenal surgery. Lack of tactile feedback may result in tissue trauma including adrenal capsular tear [11]. The surgeon is compelled to rely on visual cues, and experience is required to minimize the risk of tissue injury. Some authors argue that lack of tactile feedback is balanced by improved visibility [2].

An experienced side surgeon with laparoscopic skills is necessary to assist with access, suction, and clip application or stapling, as these instruments are not yet available for robotic arms. This may present a disadvantage in community use of the robot for adrenalectomy.

Several tips are worthy of mention for robotic adrenalectomy:

1. For right adrenalectomy, the accessory port should be placed at sufficient distance from the camera port and robotic arm port to avoid interference [47]. If this accessory port is used, use of graspers in both robotic arms may be preferred [47].
2. Avulsion of the right adrenal vein is one of the most common causes of conversion and care should be taken in its isolation and control. A Statinsky clamp and 4-O Prolene on a vascular needle with a preplaced LAPRA-TY should be available if caval bleeding is encountered.
3. The left adrenal vein can always be located by first identifying the renal vein. Commonly, there are two adrenal branches off the left renal vein. Once isolated, the left adrenal vein is easier to divide because it is longer and narrower. Conversely, the right adrenal vein is easier to identify, but shorter, thus ligation is more challenging [47, 48]. Controlling the adrenal vein early is crucial to reduce the likelihood of injury during mobilization of gland.
4. In cases of bilateral adrenalectomy, the extreme articulation of the robotic arms may facilitate lateral and posterior dissection [1].

Conclusion

Data on robotic adrenalectomy demonstrate that the procedure is safe and feasible but not superior to laparoscopy in most cases. Certain advantages of robotic surgery (e.g., with intracorporeal suturing) do not apply to adrenalectomy, a primarily extirpative procedure. Nonetheless, the magnification and precision of robotic techniques may enable a more meticulous dissection during adrenalectomy. From a training standpoint, robotics may enable surgeons not extensively trained in laparoscopy to offer minimally invasive adrenalectomy to their patients [42].

There is a need for further investigation regarding the potential advantages of robotic adrenalectomy as well as more rigorous comparison with traditional laparoscopy. The role of robotics in adrenalectomy and other minimally invasive procedures should be reevaluated over time as technology changes, e.g., advances in tactile feedback, more diverse robotic instruments, and a fourth arm [36]. High-volume robotic centers that have already invested in costs of the robot may benefit most from novel applications. These centers may make robotic adrenalectomy affordable compared with other centers [47]. Furthermore, costs of equipment and maintenance may ultimately decrease with time.

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Part III

Pelvis

Surgical Anatomy of Pelvic Lymph Nodes

7

Martin C. Schumacher

7.1 Lymphatic System

In order to better understand the concept of nodal metastases from any primary tumor, including a pelvic tumor, it is important to understand the underlying mechanism of tumor cell dissemination via the lymphatic system [1].

The lymphatic system is an endothelial-lined network of blind-ended capillaries found in nearly all tissues. These capillaries are made of a single-cell layer of extensively overlapping endothelial cells with endothelial cell leaflets linked by discontinuous button-like endothelial cell-cell junctions which open in response to increased interstitial fluid pressure [2]. Due to the lack of a basement membrane and supporting smooth muscle cells, lymphatic capillaries are highly permeable to the protein-rich lymph fluid. Lymphatic capillaries possess specialized structures called anchoring filaments, which are extracellular fibrillar structures, which help to keep the lymphatics open in response to increasing interstitial pressure [3]. The lymphatic capillaries converge into pre-collecting lymphatic vessels, which carry lymph to the main collecting trunks, such as the thoracic duct, for return to the venous circulation via the anastomosis with the cardinal vein. Unlike lymphatic capillaries, pre-collecting and collecting trunks contain smooth muscle cells and pericytes. Collecting lymphatics have valves to prevent retrograde flow of lymph fluid. Lymph fluid is moved along the lymphatics by contraction of an “intrinsic” muscle pump, under adrenergic, cholinergic and peptidergic control, as well as by the “extrinsic” pump which consists of compression of the lymphatics by adjacent muscle contractions and surrounding interstitial pressure [4].

The lymphatic drainage system is important in immune mediation because it channels lymphocytes and antigen-presenting cells to their corresponding lymph nodes. On the other hand, it acts also as an important pathway for tumor cell dissemination. Several factors facilitate the entry of tumor cells into the lymphatic system: First, because lymph vessels are relatively larger in caliber than small capillaries. Second, the lack of a basement membrane and fewer intercellular junctions may aid tumor cells to enter the lymphatics. Third, the flow velocities in the lymphatics are slower than in capillaries thus cells are less at risk to sheer stress. Fourth, lymph fluid is similar in its constituents and chemistry to interstitial fluid, which in turn promotes cell viability [5]. Lymph nodes are the main site for the development of antibody-producing B-lymphocytes and produce also monocytes and plasma cells, in response to the lymph fluid [6]. Lymphatic vessels are known to contain a specific vascular endothelial growth factor (VEGF) receptor, VEGF-3 [7]. This specific

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receptor responds to stimulation from VEGF-C and VEGF-D to form new lymphatics. Certain tumors may use this mechanism to help the process of tumor cell dissemination by de novo formation of lymphatics. Experimental studies in mice have shown that blockage of VEGF-C and VEGF-D can reduce tumor cell dissemination [8].

7.2 Anatomy

A proper understanding of the location of lymph node groups in the pelvis is mandatory for formulating an appropriate treatment strategy in cancer patients. This chapter gives a fine description of lymphatic vessels and nodal stations in the pelvis according to the important pioneering work by Cunéo and Marcille more than a century ago [9, 10]. Relevant single nodes are grouped according to their anatomical region and in relation to pelvic organs.

Divided into a *parietal* and *visceral* lymph system, all the lymphatics of the pelvis drain into successive groups of nodes located at the level of the pelvic inlet, along the arcuate line (on the internal surface of the ilium) and anterior of the fifth lumbar vertebra. Mainly in close proximity to the iliac vessels and their branches, they form several ascending lymph chains which include the external iliac, internal iliac, common iliac and sacral node groups. Their corresponding collecting ducts terminate in the inferior part of the lateral aortic chain on the corresponding side (Figs. 7.1 and 7.2) [11].

7.3 Parietal Lymph Vessels and Nodes

The *parietal* lymphatics drain lymph from the anterior, lateral, posterior and inferior walls of the pelvis and included a *superficial* and *deep* lymphatic network:

- The *superficial parietal* lymph vessels drain only the pelvic floor. It comprises all soft tissues of the perineum below the outer fascial sheet of the urogenital diaphragm, including the distal part of the vagina, and the inferior part of the anal canal below the anocutaneous line [12].
- The *deep parietal* lymph vessels follow the vascular structures of the external and internal iliac vessels and drain into the inferior epigastric, circumflex iliac and sacral nodes [13]. They can be described as follows (Figs. 7.1, 7.2, 7.3, and 7.4):
  - The *deep inferior epigastric nodes* consist of three to six nodes located over the lower third of the inferior epigastric artery behind the rectus abdominis muscle. Their efferent lymphatic vessels terminate in the lateral chains of the external iliac nodes.
  - The *deep circumflex nodes*, two to four nodes, are frequently absent and drain also into the external iliac nodes.
  - The *sacral groups of nodes* are situated around the lateral and median sacral arteries and form three groups of ascending lymph chains, running along the lateral borders of the sacrum and in front of its anterior aspect on the midline. These nodes drain the presacral space between the anterior aspect of the fascia recti and the posterior sacral space. Their efferent vessels drain into the internal iliac nodes and subaortic nodes in the midline. The largest node located on the anterior aspect of the intervertebral disc L5-S1 is known as *promontorial node* [14].

7.4 Visceral Lymph Vessels and Nodes

The *visceral lymph vessels* of the pelvis are first located close to each pelvic organ (viscera), then around the different vascular pedicles of each organ and finally along the iliac vessels. From there they form rich lymph plexuses and ascending pathways which finally converge to the lateral lumbar aortic node groups (Fig. 7.1).

The *juxtavisceral nodes* can be described according to their locations as follows:

- *Anterior-*, *lateral-*, *posterior- and subvesical lymph nodes* are located on the corresponding site of the urinary bladder in the pelvis.
- *Paravaginal and parauterine lymph nodes* are situated lateral to the vagina and cervix in the female pelvis.
- *Pararectal lymph nodes* are located lateral on each side of the rectum in the pelvis.

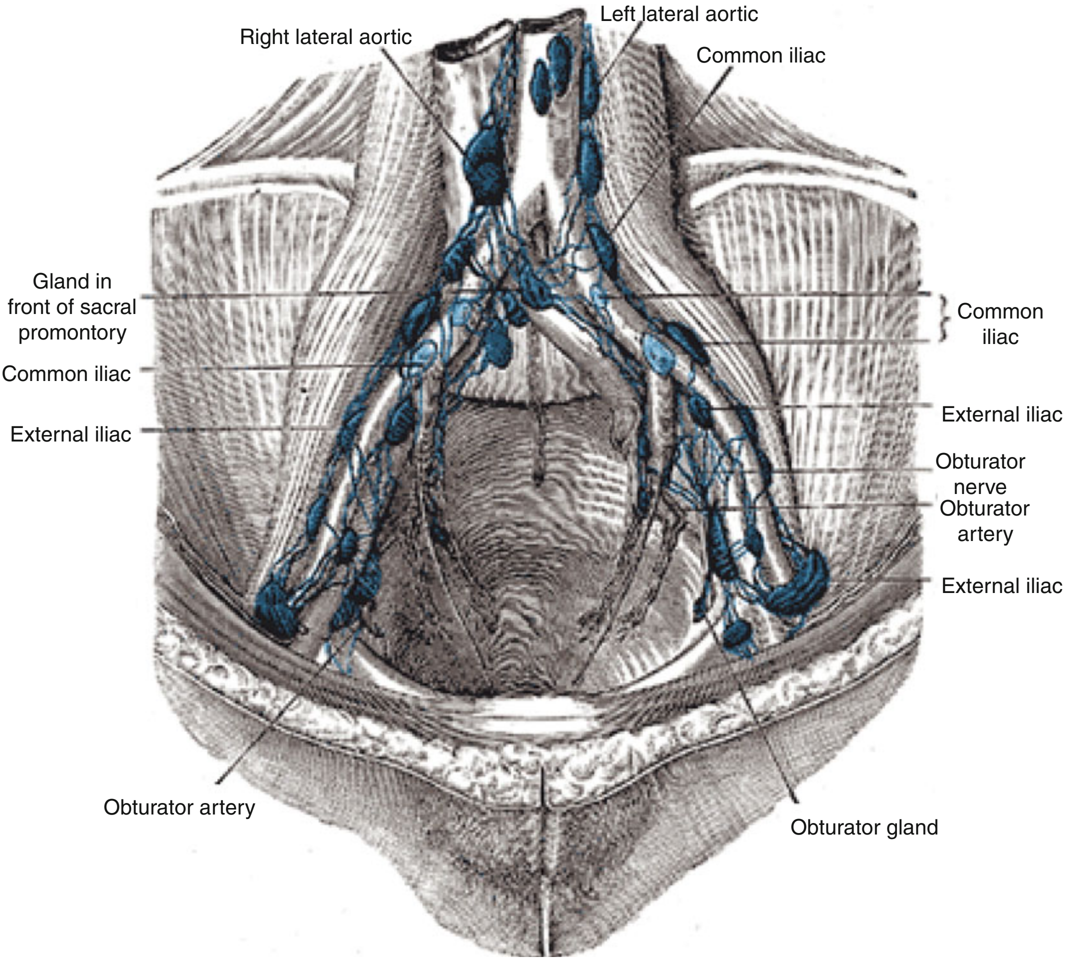

Fig. 7.1 The parietal lymph glands of the pelvis. (Cunéo and Marcille)

These above-mentioned node groups receive via afferent vessels lymph fluid from their corresponding viscera, while their respective efferent lymph vessels transport lymph to the external iliac, internal iliac or presacral lymph chains.

7.4.1 External Iliac Nodes

These nodes are grouped around the external iliac vessels, are usually nine to ten in number and have a constant arrangement, thus forming three distinct lymph node chains, each consisting of about three nodes, namely, the lateral, middle and medial groups of external iliac nodes (Fig. 7.3).

- The *lateral external iliac node chain* is located between the psoas muscle and the lateral side of the external iliac artery. The node situated under the inguinal ligament is known as the lateral lacunar lymph node [15].
- The *middle external iliac node chain* lies on the anterior aspect of the external iliac vein along the medial side of the external iliac artery.
- The *medial external iliac node chain* is situated on the medial side of the external iliac vein, against the lateral pelvic wall above the obturator nerve [14]. The lower node of this group is located behind the femoral

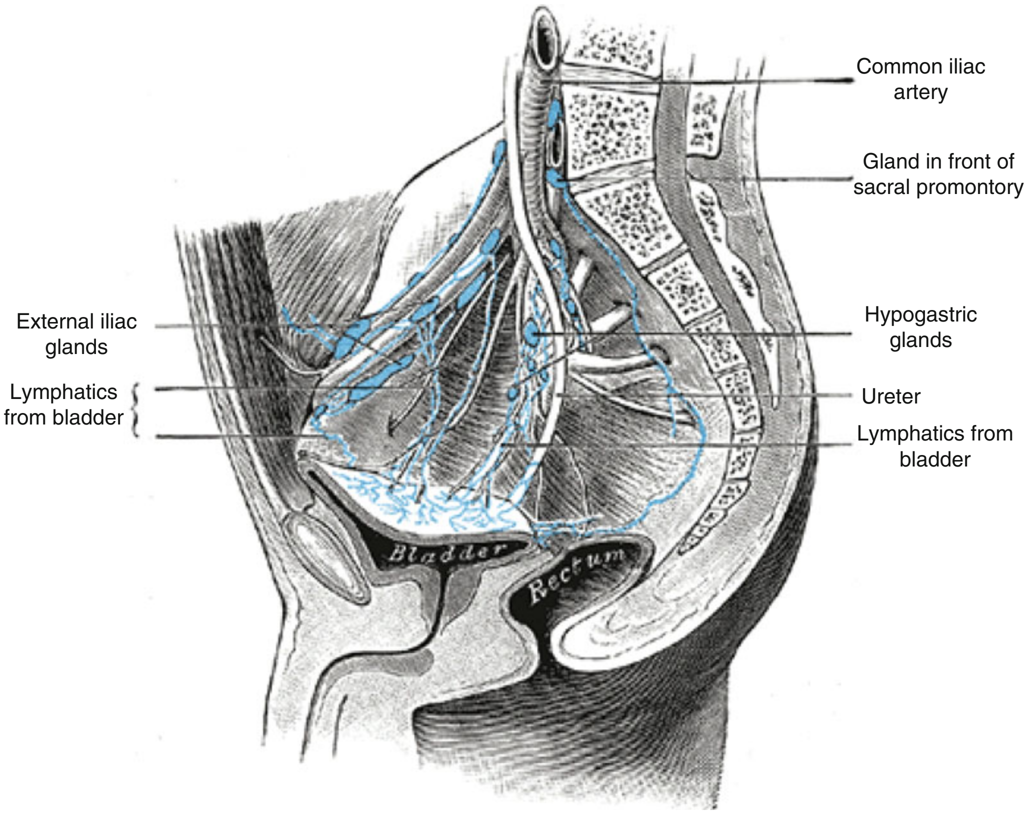

Fig. 7.2 Lymphatics of the bladder. (Cunéo and Marcille)

septum in contact with Cloquet's deep inguinal node and commonly termed medial lacunar lymph node [15]. It has been shown that these nodes are functionally linked to the external iliac chain of node groups [12]. From the surgeon's point of view, these nodes are commonly called *obturator nodes* due to their proximity with the obturator nerve. However, this terminology is misleading as stated by Sappey, as the small obturator node occupies the internal foramen of the obturator canal in the lower part of the obturator fossa (Fig. 7.1) [16].

The efferent lymph vessels of each external iliac lymph chain converge into the lower nodes of the common iliac chains. The three different chains form an extensive network between these lymph chains, which are mostly located on the anterior surface of the blood vessels, though some connecting vessels cross also posteriorly.

7.4.2 Internal Iliac Nodes

These nodes are often described in the literature as hypogastric nodes and surround the internal iliac vessels and are often situated in proximity with their different vascular branches (Fig. 7.2). Afferent vessels of the internal lymph nodes originate from the pelvic organs, namely, from the posterior part of the prostate, the lateral and lower parts of the urinary bladder, the membranous and prostatic urethra, the seminal vesicles, the middle and lower part of the vagina, the body of the uterus and the middle part of the rectum [13], [17], [18]. The lowest parts of the prostate, vagina and rectum are drained via the internal pudendal lymphatic vessels which then join the nodes of the internal iliac chain. The efferent vessels of the internal iliac node chain follow cranially within the hypogastric lamina and pass underneath the common iliac vein and terminate

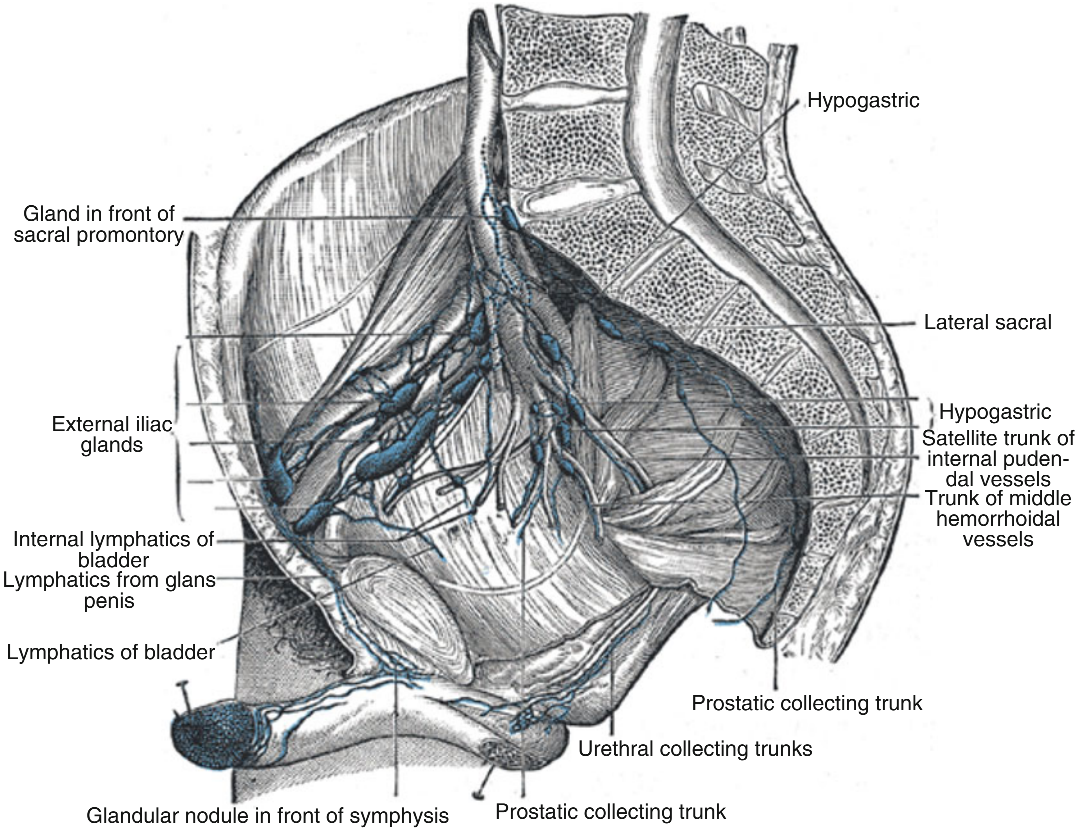

Fig. 7.3 Iliopelvic glands (lateral view). (Cunéo and Marcille)

in the intermediate group of common iliac lymph nodes [16].

7.4.3 Common Iliac Nodes

The common iliac nodes are grouped around the common iliac vessels, ranging from four to seven nodes in number and according to the afferent lymph vessels can be divided into the lateral, middle and medial groups of nodes (Fig. 7.1).

- The lateral lymph chain usually comprises two large nodes interposed between the lateral side of the common iliac artery and the medial border of the psoas muscle. These nodes drain the lymph from the lateral external iliac nodes and end in the lateral lumbar aortic node chain.
- The middle chain consists usually of three to four nodes located on the posteromedial side of the artery. On the left side they can be situated on the anterior aspect of the common iliac vein. These retrovascular nodes are located in Cunéo's and Marcille's triangular lumbosacral fossa, which is filled with adipose tissue and contains the nodes superiorly and the obturator nerve inferiorly [9].
- The medial chain runs along the inner side of the common iliac artery, and its nodes (subaortic nodes) are found just below the aortic bifurcation.

Interestingly, the lateral and middle common iliac lymph chains do not receive any direct afferent vessels from the pelvic organs. However, some lymphatics coming from the bladder neck, cervix uteri and posterior aspect of the rectum drain directly into the subaortic group of nodes. From these nodes, lymph chains continue cranially towards the preaortic, retroaortic and lateral aortic node groups. The lateral aortic lymph node

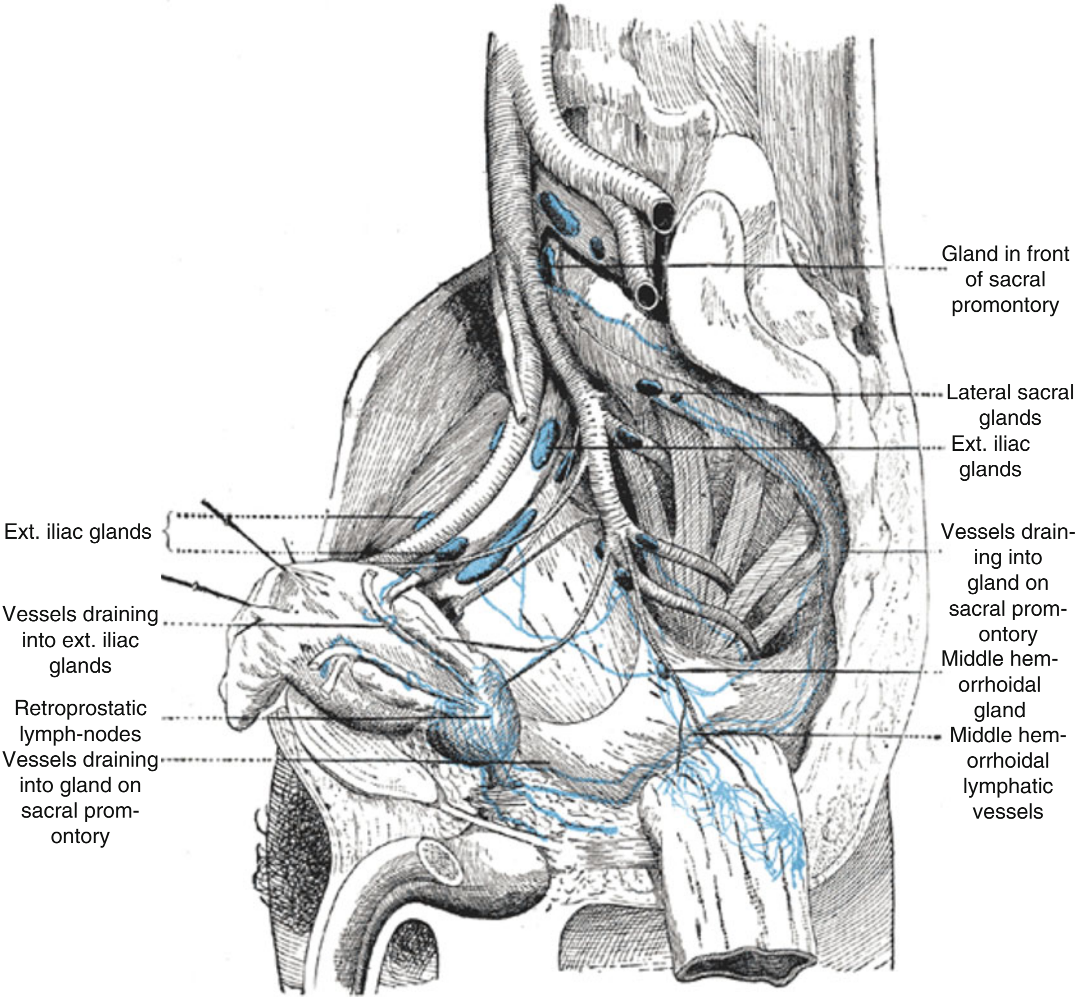

Fig. 7.4 Lymphatics of the prostate. (Cunéo and Marcille)

group is the most important group, comprising typically 15–20 lymph nodes on each side.

7.5 Bladder Cancer

The pioneering work in describing the anatomical lymph chains and nodes by Cunéo and Marcille has since then been confirmed when reporting sites of lymph node metastases at radical cystectomy [9]. Indeed, one of the first anatomical lymph node mapping studies at radical cystectomy by Smith and Whitmore concluded that nodes along the external iliac vessels, obturator fossa and common iliac vessels were frequently involved in patients with muscle-invasive bladder cancer [19]. Their results have been corroborated by complex surgical and radiological means in radical cystectomy patients by others [20, 21].

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Robotic-Assisted Pelvic Lymph Node Dissection

8

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8.1 Introduction

Radical cystectomy with pelvic lymphadenectomy represents the gold standard for treatment of muscle-invasive bladder cancer. The extent of the lymph node (LN) dissection and LN involvement during radical cystectomy are the powerful prognostic factors associated with poor oncological outcome. However, the optimal boundaries of the LN dissection during a radical cystectomy (RC) are controversial.

During the last decade, urologists worldwide have witnessed a development of laparoscopic surgical treatment due to the development of robot-assisted surgery in many urological diseases. In parallel the interest in expanding the role of robot-assisted radical cystectomy (RARC) for the management of urinary bladder cancer has increased, and more urologists have started to perform pelvic lymph node dissection (PLND) robotically.

After the initial report of the robotic-assisted pelvic lymph node dissection [1, 2] in the management of muscle-invasive bladder cancer, minimally invasive techniques have been criticized concerning the ability to adequately perform extended lymph node dissection.

However, it did not take a long time after the introduction of RARC before it was reported as a safe feasible procedure with acceptable nodal yield [3–5]. Potentially equivalent oncological outcomes to open radical cystectomy with no added morbidities have been reported [6]. Complete removal of the LN-bearing tissue up to the aortic bifurcation or inferior mesenteric artery was suggested to be more challenging using minimally invasive modalities compared to open technique. Recently, extended PLND has been demonstrated with the robotic system, with comparable LN yields [2, 7, 8]. Only one randomized study with the aim to study the difference in lymph node yield between open and RARC has been performed [9]. In this study there was no difference in the lymph node yield between open and RARC patients.

Similarly in a study comparing open and robotic-assisted lymph node dissection, Abaza et al. [10] showed no difference in the lymph node yield or the positive node rate when comparing open and robotic extended lymph node dissection.

Lavery et al. [11] have reported mean (range) nodal yield 41.8 (18–67) nodes in a group of 15 patients who underwent robotic-assisted PLND. The same authors conclude that robot-assisted

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ePLND at the time of cystectomy can be safely and effectively performed on the robotic platform with comparable nodal yields to open series at centers of excellence for cystectomy. However, nodal yields are likely to comprise a factor related to the effort of the surgeon and not only the surgical method by which the lymphadenectomy is performed.

According to International Robotic Cystectomy Consortium (IRCC) database [12], 527 patients who underwent PLND during RARC, rates of lymphadenectomy at RARC for advanced bladder cancer, and nodal yield were similar to those of open cystectomy series using a large, multi-institutional cohort of RARC patients.

8.2 Procedure

The lymph node dissection is facilitated by the use of 30° down lens, as well as by using a 4S or Si da Vinci robot which helps proximal dissection by a higher motion range of its robotic arms and longer robotic instruments. It is important to place the robotic ports higher up on the abdomen compared to the standard robotic prostatectomy in order to reach up to the aortic bifurcation (see chapter 11 on female cystectomy for port placement).

The lymph node dissection is performed after the bladder specimen is placed in an endo-catch bag and pushed away from the

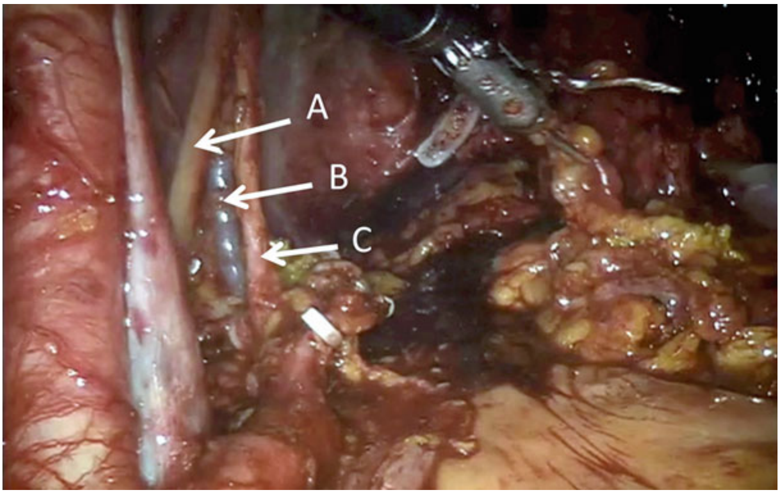

Fig. 8.1 Illustration of obturator nerve (*A*), obturator vein (*B*), and obturator artery (*C*) after lymph node dissection from the obturator fossa

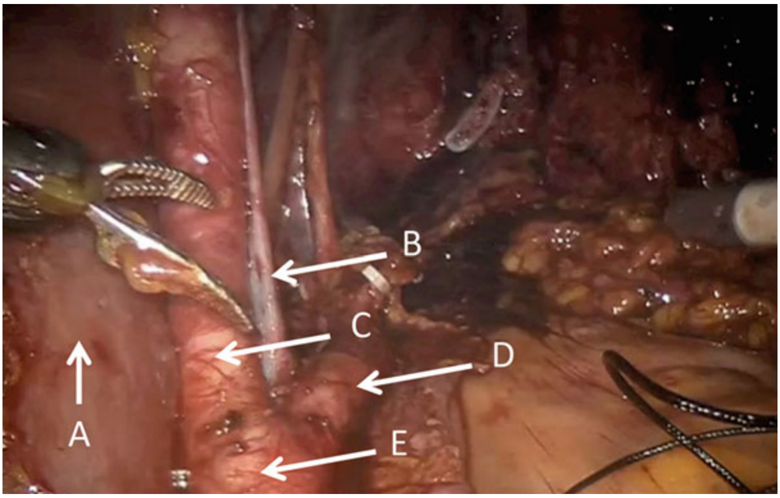

Fig. 8.2 Illustration of psoas muscle (*A*), external iliac vein (*B*), external iliac artery (*C*), internal iliac artery (*D*), and common iliac artery (*E*) after removing of lymph node along the iliac vessels

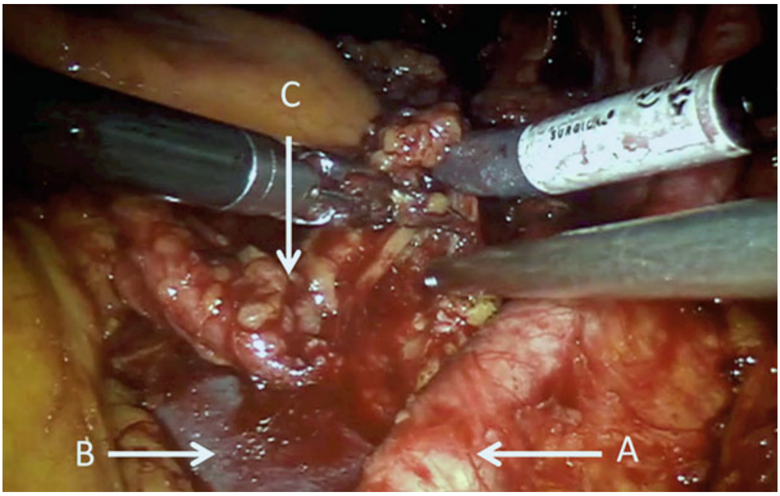

Fig. 8.3 Anatomic demonstration of common iliac artery (*A*) and vena cava (*B*) during removing of presacral lymph nodes (*C*)

pelvis or retracted through the vaginal wall incision. This approach allows clear visualization of the anatomy and helps in performing a proper lymph node dissection. Some centers advocate performing a lymph node dissection before the cystectomy, as the vascular pedicle of the bladder is clearly isolated after a meticulous pelvic lymph node dissection. We perform the lymph node dissection after the cystectomy as it provides a wide space for us to work in the narrow pelvic cavity, and the identity of the vascular pedicle during the cystectomy is relatively easy with the 3D vision provided with robotic assistance. The ePLND template used in our patients is based on the ePLND template described by Skinner [13]. Dissection is started at the external iliac vessels at the node of Cloquet and is continued to up to the aortic bifurcation. The lateral border of the dissection is the genitofemoral nerve. After identification of the obturator nerves and vessels the obturator fossa (Fig. 8.1), triangle of Marcille and the area along the internal iliac vessels (Fig. 8.2) including the presacral area (Fig. 8.3) are cleared from lymphatic tissue. The sigmoid colon is completely mobilized posteriorly for access to the presacral nodes. Paravesical nodes are removed en bloc with the specimen. Clips are utilized to hinder lymphocele formation, and meticulous care is taken not to damage the collapsed walls of the iliac and hypogastric veins.

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9

Pelvic Lymphadenectomy for Localised Prostate Cancer and Robot-Assisted Radical Prostatectomy

Christoph Schwab and Hubert John

9.1 Introduction

Pelvic lymph node dissection (PLND) as a staging method in prostate cancer (PCa) is today considered the most reliable procedure for detection of lymph node invasion (LNI) [1]. The rationale for an accurate locoregional staging lymphadenectomy in PCa is to stratify patients who might benefit from adjuvant therapeutic measures. Furthermore, adequate lymphadenectomy might help to improve cancer-specific survival or progression-free survival as has been demonstrated already for various cancer types. In the last decades, the routine usage of prostate-specific antigen (PSA) screening led to a stage shift in PCa, thus, the incidence of localised and node-negative cases has increased from about 60–80 % to almost 90 %. Which patients to select for a PLND and the optimal extent of this procedure are still under debate. Several questions focus on the following issues. Not all patients suffering from prostate cancer are at the same risk of harbouring lymph node metastasis [2–21]. The risk of nodal metastasis seems to depend mainly on clinical stage, PSA level and Gleason score. PLND has also its own morbidity [24] and requires skilled surgeons since it is a challenging and time-consuming procedure [22–24]. Last but not least, the therapeutic benefit of PLND in PCa management is currently unknown because of a lack of prospective randomised trials on this subject. Therefore, many groups are questioning the need of PLND in patients with a low- risk PCa. However, the literature also shows good arguments to perform routine PLND.

This chapter aims to review the available literature concerning the lymphadenectomy in prostate cancer and its role in staging and therapy.

9.2 Assessment of Imaging Techniques

Currently, standard imaging procedures have only a small role in predicting LNI [25–27]. Computed tomography (CT) and magnetic resonance imaging (MRI) cannot predict LNI as accurately and reliably as can an extended PLND (ePLND). The literature mostly reports the sensitivity for the CT to predict lymph node metastases as about 35 % [25]. MRI is not doing better and even dynamic-enhanced MRI or magnetic resonance spectroscopic imaging (MRSI) showed no significant advantage over CT in predicting the presence of LNI [26, 27]. But there are some innovative techniques which might change this state in the near future [28–32]. Bellin demonstrated in a group of 30 patients with genitourinary malignancies a significantly improved sensitivity and specificity of 100 and 80 %, respectively, for accurately detecting

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pelvic lymph node metastases [29] using lymphotropic paramagnetic iron oxide nanoparticles with a size of 30–50 nm as a contrast agent at MRI (lymphotropic nanoparticle-enhanced MRI (LNMRI)). In a more recent trial in 80 men with clinically localised PCa, Harisinghani showed also an increased sensitivity for detecting lymph node metastases from 35 % when using MRI alone to 90 % with the LNMRI. Specificity also increased from 90 to 98 % [28]. In the same subject, Heesakkers demonstrated a sensitivity of magnetic resonance lymphangiography (MRL) using ferumoxtran-10 as a contrast agent as high as 82 % and a negative predictive value (NPV) of 96 % in 375 patients with intermediate- to high-risk PCa [30]. These studies, however, have some limitations which have to be addressed in the near future before LNMRI will become a routine staging method for PCa [33]. Patients enrolled in these trials underwent a limited PLND (lPLND). An ePLND was performed in a few cases only in the presence of suspicious lymph nodes outside the boundaries of lPLND. Therefore, the high reported sensitivity and NPV of LNMRI might have been falsely inflated because of the significant understaging associated with lPLND [34–41]. Moreover, the conventional LNMRI has its own limitations, namely, the difficulty to discriminate benign tissue from cancer in the presence of fibrosis or lipomatosis within the lymph node or the very high reading time required for this technique and also a high interobserver variability. On the other hand, small nodal metastases can still be missed [33].

To overcome these problems, another approach has been proposed, consisting of MRI enhanced with ultrasmall superparamagnetic particles of iron oxide (USPIO) combined with diffusion-weighted MRI (DW-MRI). This approach was much faster and nevertheless quite precise for detecting pelvic lymph node metastases in patients with PCa, even in normal-sized nodes [32]. Another promising approach described choline positron emission tomography (PET)/CT in the detection of PCa nodal metastases [31]. Schiavina showed with this technique a high accuracy in detecting LNI in intermediate- and high-risk PCa patients. The sensitivity was 60.0 %, the specificity 97.6 %, NPV was reported to be 87.2 % and the number of correctly recognised cases at PET/CT was 87.7 % [31]. All the patients in this protocol were treated with ePLND.

Sentinel lymphoscintigraphy (SLN) is another technique which has been purposed as an imaging tool for planning the necessity and the extent of PLND in patients undergoing radical prostatectomy (RP). The aim of this technique, which led to the concept of sentinel node dissection, was to decrease the rate of unnecessary ePLNDs [42–48]. This approach, however, has some significant limitations. Although the sensitivity of the radio-guided sentinel lymph node dissection for detecting patients with positive nodes is extremely high (96 %), SLN is not able to identify all metastatic lymph nodes. Second, the amount of 32 % of falsely positive nodes and the fact that technetium-containing nodes can only be found intraoperatively with the collimator if it is in direct contact with the lymph node make this method of limited value in the daily practice. Other experiments trying to localise the 99mTc-containing lymph nodes more precisely, using single-photon emission CT (SPECT) fused with CT or MRI [49], were time-consuming and depended much on the skills and endurance of the reader. Thus, the experience with this approach is limited up to now.

Therefore, despite promising new imaging techniques, pelvic lymph node dissection is still considered the most reliable procedure to accurately detect lymph node metastases in PCa [50].

9.3 Location of Node-Positive Disease and Extent of Pelvic Lymphadenectomy

Prostate cancer disseminates initially to regional lymph nodes (LNs) [51]. Since the lymph node staging remains the most important prognostic factor in PCa [52], precise anatomical knowledge of the lymphatic drainage is of high importance when considering the extent of PLND.Unfortunately, there is little literature investigating the primary lymphatic landing sites in PCa. About a hundred years ago, the pathways of prostate lymphatics were already described, however, without details in primary or secondary lymphatic landing sites [53]. Several authors have since described areas in which positive lymph nodes may occur [36, 38], but there are differences in definitions of terms, for example, a lymph node may be found at the same place, but named from one group as part of the external iliac nodes, from another group as part of the internal iliac nodes or even as part of the common iliac nodes.

For the purposes of this discussion – and in accordance with the usage of most authors – three forms of lymphadenectomy in radical prostatectomy (RP) can be distinguished:

- Limited PLND: limited to the obturator fossa, between the external iliac vein, the obturator nerve and the branching off of the internal iliac artery.
- Modified PLND: obturator fossa plus the lymphatic tissue around the internal iliac artery.
- Extended PLND: includes removal of the nodes overlying the external iliac artery and vein, the nodes within the obturator fossa cranially and caudally to the obturator nerve, and the nodes medially and laterally to the internal iliac artery.

The first precise description of the prostate's primary lymphatic landing sites date from 2008 [49]. They concluded that the template of primary lymphatic landing sites is larger than previously appreciated: Nodes were found up to the inferior mesenteric artery, applying SPECT/CT/MRI after intraprostatic injection of Tc-99 m nanocolloid, which was verified with intraoperative use of a gamma probe and controlled by a systematic backup PLND. To avoid false-negative nodes, only patients without histological evidence of LN metastases were analysed. Following their meticulous analysis of the primary lymphatic landing sites in PCa, they purposed – as a compromise of operative morbidity and accuracy of staging – a template encompassing the area covered by classic extended PLND plus the nodes along the common iliac arteries up to the ureter crossing, thereby removing 75 % of all LNs.

9.3.1 Is There a Need for PLND in Low-Risk PCa?

Knowing the primary landing sites in PCa, important questions are still under debate: is there a need for PLND, and second, is there a place for limited PLND in low-risk PCa? A review of the recent literature shows several trials which have assessed the rate of LNI in low-risk PCa patients treated with either lPLND or ePLND [5, 54–59]. Despite a lack of uniformity in defining the low-risk PCa group, the rate of LNI in lPLND series is always low, ranging between 0.5 and 0.7 % [5, 54–56, 60]. In the largest low-risk PCa series in patients with cT1 PCa and PSA 6 ng/ml, the rate of LNI was 0.7 % [57]. These results have been confirmed by many groups [5, 56]; however, all of these studies are biased by the inclusion of patients treated with lPLND. Looking at ePLND series, the rate of LNI seems to increase in the high risk as well as in the low-risk PCa group [40, 58, 59]. Weckermann, for example, reported on a retrospective study a rate of LNI of 7.4 % in low-risk PCa (PSA < 10 ng/ml and biopsy Gleason score 6) treated with ePLND [58]. Heidenreich found a rate of LNI of 5.8 % in patients, with PSA < 10 ng/ml, T1c PCa and biopsy Gleason score 6, treated with ePLND [40]. The rate of LNI was even higher (11 %) in a study by Schumacher based on a cohort of 231 patients treated with ePLND where the PSA was <10 ng/ml [59]; however, this rate was only 3 % if only patients with T1–T2 PCa, biopsy Gleason score < 7 and PSA < 10 ng/ml were included.

Summarising the results, we can conclude that the overall LNI rate in the low-risk PCa group (PSA < 10, clinical stage T1–T2a and biopsy Gleason score 6) never exceeded 7 %, even among patients treated with ePLND [5, 35, 40, 54–59]. But we also have to acknowledge that only a few retrospective studies have assessed the impact of PLND on the outcome of low-risk PCa patients. They found no significant difference in biochemical recurrence (BCR) in a follow-up of maximum 10 years [54–56]. However, these studies enrolled only patients at very low risk of dying from progressive disease, even if left untreated, and they were all treated with lPLND, which seems, from what we know, not to be the appropriate procedure to assess LNI in PCA [33]. Finally, the statistical power of these studies was low. Therefore, the question if a more extensive PLND might favourably affect patient survival, even in the low-risk PCa group, is still unanswered. Prospective randomised trials including patients treated with ePLND are needed to find answers to these remaining questions.

In summary, the actual available PCa guidelines do not routinely recommend a staging PLND in low-risk PCa [1, 50, 60, 61], due to the lack of prospective randomised trials proving a significant benefit in BCR or survival in low-risk PCa following PLND, and also as the risk for positive lymph nodes does not exceed 7 % [35].

9.3.2 Extent of PLND

The literature on PLND has shown that the rate of LNI in PCa patients increases with the extent of PLND [34–41]. As PCa nodal metastases do not follow a predefined pathway of spread, lPLND might miss affected lymph nodes, which would have been detected by ePLND [62]. As mentioned above, different ways of ePLND are described: Some authors consider ePLND to be the removal of obturator, external iliac and internal iliac nodes [6, 37, 39]. Others describe also the removal of presacral nodes as a part of ePLND [36, 38, 63, 64], otherwise a substantial likelihood of overseeing positive nodes might be the consequence [63].

Finally, there are authors describing the additional removal of common iliac nodes, at least up to the ureteral crossing, to be the appropriate way to perform ePLND [38, 49]. But even with such extensive nodal dissections, approximately 25 % of lymph nodes potentially harbouring PCa nodal metastases could possibly be left inside [49].

Nevertheless, most authors agree on the fact that an extended nodal dissection should always include removal of lymph nodes along the internal iliac artery, since up to 50 % of lymph node metastases are located in this landing site [38, 40, 49, 62, 63, 65]. General agreement has also been reached that removal of lymph nodes located in the obturator fossa alone or together with the external iliac portion might significantly underestimate the true incidence of nodal metastases in PCa [33].

Briganti et al. showed an increasing likelihood to correctly predict the LNI by increasing the number of removed nodes [34]. The probability of correctly predicting the rate of LNI was almost zero when <10 nodes were removed. Otherwise, a very low risk of false-negative nodes was reported when 30 lymph nodes were removed. These results confirm the results of an autopsy study which found that an average of 20 dissected pelvic lymph nodes can be considered a representative locoregional staging of PCa [66].

Yet, there is only one prospective randomised study assessing the rate of LNI in patients treated either with lPLND or ePLND. Interestingly it did not find a significant difference in the rate of LNI between the two surgical approaches ($N=123$; 3.2 % vs. 4 % LNI; $p=0.1$) [23]. However, the results of this study have to be interpreted with caution, since the majority of the patients included had low-risk PCa. This means a low probability of LNI, even in patients treated with ePLND. Also, there are no data showing the number of lymph nodes removed in either group, and ePLND was performed on only one side. Furthermore, the field of ePLND was not defined. In respect also of the low statistical power of the trial, the validity of this study is limited.

In summary, available data seem to support the statement that if PLND is planned in patients with PCa, an ePLND significantly increases the nodal staging accuracy by decreasing the rate of false-negative findings associated with lPLND and should therefore be recommended. It is recommended that the nodes should be sent in separate containers per region for histopathology, as this will usually be associated with a higher diagnostic gain by the uropathologist. As a compromise of operative morbidity and accuracy of staging, a template encompassing the area covered by classic extended PLND plus the nodes along the common iliac arteries up to the ureter crossing seems to be appropriate. Thirdly, the actual available PCa guidelines do not routinely recommend a staging PLND in low-risk PCa.

9.4 Complications of Pelvic Lymph Node Dissection

Surgeons performing PLND are often concerned about the potentially high incidence of complications in ePLND, thus making sacrifices in the extent of lymphadenectomy. An overview in PLND complication literature shows a wide range (2–51 %) of PLND-associated complications [22–24, 36, 38, 45, 67–74] (see also Table 9.1). The specific complication of ePLND is lymphocele formation. If only the rate of lymphocele formation is the subject, then most authors report less than 10 % in their series, due to meticulous surgical technique, with ligation or clipping of all lymphatic vessels, double drainage and injecting prophylactic low molecular weight heparin into the arm, not the leg [64, 75].

The largest series ($n=963$) reporting complications after PLND showed an overall rate of complications of 19.8 % in patients treated with ePLND versus 8.2 % in those treated with lPLND ($p<0.001$) [24]. If they focussed on only the rate of lymphocele formation, then it was significantly higher in patients who underwent ePLND (10.3 % vs. 4.6 %; $p=0.01$). Conversely, Heidenreich et al. found no significant difference in frequency and severity of intra- and perioperative complications in the lPLND and the ePLND group (9 % vs. 8.7 %); the reported overall complication rate was 8.8 % [36].

But complications were not invariably high in all ePLND series. Bader et al., for example, reported an overall complication rate requiring prolonged hospitalisation of only 2.1 % [38]. However, counting only lymphoceles which led to prolonged hospitalisation or re-hospitalisation may underestimate the true risk of lymphocele formation, shown in series reporting lymphoceles of any size detected by routine use of imaging modalities in all patients [76–78]. These authors reported a rate of lymphoceles of 27–61 %, irrespective of whether they were clinically apparent or required treatment.

Despite discordant results in the literature, these data seem to suggest that PLND may not be a completely harmless procedure, even in the hands of experienced surgeons. Pelvic lymphoceles can cause further complications by compression or inflammation and are associated with an increased risk of deep venous thrombosis [79].

Although it seems logical that surgical expertise may reduce PLND-associated morbidity, it remains still unproven whether any specific surgical technique – as probably performed in any larger urologic centre – reduces the risk of lymphoceles. Thus, an intense discussion whether ePLND should be performed in all patients led to the actual guidelines, where low-risk PCa patients are recommended to be spared an ePLND [1, 50, 60, 61].

9.5 Likelihood of Nodal Disease Based on the Use of Nomograms

Nowadays we tend to rely on nomograms to predict the likelihood of LNI or local stadium of PCa. Several nomograms and predicting tables have already been developed to predict LNI and to assess the need for lymph node dissection [2–21]. Most of these nomograms use common variables such as PSA level, clinical stage and biopsy Gleason score (Table 9.2). But we should acknowledge that most of these tools are based on retrospective trials; furthermore, the nomograms, except for two [6, 7], were developed and validated in patients treated with lPLND. Therefore, underestimation of the likelihood of LNI is possible, due to the limited nodal sampling as mentioned above. Besides, none of these trials provided the number of removed lymph nodes.

The well-known Partin tables have recently been updated by Makarov et al. [5]. This tool still uses preoperative PSA, clinical stage and biopsy Gleason score to predict pathologic stage and likelihood of LNI. The predictive accuracy was 88 %. When validated in a population-based cohort of European patients, a lower accuracy of 76 % was reported [12, 13].

Work showing the relationship between the number of nodes removed and the likelihood of detecting LNI has led to the realisation that the factor of the extent of PLND should be taken into

Table 9.1 Available preoperative nomograms

Study	No. of patients	Predictors	Extend of PLND	Prevalence of LNI, %	Predictive accuracy, %
Cagiannos et al. [3]	7,014	PSA, c-stage, biopsy gleason score	Limited	3.7	76
Kattan et al. [4]	697	PSA, c-stage, biopsy gleason score	Limited	8	76.8
Makarov et al. [5]	5,730	PSA, c-stage, biopsy gleason score	Limited	1	88
Briganti et al. [6]	602	PSA, c-stage, biopsy gleason score	*Extended*	11	76
Briganti et al. [7]	278	PSA, c-stage, biopsy gleason score, % of positive cores	*Extended*	10.4	83
Bluestein et al. [8]	1,632	PSA, c-stage, biopsy gleason score	Limited	NA	NA
Bishoff et al. [9]	481	PSA, c-stage, biopsy gleason score	Limited	7.7	NA
Narayan et al. [10]	932	PSA, biopsy gleason score	Limited	11	NA
Conrad et al. [14]	344	No. of positive biopsies, no. of biopsies containing PCa of gleason score 4 or 5	Limited	8.1	NA
Roach et al. [15]	212	PSA, biopsy gleason score	Limited	17	NA
Crawford et al. [16]	4,133	PSA, c-stage, biopsy gleason score	Limited	NA	NA
Batuello et al. [17]	6,135	PSA, c-stage, biopsy gleason score	Limited	4.6	81
Han et al. [18]	5,744	PSA, c-stage, biopsy gleason score, age	Limited	5	88
Poulakis et al. [19]	201	PSA, c-stage, biopsy gleason score, pelvic coil MRI findings	Limited	10	91
Karam et al. [20]	425	PSA, c-stage, biopsy gleason score, preoperative plasma endoglin	Limited	3	97.8
Wang et al. [21]	411	PSA, c-stage, biopsy gleason score, pelvic coil MRI findings	Limited	5	89.2

PSA prostate-specific antigen, *c-stage* clinical stage, *PCa* prostate cancer, *PLND* pelvic lymph node dissection, *LNI* lymph node invasion, *MRT* magnetic resonance tomography, *NA* not available

Table 9.2 Reported complication rates after PLND

Study	*N*	Rate of complications, %	Extend of PLND	Mean number of lymph nodes removed
Stone et al. [22]	189	35.9 vs. 2	Extended vs. limited (laparoscopic series)	17.8 vs. 9.3
Clark et al. [23]	123	8.1 vs. 2.4	Extended vs. limited	NA
Briganti et al. [24]	963	18.9 vs. 7.3	Extended vs. limited	17 vs. 7
Heidenrich et al. [36]	203	8.7 vs. 9	Extended vs. limited	28 vs. 11
Bader et al. [38]	365	2.1	Extended	21 {median}
Jeschke et al. [43]	71	7	Extended (laparoscopic series)	NA
Schumacher et al. [59]	122	4.8	Extended	22 {median}
Herrell et al. [67]	68	20	Limited	9.2
Keller et al. [68]	90	7.8	Extended	19
Wyler et al. [69]	123	4	Extended (laparoscopic series)	21
Pepper et al. [70]	260	3.5	Extended	NA
McDowell et al. [71]	217	22	Extended	NA
Paul et al. [72]	150	51	Extended	NA

N Number of patients enrolled, *PLND* pelvic lymph node dissection

account. The first nomogram based on data of patients treated with ePLND was published by Briganti et al. [6]. An accuracy of 76 % to correctly predict local stage and LNI was reported, relying on clinical stage, PSA and biopsy Gleason score. The accuracy was even better, if data on tumour volume such as percentage of positive cores are included in multivariable models [7].

In conclusion, using nomograms we should remember one important thing: They remain probability models in any case and do not make a definite diagnostic statement about an individual patient. They always depend on the original cohorts of patients from which they were derived and validated. The accuracy of prediction is therefore limited. There is also still a debate about the cut-off of LNI probability, where a PLND could be spared. Should this be <7 % or even lower? These thoughts should be carefully discussed with the patient before radical prostatectomy. Considering the low rate of added morbidity, many urologists and patients will probably favour a higher accuracy of staging and opt for a PLND.

All of these data were recently reviewed and included in the available PCa guidelines [1, 50, 60, 61].

9.6 Influence of Lymphadenectomy on Outcome in RP

Besides being the most reliable staging procedure in PCa, ePLND might have a therapeutic effect on the outcome of PCa. Up to now, this question remains unanswered because of the lack of prospective randomised trials. But there are encouraging results which might support the thesis of therapeutic benefit after PLND. Already in 1987, Golimbu et al. reported a good overall survival in patients with only one involved lymph node after RP with PLND [80]. Bader et al. reported a significant correlation of the number of nodes removed during lymphadenectomy and time to progression [38]. Masterson et al. [41] also found a significant inverse association between the number of removed lymph nodes and biochemical recurrence-free (BCR-free) survival in node-negative patients ($p = 0.01$). This position is supported by the Johns Hopkins group; they reported a prolonged 5-year PSA BCR-free survival in ePLND versus lPLND [37]. In another population-based study with a 10-year follow-up, patients undergoing PLND had a lower risk of prostate cancer-specific death at

10 years than did those who did not undergo lymphadenectomy [81]. The risk to die of PCa was 23 % lower after ePLND and 15 % lower after lPLND in pN0 cases after 10 years. The limitation of this trial is the lack of a standardised pathologic assessment of the removed lymph nodes, which is important for determining reliable nodal counts.

These results may be due to the removal of micrometastases, which may support the therapeutic role of PLND in this patient category. But there are also opposing results challenging this thesis. Di Marco et al., for example, found no survival benefit associated with an increasing number of removed lymph nodes in node-negative patients in a series over 13 years [82]. Bhatta-Dhar et al. retrospectively analysed the biochemical failure rate in 336 low-risk PCa patients, of whom 140 had undergone PLND and 196 had not, and found no significant difference in BCR rate after a follow-up of 60 months (14 % vs. 12 %) [54]. Berglund reported results of a retrospective CaPSURE analysis of 4,693 RP cases with and without lPLND. Stratification of patients into risk groups in this analysis showed no overall influence of lPLND versus no PLND on BCR-free survival rates in the low-risk group, but, also in the intermediate- or high-risk group, there was no benefit in BCR-free survival [56].

In summary, the question of whether PLND can have an impact on node-negative PCa still needs to be elucidated.

Considering the data above, a possible bias might complicate correct interpretation and needs to be discussed. The positive association between PLND extent and cancer outcome in node-negative patients might be based on a misinterpretation of these data caused by the Will Rogers phenomenon [83, 84]. The Will Rogers phenomenon is obtained when moving an element from one set to another set raises the average values of both sets. It is based on the following quote, attributed to comedian Will Rogers (1879–1935): When the Okies left Oklahoma and moved to California, they raised the average intelligence level in both states. The effect will occur when both of these conditions are met: The element being moved is below average for its current set. Removing it will, by definition, raise the average of the remaining elements. The element being moved is above the current average of the set it is entering. Adding it to the new set will, by definition, raise the average.

In the context of PLND, if the number of removed negative lymph nodes is investigated as a prognosticator, it is clear that patients treated with ePLND have a higher likelihood of being really node negative without overlooked metastases. If a patient has a positive node in an area that is covered by an extended dissection but not by a limited dissection, this patient is excluded from the analyses in the group of ePLND patients, as he is node positive, and only node-negative patients are left in the analyses. But the same patient is included in the group with a limited dissection. This means that different groups are compared at a certain disease stage, and the benefit of the group with an extended dissection can be explained by the different disease stages. In other words, after a limited dissection, the likelihood of overlooked metastases is higher, and it is these overlooked positive nodes, instead of the removal of negative nodes, that influence the prognosis [83, 84]. Similar results can be achieved when considering only patients with positive nodes. Indeed, in patients in whom many nodes are removed, the incidence of finding positive nodes would be high, and the outcome of these patients would be relatively good because many patients would have only small volume metastatic disease. At the same time, when comparing node-positive patients between a series with ePLND or lPLND, the patients with positive nodes would again have a much better outcome in the series with ePLND because they would contain the patients who had small nodal disease. These observations suggest that the only solution to answering the question of whether or not removal of the lymph nodes has a role beyond diagnostic purposes is to conduct a prospective randomised trial in which patients are randomised to either no PLND or ePLND [33].

Even without available evidence, proving the therapeutic role of PLND in PCa, long-term outcome of patients with LNI, undergoing RP and PLND, is not necessarily poor [85–95].

Cheng et al. reported a 79 % 10-year cancer-specific survival in a large series of 322 patients treated with RP [87]. Ninety-two percent of the patients in this trial received adjuvant androgen deprivation therapy (ADT). Boorjan et al. updated the same collective in 2007, including 505 patients treated with RP and PLND, finding a 10-year cancer-specific survival rate of 85.8 %. Again, about 90 % of those patients received ADT [88]. Bader et al. reported a 74 % 5-year cancer-specific survival rate in a cohort of 92 patients treated with RP and ePLND without adjuvant treatment [86]. Data from the same group reported by Schumacher et al. showed a 60 % cancer-specific survival rate at 10-year follow-up in 122 patients [92]. Spiess et al. found the 5- and 10-year disease-specific survival rates to be as high as 94 % and 75 %, respectively, in a series of 100 node-positive patients [93]. And even after a longer follow-up of 15 years, Briganti et al. found a cancer-specific survival rate of 78 % in 703 node-positive patients, undergoing multimodal treatment [89]. As expected, BCR-free survival rates are reported to be poorer than cancer-specific survival rates [41, 96].

Looking at the data of cancer-specific survival rate in node-positive patients, there is one interesting question to which some authors tried to find an answer: Is there a difference in cancer-specific survival (CSS) in node-positive patients depending on the amount of positive nodes? Several trials have indeed shown that patients with low volume of lymph node metastases have significantly higher CSS rates compared to patients with more extensive LNI [85–89, 92, 96, 97]. Describing the survival difference in node-positive patients, the term of lymph node density (LND) was introduced. Daneshmand et al. reported on a large retrospective study a higher risk for clinical recurrence in patients with a LND > 20 % comparing with those at a LND < 20 % (relative risk: 2.31; $p < 0.001$) [85]. Other authors confirmed these findings [87, 96]. Cheng et al., for example, showed that the 10-year cancer-specific survival rate was not significantly different from the cancer-specific survival of patients without nodal involvement. He found a cancer-specific survival rate of 94 % in patients with a single node metastasis [87]. Furthermore, even node-positive patients receiving no adjuvant treatment seem to have a better prognosis if there is only one node involved. Schumacher et al. reported significantly higher 10-year cancer-specific survival rates in patients with one or two positive nodes (78.6 %) compared with patients with >2 positive nodes (33.4 %) [92]. And Bader et al. (2003) already found BCR-free survival rates much higher in patients with one positive node compared to patients with two or more positive nodes not receiving any adjuvant therapy (39 % vs. 12 %, respectively) [86]. Briganti et al. demonstrated that patients with up to two positive nodes experienced excellent cancer-specific survival, which was significantly higher compared to patients with more than two positive nodes (84 % vs. 62 %; $p < 0.001$, at 15-year follow-up, $n = 703$). Moreover, a significant improvement in CSS prediction was reached when the number of positive nodes was considered. They proposed that their results reinforce the need for a stratification of node-positive patients according to the number of positive nodes and that patient classification according to number of positive nodes should be considered a key variable for CSS predictions of node-positive patients [89].

Summarising all these data, we can conclude that the impact of PLND as a curative treatment remains an unanswered question. Only prospective randomised trials comparing the effect of PLND versus no PLND in high-risk patients would show the role of PLND on survival rates in PCa patients. Nevertheless, there is some indirect evidence that ePLND may have a therapeutic benefit on PCa patients, particularly in those patients with low LNI. Thus, such studies are unlikely to pass an ethical committee.

9.7 Pelvic Lymphadenectomy in Robot-Assisted Radical Prostatectomy

Robot-assisted laparoscopic radical prostatectomy is becoming a popular procedure worldwide. A rapidly increasing number of publications reporting various refinements of technique as well as functional outcomes and early oncologic results show the increasing importance of this approach [98–100]. The first report from PLND in robot-assisted laparoscopic prostatectomy (RALP) dates from 2001 [101]. Guilloneau showed the feasibility of a PLND even in RALP. However, since then, the PLND undertaken with laparoscopic or robot-assisted RP has usually been performed as a limited lymphadenectomy. This is in contrast to the ongoing debate concerning the extent of and the indication for a lymph node dissection in patients undergoing RP for PCa. However, increasing evidence supports an extended lymph node dissection in patients with prostate cancer once the prostate-specific antigen (PSA) level is >10 ng/ml or the Gleason score totals ≥7. Feicke et al. recently reported their experience and technique of extended PLND in RALP and confirmed the feasibility of this approach; furthermore, the lymph node yield as well as the complication rate was reported to be in the range of open series [102].

9.8 Technique of PLND in Robot-Assisted RP

As with any other procedure, the robot-assisted laparoscopic extended pelvic lymph node dissection (RALEPLND) has to be standardised. The intraoperative orientation is facilitated by proceeding from one landmark to the next.

Most authors propose a template for PLND according to Bader et al. and their recent modification by Mattei et al., proposing to include the common iliac region up to the ureteral crossing [38, 40, 49, 69, 103].

Of high importance is the identification of several important landmarks: the median and medial umbilical folds and the external iliac artery usually recognised with its pulsation. Frequently, the vas deferens and the ureter are already visible beneath the peritoneum, after mobilising the right ascending and left descending as well as sigmoid colon.

After identification of these landmarks, the incision of the peritoneum starts laterally to the medial umbilical fold longitudinally along the external iliac vessels. Distally, the incision and dissection is carried out until the pubic bone is clearly identified. Proximally, the peritoneal incision proceeds up to the crossing of the ureter over the common iliac artery. The vas deferens is cauterised and divided. After these steps, the cranial and caudal boundaries of the lymph node dissection are defined.

We start the ePLND within the obturator fossa. The technique does not differ from the operative surgical technique employed at open RP. The most important step in this region is the identification of the obturator nerve, which has to be preserved. The dissection is initiated at the angle between the external iliac vein and the ramus ossis pubis. Only after clear identification of the obturator nerve is the distal end of the packet secured with Weck Hem-o-lok® clips and divided. The packet is dissected beneath the external iliac vein and mobilised to the pelvic side wall, which is the lateral boundary of this area. The proximal attachments of the packet are dissected using a combination of sharp and blunt dissection, if possible without cauterisation, always paying attention to avoid any injury to the nerve. In most cases the packet can be evacuated through the 12-mm laparoscopic port. If not, the use of a specimen bag can be considered in order to avoid spilling of tumour cells.

The next step is the dissection of the external iliac packet. It starts distally with the division of the adventitia overlying the external iliac vein. The distal end of the packet is divided and secured with Hem-o-lok® clips. Care must be taken not to disturb the tissues overlying and surrounding the external iliac artery as these contain the lymphatic vessels that drain the leg. Disruption of these lymphatic vessels carries the risk of lymphocele formation and lymphedema of the lower extremities. The lymphatic packet is grasped and retracted in a cranio-medial direction, which allows for blunt and sharp dissection of the packet from the underlying vein. The dissection proceeds until the ureter crossing is reached.

The internal iliac artery is usually identified after the initial peritoneal incision. Normally, the bifurcation of the common iliac artery is visible

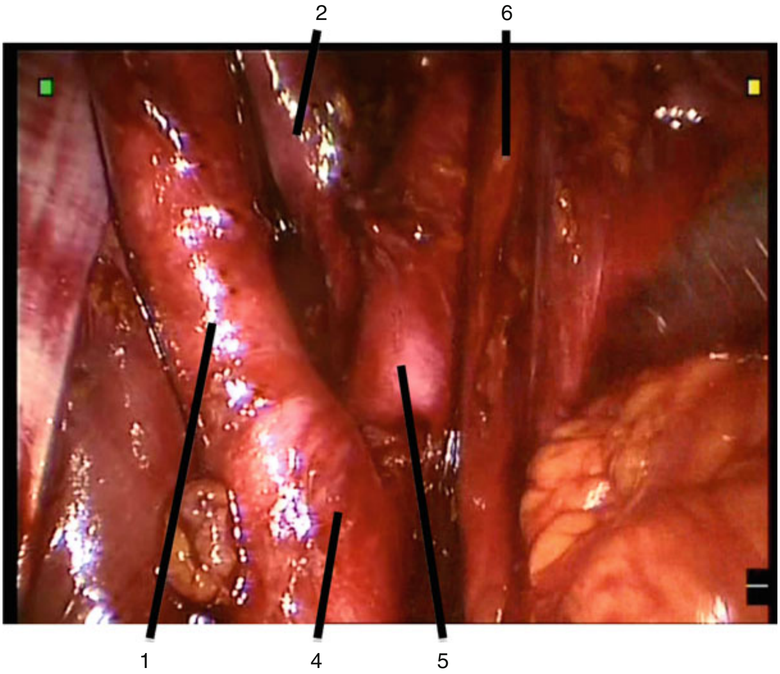

Fig. 9.1 Proximal situs after ePLND. *1* – external iliac artery. *2* – external iliac vein. *4* – common iliac artery. *5* – internal iliac artery. *6* – ureter

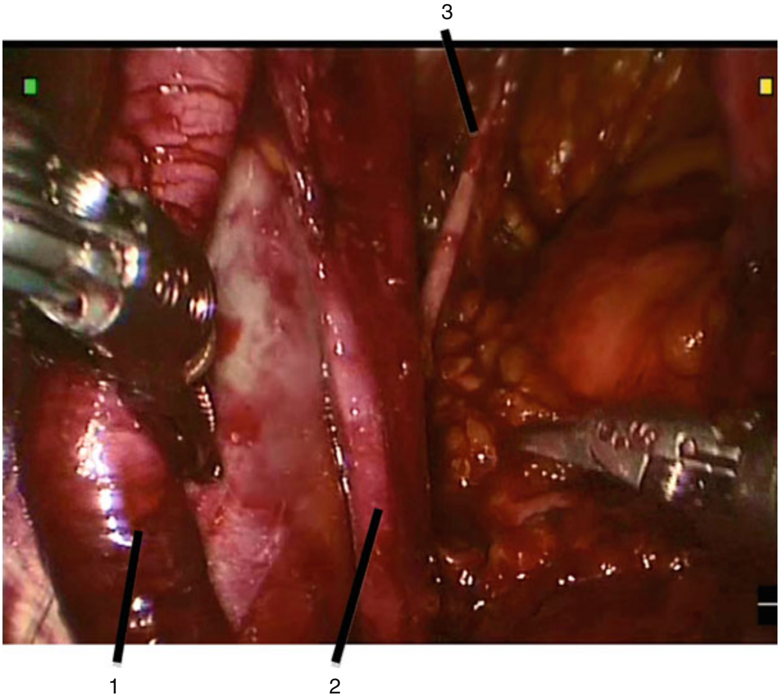

Fig. 9.2 Separation of the external iliac artery and vein distal to the bifurcation of the common iliac artery, in order to assure that all lymphatic tissue has been cleared out of this region. *1* – external iliac artery. *2* – external iliac vein. *3* – obturator nerve

after the completion of the dissection of the external packet (Fig. 9.1). Alternatively, following the medial umbilical ligament down to the pelvic floor will lead to the internal iliac artery. The lymphatic tissue overlying the internal iliac artery and its obturator and especially the medial vesical branches is completely removed. Special attention is paid to the careful dissection of the tissues medial to the internal iliac artery, since there are often minor bleeding spots.

At the end of the lymphadenectomy, we separate the external iliac artery and vein just distal to the bifurcation of the common iliac artery, in order to control the obturator nerve in its proximal course and to assure that all lymphatic tissue has been cleared out of this region (Fig. 9.2).

The lymph node packets from each region are removed and sent to the pathologist separately.

Complications of robotic ePLND are bleeding, lymphocele formation and vascular or neural injury. Clipping of lymphatic vessels is of great importance to prevent lymphocele formation. The transperitoneal approach better precludes a lymphocele formation. Bleeding can normally be controlled by clipping or gentle coagulation, and nerve injury should not occur with proper technique, avoiding sharp dissection or clipping before identification of the obturator nerve.

Conclusion

From this review we can conclude the following: PLND is still considered the most accurate procedure to detect local lymph node metastasis, allowing a reliable staging in PCa. Up to now, current imaging techniques cannot give equivalent information comparing to an ePLND. Second, lPLND is not able to detect all positive lymph nodes in every case. The actual literature associates lPLND with a high rate of false-negative findings. Increasing the extent of PLND leads to a more reliable assessment of LNI. On the other hand, the more extensive the PLND is performed, the higher the rate of complications is reported. The extent of lymph node involvement, however, is one of the strongest prognostic factors of cancer-specific survival. However, outcome of node-positive patients undergoing ePLND is not invariably poor; patients with a low nodal burden show often a good long-term survival.

Thirdly, most authors agree that a staging ePLND might be spared in low-risk PCa, since up to now, no prospective randomised studies could find a better cancer control or improved survival after ePLND in these patients. But it seems important to keep in mind that there is still a substantial risk of preoperative understaging and undergrading which must be taken into account on an individual basis when deciding to perform PLND or not. Furthermore, the assumption that low-risk PCa patients are of low risk harbouring lymph node metastasis is based on nomograms derived from series of lPLND, which explains their limited value. The risk of leaving metastases inside by sparing PLND must therefore be discussed with the patient. In this case, a rising PSA soon after RP will probably bring the diagnosis some months later. Fourthly, the feasibility of lPLND as well as ePLND in robot-assisted prostatectomy is well reported and therefore should not be spared if indicated. And as a last conclusion, actual guidelines and most authors agree that if PLND is planned at the time of RP, it should be extended.

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Part IV

Bladder

Surgical Anatomy of the Bladder

10

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10.1 Introduction

Advancing from open to endoscopic surgery and continuing to robotic-assisted endoscopic surgery does not change the anatomical facts, but visual perspective changes literally. Both the angle of view of topographic relations between anatomical structures and the attention to details have been modified and enhanced by the technical development. Magnification and stereoscopic view along with the possibility of reduced tremor and precise preparation opened up these real-time insights into human pelvic anatomy. The following chapter addresses the macroscopic and microscopic anatomy of the urinary bladder with regard to special needs of a surgeon working endoscopically. In addition to basic anatomical knowledge, this chapter emphasizes the topographic female and male anatomy of the pelvis, the urethral sphincter mechanisms, and the continuously evolving field of genitourinary tract innervation. Whereas gross anatomy is substantially investigated and well known, microscopic anatomy, especially the complex pelvic neural network and the ultra structure of the rhabdosphincter, is still in the spotlight of scientific interest. The prostate and the periprostatic nerve courses are excluded and focused on in another chapter. The combination of new findings with traditional anatomical knowledge into urological practice will improve the treatment success for our patients after robotic pelvic surgery.

10.2 The Anatomy of the Urinary Bladder: A Look Back into History

A catheter made of bronze draining the urinary bladder was described for the first time in Egypt about 1000 B.C., and bladder stone surgery also seems to have been practiced. Classifications of functional diseases of the urinary bladder have been described by Hippocrates of Cos (about 460–370 B.C.) based on observational studies. Herophilus of Chalcedon demonstrated the existence of the prostate for the first time with human cadaver studies in 300 B.C.. Precursors in human anatomy especially with regard to the urogenital tract were Leonardo da Vinci (1452–1519), Andreas Vesalius (1514–1564) from Brussels, and their successor Eustachi (1500–1574) after a widespread rejection of anatomical studies up to the Middle Ages. The anatomy of the urogenital tract was further characterized with the description of the seminal vesicles by Étienne de la Rivière of Paris, the investigation of the renal function by Marcellus Malpighi (1628–1694), and the description of the renal tubules by Lorenzo Bellini (1643–1704). The enhanced technical possibilities of microscopic pathological examination advanced the basic anatomical knowledge. Mery described the existence of the

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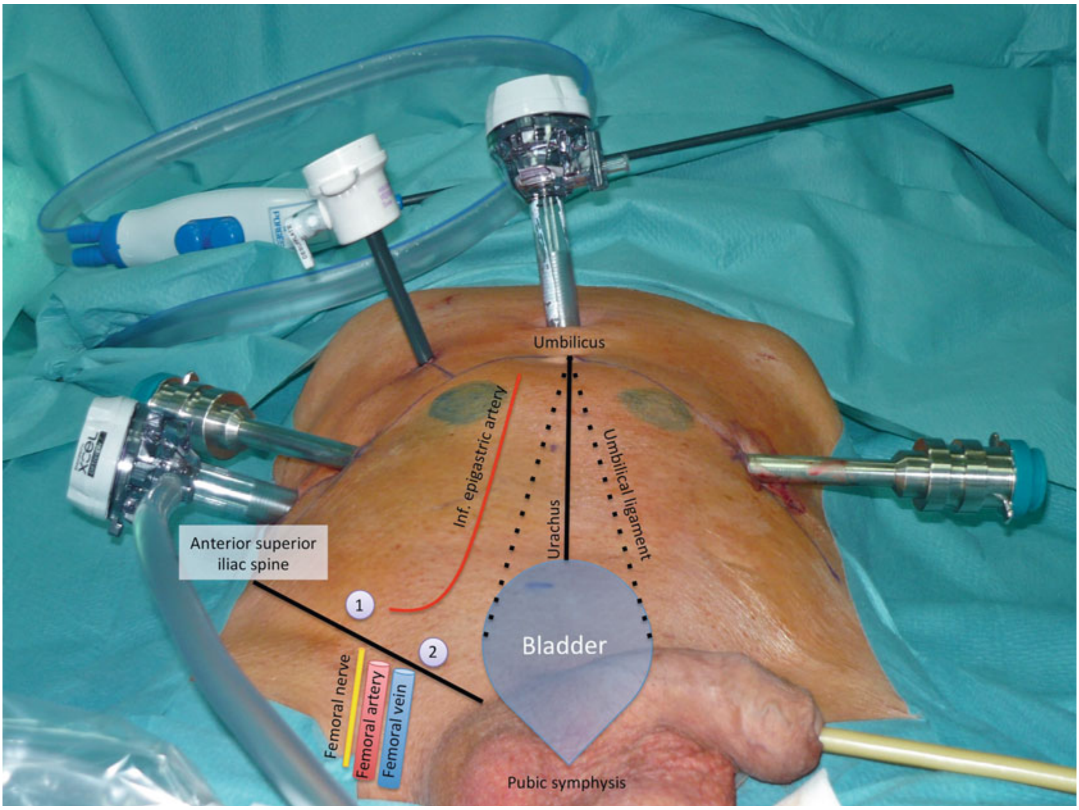

Fig. 10.1 Anatomical landmarks in projection on the external abdominal wall (internal inguinal ring (*1*), external inguinal ring (*2*), trocar positioning for robotic-assisted radical cystectomy)

bulbourethral glands, which was later attributed to Cowper in 1684. Giovanni Battista Morgagni (1682–1771) is presumed to be the founder of the study of the pathology of the urinary tract based on his work "De sedibus et causis morborum." He is also considered the first to describe prostatic hyperplasia. One of the milestones in urology – urological endoscopy – goes back to Phillip Bozzini of Frankfurt who invented the first endoscope using candlelight in 1806. This made possible the exploration of the internal anatomical details of a living individual [23].

10.3 The Anterior Abdominal Wall: Anatomical Landmarks

Knowledge about the different anatomical structures of the anterior abdominal wall is crucial for laparoscopic and robotic-assisted surgery. Trocar positioning and the first steps of intrapelvic preparation require orientation at the different anatomical landmarks. Figure 10.1 illustrates a projection of the main structures onto the skin of the anterior abdominal wall, whereas Fig. 10.2 presents a combined realistic and delineated laparoscopic insight into the male pelvis at the beginning of robotic-assisted pelvic surgery. Five tissue folds subdivide the anterior abdominal wall. The median umbilical ligament raising the median umbilical fold between the apex of the urinary bladder and the umbilicus originates from the former embryonic urachus (connecting the urinary bladder to the embryonic allantois) and is located between the transversalis fascia and the peritoneum. The medial umbilical folds on both sides of the median umbilical fold accommodate the remnants of the fetal umbilical arteries. The excavation in between is called the supravesical fossa. The medial umbilical ligaments are

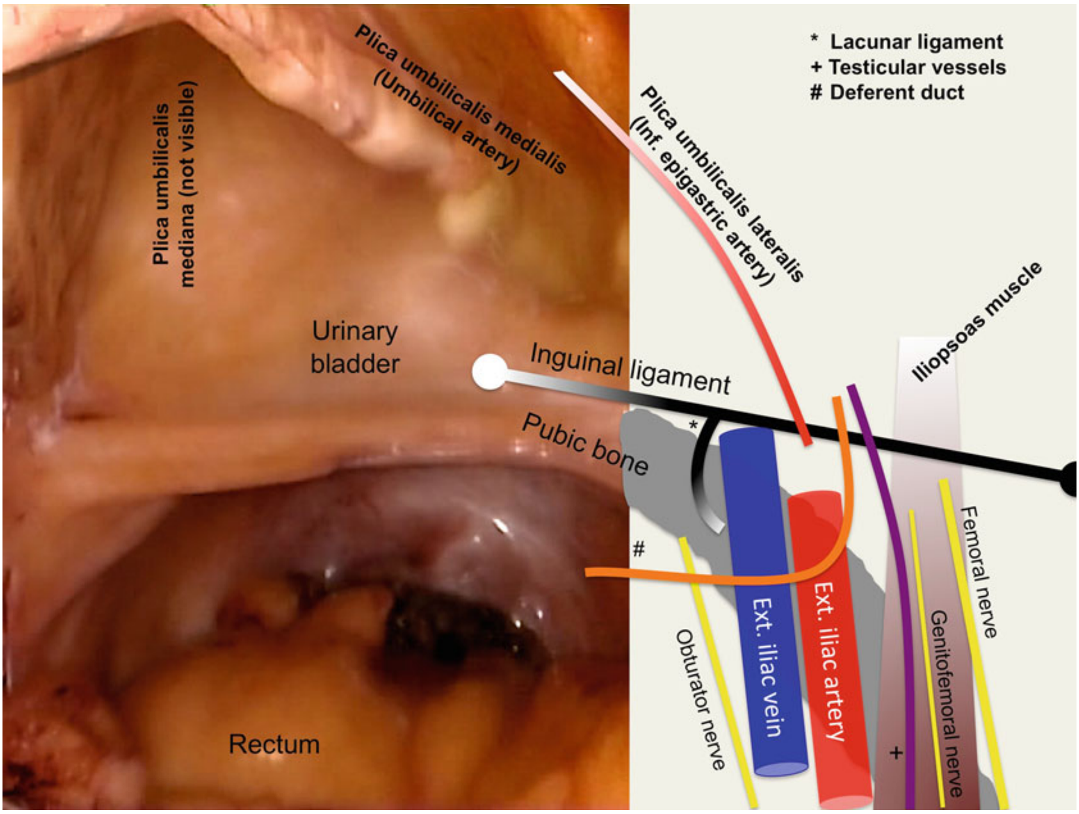

Fig. 10.2 Intrapelvic anatomical landmarks. *Left*: laparoscopic view into the male pelvis (trocar position below the umbilicus). *Right*: anatomical structures of the inguinal region and the internal abdominal wall (additional annotation: deferent duct (#, *orange*), testicular vessels (+, *violet*), lacunar ligament (*))

guiding structures during cystectomy to identify the upper vesical pedicle including the superior vesical artery. Both inferior epigastric arteries form the lateral umbilical folds. Hernia classification is defined by the reference of the location of hernia passage to the lateral umbilical fold. Medial to the lateral umbilical fold, the medial inguinal fossa represents the passage of direct inguinal hernias. The lateral inguinal fossa is idem to the deep inguinal ring – the entry to the inguinal canal. An indirect inguinal hernia could accompany the components of the spermatic cord through the inguinal canal. The iliopectineal arch subdivides the space below the inguinal ligament, which connects the anterior superior iliac spine to the pubic tubercle and is formed by the external abdominal oblique aponeurosis. The muscular lacuna laterally contains the iliopsoas muscle and the femoral nerve, and the vascular lacuna medially includes the external iliac vessels. The lacunar ligament is directly located medial to the external iliac vein connecting the inguinal ligament to the superior pubic ramus and represents the caudal extent during lymphadenectomy for prostate or bladder cancer (Fig. 10.3) [3, 5, 12].

10.4 Anatomical Topography of the Female Pelvis

A plain sacral promontory and wide-open iliac wings characterize the female pelvic bone. Main organs of the peritoneal and subperitoneal pelvic cavity are the urinary bladder, the ureters, the uterus, the vagina, the ovaries, the oviducts, and the rectum. The parietal peritoneum covers approximately the upper half of the urinary bladder, the uterus, the adnexa, and the anterior wall

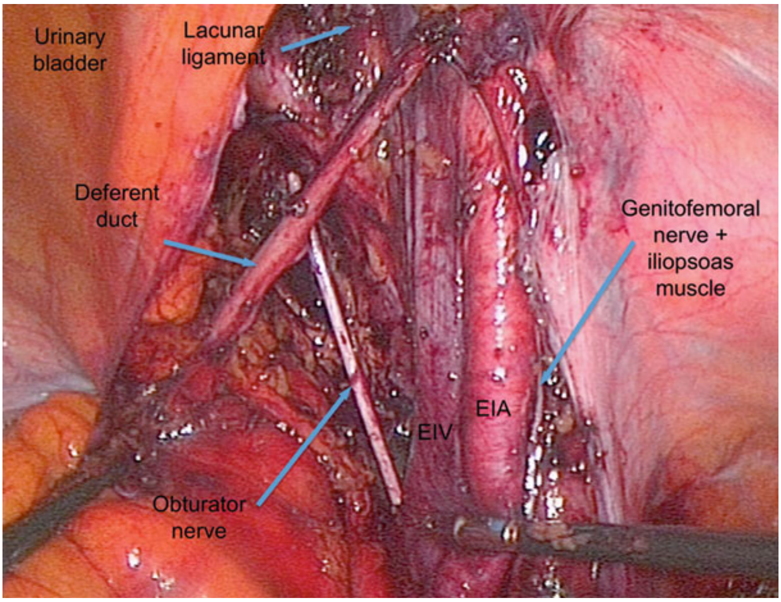

Fig. 10.3 Situs after laparoscopic lymphadenectomy for prostate cancer; *EIV* external iliac vein, *EIA* external iliac artery. The lacunar ligament is the distal extent of pelvic lymphadenectomy

of the rectum, which results in varying peritoneal conditions. The position of the uterus between the urinary bladder and the rectum develops the rectouterine excavation (Douglas' fold) and the vesicouterine excavation. Different ligaments retain the uterus in its position: the cardinal ligaments (transverse cervical ligaments) contain the uterine arteries, the uterine venous plexus, and the parts of the distal third of the ureters and connect the cervix to the lateral pelvic wall. The bilateral peritoneal duplication between the uterus and the pelvic wall in cranial continuation to the cardinal ligaments is called ligamentum latum (broad ligament) although it is not a ligament in the anatomical sense. The suspensory ligaments contain the ovarian vessels and connect the ovaries to the lateral wall of the pelvis. In the other direction the ovarian ligaments connect the ovaries to the uterus – additional vessels originating from the uterine arteries are included in these structures. The round ligaments represent connections between the deep inguinal rings and the uterine horns. The rectouterine folds mark the borders of the rectouterine excavation – they consist of fibrous tissue and smooth muscle fibers and also include the inferior hypogastric plexus (Fig. 10.4). The pelvic fascia (endopelvic fascia) subdivided into the parietal and the visceral layer covers the borders of the subperitoneal space (also called cavum retzii) and forms the superior layer of the fascia of the pelvic diaphragm. The urinary bladder is attached to the symphysis pubis via the pubovesical ligaments with lateral connections to the superior layer of the fascia of the pelvic diaphragm [3, 5, 12, 15].

10.5 Anatomical Topography of the Male Pelvis

Compared to the female pelvis, in male humans the pelvic bone is narrower and marked by a more protruding sacral promontory resulting in a heart-shaped pelvic entry. The pelvis comprises the urinary bladder, the ureters, the prostate, the seminal vesicles, the deferent ducts, and the rectum. The lowest point of the abdominal cavity between the urinary bladder and the rectum is called the rectovesical excavation (Fig. 10.5). The rectovesical fold borders the excavation laterally and includes the inferior hypogastric plexus (Fig. 10.6). The deferent ducts shape the paravesical fossa by raising a peritoneal fold. The current literature presents an inconsistent description and nomenclature of the subperitoneal fasciae especially on closer inspection of the periprostatic fasciae and the

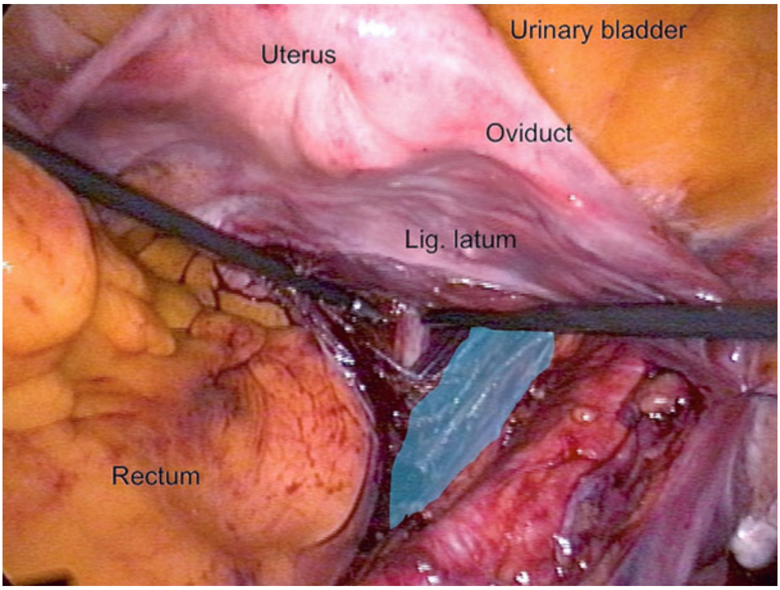

Fig. 10.4 Laparoscopic insight into the female pelvis during sacrocolpopexy. The rectovaginal fold including the inferior hypogastric plexus (*right side*) is marked lucent *blue*

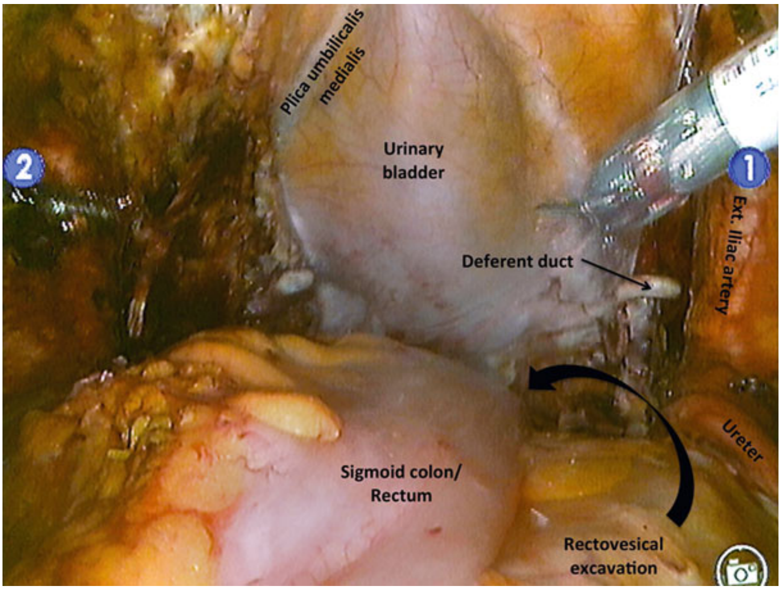

Fig. 10.5 Anatomical landmarks during robotic-assisted laparoscopic cystectomy after the first step of lymphadenectomy

rectoprostatic septum, which separates also the urinary bladder and the rectum starting from the rectovesical excavation ("cul-de-sac"). Comparable to female anatomy, the pelvic fascia also consists of two elements: a parietal layer, which covers the lateral wall of the pelvis, and a visceral layer (clinically "endopelvic fascia") overlaying the pelvic organs. The intersection of both layers is called the tendinous arch of pelvic fascia. It remains still under discussion if the prostates' own fascia separates the gland. The fact of an absent fascia in the apical region of the prostate and the formation of the so-called puboprostatic ligaments by an aggregation of the endopelvic fascia suggest that the visceral layer of the pelvic fascia and the fascia of the prostate correlate. Possibly, muscle fibers (smooth or striated) also contribute to the configuration of the puboprostatic ligaments. Similarly, the configuration of the Denonvilliers' fascia is not

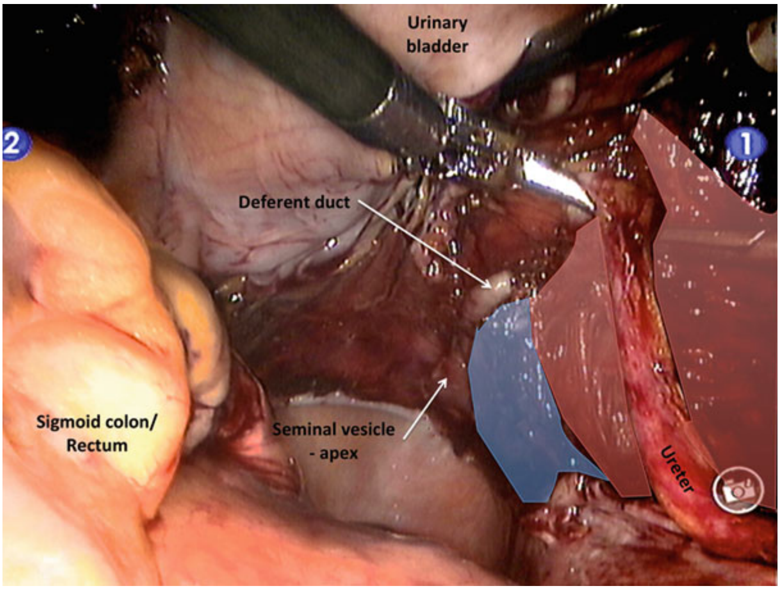

Fig. 10.6 Topographic anatomy during mobilization of the ureter and the vascular pedicles of the urinary bladder (marked lucent *red*) in robot-assisted laparoscopic radical cystectomy; the inferior hypogastric plexus (lucent *blue*) is located medial to the ureter and lateral to the apex of the seminal vesicle

clarified in the literature. The anatomical nomenclature utilizes the description rectoprostatic septum as a membranous separation between the rectum and the ventrally located urinary bladder with the prostate. The fascia emerged from two layers of a peritoneal cul-de-sac ranging from the deepest point of the rectovesical excavation to the pelvic floor. Currently, it is assumed that microscopically the rectoprostatic septum consists of two former peritoneal layers, which in the majority of cases cannot be divided bluntly. It is assumed that authors illustrating techniques of fascia separation are referencing the space between Denonvilliers' fascia and the rectal fascia propria (a part of the visceral layer of the pelvic fascia) [3–5, 12, 18, 20, 21, 24, 26, 27].

10.6 Macroscopic and Microscopic Anatomy of the Urinary Bladder

The urinary bladder is a muscular, distensible organ for urine collection and controlled micturition. Macroscopic anatomy subdivides the urinary bladder into the apex, the corpus, the fundus, and the collum (with the trigone) (Fig. 10.7). The average filling volume ranges between 300 and 500 cm^3. The interureteric crest raised between the obliquely passing ureters characterizes the trigone. The urinary bladder wall is structured into the mucosa (transitional cells), the submucosa, the detrusor muscle (three layers), and the surrounding adipose and connective tissue (Fig. 10.7). A direct adhesion of the mucosa to the submucosa exists in the trigone area; the other parts of the urinary bladder demonstrate a loose connection between these two layers. The detrusor muscle is subdivided into three layers: an external and internal longitudinal muscle layer and an interjacent circular layer. The circular layer does not reach the bladder neck including the trigone. The longitudinal muscle fibers (also forming the Waldeyer's sheath of the ureterovesical junction) in conjunction with the extending longitudinal fibers of both ureters extend below the bladder neck and reach the muscular layers of the urethra. In male humans these structures reach the point of the seminal colliculus.

Table 10.1 gives an overview of pelvic and especially genitourinary arterial blood supply. The urinary bladder generally receives two main branches of each of the internal iliac arteries: the superior vesical artery and the inferior vesical artery (clinically the superior and inferior vesical pedicle). The superior vesical artery descends from a common branch with the former umbilical artery proceeding in the medial umbilical

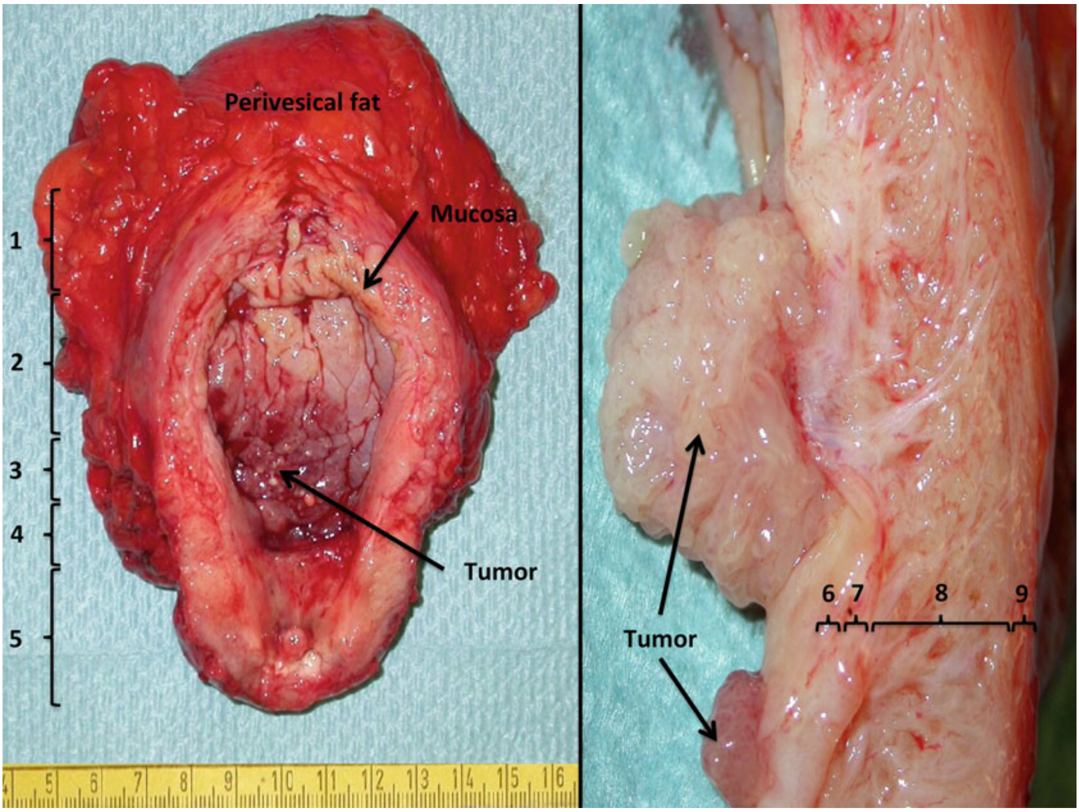

Fig. 10.7 Macroscopic anatomy of the urinary bladder. *Left*: male cystectomy specimen ventrally incised; *1* apex, *2* Corpus, *3* Fundus, *4* Collum/Trigone, *5* Prostate with verumontanum. *Right*: Cross section of cystectomy specimen with muscle bladder cancer; *6* mucosa, *7* submucosa, *8* detrusor muscle (three layers), *9* adventitia with perivesical fat tissue or serosa (peritoneum)

ligament. The inferior vesical artery arises from a common branch of the middle rectal artery. Prostatic branches generally derive from the inferior vesical artery. Venous drainage of the urinary bladder is secured through varying distinct venous plexuses on both sides of the vesical base. These venous vessels communicate extensively with the prostatic venous plexus in male and the vaginal venous plexus in female humans.

A complex neural system facilitates a correct functioning of the urinary bladder to control urine storage, continence, and micturition. Interactions between independent reflex pathways and arbitrary actions are necessary for a precise process. Both the autonomous and the somatic nervous system contribute to lower urinary tract innervations to facilitate bladder filling and emptying. Table 10.2 systematically illustrates the nerves and plexus of the pelvis including their neural function.

Parasympathetic and sympathetic nerve fibers reach the urinary bladder and adjacent organs through the inferior hypogastric plexus (pelvic plexus). Anatomically, the inferior hypogastric plexus derives from the singular superior hypogastric plexus, which reaches the pelvis proximally and medial to the crossing of the distal ureter and the common iliac artery on both sides (Fig. 10.8). The inferior hypogastric plexus is part of the rectouterine or rectovesical fold as described previously (Figs. 10.4 and 10.6). The plexus extends laterally to the rectum, the vagina (in females, Fig. 10.9), the bladder neck, and the seminal vesicles (in males) in a sagittal direction (Fig. 10.10). An allocation of nerve fibers within the plexus to innervated targets seems to be

Table 10.1 Pelvic vascularization: main arteries with origin, branches and supplied organs [3]

Artery	Origin	Main branches	Blood supply to (lead structure)
Testicular/ovarian	Abdominal aorta	–	Testes (spermatic cord)/ovaries (suspensory ligament)
Inferior mesenteric	Abdominal aorta	Left colic art	Descending colon
		Sigmoid branches	Sigmoid colon
		Superior rectal art	Rectum
Middle sacral	Abdominal aorta	–	Sacral nerves, coccygeal glomus
Common iliac	Abdominal aorta	External iliac	(Ureter crosses iliac bifurcation)
		Internal iliac	
External iliac	Common iliac	Inferior epigastric	Rectus abdominis muscle (lateral umbilical fold)
		Deep circumflex iliac	Surrounding muscles/structures
		Femoral	Leg (vascular lacuna)
Internal iliac	Common iliac	See below	See below
Iliolumbar	Internal iliac (parietal branch)	…	Iliopsoas and quadratus lumborum muscle, spinal cord
Lateral sacral	Internal iliac (parietal branch)	…	Erector spinae muscles
Obturator	Internal iliac (parietal branch)	Pubic branch	Surrounding tissue (anastomosis to inferior epigastric art. – corona mortis)
		Anterior branch	Anterior adductor muscles
		Posterior branch	Posterior adductor muscles
		Acetabular branch	Femur head
Superior gluteal	Internal iliac (parietal branch)	–	Gluteal muscles (suprapiriform foramen)
Inferior gluteal	Internal iliac (parietal branch)	–	Gluteal muscles (infrapiriform foramen), hip external rotators, ischial nerve
Umbilical	Internal iliac (visceral branch)	Obliterated distal part	(Medial umbilical fold)
		Superior vesical art.	Urinary bladder, prostate, ureter
		Art. of the vas deferens	Vas deferens
Inferior vesical	Internal iliac (visceral branch)	–	Urinary bladder, prostate, seminal vesicles/vagina
Uterine	Internal iliac (visceral branch)	Vaginal branch	Vagina
		Arcuate vessels	Uterus (broad ligament)
		Ovarian branch	Ovary (ovarian ligament)
		Tubal branch	Uterine tube
Middle rectal	Internal iliac (visceral branch)	–	Rectum and surrounding organs
Internal pudendal	Internal iliac (visceral branch)	Inferior rectal art.	Rectum
		Perineal art.	Perineum
		Posterior labial/scrotal branch	Labia/scrotum
		Art. of the bulb of vestibule/penis	Urethra, bulb of vestibule/corpus spongiosum
		Dorsal art. of clitoris/penis	Corpus cavernosum clitoridis/glans penis
		Deep art. of clitoris/penis	Corpus cavernosum clitoridis/penis

…=different small branches, *art.*=artery

Table 10.2 Main nerve pathways of the pelvis [3]

Nerve	Spinal origin	Intermediary trunk	Innervation
Iliohypogastric	L1	Lumbar plexus	M: transversus abdominis and internal oblique muscle S: hip and lower abdominal wall
Ilioinguinal	L1	Lumbar plexus	M: abdominal muscles S: inguinal region, penile root, proximal medial femoral skin, scrotum/labia majora
Genitofemoral	L1/2	Lumbar plexus	M: cremaster muscle S: tunica vaginalis, tunica dartos, hiatus saphenus
Lateral femoral cutaneous nerve	L2/3	Lumbar plexus	M: – S: anterolateral femoral skin
Femoral nerve	L2/3/4	Lumbar plexus	M: iliopsoas/pectineus/sartorius/quadriceps femoris muscle S: anteromedial femoral skin, anteromedial crural skin, medial forefoot skin
Obturator	L2/3/4	Lumbar plexus	M: external obturator/pectineus/adductor brevis/adductor longus et magnus et minimus/gracilis muscle S: distal medial femoral skin
Inferior gluteal	L4/L5/S1	Lumbosacral plexus	M: gluteus maximus muscle S: –
Posterior femoral cutaneous	S1/2/3	Sacral plexus	M: – S: gluteal skin, posterior scrotal/labial skin
Ischial	L4/S1/S2/S3	Lumbosacral plexus	M: ischiocrural and forefoot muscles S: crural and forefoot skin (except medial)
Pudendal	(S2)/S3/S4	Sacral plexus	M: levator ani muscle, external urethral sphincter and urogenital diaphragm S: skin above the ischial tuberosity, labia (majora and) minora and clitoris, penile skin with glans and prepuce
Coccygeal	S5/Co1	Coccygeal plexus	M: – S: anococcygeal skin
Sacral splanchnic	Sympathetic trunk	Superior hypogastric plexus	Sympathetic: urinary bladder, internal sphincter complex, ejaculation reflex
Pelvic splanchnic	S2/S3/S4	Inferior hypogastric plexus – prostatic plexus – cavernous nerve	Parasympathetic: erectile function

M motoric, *S* sensory

possible. Roughly, the anterior part is responsible for urogenital innervations, and the posterior part serves the rectum.

The sympathetic fibers of the inferior hypogastric plexus arise from two superior retroperitoneal sympathetic chains called sacral splanchnic nerves, which pass topographically through the superior hypogastric plexus. Sympathetic excitations lead to urinary bladder filling based on an inhibition of the detrusor muscle and a stimulation of the smooth muscle sphincter cells at the bladder neck and the urethra. Parasympathetic fibers within the pelvic splanchnic nerves from the sacral spinal cord (S2-S5) exit through the

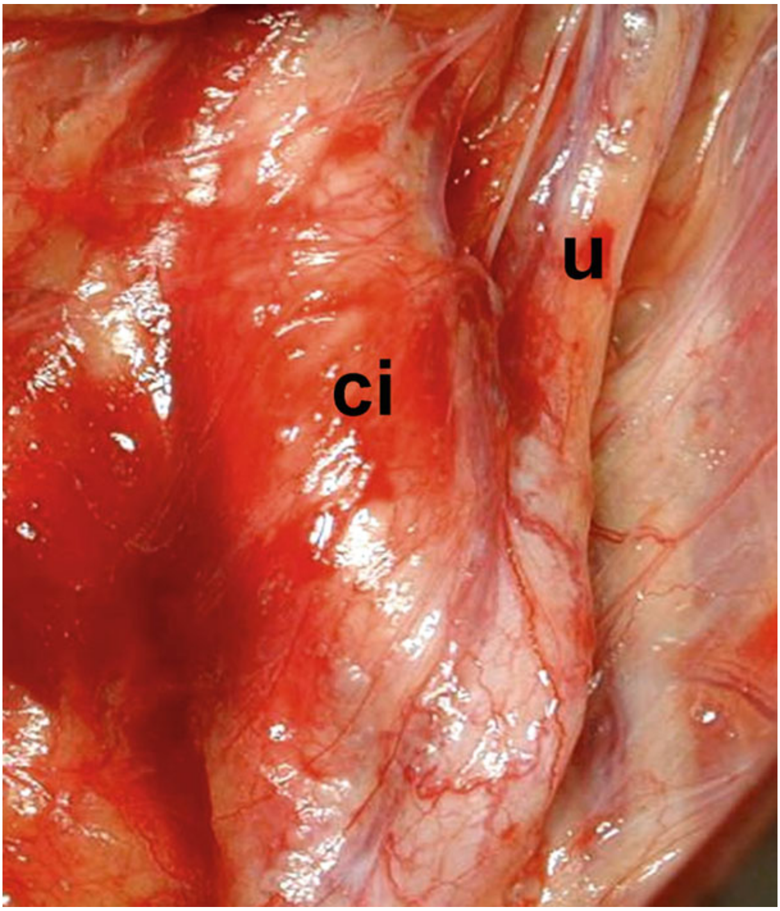

Fig. 10.8 Nerve course of the sympathetic fibers deriving from the superior hypogastric plexus (*ci* common iliac artery, *u* ureter) (Schilling et al. [16])

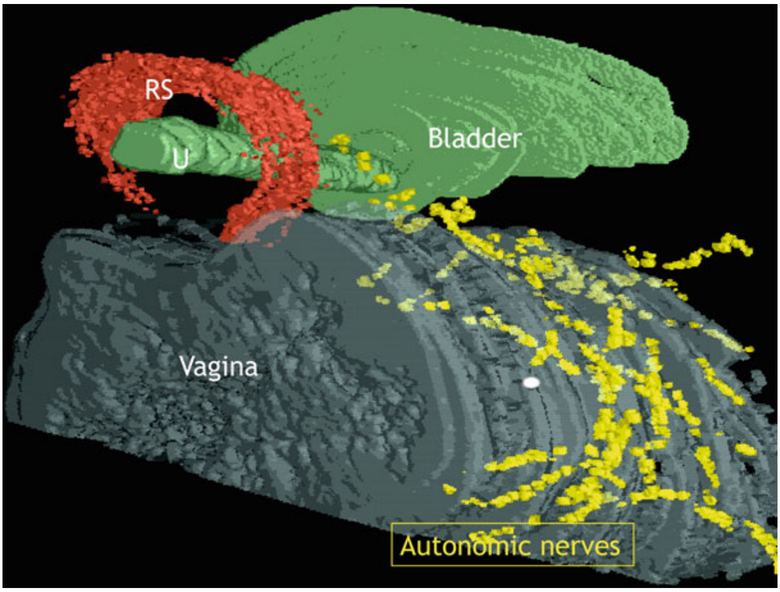

Fig. 10.9 Fetal female pelvic study illustrates 3D distribution pattern of autonomic nerves between the rhabdosphincter, the urethra, the urinary bladder, and the vagina (Colleselli et al. [6])

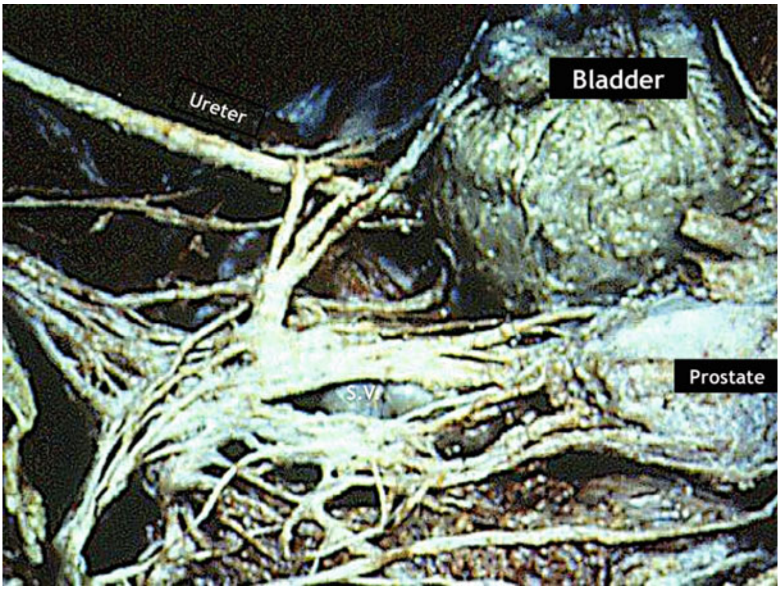

Fig. 10.10 Human male cadaver study to illustrate topographical relation of the complex intrapelvic nerve plexus to the urinary bladder, the ureter, the male adnexa, and the prostate. The superior vesical artery crosses the ureter almost orthogonally (Colleselli et al. [6])

foramina of the sacral bone and reach the bladder by passing the inferior hypogastric plexus. Both urinary bladder sensation (and presumably of the proximal urethra as well) and contraction of the detrusor muscle are mediated through the parasympathetic nervous system. The pudendal nerve is part of the somatic nervous system and innervates the striated parts of the external urethral sphincter among others. After distribution of the lumbosacral plexus, the pudendal nerve leaves the pelvis by surrounding the ischial spine and proceeds through the pudendal canal (Alcock's canal) at the bottom of the inferior pubic bone. Stimulation results in increased contraction of the external urethral sphincter and adjacent segments of the levator muscle. Complex interconnections on different sections of the central nervous system including the Onuf's nucleus (located in the sacral part of the spinal cord), the periaqueductal gray, the pontine micturition center, and the frontal lobe of the cerebrum are involved in the process of filling and emptying [1–3, 5, 8, 12, 16].

10.7 Anatomic Abnormalities of the Urinary Bladder

Unexpected intrapelvic anatomic anomalies or alterations have not been exposed preoperatively in all cases depending on the treated disease and the guideline-based extend of preoperative staging diagnostics. The following changes in human pelvic anatomy should be expected more or less frequently. Urinary bladder diverticula can be subdivided into congenital and acquired forms. The prevalently bilateral para-ureteral diverticulum (Hutch diverticulum) is most often congenital and results in the majority of cases in vesicoureteral reflux. Acquired diverticula occur due to infravesical obstruction and can develop to considerable dimensions. Anomalies of urachal obliterations could be found only in rare cases. Four different types of malformation can be distinguished: (1) persistent urachus with continuous urine leakage, (2) urachal cyst located in the course of the medial umbilical ligament, (3) umbilical-urachus sinus with obliteration toward the urinary bladder, and (4) vesicourachal diverticulum with obliteration toward the umbilicus [3, 5, 9].

10.8 Pelvic Floor

Two distinct fibromuscular layers complete the inferior pelvic aperture: the pelvic diaphragm and the urogenital diaphragm. The pelvic diaphragm consists of the coccygeal muscle and the levator ani muscle, which in turn consists of the following structures, named according to their origins and insertions: the pubococcygeal muscle, the iliococcygeal muscle, and the puborectalis muscle. The endopelvic fascia forms the superior layer of the levator ani fascia, and a separate layer covers the caudal part; the pelvic insertion of the levator ani muscle is called the tendinous arch of levator ani. The levator ani muscle forms an archway-shaped opening for the anus and urethra in males and the anus, the vagina, and the urethra in females. The innervations derive principally from the sacral plexus (S3 and S4); some nerve fibers reach the puborectalis muscle via the pudendal nerve. Even though the contributions of the shape topography and the contraction of the pelvic diaphragm to anal continence seem to be proven, it is still unclear to what extent these anatomical structures also affect urinary continence. Recent publications have reported the muscular independence between the pelvic diaphragm and the striated external urethral sphincter, whereas an association by connective tissue forming a tendinous connection starting from the inferior part of the external urethral sphincter in females could be demonstrated. Due to these interactions, authors suggest the necessity of an intact pelvic diaphragm for urinary continence.

The urogenital diaphragm is not part of the anatomical nomenclature, and the exact anatomical and histomorphological constitution is still under investigation. Anatomical atlases report that the urogenital diaphragm consists of the deep transverse perineal muscle (less developed in females) with a superior and inferior urogenital fascia. Additionally, the superficial transverse perineal muscle inserting at the perineal body (central tendon of the perineum), the striated external urethral sphincter, and the surrounding connective tissue completes the traditional view of the urogenital diaphragm. Some authors report the existence of a deep transverse perineal muscle, but most of the recent studies could not verify this conclusion. The urogenital diaphragm is described as layers of connective tissue embedding the external urethral sphincter in conjunction with the perineal body, the inferior pubic bone, and the superficial transverse perineal muscle. The internal pudendal artery and the pudendal nerve are located directly below the urogenital diaphragm. The bulbourethral glands (Cowper's glands) are situated laterally to the membranous urethra integrated inside the urogenital diaphragm [3, 5, 7, 11, 13, 14, 17, 19, 25].

10.9 Male Urethra

The male urethra is subdivided into the intramural preprostatic urethra at the bladder neck, the prostatic urethra, the membranous urethra, and the spongy urethra. Transitional cells form the mucosa of the proximal parts, whereas the distal section toward the navicular fossa is marked by a stepwise transition over stratified columnar to stratified squamous cells. The muscular layer is subdivided into an inner longitudinal, an intermediate circular, and an inconsistently described outer longitudinal stratum. The bulbourethral artery originating from the internal pudendal artery provides blood supply and enters the spongy urethra at the level of the penile bulb [3, 5, 12].

10.10 Female Urethra

The female urethra measures about 4 cm starting from the urinary bladder neck to the vaginal vestibule. The muscular layer consists of an inner longitudinal and a surrounding circular oriented stratum. Figure 10.11 illustrates the innervations and blood supply of the female urethra, which is guaranteed by the internal pudendal artery and the pudendal nerve [3, 5, 12].

10.11 Sphincter Mechanisms

The voluntary, striated, external urethral sphincter (rhabdosphincter) located in the urogenital diaphragm and the autonomous, smooth internal sphincter (lissosphincter) located in the bladder neck have been reported to be responsible for urinary continence in the past. Extensive investigation led to substantial change of the anatomical and functional understanding of the sphincter complex (Fig. 10.12). Although there is discussion about the detailed anatomical formation and the interaction, three components of the sphincter complex are commonly accepted: the smooth detrusor muscle fibers of the bladder neck including the trigone, the intrinsic smooth muscle fibers of the urethral wall, and the external urethral sphincter.

10.11.1 The Bladder Neck Component

The existence of an isolated, circular oriented smooth muscle sphincter at the internal urethral orifice has been denied by different authors over the last two centuries, regardless many anatomical atlases still illustrate a typical inner urinary bladder sphincter. In fact, a complex network of smooth muscle strands is formed at the bladder outlet, where detrusor muscle fibers condense toward the trigone, longitudinal fibers proceeding from the ureteral orifices and smooth intrinsic fibers of the urethral wall arrange a muscular compartment innervated by the autonomic nervous system. In male humans, muscle fibers originating from the ureteral orifices distend downward into the verumontanum.

10.11.2 The Urethral Wall Component

The smooth muscle fibers of the urethral wall are integrated continuously from the bladder neck component into the urethral closure mechanism. The urethral muscular element consists of inner longitudinal and surrounding circular oriented muscle fibers. Inconsistently, an outer longitudinal muscular layer has been described. Also these smooth muscle fibers receive autonomic innervations (Fig. 10.11).

10.11.3 The External Urethral Sphincter

To date, a generally accepted anatomical and functional concept of the external urethral sphincter complex is still outstanding. Consensus exists regarding the three dimensional profile of the external urethral sphincter, which is described to be omega or horseshoe shaped in male as well as in female humans (Fig. 10.12). Consequently, muscle fibers are located at the anterior and lateral part of the urethra. Fibrous tissue completes the horseshoe shape dorsally by an interconnection of the posterior muscular ends of the external urethral sphincter. It is under discussion if the external urethral sphincter is actually part of the urogenital diaphragm and hereby embedded into the doubtfully existing deep transverse perineal muscle. More and more it becomes obvious that the external urethral sphincter should be interpreted as an independent complex, which is supported by only fibrous connection to the surrounding tissue, especially the pelvic diaphragm with the puborectalis muscle. Similarly, the vertical extent and the histological constitution of the external urethral sphincter are under intensive investigation. In male humans it is assumed that the striated muscle fibers of the pronounced anterior part of the sphincter disperse below the puboprostatic ligaments over the anterior face of the prostate. A communication of the striated muscle fibers with structures of the urinary bladder neck is still not clarified. In females it could be demonstrated that parts of the striated external sphincter could only be found in the two distal thirds of the urethra. It has been well established for a long time that striated muscle fibers mainly participate in the configuration of the external sphincter. Regarding functional aspects the external sphincter has to secure continence continuously by a static closure pressure as well as during stress episodes with rapidly increased demand of urethral obstruction. The existence of two specified striated muscle fibers, "slow twitch fibers" for basal pressure and "fast twitch fibers" for rapid pressure increases, as well as the existence of a smooth muscle component ("lissosphincter") located within the main part of striated fibers (named the internal urethral sphincter) are two possible explanations to fulfill the intention of continence. The pudendal nerve comprises the axons for somatic innervations of the voluntary susceptible striated external sphincter (Fig. 10.11). Whether autonomous fibers deriving from the inferior hypogastric plexus with potential impact after nerve sparing ablative pelvic surgery are involved in the sphincter innervations is still under investigation [3, 5–7, 10, 12–14, 19, 21, 22, 25].

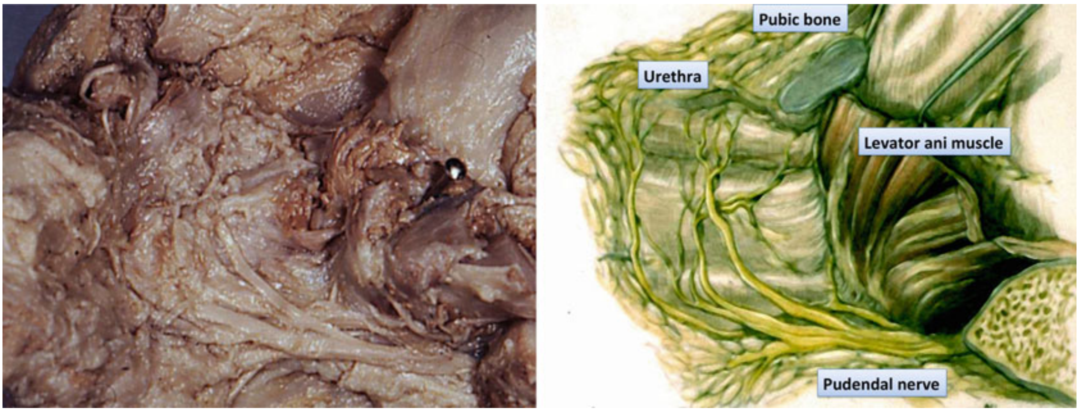

Fig. 10.11 Human female cadaver study illustrating the pudendal nerve arising from the Alcock's canal to innervate the distal third of the urethra including branches to the rhabdosphincter (Colleselli et al. [6]; additional annotations have been made for clarification)

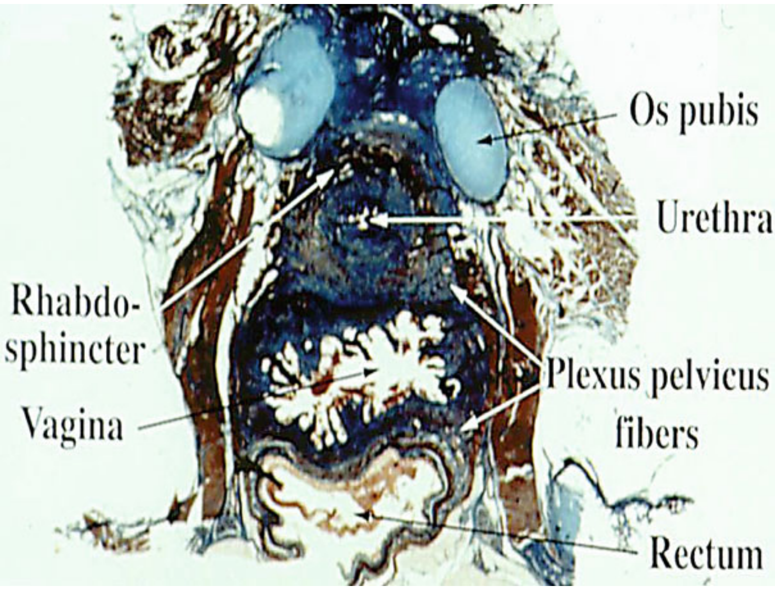

Fig. 10.12 Fetal female pelvis illustrating the omega-shaped rhabdosphincter surrounding the urethra and the topographical location of pelvic plexus (Colleselli et al. [6])

10.12 Summary

Robotic-assisted surgery of the pelvis facilitates above all a stereoscopic and more detailed view of anatomical structures, which could not be realized by the naked human eye during open surgery. Therefore, robotic-working surgeons benefit especially from submacroscopic and microscopic anatomical knowledge to reach the optimal oncological and functional outcome for their patients. Special attention has to be paid to the distinct vascular and neural structures with the most pronounced impact on urinary continence and erectile function.

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11

Robotic-Assisted Radical Cystectomy for Bladder Cancer in the Female

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and Peter Wiklund

11.1 Introduction

One of the distinctive features of bladder cancer is the influence of gender on incidence and mortality. The male-to-female ratio of bladder urothelial carcinoma at diagnosis in the USA and Northern Europe is 3:1. This is commonly attributed to the different patterns of smoking and industrial carcinogen exposure between the sexes as well as to uncertain hormonal and biological factors. Although women are generally less likely to develop bladder cancer, once they acquire this disease, they have a less favorable prognosis. Furthermore, benign conditions can imitate early signs of bladder cancer in the female thus delaying its diagnosis [1].

The gold standard operation for invasive bladder cancer in women is anterior exenteration with removal of the bladder, urethra, uterus, vagina, and the ovaries [2]. In low-stage disease, a urethral and vaginal-sparing operation may be attempted due to a low likelihood of urethral, vaginal, or cervical involvement [3]. The first laparoscopic radical cystectomy for bladder cancer in a female patient was described by Sanchez de Badajaz et al. in 1995 [4]. Since then, various authors have reported small series of laparoscopic radical cystectomy in women, while Menon et al. was the first to describe robotic-assisted radical cystectomy (RARC) with continent urinary diversion in female patients [5]. In an effort to reduce blood loss and hospital stay and achieve early return of bowel function as well as rapid convalescence, RARC has emerged as a minimally invasive alternative and has been reported in the literature mainly for male patients [6–8]. The encouraging oncologic, functional, and perioperative results in males [6–9] combined with growing experience in robotic female pelvic procedures in the gynecologic literature [10] have set a firm foundation for the RARC in females.

11.2 Anatomical Considerations; Differences from Male Cystectomy

Since robotic-assisted radical prostatectomy has gained popularity, increasingly more urologists have familiarized themselves with the laparoscopic pelvic anatomy and subsequently with the cystectomy operation [11]. However, there are differences in the anatomy of the pelvis between the two genders, which a surgeon should have in mind before engaging in robotic cystectomy operations in females (Fig. 11.1). The broader pelvis coupled with the shorter mean body height compared to males facilitates a wider and more superior port placement, thus avoiding potential clashing of the instruments

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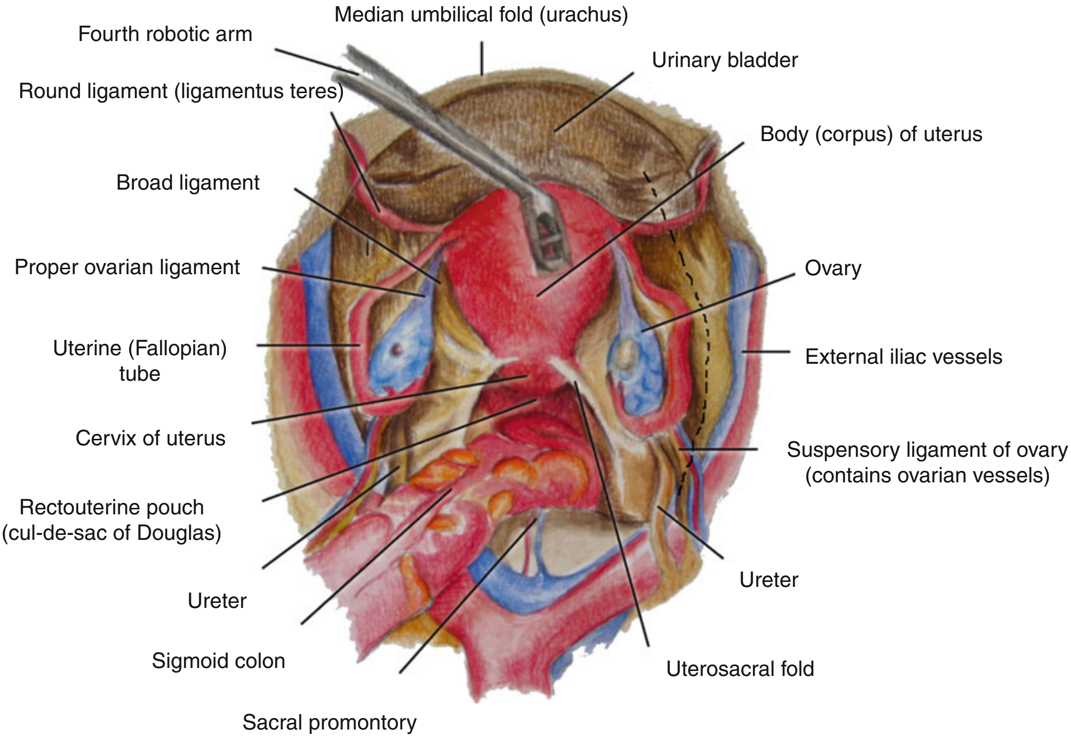

Fig. 11.1 Superior view of the female pelvis as seen during robotic surgery with the fourth robotic arm lifting the uterus. During RAAPE the suspensory ligament of the ovary as well as the broad and round ligaments of the uterus is divided as shown by the *dotted line*

with no compromise in the urethral access and dissection. Furthermore, if an intracorporeal diversion is performed, the operation can be completed with no extension of a port incision since the specimen can be extracted through the vagina. On the other hand, with robotic prostatectomies and male cystectomies occupying the vast majority of the urologic pelvic operations, the female pelvic anatomy may be less familiar to the urologic surgeon rendering the operation more challenging. Additionally, in most circumstances female cystectomy includes exenteration of the anterior pelvic organs including the ovaries, fallopian tubes, uterus, cervix, and part of the anterior wall of the vagina, making this procedure even more demanding [12]. This might account for the increased blood loss compared to male cystectomies as reported in the open cystectomy literature [13, 14].

11.3 Patient Selection and Preoperative Care

Females with good health and performance status are generally candidates for robotic cystectomy. Severe cardiopulmonary compromise and obesity may limit ventilation and cardiac function due to the steep Trendelenburg position combined with the pneumoperitoneum in a prolonged surgical operation. Previous abdominal surgery, though not a contraindication, should be carefully considered, and bulky disease should be avoided. Careful patient selection is of paramount importance especially in the initial experience.

Patient preparation includes lab work, imaging studies, and informed consent. Bowel preparation may be given preoperatively. This includes administration of magnesium citrate and restriction to a clear liquid diet 24 h before surgery, while an enema can be given the morning of the operation [15]. Interestingly, recent colorectal literature questions the advantage of bowel preparation [16]. In fact, we do no longer perform bowel preparation at Karolinska Institute in our RARC patients. A stoma therapist nurse marks the potential site of the exteriorized ileal conduit in all patients.

11.4 Intraoperative Preparation

Under general anesthesia, the patient is placed in a supine lithotomy position and prepared. Before inclining the table in a steep Trendelenburg (25°) position, it is important to secure the patient with heavy straps. Due to extensive operating time, additional attention should be given to avoid neuromuscular injuries by placing adequate padding on all pressure points. A nasogastric tube and Foley urethral catheter are routine. After disinfection of the vagina, a uterine manipulator is placed to aid dissection around the adjacent structures during the operation. The scrub nurse should prepare the essential laparoscopic and robotic tools (Table 11.1) as well as the necessary sutures, to prevent any delay in an already long operation. Broad-spectrum antibiotics are administered at the time of anesthetic induction just before the procedure while fluids intraoperatively are restricted to a minimum.

11.5 Port Placement

Port placement is crucial for a trouble free and successful robotic cystectomy operation. The six-port transperitoneal configuration used is similar to the male robotic cystectomy port placement, while the advantage of a wide pelvis aids in spreading apart of the ports, thus avoiding potential clashing of the instruments (Fig. 11.2). The camera port (C) is placed 5 cm above the umbilicus (U) in the midline by a small minilaparotomy incision. Under direct vision, two robotic ports R_1 and R_2 are placed 8–10 cm from the camera port on either side and level with the umbilicus. The third robotic port (R_3) is placed above and medial to the left anterior superior iliac spine (ASIS) through a 15-mm laparoscopic port permitting interchangeably the use of robotic instruments and the laparoscopic stapling device. Additionally, two 12-mm assistant ports (L) are placed one just above the right ASIS and the other midway between the right robotic port and the camera port [6, 8].

Table 11.1 Robotic and laparoscopic instrumentation

Recommended robotic instruments:
1 Monopolar curved scissors (hot shears)
1 Maryland bipolar forceps
1 Large needle driver
2 EndoWrist Cadiere forceps
Recommended laparoscopic instruments:
1 endoscopic 5 mm suction/irrigation device
1 endoscopic 5 mm locking grasper
1 endoscopic 5 mm scissors
1 endoscopic 5 mm Kelly
1 endoscopic 5 mm Babcock
1 endoscopic applier for Large Hem-o-Lok™ clip (Weck Closure Systems, RTA, USA)
1 Endo GIA™ Ultra Universal Stapler (Covidien, USA) with 60 mm vascular loads
1 Endo Catch™ II 15 mm Specimen Pouch (Covidien, USA)
2 Endo Catch™ Gold 10 mm Specimen Pouch (Covidien, USA)
1 LigaSure Atlas™ 10 mm (Covidien, USA)
1 endocopic LAPRA TY™ clip applier (Johnson & Johnson Health Care Systems, Inc. USA)

11.6 Robotic Operation: Procedural Steps

Female radical cystectomy has been described with various modifications in the technique according to the literature [5, 6, 8, 17–20]. Most importantly, depending on the clinical stage and age of the female patient, the surgeon has to decide whether a robotic-assisted anterior pelvic exenteration (RAAPE) or vaginal sparing RARC with preservation of the internal genital organs (Fig. 11.3(1)) should be offered to the patient. Furthermore, during RAAPE the bladder, uterus, cervix, and anterior wall of the vagina can be

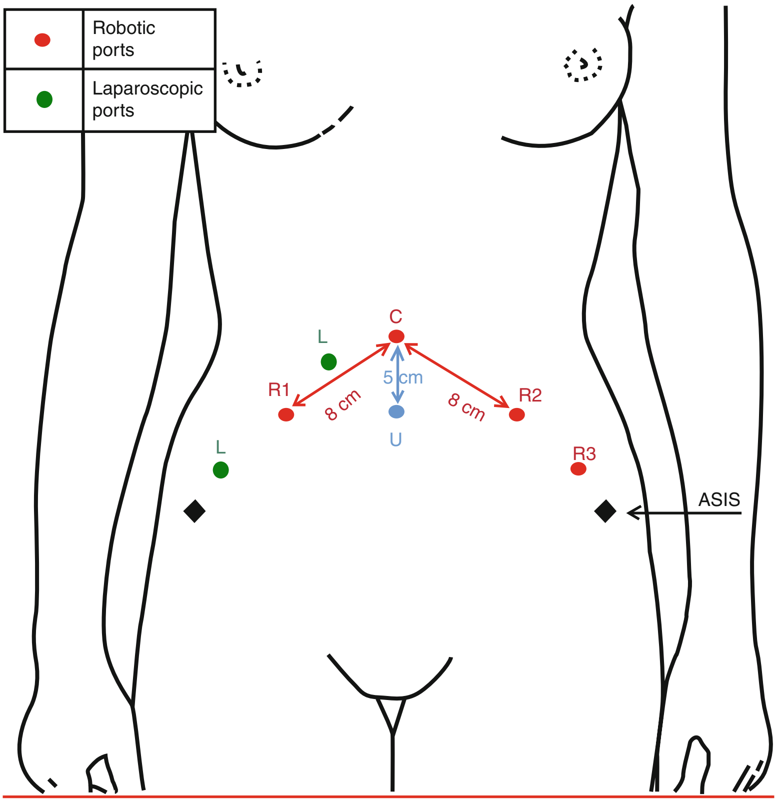

Fig. 11.2 Port placement. The robotic ports appear in red while the assistant ports in *green*. *U* umbilicus, *ASIS* anterior superior iliac spine, *C* robotic camera port, R_1 right robotic port, R_2 left robotic port, R_3 the third robotic port is placed through a 15-mm conventional port, permitting interchangeably the use of robotic instruments and the laparoscopic stapling device, *L* laparoscopic assisting ports

dissected en bloc by entering the plane of dissection between the uterus and rectum and consequently transecting the posterior wall of the vagina (Fig. 11.3(3)) [20]. Alternatively, the bladder can be removed en bloc with the anterior wall of the vagina by entering the plane of dissection between the vagina and bladder and then transecting the anterior wall of the vagina (Fig. 11.3(2)), while the internal genital organs can be removed separately [5, 6, 8, 17–19].

11.6.1 Anterior Pelvic Exenteration (Surgical Technique with Four Robotic Arms)

1. *Adhesiolysis – Exposure of the Douglas pouch*: Initially, adhesions of the sigmoid colon over the bladder and left side of the pelvis are released. The uterus is lifted anteriorly and positioned under stretch by the fourth robotic arm in order to facilitate access to the Douglas pouch. The small bowel is vacated from the true pelvis (Fig. 11.4).
2. *Dissection of the ureters*: An inverted U-shape incision of the peritoneum is performed at the Douglas pouch near the junction of the uterus and the posterior vaginal wall. The location of the incision can be determined with external handling of the uterine manipulator. This incision is extended laterally, and cephalad transversing the uterosacral ligament reaching a few centimeters above the common iliac vessels bilaterally. Through this incision the ureters can be identified at their crossing over the iliac vessels. The goal is to mobilize the ureters from this point in an antegrade fashion to the bladder where they will be ligated and transected (Fig. 11.5). A combination of sharp and blunt dissection is used to free the ureter

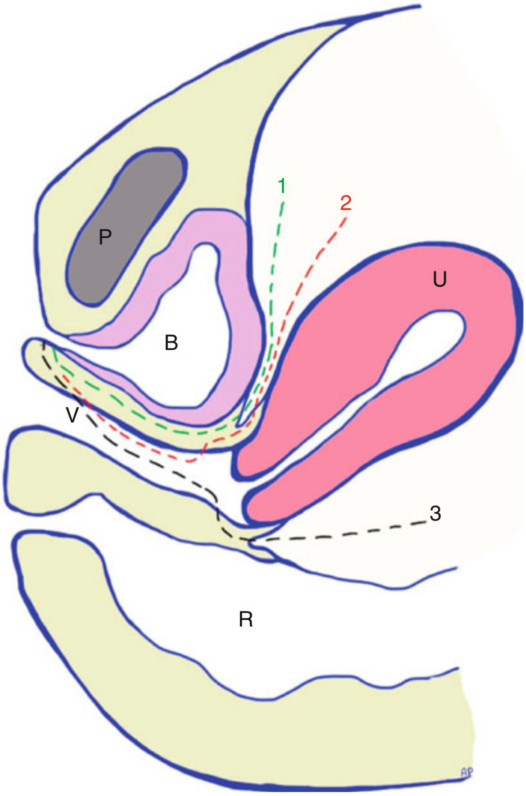

Fig. 11.3 Plane of dissection during vaginal sparing RARC with preservation of internal female genitalia (*1*). Bladder with en bloc dissection of the anterior vaginal wall (*2*). En bloc dissection of bladder with uterus and cervix (*3*). *P* pubic bone, *B* bladder, *U* uterus, *V* vagina, *R* rectum

from the adjacent tissues without directly handling the ureter so as not to devascularize it. During the dissection of the ureter, attention should be given at the level of the cervix to the crossing uterine vessels crossing the ureter from lateral to medial ("water under the bridge"). The division of the ureter should be as close as possible to the uterovesical junction using two Hem-o-Lok$^{\text{TM}}$ clips (Weck Closure Systems, Research Triangle Park, USA) on each side. A stay suture is tied at the proximal clip before placement facilitating the identification of the ureters and the later reconstruction process. Distal margins of the ureters may be sent for frozen section. The dissected ureters are tucked in the upper abdomen away from the pelvic area.

3. *Division of the suspensory ligament of the ovary and the supporting ligaments of the uterus*: The suspensory ligament or infundibulopelvic (IP) ligament of the ovary on either side resides superiorly and laterally to the ovary itself and encompasses the ovarian vessels. With the fourth robotic arm retracting the uterus medially, the peritoneum overlying the IP ligament is incised, and the ovarian vessels are clipped or alternatively fulgurated and consequently divided. This incision is extended with monopolar scissors

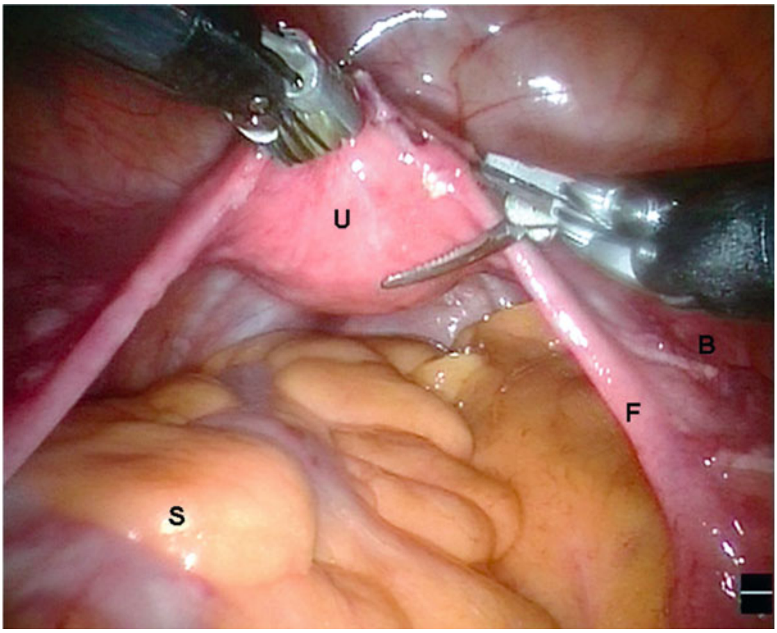

Fig. 11.4 The uterus is lifted by the fourth robotic arm. *U* uterus, *B* broad ligament, *S* sigmoid, *F* fallopian tube

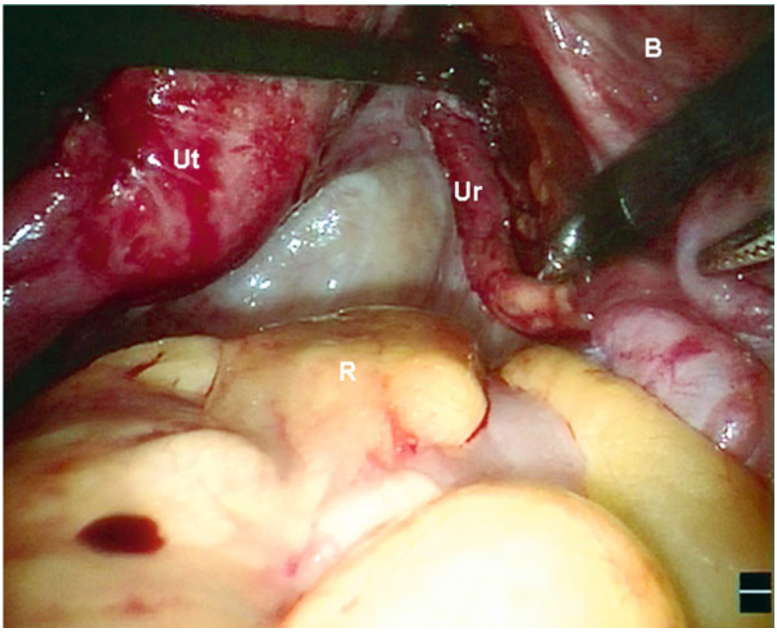

Fig. 11.5 Dissection of the right ureter. *Ut* uterus, *Ur* ureter, *B* broad ligament, *R* rectum

along the broad ligament dividing it laterally to the fallopian tubes and medially to the external iliac vessels (Fig. 11.1). During this dissection the round ligament is encountered and divided. At the level of the cardinal ligaments, the uterine artery is identified and clipped or fulgurated with the bipolar forceps. The same surgical steps are followed on the other side.

4. *Lateral dissection of the bladder*: An incision on the anterior peritoneum lateral to the medial umbilical ligament is performed on both sides. Blunt dissection through the prevesical fat is continued laterally to the bladder wall until the pubic bone and endopelvic fascia is visualized (Figs. 11.6 and 11.8). At this point the endopelvic fascia is sharply incised. This dissection is extended on either side and converged with the previously made incision on the posterior peritoneum during the dissection of the ureters, thus exposing the bladder pedicles. During this surgical step it is important not to dissect the urachus and median umbilical ligament from the anterior abdominal wall in order to keep the bladder suspended and facilitate the posterolateral dissection of the bladder vasculature.
5. *Securing the bladder pedicles*: With the bladder suspended from the anterior abdominal wall, the fourth robotic arm is used for gentle medial traction. This maneuver places the vascular pedicle under stretch thereby separating and identifying the pedicle away from the internal iliac vessels. Since the autonomic nerves responsible for sexual function are adjacent to the bladder pedicles and run along the lateral vaginal wall, care is taken for athermal dissection if a nerve sparing procedure is planned. In this case, individual clipping of the vessels is carried out with Hem-o-Lok™ clips (Weck Closure Systems, Research Triangle Park, USA). Alternatively, the pedicles can be divided using the Ligasure Atlas™ (Covidien, USA) or a vascular stapler from the assistant port after carefully identifying adequate distance from the internal iliac vessels as well as the rectum (Fig. 11.7). This part of the operation resembles the technique described on the male cystectomy section.
6. *Vaginal dissection*: With gentle movement of the uterine manipulator, the junction of the posterior vaginal wall and the uterus can be visually identified through the initial posterior incision at the Douglas pouch. With a

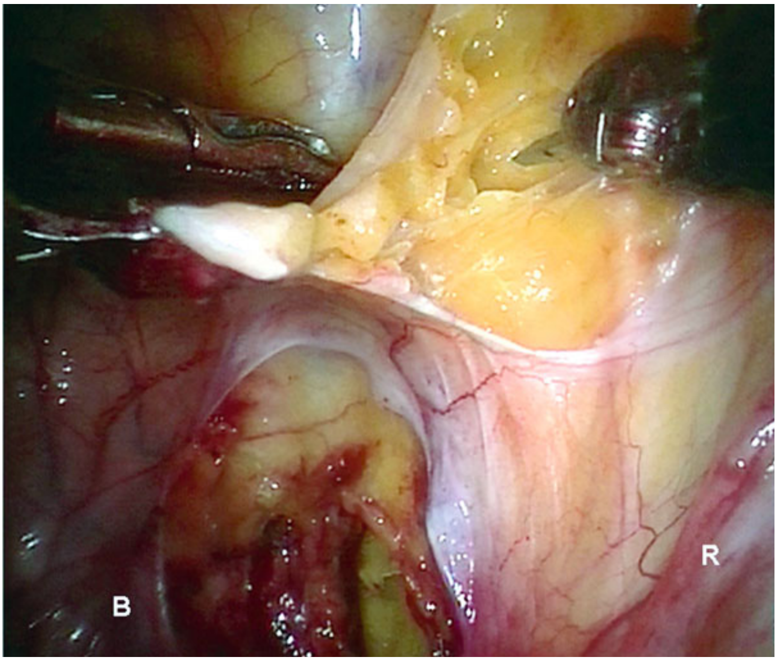

Fig. 11.6 Incision on the anterior peritoneum. *B* broad ligament, *R* round ligament

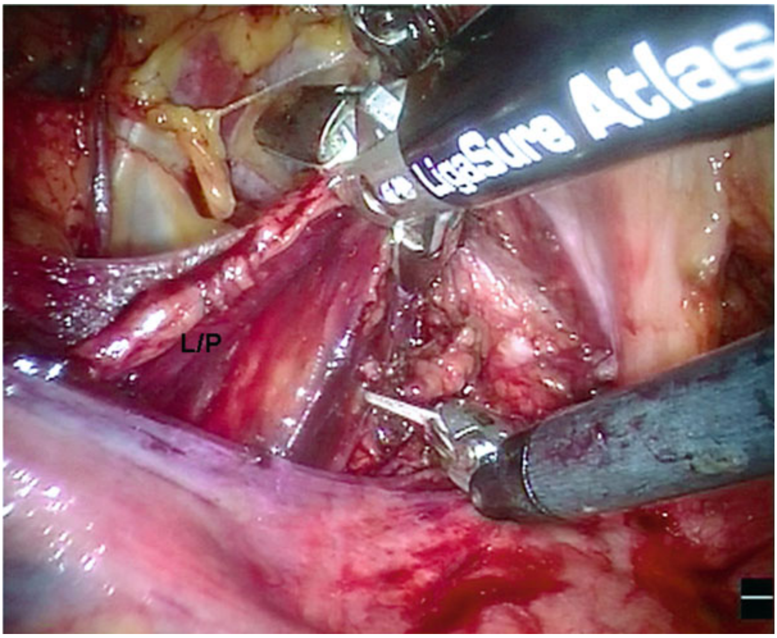

Fig. 11.7 The left bladder pedicle is divided using the Ligasure Atlas^{TM} (Covidien, USA). *L/P* left bladder pedicle

transverse incision of the posterior wall of the vagina just under the junction, the uterine manipulator is visualized. This incision is extended throughout the lateral wall of the vagina in order to ensure that the anterior segment of the vagina is removed en bloc with the bladder (Fig. 11.3(3)). Avoiding gas leakage and decrease of pneumoperitoneum pressure is crucial in this part of the operation and is effectively accomplished by sponges inserted in the vagina or alternatively by an inflated glove.

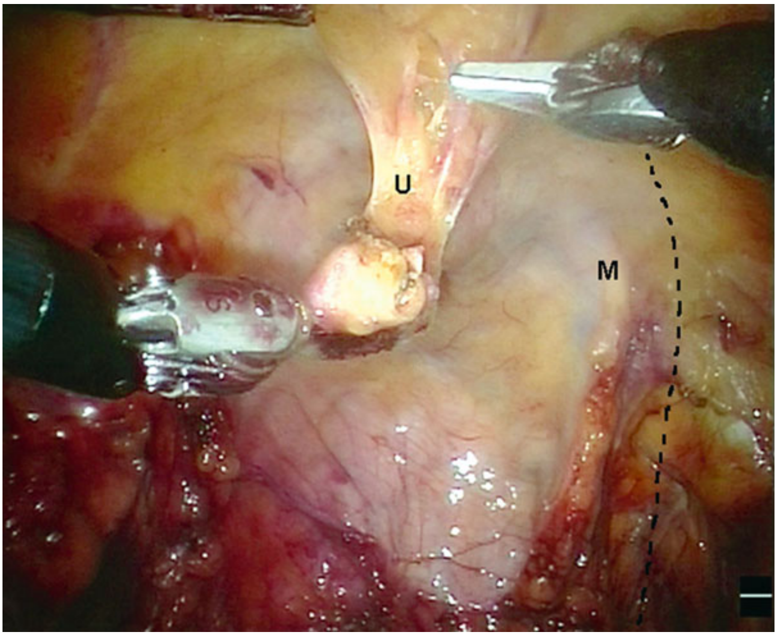

Fig. 11.8 The urachus (*U*) and median umbilical ligament are dissected from the anterior abdominal wall (surgical step 7). The ideal incision on the anterior peritoneum during the lateral dissection of the bladder (surgical step 4) is marked with dotted line. *M* medial umbilical ligament

7. *Anterior – prevesical dissection*: The urachus and median umbilical ligament that were previously left attached to the anterior abdominal wall are now taken down (Fig. 11.8). The bladder is dropped and the anterior prevesical space is entered. The dorsal vein complex (DVC) is incised. Increasing the intra-abdominal pressure to 20 mmHg and refraining from using the suction device are adequate to control venous bleeding. Arterial bleeding is controlled by bipolar cauterization.
8. *Urethral dissection*: An anterior approach to the bladder neck following its contour is applied, and the dissection continues until the urethra is visualized. Circumferential freeing of the urethra and precise transection at the level of the bladder neck is essential especially if orthotopic diversion is planned (Fig. 11.9). Gentle tagging of the Foley catheter can facilitate in the identification of the proximal limit of the urethra. Before cutting, the proximal side is either suture ligated or a Hem-o-Lok™ clip (Weck Closure Systems, Research Triangle Park, USA) is placed. This maneuver inhibits potential leakage of the bladder content. A running suture as described in the prostatectomy and male cystectomy procedure can secure the DVC and a low intra-abdominal pressure can be restored.
9. *Specimen retrieval*: The specimen is placed in a large Endo Catch™ bag (Covidien, USA) entering the abdominal cavity from the 15-mm port (R_3) after removing the fourth robotic arm with the robotic port. The bag is closed and removed from the vaginal incision. The vagina is packed again with sponges.
10. *Lymph node dissection*: This part of the operation can either be done after the cystectomy or just after the division of the suspensory ligament of the ovary and the supporting ligaments of the uterus. The technique is the same as used during the male cystectomy procedure and is described in the lymph node dissection chapter.
11. *Reconstruction of the vaginal wall*: Once the lymph nodes are bagged and taken out from the vagina, the opening of the vaginal wall is approximated by mobilizing the posterior lip of the vagina anteriorly. A 2/0 Biosyn™ (Covidien, USA) monofilament absorbable suture is used in a transverse continuous fashion (Fig. 11.10).
12. *Intracorporeal urinary diversion*: Following the completion of the cystectomy and lymph

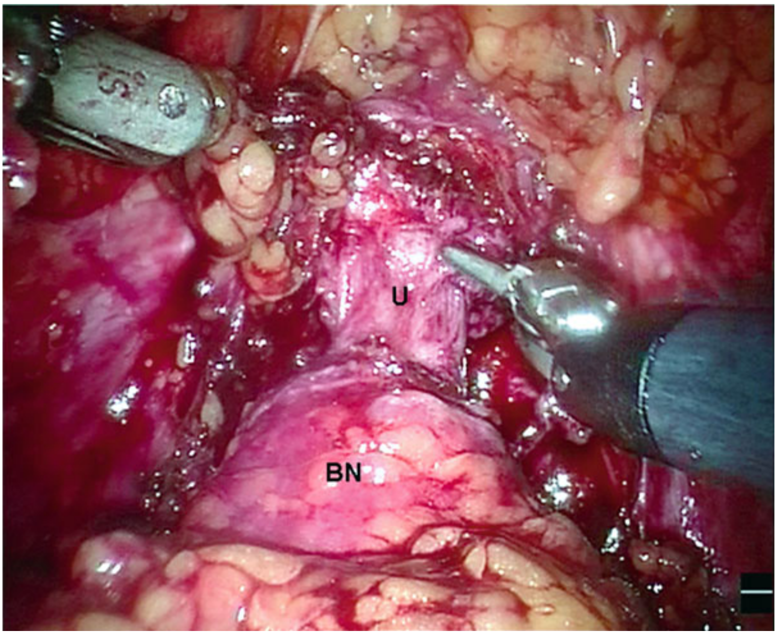

Fig. 11.9 Identifying the junction between the bladder neck (*BN*) and urethra (*U*)

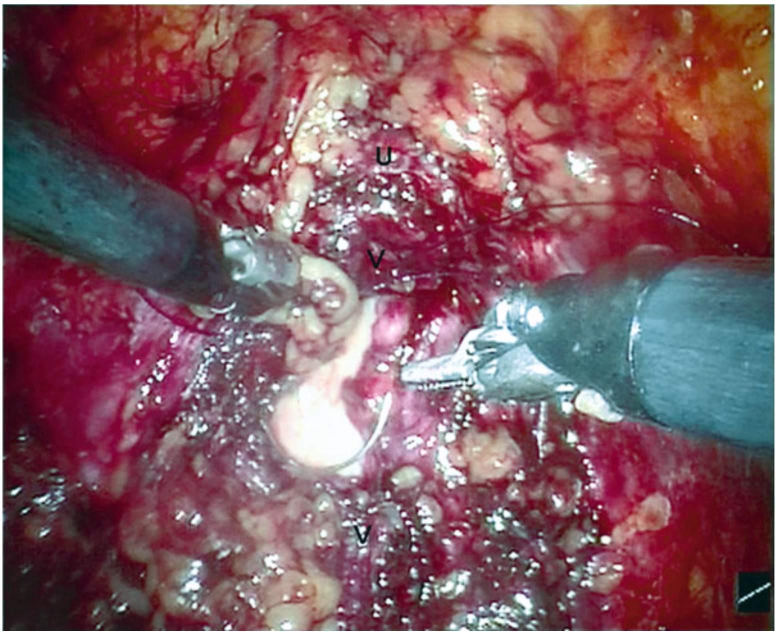

Fig. 11.10 Reconstruction of the vaginal wall with a continuous transverse suture. *U* urethra, *V* vaginal wall

node dissection, the urinary diversion is performed. This is described in detail in the intracorporeal urinary diversion chapter. At the end of the operation a pelvic drain is placed.

Alternatively, the bladder can be dissected en bloc with the anterior vaginal wall and the hysterectomy and oophorectomy done sequentially. To accomplish this, after surgical step 3, the uterus is laid on the rectosigmoid and retracted proximally with the fourth robotic arm. The peritoneum is incised between the bladder anteriorly and the uterus and vagina posteriorly. This plane can be safely identified by filling the bladder with 100–150 mL of saline and by external handling of the uterine manipulator (Fig. 11.3(2)). After completing surgical steps 4 and 5, the plane of dissection between the bladder and uterus is continued by entering the anterior wall of the vagina and visualizing the uterine manipulator. This incision is carried along the lateral vaginal wall passed the urethra ensuring adequate surgical margins. Following surgical steps 7–9 and with the radical cystectomy completed, attention is drawn to the hysterectomy and bilateral salpingo-oophorectomy. The uterus is lifted by the fourth robotic arm and the cervix is excised from the vaginal wall with ample use of cautery due to the rich blood supply of the vagina.

11.6.2 Vaginal-Sparing Cystectomy (Surgical Technique with Four Robotic Arms)

Depending on the tumor stage and age of the female patient, a vaginal-sparing technique can be implemented, thus preserving the internal genitalia and sexual quality of life. To this end, some surgical steps from the above described have to be modified. After the completion of surgical steps 1 and 2, the peritoneum is incised between the bladder anteriorly and the uterus and vagina posteriorly as described above. The *division of the suspensory ligament of the ovary and the supporting ligaments of the uterus* (Step 3) is omitted. Surgical steps 4 and 5 are followed consequently, while the *vaginal dissection* (Step 6) is skipped. Finally, the dissection between the bladder and vagina (Fig. 11.3(1)) is carried out bluntly along the vaginal wall throughout the level of the bladder neck (Fig. 11.11), thus freeing completely the posterior bladder wall from the vagina. After the *anterior–prevesical dissection* (step 7), the operation is continued as described. Following the *urethral dissection* (step 8), the bladder is freed from all remaining attachments, and the internal genital organs are left intact (Fig. 11.12).

11.7 Postoperative Care

The nasogastric tube is removed at the end of the operation, and the patient is taken to the postoperative recovery unit for observation and stabilization. A standardized cystectomy care pathway is followed for all patients regardless of their gender. This includes the use of prokinetic agents, nonnarcotic analgesics, early mobilization, and rapid alimentation regardless of bowel movement [15]. The drain tube is removed when the amount of fluid is less than 200 mL. If the postoperative course is uneventful, the ureteral

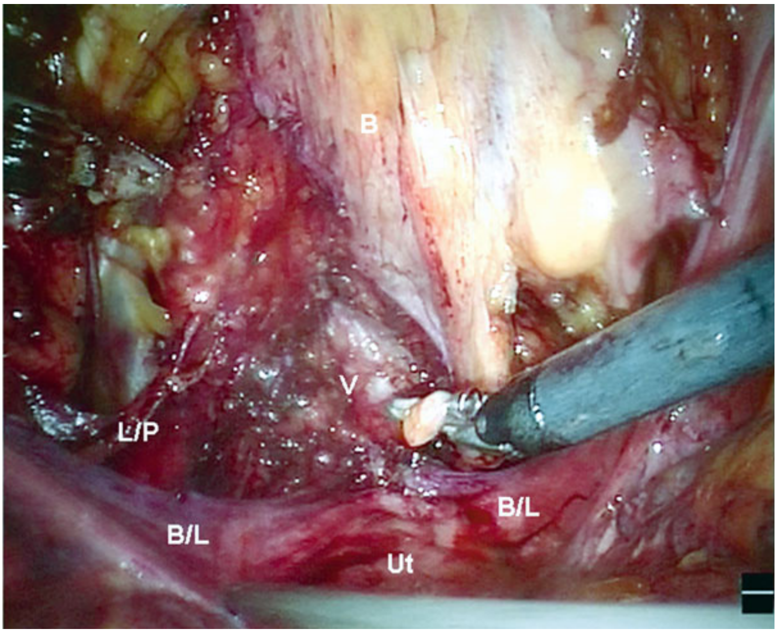

Fig. 11.11 Plane of dissection between the bladder anteriorly and the uterus and vagina posteriorly which is extended bluntly along the vaginal wall throughout the level of the bladder neck. *B* bladder, *V* vagina, *Ut* uterus, *B/L* broad ligament, *L/P* left bladder pedicle

stents are routinely removed on the seventh postoperative day and the urethral catheter 3 weeks after the operation [6].

11.8 Results

Early results in RARC have revealed comparable oncological, functional, and perioperative outcomes with its open counterpart [6, 7, 9]. Nonetheless, the majority of the RARC literature has demonstrated outcomes in predominantly male patients with only limited series concerning female cystectomy.

In a small series of three female patients reported by Menon et al., the average operating time was 160 min for the robotic radical cystectomy, while 130 and 180 min were needed additionally for the ileal conduit and neobladder, respectively. Mean estimated blood loss (EBL) was less than 100 mL, mean number of lymph node removed was 12 and the margins were negative in all specimens [5]. Guru et al. reported RAAPE in seven female patients. The mean operating time for RAAPE, lymph node dissection, and ileal conduit creation was 227, 48, and 132 min, respectively. Neobladder formation required 3 h, while the neobladder–urethra anastomosis 1 h and 43 min with robotic assistance. Mean EBL was 335 mL, and no intraoperative complications were noted. One patient developed pyelonephritis and needed readmission. A positive vaginal margin was noted in one patient with extensive disease. The average hospital stay was 8 days [17]. Lowentritt et al. reported a series of four female RARCs with a median operative time of 350 min and median EBL of 300 mL. Median lymph node yield was 12, margins were negative on all specimens, and the median hospital stay was 5 days. One patient developed deep venous thrombosis on postoperative day 5 requiring anticoagulation [18]. More recently, Pruthi et al. described RAAPE in 12 women with bladder cancer. Mean operating room time was 4.6 h, mean EBL was 220 mL, mean number of lymph nodes dissected were 19, no positive margins were observed and mean time to flatus was 1.9 days. In one case there was an inadvertent entry into the bladder intraoperatively [19].

There is only one study in the literature that compares the perioperative and pathologic outcomes between RAAPE in females and RARC in men. In this study, 10 female patients and 40 male patients were recruited. Compared to male patients, females had shorter operating room time (4.6 h vs. 5.9 h, $P<0.001$), less EBL (215 mL vs. 330 mL, $P=0.012$), and time to bowel movement

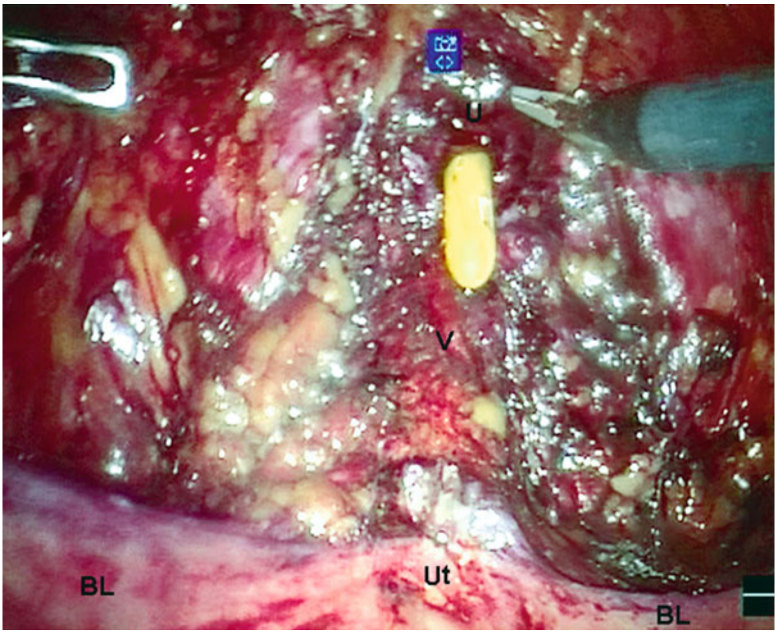

Fig. 11.12 Female pelvis after removing the bladder with internal genitalia intact in a vaginal-sparing cystectomy. *U* urethra, *V* vagina, *Ut* uterus, *BL* broad ligament

was shorter (2.4 days vs. 2.8 days, $P = 0.057$). No significant difference was noted in the number of lymph nodes removed (19 vs. 18), and the surgical margins were negative in all specimens. The authors concluded that the learning curve for RAAPE is not steep for surgeons who have previous experience with RARC in men [12].

Conclusion

Bladder cancer is an unforgiving disease, and despite technological innovations, surgical novelty should not be an excuse for compromising oncological and functional results. To this end, it is of paramount importance to comply with open surgical principles. Furthermore, reasonable perioperative outcomes with regard to operative time, EBL, and length of hospital stay should be emphasized. Previous results from male cystectomy series have assured that the above-mentioned are possible with all the advantages of a minimally invasive procedure. With experience gained from RARC in males and with good knowledge of the female pelvic anatomy, the learning curve for female RARC can be easily surpassed and excellent results can be expected.

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Male Robot-Assisted Radical Cystectomy

12

Erik P. Castle, Raj S. Pruthi, and Michael E. Woods

12.1 Introduction

The standard treatment of muscle invasive bladder cancer is open radical cystectomy (ORC) and urinary diversion. Radical cystectomy can be a challenging operation with significant patient morbidity and mortality. The urologic community has embraced laparoscopy to help decrease operative morbidity, which has been clearly seen by the widespread use of laparoscopic radical and donor nephrectomy. The first laparoscopic simple cystectomy was reported in 1992 by Parra et al. [1]. Since that publication, there have been several reports of laparoscopic radical cystectomy for malignant disease with various methods of urinary diversion. With the introduction of the daVinci® surgical system (Intuitive Surgical, Sunnyvale, CA), the prevalence of robot-assisted radical prostatectomies has seen a sharp increase, as this tool has helped surgeons overcome some of the technical challenges of pure laparoscopic pelvic surgery. It was a natural progression to apply robotic technology to laparoscopic cystectomies. In 2003, Menon et al. published the first series of robot-assisted radical cystectomy (RARC) and urinary diversion [2]. The goal of this chapter is to provide a detailed description of RARC in male patients as well as discuss pertinent literature on outcomes of this procedure.

12.2 Indications

The indications for radical cystectomy includes tumor invasion of muscularis propria, carcinoma in-situ refractory to intravesical therapy, recurrent multifocal superficial disease refractory to repeat transurethral resection with or without intravesical therapy, and may be considered for initial therapy in high-grade T1 disease, particularly in the setting of concurrent CIS. There are no absolute preoperative contraindications specific to patients being considered for RARC. There are two intraoperative situations that are absolute contraindications to proceeding with RARC. The first situation is hypotension or compromised ventilation with positioning and abdominal insufflation, which is of particular concern in obese patients. The second is CO_2 retention with insufflation resulting in unmanageable acidosis. This highlights the need for a careful preoperative cardiopulmonary evaluation in this patient population. Relative contraindications include abnormal anatomy (i.e., ectopic kidney, vascular aneurysm), morbid obesity, prior radiation, and prior abdominal or pelvic surgery. As with all laparoscopic oncology surgery, the principles of open surgery must be followed with

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RARC. If there is concern these oncologic principles will be compromised, a robot-assisted approach should not be used.

12.3 Technique

12.3.1 Port Placement

Six ports are utilized:

- One 12 mm camera port
- Three 8 mm robotic arm ports
- 15 and 5 mm assistant port

The ports are arranged in an “inverted-V” fashion (Fig. 12.1). Access and establishment of the pneumoperitoneum can be performed with a Veress or Hassan technique. The camera port is placed in the midline 4 cm cephalad to the umbilicus. The two 8 mm robotic ports (right and left arms) are placed 8–10 cm lateral to midline and 1 cm above the level of the umbilicus. Two assistant ports on the right (or left) are placed lateral to the right robotic port and the third arm port is placed superior-lateral to the left robotic port.

12.3.2 Mobilization of the Sigmoid and Left Colon

A 30° down lens can be used at the outset of the procedure. This allows for better visualization of the pelvis and retroperitoneum during the lymphadenectomy. This will be changed to a 0° lens for the posterior dissection. The procedure is begun by incising peritoneum lateral to the left colon. The left colon and sigmoid colon should be released from the left side wall to allow access to the left iliac vessels and left ureter.

12.3.3 Development of the Left Paravesical Space and Division of the Left Ureter

With the left medial umbilical ligament identified, the peritoneum lateral to the ligament and medial to the left iliac vessels should be incised. Blunt dissection is employed to expose the endopelvic fascia. In male patients, dividing the vas deferens allows the bladder to be retracted medially and facilitates exposure of the pelvic vasculature.

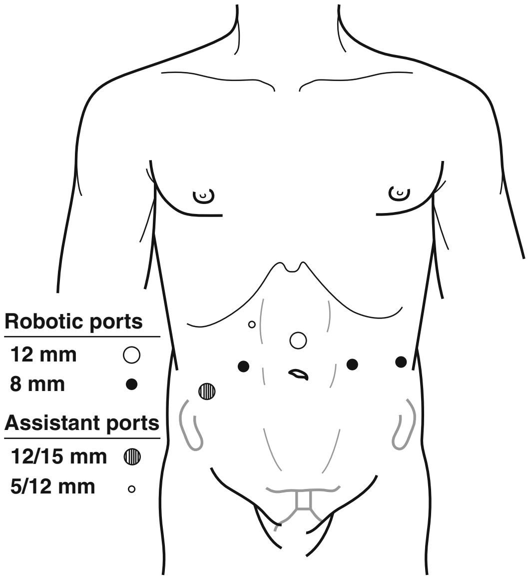

Fig. 12.1 Port placement for robot-assisted radical cystectomy

The left ureter is identified crossing over the iliac vessels. The ureter should be dissected free of its underlying structures while preserving as much periureteral tissue as possible. The distal end can be dissected down to its insertion into the bladder. The left umbilical artery and/or left superior vesical artery should be seen just lateral to the insertion of the ureter into the bladder and clipped/ligated to allow for more length on the ureter. The ureter can be clipped distally with a locking clip. The proximal clip on the ureter should have a suture pre-tied to the clip (10–12 in.) so no additional “tagging” or marking of the ureter is required later in the procedure. The ureter should be dissected free of its attachments cephalad. This should be done *before* dividing the ureter as proximal dissection can be difficult once the ureter is divided. The ureter can then be divided sharply. A margin can be sent for frozen section at this point. It should be noted that too much or too aggressive dissection proximal on the ureter can result in devitalization of the ureter and may contribute to anastomotic stricture in the postoperative setting. In many cases, individual vessels from the common iliac or distal aorta can be seen and preserved to maintain ureteral blood flow.

12.3.4 The Left Pelvic Lymphadenectomy

The authors currently use a Maryland bipolar in one hand and monopolar scissors in the other hand. The dissection is begun on the left external iliac artery. A “split-and-roll” technique is utilized. The dissection should be carried proximally up to the bifurcation of the aorta. Great care should be taken during dissection along the external and common iliac veins due to the collapsed nature of the veins from the pressure of the pneumoperitoneum. By following a line directly posterior to the point where the external iliac vein crosses the pubic ramus, one can find the obturator nerve and vessels. The hypogastric artery should be skeletonized. Locking clips can be used at the discretion of the surgeon but we recommend using one clip on the distal and proximal borders of the packet to minimize the risk of lymph leak.

In order to maximize the removal of lymph nodes from the pelvis, dissection should be carried lateral to the external iliac vessels (“space of Marcille”). This facilitates removal of the proximal internal iliac lymph nodes and lymph nodes posterior and inferior to the obturator nerve. Lymph nodes can be removed in separate packets with 10 mm specimen retrieval bags. A small arterial branch to the psoas muscle may be encountered along the proximal portion of the external iliac artery and can be spared or clipped and divided.

12.3.5 Development of the Right Paravesical Space, Right Ureter, and Right Lymphadenectomy

The right paravesical space is developed similar to the left. Dissection is similar as done on the left, but it should be noted that the incision in the retroperitoneum on this side should be extended onto the right side of the sigmoid mesentery to develop the preaortic space and allow for passage of the left ureter. It is important to develop a relatively large space in this region. Often there is fear to do aggressive blunt dissection due to concern for the mesenteric vessels; however, if the surgeon stays close to the great vessels, the space is very safe to develop.

12.3.6 Identification, Ligation, and Division of the Superior Vesical Arteries

The umbilical and superior vesical arteries are clearly seen at the completion of the lymphadenectomy and are clipped. Clipping is recommended and may allow for more distal dissection of the ureters. If the ureters have not already been tagged with a pre-tied clip, then one should switch instruments to needle drivers and tag the distal ends of both ureters.

12.3.7 Transferring the Left Ureter Through the Sigmoid Mesentery

The left ureter can be transposed behind the sigmoid mesentery with the help of the right side assistant. The right side assistant should gently advance a blunt-tipped instrument below the mesentery along the anterior surface of the aorta. If the robotic “third arm” has been placed on the right side, then it can be passed through. The tag on the left ureter can be grasped and the ureter should easily pass through the mesenteric window.

12.3.8 Tagging the Distal Ileum with 8–10 in. 2-0 Vicryl Suture

The ileum should be tagged with a 2-0 Vicryl suture. This too should be left at least 10–12 in. in length. We recommend mobilizing the lateral attachments of the cecum so as to facilitate delivery of the ileum into the abdominal incision and make identification of the distal portion of the ileum easier.

12.3.9 Development of the Prerectal and Posterior Vesical Space

The camera lens can be changed to a 0° (degree) lens for optimal visualization. The peritoneum extending from the posterior bladder to the anterior sigmoid should be incised. Using blunt and careful cautery dissection, the prerectal space is developed. One must employ the assistant(s) to retract the bladder and its posterior structures anteriorly. In male patients, Denonvillier's fascia needs to be incised to carry the dissection as far caudad as possible. The dissection should be carried down to the rectourethralis muscle. If nerve sparing is desired, then one should dissect anterior to Denonvillier's fascia and leave it on the anterior rectal surface staying close to the prostate.

12.3.10 Division of the Remaining Inferior Vesical Vessels

Once the limits of dissection are reached along the posterior aspect of the bladder, the lateral attachments of the bladder can be divided. For a non-nerve sparing procedure, this can be done with locking clips or a combination of the bipolar instrument and the monopolar instrument of choice. An endovascular stapler can be used on both sides as well but we recommend using locking clips as it yielded a more controlled dissection and preserved planes of dissection. It should be remembered that the dissection should be carried caudad through the endopelvic fascia thereby completely mobilizing the bladder from its lateral attachments and the rectum. Often a combination of lateral and posterior dissection is used in an alternating fashion to complete the dissection.

12.3.11 Preservation of the Neurovascular Bundles

In nerve-sparing procedures, the neurovascular bundles are encountered as they project off the posterior-lateral aspects of the prostate down to the anterior surface of the colon. The bundles can be mobilized by releasing lateral fascia anterior to the bundles along the surface of the prostate or vagina. This dissection is connected to the incision anterior to Denonvillier's fascia that has already been performed during creation of the prerectal space. The inferior vesical pedicles and prostate pedicles should be clipped and divided with cold scissors to avoid neurovascular injury. The nerve sparing should be carried down to the genitourinary diaphragm to prevent injury during the apical and urethral dissection.

12.3.12 Mobilization of the Bladder and Completion of the Apical Dissection

The remaining bladder attachments should only be the urachus, anterior attachments, prostate, and urethra. The medial and median umbilical ligaments should be divided as far proximally as possible with electrocautery. The dissection and peritoneal incision is carried lateral to the medial umbilical ligaments caudad to the anterior surface of the bladder. If not already done, the endopelvic fascia should be incised bilaterally. The apical dissection of the prostate or vagina is then completed. At this point the dorsal venous complex can be ligated in a figure of eight fashion. Although an endovascular stapler can be employed for this step, we feel the suture ligation allows for better visualization and identification of the urethra. Furthermore, when a stapler is used, there is likely to be venous ooze into the pelvis once the abdomen is opened for the diversion.

12.3.13 Dissection, Ligation, and Division of the Urethra

It is very important to dissect out a generous urethral stump. This is important even in cases without a planned neobladder. A generous urethral stump allows for easier application of a locking clip or suture ligation to prevent tumor spillage during division. If the previous posterior dissection was adequate, there should be minimal posterior tissue other than some minor remnants of rectourethralis. A frozen section can be taken from the proximal portion of the divided urethra if needed.

12.3.14 Specimen Extraction

The entire specimen can be entrapped in a 15-mm specimen retrieval bag. It will be extracted through a 5–6-cm infraumbilical or periumbilical incision. Prior to extraction, the tags on the ureters and the ileum should be grasped in a locking grasper by the bedside assistant to allow delivery into and through the extraction incision.

12.4 Postoperative Care

A nasogastric tube is not routinely left in place. The patients are maintained on broad-spectrum antibiotics for 24 h and can be transitioned to oral regimens based on surgeon preference. Epidural catheters are not used. Intravenous morphine and/or ketorolac are usually adequate for pain management and can be promptly switched to oral narcotics once the patient is tolerating a diet.

It is important to increase patient activity as early as the day of surgery. Patients are encouraged to sit in a chair the same night of surgery. They are ambulated on the first postoperative day. Bisacodyl suppositories are administered each morning starting on the first postoperative day until bowel function returns. A liquid diet is started once bowel function returns which may be as early as the second or third postoperative day. Daily serum chemistry and hematocrits may be followed until discharge based on surgeon preference. Most patients do not seem to have significant third spacing and will rarely require additional fluid replacement other than standard maintenance fluids. Although postoperative hemorrhage and delayed bowel injury is rare, patients need to be monitored closely for these complications.

Ureteral stents and abdominal drains should be managed according to surgeon preference. Currently, the authors remove stents from a urostomy at 7–10 days. Foley catheters are removed from neobladders in 14–21 days. If the stents were not secured to the Foley during creation of the neobladder, then they are removed cystoscopically at the time of Foley removal in the office. The decision to perform a cystogram at the time of Foley removal is based on surgeon preference and can be decided on an individual case basis.

It should be noted that patients can be discharged home rather quickly which may require leaving drains or stents in place until the first office follow-up. The authors have found that some patients may have a continued leak of lymphatic fluid through a drain site up through the fifth or sixth postoperative day. We believe this is seen because patients are discharged home before their lymphatic channels have completely sealed. Consequently, the abdominal drain may be left in place until their first postoperative follow-up which is on postoperative day 7. If the drain is removed before discharge, then a urostomy appliance can be placed over the drain site to collect the fluid until the incision heals and drainage ceases. We have found this drainage to be self-limiting and uniformly resolves spontaneously as the lymphatic fluid is absorbed intraperitoneally. If there is any concern of a urine leak, the fluid may be sent for creatinine analysis.

12.5 Perioperative Outcomes

There have been several large series demonstrating promising perioperative outcomes of patients undergoing RARC [3–6]. Operative times range from 275 to 380 min, blood loss from 270 to 400 cc, length of stay from 4.9 to 10 days, with overall and high-grade complication rates from 34 to 52 % and 8 to 24 %, respectively. These outcomes are summarized in Table 12.1. RARC has been shown to decrease complications compared to open radical cystectomy in a nonrandomized study [7].

12.6 Pathologic Outcomes

Two important pathologic issues that need to be addressed during RARC are incidence of positive surgical margins (PSM) and an adequate pelvic lymph node dissection (PLND). The importance of achieving negative surgical margins during radical cystectomy cannot be overstated as patients with positive soft-tissue margins have increased recurrence rates and almost a threefold

Table 12.1 Perioperative outcomes of RARC

	No. patients	EBL (cc)	Operative time (min)	Length of stay (days)	Overall complication (%)	High-grade complication (%)
Kauffman et al. [3]	79	400	360	5	49	21
Khan et al. [4]	50	340	361	10	34	10
Pruthi et al. [5]	100	271	275	4.9	41	8
Hayn et al. [6]	156	400	380	8	52	24

Table 12.2 Pathologic outcomes of RARC

	No. patients	PSM (%)	Lymph node yield (no.)
Kauffman et al. [3]	79	7.6	18.4
Khan et al. [4]	50	2	17
Pruthi et al. [5]	100	0	19
Hellenthal et al. [10, 17]	513	6.8	17.8
Davis et al. [18]	11	0	43
Lavery et al. [19]	15	n/a	41.8
Schumaker et al. [11]	230	2.6	n/a
Nix et al. [20]	21	0	19[a]
Robotic open	20	0	18

[a] Prospective randomized trial of RARC vs. ORC

decrease in survival [8, 9]. The reported rate of PSM for RARC ranges from 0 to7.6 % [3–5, 10, 11]. Novara et al. provided a benchmark from the open radical cystectomy literature in a multi-institutional series of over 4,000 patients where the PSM rate was 6.3 % [12]. The inclusion of a pelvic lymphadenectomy at the time of cystectomy provides both prognostic information and potential therapeutic benefit [13, 14]. Furthermore, the number of lymph nodes removed has been shown to have prognostic significance by several authors and it is also well established that an extended template will improve lymph node yield [13–16]. The reported lymph node yield for lymphadenectomy during RARC range from 17 to 43, with most centers performing an extended template [3–5, 17–19]. In a prospective randomized trial, Nix et al. demonstrated no difference in lymph node yield between robotic and open cystectomy [20]. In a unique study by Davis et al., robotic lymph node dissections had a yield of 93 % compared to open lymphadenectomy when a “second look open dissection” was used following the robotic PLND [18]. These outcomes are summarized in Table 12.2.

12.7 Survival Following RARC

Robot-assisted radical cystectomy is in its infancy so no long-term oncological follow-up exists, but there are several reports of short and intermediate-term follow-up that have emerged. Pruthi and Wallen reported short-term cancer outcomes in 50 patients [21]. They had a mean follow-up 13.2 months and experienced an overall and disease-specific survival of 90 and 94 %, respectively. Dasgupta et al. recently published their RARC experience in 20 patients with >6 months follow-up [22]. This cohort had a mean follow-up of 23 months, with overall and disease-free survival of 95 and 90 %. Martin et al. reported outcomes in series of 80 patients with the longest mean follow-up to date from Mayo Clinic in Arizona [23]. Fifty-nine patients had >6 month follow-up with a mean follow-up of 25 months (range 6–49) The overall survival at 12, 24, and 36 months was 82, 69, and 69 %, respectively, and recurrence free survival at 12, 24, and 36 months was 82, 71, 71 %, respectively (Fig. 12.2). Karolinska Institute found 83 % disease specific survival with a mean follow-up of 25 months [11]. Kauffman et al. report 2-year

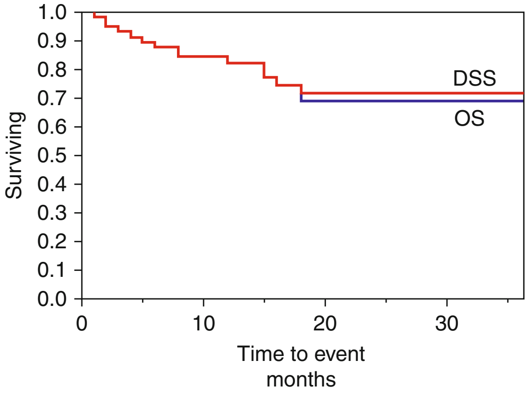

Fig. 12.2 Kaplan-Meier Survival Curves - overall survival (OS) and disease-specific survival (DSS)

disease-free, cancer-specific, and overall survival of 74, 85, and 79 %, respectively [24]. Clearly, oncological outcomes as measured by survival are equivalent in the intermediate term. Nevertheless, long-term follow-up is still eagerly awaited.

Conclusion

Robot-assisted radical cystectomy in the male patient is a feasible and reproducible operation. With appropriate steps and adherence to a standardized technique results are often superior with regard to recovery in the immediate postoperative period and complications can be kept to a minimum. Intermediate oncological outcomes are favorable and with increasing application, RARC will become a part of the urologist's armamentarium to treat invasive bladder cancer.

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Robotic-Assisted Intracorporeal Urinary Diversion

13

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13.1 Introduction

The creation of the urinary diversion is a challenging surgical part after radical cystectomy and holds a special place in the development of urological practice. Following cystectomy, urine can either be diverted into an incontinent stoma, into a continent urinary reservoir catheterised by the patient or controlled by the anal sphincter, or into an orthotopic bladder substitute so that the patient voids per urethra.

During the last decade, urologists worldwide have witnessed a tremendous development of laparoscopic surgical treatment due to the development of robot-assisted surgery in many urological diseases. In parallel, the interest in expanding the role of robot-assisted radical cystectomy (RARC) for the management of urinary bladder cancer has risen during the last years and continues to grow. Robotic-assisted laparoscopic techniques have emerged allowing surgeons to more readily overcome the difficult learning curve and shorten operative times in minimally invasive abdominal and pelvic operations [1].

RARC has been grown steadily during the last years and has replaced LRC in centres where the robot is available. The neobladder can be formed intracorporeally [2–5], but operative time may be reduced if this is done extracorporeally through the same incision used to deliver the cystectomy specimen.

Most RARC surgeons advocate a combination of robotic-assisted laparoscopy and open surgery, performing the cystectomy and extended PLND with the robot, but due to technical difficulties and longer operative time [6–10] using an extracorporeal approach for the construction of the conduit or neobladder [6]. However, some centres including our own institution have developed techniques for RARC with a complete intracorporeal urinary diversion [2, 3].

Herein, we describe step by step the method used at the Karolinska Institutet for robot-assisted urinary diversion with ileal conduit and orthotopic neobladder by intracorporeal technique.

13.2 Patient Selection

The inclusion criteria for robotic-assisted continent or non-continent urinary diversion are the same as for open surgery. The selection process includes preoperative investigation to ensure fitness for surgery as well as specific counselling about robotic technology. Patients with decreased pulmonary compliance who cannot tolerate the Trendelenburg position are not candidates for the robot-assisted technique. Furthermore, if the patient has a history of previous extensive abdominal surgery, RARC may be contraindicated. Patients with bulky disease should be avoided.

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13.3 Preoperative Preparation

In patients scheduled for receiving an intracorporeal orthotopic neobladder, mechanical bowel preparation (osmotic laxative) may be used the day before surgery. A stoma site is also marked the day before surgery. Broad-spectrum intravenous antibiotics are administered at the start of the procedure.

13.4 Operative Setup

13.4.1 Patient Position

After induction of general endotracheal anaesthesia, a nasogastric tube and an 18-Ch Foley urinary catheter are inserted. The patient is placed in lithotomy position with arms adducted and padded. The legs are also abducted and slightly lowered on spreader bars. The table is placed in 25° Trendelenburg position during the RC and PLND. For the urinary diversion, the Trendelenburg position is decreased to 10–15°.

13.4.2 Equipment

The technique is challenging, requiring conventional laparoscopic infrastructure as well as an assistant skilled in conventional laparoscopy. Standard laparoscopic surgical equipment must be supplemented by some extra instruments (Ligasure® Covidien, surgical endoscopy clip applicators, laparoscopic Endo-Catch bags and laparoscopic stapler for intestinal stapling).

13.4.3 Trocar Configuration

Port placement is critical for successful robotic surgery. A six-port technique is used with the camera port placed 5 cm above the umbilicus in the midline. The camera port is placed by a small mini laparotomy as described by Hasson [11], and the other ports are placed in view of the camera. Pneumoperitoneum between 10 and 12 mmHg is desirable during the procedure, but during the port placement, a pressure of 18 mmHg can be helpful in creating additional tension on the abdominal wall. Two robotic ports are placed symmetrically and level with the umbilicus on the left and right side, lateral to the rectus sheath. A third robotic instrument port is placed just above and medial to the left anterior superior iliac spine through a 15-mm port, thereby enabling laparoscopic stapling by the assistant when the third robotic port is temporarily disconnected. Two assistant ports are placed, one on either side of the right robotic instrument port (Fig. 13.1).

13.4.4 Urinary Diversion

13.4.4.1 Orthotopic Neobladder

Anastomosis Between the Urethra and Ileum

After the cystectomy and the lymph node dissection are finished, the urinary diversion is performed. The first step is to perform an anastomosis between the ileum and the urethra. The 0° lens is used for this initial step. The ileum is sufficiently mobilised in order to reach down to the urethra. This is important for two reasons, first the anastomosis between the neobladder and urethra can be performed without tension, and second the neobladder will be placed correctly in the small pelvis during the whole procedure. This will help during construction of the neobladder by running suture. A 20-Ch opening (Fig. 13.2) is made in the antimesenteric site of ileum, using robotic scissors. The anastomosis is performed according to the Van Velthoven technique with a 16 cm 4-0 Quill™ suture, allowing for 10–12 stitches (Fig. 13.3). A needle driver and a Cadiere are used to establish the anastomosis.

Isolation of 50-cm Ileum

The orthotopic neobladder is fashioned from a 50-cm segment of terminal ileum. The intestine is isolated using laparoscopic Endo-GIA with a 60-mm intestinal stapler (Fig. 13.4). The stapler is inserted by the assisting surgeon, using the 15-mm port on the left side. The ileum is stapled 40 cm proximal to the urethral-ileal anastomosis.

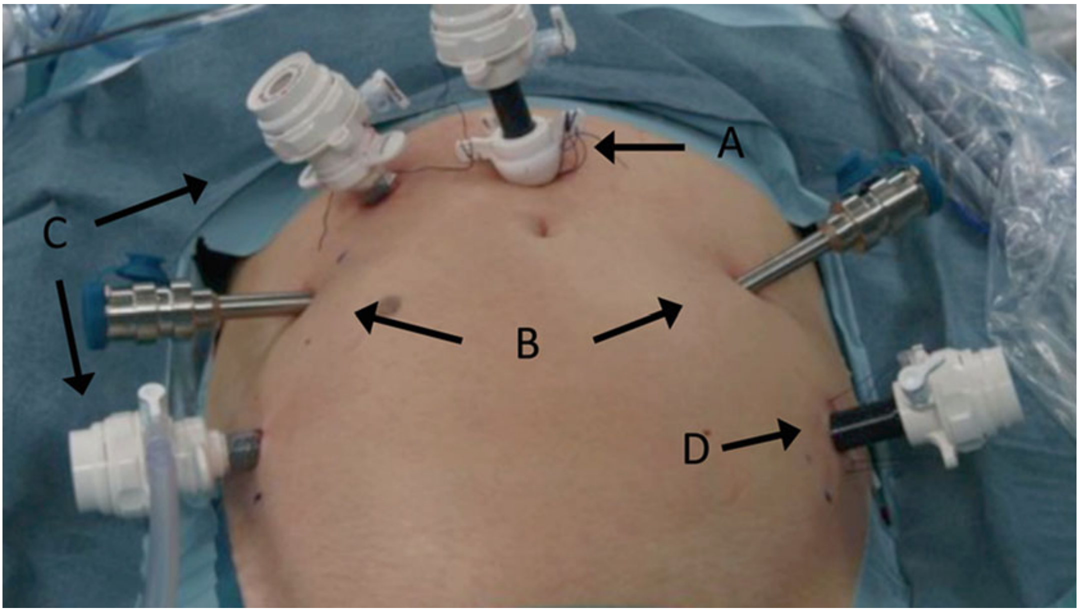


Fig. 13.1 Trocar placement for standard da Vinci system. (*A*) Camera trocar. (*B*) 8-mm trocar, right and left robot instrument. (*C*) 12-mm trocar, suction, bowel grasping, Ligasure. (*D*) 15-mm four robotic arm, specimen retrieval and stapling

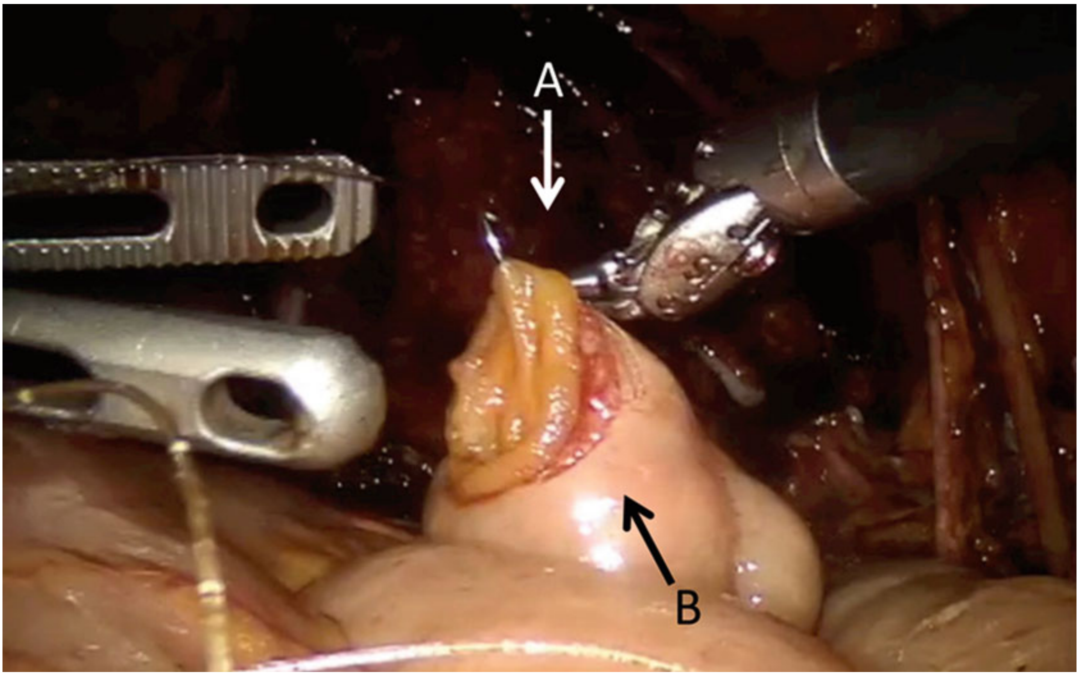


Fig. 13.2 An opening (*A*) in the ileum (*B*) is performed to allow the passing of a 20-Ch catheter

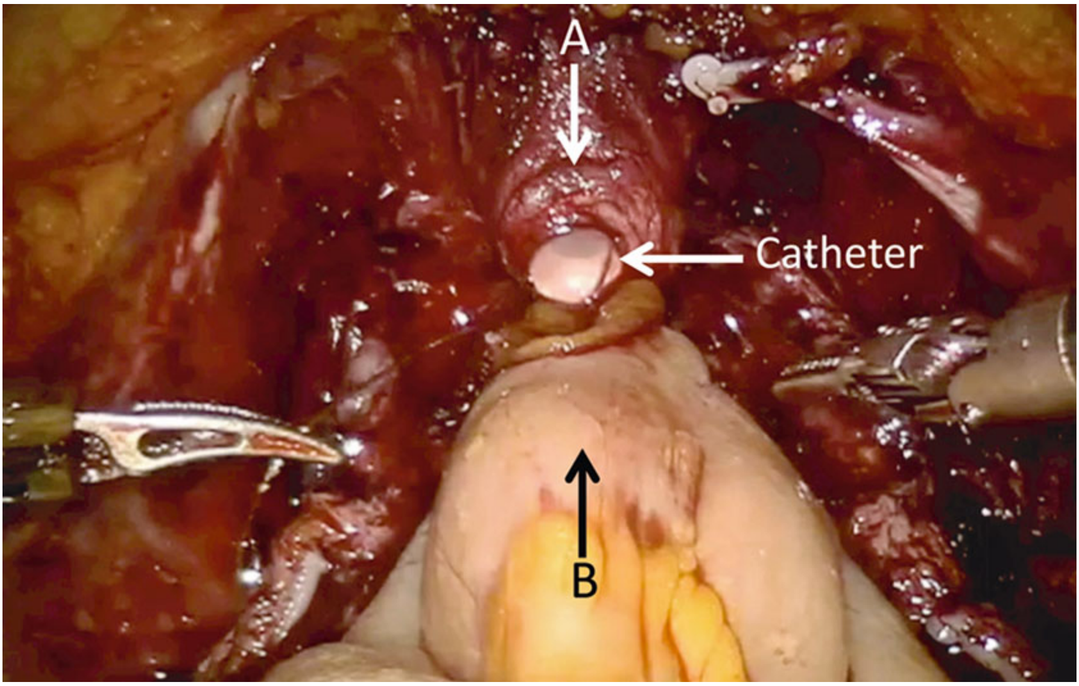
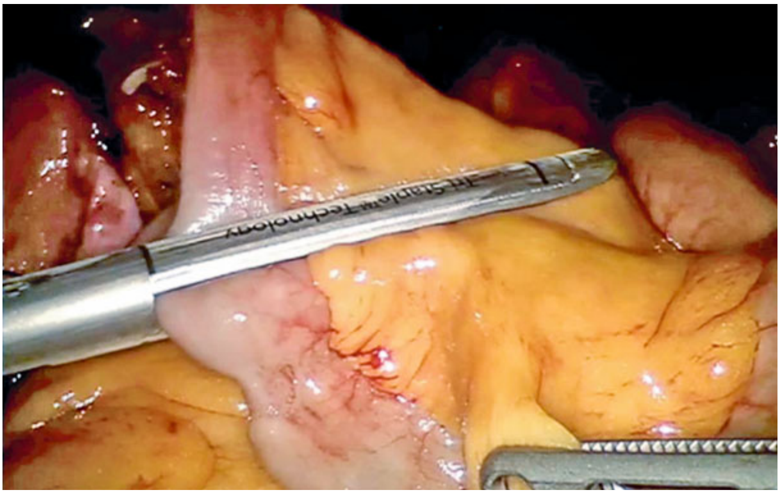


Fig. 13.3 Anastomosis between urethra (*A*) and ileum (*B*) using a 16-cm 4-0 Quill™ suture

Fig. 13.4 Stapling of the ileum, using Endo GIA 60 mm



The continuity of the small bowel is restored by using Endo-GIA with a 60-mm intestinal stapler, positioning the distal and proximal end of the ileum side to side with the antimesenterial parts facing each other (Fig. 13.5). An additional transverse firing of the Endo-GIA stapler is used to close the open ends of the ileal limbs (Fig. 13.6).

Detubularisation

The distal 40 cm of the isolated ileal segment is detubularised along its antimesenteric border

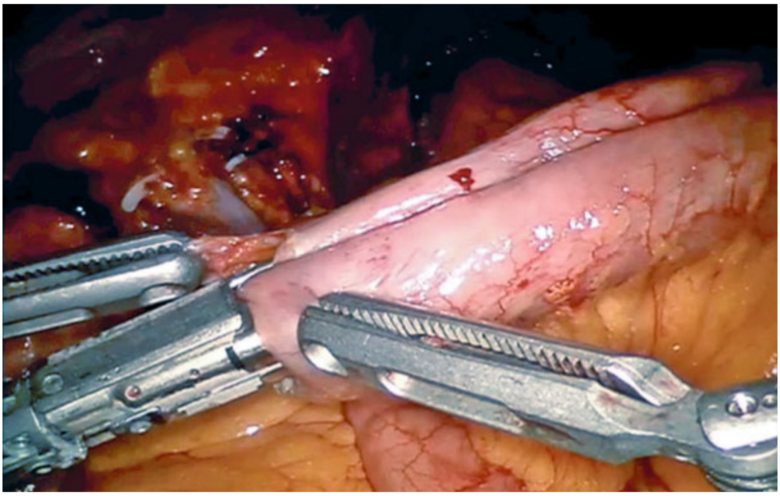


Fig. 13.5 Side to side anastomosis of the ileum by Endo GIA 60 mm

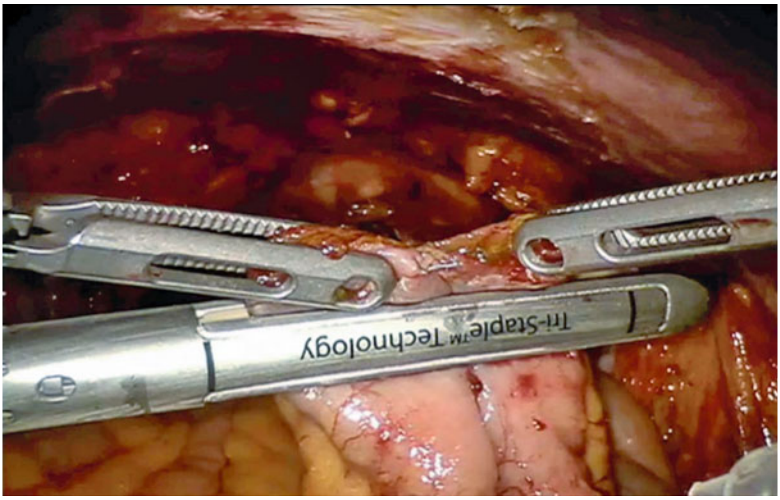


Fig. 13.6 Closing of the open end of the ileal limbs, using the Endo GIA stapler

with cold scissors (Fig. 13.7), leaving a 10-cm intact proximal isoperistaltic afferent limb. Care is taken not to interfere with the sutures used for the anastomosis to the urethra (Fig. 13.8).

Formation of Studer Neobladder

After detubularisation, the posterior part of the Studer reservoir is closed using multiple running sutures (15-cm 3-0 V-Loc™) in a seromuscular fashion, avoiding suturing the mucosa. After the posterior part is sutured, the distal half of the anterior part of the reservoir is sutured, using the same suture. The 0° or 30° lens can be used for this part of procedure. The proximal half of the anterior part of the reservoir is left open and is closed in the last part of the procedure.

Ureteric Entero-Anastomosis

The anastomosis between the ureters and the afferent limb is performed using the Wallace technique [11] using a 0° lens. A 3-0 Biosyn® stitch is placed at the distal end of each ureter. The left ureter is tunnelled under the sigmoid mesentery to the right side. The ureters are then incised and spatulated 2 cm (Fig. 13.9). The posterior walls

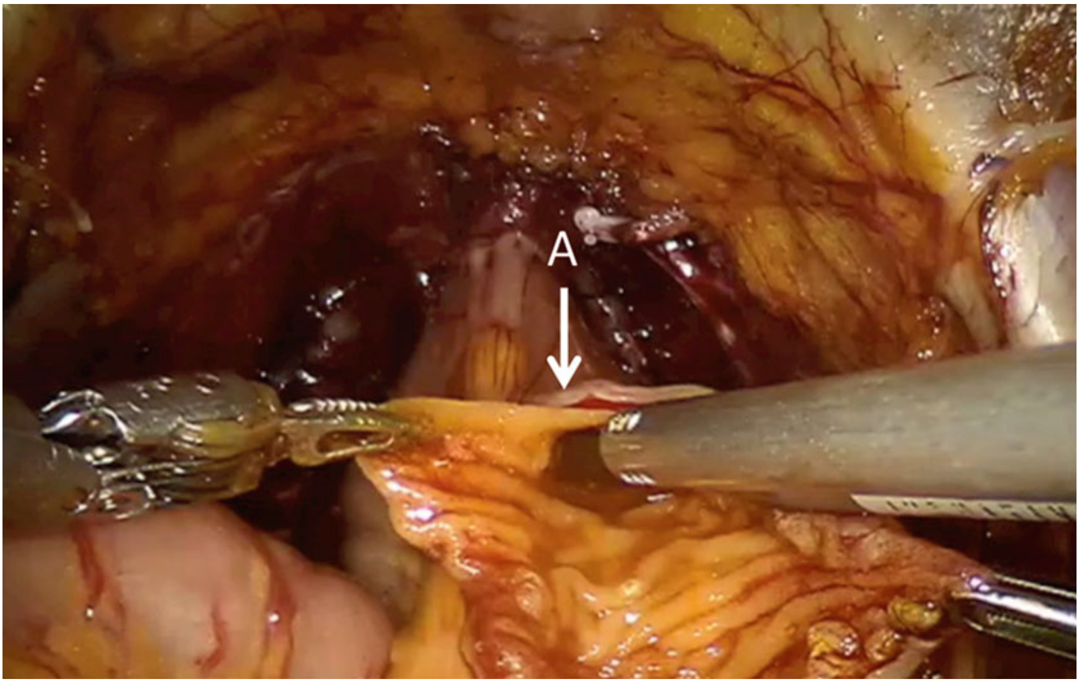


Fig. 13.7 Detubularisation of the ileum, antimesenterically (*A*) in order to create the neobladder

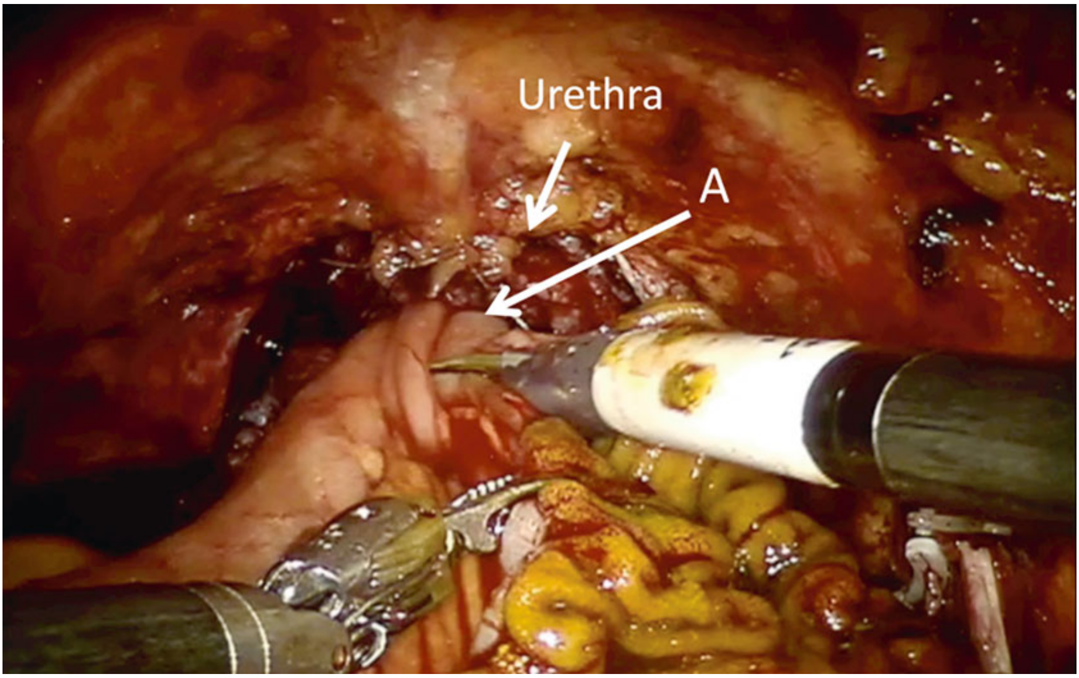


Fig. 13.8 Detubularisation, close to the ileourethral anastomosis (*A*), special care is taken not to interfere with the anastomotic suture

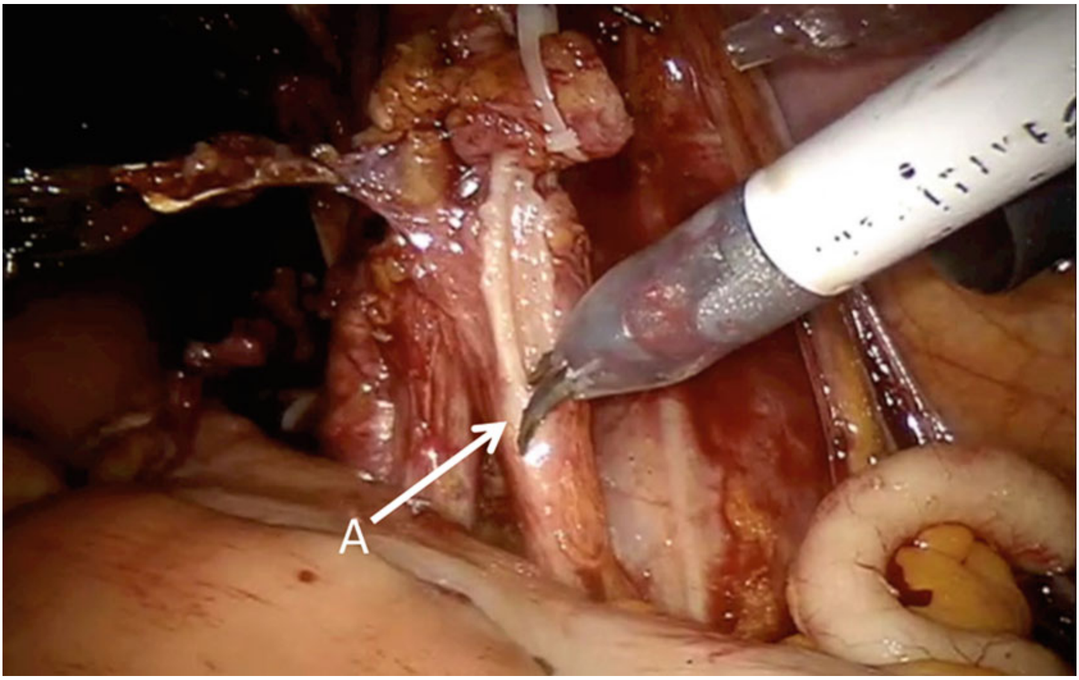


Fig. 13.9 Spatulation of the right ureter (*A*)

of the ureters are sutured side to side, using a 15-cm 4-0 V-Loc™ suture. Before the anastomosis between the ureters and the intestinal loop is performed, two Single-J 40-cm ureteric stents are introduced with Seldinger technique [12] through two separate 4-mm incisions at the lower part of the abdominal wall. The stents are pulled through the afferent limb (Fig. 13.10) and pushed up into the ureters on each side (Fig. 13.11). The ureters are then sutured to the afferent limb of the Studer pouch, using a 16-cm 4-0 Quill™ suture (Fig. 13.12). After the ureteric entero-anastomosis is completed, the stents are sutured and fixed to the skin.

Closure of the Studer Reservoir

The remaining part of the reservoir is then closed with a running 3-0 V-Loc™ suture, using a 0° lens. The balloon of the indwelling catheter is filled with 10 cc. The neobladder is then filled with 50 cc of saline to check for leakage (Fig. 13.13). If leakage is observed, extra sutures will have to be considered. A 21-Ch passive drainage is introduced and placed in the small pelvis.

13.4.4.2 Ileal Conduit, Intracorporeal Technique

Twenty centimetre of intestine is isolated from the terminal ileum, using an Endo-GIA with 60-mm intestinal staples. The continuity of the small bowel is restored as described above. The distal end of the conduit is fashioned as a stoma by the surgical assistant at the previously marked site on the abdominal wall. The left ureter is tunnelled under the sigmoid mesentery to the right side. The ureters are then incised and spatulated 2 cm. The Wallace technique is used here as described above. Single-J 40-cm ureteric stents are then introduced through the isolated ileal segment (ileal conduit). The stents are then pushed up into the ureters on each side and the ureteroenteric anastomosis is completed, using a two times 16-cm 4-0 Quill™ suture.

13.4.5 Special Considerations

13.4.5.1 Patient Position

Care should be taken to use a pneumatic leg compression system due to risk of decreased vascular

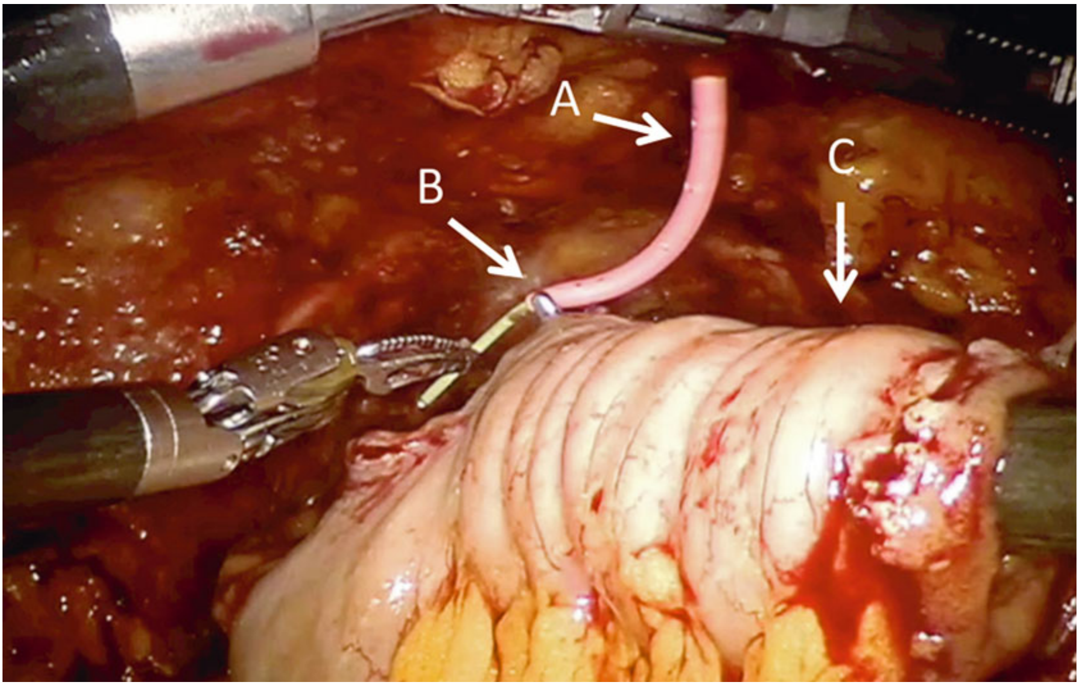


Fig. 13.10 Placement of a ureter stent (*A*) through a 3-mm port. The right robotic instrument (*B*) grasps the tip of the stent and inserts it upwards through the afferent limb (*C*) of Studer reservoir

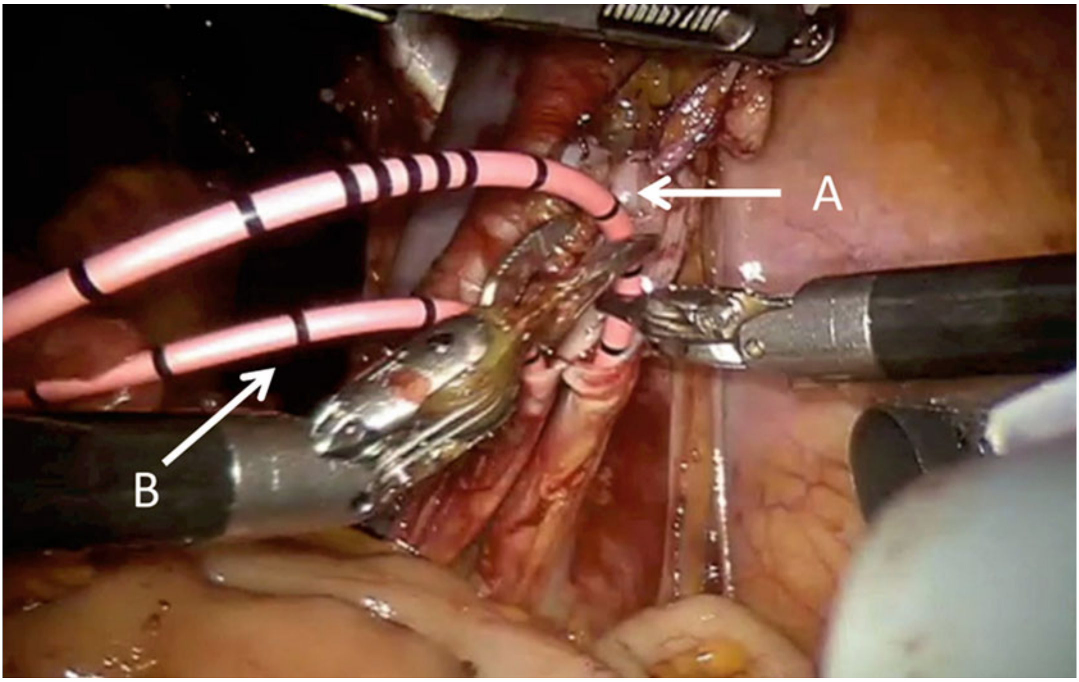


Fig. 13.11 Placement of a stent into the right ureter (*A*). The left ureter stent is already in place (*B*)

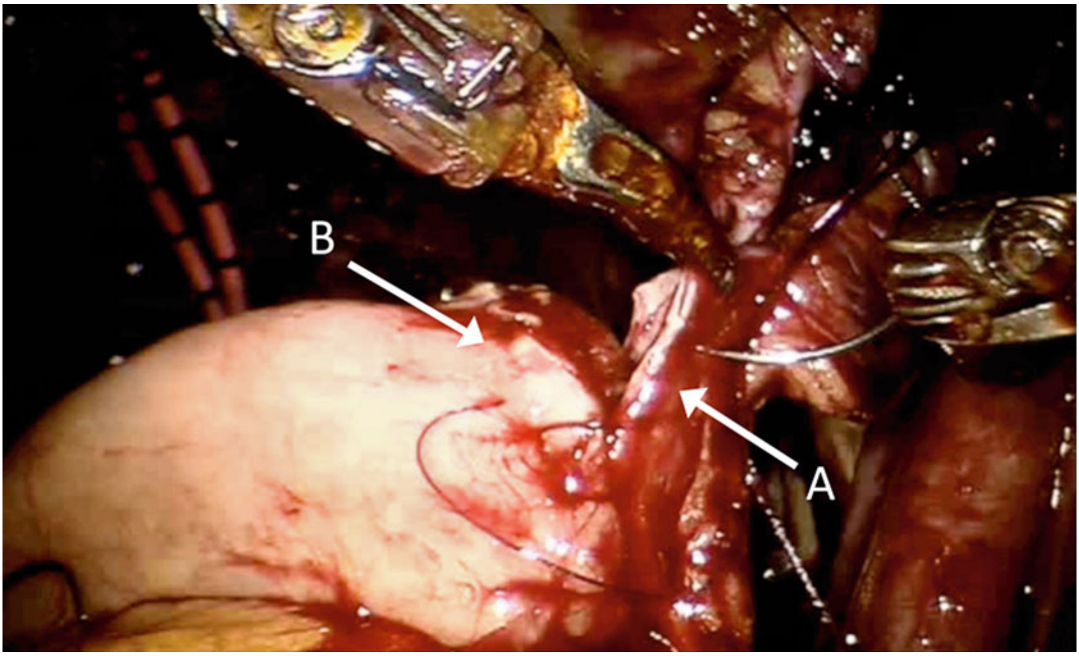


Fig. 13.12 Anastomosis between Wallace plate (*A*) and afferent limb (*B*) of the Studer reservoir, using a seromucosal suturing technique

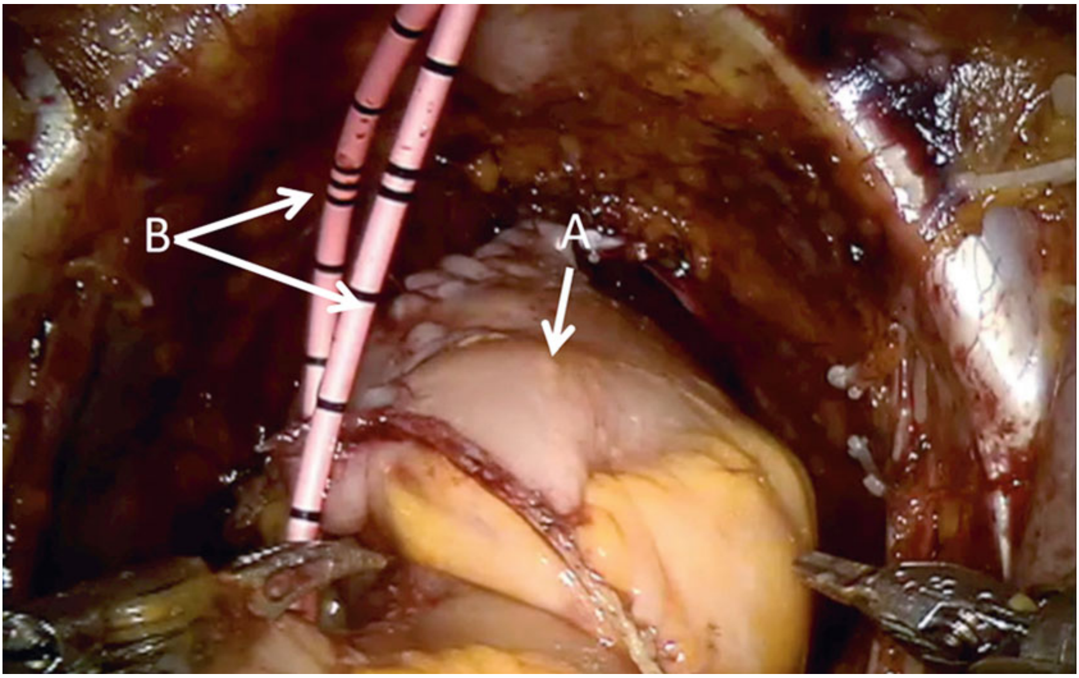


Fig. 13.13 After the neobladder (*A*) is completed, it is filled with 50-cc saline to check for leakage. The ureteric stents (*B*) are placed separately in the Studer reservoir

perfusion during the procedure. To avoid cardiovascular complications for the patient, anticoagulant treatment is started with low-molecular-weight heparin according to the patient's body weight, the evening before surgery and until the patient is fully mobilised. It is feasible to perform the urinary diversion with a 10–15° Trendelenburg, as a higher Trendelenburg inclination is to be avoided to minimise the risk for cardiopulmonary complications.

13.4.5.2 Port Position

It is always important to make sure the fourth arm port and the left robotic arm port are not in the same alignment to avoid clashing of the robotic arms.

13.4.5.3 Urethral-Neobladder Anastomosis

Making the anastomosis between the urethra and the ileum should be the first step in the formation of an intracorporeal orthotopic neobladder. This is a critical step because the anastomosis can be made without tension, and the neobladder will be placed correctly in the small pelvis during the whole procedure.

13.5 Steps to Avoid Complication

Shoulder pads should be avoided due to high risk for plexus damages. Care should be taken during the tunnelling of the left ureter behind the colon sigmoid to avoid damaging any vascular structures. It is important to check for leakage after the neobladder has been created. Extra suturing to secure a water-tight reservoir and anastomosis is fundamental to decreasing postoperative complications.

13.6 Discussion

With the introduction of the da Vinci® robotic system (Intuitive Surgical) in urological clinical practice, a large number of robot-assisted surgical procedures have been performed. Compared with the traditional laparoscopic technique, the hand-eye alignment and depth perception provided by the robotic system are advantageous and may eventually be superior to using open procedures, resulting in less surgical morbidity and a shorter learning curve. However, RARC with totally intracorporeal urinary diversion is still considered a technically challenging procedure [2, 3, 9]. Since the first report by Beecken et al. [2] in 2003 RARC, PLND and urinary diversion have been adopted by several institutions worldwide, and today >1,500 procedures have been reported to the IRCC.

It has been debated whether the intracorporeal technique for urinary reconstruction has any advantages over the extracorporeal technique. The intracorporeal technique allows the restoration of small bowel continuity and the construction of the neobladder performed without incision of the abdominal wall. In the female, the specimen may be taken out through an incision in the vaginal wall, and in the male, the specimen is extracted through a small incision at the end of the procedure. It has been argued that the intracorporeal approach should only be used if specimen retrieval may be performed without an additional incision. The intracorporeal reconstruction is less traumatic for the patient, but on the other hand, more technically demanding for the surgeon. Robotics makes an intracorporeal technique a more feasible procedure even though most centres prefer an extracorporeal approach for urinary diversion [6–8, 10]. One major advantage of performing the urinary diversion intracorporally is that performing the running suture of the anastomosis between the urethra and the ileum minimises the risk of urinary leakage. There is also less traction to the anastomosis between the reservoir and the urethra using an intracorporeal approach, as an appropriate ileal segment long enough to reach down to the urethra can be used [1].

The robotic system may positively influence functional results at RARC, especially if a nerve-sparing procedure is attempted. Furthermore, this system might facilitate suturing the anastomosis between the urethra and the reservoir, which in turn may improve urinary continence.

Conclusion

RARC with totally intracorporeal urinary diversion for patients with TCC of the bladder is technically feasible and reproducible with results comparable with those from ORC series and with acceptable complication rates, adequate lymph node yield and good functional results.

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Technique of Extracorporeal Urinary Diversion

14

Kevin G. Chan and Timothy G. Wilson

14.1 Introduction

The purpose of this chapter is to provide a step-by-step approach to the different extracorporeal urinary diversions that may be performed in the setting of robotic-assisted laparoscopic radical cystectomy (RARC). Recent reports indicate comparable results to open surgery with regard to intermediate-term oncological outcomes and extent of pelvic lymph node dissection [1, 2]. However, operative times are one of the main obstacles that hinder widespread acceptance of RARC. Extracorporeal urinary diversion with RARC provides a method of reconstruction that mirrors that of open surgery with regard to operative times [3]. Complication rates and functional outcomes with extracorporeal urinary diversion also appear comparable to open series [4–6].

We will discuss in detail the extracorporeal techniques of a Studer orthotopic neobladder, Indiana pouch continent cutaneous urinary diversion, and ileal conduit urinary diversion. At our institution, we have performed more than 250 RARCs. All urinary diversions were performed extracorporeally and the majority were continent urinary diversions. We describe our technique that follows a common template, which can be applied to all types of urinary diversion.

We first describe the technique of the Studer orthotopic neobladder. This is the most technically difficult of the three diversions because there are more maneuvers required to adapt it to robotic surgery, and because the robot needs to be re-docked. The Indiana pouch and ileal conduit techniques are simpler variations of the same basic template. The port site placement used for the cystectomy portion and referenced later in this chapter has been previously described [7].

14.2 Studer Orthotopic Neobladder

The extracorporeal Studer neobladder technique is best described in three stages: steps performed prior to undocking the robot, steps performed while the robot is undocked, and steps performed when the robot is re-docked.

14.2.1 Steps Performed Prior to Undocking the Robot

During the course of the radical cystectomy, there are a number of maneuvers that facilitate the creation of the neobladder. We typically divide our ureters early in the operation. The ureters are divided between extra large Weck Hem-o-lok® clips. The clips have a pre-tied 8-cm dyed or un-dyed suture to denote left and right. The clips are placed on the ureter through the right iliac 12-mm bedside assistant's port in a right to left

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orientation. This allows us to identify any twists in the ureter at the time of the uretero-ileal anastomosis. The ureteral sutures are placed aside, out of the operative field, during the completion of the cystectomy.

As the urethra is divided, we place a 9-in. 2-0 Vicryl™ (Ethicon, New Brunswick, NJ) suture at the 6 o'clock position of the urethra that will be used for the first stitch in the urethral anastomosis. The needle is set aside in the retropubic fat so that it can be easily found when the robot is re-docked for the anastomosis.

Once the cystectomy and lymph node dissection are complete, there are a small number of final steps performed prior to undocking the robot. The left ureter is brought under the sigmoid mesentery by guiding the attached suture with a laparoscopic grasper. An 8-cm silk stitch is placed in the terminal ileum to allow for quick identification through the small midline incision. A 16-Fr red Robinson catheter with an 8-cm silk suture pre-tied to the end is placed in the urethra. The catheter will later be sutured to the neobladder to serve as a handle for the assistant to bring the assembled neobladder down into the pelvis. The two ureteral sutures, the ileal suture, and the red Robinson suture are then placed into the assistant's laparoscopic grasper by the console surgeon. This allows for all four of the components to be readily available for the urinary diversion when the robot is undocked and the midline incision is opened.

14.2.2 Steps Performed After Undocking the Robot

The robot is undocked but kept sterile as it will be used for the urethral anastomosis. The gas is turned off and all port sites are kept in place with the exception of the midline port. We keep the patient in Trendelenburg position to keep the small bowel out of the way during the neobladder construction. The midline incision is extended inferiorly 6–8 cm, and the specimen is extracted using an Endo Catch™ II 15-mm specimen pouch (Covidien, Mansfield, MA). The use of the specimen bag serves to preserve the intact specimen and to also facilitate using a smaller incision. While the specimen can be removed through a generally smaller incision, 6 cm is approximately the smallest incision that allows us to place the constructed neobladder back into the abdomen.

The laparoscopic grasper holding the sutures on the ureters, ileum, and urethral catheter is brought out through the midline incision. The ureters are placed in their correct anatomic orientation, using both visual and manual evaluation to check for twisting or crisscrossing of the ureters.

The ileum is then brought out through the incision to create the ileal neobladder. For orthotopic diversions, we prefer a low-pressure ileal reservoir as described by Studer; however, this technique will also accommodate most other types of orthotopic diversion [8].

Prior to the construction of the reservoir, bowel continuity is restored by means of a stapled anastomosis and the mesenteric trap is closed.

We isolate a 60-cm segment of distal ileum beginning 15 cm proximal to the ileocecal valve. We prefer to discard a 5-cm segment of ileum proximally to afford us better mobility of the neobladder down to the urethra and farther from the bowel anastomosis (Fig. 14.1). The neobladder is constructed in the exact manner as would be done open.

Once the neobladder is complete, we estimate the most dependent portion where we think the urethra will be anastomosed. We place a dyed 0 Vicryl™ figure-of-eight suture at the estimated 6 o'clock portion of the neourethra that will be used as a handle by the console surgeon's fourth arm using a ProGrasp™ forceps (Fig. 14.2). An additional suture is placed in the same position and sutured to the red Robinson catheter that is in the urethra. This acts as an additional handle for the bedside assistant to help bring the neobladder down into the pelvis. An un-dyed Vicryl™ is placed at the 12 o'clock portion of the neourethra to give the console surgeon better orientation of the pouch and to provide an additional handle with which to manipulate the pouch.

The neobladder is then placed into the pelvis with only the afferent limb and bilateral ureters exposed at the midline incision (Fig. 14.3). An Adson-Beckman retractor is sometimes

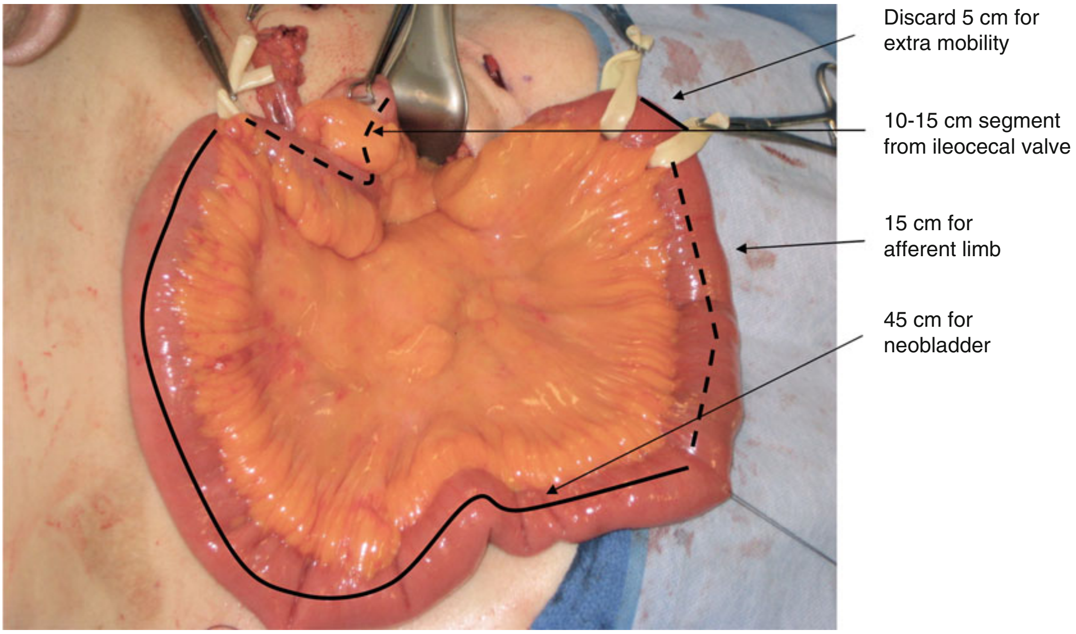

Fig. 14.1 The 6-cm incision provides excellent exposure of small bowel for neobladder reconstruction

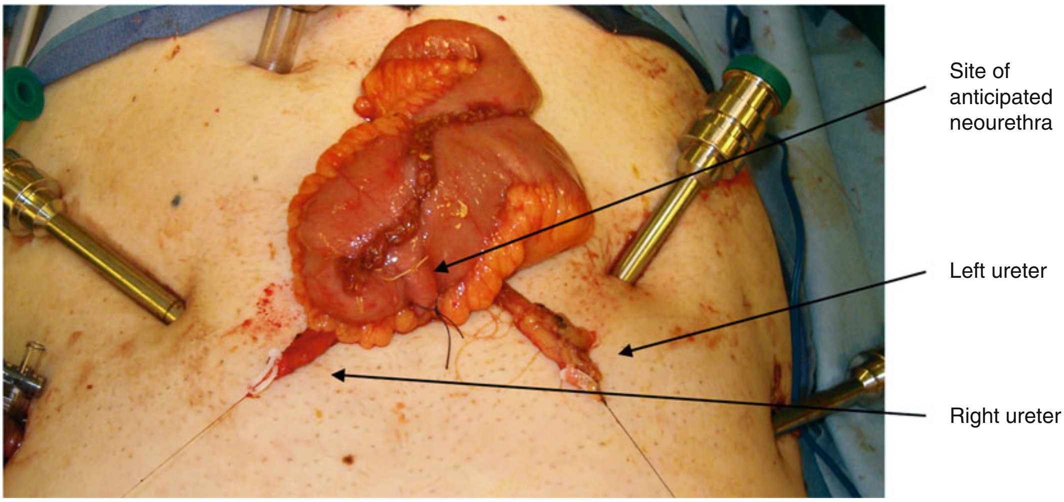

Fig. 14.2 The neobladder is completed with the 6 and 12 o'clock sutures placed at the site of the anticipated neourethra

used to improve exposure for the uretero-ileal anastomosis.

The ureters are once again inspected to ensure they are oriented in their correct anatomic positions. Each ureter is then spatulated and individually sewn in an end-to-side fashion with interrupted 4-0 Vicryl™ sutures. Each uretero-ileal anastomosis is stented with an 8-Fr feeding tube that is brought out through an opening in the afferent limb and beside the right paramedian robotic port. The feeding tubes are secured at the afferent limb with a 3-0 plain gut purse-string suture.

The midline incision is then closed to the level of the camera port site. We utilize four pre-placed interrupted size one polypropylene sutures at the

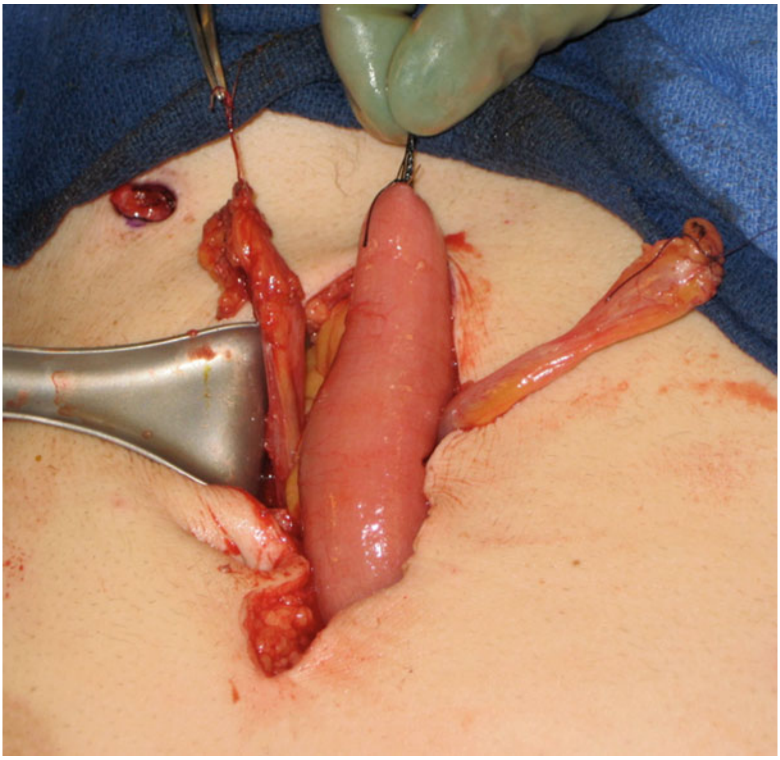

Fig. 14.3 The completed neobladder is placed back into the abdomen, leaving only the ureters and afferent limb exposed for the uretero-ileal anastomoses

superior aspect of the incision where the camera port is replaced. We are then able to tie down one or two of the interrupted sutures with the port in place to ensure an airtight seal for re-insufflation. The robot is then re-docked.

14.2.3 Steps Performed After Re-docking the Robot

The urethral anastomosis is performed robotically using either a 0° or 30° down lens. We first inspect the uretero-ileal anastomoses to ensure they are lying in their correct orientation.

The redundant sigmoid colon is moved out of the pelvis. The neobladder is then brought down into the pelvis by the console surgeon using the pre-placed 6 o'clock Vicryl™ handle and the fourth arm. The assistant can aid in the maneuver by placing gentle traction on the red Robinson catheter that is also attached to the 6 o'clock position of the neobladder.

Occasionally, the neobladder does not completely reach the urethra, creating tension at the anastomosis. Two maneuvers can be employed to decrease this tension. The first is simply perineal pressure. The second is to undock the robot, minimize the Trendelenburg, and re-dock the robot.

The site of the urethral anastomosis on the neobladder is opened using a robotic shears. This site is determined by choosing an area where the opening is well visualized and easy to work with.

Using the 2-0 Vicryl™ suture that was pre-placed at the 6 o'clock position of the urethra at the time of the urethral division, we begin the urethral anastomosis by re-approximating the urethral plate with 3–4 interrupted sutures. Additional 3-0 Vicryl™ sutures are placed at the 5 and 7 o'clock positions and run anteriorly to be tied at 12 o'clock. We typically use CT-3 needles for the urethral anastomosis, but RB-1 needles are sometimes used in very narrow pelvises.

The completed anastomosis is tested by irrigating the neobladder with 60–120 ml of normal saline. Any visible area of extravasation from either the neobladder or the anastomosis is reinforced with an additional 3-0 Vicryl™ suture.

A new two-way 18-Fr hematuria catheter is placed into the neobladder to gravity drainage.

A closed suction drain is placed through the left paramedian robotic port and placed over the urethral anastomosis and adjacent to our uretero-ileal anastomoses. The drain and stents are secured with sutures. The robot is then undocked. The closure of the midline incision is completed with the pre-placed polypropylene sutures. The stents are cut 5 cm from the skin and placed to gravity drainage using a urostomy drainage bag, and the skin incisions are closed.

14.3 Indiana Pouch Continent Cutaneous Catheterizable Reservoir

With the Indiana pouch, minimal steps are required prior to undocking the robot. As with the neobladder, the ureteral sutures are secured with a laparoscopic grasper through the right iliac port.

We undock the robot but keep the abdomen insufflated with all ports in place. The Trendelenburg is decreased and the table tilted left as far as possible. Using our existing port placements, we use a conventional laparoscopic technique to mobilize the right colon and hepatic flexure.

The table is then leveled, the ports are removed, the midline camera incision is extended inferiorly 7–8 cm, and the specimen is removed. This incision is larger than the incision made for the neobladder because the pouch tends to be bigger and this also allows us better exposure for the uretero-colonic anastomoses. In obese patients, the size of this incision may need to be further increased to optimize exposure.

We isolate the 15 cm of proximal ileum along with 31 cm of right colon (Fig. 14.4). The avascular plane of Treves is divided to allow mobility to our stomal segment. Bowel continuity is then reestablished using a side-to-side ileal-colic-stapled bowel anastomosis. The mesenteric trap is then closed.

We perform a modified Indiana pouch as described by Ahlering et al., but this technique can be adapted to most continent catheterizable pouches [9]. We use a 24-Fr Malecot catheter as a suprapubic catheter that exits out the most superior aspect of the Indiana pouch and is brought out through the assistant's epigastric port site. The suprapubic tube is secured to the anterior abdominal wall in a Stamm fashion. The right paramedian robotic port site is then used as the stoma location, provided it is traversing the rectus abdominus. If the suprapubic port site is too high, it can distract and place tension on the ureteral anastomoses. In this situation, we use the right paramedian robotic port site for the suprapubic tube, and create a separate more inferior opening for the stoma.

The ureters are anastomosed to the Indiana pouch separately in an end-to-side fashion and stented with 8 French feeding tubes. The stents are secured at an opening in the Indiana pouch with a 3-0 plain gut suture and brought out through the right iliac port site. The stents are secured at the skin with a suture and placed to a urostomy gravity drainage bag. A closed suction drain is placed along the pouch and adjacent to our uretero-colonic anastomoses and brought out through the left paramedian robotic port site. The stoma is dressed with a petroleum dressing and not cannulated until the time of pouch training. The midline incision is then closed.

14.4 Ileal Conduit Urinary Diversion

Prior to undocking the robot, as with the neobladder, the ureteral and ileal sutures are secured on a laparoscopic grasper through the right iliac port. The ports are then removed and the midline camera port site is extended 4–5 cm. This incision can be smaller since it does not have to accommodate a pouch. The specimen is removed and the ureters and ileum are brought out through the incision and oriented.

We isolate our distal ileal segment in the conventional open fashion, discarding an additional 5-cm segment of ileum proximally to give us additional mobility of the afferent aspect of our conduit. Bowel continuity is reestablished with an ileal-ileal side-to-side stapled anastomosis.

Our uretero-ileal anastomoses are performed using a Bricker end-to-side spatulated

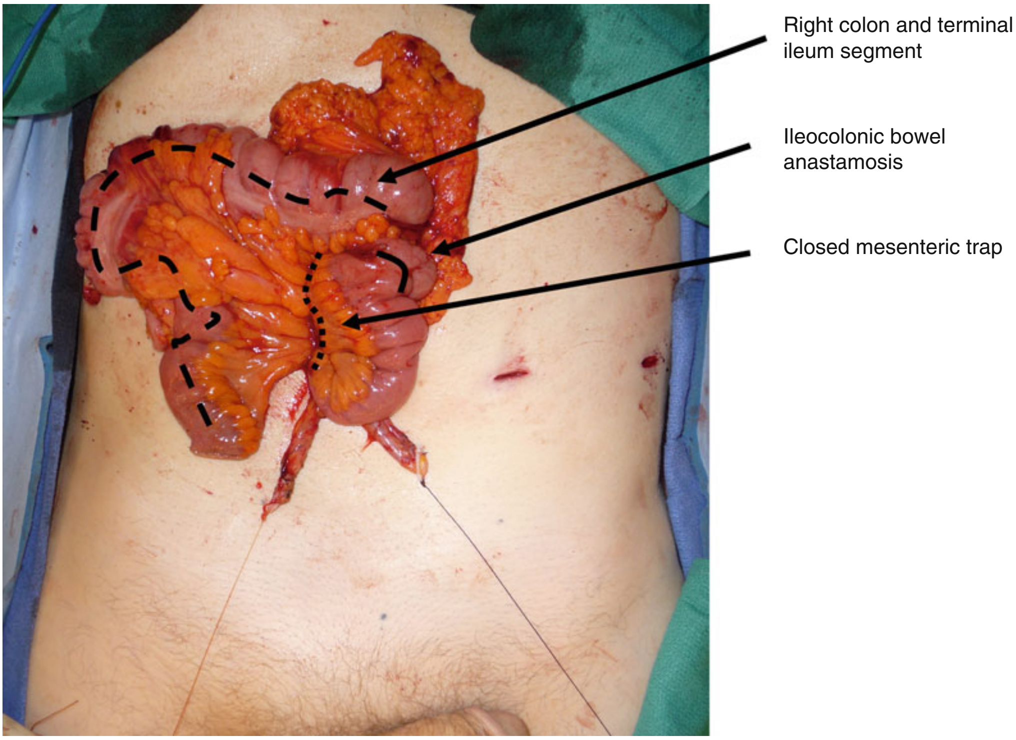

Fig. 14.4 An 8-cm midline incision allows excellent exposure of the right colon and terminal ileum for Indiana pouch construction. Here, the ileal-colic anastomosis is completed and the mesenteric trap closed

anastomosis bilaterally. We mature the stoma and place our closed suction drain into the pelvis and adjacent to our uretero-ileal anastomoses. Our stents are brought out through the stoma and secured with a suture. The midline incision is then closed.

14.5 Postoperative Care

Patients are placed on Alvimopan prior to the induction of anesthesia and continued on this postoperatively until first bowel movement. Nasogastric tubes are removed at the end of surgery or on the morning of postoperative day 1. Clear liquid diets are started with the resumption of flatus. Patients are discharged home when tolerating a regular diet. The closed suction drain is typically removed at the time of discharge if outputs stay at or below 200 ml/8 h.

For the continent diversions, a pouchogram is obtained at 3 weeks after surgery, and the urinary or suprapubic catheter and stents are removed if no extravasation is identified. A renal ultrasound is obtained 6 weeks after stent removal as a baseline evaluation of the upper tracts.

14.6 Advantages and Disadvantages of Extracorporeal Urinary Diversion

The key advantage of extracorporeal urinary diversion compared to the intracorporeal technique is the utilization of open suturing. This results in a shorter learning curve, operative times comparable to open procedures, less time under general anesthesia for the patient, and ultimately less cost. Other advantages include minimizing fecal contamination of the peritoneal cavity and minimizing surgeon fatigue.

The main disadvantage of the extracorporeal urinary diversion is the need for a larger incision (typically ranging from 5 to 8 cm) which can lead to poorer cosmesis and theoretically a higher pain medication requirement. Another potential problem cited with the extracorporeal technique is impaired tissue orientation/positional distortion and the need for considerable mobilization of the ureters, both of which may contribute to ischemia and possible ureteral stricture. Other disadvantages include increased evaporative fluid loss and external bowel manipulation, both of which may contribute to ileus.

14.7 Complications and Outcomes

As the technique of RARC matures, we are seeing complication rates at least comparable to open surgery [1, 2, 4]. However, there is a paucity of data looking at functional outcomes with extracorporeal orthotopic and cutaneous continent urinary diversion in the RARC setting. We evaluated 44 patients undergoing an extracorporeal orthotopic Studer neobladder and found a 78 % daytime continence rate [5]. In our evaluation of 24 patients undergoing extracorporeal Indiana pouch urinary diversion, all 24 patients achieved complete continence [6]. While the data is still limited, it appears that both complications and functional outcomes with extracorporeal urinary diversion are comparable to open techniques.

Conclusion

The extracorporeal urinary diversion technique provides an effective and smooth transition from open radical cystectomy to the labor-intensive technique of RARC. We expect that with refinements in technology and surgical technique, complication rates and functional outcomes will continue to improve upon existing open surgical standards.

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Robot-Assisted Laparoscopic Ureteral Reimplantation

15

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15.1 Introduction

Clinical indications for ureteral reconstruction include strictures, trauma (often iatrogenic), vesicoureteral reflux (VUR), fistulas and malignancy. Traditional open surgery remains the gold standard for ureteral reimplantation with good long-term results (success rates over 90 %) [1–3]. Short ureteral defects can be managed by uretero-ureterostomy or ureteroneocystostomy. Longer defects require complex procedures such as psoas hitch ureteral reimplantation often combined with a Boari flap.

Laparoscopy provides patients the advantages of quicker recovery, low postoperative morbidity, less postoperative pain, less blood loss and better cosmetic results [4–7]. Successful results using laparoscopic ureteral reimplantation have been reported in the literature to treat both benign and malign diseases [7–13].

However, with the advent of robotic surgery, these procedures began to be performed with robotic assistance. Conventional laparoscopic surgery has some limitations like lack of three-dimension (3D) vision, poor manoeuvrability and ergonomic movement of instruments which lead to a difficulty in intracorporeal suturing. Due to clutch function and the sitting position of the surgeon, robotic assistance really offers beside significant technical advantages ergonomic working position for the surgeon. The da Vinci® surgical robotic system (Intuitive Surgical Inc., Sunnyvale, CA) is being increasingly used to perform complex reconstructive urologic surgeries. The feasibility of robotic assisted laparoscopic (RAL) Cohen cross-trigonal ureter reimplantation in VUR procedure was investigated in animal model by Olsen et al. in 2003 [13]. After Yohannes et al. published the first case of robot-assisted laparoscopic ureter reimplantation (RALUR) for a left distal ureteral stricture [14], an increased number of cases were reported with using robotic technology in direct ureter reimplantation or Boari flap, with or without psoas hitch [15–27]. The advantages of robotic surgery like three-dimensional visualisation, increased degree of freedom in movement and avoiding physiologic tremor, especially in the dissection and suturing of the anastomosis in the narrow small pelvis, can overcome limitations of conventional laparoscopy.

15.2 Indications

Clinical indications for RALUR are ureteral strictures, iatrogenic injuries, VUR, ureterovaginal fistulas and low-grade distal urinary tract transitional cell carcinoma.

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15.3 Surgical Technique

Our technique for robotic ureter reimplantation is based on the transperitoneal approach. We are using compression socks to lower extremities and prophylactic antibiotics (second generation cephalosporin) before the operation.

Under general anaesthesia, a 16-F Foley catheter is inserted in the bladder with the patient placed in supine position, the legs are slightly abducted (lithotomy position) and all pressure points padded. The skin is incised over 15 mm transversely just below the umbilicus, and the pneumoperitoneum approach is performed by using either a Veress needle or Hasson technique (Fig. 15.1a, b). We prefer a supraumblical incision for the ureter strictures above the iliac crest. After creation of a pneumoperitoneum (15 mmHg, maximum flow: 15 L/min), a 12-mm optic port is placed below the umbilicus. The trocars are placed under direct vision using a 30° binocular lens, as shown in Fig. 15.1. The 8-mm Da Vinci trocars are placed along the lateral border of the rectus muscle 2–3 cm below the level of the infraumbilical camera access.

Two (5-mm left and 10-mm right) accessory ports are placed in upper abdomen a few centimetres above the medial Da Vinci trocars under endoscopic vision. The patient is than placed in a Trendelenburg position, and the robot is docked like in robotic prostatectomy.

In case of sufficient ureteral length the modified Lich–Gregoir technique, as used by transplant surgeons, offers the advantage of minimal bladder opening. Another alternative represents the Politano–Leadbetter type of ureteral implantation with mucosal flap or the classical submucosal tunnel. In case of a short ureter, a Boari flap may become necessary. In all these modifications, we emphasise a vesico-psoas hitch to stabilise the anastomosis.

15.3.1 Ureteral Dissection

The console surgeon operating with a bipolar forceps on the left arm and a monopolar scissors on the right. The peritoneum is incised on the psoas, above the level of the iliac vessels and the ureter is isolated stepwise until the stricture site could be identified (Figs. 15.2 and 15.3). In tumor cases, the distal part is ligated with Hem-o-lock clips, excised completely down to the bladder and sent for a frozen section, confirming the absence of residual tumor. The ureter is spatulated using the right-curved scissors (Fig. 15.4).

15.3.2 Mobilisation of the Bladder

The anterior peritoneum is incised anteriorly and the retropubic space of Retzius entered. The bladder is filled with 250 ml normal saline and the Retzius space improved by blunt dissection, followed by division of both lateral umbilical ligaments.

15.3.3 Vesico-Psoas Hitch with/without Boari Flap

The fixation of the bladder on the psoas tendon is performed using the needle holder on the right side. We used 3–4 interrupted sutures (Vicryl 3-0, SH needle, 15 cm) for hitching the bladder with a slide-knot technique (Fig. 15.5). If necessary, a Boari flap is created starting about 3 cm from the bladder neck and extending to the dome. The flap is also fixed to the psoas muscle with the anterolateral surface of the bladder serosa.

15.3.4 Creation of Submucosal Tunnel and Ureteral Anastomosis

To create a nonrefluxing ureteroneocystostomy, a submucosal tunnel of 3-cm mucosa flap is formed starting at the medial rim of the hitched bladder using robotic-assisted scissors. Thereafter, the ureter is spatulated and anchored to the detrusor muscle at the caudal end of the flap by using interrupted sutures (Vicryl 3-0, RB needle, 15 cm) and then covered by the flap, thereby creating a submucosal tunnel. In some cases, the ureter can be anastomosed to the bladder (i.e. Boari flap) with interrupted sutures. A guide wire is passed retrogradely in the ureter followed by placement

Fig. 15.1 **(a, b)** Trocars and patient positioning for robotic ureteral reimplantation

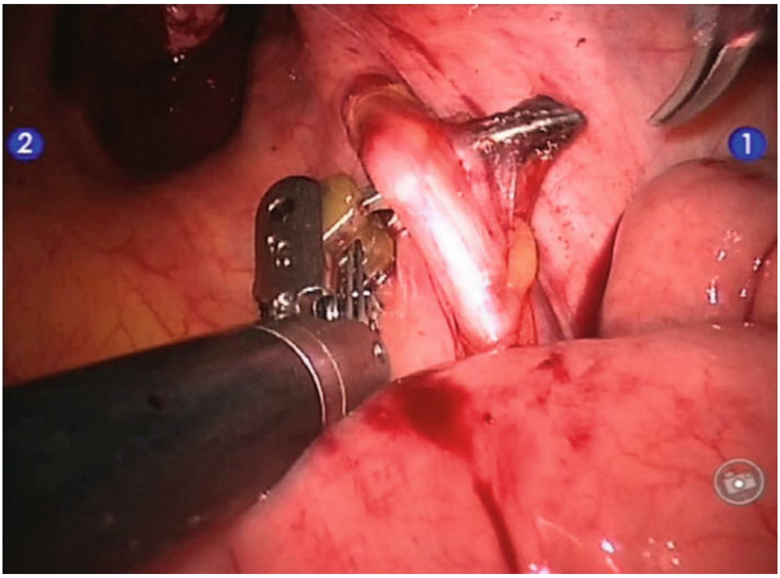

Fig. 15.2 Robotic preparation of the left ureter

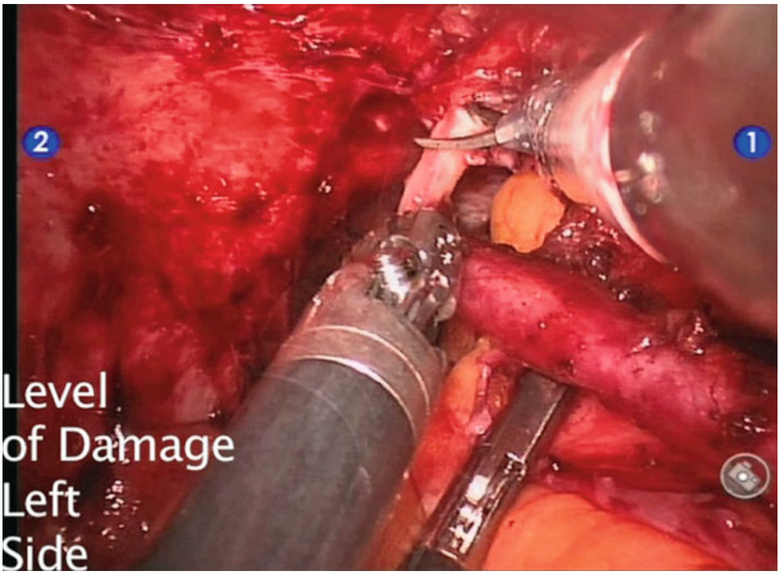

Fig. 15.3 The ureter is isolated stepwise until the stricture site could be identified

of a 6 F open-end pigtail catheter (Figs. 15.6 and 15.7). In some cases to placing the pigtail catheter preoperatively can facilitate this step.

15.3.5 Modified Lich–Gregoir Technique

Incision of detrusor fibres is carried out with a round tip scissors in order to create a 2–2.5-cm detrusor incision. Haemostasis is achieved with fine application of bipolar cautery (Maryland grasper) and care is taken to identify and avoid any injury to the bladder mucosa (Fig. 15.8).

The mucosa to mucosa anastomosis is performed after minimal opening of prepared bladder mucosa on the cranial end using 4/0 single PDSII sutures. The detrusor muscle is approximated over the underlying ureter anastomosis. Simple interrupted sutures of 3/0 Vicryl are

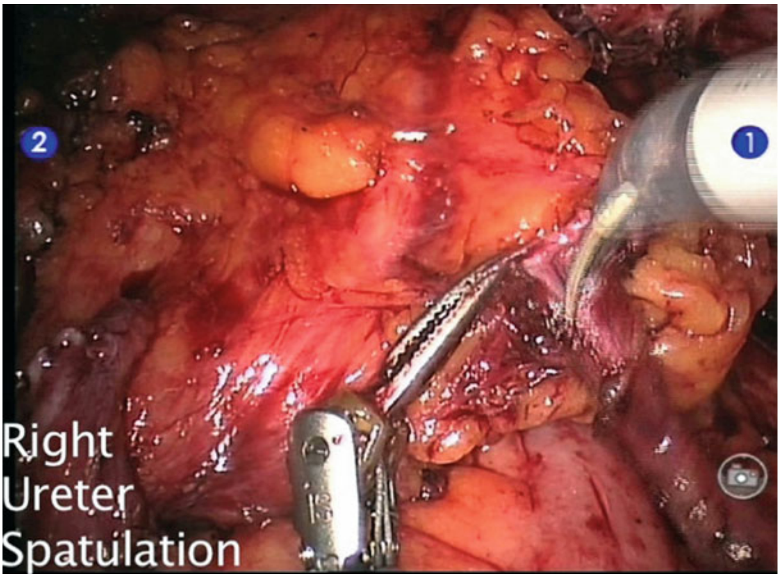

Fig. 15.4 Spatulation of right ureter using Maryland grasper and curved scissors

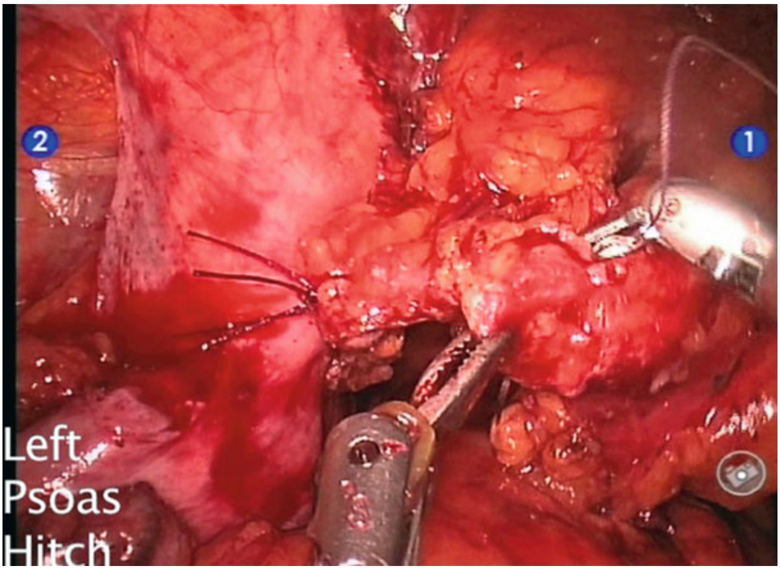

Fig. 15.5 Performing the psoas hitch on the left side

used to approximate the detrusor muscle (Fig. 15.9).

15.3.6 Closure of the Bladder

Tubularisation of the Boari flap is accomplished with interrupted (Vicryl 3-0, SH needle) sutures. Closure of the bladder performed in continuous fashion using barbed polyglyconate sutures (V-Loc 180^{TM}; Covidien, Tyco Healthcare Group, Norwalk, Connecticut, USA). The bladder peritoneum is wrapped around the anastomotic site to prevent extravasation (Fig. 15.10). Water tightness is confirmed by filling the bladder with 300-ml saline via the indwelling Foley urethral catheter. A drain is placed at the site of the anastomosis.

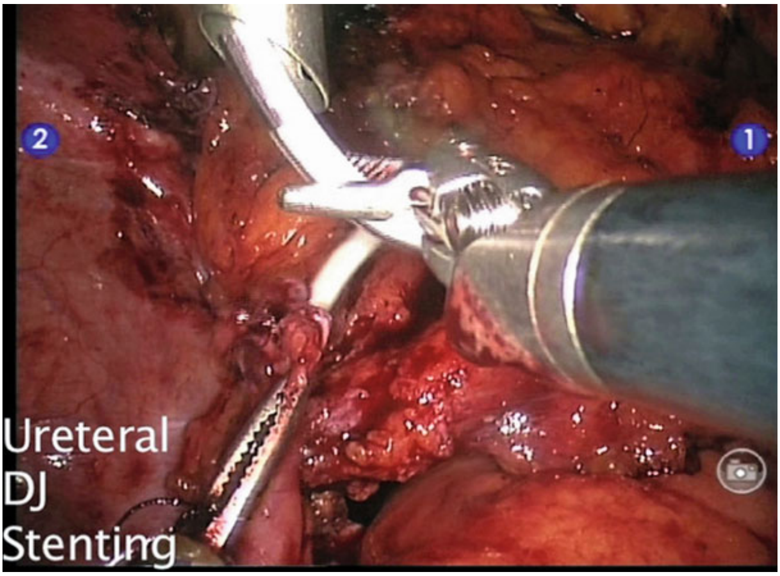

Fig. 15.6 Intraoperative stenting the left ureter using right needle holder and left grasper

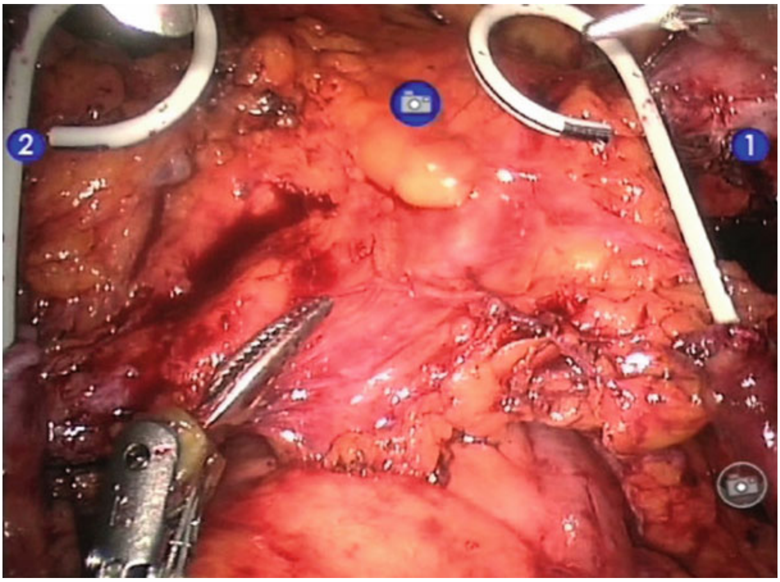

Fig. 15.7 Bilateral ureter stenting before the reimplantation

15.4 Procedures and Outcomes

15.4.1 Vesicoureteral Reflux: Management

The standard surgical treatment of VUR is ureteral reimplantation either transvesical or extravesical. Peters et al. first published his experience in bilateral VUR repair with intravesical reimplantation using robotic assistance. Ports are placed in the dome of the bladder, and the procedure is performed in a fashion identical to that used for open transtrigonal (Cohen) reimplantation [16]. The newly developed voiding dysfunction, which can be up to 10 %, is an annoying complication of extravesical reimplantation. Casale et al. published a nerve-sparing robotic extravesical ureter reimplantation of 41 patients having bilateral VUR

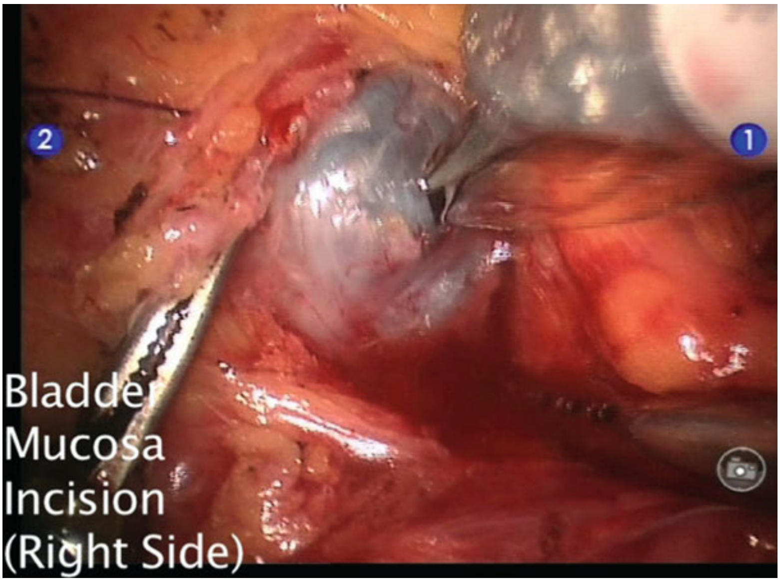

Fig. 15.8 Incising the bladder mucosa for the reimplantation (Lich-Gregoir)

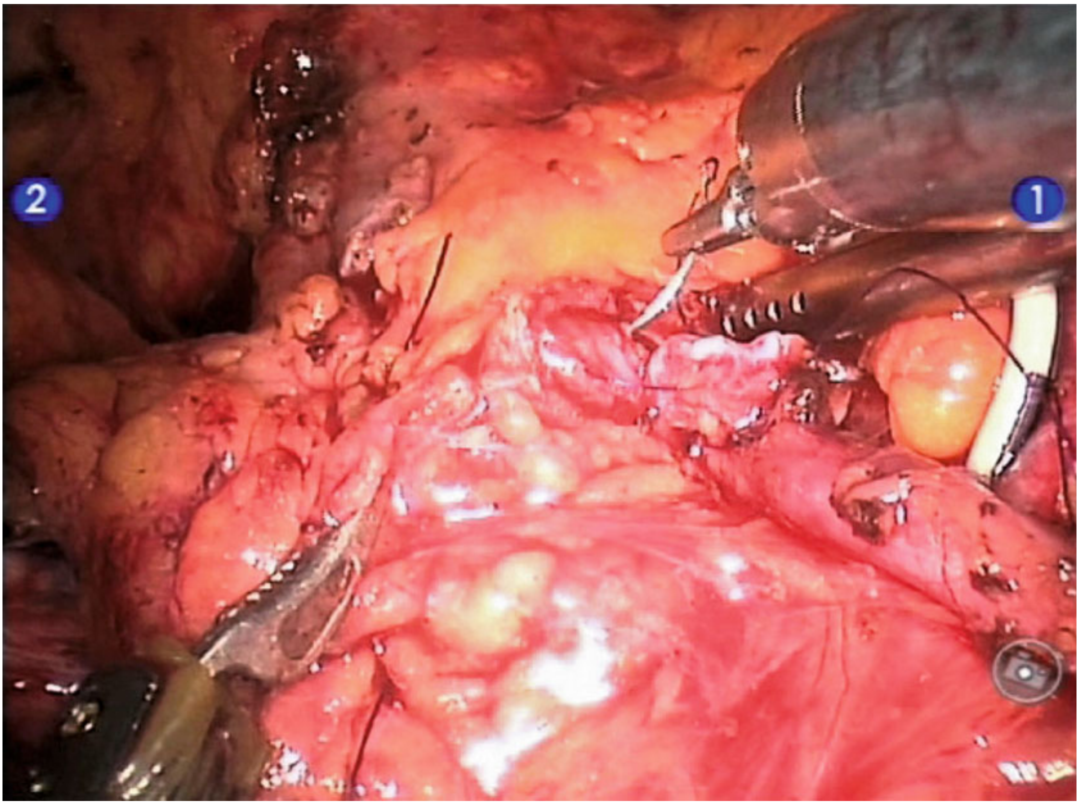

Fig. 15.9 The detrusor muscle is approximated over the underlying ureter anastomosis. Using simple interrupted 3/0 Vicryl sutures

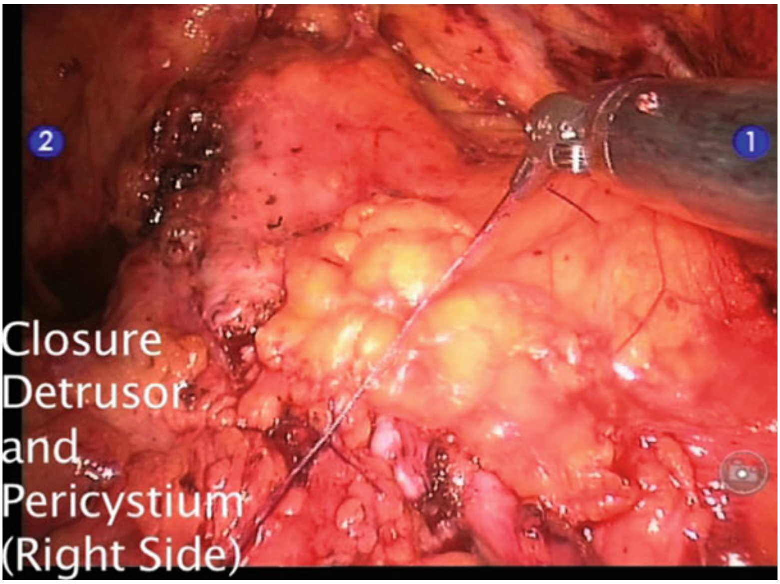

Fig. 15.10 Closing the bladder and confirming the water tightness by filling the bladder with saline

with a success rate of 97.6 % and observed no postoperative urinary retention [11]. In another series of 16 extravesical RALUR in children, there were three reflux failures or reflux downgrades, with one mild urinary retention and one urinary leakage [17]. In a comparative study with 19 intravesical and 20 extravesical RALUR compared with 22 intravesical and 17 extravesical open ureter implantation, there were no difference between success rates of RALUR and open ureteral implantation. Although patients undergone intravesical robotic-assisted reimplantation had a shorter duration of urinary catheter drainage, fewer bladder spasms and a shorter hospital stay compared to those who undergone the intravesical open technique, there were no difference in these parameters between the extravesical techniques [27].

15.4.2 Boari Flap Procedure

Laparoscopic creation of Boari flap was first described in 2001 by Fugita et al. After using robotic assistance in reconstructive operations, Schimpf et al. published a case of robotic assisted laparoscopic Boari flap ureteral reimplantation. In 2009, they also published a series of 11 patients who underwent RAL distal ureteral surgery for different aetiologies. They used Boari flap in two cases; one for recurrent ureteral stricture and the other for ureteral cancer. In ureteral stricture case, they had an external iliac vein injury during the sharp dissection due to inflammation adhering the ureter to the vein and repaired it robotically [23]. Another single institutional pilot experience was published by Allaparthi et al. for distal ureteral low-grade urothelial cancers. They had no operative or postoperative complications and good oncological results in a median follow-up of 6 months [24]. These limited cases show RAL Boari flap reconstruction is safe and feasible with the advantages over conventional laparoscopy like facilitation of intracorporeal suturing, three-dimensional visualisation, improved ergonomics and freedom of movement.

15.4.3 Psoas Hitch Ureteral Reimplantation

Ureter reimplantation can be combined with a psoas hitch or Boari flap to gain additional length when ureteral length is insufficient for direct reimplantation. Psoas hitch elevates the ipsilateral part of the bladder which is important for a tension-free anastomosis to prevent an anastomotic stricture in open and laparoscopic procedures. Uberoi et al. first described the technique for RAL distal ureterectomy and reimplantation with psoas hitch for a distal ureteral carcinoma [19]. Glinianski et al. reported distal ureterectomy and ureteral reconstruction with psoas hitch in nine patients with ureteral carcinoma. In this series, only six patients needed a psoas hitch; three had a reimplantation into the bladder dome without psoas hitch. The mean overall follow up was 23 months. One patient presented a partial stricture at the ureteral anastomosis, and one patient presented recurrence involving the liver, retroperitoneal nodes and omentum 28 months after the operation. There is a concern of tumor seeding in minimal invasive surgeries, and care should be taken to avoid spillage of tumour at least by clipping the distal and proximal edges of the tumor [20]. Patil et al. published the largest series of RALUR with psoas hitch in 2008. It was a multi-institutional and multinational series including ten ureteral strictures and two ureterovaginal fistula indications for ureteral reimplantation. The results were successful after a mean follow-up of 15.5 months [21].

15.4.4 Tapered Ureteral Reimplantation for Megaureter

Hemal et al. firstly described the robotic repair of obstructive megaureter in a series of seven patients. They performed all the cases robotic assisted and in transperitoneal fashion, except the two who had needed an extracorporeal ureteral tapering. The total mean console time was 127.5 min (100–210 min). They had only one perioperative urinary tract infection and good functional results with an average follow-up time of 16 months. The tapering was done only in the terminal 5–7 cm of the distal ureter over a 10-F feeding tube or ureteric catheter inserted through one of the 5-mm assistant port [25]. Recently, Goh and Link presented a case with a total operative time of 262 min and used an additional third robotic arm for upward traction of ureter dissection [26].

15.5 Complications and Management

Intraoperative complications include urinary extravasation/bladder injury, excessive bleeding, ureteral injury and pelvic or abdominal organ injury. Vessel (external iliac vein injury) and intestinal injuries can be managed with robotic suturing [23]. Postoperative bladder urine extravasation and also voiding dysfunction, especially after bilateral extravesical reflux surgery, should be treated with indwelling urethral Foley catheter or with a percutaneous suprapubic tube [17, 27]. The most common complications after the operation are ureteral leakage. These patients were treated with placement of a Double-J stent for 2–4 weeks [27]. Stricture formation is another complication resulting from either ischemia or excessive tension of the anastomosis. Ureteral stricture after RALUR with psoas hitch was reported in one case with ureteral cancer. The stricture was managed with balloon dilatation, but after the stricture recurrence, periodic stent changes were performed considering of advanced age and comorbidities [20]. Complications in the literature are summarised in Table 15.1. In our opinion, the magnification and easy suturing in robotic assisted surgery may decrease the complications during ureteral reimplantation, but large and long follow-up needed to evaluate these advantages.

Conclusion

Laparoscopic ureteral reimplantation is technically demanding even for experienced surgeons, and each case represents a different challenge based on aetiology and location of the stricture. Despite the difficulties of the procedure, magnification and high-definition visualisation allow a clear identification of ureter and bladder as well as of the surrounding tissues.

RALUR is safe and feasible with the clear advantages over conventional laparoscopy like three-dimensional visualisation and increased degree of freedom, especially during dissection and suturing. Due to clutch function and sitting position of the surgeon, robotic assistance offers significant technical and ergonomic advantages particularly in bilateral cases.

Table 15.1 Summary of robot-assisted laparoscopic ureteral reimplantation (RALUR) series in literature

References	Number of cases	Diagnosis	Surgery type	Success rate (%)	Complications
Peters and Woo [16]	6	Vesicoureteral reflux	Intravesical bilateral RALUR	83.3	Urine leakage (n:1)
Cascale et al. [11]	41	Vesicoureteral reflux	Nerve sparing extravesical RALUR	97.6	None
Patil et al. [21]	12	Ureteral stricture (10) Ureterovaginal fistula (2)	RALUR with psoas hitch	100	None
Lendvay [17]	16	Vesicoureteral reflux	Extravesical RALUR	81.2	Urinary retention (n:1) Urine leakage (n:1)
Glinianski et al. [20]	9	Ureter cancer	RAL distal ureterectomy and UR (n:1) RALUR with psoas hitch (n:6)	100	Ureteral stricture (n:1) Aspiration pneumonia (n:1 with large hiatal hernia)
Hemal et al. [25]	7	Primary symptomatic obstructive megaureter	RAL ureteric tapering and ureteroneocystostomy	100	Perioperative urinary tract infection with fever (n:1)
Schimpf and Wagner [23]	11	Ureter cancer (6)	RAL distal ureterectomy and UR (n:4)	100	External iliac vein injury (n:1) (repaired robotically)
		Bladder diverticulum (2)	RAL diverticulectomy and UR (n:2)		Ileus (no intervention) (n:1)
		Ureter obstruction (2)	RALUR with Boari flap (n:2)		Haematuria (fulguration) (n:1)
		Ureter injury (1)	RALUR with psoas hitch (n:3)		
Marchini et al. [27]	39	Vesicoureteral reflux	Intravesical RALUR (n:19)	92.2	Bladder leak (n:4)
			Extravesical RALUR (n:20)	100	Urinary retention (n:2) Ureteral leakage(n:2)

UR ureteral reimplantation, *RAL* robot-assisted laparoscopic

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Part V

Prostate

Surgical Anatomy of the Prostate for Radical Prostatectomy

16

Arnauld Villers, Thierry Piechaud, Jochen Walz,
and Yael Butet

16.1 Introduction

This chapter on prostate surgical anatomy for radical prostatectomy describes anatomic points and practical surgical options of fascial dissection. Clear understanding of the periprostatic fascia helps in identifying the correct planes of surgical dissection and in communication between surgeons. Recent results are related to the identification of the multilayered prostatic fascia (PF), which permits definition of dissection planes for complete oncologic excision of the prostate and preservation of both the external urinary sphincter responsible for urinary continence and the autonomic nerves responsible for erectile function and urinary control [1].

16.2 Pelvic Fasciae, Parietal and Visceral, and Their Surgical Importance

16.2.1 General Considerations

The pelvic fasciae are either parietal or visceral. The visceral fascia comprises the connective fatty tissue, with neurovascular supply located medial to the parietal/pelvic fasciae. It covers and is adherent to all surfaces of bladder, prostate, seminal vesicles, rectum, and pudendal vasculature. Its thickness varies according to the amount of vessels and nerves it contains. Consequently, this so-called visceral fascia is not a discrete structure but rather a connective and mainly adipose thick structure which does not fulfil the fascial definition. A fascia is defined as a discrete organized structure which can be grasped, identified on dissection, and separated as a whole from adjacent tissues. It has a function of covering, of enveloping membrane. It is made of connective layers of mesenchymal tissue (muscle and fibrous fibres). It is different from a sheath of adipose tissue surrounding neurovascular structures (as in the retroperitoneum or pelvic spaces). Surgical anatomy is based on gross tissue identification.

The parietal fascia, e.g., endopelvic fascia, fulfils the fascial definition. It can be divided sharply and released as a whole from adjacent structures. Whereas referring to this adipose multilayered tissue of the so-called visceral fascia as a fascia is not very convincing, it cannot be released as a whole

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from adjacent structures since it is adherent to the visceral pelvic organs such as bladder wall or prostatic stroma without entering into their muscular and fibrous fibres stroma. In that sense, one can refer to the so-called visceral fascia as an adipose meso- or visceral fibro-fatty sheath containing neurovascular supply to intrapelvic organs and corpora cavernosa. However, a consensus in the surgical literature is in favour of using the word fascia for visceral adipose multilayered periprostatic tissue (Figs. 16.1, 16.2, 16.3, 16.4, 16.5, 16.6 and 16.7).

16.2.2 Parietal Pelvic Fasciae

The fascial tendinous arch of the pelvis (FTAP) (arcus tendineus fasciae pelvis, TA) results in a thickening of parietal and visceral components of the pelvic fascia and stretches from the pubovesical (pubo-prostatic) ligaments to the ischial spine. When the levator ani (parietal or endopelvic) fascia is incised just lateral to the fascial tendinous arch of the pelvis, the bare levator ani muscle that overlies the obturator internus above and the ischio-anal fossa below appears laterally.

16.2.3 Visceral Prostatic Fasciae

The fascia covering the glandular surface of the prostate has been referred to as lateral pelvic fascia by Costello et al. [2], Takenaka et al. [3], and in the past by Walsh and Partin [4]. Myers and Villers [5], Stolzenburg et al. [6], and Tewari et al. [7] called the fascia next to the prostate the periprostatic fascia (PPF); Graefen et al. [8] and Budaus et al. [9], the para-pelvic fascia; and Menon et al. [10], Secin et al. [11], and, more recently, Nielsen et al. [12], the prostatic fascia. Located underneath the remnant levator fascia on the lateral surfaces of the prostate, the prostate visceral fascia where it is multilayered contains fat, smooth muscle, and collagen fibres. It is easier to identify grossly when nerves and vessels run among its layers. It consists of three parts (according to its location):

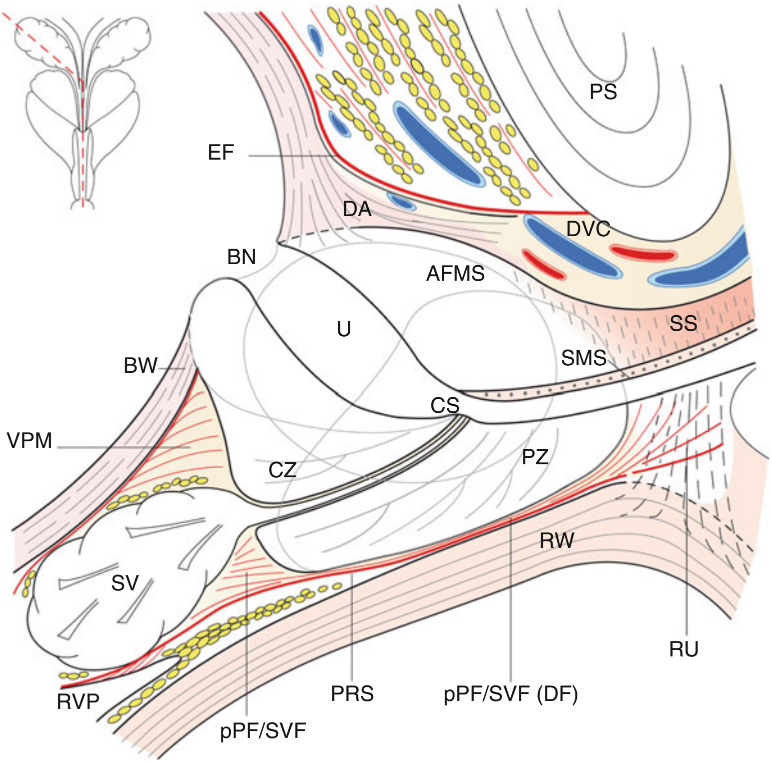

Fig. 16.1 Sagittal section of prostate, bladder, seminal vesicles, urethra, and periprostatic fasciae. *AFMS* anterior fibromuscular stroma, *BW* bladder wall, *BN* bladder neck, *CS* colliculus seminalis, *DVC* dorsal vascular complex, *EF* endopelvic fascia, *DA* detrusor apron, *RU* rectourethralis, *PS* pubic symphisis, *pPF/SVF (DF)* posterior prostatic fascia/seminal vesicle fascia (Denonvilliers' fascia), *PRS* prerectal space, *CZ* central zone, *PZ* peripheral zone, *RW* rectum wall, *RVP* rectovesical pouch, *SMS,* smooth muscle sphincter, *SS* striated sphincter, *SV* seminal vesicles, *U* urethra, *VPM* vesicoprostatic muscle

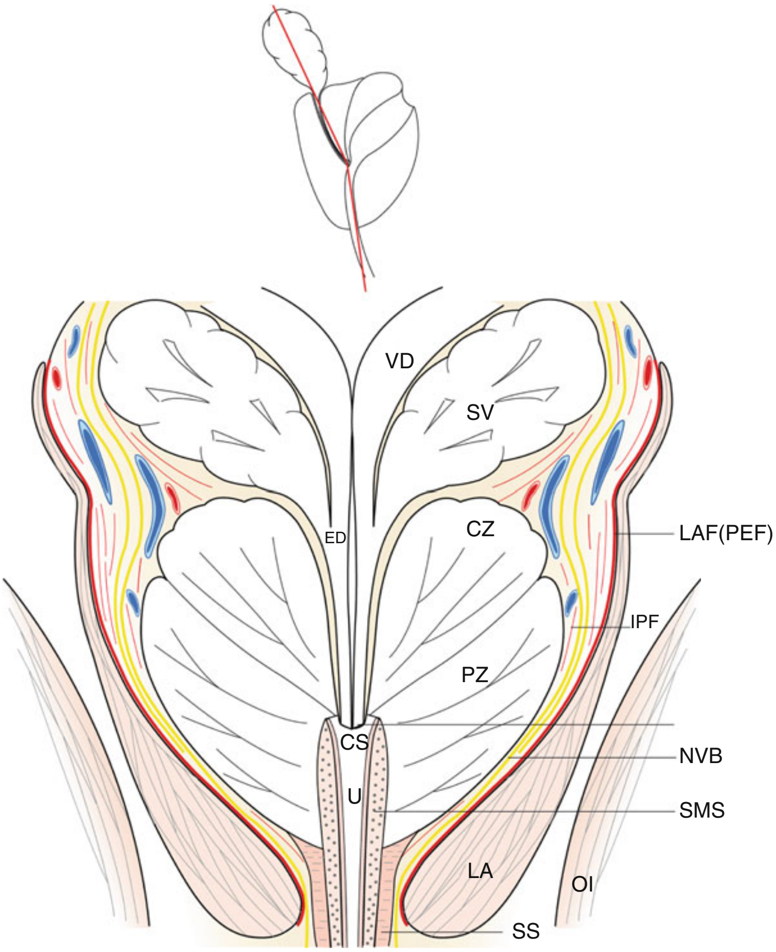

Fig. 16.2 Coronal section of prostate and periprostatic fasciae at the level of the colliculus seminalis. *VD* vas deferens, *PEF* prostatic endopelvic fascia, *SV* seminal vesicles, *ED* ejaculatory ducts, *CZ* central zone, *PZ* peripheral zone, *U* urethra, *CS* colliculus seminalis, *EPF* endopelvic fascia, *LA* levator ani, *LAF* levator ani fascia, *SMS* smooth muscle sphincter, *SS* striated sphincter, *NVB* neurovascular bundle, *OI* Obturator internus

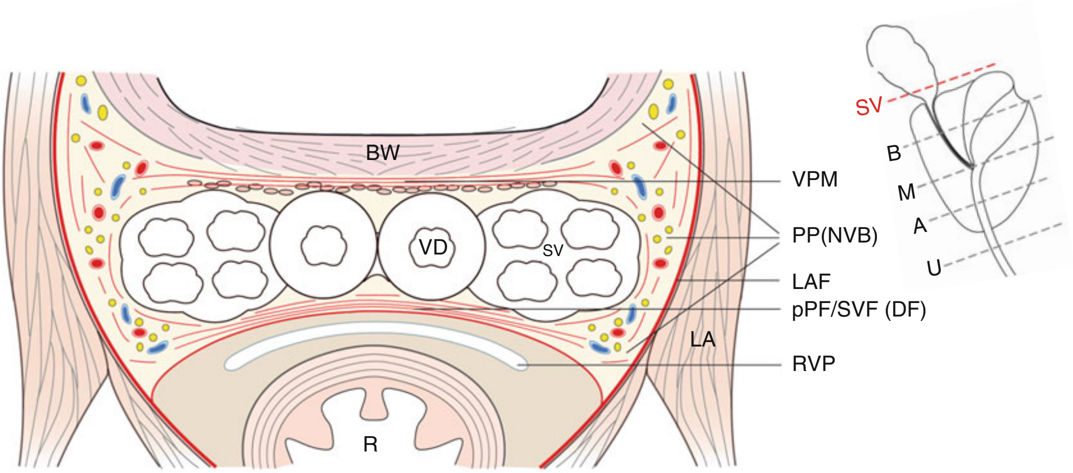

Fig. 16.3 Transverse section of seminal vesicles, bladder, and surrounding fasciae. *BW* bladder wall, *VD* vas deferens, *SV* seminal vesicles, *LA* levator ani, *LAF* levator ani fascia, *PP(NVB)* pelvic plexus (neurovascular bundle), *pPF/SVF* posterior prostatic fascia/seminal vesicle fascia (Denonvilliers' fascia), *R* Rectum, *RVP* rectovesical pouch, *VPM* vesicoprostatic , *B* base, *M* mid, *A* apex, *U* urethra

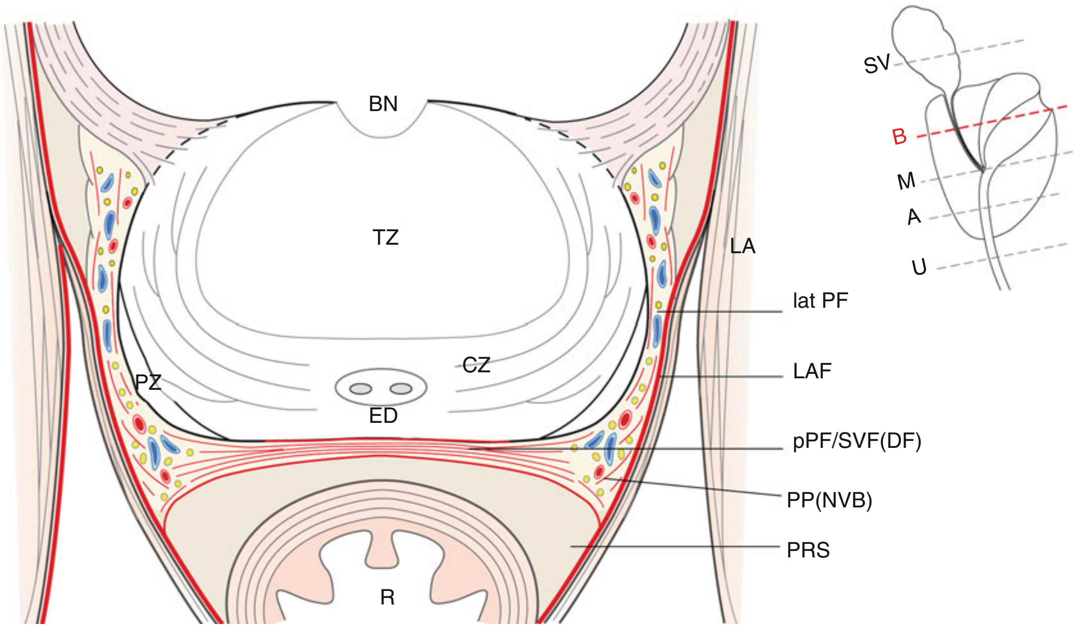

Fig. 16.4 Transverse section of prostate and periprostatic fasciae at the level of the prostatic base. *BN* bladder neck, *BW* bladder wall, *ED* ejaculatory ducts, *CZ* central zone, *PZ* peripheral zone, *TZ* transition zone, *LA* levator ani, *LAF* levator ani fascia, *PP(NVB)* pelvic plexus (neurovascular bundle), *pPF/SVF* posterior prostatic fascia/seminal vesicle fascia (Denonvilliers' fascia), *PRS* prerectal space, *R* Rectum, *SV* seminal vesicles, *B* base, *M* mid, *A* apex, *U* urethra

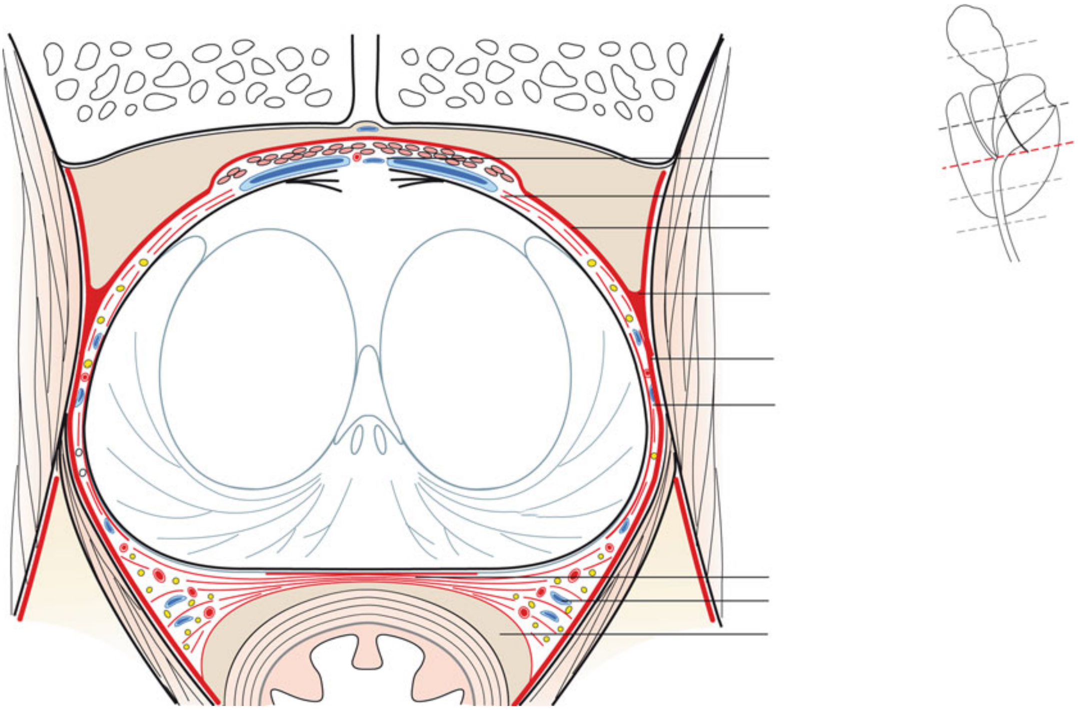

Fig. 16.5 Transverse section of prostate and periprostatic fasciae at the level of mid prostate. *ED* ejaculatory ducts, *AFMS* anterior fibromuscular stroma, *PZ* peripheral zone, *TZ* transition zone, *U* urethra, *DA* detrusor apron, *DVC* dorsal vascular complex, *EF* endopelvic fascia, *FTAP* fascial tendinous arch of the pelvis, *LAF* levator ani fascia, *NVB* neurovascular bundle, *latPF* lateral prostatic fascia, *pPF/SVF* posterior prostatic fascia/seminal vesicle fascia (Denonvilliers' fascia), *PRS* prerectal space, *R* Rectum, *SV* seminal vesicles, *B* base, *M* mid, *A* apex, *U* urethra

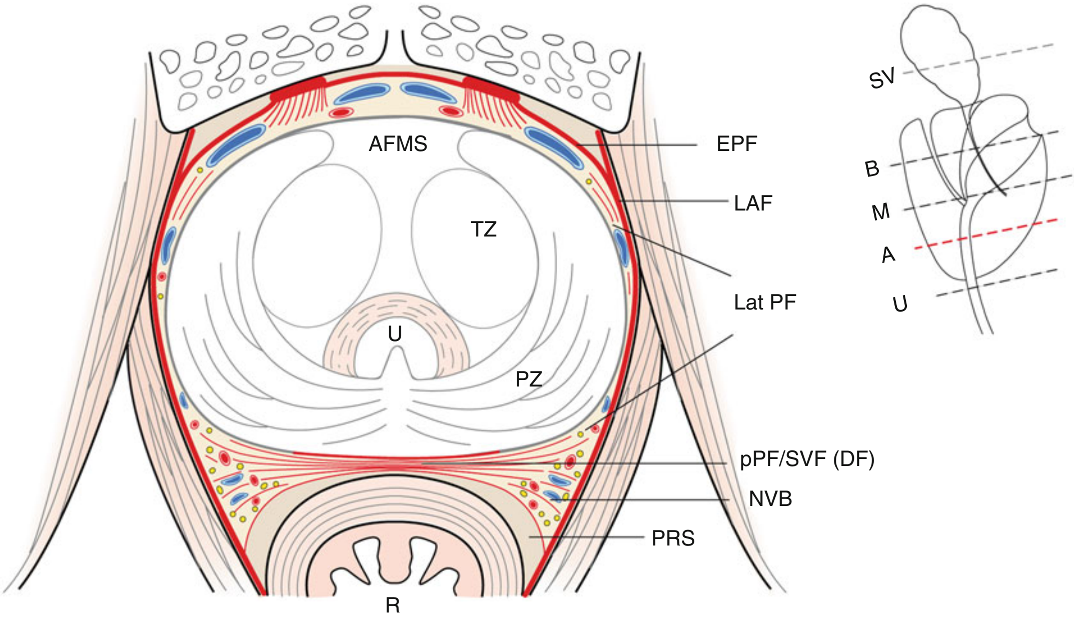

Fig. 16.6 Transverse section of prostate and periprostatic fasciae at the level of the apex. *AFMS* anterior fibromuscular stroma, *PZ* peripheral zone, *TZ* transition zone, *U* urethra, *EPF* endo pelvic fascia, *LAF* levator ani fascia, *NVB* neurovascular bundle, *latPF* lateral prostatic fascia, *pPF/SVF*, posterior prostatic fascia/seminal vesicle fascia (Denonvilliers' fascia), *R* Rectum, *PRS* prerectal space, *SV* seminal vesicles, *B* base, *M* mid, *A* apex, *U* urethra

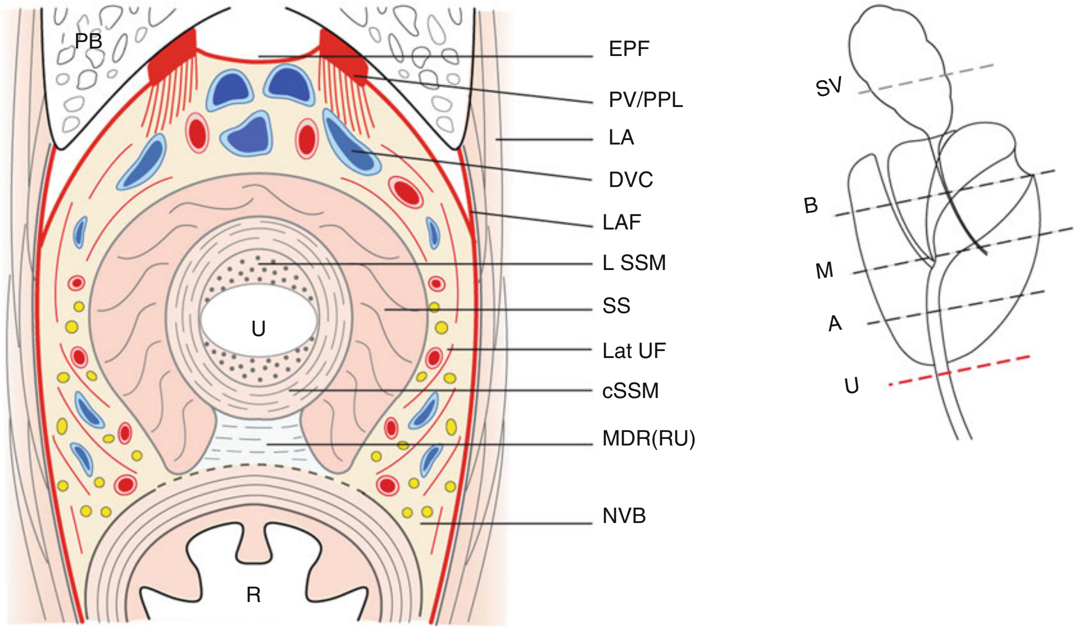

Fig. 16.7 Transverse section of urethra at the level striated urethra. *PV/PPL* pubovesicle/puboprostatic ligaments, *EPF* endopelvic fascia, *LA* levator ani, *LAF* levator ani fascia, *DVC* dorsal vascular complex, L*SSM* longitudinal smooth sphincter muscle, *SS* striated sphincter, *LatUF* lateral urethral fascia, c*SSM* circular smooth sphincter muscle*, MDR(RU)* median dorsal raphe (recto urethralis), *NVB* neurovascular bundle, *R* Rectum, *PB* pubic bone, *SV* seminal vesicles, *B* base, *M* mid, *A* apex, *U* urethra

Anterior prostatic fascia. This element fused to the endopelvic fascia is associated with the anterior surface of the prostate where it covers the detrusor apron, contains the dorsal vascular complex, and is fused in the midline with the anterior fibromuscular stroma of the prostate

Lateral prostatic fascia. Medial to the levator ani fascia, the lateral glandular surface of the prostate is covered by a multilayered fascia. Its layers extend from the anterolateral prostate, then posteriorly or dorsally to embrace the neurovascular bundle with the outer levator ani fascia passing lateral to the neurovascular bundle.

Posterior prostatic fascia and *seminal vesicular fascia. These are* known eponymically as Denonvilliers' fascia (septum rectovesical, TA). The foregoing terminology does not capture the continuous sweep of the fascia from the posterior surface of the prostate superiorly over the posterior surfaces of the seminal vesicles (Fig. 16.1). We propose herein SVF and pPF to describe anatomically this posterior fascia, which is neither rectal nor a septum. The SVF and pPF are separated from the rectal fascia propria by a prerectal cleavage plane, which trails distally from the variable distal end point of the rectovesical pouch. This cleavage plane is a remnant of the two peritoneal layers that fused and disappeared before birth. On the posterior surface of the prostate, the SVF and pPF has no macroscopically discernible layers. Distally, the pPF thickens and is demonstrably multilayered just distal to the prostato-urethral junction. The pPF extends posterior to the prostate apex and sphincteric urethra and, as a terminal plate [5, 13], has direct continuity with the midline raphe ending in the perineal body or central tendon of the perineum. The rectourethralis division is not part of radical retropubic procedure. The final posterior cut at the prostato-urethral junction is through the 'terminal plate' of Denonvilliers' (prostato-rectal) fascia. In contrast to the posterior surface of the prostate, the SVF is frequently multilayered over the seminal vesicles (predominance of smooth muscle fibres which are seen grossly), but is, with only very rare exception, a single layer of fascia over the immediate posterior surface of the prostate [13,14]. It has been suggested to distinguish a part of SVF anterior to the seminal vesicles and a part of SVF posterior to the seminal vesicles. The anterior part has been referred to as vesicoprostatic muscle [15]. Posterolaterally, the neurovascular bundle (NVB) is embedded in the SVF and pPF, and medial to the levator fascia, which passes lateral to the bundle (Fig. 16.4); thus, in axial or transverse histological section, the NVB is bounded by a triangle of fascia as illustrated by Kourambas and colleagues [16]. The radical prostate specimen should be covered with Denonvilliers' fascia particularly at the prostato-seminal vesicular junction because this is a location for the early extraprostatic extension of cancer.

16.3 Fascial Surgical Dissection

16.3.1 Definitions of Fascial Dissection

We propose, from an anatomic standpoint with respect to surgical dissection of the prostate, the following:

1. Extrafascial plane of dissection would define the prostate removed with all layers of visceral and parietal fascia present on the specimen (wide resection).
2. Interfascial dissection would define partial fascial thickness removal laterally and posterolaterally, with thin layers of fascial tissue left on the specimen. Grossly, over all the lateral aspect of the specimen, thin fascial layers can be grasped with a forceps, and microscopically some layers of adipocytes and/or connective tissue are always seen adherent to the glandular prostatic surface which is not at the margin. Usually, anteriorly and posteriorly, at the midline where it is fused with the glandular prostate, visceral and parietal fascia are present on the specimen (extrafascial).
3. Intrafascial plane of dissection would define some portion of the visceral PP fascia being absent on the specimen. Grossly, nothing can be grasped with a forceps, and microscopically no layers of adipocytes can be seen

outside the glandular prostatic surface which is the margin. Usually, posteriorly, at the midline, pPF (DF) fascia is present on the specimen (extrafascial). Anteriorly, visceral and parietal fascia can be removed with an intrafascial dissection (DVC is not divided) to preserve continence or, for example, in the perineal approach. Intrafascial dissection carries with it the greatest risk of inadvertent iatrogenic capsular penetrations.

16.3.2 Options of Dissection at the Lateral Aspect of the Prostate (Fig. 16.8)

After the endopelvic fascia is incised just lateral to the FTAP, the levator muscle fibres are displaced laterally to expose the lateral surfaces of the prostate. This levator ani fascia remains adherent to the lateral PF of the prostate and extends in a posterior direction continuously over the

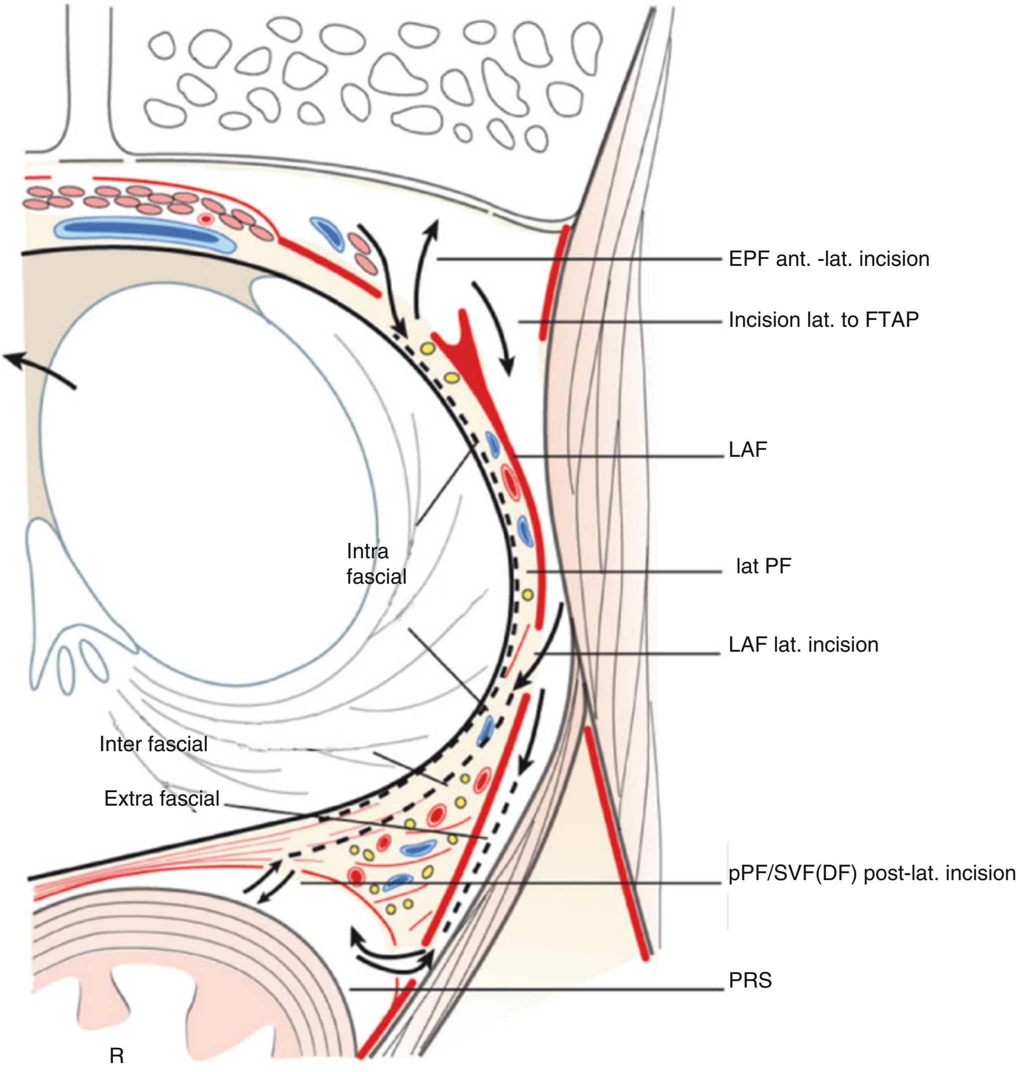

Fig. 16.8 Three different surgical dissection planes are demonstrated: intrafascial, interfascial and extrafascial. Transverse section of prostate and periprostatic fasciae at the level of the mid prostate. *EPF* endopelvic fascia, *FTAP* fascial tendinous arch of the pelvis, *LAF* levator ani fascia, *latPF* lateral prostatic fascia, *pPF/SVF* posterior prostatic fascia/seminal vesicle fascia (Denonvilliers' fascia), *R* Rectum, *PRS* prerectal space, *SV* seminal vesicles, *B* base, *M* mid, *A* apex, *U* urethra

neurovascular bundle and the rectum and distally over the prostato-urethral junction and its surrounding vessels. Some authors have suggested that avoiding incision of the endopelvic fascia during radical prostatectomy, often combined with an intrafascial nerve-sparing procedure, might improve early recovery of urinary continence as well as improve post-operative erectile function, but definitive evidence has yet to be established.

During interfascial dissection, scissors may progress within the thickness of this visceral sheath, leaving some layers on the gland and some on the side of the parietal fascia. Small perforating vessels and nerves to the prostate are to be divided at that time. The amount of connective tissue layers preserved depends upon the location on the prostate surface and upon the size of the gland. For example, at the anterolateral aspect of the gland, the LPP is 2 mm in normal glands and 1 mm in enlarged glands, and once a layer of 0.5–1 mm of areolar fatty and fibrous tissue has been left on the gland surface, the remaining thickness left on the lateral side adherent to the parietal fascia is almost absent or less than 0.5 mm. This safety zone PP fascia covering the specimen reduces the risk of positive surgical margins. This is important because perineural tumour extension has been shown to involve microscopic posterolateral nerves to the prostate in the area of the NVB. This is the main mechanism of extraprostatic extension and an important factor for positive margins [13,17,18].

16.3.3 Options of Dissection at the Base of the Prostate and Seminal Vesicles

Laparoscopic/robotic retropubic approach may perform an extrafascial (Fig. 16.9) or intrafascial (Fig. 16.10) dissection of the seminal vesicles/vas deferens and of the prostatic base. These options should be part of the surgeon experience and be used according to the risk of positive margins in case of cancer at the base with extraprostatic extension to the pPF/SVF (DF) or to the seminal vesicles. Same options of bladder neck excision/preservation can also be used.

16.3.4 Options of Dissection at the Apical Aspect of the Prostate

Laparoscopic/robotic retropubic approach may divide the prostate apex, urethra, and terminal plate of *pPF/SVF (DF)* from an anterior or posterior approach (Fig. 16.11) [19].

16.4 Proximal Bladder Neck Sphincter and Detrusor Apron

There is only one sphincter at the bladder neck. Loss of anatomic integrity and compromised neural innervation must then contribute to the observation that the bladder neck never regains normal sphincteric function in the post-operative period. Attempts to preserve the bladder neck during RP may expose cancer if located at the anterior margin [18]. From the bladder neck to approximately the mid-anterior commissure of the prostate, the anterior surface of the prostate is covered by outer longitudinal smooth muscle of the bladder in a layer, a detrusor apron, that extends distally to end as two pubo-vesical ligaments on either side of the pubic symphysis (Fig. 16.1) [20]. The bunching manoeuvre over the anterior commissure of the prostate allows haemostasis of the anterolateral pudendal plexus as well as significantly increasing visibility of the adjacent anterolateral surfaces of the prostate for the purpose of subsequent NVB preservation. Furthermore, the bunching facilitates control of any anastomotic veins (and there is pronounced variability) traversing the lateral surface of the prostate from NVBs to the anterolateral plexus [20].

16.4.1 Urethral Stump (Sphincteric Urethra) Preservation

Variations in apical configuration of the prostate affect the exit of the sphincteric (membranous) urethra from the prostate [20]. Laterally, thickened fascial band components of the DVC called Walsh's pillars or Müller's ischioprostatic ligaments provide insertion for the anterior layer of

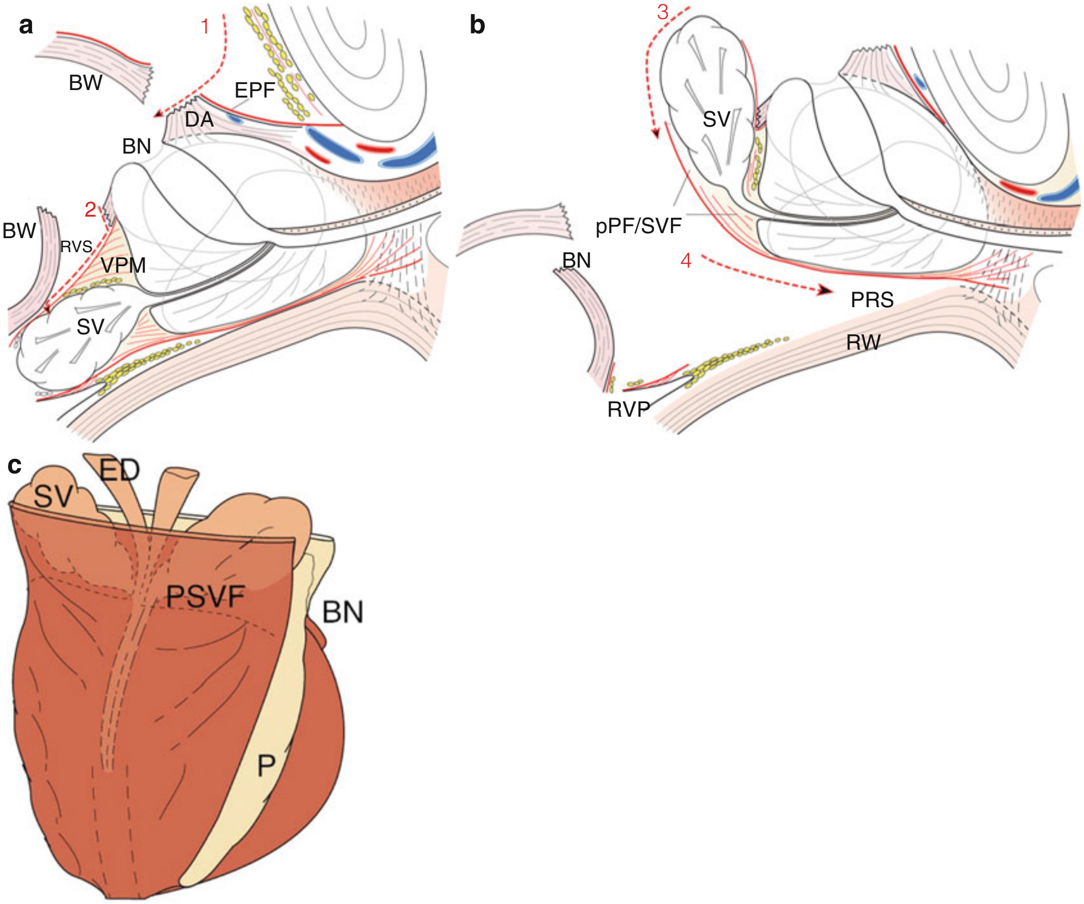

Fig. 16.9 Laparoscopic/robotic retropubic approach showing extrafascial dissection of seminal vesicles/vas deferens and prostatic base. (**a**) Sagittal section. Anterior *BN* division (*1*) without sphincteric preservation, extrafascial development of *RVS* (*2*) between *BW* and *VPM* or anterior *SVF*. (**b**) Sagittal section. *SV* tips are exposed and *VD* are divided (*3*). Extrafascial development of *PRS* anterior to *RVP* and posterior to *SVF* (*DF*), at distance from prostatic base (*4*). (**c**) Posterolateral 3D view of specimen showing *PSVF* covering prostatic base and proximal part of *SV* and *VD*. *BW* bladder wall, *BN* bladder neck, *EPF* endopelvic fascia, *DA* detrusor apron, *PRS* prerectal space, *RW* rectum wall, *RVS* retrovesical space, *RVP* rectovesical pouch, *SV* seminal vesicles, *U* urethra, *VPM* vesico prostatic muscle, *pPF/SVF (DF)* posterior prostatic fascia/seminal vesicle fascia (Denonvilliers' fascia), *P* prostate glandular surface, *ED* ejaculatory duct

the striated sphincter. Posteriorly, there is a variably thick fibrous tissue raphe striated sphincter into which is inserted the circular component fibres of the horseshoe-shaped striated sphincter [21].

16.4.2 Prostatic Surface (So-Called Capsule)

There is no prostatic capsule. The structure that we call the 'capsule' is a transversely arranged fibromuscular layer that is recognized at the outermost region of the prostate surface, but [22] at the posterolateral apex or base and at the bladder neck. Vessels and nerves, coursing within this adipose tissue, enter into the prostate at these areas; thus, the so-called capsule does not exist due to merging with the so-called visceral fascia, which is adherent to the prostatic stroma. These transversely arranged fibromuscular layers contain the spread of cancer [13]. Consequently, there is always peril at the apex. In the absence of BPH, it is sometimes difficult to define the prostato-urethral junction.

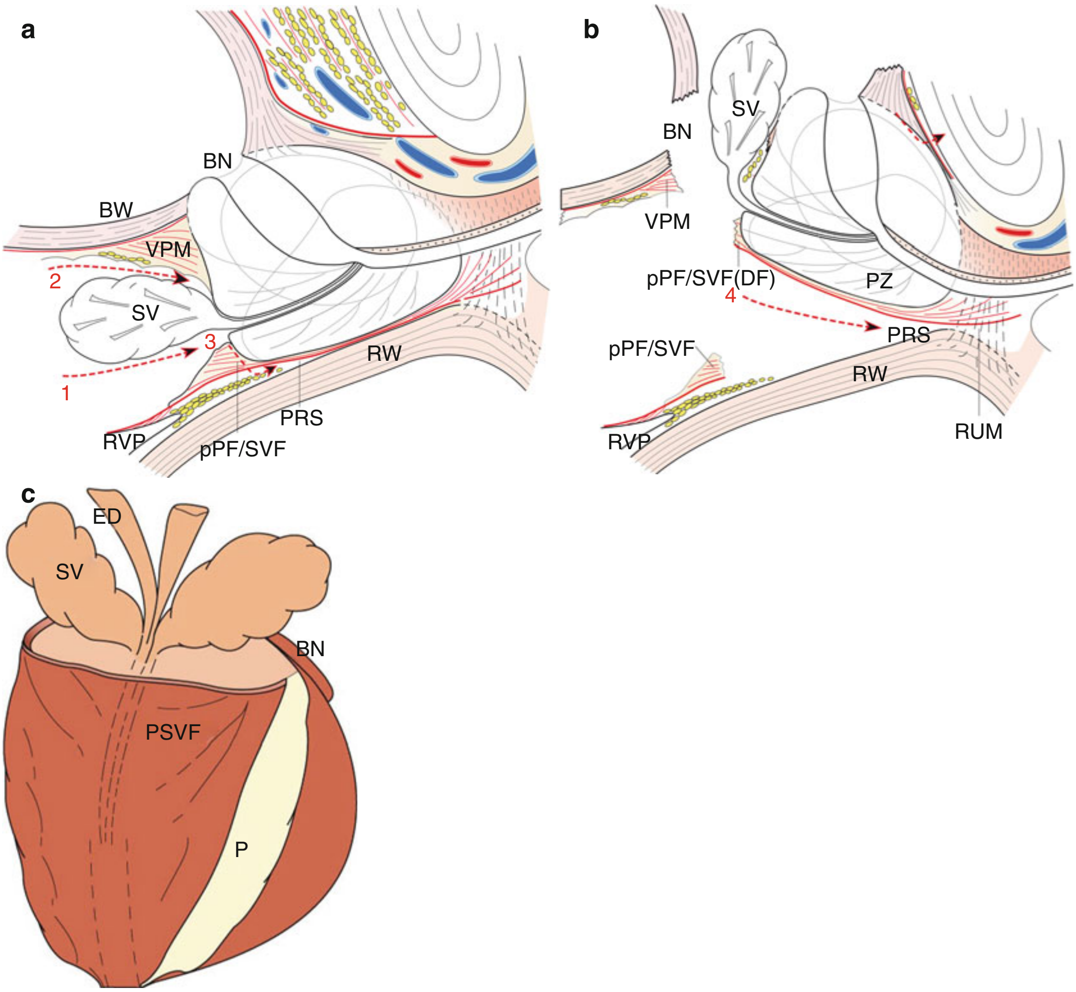

Fig. 16.10 Laparoscopic/robotic transperitoneal approach showing intrafascial dissection of seminal vesicles/vas deferens and prostatic base. (**a**) Sagittal section. Peritoneum division, exposition of *SV* tips *VD* division. Intrafascial development of *SV* and *VD*, posterior to *VPM*/anterior *SVF*(DF) (*1*), and anterior to *RVP* and posterior *SVF*(DF) up to the prostatic base (*2*). (**b**) *PZ* peripheral zone, *RUM* rectourethralis muscle, Sagittal section. After division of *BN* and *SV* anterior retraction, division of posterior *SVF*(DF), at its junction with *pPF*(DF) (*3*) to get into the *PRS* posterior to *SVF* (DF), and extrafascial development of *PRS* (*4*). (**c**) Posterolateral 3D view of specimen showing *PSVF* covering prostatic posterior surface but not prostatic base and not proximal part of, *SV* and *VD*. *BW* bladder wall, *BN* bladder neck, *EPF* endopelvic fascia, *DA* detrusor apron, *PRS* prerectal space, *RW* rectum wall, *RVS* retrovesical space, *RVP* rectovesical pouch, *SV* seminal vesicles, *U* urethra, *VPM* vesico prostatic muscle. *pPF/SVF (DF)* posterior prostatic fascia/seminal vesicle fascia (Denonvilliers' fascia), *P* prostate glandular surface, *ED* ejaculatory duct

16.4.3 Rectourethralis

The rectourethralis is a fibromuscular complex that produces anterior angulation of the anorectal junction as noted above. It consists primarily of a dominant (more substantial) midline component of smooth muscle from the anterior wall of the anal canal coming from below (anoperinealis, TA) and a less dominant midline component of smooth muscle from the anterior wall of the rectum coming from above (rectoperinealis, TA). These two components then converge from below and above, respectively, and insert into the perineal body (central tendon of the perineum, Fig. 16.1). There is no direct urethral attachment. Importantly, the attachment anteriorly is distal to the posterior apex of the prostate, and

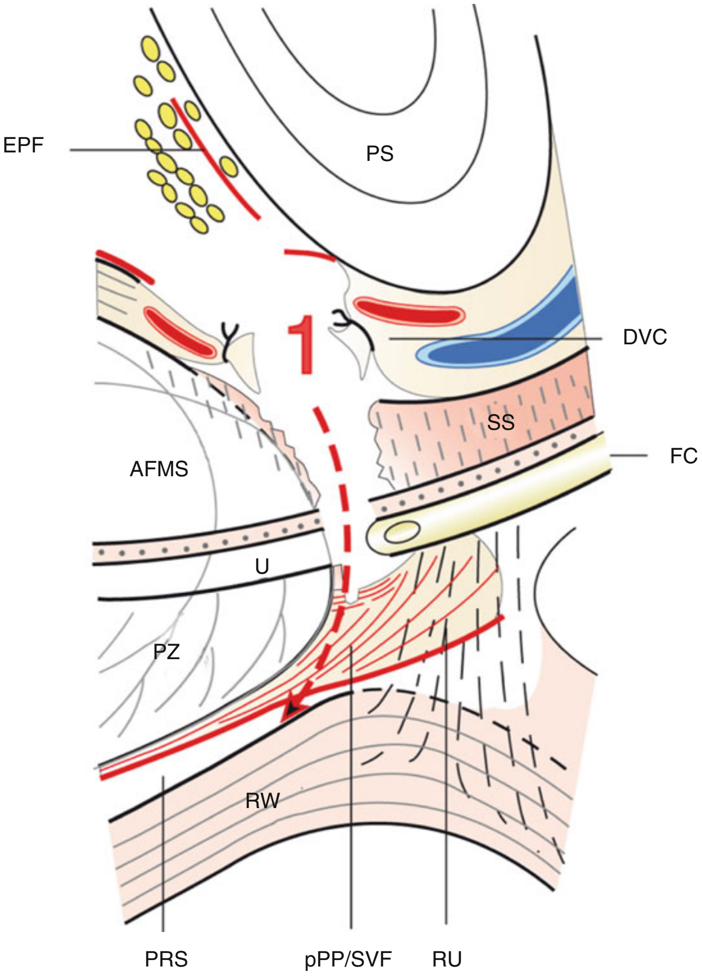

Fig. 16.11 Laparoscopic/robotic retropubic approach showing division of prostate apex, urethra, and terminal plate of *pPF/SVF (DF)(1)*. *AFMS* anterior fibromuscular stroma, *DVC* dorsal vascular complex, *EF* endopelvic fascia, *DA* detrusor apron, *RU* rectourethralis, *PS* pubic symphysis, *pPF/SVF (DF)* posterior prostatic fascia/seminal vesicle fascia (Denonvilliers' fascia), *PRS* prerectal space, *PZ* peripheral zone, *RW* rectum wall, *SS* striated sphincter, *U* urethra, *FC* foley catheter

therefore the rectourethralis is not part of the retropubic operation as it is in the perineal operation. Descriptions of the retropubic operation often mistakenly describe transection of the rectourethralis after urethral transection when what is being described is actually transection of the termination of the PSVF as it joins the midline fibrous tissue raphe of the perineal body. The rectourethralis attachment varies considerably in bulk from thick to thin [13].

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17

Anatomical Aspects of the Neurovascular Bundle in Prostate Surgery

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17.1 Introduction

Over recent years, widespread prostate-specific antigen screening has resulted in a downwards stage migration of prostate cancer in developed nations, with most patients being diagnosed nowadays at a younger age with early organ-confined disease [1–3]. Radical prostatectomy has a proven survival benefit over conservative treatment [4, 5], and thus is the gold standard for the management of clinically localized prostate cancer. Hence, with more patients undergoing surgery, minimizing functional loss is of utmost importance. However, despite recent advances in surgical technique and technologies, return of erectile function sufficient for sexual intercourse at 1 year after surgery varies from 15 to 87 %, respectively, in contemporary series of radical prostatectomy [6–8]. For younger men, post-prostatectomy erectile dysfunction (PPED) significantly affects their sense of masculinity and their daily interactions with women [9, 10]. Patient age, clinical and pathological stage of cancer, preoperative potency status, and aggressiveness of nerve-sparing are the most significant factors for recovery of potency after surgery [11–13]. Surgeon experience and surgical volume, penile ischemia and subsequent fibrosis, and veno-occlusive disease are also important for successful return of sexual function following surgery [14, 15].

Much of the progress achieved in the past two decades in improving potency outcomes after radical prostatectomy has resulted from an improved appreciation of the anatomical basis of the nerves responsible for erection. Diminished innervation of the corpora cavernosal tissue prevents the release of nitrous oxide from non-adrenergic non-cholinergic nerves, decreases the production of cyclic nucleotides within the vascular smooth muscle, and causes impairment of vascular engorgement.

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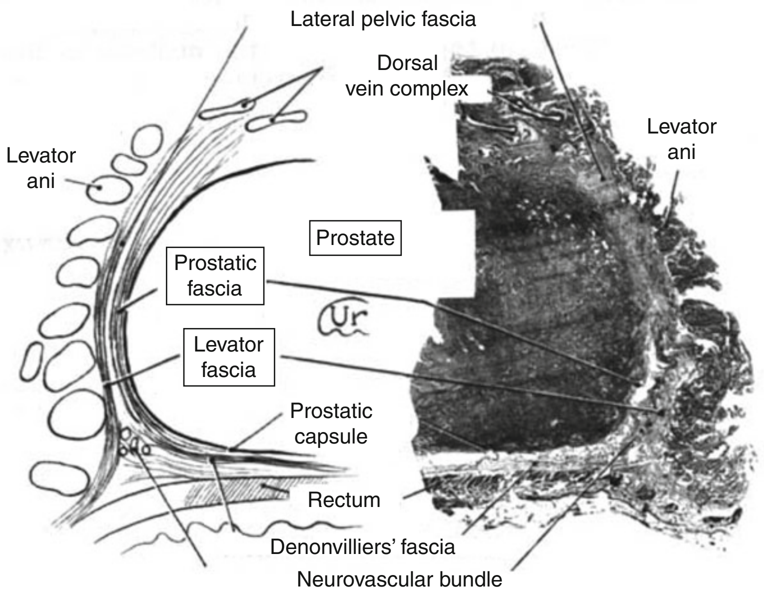

Fig. 17.1 Cross section of adult prostate demonstrating the posterolaterally situated neurovascular bundle running between the layers of the lateral pelvic fascia – the levator fascia lies lateral, and the prostatic fascia lies medial to the bundle (© Copyright 1996 Brady Urological Institute)

Vascular injury, namely, arterial insufficiency and veno-occlusive leakage, is becoming increasingly implicated as a cause of erectile dysfunction after radical prostatectomy [16–18]. Recent advances in the anatomical course of these cavernosal nerves have led to various innovative techniques for improving nerve-sparing radical prostatectomy (nsRP). In addition, developments in fibre-optic imaging technologies have led urologists to explore their potential for improved visualization of the erectogenic neural scaffold during nsRP.

17.2 Anatomical Basis of Erectogenic Nerve Preservation

17.2.1 Neurovascular Bundles and Cavernosal Nerves

The autonomic neural system is directly responsible for penile erection. The inferior hypogastric plexus (IHP), also termed the pelvic plexus, is responsible for the mechanisms of erection, ejaculation, and urinary continence. The IHP contains sympathetic and parasympathetic components. The sympathetic fibres arise from T11 to L2 ganglia, while the parasympathetic fibres originate from the ventral rami of S3 and S4. The IHP is a dense network of neural fibres located within a fibro-fatty, sub-peritoneal plate between the urinary bladder and rectum [19].

Walsh and Donker [20] first detailed the anatomy of the nerves supplying the corpora cavernosal in male stillborns. Subsequent cadaveric and intraoperative studies by Walsh [21, 22] demonstrated that the neurovascular bundles (NVB) run posterolateral to the prostate between two layers of lateral pelvic fascia – the prostatic fascia medially and levator fascia laterally (Fig. 17.1). These neurovascular bundles consist of (1) the cavernosal nerves (CN) directly responsible for erectile function, which originate from the most inferior portion of the IHP; (2) the arterial branches from the inferior vesical artery; and (3) venous vessels. The majority of these cavernous nerve fibres, approximately 6 mm wide, then run caudally at the 3 and 9 o'clock positions of the membranous urethra beneath the striated sphincter at the prostatic apex (Fig. 17.2).

17.2.2 Anatomical Variants of Cavernosal Nerves

Recent studies have reported variants to the 'train track' course of cavernosal nerves described above. Costello et al. [23] demonstrated that the NVBs in male cadavers descend posteriorly to the seminal vesicles, converging at the mid-prostatic

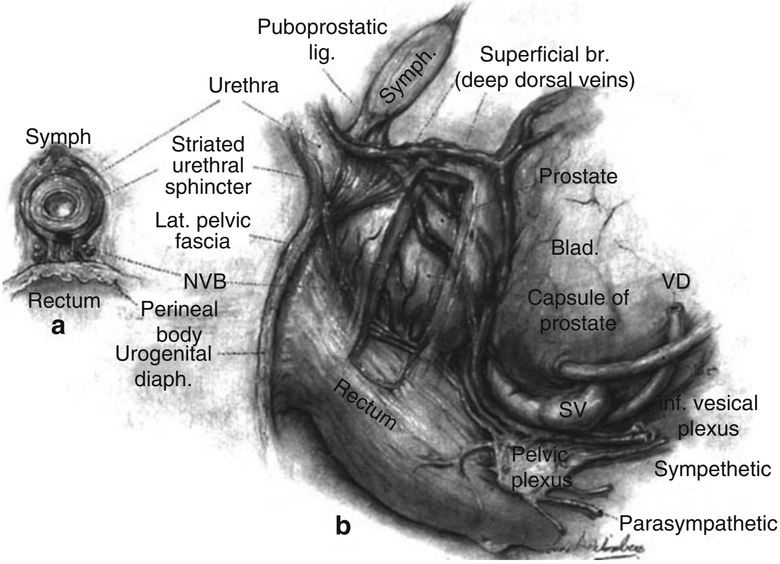

Fig. 17.2 (**a**) Cross section of membranous urethra just distal to the prostatic apex, demonstrating the relationship of the neurovascular bundle to the striated urethral sphincter and the perineal body. (**b**) Lateral view of the neurovascular bundle, tracing its course from the pelvic plexus through the layers of the lateral pelvic fascia distally to lie lateral to the membranous urethra (© Copyright 1996 Brady Urological Institute)

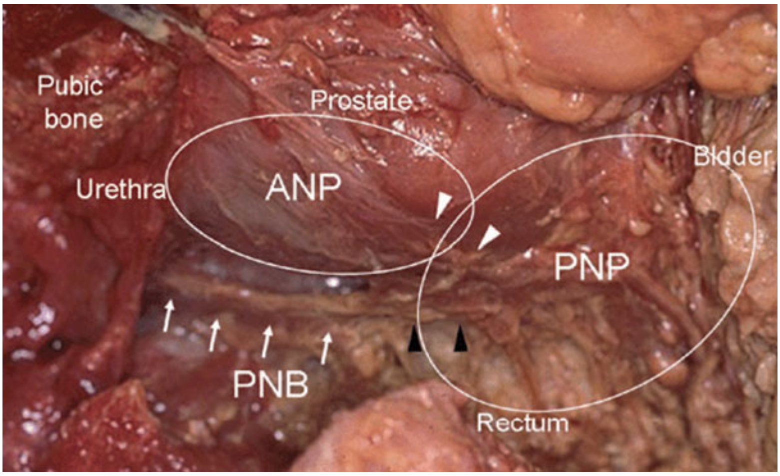

Fig. 17.3 Gross anatomy photograph (*right*) showing the proximal neurovascular plate (*PNP*), predominant neurovascular bundle (*PNB*), and accessory neural pathways (*ANP*)

level and then diverging on approaching the prostatic apex into indistinguishable fibres. Takenaka et al. [24] highlighted the lattice-like distribution of the NVB on the lateral surface of the prostate, demonstrating that the NVB is more a network of multiple fine dispersed nerves than a distinct structure. Kiyoshima et al. [25] further reported that these dispersed nerve fibres are located between the prostate capsule and the levator fascia. Eichelberg et al. [26] also found that only 46–66 % of all nerves were found in the classical posterolateral location as described by Walsh, while 21–29 % were found on the anterolateral surface of the prostate.

17.2.3 Trizonal Hammock Concept

Tewari and colleagues [27, 28] proposed that the periprostatic nerves consistently fell into three broad surgically identifiable zones: the proximal neurovascular plate (PNP), the predominant neurovascular bundle (PNB), and the accessory neural pathways (ANP) (Fig. 17.3). The predominant neurovascular bundles are usually located in a posterolateral groove on the side of the prostate. Significant variations in the location, shape, course, and composition of this bundle occur. They can be widespread on the rectum, Denonvilliers' fascia, and lateral pelvic fascia, or they can be

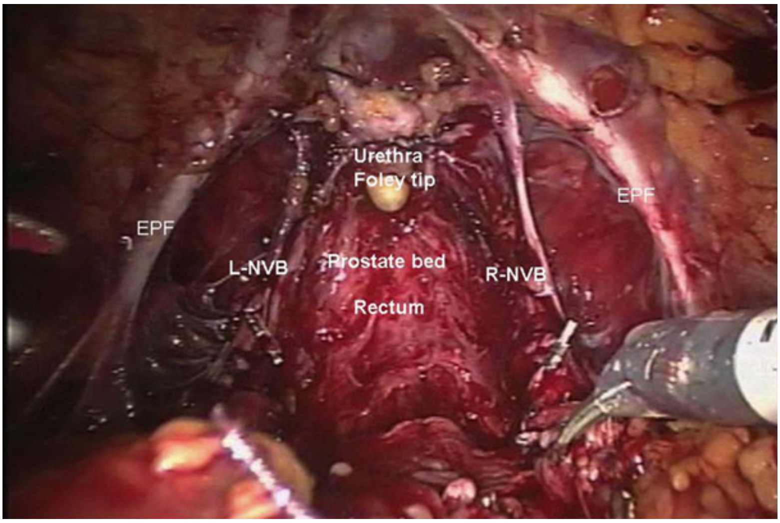

Fig. 17.4 View of the left and right neurovascular bundles (*L-NVB* and *R-NVB*) in the prostatic fossa after removal of the prostate gland. Note that the NVBs are closely related to the prostatic pedicle and prostatic fascia, and its branches can sometimes be intermingled with the lateral pedicles of the prostate (*EPF* endopelvic fascia)

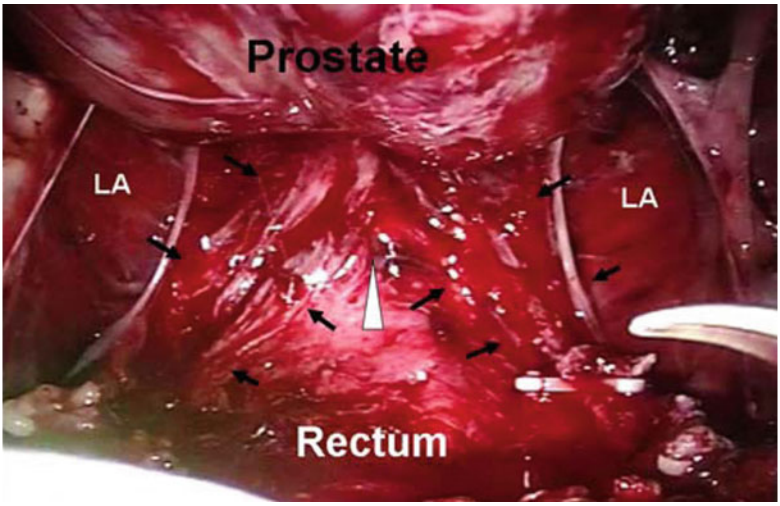

Fig. 17.5 Retro-apical region of the prostate has a rich plexus of nerves formed by cross-communicating (*White arrow head*) fibres between the left and right neurovascular bundles and fibres (*LA* levator ani, *Black arrows* neural tissue)

circumscribed on the posterolateral groove enclosed in the triangular space. The PNB is closely related to the prostatic pedicle and prostatic fascia, and its branches can sometimes be intermingled with the lateral pedicles of the prostate (Fig. 17.4). Correlating their anatomic findings from cadaveric dissections to intraoperative video footage and final histology slides, Tewari's group observed accessory neural pathways in several locations around the prostate: specifically, between the prostatic and levator fascia, posterior to the prostate and in the layers of Denonvilliers' fascia, in several planes between the layers of lateral pelvic fascia, and even in the outer layers of the prostatic capsule. The superficial layer of Denonvilliers' fascia has cross-communicating fibres between the left and right neurovascular bundles. Distally, these bundles coalesce to form a retro-apical plexus. In up to 35 % of cases, this distal plexus penetrates the rectourethralis muscle (Fig. 17.5). Being the final exit pathway for the cavernous and retro-apical nerves, these delicate structures may easily be damaged during urethral transection and anastomosis. Tewari observed that the overall architecture of these delicate erectogenic nerves coursing around the prostatic capsule is similar to suspension of a weight in a hammock (Fig. 17.6), and that nerve preservation should not

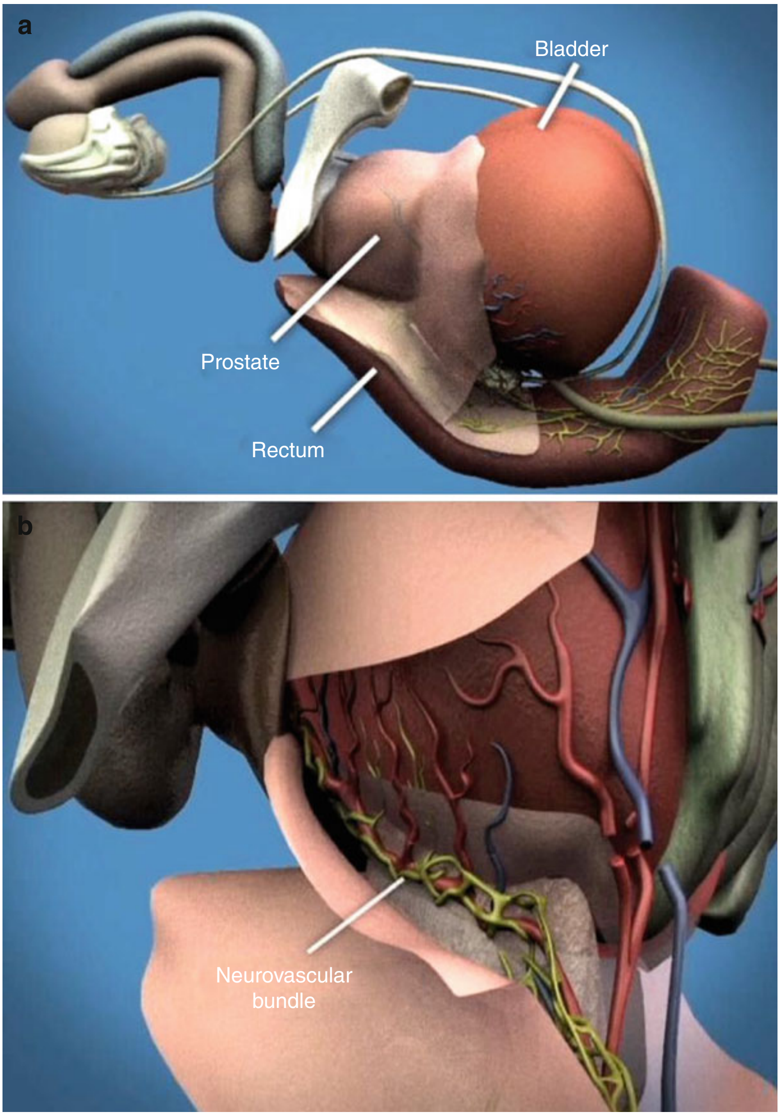

Fig. 17.6 (**a**) Graphical representation of the pelvic anatomy encountered by surgeons during robotic-assisted radical prostatectomy. (**b**) Close-up pictorial representation of the delicate scaffold of erectogenic nerves that run in the fascial planes around the prostatic capsule

be considered a discrete technical manoeuvre, but rather an overarching surgical priority to be pursued at all stages of this complex procedure for achieving optimal outcomes [28].

17.2.4 Fascial Planes Surrounding the Prostate Capsule

Correlating their intraoperative observations during robotic-assisted radical prostatectomy with histological specimens, Tewari and Menon recognized that numerous nerve bundles are present in the different layers of fascia enveloping the prostate [29] (Figs. 17.7 and 17.8). The lateral pelvic fascia (LPF) – a multilayered fascial covering – surrounds the prostatic capsule. The medial, well-defined component of the LPF is known as the prostatic fascia, and directly wraps around the prostate capsule. The laterally defined part of LPF is the levator fascia, which lies on the levator muscles. Interposed between the prostatic fascia and the levator fascia are the periprostatic venous plexus and the neurovascular tissue that travel distally to supply the sphincter, urethra, and cavernous tissue. These neural

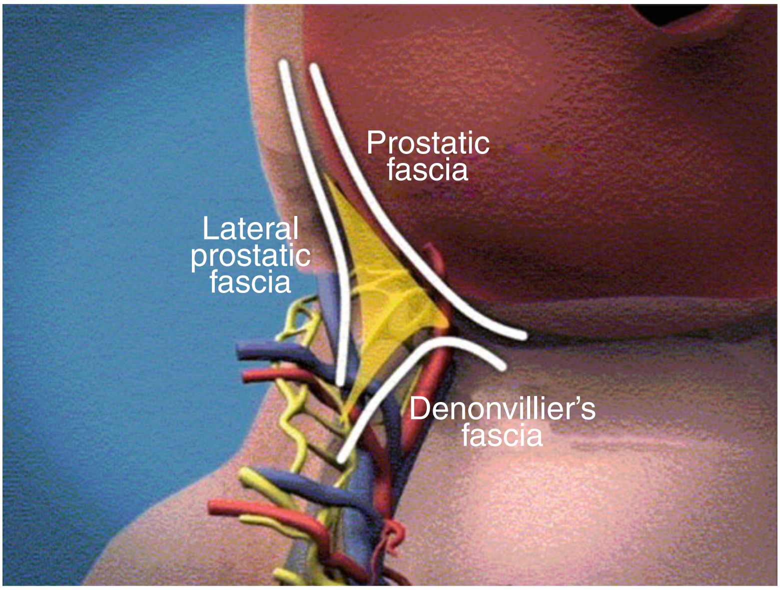

Fig. 17.7 Graphical representation of the neurovascular triangle, which is a potential avascular space bounded posteriorly by the Denonvilliers' fascia, laterally by the levator fascia, and medially by prostatic fascia covering the prostate capsule

fibres can travel close to the vessels, or occasionally, independently, on the surface of the prostate or laterally on the rectum.

17.3 Advances in Cavernosal Neural Imaging

With the above-described plethora of nerves outside the conventional posterolateral NVB, it can be difficult for surgeons to identify these accessory pathways. In recent years, significant efforts have been made to improve real-time identification and preservation of these cavernosal nerves during radical prostatectomy. Optical magnification of the operative field with surgical loupes has been demonstrated to improve earlier return of potency and lower rate of positive surgical margins following retropubic radical prostatectomy [30, 31]. Intraoperative nerve stimulation and tumescence monitoring using the CaverMap™ has also been reported to help improve potency outcomes, although its specificity for accurate NVB identification has remained weak with considerable background variables contributing to penile tumescence [32–34]. Ukimura and Gill reported that real-time TRUS using power Doppler during laparoscopic radical prostatectomy helped the surgeon identify the anatomical course of the NVB, measure the number of visible vessels and quantify arterial blood flow resistive index in the NVB [35]. However, the variability of NVB imaging with positioning of the ultrasound probe, insufficient resolution for defining microscopic structures, and operator dependency of this approach has not resulted in this technique being adopted by other centres.

Recent advances have been made in fibre-optic-based imaging technologies for visualizing biological structures at a cellular and microscopic level, such as optical coherence tomography (OCT) [36], spectroscopy (elastic scattering [37], Raman [38]), and fluorescent imaging (confocal microscopy [39], multiphoton nonlinear microscopy [40]). These technologies may become integrated in the future onto the robotic platform for use in real-time identification of nerves during radical prostatectomy and may provide yet more anatomical information about the cavernosal neural architecture during prostate surgery.

Conclusions

The cavernosal nerves that are vital for erectile function are not simply distributed as train tracks on the posterolateral aspect of the prostate, but rather can be divided into three zones: the proximal neurovascular plate, the predominant neurovascular bundle, and the accessory neural pathways. Better appreciation of this

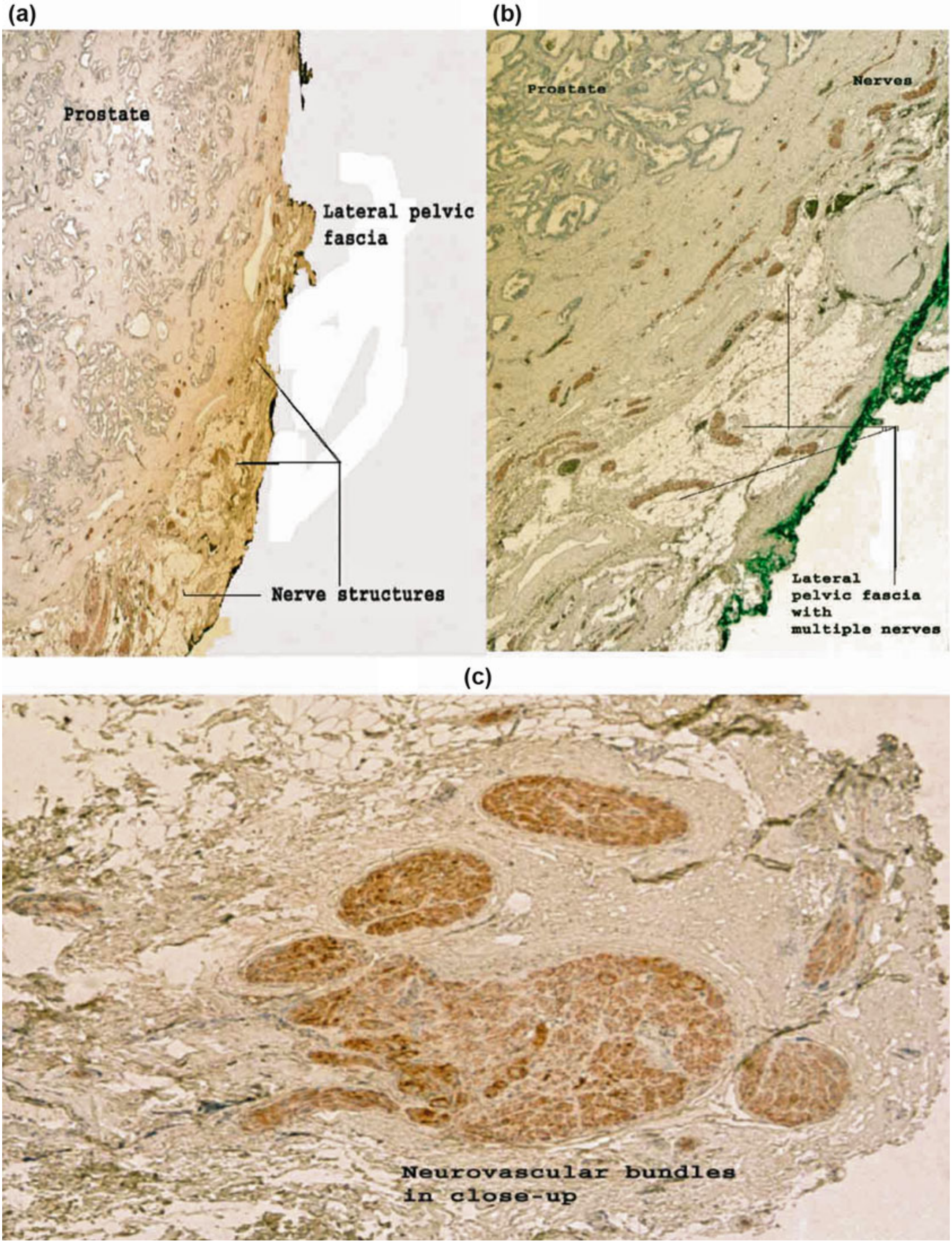

Fig. 17.8 Microscopic images of the nerves in the lateral pelvic fascia (brown structures) (note the small nerves posterior and anterolateral to the prostate): (**a**) low magnification; (**b**) medium magnification; (**c**) high magnification (© Elsevier Inc [29])

anatomy is key to the optimization of sexual outcome after radical prostatectomy and is currently facilitated by the magnification allowed in the robotic platform. Future advances in fibreoptic imaging technologies may bring about further knowledge of this important anatomy.

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Part VI

Benign Disease

Robotic Adenomectomy

18

Hubert John

Open surgery is recommended as the first-line treatment for severely enlarged glands in benign hyperplasia, and many therapeutic options have been proposed for benign glands larger than 80 g. The retropubic transvesical technique (Freyer) and the suprapubic transcapsular operation (Millin) are still widely accepted as the gold standard. However, the blunt dissection of the adenoma from the capsule, especially in the apical and sphincteral areas makes this procedure very invasive.

Open transvesical (Freyer [1]) or transcapsular (Millin [2]) prostatectomies still present significant morbidity and complication rates. In a contemporary series from 2002 with 1,800 patients and an overall complication rate of 29 %, severe bleeding was found in 12 %, as well as a transfusion rate of 8 % and sepsis occurred in 9 % [3]. Another recent multi-centre study of 902 patients with an overall complication rate of 17 % describes an 8 % transfusion rate, urinary infections in 5 % and surgical revisions due to severe bleeding in 4 % [4] (Table 18.1). Open prostatectomy is still a common treatment for benign prostate enlargement especially in technically developed areas with a range of up to 40 % of all cases performed [3, 5, 6].

A variety of minimally invasive treatment techniques have been proposed, primarily using laser technology. Holmium laser ablation and enucleation, KTP-laser prostatectomy and photosensitive vaporisation of the prostate have been proposed [7]. Significantly shorter operative, catheterisation and hospitalisation times were found in patients undergoing Holmium laser enucleation (HoLEP) of the prostate compared to open prostatectomy in a comparative study [8]. The improvements in micturition obtained with HoLEP and compared to open prostatectomy were found to be equally good 5 years postoperatively, and reoperation rates were similarly low [9]. Conventional laparoscopic adenomectomy in transperitoneal and extraperitoneal technique has been repeatedly evaluated since 2002 [10–15]. The large Italian and Bavarian multi-institutional studies in open prostatectomy [3, 4] observed similar functional outcomes and complication rates when compared to laparoscopy [11–16], however with significantly longer hospital stays than in the laparoscopic series (Table 18.1). So far, over 800 conventional laparoscopic simple prostatectomies have been reported in the literature [17]. However, laser and conventional laparoscopic techniques are still not wide-spread due to long learning curves, absent long-term outcomes and a lack of endourological expertise and equipment.

Pilot series reveal initial experiences in robotic pre-peritoneal and transperitoneal adenomectomy using a da Vinci® robotic surgical system from 2007 (Table 18.1). Robotic surgery

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Table 18.1 Robotic adenomectomy: open, conventional laparoscopic and robotic series

Author	Year	*N*	Op. time (min)	Blood loss (ml)	Transfusion rate (%)	Specimen weight (g)	Catheter (day)	Reoperations (%)	Hospital (day)
Open (Freyer, Millin)									
Seretta et al. [3]	2002	1,800	NA	NA	8	NA	5	5	7
Gratzke et al. [4]	2007	902	81	NA	8	84	NA	4	12
Laparoscopic transperitoneal									
Mariano et al. [10]	2006	60	138	330	0	131	5	NA	3
Sotelo et al. [14]	2005	17	156	516	29	72	6	0	2
Rey et al. [13]	2005	5	95	NA	NA	120	3	0	4
Baumert et al. [16]	2006	30	115	367	3	77	4	0	5
Laparoscopic pre-peritoneal									
Van Velthoven et al. [15]	2004	18	145	192	0	48	3[b]	6	6
Rehman et al. [12]	2005	2	180	125	0	120	NA	0	NA
Robotic transperitoneal									
Sotelo et al. [17]	2008	7	205	298	0	50	7	0	1
Singh et al. [31]	2010	1	300	600	0	384	NA	0	3
Sutherland et al. [21]	2011	9	183	206	0	136	13	0	1.3
Robotic pre-peritoneal									
John et al. [18]	2007	1	NA	NA	0	NA	5	0	NA
Yuh et al. [20]	2008	3	211	560	33	301	NA	1	1.3
John et al. [19]	2009	13	210 (140[a])	500 (300[a])	0	82	6	0	6

[a] Finger-assisted enucleation technique [29]

[b] Recatheterisation in 22 %

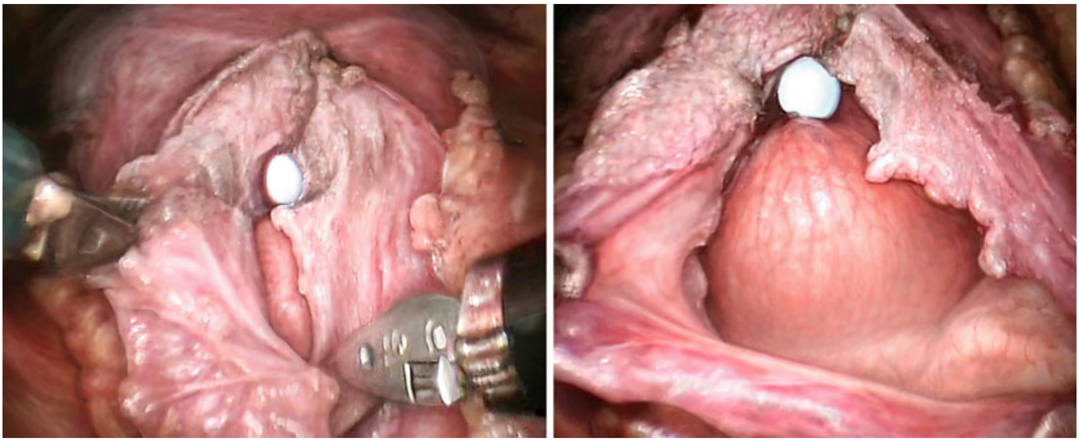

Fig. 18.1 Longitudinal incision of the ventral bladder neck and access to the prostatic capsule

offers distinct advantages over conventional laparoscopy, such as six degrees of freedom, dexterity enhancement, stereovision and tremor filtering. The feasibility of robot-assisted adenomectomy in pre-peritoneal technique was first reported in 2007 by our group [18, 19] and confirmed by Yuh et al. [20]. Sotelo [17] used a transperitoneal access in seven patients, as has Sutherland recently [21] (Table 18.1). We prefer an extraperitoneal approach using three arms with a five-trocar access, as it best imitates the open Millin or Freyer procedure [22, 23] (Fig. 18.1). Less subileus, faster and earlier return to full diet [24, 25] and less postoperative pain [25, 26] have been described after extraperitoneal access for radical prostatectomy. Additionally, potential urinary leaks do not cause chemical peritonitis. Other studies found no difference between the extra- and transperitoneal techniques for radical prostatectomy [27]. Following robot installation, we first perform a longitudinal cystotomy, which extends to the anterior aspect of the prostatic capsule. The enucleation is achieved by blunt dissection and electrocautery, as well as with bipolar diathermy or harmonic scalpel (Figs. 18.2 and 18.3). However, this crucial step is still in evolution. As it is time-consuming, blood loss can be considerable despite an insufflation of 12 mmHg. To reduce bleeding, sutures of the dorsal venous plexus and on the lateral pedicles of the prostate near the bladder neck have been proposed [10, 28]. As, in our experience, proper enucleation of large prostates is still sub-optimal, we suggest that single finger assistance may help overcome these difficulties [29]. In fact, in the last three cases using open finger enucleation over a 5-cm suprapubic incision, the total operative time was reduced to 140 min and blood loss to 250 ml (Table 18.2). The postoperative course for the patient and nursing staff is remarkably easy [30] as drains are removed expeditiously, and only a simple transurethral irrigation catheter is needed to drain the bladder. Following initial experience with moderate prostate sizes, teams proceed to larger glands and even giant prostates of up to 380 g resection weight have been reported [31].

The feasibility of pre-peritoneal laparoscopic robot-assisted prostate adenomectomy was evaluated at our institution between November 2, 2006 and April 4, 2008 [19]. Thirteen patients with a median age of 70 (53–72), BMI of 26 (23–31), clinical prostate volume estimated by transrectal ultrasound of 100 (90–180) ml and 85 (10–250) ml residual urine were entered in this pilot series (Table 18.3). A three-arm da Vinci® Surgical System and five-port access was used. Extraperitoneal laparoscopic approach was performed by balloon-dilatation, and five trocars were positioned (12-mm camera-port, 2×8-mm robotic ports, 5-mm and 12-mm assistant ports) in the same technique as for extraperitoneal robotic radical prostatectomy [22, 23, 32, 33]. After the bladder was filled with 200-ml saline, a vertical cystotomy

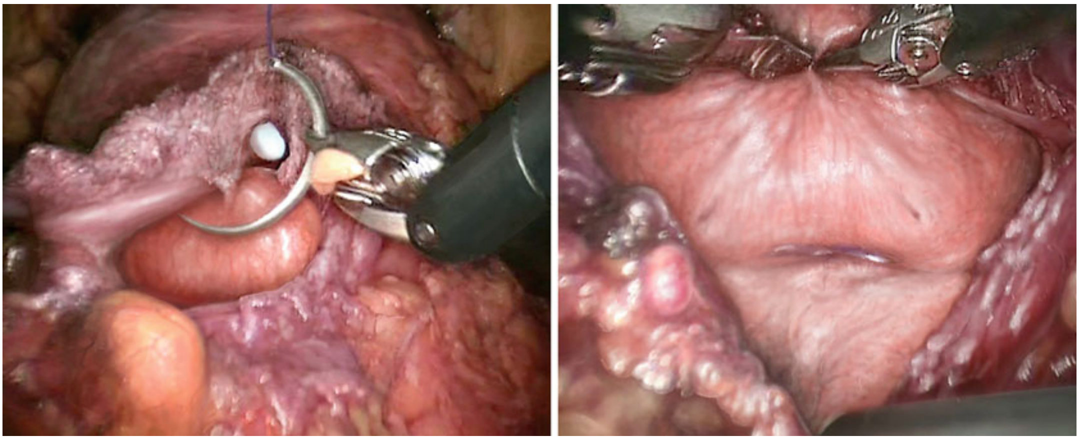

Fig. 18.2 Exposure of the ureteral crest and orifices by holding sutures

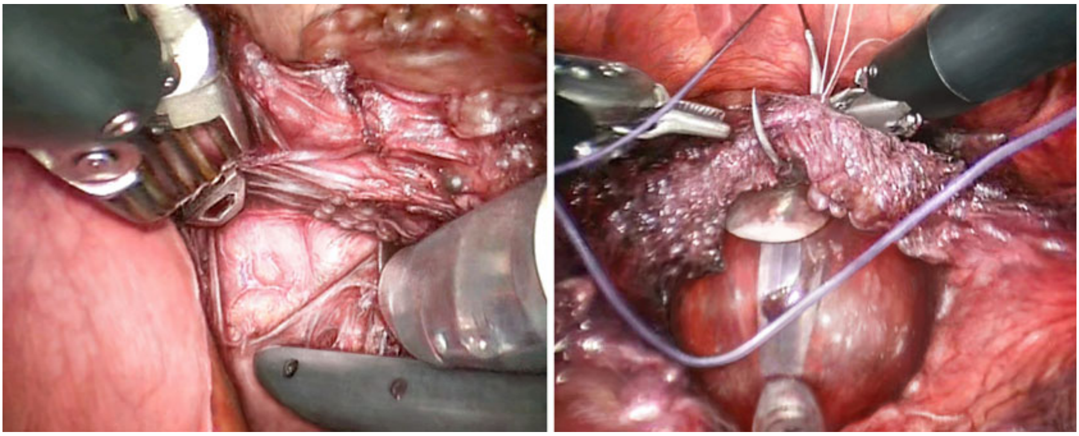

Fig. 18.3 Prostate adenoma enucleation (*left*) and closure of prostatic capsule and bladder by continuous suture

was performed up to and within the prostatovesical junction (Fig. 18.1). Two preliminary holding sutures exposed the ureteral crest. The ureteral crest, the ureteral orifices and a possible median lobe were then exposed (Fig. 18.2). A deep, hot-scissor incision created the dissection plane at the dorsal bladder neck. The surgical avascular zone was developed in descending technique towards the apex. The median lobe and both lateral lobes were gently freed from the capsule as a whole or one lobe at a time, using hot-scissor electrocautery and blunt dissection (Fig. 18.3). In the last three cases, single finger assistance was used to facilitate the enucleation phase [29]. Perforating arteries were controlled by bipolar coagulation. Apical dissection was performed under visual control to prevent sphincteral injury. The specimen was laid aside until retrieval. After total removal of the adenoma, haemostasis was achieved under visual control within the prostatic fossa. Haemostatic sutures of Vicryl 2-0 on a UR-6 needle were placed between prostate fossa and the posterior bladder neck. A Couvelaire catheter Ch20 was introduced and blocked in the prostatic fossa. Finally, the prostate capsule and the urethrovesical incision were closed water-tight by a running Vicryl 2-0 suture (Fig. 18.3). A suction drain was placed, and the specimen was removed via Endo-bag through the sub-umbilical incision. Data was collected with the jmp-7 programme, statistical analysis was based on the Mann–Whitney-test, and $p < 0.05$ was accepted for significance.

Table 18.2 Operative data and clinical outcome

	Median (min-max)
Operative data	
Conversion rate	0/13 (0 %)
Total operative time (min)	210 (150–330), 140 (110–180)[a]
Blood loss (ml)	500 (100–1,100), 250 (200–350)[a]
Transfusion rate	0/13 (0 %)
Outcome data	
Hospitalisation (days)	6 (5–15)
Adenoma weight (g)	82 (50–150)
Indwelling catheter time (days)	6 (3–15)
Return to work (days)	13 (8–17)
Follow-up time (months)	13 (2–18)
Residual urine (ml)	0 (0–60)
Flow (ml/s)	23 (3–33)

[a] Patients with single finger assisted enucleation ($n=3$)

Table 18.3 Patient data

Patient data	Median (min-max)
Number of patients (*N*)	13
Age (years)	70 (53–72)
Body mass index (BMI)	26 (23–31)
Estimated prostate volume (ml)	100 (90–180)
Residual urine (ml)	85 (10–250)

Total operative time (skin-skin) was 210 (150–330) min (Table 18.2). Blood loss was 500 (100–1,100) ml. Single finger assistance improved total operative time to 140 (110–180) min ($p=0.007$) and blood loss to 250 (200–350) ml ($p=0.02$). No blood transfusions were needed. No open conversions occurred. Prostate specimen enucleate weight was 82 (50–150)g. Histopathology confirmed benign prostate hyperplasia in all cases. The indwelling catheter was removed after 6 (3–15) days. One patient had an anastomotic urinary leak at the anterior aspect of the bladder and needed transurethral catheterisation for 2 weeks. Return to work was 13 (8–17) days after hospital discharge. No peri-operative reoperations were performed. In one patient, a bladder neck stricture was incised transurethrally at 4 months postoperatively. After a follow-up period of 13 (2–18) months patients had no residual urine and a urinary flow rate of 23 (3–33) ml/s.

Robotic pre-peritoneal adenomectomy may become more popular with increasing availability of robotic systems and trained urological teams. Presently the open retropubic adenomectomy remains the standard in the urological community despite the good results of Holmium-laser-enucleation, and laparoscopic and robot-assisted surgery, in addition these minimally invasive procedures for large benign prostates remain exclusive to sub-specialised centres. Prospective future comparative studies are needed to determine the definitive place of robotic adenomectomy as open retropubic prostatectomy has set a high standard against which any new technique must prove itself.

Robotic extraperitoneal transvesical prostatectomy for severely enlarged glands is feasible, reproducible and offers distinct benefits compared to open surgery regarding intra-operative visual control of the prostatic fossa. However, overall objective intra- and postoperative data do not yet reveal clear benefits of the robotic laparoscopic technique. The potential advantages of the minimally invasive approach may be relativised by the longer total operative time due to stepwise prostate extraction in very big glands. Further development of the technique is needed to decrease enucleation time and total blood loss.

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Part VII

Radical Prostatectomy

Trans- and Extraperitoneal Approach for Robotic-Assisted Radical Prostatectomy

19

Marcus Horstmann and Hubert John

19.1 Introduction

The number of robotic-assisted radical prostatectomies has increased tremendously in recent years. In the United States, more than 70 % of radical prostatectomies are performed with a robotic system [1, 2]. Advances of the console, the surgical arm cart as well as standardisation of the procedure have made robotic-assisted radical prostatectomy a success [3]. Its advantages over conventional laparoscopy, such as seven degrees of freedom, dexterity enhancement, stereovision and tremor filtering result in a steeper learning curve for surgeons in comparison to conventional laparoscopy and allows for open surgeons easier adoption of minimal invasive techniques [4].

The technique of robotic-assisted radical prostatectomy was first described in 2001 using a transperitoneal access [5]. This approach has remained the most common and the most favoured. The feasibility of an extraperitoneal access was first reported by Gettman and Abbou in 2003 [6]. Since then the extraperitoneal approach has been routinely described [7, 8] and compared to the transperitoneal approach for radical prostatectomy [9–12]. It mimics the open retropubic technique and offers some distinct advantages over the transperitoneal approach. This chapter describes both techniques step by step and discusses their advantages and disadvantages with the recent literature.

19.2 Transperitoneal (TP) Approach: Step by Step

19.2.1 Installation of the Patient

The patient is placed under general anaesthesia and full relaxation in a supine position. The legs are slightly abducted and fixed into padded receptacles (Fig. 19.1). The arms of the patient are placed alongside the body in arm padding. A 20 Fr. silicon urinary catheter is inserted to fully drain the bladder.

19.2.2 Trocar Placement

A supra-umbilical midline incision of 2–3 cm is performed, and the anterior rectus fascia is exposed from fatty tissue by two Langenbeck retractors. Using the Hasson technique, the anterior and posterior sheet of the rectus fascia and the peritoneum are opened stepwise (Fig. 19.2). The camera trocar (Ethicon®) is inserted into the abdominal cavity, and a pneumoperitoneum with high flow CO_2 insufflation is installed. Alternatively the pneumoperitoneum can be created by a Veress needle. To avoid CO_2 leakage, the skin incision is closed by a continuous

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Fig. 19.1 Patient positioning and monitoring. The patient is placed in a supine position, the legs slightly abducted. The legs are fixed with towels, in padded channels. Monitoring is achieved by a O_2 saturation (*arrow*) at the right big toe, (*arrowhead*). Central venous monitoring is not routinely necessary

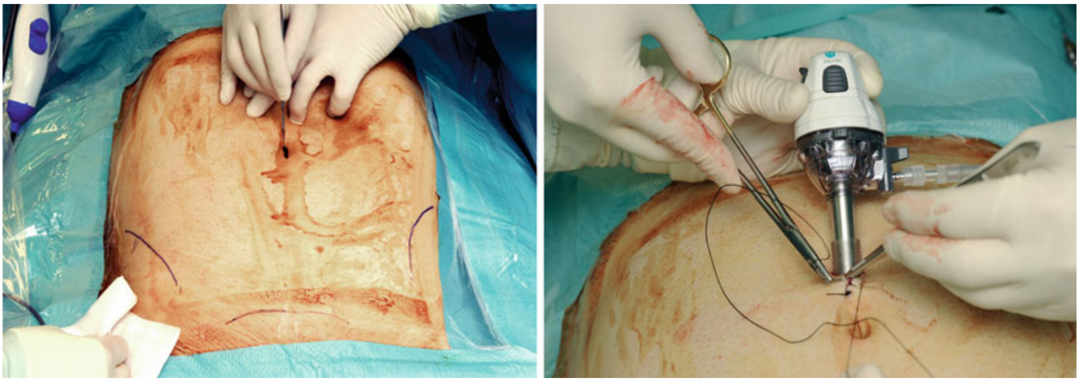

Fig. 19.2 Median supra-umbilical incision and transperitoneal positioning of the optic trocar. Skin closure after creation of the pneumoperitoneum to avoid leakage

suture. The da Vinci® camera (Intuitive Surgical®) with a 0° optic is inserted and the abdominal cavity is explored. In case of clear vision and no adhesions, the right 8-mm robotic trocar (Intuitive Surgical®) is placed under endoscopic control about 10 cm laterally to the umbilicus with a maximal distance of 18 cm to the pubic bone (Fig. 19.3). Translumination is used to avoid vessels of the abdominal wall (epigastric vessels).

Three to four fingers laterally to the right robotic port and preferably 2–3 cm more cranially, by a 12-mm assistant trocar (Versaport®, Covidien) is placed with a minimal distance of 3 cm to the iliac crest. CO_2 insufflation is connected to this assistant port, and the left 8-mm robotic trocar is placed about 10 cm laterally to the umbilicus under endoscopic vision through the Versaport (right assistant trocar) (Fig. 19.4). Then a 5-mm assistant trocar is placed between the

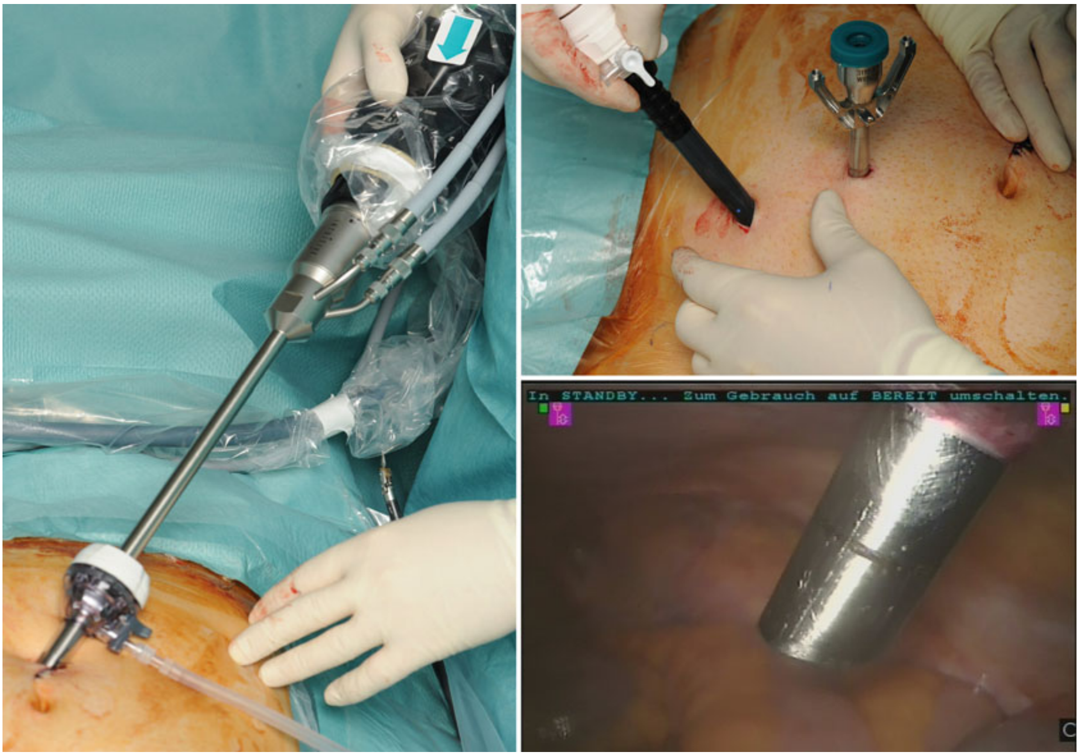

Fig. 19.3 Insertion of the right robotic trocar and the 12 mm assistant trocar under visual control

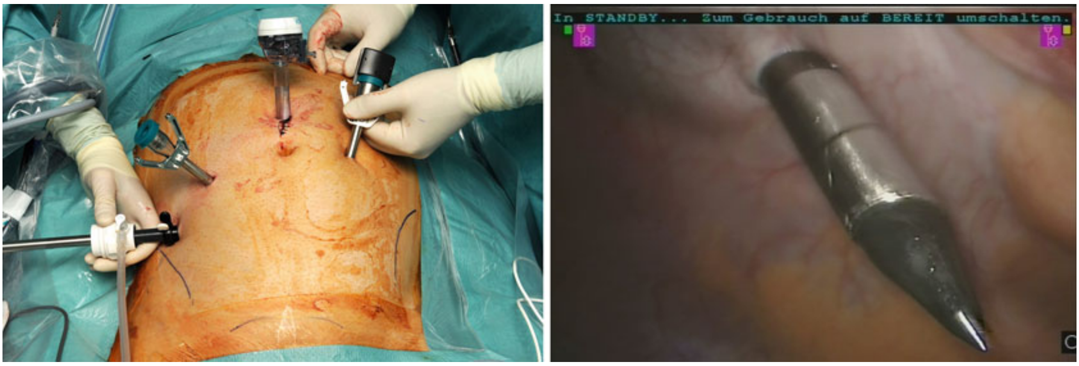

Fig. 19.4 Insertion of the left robotic trocar under visual control through the 12 mm assistant trocar

camera port and the right robotic port (Fig. 19.5). The final position of all trocars is shown in Fig. 19.6. The patient is then put into a Trendelenburg position of about 35°, and the surgical arm cart is pushed into position. The column is positioned between the feet and the camera arm is connected. The 0° 3D endocamera is introduced under vision into the abdominal cavity and gently elevated with the camera arm lifting the abdominal wall (‘laparo-lift’). Both robotic arms are connected to the robotic trocars, and the position of the surgical arm cart is checked. Compression of the lower extremities by the robotic arms is excluded, and the most optimal

Fig. 19.5 Incision for the 5 mm assistant trocar

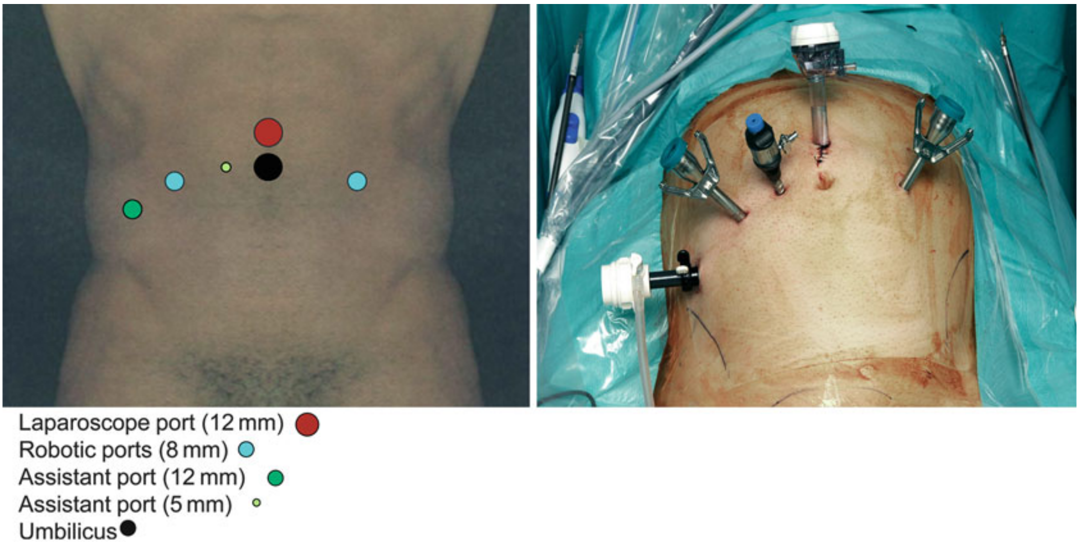

Fig. 19.6 Final port placement in transperitoneal robotic prostatectomy

working angles for each robotic arm are established. The bipolar and monopolar cables are connected onto the bipolar forceps and the monopolar scissors, respectively. The robotic instruments are attached to the robotic arms and inserted under endoscopic control into the abdominal cavity. Usually right-handed surgeons use a pair of monopolar scissors on the right and a bipolar forceps on the left side. Finally, the assistant's instruments: a suction device and a Johann forceps are introduced under optical control. The transperitoneal access is then accomplished, and the radical prostatectomy can be started.

In case of adhesions, modifications to the sequence and the localisation of the ports have to be considered. Minor adhesions can be removed by the console surgeon using the robotic system after installation of the surgical arm cart. In case of severe adhesions which do not allow regular port placement, standard laparoscopic adhesiolysis has to be performed prior to the connection of the surgical arm cart.

19.3 Extraperitoneal (EP) Approach: Step by Step

19.3.1 Installation of the Patient

The patient is prepared and positioned analogous to the above-described transperitoneal approach, although the Trendelenburg can be considerably reduced to around 20° (Fig. 19.1).

19.3.2 Trocar Placement

The skin is incised over 2 cm transversely just below the umbilicus. With two Langenbeck retractors, the anterior rectus fascia is freed. The anterior rectus sheet is incised vertically over 1 cm (Fig. 19.7). The two Langenbecks divide the rectus muscle and expose the posterior layer of the rectus sheet. The preperitoneal space is freed by blunt finger dissection and further developed with an inflatable balloon trocar (Tyco®). The balloon is filled by 10–15 pumping actions, until the extraperitoneal space is appropriately created (Fig. 19.8). Balloon dilation must be carefully performed to avoid bladder ruptures that have occurred in cases of over-dilatation. The first 8-mm robot trocar (Intuitive Surgical®) at the left side is bluntly introduced between the subumbilical incision and the left anterior iliac crest, about 1 cm lower than the optical trocar incision (Fig. 19.9). Then, the 12-mm optic trocar (Ethicon®) is introduced and the insufflation is started (high flow, maximal intra-abdominal pressure 12 mmHg). After closing the incision around the trocar with a silk suture to prevent gas loss, an inspection of the extraperitoneal space is performed with the 0° 3D endocamera. Under direct vision, the camera can be used to increase the size of the extraperitoneal space by gently sweeping the peritoneal borders latero-cranially (Fig. 19.10). The extraperitoneal exposure is expanded by circular movements of the tip of the camera and the optical trocar – until the second 8-mm robot trocar can be placed under visual control. Performing an extraperitoneal approach, the robotic trocars are placed about 1–2 cm caudal to the camera port. The 12-mm disposable assistant trocar (Versaport®, Covidien) at the right side is placed just craniomedial of the right anterior iliac crest. Finally, the 5-mm assistant trocar is placed in between, but about 2 cm cranial to the right robotic and the optic trocar (Fig. 19.11). The abdominal wall is slightly lifted by the camera arm trocar ('laparo-lift').

Alternatively to the right sided 5-mm trocar, a 10-mm trocar can be introduced medial of the left iliac crest in the two-assistant situation. Usually

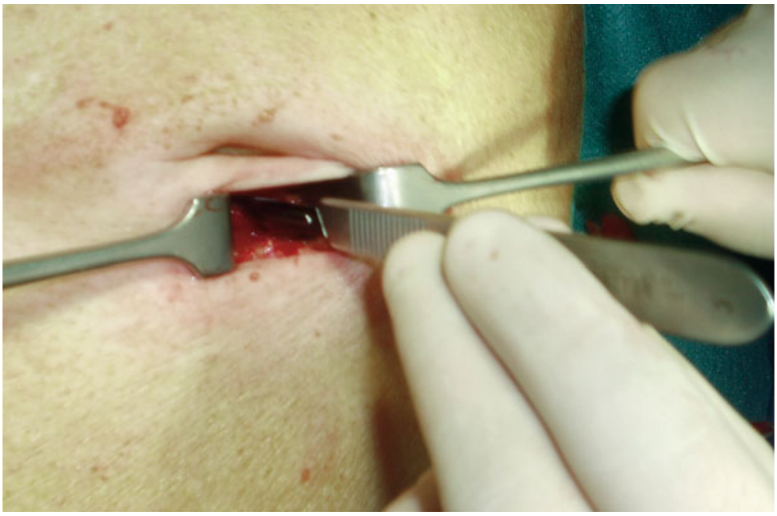

Fig. 19.7 Incision of the anterior rectus fascia. After the infra-umbilical incision is performed and the fascia exposed by the Langenbeck retractors, the anterior rectus fascia is incised vertically over 1 cm

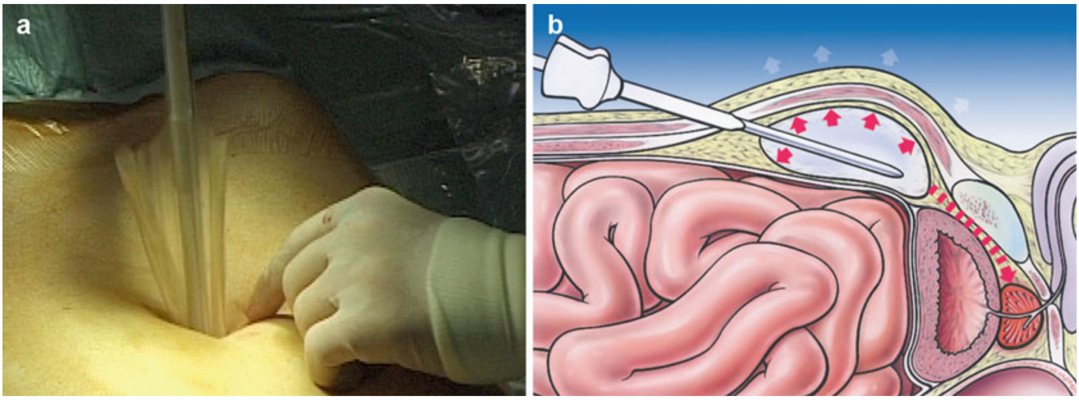

Fig. 19.8 Balloon-dilatation of the extraperitoneal space. (**a**) After a 2 cm infra-umbilical transverse incision, the balloon trocar is inserted and the pre-peritoneal space created. (**b**) Direct access to the bladder and prostate is achieved

Fig. 19.9 First robotic trocar placement. The tip of the right index finger guides the blunt obturator tip of the 8 mm robotic trocar down into the extraperitoneal space that has been created by prior balloon dilatation

another 5-mm suprapubic trocar is not needed, which some groups introduce routinely during the intervention. Minimal Trendelenburg position is required (15–25°). The column of the arm cart is placed between the legs, and the robot arms are attached to the trocars. Both arms are connected and the EndoWrist® instruments (bipolar forceps on the left side and curved scissors on the right side) are inserted under visual control. The bipolar and monopolar cables are attached to their respective instruments. Before starting with the operation, it is insured that the lower extremities are not compressed by the robotic arms. The console surgeon leaves the operating table after port placement and is not sterile scrubbed during the remaining procedure. Usually, the console surgeon works with the pyramid tip (PreCise™) Maryland forceps or PK™ dissecting forceps at the left side and cold or hot scissors at the right side. An aspirator serves the operating field through the 10-mm trocar from the right side. The intra-abdominal CO_2-pressure is regulated at 12 mmHg but may be increased during the dissection of the Santorini plexus to 18 mmHg to avoid bleeding and reduced to 8 mmHg at the end of the procedure to check haemostasis.

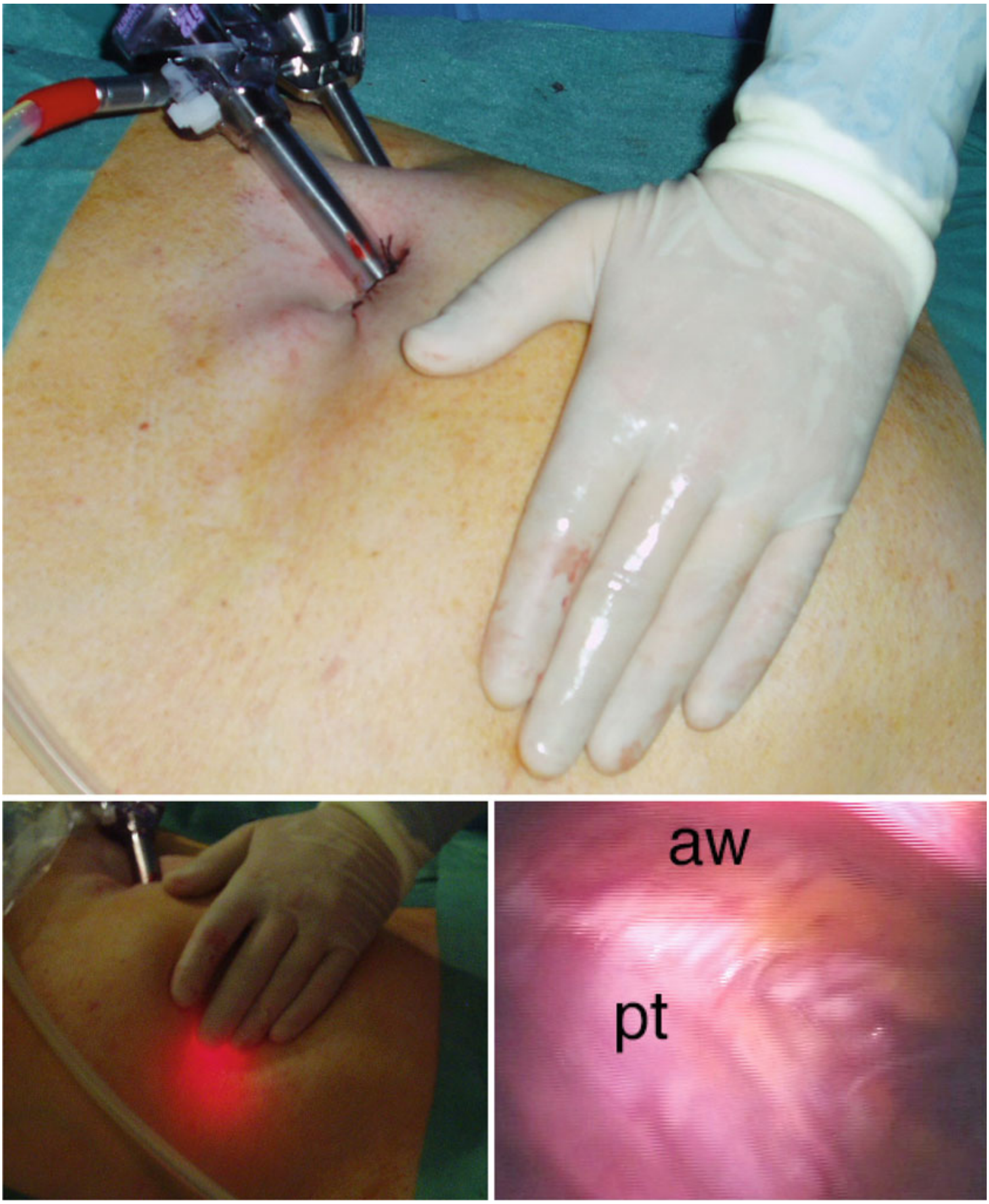

Fig. 19.10 Expanding the extraperitoneal working space under trans-illumination, the camera can be used to enlarge the extraperitoneal space by gently sweeping the peritoneal borders to the side and upwards (*pt* peritoneum, *aw* abdominal wall)

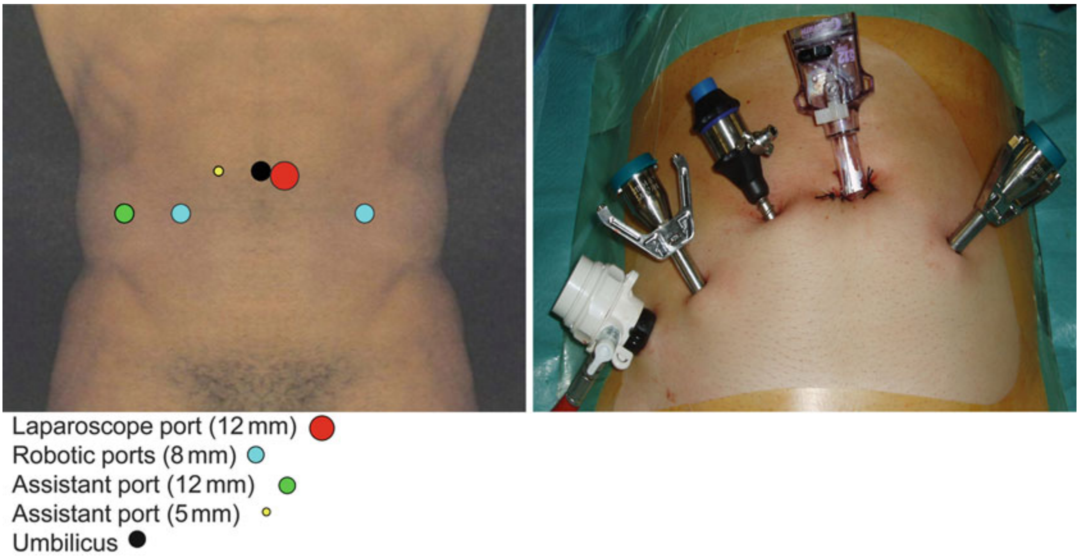

Fig. 19.11 Final port placement in an extraperitoneal robotic prostatectomy

19.4 Discussion

The debate which approach in which patient is more appropriate for radical prostatectomy first started in standard laparoscopy. Some authors described the advantages of the transperitoneal procedure with an easier approach and a bigger operating space whereas others stressed the advantages of an extraperitoneal procedure due to its reduced risk of intra-abdominal complications [13–15]. Since the introduction of robotic-assisted radical prostatectomy, this discussion continued. Currently, the transperitoneal approach is the most favoured and most often performed. Similar to standard laparoscopy, it is widely perceived to offer a larger working space, an easier port placement and connection to the robotic arm cart. However, also in robotic surgery the extraperitoneal approach offers some distinct advantages over the transperitoneal approach. Recent studies have compared the transperitoneal to the extraperitoneal approach for radical prostatectomy [9–12, 16] (Table 19.1). However, no consensus upon which approach should be used has been found [17].

19.4.1 Trocar Placement

In the transperitoneal approach, the camera is placed in a midline position just above the umbilicus, and the robotic trocars are ideally placed laterally to the umbilicus. In case of large patients, the distance of about 18 cm to the symphysis should not be exceeded. In extraperitoneal robotic-assisted radical prostatectomy, the trocars are placed more caudally with the robot trocars 1–2 cm below the infra-umbilical camera access. This is necessary not to injure the peritoneum which generally can be mobilised up to that level. In case of an accidental pneumoperitoneum, it should be corrected by a drainage cannula placed in the upper left quadrant of the abdomen (Table 19.3).

Especially in the extraperitoneal approach, the close vicinity of the robotic and assistant instruments can create some conflict. In our experience most often it can be overcome by minimal lateral displacement of the camera and/or robotic trocars. In general the extraperitoneal space is large enough, even to work with a fourth arm [18]. In patients with a very narrow pelvis, the use of bilateral assistant trocars can be recommended (Tables 19.2 and 19.3).

Table 19.1 Synopsis of four recent studies evaluating the trans- vs. the extraperitoneal approach

	Chung et al. [12]			Madi et al. [11]			Atug et al. [10]			Capello et al. [16]		
Approach	EP	TP	*p*	EP	TP	*p*	EP	TP	*p*	EP	TP	*p*
Study design	Prospective, non-randomised			Prospective, non-randomised			Retrospective, non-randomized			Prospective, non-randomized		
Patients (*n*)	155	105		34	21		40	40		31	31	
Mean operative time (min)	150	162	0.078	214	241	0.017	229	236	0.5722	181	191	0.2
Access time (min)	n.e.	n.e.		24	21		n.e.	n.e.		25	18	<0,001
Console time (min)	89	107	0.030	n.e.	n.e.		184	191	0.6580	n.e.	n.e.	
Preoperative data												
Mean age (years)	66	66	0.612	60	59	0.76	60	60	0.9073	56	59	0.06
BMI (kg/m^2)	24	24	0.386	n.e.	n.e.		28	27	0.6638	30	27	0.004
PSA (ng/ml)	16	15	0.138	Equal	Equal		7.4	7.2	0.8708	7.8	6.1	0.014
Post-operative data												
Pathological stage (%)												
pT2	61	66	0.080	80	90	0.46	73	78	0.7968	90	78	
pT3-T4	39	34		20	10		27	23		10	22	
Positive margins (*n*)	35	26	>0.1	8	4	0.75	8	7	0	1	0	
Lymph nodes removed (*n*)	10	11	0.091	n.e.	n.e.		9	13	0.0017	n.e.	n.e.	
Complications												
Overall (%)	7	19		3	5		13	13		0	3	
Blood loss (ml)	351	362	0.060	125	150	0.042	221	250	0.5199	199	163	0.019
Ileus (*n*)	0	7		0	1		0	1		0	0	
Hernia (*n*)	1	8		0	0		0	0		0	0	
Lymphocele (*n*)	10	4		0	0		0	0		0	0	
Conversion (*n*)	0	0		0	0		0	0		0	0	
Pain (*10-cm visual analog scale*)				n.e.	n.e.		n.e.	n.e.		n.e.	n.e.	
POD 1	3	6	<0.001									
POD 2	2	5	<0.001									
POD 3	1	2	0.089									
Functional outcome				n.e.	n.e.		n.e.	n.e.		n.e.	n.e.	
Nervesparing (uni/bilateral (*n*))	28/98	19/65					36	35				
Potency rates after 12 m (uni-/bi-%)	46/55	43/52					n.e.	n.e.				
Continence rates after 12 m (%)	99	97										

n.e. not evaluated; *EP* extraperitoneal; *TP* transperitoneal; *POD* postoperative day; *m* month

Table 19.2 Benefits of the extraperitoneal approach

Shorter operative time [6, 14, 19–22]
Better ventilation due to reduced Trendelenburg position
Open dissection planes after previous intraperitoneal surgery [23]
Better working space in obese patients [23]
Less subileus, return to full diet earlier [6, 24]
Less abdominal pain [6, 19]

Table 19.3 Pitfalls and tricks in the extraperitoneal approach

Problem	Solution
Peritoneal leak	Drain with solution cannula
Extraperitoneal dilatation impossible	Change to transperitoneal access
Very small pelvis	Bilateral assistant trocar position
Interferences robotic/conventional Instruments	Transpose robotic trocar 1–2 cm
Tension on anastomosis	Reduce CO_2 pressure (aspirator), use forceps for bladder wall

19.4.2 Intraoperative Ventilation

In both techniques the robot is positioned between the slightly abducted legs which ensure access to the perineum and rectum if necessary. In the transperitoneal access, a Trendelenburg position of about 35° has to be established in comparison to about 20° in the extraperitoneal approach. This improves intraoperative ventilation and prevents conjunctival oedema. Also the fact that no pneumoperitoneum is created in the extraperitoneal procedure facilitates intraoperative ventilation. Additionally, the robot arms are more easily connected in a minimal Trendelenburg position with less danger of compression of the lower limbs.

19.4.3 Avoiding the Intraperitoneal Cavity

The extraperitoneal approach strictly avoids the intraperitoneal cavity by using the peritoneum as a natural barrier and bowel retractor. This makes it the access of choice in patients after extensive pelvic surgery or inflammations with adhesions and fixed intestinal slings. In case of a pelvic kidney and patients after renal transplantation, a high trocar placement is required, and therefore a transperitoneal approach is recommended. Generally, using the extraperitoneal approach, the risk of bowel injury is very low, and post-operative ileus and peritonitis are rare. With the extraperitoneal approach, less subileus and earlier return to full diet [15, 24] combined with less abdominal pain have been described [15, 19]. Also trocar hernias are reported less frequently. Next, the extraperitoneal approach proved to be superior in patients with gross obesity [24]. This is because less bowel interference is observed, and the working space generally is created easily through the fatty tissue. Even though the extraperitoneal approach is feasible [16] in patients in whom this space is closed due to prior laparoscopic hernia repair, we generally recommend a transperitoneal approach in these patients (Table 19.4).

Table 19.4 Recommendations which approach to choose

Transperitoneal AP	Extraperitoneal AP
Extended lymphadenectomy	No extended lymphadenectomy
Pelvic or transplanted kidney	Severe adhesions
Uni- or bilateral mesh implant	Severe obesity Patient cannot endure steep Trendelenburg

AP approach

19.4.4 Operative Time

In recent publications total operative time is reported to be equal or shorter for extraperitoneal than for transperitoneal robotic-assisted radical prostatectomy (Table 19.1). Chung et al. reported a shorter overall operative time in extraperitoneal (150.3 ± 47.7 min) in comparison to transperitoneal procedures (162.1 ± 31.5 min) [12]. Also Madi et al. and Atug et al. described a shorter operative time in extraperitoneal than in transperitoneal prostatectomies (EP 214 min vs. TP 247 min, p =0.017 and EP 229 min vs. TP

236 min, $p = 0.5722$) [10, 11]. Capello et al. reported an overall operative time of 181 min using the extraperitoneal approach and 191 min using the transperitoneal approach ($p = 0.2$) [16]. The reduced or equal overall operative time was mostly due to a reduced console time, because peritoneal dissection and bladder mobilisation were not necessary in the extraperitoneal approach. Chung et al. reported a significant shorter console time of 89.1 ± 19.8 in the extra- versus 107.8 ± 19.7 in the transperitoneal approach ($p = 0.030$). Similar results were presented by Atug et al. However, the extraperitoneal approach itself took longer in most series [11, 16]. This was mainly attributed to the fact that additionally to the port placement the retrovesical space had to be established by balloon dilatation. In our experiences of 170 prostatectomies, mean time for an extraperitoneal approach was 21 min. The transperitoneal approach took in average 19 min [25]. All other surgical steps (from opening of the endopelvic fascia) such as removal of the prostate, preparation of the neurovascular bundle and time for anastomosis were reported to be equal in the literature as well as in our experience.

19.4.5 Anastomosis

Some authors argue that urethrovesical anastomosis is easier to perform using a transperitoneal approach. Reasons are mainly a larger working space and less tension on the anastomosis due to the mobilised bladder. As possible solutions in the extraperitoneal approach perineal pressure, reduction of the CO_2 pressure and bladder mobilisation were proposed (Table 19.3) [9]. Even though described as more difficult, objective outcome measurements such as time for anastomosis, the number of patients with non-watertight anastomosis and the days of catheterisation showed no differences regarding the approach in the current literature. The extraperitoneal approach was described as advantageous in case of urinary leakage as urine could not enter the abdominal cavity avoiding peritoneal irritation [9, 11].

19.4.6 Lymph Node Dissection

Standard lymph node dissection is described as feasible using both approaches. However, Atug et al. reported a reduced space especially in the region of the bifurcation of the iliac vessels using the extraperitoneal approach which is considered necessary for an extended lymph node dissection [9, 10]. Consequently, Atug et al. reported a reduced mean number of lymph nodes in patients after extraperitoneal prostatectomy when compared to patients after transperitoneal prostatectomy (EP: 8.7 nodes vs. TP: 13.2). Similar problems were discussed by Capello et al. who nevertheless concluded that a standard template lymphadenectomy can be carried out using both approaches [16]. Chung et al. reported in their series no differences in the number of removed lymph nodes (EP 10.8 ± 6.2 vs. TP 9.7 ± 5.7) [12]. They concluded that even though slightly more challenging similar lymph node dissection was feasible using both techniques. In our experience an extended lymph node dissection covering the template of the iliac bifurcation including clear visualisation of the ureter is only possible using the transperitoneal approach [25]. In this setting the more cranial trocar placement allows an easier access to the cranial lymph node dissection planes including the iliac bifurcation. Such an extended lymph node dissection should usually result in 18 or more lymph nodes. In that situation the transperitoneal approval additionally offers the advantage of less lymphocele formation. With regard to the easier approval and the reduced risk of lymphoceles, we therefore recommend the transperitoneal approval in patients in whom an extended pelvic lymph node dissection is necessary (Table 19.4).

19.4.7 Nerve Sparing

Technically nerve sparing can be performed equally using both approaches. In the most recently published series, the decision if nerve sparing was performed or not was independent of the chosen access. In the series of Chung et al. and Atug et al., this resulted in an equal number of patients with uni- or bilateral nerve sparing [9, 12]. In these groups none of the authors described any advantages or disadvantages for nerve sparing using one approach or the other.

19.4.8 Complications

Several studies investigated post-operative complications after robotic-assisted radical prostatectomies using both approaches (Table 19.1). In the series of Chung et al., overall complication rates were higher after transperitoneal prostatectomies (TP: 20 (19 %) vs. EP 11 (7.1 %), $p=0.73$) [12]. Post-operative ileus was observed in 7/105 (6.7 %) patients after trans- and in 0/155 (0 %) patients after extraperitoneal prostatectomy. Also a higher incidence of inguinal and ventral hernias in the transperitoneal group (eight after TP (five inguinal/three ventral) vs. 1 inguinal after EP) was observed. Only lymphoceles were more frequent in the extraperitoneal group (TP: 4 (3.8 %) vs. EP: 10 (6.5 %)). No differences were found in blood loss using both techniques. Studies of Madi et al., Atug et al. and Capello et al. reported no differences of complication rates [9, 11, 16]. Still Madi et al. reported in one out of two patients with post-operative complications a prolonged ileus due to urinary extravasation after transperitoneal prostatectomy. Another patient who also had urinary extravasation was successfully treated at home after an extraperitoneal procedure. Also Atug et al. reported one case of post-operative ileus due to urinary extravasation after a transperitoneal prostatectomy which was not observed in patients after an extraperitoneal intervention; however, overall complication rates were equal and mainly vascular complications (deep vein thrombosis, pulmonary embolism, epigastric vessel injury). In the extraperitoneal approach, some authors discuss a higher risk of epigastric vessel injury due to a more caudal trocar placement. Still, no differences were found in any recent study regarding this complication. Conversion was described in none of the series underlining the safety and feasibility of both approaches.

19.4.9 Post-operative Pain

Only Chung et al. investigated differences in post-operative pain in patients operated using either the trans- or extraperitoneal approach [12]. In their study patients with an extraperitoneal procedure reported less pain after radical prostatectomy. Post-operative pain was reported using a 10-cm VA (Visual Analog) scale and the amount of analgetics as outcome parameters. Although there were no significant differences between both groups in the quantity of opioides used, pain scores on post-operative day 1 and 2 were significantly lower in the extraperitoneal than in the transperitoneal group (2.7 vs. 6.3 and 2.1 vs. 4.8, respectively, $p<0.001$). This resulted in the conclusion that post-operative pain was lower after an extraperitoneal prostatectomy. Similar results were also described in a study by Remzi et al. who compared extraperitoneal to transperitoneal laparoscopic radical prostatectomy [19].

19.4.10 Oncological Outcome

According to the studies cited above, oncological outcome seems to be equal using both approaches [9, 11, 12, 16]. In the series of Chung et al. with similar preoperative tumour and prostate characteristics of both groups oncological outcome such as positive surgical margins and post-operative tumour stage were equal [12]. Interestingly in their study, the number of resected lymph nodes was also reported to be equal using both techniques. Also Madi et al., Atuq et al. and Capello et al. reported in their series similar results regarding positive surgical margins and post-operative tumour stage [4, 5, 16]. In these studies preoperative tumour and prostate characteristics were equal in both groups, as well. In all cited studies, the decision which approach was chosen was irrespective of preoperative oncological parameters.

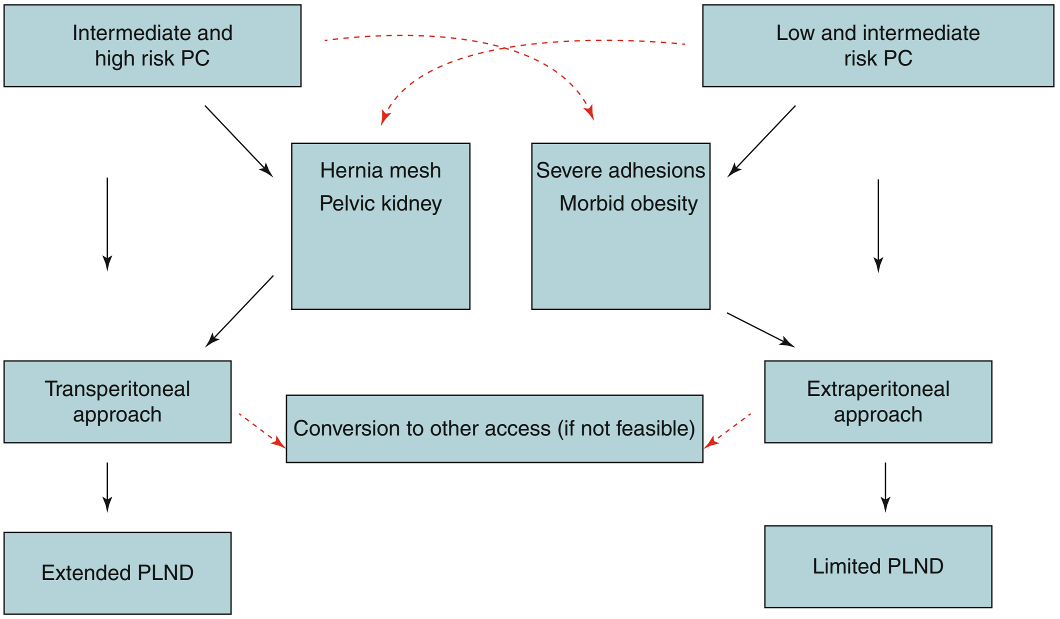

Fig. 19.12 Flow chart for decision making: choice of approval; *PC* prostate cancer, *PLND* Pelvic lymph node dissection

19.4.11 Functional Outcome

Only the study of Chung et al. compared post-operative functional outcome after robotic-assisted radical prostatectomy using both approaches [12]. Principal limitations of such comparisons include evolving surgical techniques and growing individual surgical experience during the learning curves. This might have a bigger impact on functional and oncological results than the approach itself. Nevertheless, the study of Chung et al. reported similar or even slightly better functional results in patients after an extraperitoneal approach. Functional outcome was considered possible for evaluation as pre- and post-operative functional and oncological parameters as well as the number of patients who had uni- or bilateral nerve sparing were the same. Continence and potency rates were evaluated using the IIEF-5-score, pad use per day and the incontinence questionnaire: ICIQ-UI SF. For patients with preserved bilateral bundles, potency rates were 51.8 % in the trans- and 54.8 % in the extraperitoneal group, and continence rates were 96.6 % in the trans- and 98.6 % in the extraperitoneal group 12 months after surgery. Interestingly even though final results were similar, early continence rates at 2 weeks, 1 month and 3 months were significantly better after an extraperitoneal approach. Again it has to be pointed out that such a comparison as described above is difficult to interpret especially in non-randomised studies. It has to be mentioned as well that so far no other comparative functional outcome data are published to our knowledge.

Conclusions

Although the transperitoneal approach is favoured by the majority of the robotic teams, the extraperitoneal approval finds growing popularity. Figure 19.12 and Table 19.4 give an overview of how we proceed in decision-making which access to choose in robotic-assisted radical prostatectomies. In low risk cancers, we routinely use an extraperitoneal approach combined with a limited pelvic lymphadenectomy. Only if hernia mesh implants or pelvic kidney is present or if the extraperitoneal approach is simply not feasible then a transperitoneal approach is chosen. In case of intermediate or high-risk prostate cancer, we prefer a transperitoneal approach that allows an extended lymphadenectomy. In intermediate and high-risk cancers, we only switch to an extraperitoneal approach in case of severe adhesions or morbid obesity. While oncological and functional outcome seem to be similar in both techniques, the extraperitoneal approach offers in our opinion some distinct benefits in avoiding the intraperitoneal cavity (Table 19.2). However, special circumstances as described above ask either for a transperitoneal or extraperitoneal technique. Therefore, centres of robotic expertise should train the parallel use of both approaches.

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Radical Prostatectomy: Anterior Approach

20

Charles-Henry Rochat

20.1 Introduction

Having had the opportunity to introduce the laparoscopic prostatectomy in Switzerland in March 1999, with the support of Dr. Richard Gaston, I overcame the first learning curve of the Montsouris technique [1]. Subsequently, I worked with Dr. Pierre Dubernard on the development of retrograde extraperitoneal laparoscopic prostatectomy (RELP) [2]. Thus, when we began the robotic-assisted laparoscopy program at the General Beaulieu Clinic in Geneva in 2003, I had already gained experience with various laparoscopic techniques. Over the years, I have had to adapt my robotic technique because of accounts and discussions from many conferences in which I have participated and also based on my own evaluation. Nowadays, I favor the anterior antegrade transperitoneal robotic approach [3] and reserve the extraperitoneal method for patients with a history of heavy abdominal surgery. I sometimes use the transperitoneal posterior approach [4] when I want to ensure that the rectal cleavage plane is healthy.

When using the anterior approach the prostate and seminal vesicles are viewed from above, whether following a transperitoneal or extraperitoneal approach. The dissection of the prostate is carried out in a retrograde or antegrade manner but in both cases, the deferential ampulla and the seminal vesicles are approached secondarily. The posterior approach on the contrary first exposes the vas deferens and the seminal vesicles.

Without going back over the history of the first laparoscopic prostatectomies we can observe a gradual abandonment of the posterior approach in favor of the anterior approach, which only requires a single peritoneal incision, thus enabling the course of the operation to flow better. Partial preservation of the seminal vesicles, with the aim of not damaging the neurovascular bundles passing at the tip, proves to be easier with the anterior antegrade method as the prostate can be raised at this point in the operation to better present the structures. During the posterior approach the prostatic vesicle block is immobile as it will not have been dissected before the seminal vesicles are prepared. Nevertheless, it is good to be familiar with the posterior approach, which guarantees checking the cleavage plane between the prostate and the rectum. This concerns patients with cT3 tumors, cases of salvage prostatectomy after radiotherapy or HIFU, or even patients with a history of rectal surgery.

The arrival of robotics has induced a surgical revolution and nowadays it is rare to find surgeons who have mastered both laparoscopic and radical prostatectomies. Most often the path leads directly from open surgery to robotic-assisted surgery [5] and in the future it is likely that some urologists will begin their training in robotics straight away. With only one dissection technique? When will

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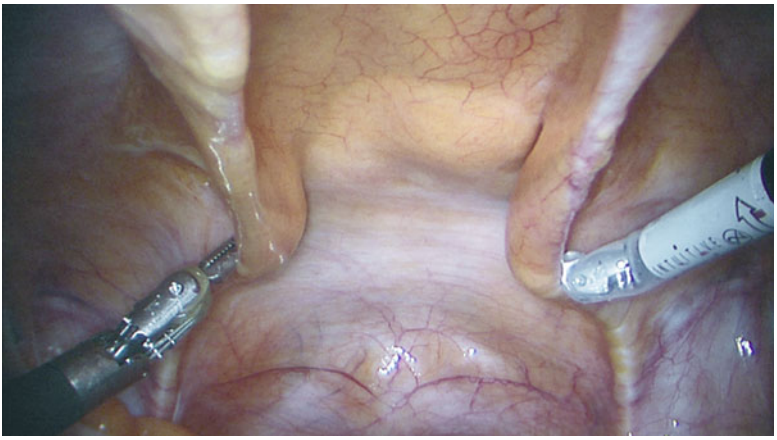


Photo 20.1 External view of umbilical arteries

there be a consensus? Whether returning to an anterior or posterior approach, the choice is mainly based on the approach to the deferential ampulla and the seminal vesicles. This choice bears no influence on the positioning of the patient or the trocars. It probably does not influence the operative time. None of randomized prospective studies have been able to show any difference on postoperative erectile function, depending on whether the seminal vesicles were approached anteriorly or posteriorly. Only the surgeon's routine will prevail, and it is mainly those who used to follow the posterior approach by laparoscopy for the seminal vesicles who continue to do so by the robotic-assisted approach. If the posterior approach to the seminal vesicles is an option, the anterior approach is still an integral part of the operation. The key to this anterior dissection is dropping the bladder and retracting the fat from the anterior surface of the prostate.

20.2 Access

Dropping the bladder can be done using the transperitoneal or extraperitoneal method, the aim being to release it at the height of the transverse crossing of the vas deferens. Not only is it necessary to release the bladder in order to carry out the prostatectomy but its mobility is essential to performing a tension-free vesicourethral anastomosis.

Here we will discuss the anterior transperitoneal approach up until the dissection of the deferential ampulla and the seminal vesicles as opposed to the posterior approach, which will be described in the following chapter. The section on the bladder neck, part of the initial phase of the vesico-prostatic cleavage plane, is described in a different chapter of the book.

20.2.1 Dropping the Bladder by the Transperitoneal Method

We use a 0° optic lens, arm number three with bipolar forceps, arm number one with monopolar scissors, and arm number two in waiting position. The assistant uses a Johann forceps through a median trocar and a suction device through a right lateral trocar. This configuration avoids conflict between the arms. Arm number two has Cadiere forceps or Cobra grasper forceps and will be used to apply traction to the bladder once it has been released. The inverted V created by the umbilical arteries can be used as a marker.

The incision begins on the right side, lateral to the union of the umbilical arteries, and is done with 40 W current monopolar scissors. An avascular plane opens quickly, aided by the dissection of the CO_2 to a pressure of 14 mmHg. The assistant, using the suction cannula helps to drop the bladder and find contact with Cooper's ligament and the pubis.

The incision of the peritoneum continues medial to the deep inguinal ring and then rejoins the vas deferens, which is followed over a few centimeters into its transverse section.

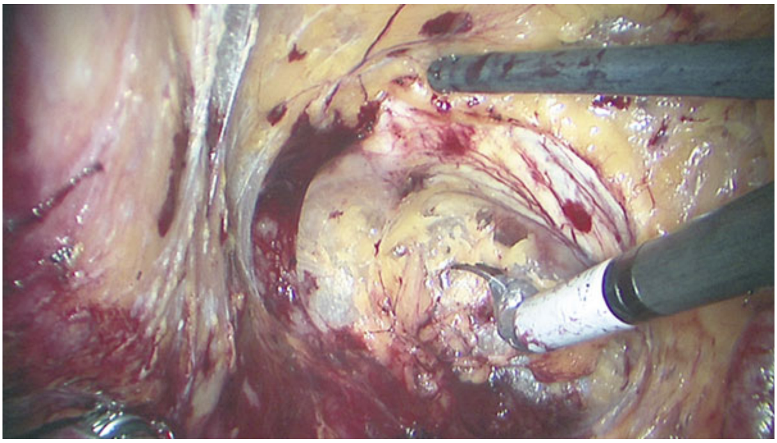


Photo 20.2 Dropping the bladder and exposure of the pubis

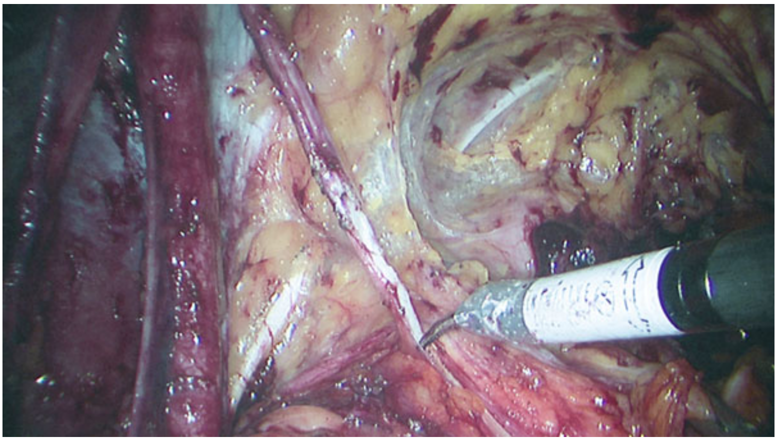


Photo 20.3 Bladder dissection up to the vas deferens (*left side*, notice previous lymphadenectomy)

It is not necessary to cut it here. This operation is performed exactly the same way on the other side. The endopelvic fascia is then relieved of all its fat.

Fat is also retracted from the puboprostatic ligaments and the superficial Santorini's veins are coagulated and sectioned. Special attention must be paid to preserving any accessory pudendal arteries running along the pelvic fascia.

Small fatty obturator hernias are often encountered. They are reduced in order to give better access to the operative field.

20.3 Special Cases

20.3.1 Presence of Inguinal Hernia

If the presence of an indirect inguinal hernia is noticed during the dissection of the space of Retzius care must be taken to reduce it by widely separating the hernial sac from the spermatic cord, at the height of the psoas muscle. The Bogros space will be completely dissected in this case. If a direct hernia is present within the epigastric vessels the hernial sac will be completely released and suppressed with the peritoneal sac. The defect can be treated by a nonabsorbable mesh providing that it is recovered from the peritoneum at the end of the operation. For this, we use a self-locking, barbed resorbable thread suture. Some new meshes are now available that require no peritoneal closure, as they can be in contact with the guts.

20.3.2 State After Laparoscopic Hernia Repair

Radical prostatectomy patients undergo laparoscopic hernia repair with the mesh relatively frequently. This is not a contraindication to a

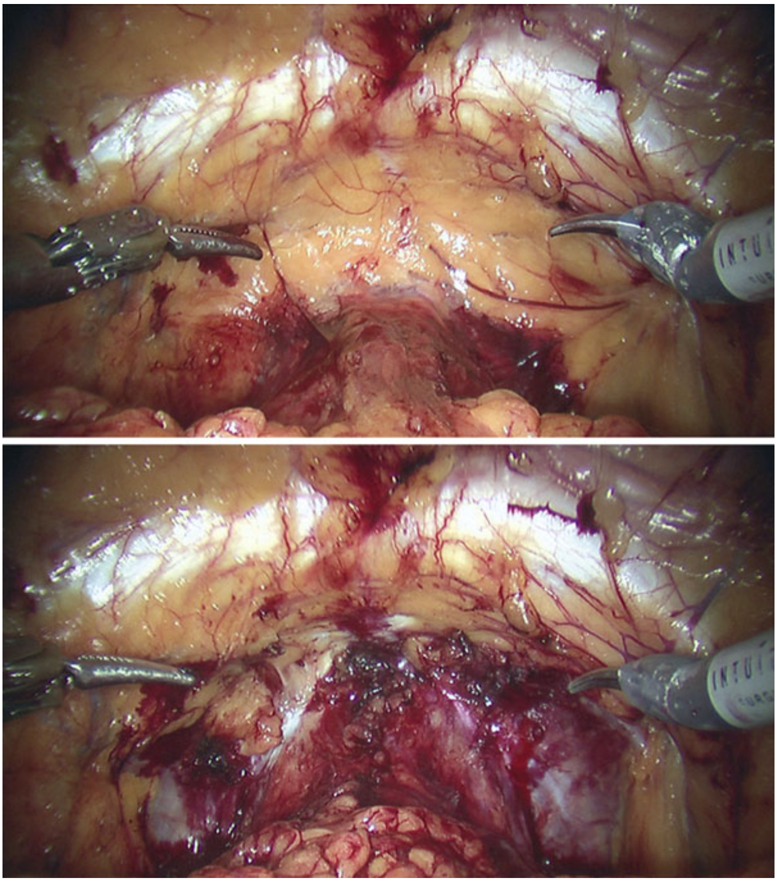


Photo 20.4 Removal of fatty tissue covering the endopelvic fascia before/after

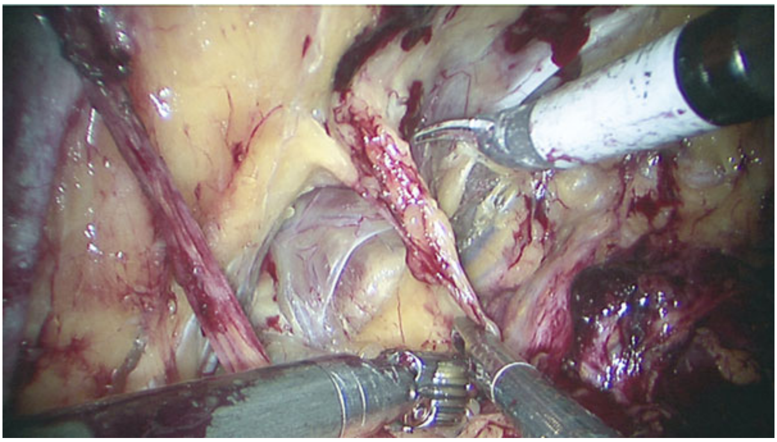


Photo 20.5 Removal of an obturator fat hernia

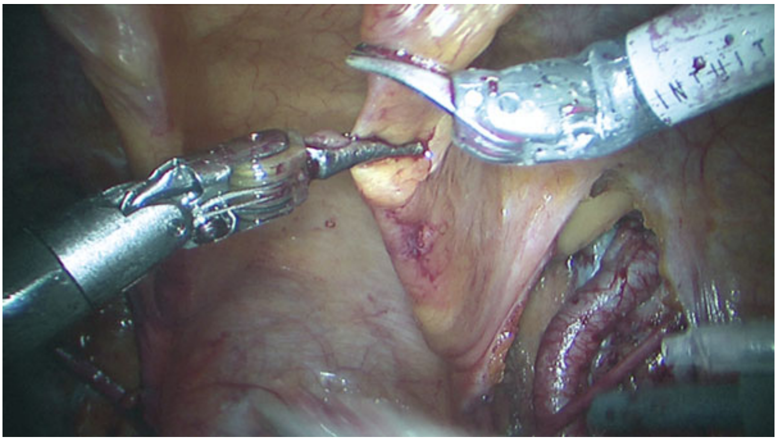


Photo 20.6 Incision of the umbilical artery (*right side*) after completion of the external iliac artery lymphadenectomy

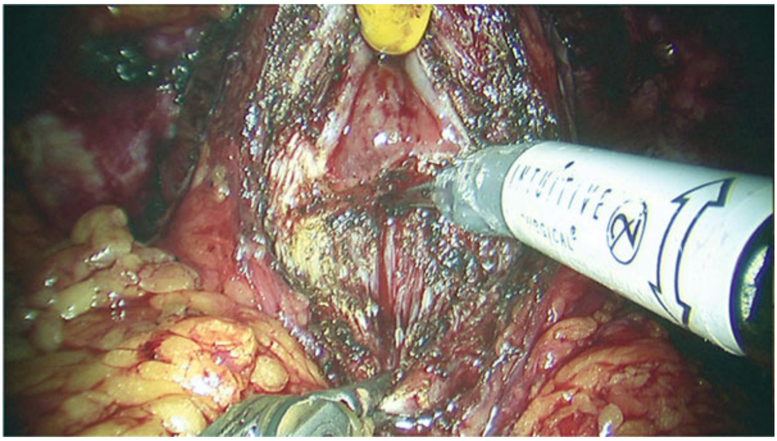


Photo 20.7 View of the Vesico-prostatic muscle

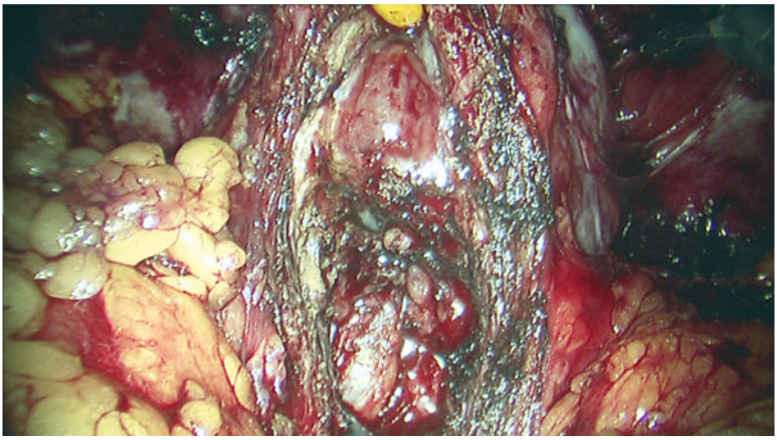


Photo 20.8 View of the deferential ampulla

Photo 20.9 Traction on the right vas

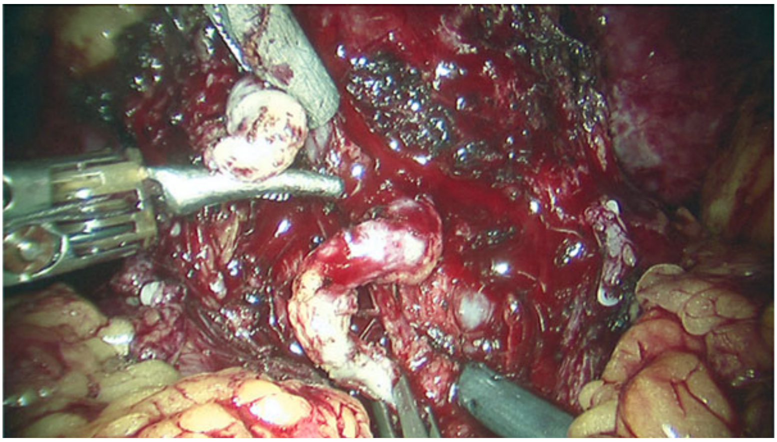
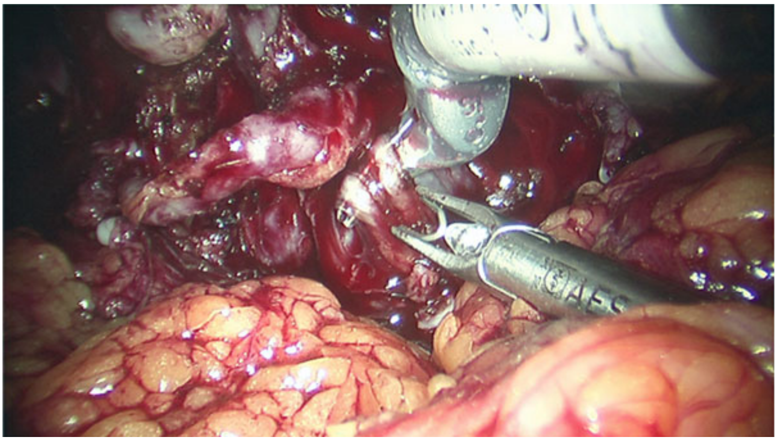


Photo 20.10 Clipping of the vascular pedicles of the seminal vesicle



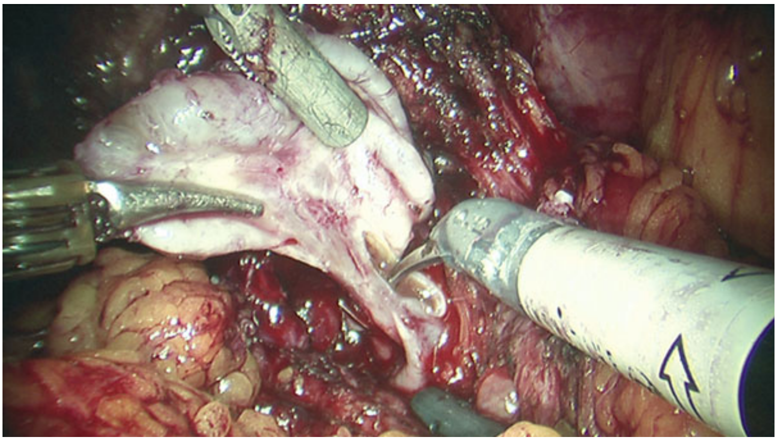


Photo 20.11 Preservation of the tip of the right seminal vesicle

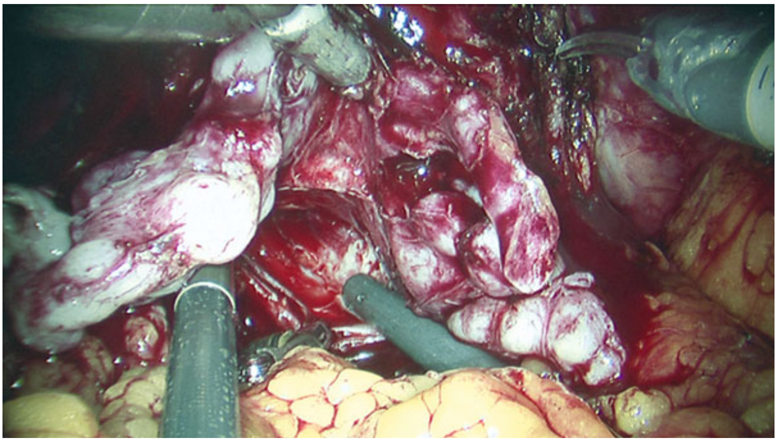


Photo 20.12 Opening of the posterior Denonvilliers fascia and initiation of the prostate-rectal cleavage

laparoscopic prostatectomy. The dissection of the prostrate is, in fact, done below the mesh. The only difficulty lies in detaching the bladder, which can be fixed above the pubis by attachments. Detachment can be aided by filling the bladder with 200 cc of NaCl.

20.3.3 Initial Lymphadenectomy

If an extensive lymphadenectomy is indicated (Gleason ≥ 7, PSA ≥ 15) the operation can begin with the lymph node dissection and possible extemporaneous examination. In this case the peritoneum is opened over the common iliac artery up to the epigastric vessels and the assistant medially retracts the umbilical artery in order to open up the dissection field. The bladder is dropped afterward.

20.4 Anterior Approach to the Deferential Ampulla and Seminal Vesicles

After sectioning the bladder neck and partially sectioning the prostate pedicles an incision is made through the vesicoprostatic muscle (previously named the anterior Denonvilliers fascia) in order to expose the deferential ampulla in the middle. This dissection is made with the aid of 30° downward optic lens

The assistant takes the vas deferens, as distally as possible with the Johann forceps and the vas deferens is then sectioned using the monopolar scissors. It is then coagulated. The traction on the Johann forceps enables a good opening angle on the median side of the seminal vesicles.

The seminal vesicle arteries are clipped with two 2-mm clips (Aesculap Challenger) on their distal extremities.

For low-risk cancers the tips of the seminal vesicles are left in place by cutting through the seminal vesicles without electrocoagulation.

The dissection continues by opening the posterior Denonvilliers fascia in order to initiate the cleavage plane between the prostate and rectum in the middle and to begin to free the neurovascular bundles laterally.

Conclusion

The observation of current trends favors robotic-assisted laparoscopic prostatectomies with an anterior approach to the seminal vesicles. An expert surgeon should nevertheless be familiar with several methods for approaching the deferential ampulla and seminal vesicles. Posterior dissection, continued until the apex, offers a guarantee for those cases where we fear that the cleavage plane between the prostate and the rectum may present adhesion problems.

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Robotic Prostatectomy: The Posterior Approach

21

Randy Fagin

21.1 Background

For over 15 years, urologists have described individual techniques for the laparoscopic approach to the seminal vesicles. These approaches have received the greatest attention over the last 10 years as the robotic approach to radical prostatectomy has gained popularity. Despite the differences in technique preferred and professed by individual surgeons, the dissection of the seminal vesicles during robotic prostatectomy can be broken down into two basic approaches: dissection posteriorly where the surgeon performs this portion of the operation below the bladder prior to opening the extraperitoneal space or dissection anteriorly where the surgeon performs this portion of the procedure through the posterior bladder neck after opening the extraperitoneal space and dissecting the prostate off of the bladder. There have been published articles, podium lectures, and editorials, including a point counterpoint written by myself and Dr. David Lee, espousing the personal preferences of experienced surgeons. To date, there is no consensus on a "superior" technique, only opinion as to advantages of each approach in the hands of individuals. Having learned my laparoscopic prostatectomy technique from the time I spent in the operating room with Drs. Guilloneau and Vallancian in 2000, I have always approached the seminal vesicles posteriorly, under the bladder, prior to opening the extraperitoneal space. When I made the transition from laparoscopy to robotics in 2004, I transferred my laparoscopic technique to the robotic platform and have continued to use the posterior approach to the seminal vesicles in over 2,100 robotic prostatectomies to date. In listening to the debate over whether the anterior or posterior approach is superior, it is my opinion that the answer is neither. Each technique has its merits in the hands of individual surgeons. However, when looking at the two techniques from the perspective of consistency, efficiency, and complexity one can begin to appreciate the assets of the posterior approach.

Understanding how the posterior approach allows the surgeon to have consistency, efficiency, and simplicity when performing this portion of the operation can be best explained in the context of access and efficiency. After discussing these assets, I will then describe the details of performing the posterior technique, the keys to success with it, and tips to avoid complications.

21.2 Access

Because the posterior approach is performed prior to dropping the bladder, the working space can make use of the entire abdominal cavity.

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This large working space reduces the potential for instrument collisions, reduces the need for intricate coordination of movements between the surgeon and assistant, and improves the surgeon's orientation by giving him a broad view of the surrounding anatomy. Furthermore, access to the seminal vesicles and vas deferens via the posterior approach is not limited or restricted by variations in patient anatomy like the size and length of the seminal vesicles, the size of the prostate, or the presence of a median lobe or protuberant lateral lobes. This lack of variability in anatomy allows for consistency and predictability in performing this portion of the operation.

21.3 Efficiency

The posterior approach also allows this portion of the operation to be performed with great efficiency. When performing the posterior approach, because the access to the vas deferens and seminal vesicles is not limited or affected by patient anatomy (the size and length of the seminal vesicles, the size of the prostate, or the presence of a median lobe or protuberant lateral lobes), the dissection is very consistent which improves reproducibility and reduces the time that it takes to complete this portion of the procedure. The large working space and ease of access to these structures also mean that the surgeon needs only one assistant whose job is to simply retract the anterior reflection of the peritoneal incision anteriorly also lending to the simplicity, efficiency, and reproducibility of this approach. Performing the posterior approach to the vas deferens and seminal vesicles also makes the posterior bladder neck dissection efficient. By approaching the vas deferens and seminal vesicles posteriorly, the posterior bladder neck dissection is simplified in that it becomes a straightforward midline dissection where the surgeon merely follows the contour of the bladder until reaching the previously created "hole" where the freed vas deferens and seminal vesicles reside.

21.4 Technique for the Posterior Approach to the Vas Deferens and Seminal Vesicle

21.4.1 Avoiding Injury to the Ureters

Before discussing the "how to" let me spend a moment discussing the "how to avoid" in the context of ureteral injuries. Due to the proximity of the ureters when performing this technique, there has been discussion over the potential for ureteral injury and cases of ureteral cauterization, ligation, and transection have been reported. Because of the ease of access to this location and the ability to gain perspective relative to surrounding structures, ureteral injury can be easily avoided if one familiarizes oneself with three facts about the anatomy in that region and follows three simple rules.

21.4.2 Three Important Anatomy Facts

1. The ureters are located superior and lateral to the location of the vas deferens.
2. The vas deferens meet in the midline and the ureters do not.
3. The seminal vesicles lie behind the vas deferens and not behind the ureters.

Understanding these three simple anatomy facts, however, is not enough. To avoid injury to the ureters, these facts must be applied in the context of following the three important rules below.

21.4.3 Three Important Rules

1. Make your peritoneal incision low and in the midline.
2. After incising the peritoneum, only use blunt dissection.
3. When dissecting out the vas deferens and seminal vesicles, only dissect on these structures, never around them.

Let's explore these three rules in greater detail and discuss how our three anatomy facts should

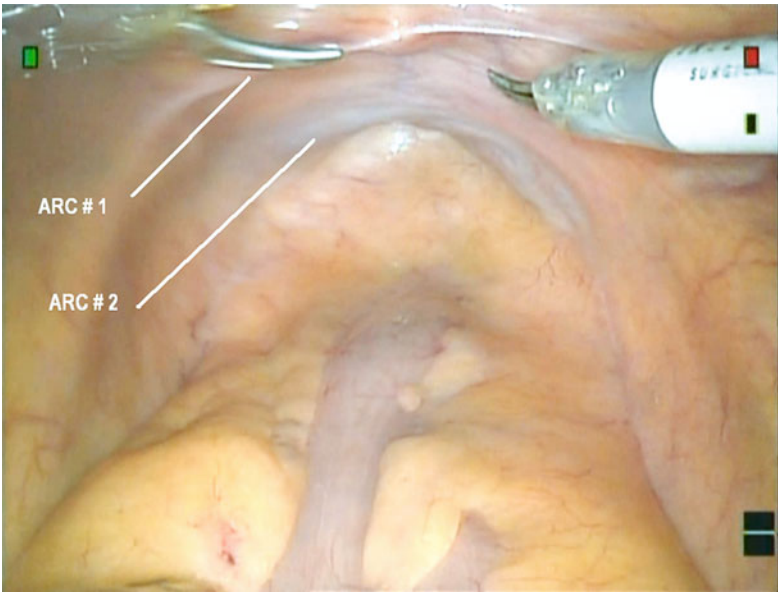

Fig. 21.1 Posterior arcs

be applied in this context as we describe the technique for the posterior approach to the vas deferens and seminal vesicle.

21.4.3.1 Step 1: Make Your Peritoneal Incision Low and in the Midline

The initial opening in the peritoneum should be made low and in the midline. Technically, there are supposed to be two arcs (Fig. 21.1) as the peritoneum arises off the rectum. The incision to access the seminal vesicles and vas deferens is traditionally described as being made in the lower of the two arcs (ARC #2 in Fig. 21.1). In real practice, however, these two arcs do not always exist, so I prefer a more predictable anatomic landmark: the junction of the sigmoid/rectum and the peritoneal reflection (Fig. 21.2). Using this landmark, I simply make my incision in the midline, ½ cm above the transition point where the peritoneum arises off the distal sigmoid colon/rectum. Figure 21.2 demonstrates this point at the tip of the scissors, and Fig. 21.3 shows this location after making the initial incision in the peritoneum. Staying low and in the midline here will keep you away from the ureters *which are located superior and lateral to the location of the vas deferens.* After making the peritoneal incision, it is important to note that the way in which you dissect becomes important in keeping you from inadvertently injuring surrounding structures.

21.4.3.2 Step 2: After Incising the Peritoneum, Only Use Blunt Dissection

Once the peritoneal incision is made, there is a real plane between the perivesical fat and the vas deferens and seminal vesicle. After opening the peritoneum, have your assistant retract anteriorly on the anterior leaf of the incision. If the surgeon then uses blunt dissection to simultaneously spread anteriorly and posteriorly with the instruments in the right and left hands, a thin layer of areolar tissue will become apparent. Continued blunt dissection in this manner and in this plane will lead to visualization of the vas deferens with the seminal vesicle directly behind it (Fig. 21.4). This blunt spreading dissection is important because continued sharp dissection and cauterization after making the peritoneal incision increases the potential for dissection in the wrong plane resulting in injury to the detrusor and/or ureters. Once the structure believed to be the vas deferens comes into view, there are two more steps I would recommend prior to transection or ligation to

Fig. 21.2 Peritoneal reflection

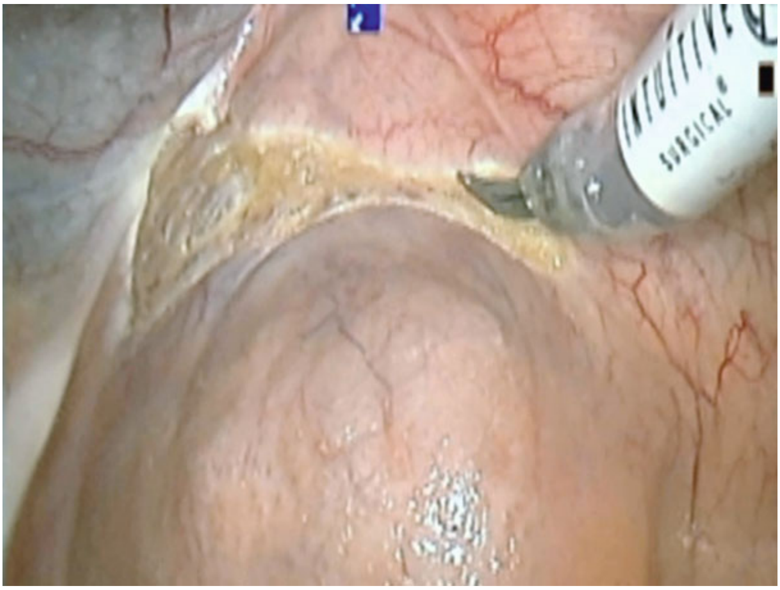

Fig. 21.3 Initial incision in peritoneum

ensure that the structure you are dissecting is truly vas deferens and not ureter. The first step to ensure the dissected structure is vas deferens is to trace the structure to the midline. If the structure being dissected meets a similar structure in the midline (and that similar structure it meets in the midline is arising from the opposite side), then the structure being dissected is vas deferens. Quite simply, *the two vasa deferentia meet each other in the midline and the ureters simply do not*. The second step is to perform blunt dissection behind the tubular structure believed to be vas deferens. This dissection will reveal the seminal vesicle if the structure being dissected is the vas deferens since *the seminal vesicles lie behind the vas deferens and not behind the ureters*. Once these two confirmations have been made, then

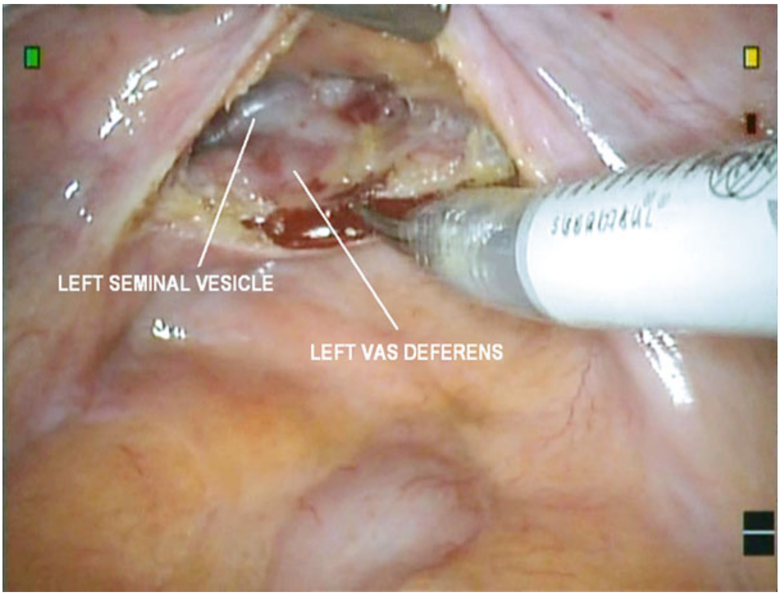

Fig. 21.4 Exposure of left seminal vesicle and vas deferens

transection and/or ligation of the vas deferens can be performed safely.

21.4.3.3 Step 3: When Dissecting out the Vas Deferens and Seminal Vesicles, Only Dissect on These Structures, Never Around Them

Despite doing all of the above, there is still the potential to injure the bladder or ureters if one additional rule is not followed. When dissecting out the vas deferens and seminal vesicles, the surgeon should only dissect *on* these structures and *never around* them. Performing dissection and cauterization in the tissues surrounding the vas deferens and seminal vesicles has the potential to injure those structures that lie within proximity (bladder, ureters, and neurovascular bundles). There is a true plane that separates the vas deferens and seminal vesicles from the surrounding structures. The simple task of dissecting and cauterizing *on* the vas deferens and seminal vesicle and then peeling the surrounding structures off bluntly can prevent injury to these nearby structures.

After dissection of the vas deferens and seminal vesicles bilaterally, many surgeons then incise Denonvilliers fascia and dissect the prostate off the rectum. I prefer not to incise Denonvilliers fascia at this time. At this point in the procedure, although you are able to perform this dissection, you do not have knowledge of where the neurovascular bundles are in relation to the viewed anatomy, and inadvertent injury to them can occur especially when you dissect toward the apex of the prostate where the two bundles are known to converge toward the midline. By waiting until after the posterior bladder neck dissection is performed, to incise this fascia and perform the dissection of the prostate off the rectum, the surgeon will have a greater appreciation for the lateral and medial limits of the prostatic pedicle and neurovascular bundles. This perspective allows for a more controlled incision in Denonvilliers fascia and an improved ability to avoid inadvertent injury to the neurovascular bundles. In addition, if one makes the incision in Denonvilliers and attempts to dissect the prostate off the rectum, and bleeding occurs in this deep hole, the surgeon's only solution is cauterization which also has the potential to injure the neurovascular bundles as well as the rectum.

Another asset of the wide access afforded by the posterior approach is related to the importance of staying athermal at the tips of the seminal vesicles. Due to the proximity of the tips of the seminal vesicles and the neurovascular bundles, remaining athermal at this location is important to improving potency outcomes. Because of the large working space afforded by the posterior technique, it is consistently easy to stay athermal at the tips and lateral portions of the seminal vesicles.

In conclusion, as surgeons decide on a method to approach the vas deferens and seminal vesicles for robotic prostatectomy, the posterior approach affords wide access, minimal dependence on one's assistant, consistency, and efficiency. This does not, however, mean that this approach is superior to the anterior approach. It is my belief that surgeons benefit from knowledge of both techniques and that to perform this portion of the operation consistently well, each surgeon should choose the technique that they prefer and perform it consistently.

Suggested Readings

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Bladder Neck Dissection During Robotic-Assisted Laparoscopic Radical Prostatectomy

22

Thierry Piechaud and Filippo Annino

22.1 Introduction

The approach to the bladder neck (BN) is the first critical step of antegrade laparoscopic radical prostatectomy. Its identification can be difficult in some cases, and a mistake at this point of the surgery can compromise the rest of the operation, influencing the next steps of dissection as well as the anastomosis.

Because of the complexity of the continence mechanism, the value of preserving the BN during radical prostatectomy is still debated, even if there is some evidence for an earlier return to continence in the cases where it is preserved [1]. Preservation of the BN does not seem to be correlated with a higher risk of positive margins [2, 3], even if some authors suggest that a wide resection of the BN decreases the positive surgical margin rate [4]. In our opinion, an accurate dissection of the BN and its preservation, especially of the posterior wall, could improve the early return to continence.

The preservation of the BN is not always possible during laparoscopic radical prostatectomy, particularly when a large median lobe is present, and preservation is never possible in case of a previous TURP in which the BN was destroyed. In suspected clinically advanced disease or in the case of positive biopsies at the base of the prostate, we suggest nonpreservation of the BN.

For all the above-mentioned reasons, we describe different approaches to dissection of the BN for each one of these scenarios.

22.2 Anatomy of the Bladder Neck

The bladder neck is the junction between the urinary bladder and the prostatic urethra and is placed at the distal corner of the trigone. At this level, the detrusor muscle is clearly separable into the three layers: inner longitudinal, middle circular, and outer longitudinal layers.

In men, radially oriented inner longitudinal fibers pass through the internal meatus to become continuous with the inner longitudinal layer of smooth muscle in the urethra.

The middle layer forms a circular preprostatic sphincter that is responsible for continence at the level of the bladder neck.

The outer longitudinal fibers are thickest posteriorly at the bladder base. In the midline, they insert into the apex of the trigone and interweave with the smooth muscle of the prostate to provide a strong trigonal backing. Laterally, the fibers from this posterior sheet pass anteriorly and fuse to form a loop around the BN. This loop is thought to participate in continence at the BN. On the lateral and anterior surfaces of the bladder, the

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longitudinal fibers are not as well developed. Some anterior fibers course forward to join the puboprostatic ligaments [5].

22.3 Anatomical–Surgical Correlations

As explained previously, the BN is composed of three layers of detrusor muscle and has in its luminal part the mucosa which continues together with the inner longitudinal fibers into the prostatic urethra.

On a three-dimensional view, we can identify six regions around the BN, like the faces of a cube.

Anterior to the BN are the Retzius space, the endopelvic fascia with the end of the puboprostatic ligaments, and the superficial branch of the deep dorsal vein of the penis. Proximally, the BN is related to the bladder lumen and the trigone. Laterally and behind the lateral part of the BN, we find the prostatic pedicles and the neurovascular bundles of the prostate as well as the lateral part of the seminal vesicles. Posterior to the BN we find, under the Denonvilliers fascia, the ducts vasa deferentia and the medial part of the seminal vesicles.

Posterior to the BN was always considered to be the anterior layer of the Denonvilliers fascia, which was considered to be a muscular layer of longitudinal fibers. Recently, Secin et al. reported an anatomical study demonstrating that this layer corresponds to the posterior longitudinal fascia of the detrusor muscle which is externally upholstered by the bladder adventitia [6].

Caudally, the BN has a close relation with the prostate, which in this area does not have a really well-defined capsule; however, at this level with the introduction of laparoscopy, and even more with the robotic approach to radical prostatectomy, we are able to find a real anatomical space in which we can clearly separate the muscular fibers of the bladder neck from the prostatic base. We describe this technique but want to highlight the reality of this anatomy, in which it is possible to find the initial part of the urethral tube, in the initial part of the supraprostatic dissection.

22.3.1 Median Lobe

The normal anatomy can be modified in the case of a large median lobe, where usually the posterior relations are changed. In fact, the presence of a voluminous median lobe pushes the BN cranially, reducing its distance from the ureteral orifices and separating the ducts and the seminal vesicles, which in some cases can be placed far away from the BN, with consequent difficult identification of the right plane of dissection.

This specific situation does not modify the anterior relations of the BN, but it can compromise the right identification of his position during the procedure. For this reason, the presence of a median lobe should be well investigated before the surgery with an ultrasound or an MRI.

22.3.2 Previous TURP

In the case of a previous TURP, the BN is usually destroyed and modified in its medial portion. In this case, the BN can be very close to the ureteric orifices. This modified anatomy should be well considered in order to prevent injury in the ureteric orifices during the dissection. It is also important to try and leave sufficient space between the limit of resection and the ureteric orifices to achieve a pristine urethrovesical anastomosis, without risk of injury to one or both ureteric orifices.

22.4 Functional and Oncological Principles of Bladder Neck Preservation

Radical prostatectomy should aim to maintain sexual function and achieve early continence after surgery, without hindering the final oncological outcome of the procedure.

In previous years, a great effort has been put into developing technical refinements in order to improve the clinical outcome and minimize the morbidity of radical prostatectomy. Various mechanisms responsible for male urinary continence have been reported in the literature, but no single definitive conclusion has been reached [7]. The factors favoring continence preservation after radical prostatectomy seem to be (a) the preservation of pelvic floor structures, (b) external urethral sphincter muscle and the anterior urethral support, and (c) the preservation of the neurovascular bundles. Another important role seems to be the age of the patient. As the patient ages, the elasticity of the pelvic floor muscles appears to diminish, and there is limited ability for nerve recruitment [8–13].

Puboprostatic ligaments support the external striated urethral sphincter, and their anatomical and morphological stability seems to have an important role in achievement of continence after radical prostatectomy, even if this remains an issue of debate.

Since Young in 1905 first described the role of puboprostatic ligaments in supporting the BN and promoting urinary continence after perineal radical prostatectomy, many authors have quoted the important role of this hypothesis, concluding that the ligaments are part of a larger urethral suspensory mechanism, stabilizing the membranous urethra to the pubic bone, thereby assuring continence [14, 15].

Other authors have reported a positive correlation between the mean urethral length and the continence rate showing a difference in the maximal urethral closure pressure [16, 17].

Poore et al. examined the effects of puboprostatic ligament and/or BN preservation on urinary continence after radical retropubic prostatectomy and observed an early return to continence with BN preservation but the same final outcomes with a puboprostatic ligament preservation technique or a combination of both [1].

Deliveliotis et al. evaluated three groups of patients in which they preserved the BN, the puboprostatic ligaments, or both and reported no difference on the final continence rate but an early return to continence in the patients in whom the BN had been preserved [3].

The puboprostatic ligament-sparing technique, as well as the BN-sparing technique, can be discussed also from the point of view of their oncological outcomes. Some authors suggest that sacrificing the puboprostatic ligaments and the BN decreases the apical positive margins [4]; however, this idea is controversial, since other authors have shown no significant differences in positive margin rates between two groups of patients treated with or without puboprostatic ligament-sparing technique [18].

Even if this point is still debatable, if the preservation of the BN does not clearly demonstrate an improvement in the rate of final continence, some studies suggest an earlier recovery of continence, with an obvious improvement in the quality of life, without an increase in the rate of positive margins [1, 3, 18].

22.5 Surgical Technique of Bladder Neck-Sparing Dissection During Robotic-Assisted Prostatectomy

We describe initially the classical approach and dissection of the BN during a transperitoneal laparoscopic radical prostatectomy assisted by the Robotic Intuitive Surgical System, known as the da Vinci robot, which can provide two or three operative arms. The dissection of the BN could be performed with both systems without substantial differences.

In this chapter, we describe the use of the four-arm da Vinci robot, but in the case of the three-arm robot, the third arm can easily be substituted by the assistant grasp. This can be achieved working with one assistant on the right side of the patient or with two assistants, where the second assistant should be placed on the left side of the patient in the same place as the fourth arm of the robot.

Next, we describe port positioning and the use of the fourth arm to illustrate how to use it.

We find it more comfortable using the red arm on the left side to leave enough space for the assistant who is placed on the right side of the patient. The dissection is performed using the yellow arm placed on the right iliac fossa, between the right anterior superior iliac spine (ASIS) and the umbilicus in the middle line or to the proximal third, depending on the position of the assistant ports. With this arm, we use the monopolar

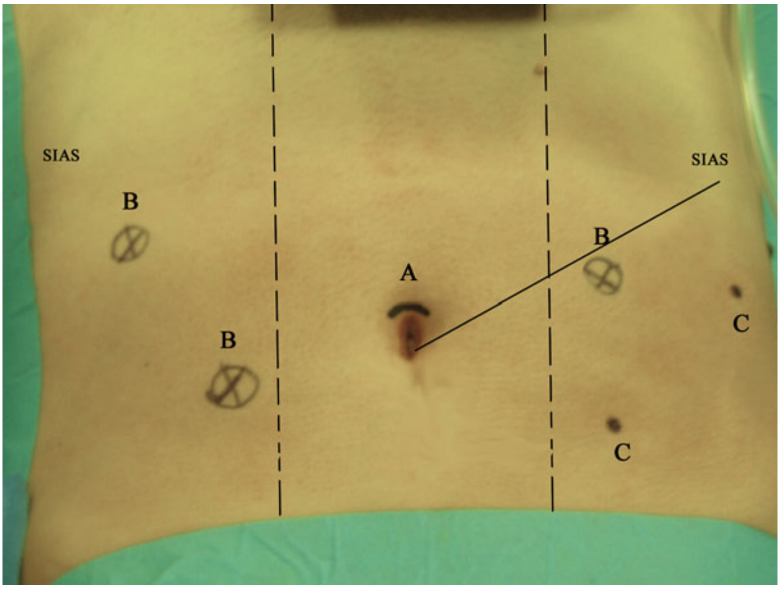

Fig. 22.1 Port positioning. (**a**) The optical 12-mm port is placed under or above the umbilicus. (**b**) The three operative 8-mm robotics ports are placed in the middle line between the right superior anterior iliac spine and the umbilicus for the yellow arm, 2 cm cranially to the optical port laterally to the left rectus muscle and three transverse fingers cranially to the left iliac crest at the anterior axillary line. (**c**) The two ports for the assistant are placed three transverse fingers cranially to the right iliac crest on the anterior axillary line and 3 cm cranially to the camera laterally to the right rectus muscle

scissors or the monopolar hook. We suggest to perform the entire procedure with the monopolar scissors on the right arm, to avoid multiple changes of instruments, and to reduce the costs.

On the left side of the patient, we place the green arm 2 cm laterally to the left rectus muscle and 2 cm cranially to the port for the camera. The red arm is placed as lateral as possible on the anterior left axillary line, three fingers cranially to the left ASIS. The assistant works with two 5-mm ports on the right side (Fig. 22.1).

We always begin with the division of the left colon adhesions in order to better mobilize the bladder once separated from the anterior abdominal wall. This maneuver is performed incising the umbilical arteries as high as possible and continuing the dissection laterally until the vasa deferentia are reached. It is very important to open this space well, incising the peritoneum as cranially as possible to achieve a better mobilization of the bladder (Fig. 22.2).

After the dissection of the Retzius space, the anterior part of the prostate and the endopelvic fascia are liberated from the surrounding fat tissue. During this maneuver which should be continued laterally until the level of the umbilical artery is reached, the superficial branch of the deep dorsal vein of the penis is treated with the bipolar cautery and is divided. The puboprostatic ligaments are also freed from the fat tissue and well identified. At this point, the vesicoprostatic junction is clearly visible, and its lateral margins are free to begin the dissection. If the endopelvic fascia is well prepared, we can identify the prostate, the bladder with the catheter balloon (previously inflated with 4–5 cc of water), and the puboprostatic ligaments reaching the BN (Fig. 22.3).

A little trick to better identify the BN and to begin our dissection in the right place is to follow the puboprostatic ligaments which usually cross at the level of the BN. At this point, the balloon of the bladder catheter can be deflated. Another trick is to follow the deflation of the balloon which can allow better identification of the BN. At this step, the fourth arm is introduced. We use a pro-grasp (Johannes) to gently retract the bladder to create a little tension on the BN, in order to better identify it. This maneuver is very important and allows an easier identification of the vesicoprostatic junction, even in situations where there is an evident median lobe. With this we cannot miss our site of dissection (Fig. 22.4).

The aim of the procedure is to find the vesicoprostatic plane that we mentioned in the paragraph covering anatomy. To achieve this step of the surgery, it is very important to prepare the endopelvic fascia, the BN, and the anterior surface of the prostate and to gently retract the bladder with the robotic grasper. We begin at this point, with a combination of blunt

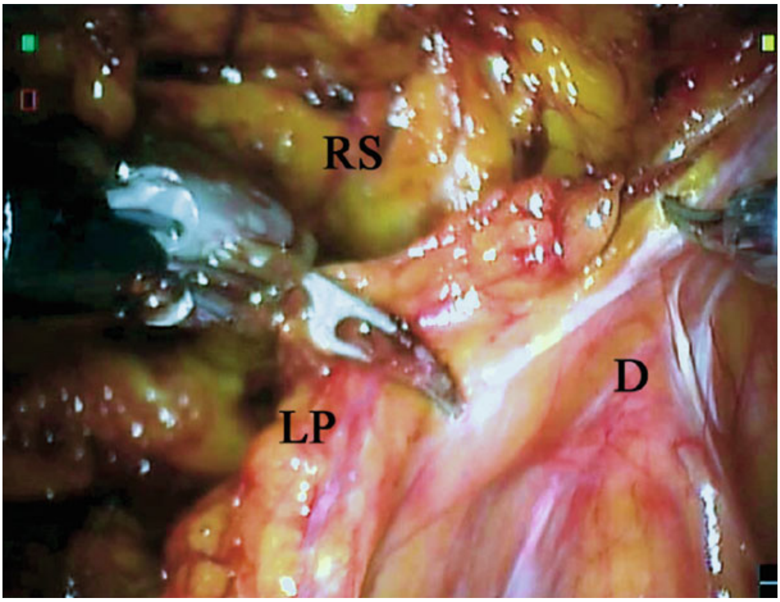

Fig. 22.2 The bladder is separated from the abdominal wall, and the peritoneum is opened until the vas deferens is reached as laterally and cranially as possible, to achieve complete mobilization of the bladder. This image is the detail of the right side where the peritoneum is incised until vas deferens is reached. *D* vas deferens, *RS* retius space, *LP* limit of peritoneum incision

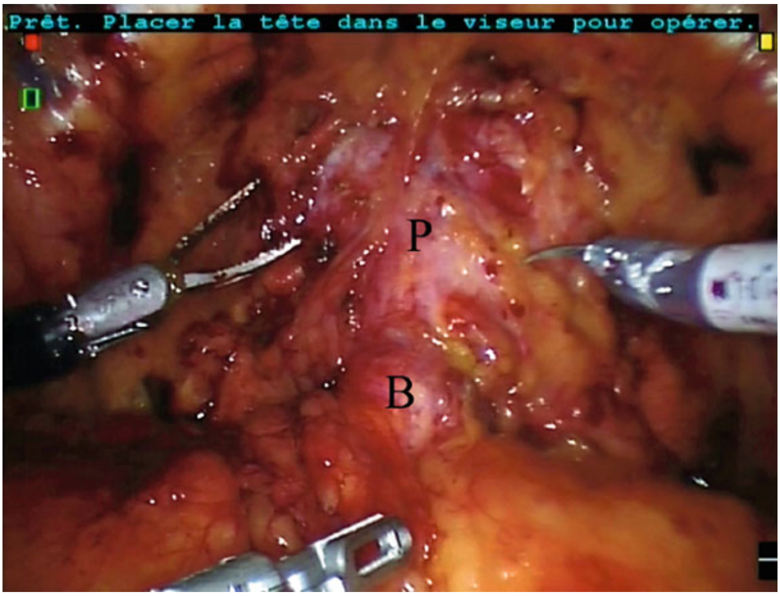

Fig. 22.3 Vision of the prostate (*P*) freed from the fat tissue. The bladder neck and the balloon of the bladder catheter (*B*) are clearly visible

and sharp dissection that can be performed as distal as we see the vesical fibers on the anterior prostatic surface or can begin from one side (Fig. 22.5) of the supposed BN in order to move the fibers medially and discover the anterior surface of the prostate (Fig. 22.6). The hemostasis is achieved at this step using the monopolar or the bipolar cautery.

Once the first layers of muscular fibers are dissected from the prostate base, we must follow the plane at 12 o'clock and laterally to the BN at 2 and 10 o'clock, until we clearly identify the inner longitudinal fibers of the BN coming out from the external layer of the outer longitudinal fibers and continuing in what we call "preprostatic urethra" (Fig. 22.7).

When this structure is identified, we continue always with blunt and sharp dissection laterally to the urethra with the aim of passing behind the urethra, preserving the proximal urethral

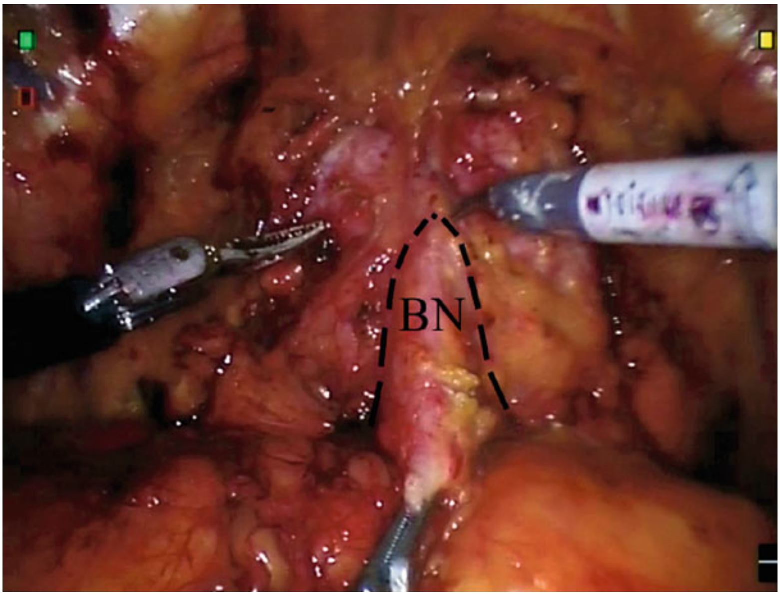

Fig. 22.4 The balloon of the bladder catheter is deflated, and a moderate traction is performed on the bladder, and the right position of the bladder neck is identifiable. If compared with Fig. 22.3, one can see how the real site of the bladder neck (*BN*) is higher on the prostate base and more caudal of the one identified with the balloon of the bladder catheter

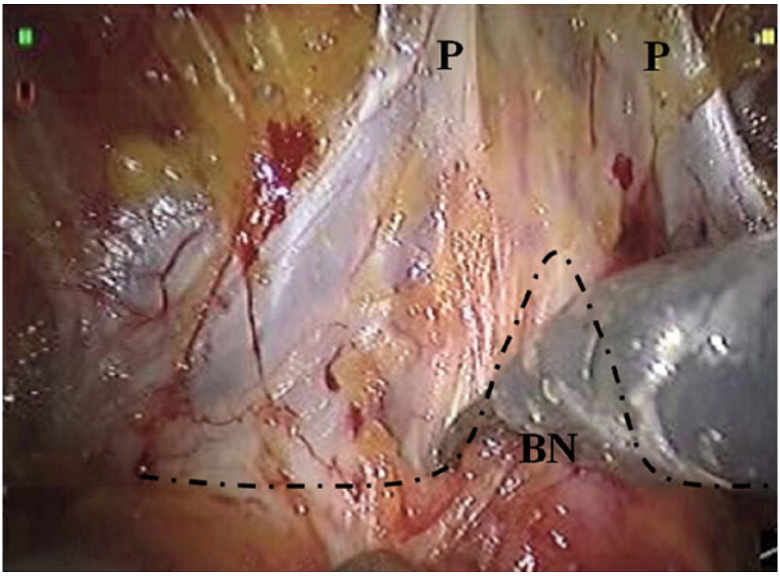

Fig. 22.5 A sharp and blunt dissection of the bladder neck begins at the 10 o'clock position. *P* puboprostatic ligaments, *BN* bladder neck

sphincter (Figs. 22.8 and 22.9). To better achieve this step, we can open the space laterally in the direction of the prostatic pedicles as far as necessary to have enough space.

Once the bladder external layer of muscular fibers is completely dissected from the prostatic base all around, the inner longitudinal layer and the preprostatic urethra are clearly visible, coming out from the BN and continuing into the prostate, and we can take out the bladder catheter and transect the urethra (Fig. 22.10).

With this kind of dissection, the posterior plane of the BN is at this point partially freed so that in the next step, we have to continue the dissection of the same plane in order to reach the

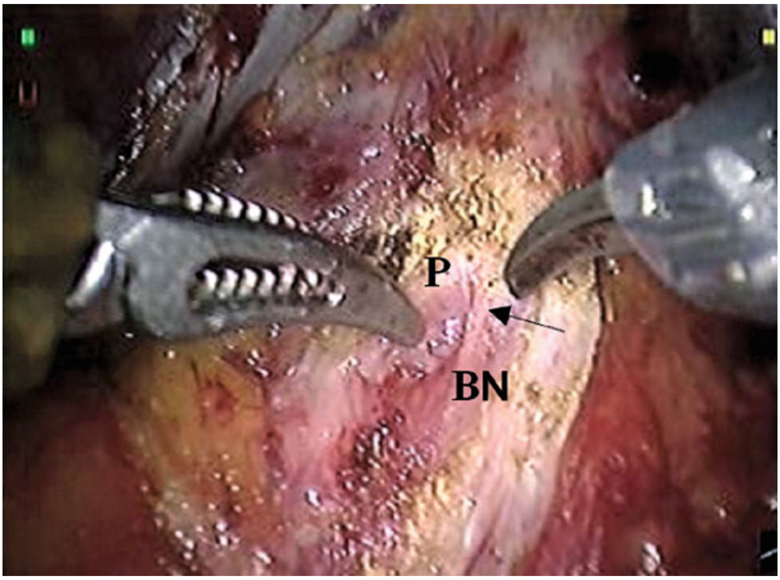

Fig. 22.6 The plane between the prostate base (*P*) and the bladder neck (*B*) is going to be dissected. The muscular fibers are clearly visible (*arrow*)

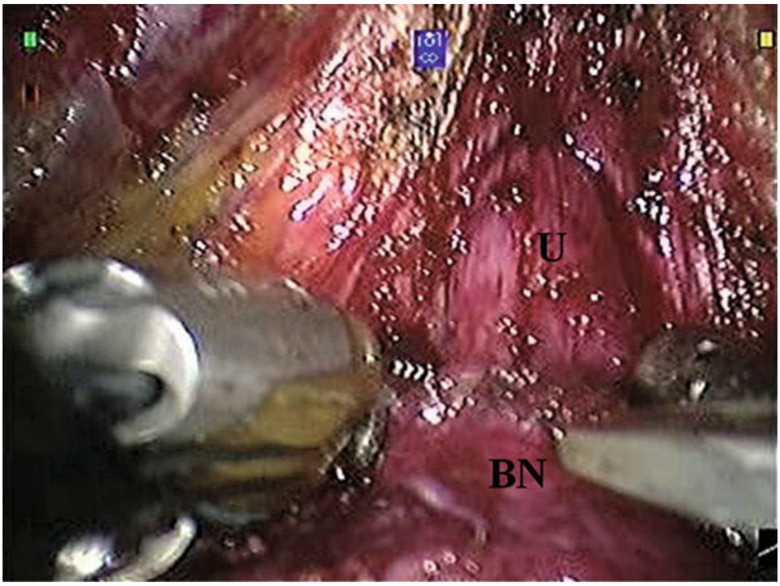

Fig. 22.7 The preprostatic urethra (*U*) and the bladder neck (*BN*) are dissected on their anterior planes. The longitudinal fibers of the urethra are clearly visible

anterior layer of the Denonvilliers fascia (Fig. 22.11). We begin the dissection behind the BN, and we move laterally until the medial margin of the prostatic pedicles.

Once the Denonvilliers fascia is reached, the bladder should be completely detached from the prostate base apart for the lateral prostatic pedicles, and we are ready for the next step which is the dissection of the seminal vesicles (Fig. 22.12).

22.5.1 Median Lobe

In the previous paragraph, we described how to perform the dissection of the BN in a standard case. Now examine the difference in the procedure when an enlarged median lobe is present.

As explained previously, in the case of an enlarged median lobe, we usually find a somewhat different anatomy, with reference to supports from the surrounding structures, especially

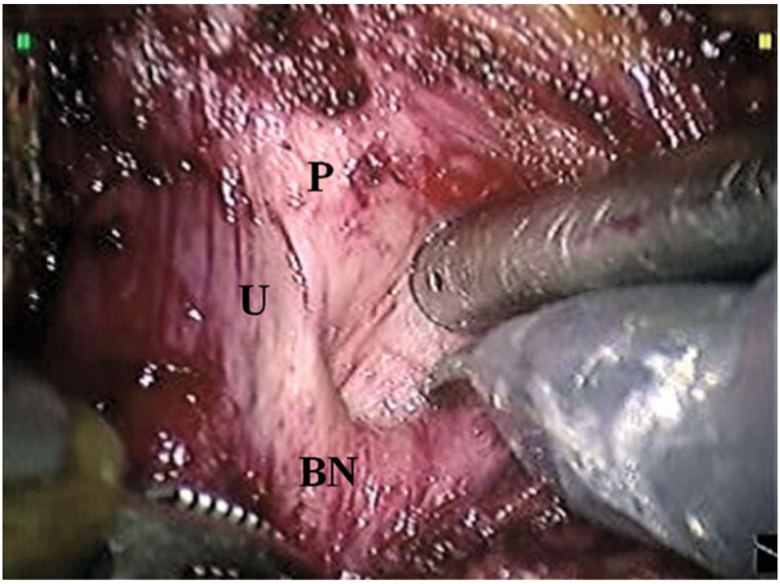

Fig. 22.8 The right lateral margin of the urethra and the bladder neck is dissected from the prostate base. One can clearly identify the prostate (*P*), the bladder neck (*BN*), and the preprostatic urethra (*U*)

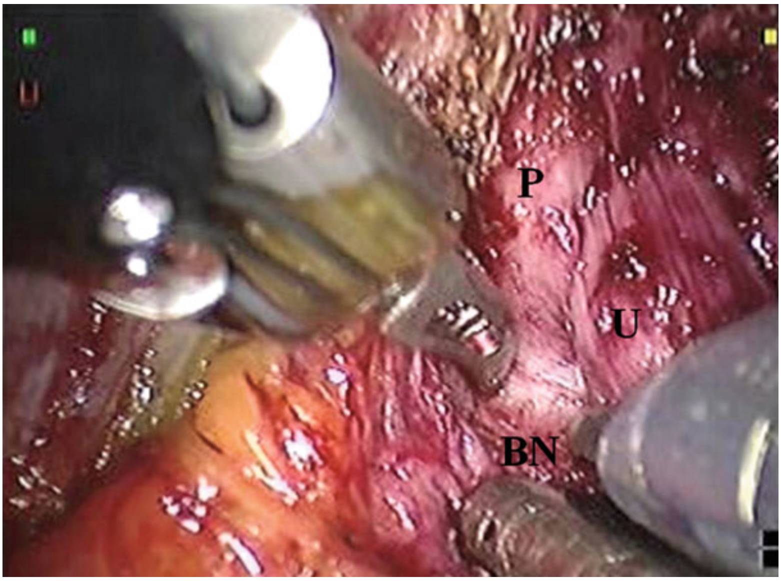

Fig. 22.9 The left lateral margin of the urethra and the bladder neck is dissected from the prostate base. One can clearly identify the prostate base (*P*), the bladder neck (*BN*), and the preprostatic urethra (*U*)

with the seminal vesicles. With the presence of a median lobe, the site of the BN appears to be more cranial. This can lead to dissection starting at a point too cranial with the risk of opening the bladder on his anterior surface and thus losing the ability to preserve the BN. For this reason, once the endopelvic fascia is well prepared, we should follow the same steps explained elsewhere in this book, to better expose the BN (balloon of the bladder catheter deflating, traction on the bladder). Once the right site is identified, we perform the same sharp and blunt dissection of the anterior fibers from the prostate base searching the plane of dissection between it and the external fibers of the bladder. If we find the right plane, we will be able to identify the preprostatic urethra as described previously. In this case, it appears larger than usual because of the presence of the underlying median lobe. Our dissection can now continue in two different ways: with a

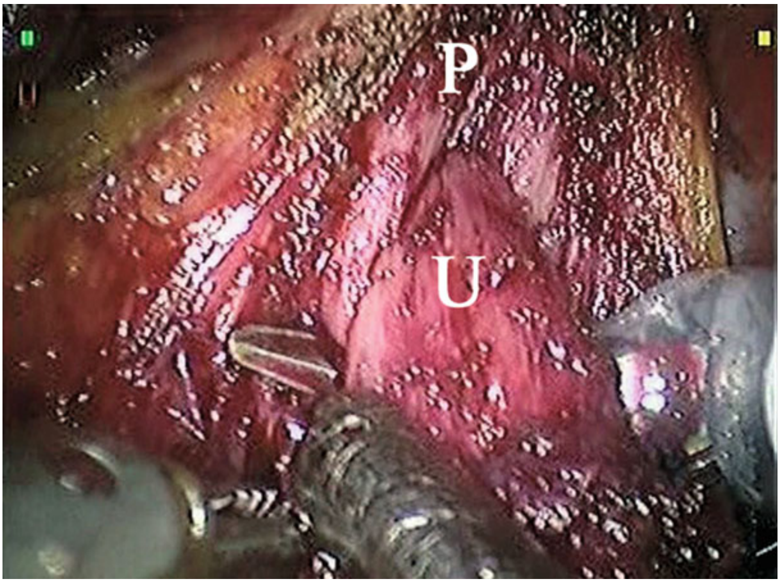

Fig. 22.10 The preprostatic urethra is completely isolated and prepared for transection. *U* preprostatic urethra, *P* prostate base

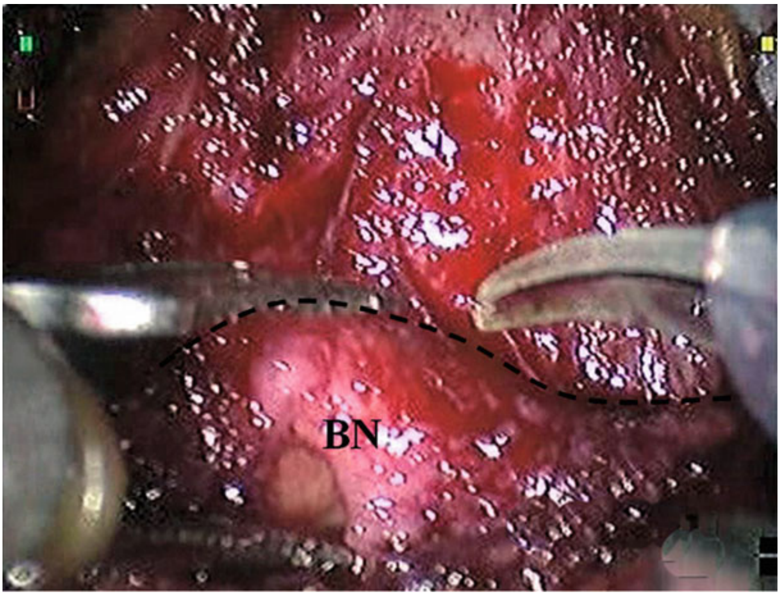

Fig. 22.11 The posterior plane of the bladder neck is going to be dissected from the prostate base. After the division of the "preprostatic urethra," the posterior plane is clearly identifiable (*curve*). The bladder neck (*BN*) is visibly preserved

lateral blunt dissection of the urethral mucosa from the median lobe, delaying its transaction, or with the division of the anterior portion of the urethra and a delayed dissection of the median lobe from the urethral mucosa. A third kind of dissection is performed without BN preservation and will be described later.

The first approach is performed using a laterally gentle, blunt separation of the preprostatic urethra from the underlying median lobe. After the identification of the preprostatic urethra, we continue its isolation in its lateral portion in order to pass behind it. In this case, we will progressively identify the median lobe which prevents this maneuver. Once the median lobe and its limit with the urethra are well identified, we can begin to move the urethra from the median lobe. This is possible, of course, especially with the robot-assisted approach; however, in some cases, this will not be possible because of fibrous attachments.

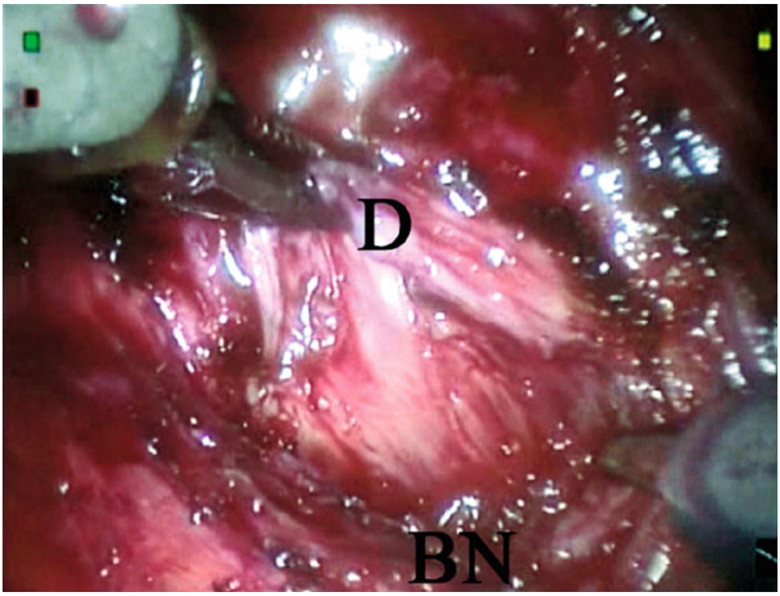

Fig. 22.12 After the posterior plane of the bladder neck is completely dissected, the anterior Denonvilliers fascia (*D*) is identified and incised to dissect the seminal vesicles. In this figure, the transected bladder neck (*BN*) is laying down, and the bipolar grasp is holding the Denonvilliers fascia to expose it, so that it can be incised

Once the urethra is completely freed from the median lobe, we can usually pass behind it with our grasp or with the scissors, transect the urethra, and continue our dissection of the posterior plane. In most cases, we will have the muscular fibers and the mucosa of the BN preserved, and we will be ready to easily perform the subsequent steps of our prostatectomy.

When the urethra is identified but not easily dissected from the median lobe, we can incise it on its anterior surface before dissecting the posterior plane from the median lobe.

Once the urethra is open, we can dislocate the median lobe outside of the urethra and proceed incising the urethral mucosa on the median lobe. Once the mucosal and the urethral muscular layer are incised, we can perform a dissection of them from the underlying median lobe using again a sharp and blunt dissection.

This maneuver needs to be performed with very gentle dissection because the urethra is usually very thin. The robot allows one to achieve this step, a step which is not always possible with the traditional laparoscopic approach.

Once the urethra is completely dissected on its posterior plane, we should continue our dissection following the muscular fibers carefully, cranially, and laterally, in order to not enter into the abdomen, until we are able to find the anterior layer of Denonvilliers fascia and then the vas deferens.

22.5.2 Previous TURP

The dissection of the BN, even in case of previous endoscopic resection, should follow the same initial steps, as previously described, in order to identify the vesicoprostatic junction. Even if we give the same attention in identification of key steps, this can be, in some cases, a real challenge because of the possible presence of fibrous scar tissue. The difference that can be encountered during the dissection will appear when we are getting close to the preprostatic urethra. In its lateral margins, the plane of our dissection will become unclear, and the tissue will be usually very sticky and with no clear plane. When we reach this point and cannot progress with blunt dissection, it is often not possible to clearly isolate the preprostatic urethra as shown previously. For this reason, we usually proceed with sharp dissection and then the incision of the BN at this level initially on its anterior surface. Once the BN is open, we proceed with the identification of the ureteric orifices, and we perform a sharp dissection of the posterior margin of the BN, as far as possible from the ureteral orifices, then continuing with sharp and blunt dissection of the posterior plane as described previously.

In some cases, when the BN is preserved during the endoscopic resection and the inflammatory reaction of the previous surgery did not occur, it is possible to isolate a sort of preprostatic urethra that is usually shorter and not as clear as usual. Once it is identified and isolated, it is transected and the dissection proceeds in the same way as described previously.

22.5.3 Wide Resection of the Bladder Neck

In case of positive biopsies on the prostate base, we do not suggest to preserve the BN as described previously, in order to not risk positive margins at this level. In this case, we proceed always with the preparation of the endopelvic fascia and with the same steps in order to identify the vesicoprostatic junction. Once its identification is achieved, we use a sharp dissection with monopolar cautery of all the muscular layers of the BN, on its anterior surface first and then, once the BN is opened, we proceed with the incision of its posterior surface and in the dissection of the posterior plane. Our dissection is performed with a safety distance from the prostate base which allows us to avoid any risk of positive margins. Of course, with this dissection, we should perform a BN reconstruction before beginning the anastomosis. This is possible without any difficulty using the robot because of its well-known EndoWrist instruments (Intuitive Surgical, Sunnyvale, Calif.). We can perform a posterior BN reconstruction before the anastomosis, or we can complete this step on the anterior surface of the BN at the end of our anastomosis. These steps are clearly discussed elsewhere in this book.

22.5.4 Indications and Choice of Technique

It is clearly possible dissect precisely between prostate and bladder, with full preservation of the BN unit. We think that this kind of preservative dissection is extremely relevant for the formation of the future anastomosis, which becomes a “uretro-urethral anastomosis,” and the future postoperative continence; however, as reported by some authors, this technique could lead to an increasing rate of positive margins on the primary part of the prostate [4]. Therefore, we reserve this ultra-BN preservation dissection to the cases of localized prostatic cancers, with negative biopsies on the prostatic base, without MRI tumoral localization on the base and without clinical abnormality on the base in digital examination.

In these last situations, we recommend to enlarge the BN dissection in order to let a little part of it get fixed on the prostatic base.

22.6 Bordeaux Series

In our institution (Clinique Saint Augustin, Bordeaux, France), we performed from January 2005 to June 2007, 677 robot-assisted radical prostatectomies. Five different surgeons have performed the same technique of BN preservation, as described in this chapter, in 614 cases (90.6 %). In the other, 9.4 % of patients the BN were not preserved, and these cases included cases which we considered a contraindication: previous TURP, voluminous median lobe which did not allow preservation, multiple positive biopsies at the base, and cases limited by technical problems of dissection.

In our series, we observed 80 % of continence (no pads) at 4 months and 91 % at 12 months, with less than 1 % of anastomotic leakage in immediate postoperative time and less than 2 % of anastomotic stenosis.

Our functional results are suggestive of an earlier return to continence, without significantly better results on final continence, in keeping with other series where a BN-sparing technique was used [3].

Concerning the oncological outcome, we observed a positive margin rate on the base of 3 % of cases for pT2 disease and of 5 % for pT3 disease. These results are comparable to those reported from some authors in non-sparing BN series [2, 4] as well as series of BN-sparing technique [3].

Conclusion

The use of robotic assistance gives a fantastic quality of vision and precision of gesture for this difficult step of the radical prostatectomy. It allows a very precise choice of the plane of dissection and a high level of preservation of the BN, which can be adapted to the oncological characteristics and the anatomical specifics of the patient.

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23 Techniques of Nerve Sparing in Robot-Assisted Radical Prostatectomy

Ananthakrishnan Sivaraman, Sanket Chauhan, Oscar Schatloff, and Vipul R. Patel

23.1 Introduction

Cancer prostate is the most commonly diagnosed cancer as well as the second most common cause of death in the United States of America. In 2009, as many 192,280 (25 %) men were estimated as new diagnosis with prostate cancer [1]. Of the several treatment options available, surgery is the gold standard and offers potential for long-term cure [2].

Though the approach and techniques of radical prostatectomy have changed over the years the principles remain the same. Oncological cure assumes primary importance followed by preservation of continence and then potency.

Hugh Hampton Young [3] introduced perineal prostatectomy in 1904, and Terrence Millin [4] introduced the retropubic prostatectomy in 1945 [4]. The popularity of these procedures was not high because of major side effects. Most patients were impotent and incontinent, and in 1970s, radiotherapy was considered as a less troublesome alternative for the patient.

Nerve sparing gained importance after the seminal work by Walsh and Donker [5] showed the location and advantages of preservation of cavernous nerves. The rapid dissemination and encouraging results of anatomical radical retropubic prostatectomy (RRP) changed patient's and surgeon's perception of this surgery. With subsequent adoption of laparoscopy and robotics in performing RRP, the magnification (10×) the dexterity (7 degrees of freedom of motion) which has resulted in good outcomes has played a major part in dissemination of RRP so much so that more than 85 % of all radical prostatectomies performed in the US are done with robotic assistance [6].

Today's patients are both younger and healthier with a no compromise attitude. They expect the trifecta, i.e., being cancer-free, continent, and potent [7]. Nerve sparing has been shown to improve potency and continence. With the advent of robot-assisted radical prostatectomy (RARP), nerve sparing has become more prevalent. As a result, more surgeons have developed varying methods of preserving the cavernous nerves. This chapter deals with the varying techniques of nerve sparing. Nerve sparing needs a thorough understanding of the neurovascular anatomy of the cavernous nerves as well as the fascial layers surrounding the prostate.

23.2 Neurovascular Anatomy

The innervations for erectile function come from the pelvic splanchnic nerves. They originate from anterior sacral roots of S4 with minor contributions from S2 to S3. The parasympathetic nerves converge with the sympathetic fibers from the hypogastric nerves to form the pelvic plexus. The pelvic plexus is rectangular, approximately 4–5 cm

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in length with its midpoint being at the tip of the seminal vesicles. It is retroperitoneal and fenestrated and lies in the anterior wall of the rectum. Tewari et al. have termed this the proximal neurovascular plate [8]. According to Costello et al. [9], there are three reflections of neural tissue from the pelvic plexus to the bladder, seminal vesicles, and prostate. The anterior reflection travels across the seminal vesicles on the inferolateral aspect of the bladder. The anteroinferior reflection travels across the lateral aspect, and the inferior reflection travels across the inferolateral aspect of the prostate.

23.2.1 The Neurovascular Bundle

The components of anteroinferior and inferior reflections of the pelvic plexus have been construed as the neurovascular bundle (NVB) of Walsh [10]. It has been suggested that they are primarily responsible for erectile function. This has been classically described as a tubular structure that is running along the posterolateral aspect of the prostate enclosed in the fascial sheaths around the prostate and closely associated with capsular vessels. The neurovascular bundle varies in size and shape as well as course from base to apex of the prostate. It is thickest at the base of prostate, converges at the mid part, and then diverges as it moves toward the apex. Tewari et al. [8] have described this neural tissue as predominant neurovascular bundle. In their studies, they found that 65 % of the time this bundle had a medial extension, and 30 % of the time it converged medially behind the apex of the prostate. They also described accessory neural pathways, which varied in course from anterolateral aspect to the posterior part of the prostate. These supposedly provide additional neural pathways for erections and may come into play if the NVB is damaged.

23.2.2 Fascial Layers Surrounding the Prostate

The prostatic capsule in not considered a true capsule but a fibromuscular band located between the glandular units and the periprostatic connective tissue [11].

The endopelvic fascia is a multilayer fascia that covers the prostate and the bladder and is linked to the prostate capsule by collagen fibers, finally inserting in the form of puboprostatic ligaments to the pubic bone. The part of the endopelvic fascia that covers the prostate is called the prostatic fascia. The outer part of the endopelvic fascia is called the levator fascia or the lateral pelvic fascia. The two layered Denonvilliers fascia is in between the rectum and the prostate. The posterior layer covers the rectum, while the anterior layer covers the dorsal aspect of the prostate. The anterior layer fuses with the lateral pelvic fascia.

There are distinct planes that can be defined in theory but can defeat even the most experienced surgeon during surgery. The intrafascial plane is the plane in between the prostatic capsule and the prostatic fascia [12]. The interfascial plane is the plane in between the prostatic fascia and the levator fascia [12]. Posteriorly the interfascial plane exists as the space between the prostatic fascia and the Denonvilliers fascia and in between the prostatic fascia and the anterior extension of the Denonvilliers fascia. The neurovascular bundle of Walsh is thought to travel in this interfascial plane along the dorsolateral aspect of the prostate, in between the anterior extension of the Denonvilliers fascia and the levator fascia. Extrafascial plane is lateral to the levator fascia. Both intrafascial and interfacial dissection may result in preservation of the neurovascular bundle, and an extrafascial dissection would result in damage to all or part of the NVB.

23.3 Approach to Nerve Sparing

Open radical prostatectomy has always been classically a retrograde prostatectomy and a retrograde nerve sparing [13]. The apex of the prostate is dissected first and nerve sparing proceeds from the apex to the base. As minimally invasive surgery was introduced, the approach shifted from a retrograde approach to an antegrade one where the bladder neck is dissected first and the nerve sparing proceeds from the base to the apex

[14]. Hence, the approach could be either retrograde or antegrade nerve sparing.

23.4 Types of Energy Use in Nerve Sparing

Physical nerve preservation alone may not be sufficient for early return of function. These are tenuous, nonmyelinated nerves that require gentle dissection without traction to avoid any damage. Moreover, thermal energy when used for dissection can cause temporary or permanent damage to these nerves. In a study done by Ong et al. [15], comparing monopolar, bipolar, and harmonic energy with no energy (athermal) nerve sparing in a canine model, the postoperative intracavernous pressures were substantially decreased in the energy groups as opposed to the athermal and control groups. Hence, the type and the amount of energy used have an impact on the return of erectile function.

Ahlering et al. [16] in their case control series demonstrated the effect of thermal energy on the return of sexual function. About 8.3 % (3/36) were potent in the cautery group as opposed to 43 % (10/23) in the cautery-free group. Moreover, they also studied the effects of hypothermic nerve sparing on 50 patients. Pelvic cooling was achieved with cold saline irrigation as well as endorectal cooling balloon cycled with 4° saline. This method resulted in significant improvement in continence and potency; results have yet to be published [17].

KTP laser has been analyzed as an energy source to aid in nerve sparing [18]. Gianduzzo et al. have recently evaluated cavernous nerve function following KTP laser dissection and compared outcomes to those of ultrasonic shears and scissors [19]. They compared several parameters including intracavernous nerve pressure after cavernous nerve stimulation acutely and 1 month after stimulation as well as histological evidence of thermal spread in harvested peritoneum. They showed that KTP laser had similar outcomes to athermal technique and was superior to ultrasonic shears for preserving cavernous nerve function. Hence, the energy source (cautery, harmonic, ultrasonic shears, or laser) or the lack thereof (athermal) will have an impact on the functional outcome.

23.5 Categorization of Nerve Sparing

Nerve sparing has been found to positively influence both potency [10] and continence [20]. Nerve sparing can be categorized according to the fascial planes used, the approach used, i.e., antegrade or retrograde and the type of energy used to dissect these planes and control the pedicles. Hence, we have antegrade and retrograde, unilateral or bilateral, partial or complete, interfascial, intrafascial, and extrafascial as well as the type of energy used.

23.6 The Henry Ford: Veil of Aphrodite Technique and Superveil Technique

Antegrade, Intrafascial Athermal Approach

This technique was pioneered by Menon et al. [21] from the Vatikutti Institute of Urology. This technique involves a high intrafascial anterior release of NVB. The rationale of this approach is to preserve the NVB and accessory neural pathways that have been shown to travel in the anterior and posterior aspect of the prostate. In some patients, rather than distinct neurovascular bundles, the cavernosal nerves form lattices or curtains that extend from the posterolateral to the anterolateral surface of the prostate. The veil of Aphrodite (Aphrodite is the Greek goddess of love and ecstasy) is an area of cavernosal nerves that extends from the posterolateral to the anterolateral surface of the prostate like a curtain.

The avascular plane between the posterior prostatic and the anterior layer of Denonvilliers fascia, covering the vasa and the seminal vesicles is exposed. This layer is incised, exposing the vasa and the seminal vesicles. Both the vasa and seminal vesicles are grasped and the posterior prostate is retracted upward, allowing exposure of posterior layer of the Denonvilliers fascia. An incision is made in this fascia and a plane is developed between the posterior layer of the Denonvilliers fascia and perirectal fat. This hypovascular plane can be created easily using blunt dissection. The dissection is carried down to the apex of the prostate. This plane of dissection is extended laterally to expose the lateral pedicles of the prostate, which are controlled by either clipping or individually coagulating the vessels by bipolar cauterization.

A plane between the prostatic capsule and the prostatic fascia is developed cranially, at the base of the seminal vesicles. This plane is deep to the venous sinuses of the Santorini's plexus. Sharp and blunt dissection of the neurovascular bundle and contiguous prostatic fascia is performed using the articulated "cold" scissors until the entire prostatic fascia up to the pubourethral ligament is mobilized in continuity. This plane is mostly avascular except anteriorly where the fascia is fused with the puboprostatic ligament and covers the dorsal venous plexus. The dissection is performed in such a way that curtains of periprostatic tissue hang from the pubourethral ligament, the veil of Aphrodite.

Menon et al. [21] have shown good results with his technique with intercourse rate being 93 % in men with no preoperative erectile dysfunction undergoing veil nerve-sparing surgery, although only 51 % returned to baseline function.

23.7 Superveil Technique

In the veil technique of radical prostatectomy, intrafascial (between the capsule and prostatic fascia) dissection is performed between the 1 o'clock position and the 5 o'clock position and between the 6 o'clock position and the 11 o'clock position, but not between the 11 o'clock position and 1 o'clock position, where the prostatic fascia is adherent to the capsule. In the current modification by Menon et al. [22], dissection was extended anteriorly, preserving this tissue, the pubovesical ligaments, and the dorsal venous plexus. Where the planes did not separate easily with blunt dissection, sharp dissection was used with either the cold round tip da Vinci scissors or the hot monopolar hook. At 6–18 months after surgery, 94 % of men who attempted sexual intercourse were successful with a median Sexual Health Inventory for Men (SHIM) score of 18 out of 25.

23.8 Athermal Early Release of Neurovascular Bundle

Athermal, Interfascial, Retrograde Nerve-Sparing Approach

The conventional approach to nerve sparing during laparoscopic and robotic prostatectomy has been from the prostate base to apex (antegrade). Since the NVB is closely and complexly related to the base of the prostate which might be at risk during antegrade nerve sparing, Patel et al. [23] have developed a technique, which combines elements of open and laparoscopic prostatectomy. The prostatectomy is performed in an antegrade fashion, and the nerve sparing is performed in a retrograde fashion using an athermal technique. The basic premise is that the NVB can best be identified and released at the apex of the prostate and delineated back to the pedicle avoiding the possibility of inadvertent damage while controlling the pedicle, a possibility that is present during the antegrade laparoscopic approach.

The posterior dissection after the seminal vesicles have been dissected out is carried out in the interfascial plane between the rectum and the prostate in between the two layers of the Denonvilliers fascia. The prostate is then elevated. This dissection should be carried out till the prostate is completely separated from the rectum, so that the prostate can be rotated to either side. This dissection is further extended laterally allowing the pedicles to become prominent where it can be controlled easily. The lateral pelvic fascia is incised at the level of the apex and mid portion of prostate, and an avascular plane is developed. The entire dissection is carried out athermally and in a retrograde manner. The vascular pedicle in ligated with a hemlock clip that is placed above the NVB. Early release of the bundle and delineating its entire path will avoid inadvertent damage to the NVB at this juncture. It is released distally at the apex to the level of the pelvic floor to avoid damaging it during the apical dissection or vesicourethral anastomosis. The NVB is stabilized and the prostate is gently stroked away using scissors. The interfascial plane between the NVB sheath and the prostatic fascia is relatively avascular consisting of only tributary veins, which does not require the use of energy or clipping. As the dissection proceeds in a retrograde fashion, the NVB is clearly seen being released off the prostate. The prostate pedicle can then be thinned out with sharp dissection, and the path of the NVB is delineated at this level. The clear definition of the NVB and pedicle allows placement of clips on the pedicle without compromising the NVB and sharp dissection is used to completely release the prostate. This procedure can be performed unilaterally or bilaterally. Moreover depending upon the volume, grade, and location of the cancer on the biopsy specimen this procedure can be tailored to the individual patient. On the side with more cancer, the nerve sparing can be proportionately reduced by carrying out the dissection more laterally at the level of the pedicles and NVB so as to reduce PSMs and thereby maintain oncological safety.

Patel et al. [24] have recently published data using this technique. Between January 2008 and September 2009, 1,100 patients underwent RARP. Of 1,100 patients who underwent RARP, 541 were considered preoperatively potent (shim more than 21) and of these 404 underwent bilateral nerve sparing. Potency was defined as the ability to achieve and maintain satisfactory erections for sexual intercourse >50 % of times, with or without the use of oral phosphodiesterase type 5 inhibitors. The overall potency rates were 53.5, 68.8, 91.5, 97.4, and 96.6 % at 6 weeks, 3, 6, 12, and 18 months after RARP, respectively. Potency data was collected by validated patient administered questionnaires.

23.9 Antegrade Clamp and Suture Technique

This technique was pioneered by surgeons at UC Irvine [17].

The evolution of this technique was due to the need to avoid injury to the neurovascular tissue by thermal damage when using electrocautery. Most studies evaluating neural injury have used a myelinated nerve such as the rat's sciatic nerve. However, the cavernosal nerve is an unmyelinated autonomic nerve that might respond even more poorly than thicker myelinated nerves. Donzelli and associates [25] have shown that temperatures as low as 41 °C can injure neural tissue. Alternative energy sources such as ultrasound have been introduced in an attempt to reduce tissue injury. However, the temperature of the blade of ultrasonic shears rises to 63 °C or more with as little as 3 s of application. Initially the authors used a bioadhesive, which they subsequently modified, by using suture ligation.

After the rectum is freed from the prostate, the vascular pedicles and NVB are delineated. The vascular pedicles are thinned to allow placement of laparoscopic bulldog clamps (30 mm) at least 1 cm from the prostate. Using scissors, the vascular pedicles are divided right at the prostate, and the NVB is then gently and completely dissected free of the prostatic capsule. Control of the vessels in the vascular pedicles is achieved using a running 3-0 polyglycolic acid suture ligature. Prior to removing the bulldog clamp, two throws are placed through the vascular pedicle; the bulldog clamp is then removed, and the suture is used to display the remaining vessels such that precise superficial needle placement is facilitated to avoid injury to the NVB. If pulsatile bleeding is seen along the NVB, precise ligature of the bleeding site is performed with a 4-0 suture on an RB needle. This is very much facilitated by the 10–12× magnification and ease of suturing with the robot.

One hundred and twenty-five RALPs were performed between June 2002 and March 2004 by the team at UC Irvine [17]. Preoperatively, 42 met inclusion criteria, which included age younger than 66 years, IIEF-5 of 22–25, and unilateral or bilateral nerve-sparing surgery. Thirty-eight had a follow-up data of 24 or more months. Postoperative sexual outcomes were obtained via self-administered questionnaires At 2 years, the average IIEF-5 score for the 24 potent men was

18.4, the 14 impotent men, 3.6, and overall, 13.3. Further, the mean firmness compared with preoperative baseline was 83 % with 80 % reporting that the firmness was 75–100 % of preoperative firmness. Ten had a unilateral nerve-sparing procedure, and 50 % reported return of potency versus 69.7 % with bilateral preservation ($P=0.31$). With unilateral preservation, the average IIEF-5 was 20.6; all indicated that the firmness of erections was 75–100 % of baseline levels. They demonstrated that the use of mono- or bipolar electrocautery during transection of the prostatic vascular pedicle and dissection of the NVB appears to create a dense but (mostly) reversible neurapraxia to the cavernous nerve, with return of potency being severely retarded for 15–24 months. This data showed the benefit of avoiding thermal energy in nerve-sparing surgery.

23.10 Antegrade Thermal Clip Less Approach

(Thermal Antegrade Interfascial Technique)

This technique is a modification of the antegrade open technique originally described by Kursh and Bodner [26]. It is similar to the technique described by Guillonneau and Vallancien [14], but, as opposed to the other technique, Chien et al. [27] carry out their dissection from medial to lateral than vice versa. An advantage quoted is that after having initially mobilized the neurovascular bundle, the thermal spread may theoretically diminish.

After division of the bladder neck, the previously dissected seminal vesicles and vasa deferentia are retracted anteriorly, exposing the posterior base of the prostate. The plane between both layers of Denonvilliers fascia is identified and developed, separating the prostate from the rectum. Once this plane has been dissected distally toward the apex of the prostate, the thick lateral pedicles of the prostate are visualized bilaterally. Using blunt dissection, the vascular pedicles are teased off the prostatic capsule, proceeding from the developed posterior plane in a medial to lateral direction and leading to the initial release of the vascular pedicles before the NVBs. The vascular pedicles are further mobilized off the capsule of the prostate in an anterior direction until the most distal ends of the vascular pedicles are identified before penetrating the prostatic capsule. Such small vessels are then cauterized at their most distal ends using only a bipolar device. The vascular pedicles are then swept off the prostate, further mobilizing the NVBs, which are then dissected sharply from the prostatic capsule. The dissection is continued, peeling off the periprostatic fascia, NVB, and prostate pedicle en bloc until the urethra was reached. The dissection is performed starting posteromedially at the base of the prostate, marching laterally and anteriorly, and then advancing distally, hence in an antegrade fashion. During dissection, delicate handling of the tissue minimized trauma and protected the neurovascular bundles from trauma due to traction. Avoiding monopolar cautery, ignoring small venous bleeds, and controlling only pulsatile arterial bleeds with bipolar cautery coagulation are key points of this technique.

The results released from the University of Chicago using this technique from February 2003 to May 2004 are encouraging [27]. Using a validated sexual function questionnaire, they found that, at 1 month, patients had returned to 47 % of their baseline preoperative sexual function scores. At 3, 6, and 12 months, this rate had increased to 54, 66, and 69 %, respectively. Their data at 12 months are favorable; however, only six patients had reached 1 year of follow-up.

23.11 Nerve Sparing in Laparoscopic Radical Prostatectomy

23.11.1 Clamp and Suture Technique with Ultrasound Guidance

Utilization of vascular clamps for controlling the vascular pedicle during conventional laparoscopic radical prostatectomy was reported by the Cleveland Clinic [28]. A 25 mm straight bulldog clamp is placed across the pedicle after dissecting it out. Using cold scissors, the lateral pedicle is divided leaving a 1–2 mm edge beyond the bulldog clamp. The course of the NVB is delineated with USG and flow pattern in it as well as resistive index of NVB is measured, which gives a further measure of confidence while carrying out the dissection. The authors experimented with the use of bioadhesive (FloSeal) but ultimately reverted to suturing the pedicle due to better homeostasis. Moreover, there was concern the bioadhesive had the potential to induce substantial fibrosis which may compromise the NVB. There are still concerns that the bulldog clamp could compromise the NVB. Moreover, identification of the NVB with ultrasound is at best a soft sign and hence not widely reproducible.

23.11.2 Heilbronn Technique

In the Heilbronn technique [29], lateral pelvic fascia is incised prior to the incision of the urethra and positioning the prostate on its side exposes the lateral surface of the prostate. A right angle clamp is inserted under the lateral pelvic fascia beginning at the bladder neck and extending distally toward the apex of the prostate to detach the area of the NVB from the posterolateral border of the prostate and dissect it gently from the apical part of the prostate. All the prostatic branches of the NVB are managed one by one with 5-mm titanium clip application with avoidance of cautery.

23.12 Discussion

The introduction of the anatomical nerve-sparing technique has been one of the most significant landmarks in urology and the surgical management of prostate cancer. It has helped radical prostatectomy progress from a state where impotence was guaranteed to be one in which patients expect and demand to be completely potent after surgery. Age and preoperative baseline sexual function are important determinants for postoperative return of sexual function. Robotic surgery cannot improve on patient's sexual function. Unreasonable expectations from patients undergoing "innovative surgical" intervention and inadequate counseling on the part of physicians may contribute to patient's dissatisfaction [30].

Despite refinement in surgical techniques, sexual function outcomes remain widely variable, with reported rates ranging from 10 to 97 % [31]. Reasons behind this discrepancy are multifactorial and may include differences in preoperative patient characteristics such as patient age, baseline erectile function, surgeon experience and technique, and quantity of nerves preserved. In addition, the liberal use of nonstandard sexual function definitions and reporting algorithms contribute further to this variability. Objective data using validated questionnaires and specific criteria as laid down by Mulhall [32] on nerve-sparing post-prostatectomy sexual function outcomes are the way forward if reasonable conclusions are to be made regarding outcomes.

Moreover, nerve sparing is not an all-or-none phenomenon. Bradford et al. [33] have shown that there is an incremental increase in return of sexual function based on the amount of nerves spared. Sixty patients who underwent bilateral unilateral and non-nerve-sparing surgery were analyzed with respect to pathology reports, neurovascular thickness, surgeons' intent at nerve sparing, and quality of life among each group. Surgeon's intent regardless of the amount of neurovascular tissue identified on the radical prostatectomy specimen was predictive of potency.

23.12.1 Nerve Sparing and PSM

Surgical margin (SM) status is widely reported as a significant risk factor for prostate cancer recurrence following radical prostatectomy (RP) [34, 35]. It has been supposed that preserving the neurovascular bundle may compromise cancer control due to the limited surgical margin obtained with a resultant increase in treatment failure. Moreover, sparing the neurovascular bundles adjacent to the dorsolateral aspect of the prostate fascia further reduces the safety distance between cancerous nerves and prostatic tissue which is only millimeters away, even in non-nerve-sparing prostatectomy. Therefore, the safety of prostatectomy and nerve-sparing procedure in particular has often been equated with the incidence of positive margin.

Moreover, perineural tumor spread is a mechanism of capsule penetration, and the region of the prostate adjacent to the neurovascular bundles was found to be the most common site of capsular penetration [36]. Therefore, concerns exist, that some positive margins, occurring in 7–46 % of cases after prostatectomy may be produced by nerve-sparing surgery [37, 38]. Early studies from Catalona et al. showed no higher incidence of positive margins in patients undergoing NS RP compared to non-NS RP.

Palisaar et al. [39] analyzed their historical series of patients who were candidates for nerve-sparing (NS) procedure with a contemporary cohort of patients. Out of 1,343 patients analyzed. A total of 620 patients underwent non-NS prostatectomy. Nerve-sparing procedure was performed in $n = 723$ patients (bilateral $n = 359$, unilateral $n = 364$). Pathologic T2 cancers in the non-NS vs. NS group showed a positive margin at the apex in 1.8 % vs. 3.1 %, pT3a cancers in 8.4 % vs. 3.4 %, and pT3b cancers in 6.2 % vs. 3.8 %, respectively. The percentage of positive margins in NS and non-NS cases located in the lateral aspect of the prostate specimen was similar in pT3a (4.6 vs. 3.9 %) and pT3b (3.8 vs. 3.3 %) stages. In patients with organ-confined cancer laterally located, positive margins were fivefold higher in the NS group (3.1 vs. 0.6 %). Multivariate analysis proved NS RP to be an oncologically safe procedure in appropriately selected patients using a preoperative nomogram. Moreover, in such selected cases, there was no evidence that adequacy of tumor excision, and hence long-term oncologic control is compromised by NS procedure when the impact of a positive margin was evaluated comparing between patients undergoing NS and non-NS RP only

The selection criteria for a nerve-sparing radical prostatectomy (NSRP) have not been thoroughly investigated and are based mainly on preoperative digital rectal examinations tumor volume and location on the biopsy and subjective intraoperative findings.

Graefen et al. [40] showed that the decision to spare the nerve may be based on the location of positive tumor cores without increasing the incidence of PSMs. Basing the indication for an NSRP on the results of preoperative systematic biopsies was safe according to margin status and postoperative PSA, when all patients with tumor in one of the three biopsy cores of each side of the prostate were excluded from an NS technique on that side. Such a strict approach excluded approximately 30 % of patients from NSRP unnecessarily because of tumor findings on a prostate side where the cancer is still organ confined. The authors concluded by denoting that less strict criteria would be equally safe without denying nerve sparing to a substantial subset of patients.

Conclusion

Ultimately radical prostatectomy is an oncological surgery where cancer cure is the primary goal and continence and potency form important secondary goals. Achieving the trifecta is the aim of most patients undergoing prostatectomy. Nerve sparing can be done safely and effectively without compromising oncological safety. The basic principles of nerve sparing are reducing traction, reducing thermal injury, and preserving as much of the nerve bundle as possible. Each patient and each cancer are different, and the nerve sparing essentially has to be tailored on an individual patient basis. Preoperative biopsy grade, volume, and location of tumor on the biopsies as well as preoperative SHIM score as well as intraoperative findings are factors that need to be considered in nerve preservation (Figs. 23.1, 23.2, 23.3, 23.4, 23.5, 23.6, and 23.7).

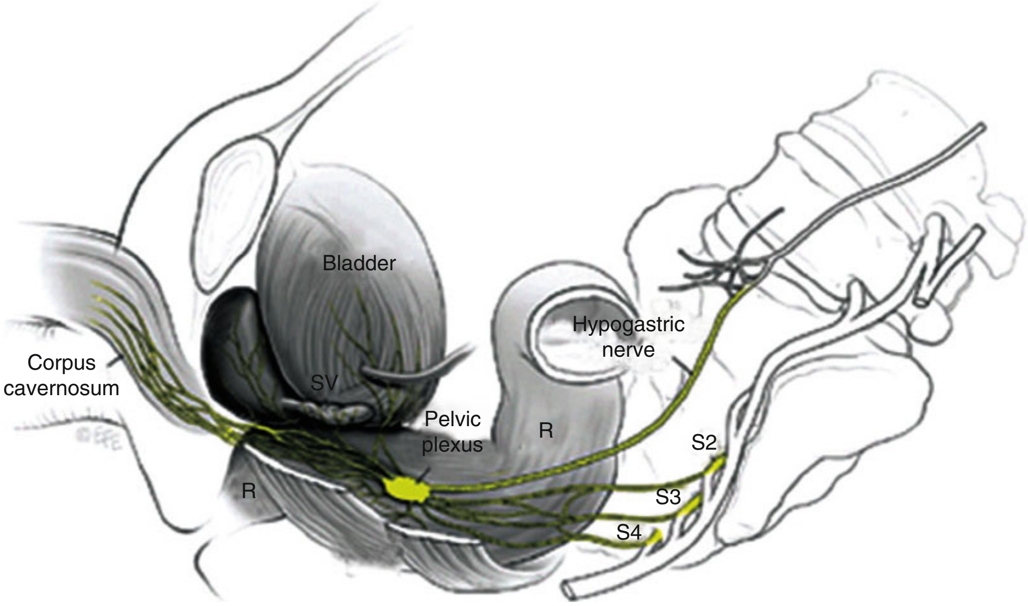

Fig. 23.1 The pelvic plexus and formation of NVB, reprinted from Costello et al. [9]

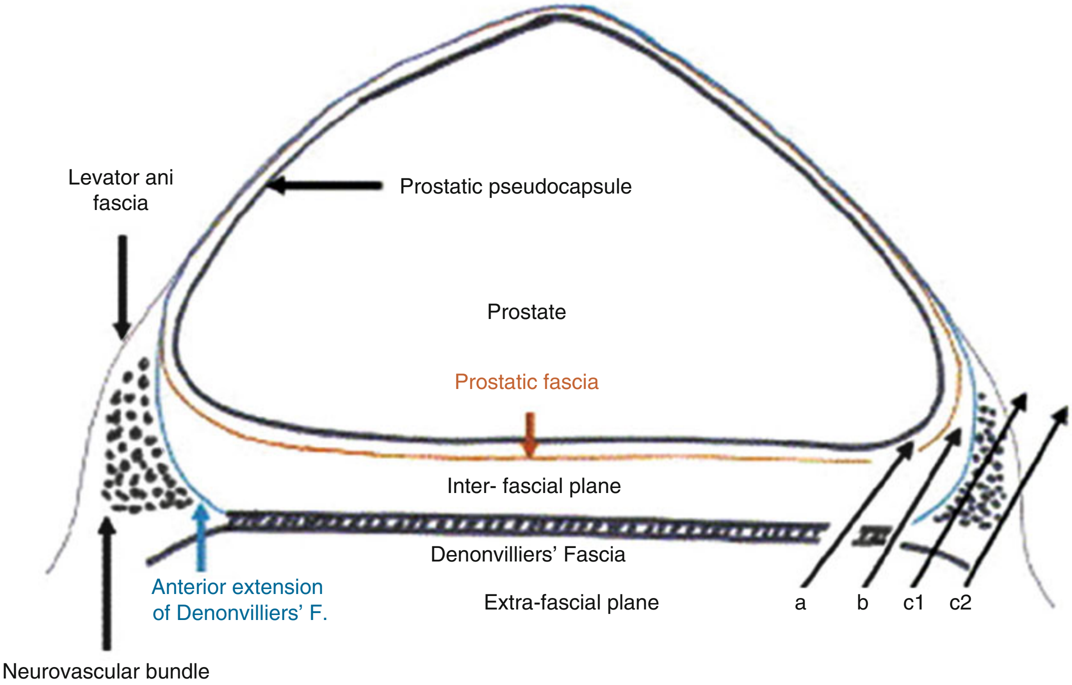

Fig. 23.2 Axial view of prostatic fascial anatomy. *a* intrafascial plane, *b* interfascial plane, *c1* extrafascial plane with partial preservation of neurovascular bundle, *c2* extrafascial plane with no preservation of neurovascular bundle [9]

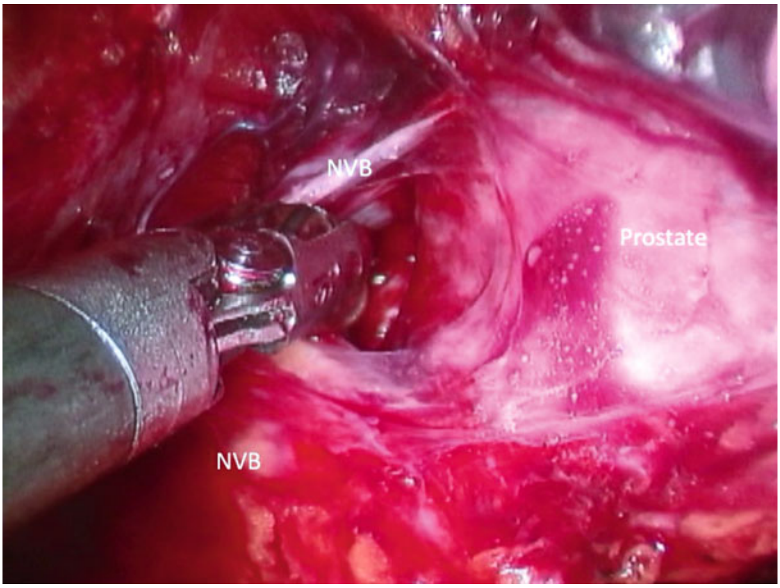

Fig. 23.3 Early retrograde release of the NVB. Scissor tips are spread in the plane between the prostate capsule and the NVB. The Maryland dissector is used to stabilize the NVB, while the scissors are used to push the prostate away from the NVB.
A separation is created between the lateral prostatic capsule and the NVB. Minor non-arterial bleeding should be tolerated as it will stop

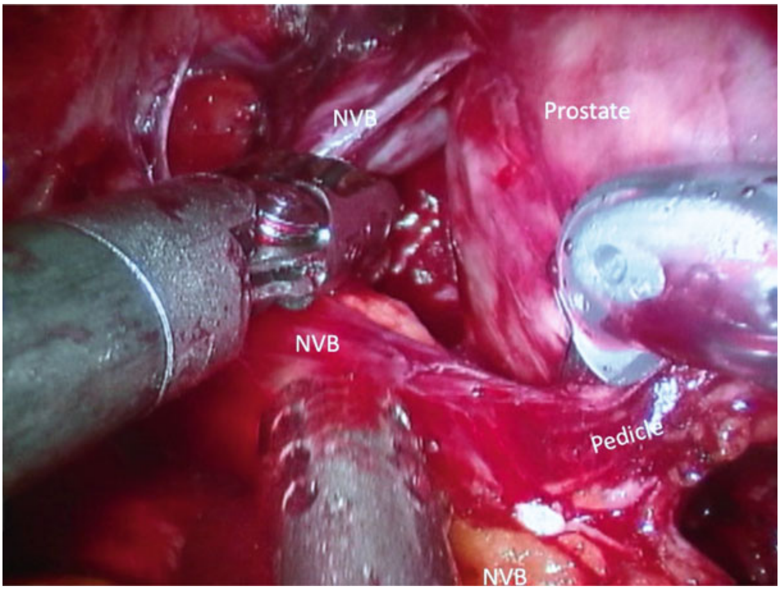

Fig. 23.4 Retrograde dissection to identify the prostate pedicle. The NVB is then released in a retrograde manner from apex to base to identify the path of the bundle. (Caution: the NVB kinks up and travels millimeters from the base of the prostate and therefore is at risk of being clipped if not being identified and released)

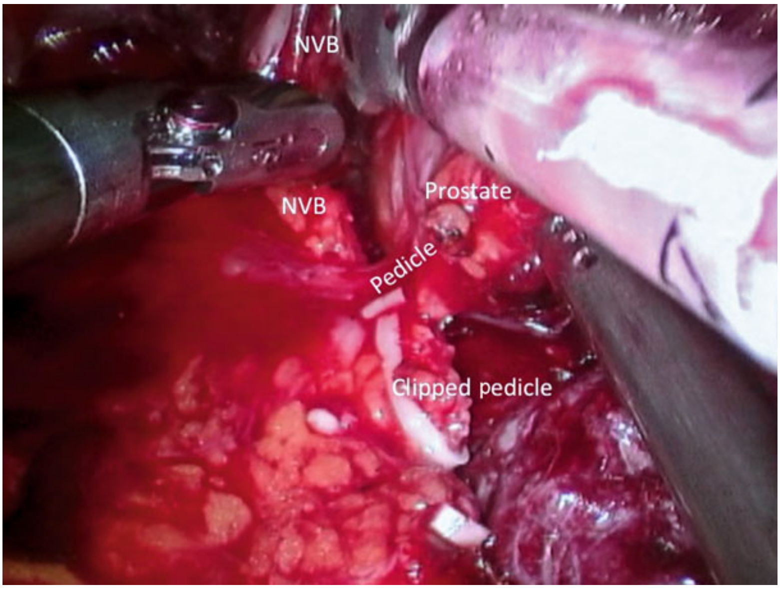

Fig. 23.5 Clipping of the pedicle. Complete path of the NVB is delineated from the apex to the base of the level of the prostate pedicle. The prostate is then rotated laterally and the pedicle is clipped under direct vision while clearly visualizing the path of the NVB at the base of the prostate; 100 mm hemlock clips are used to ligate the pedicle and are then divided with cold scissors

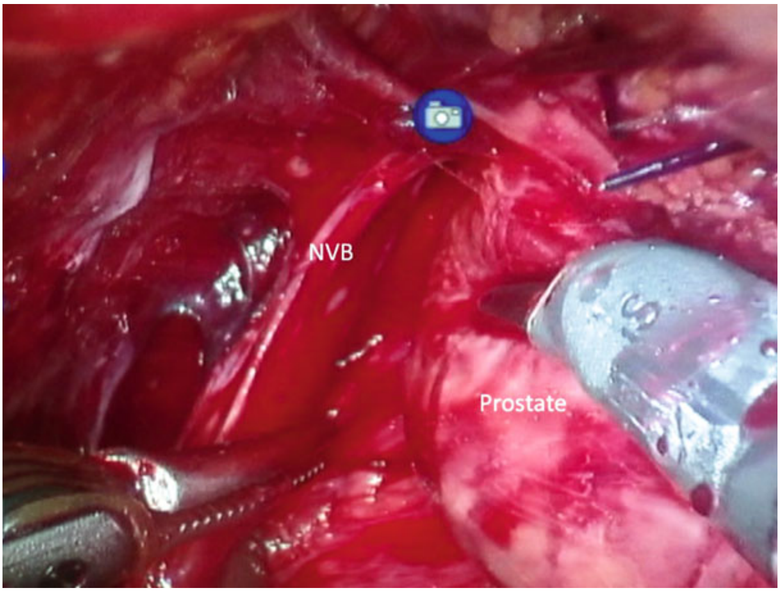

Fig. 23.6 The dissection of the NVB is extended toward the apex of the prostate and the pelvic floor. Once the prostatic pedicle is clipped, the rest of the NVB just peels away from the prostate with minimal bleeding

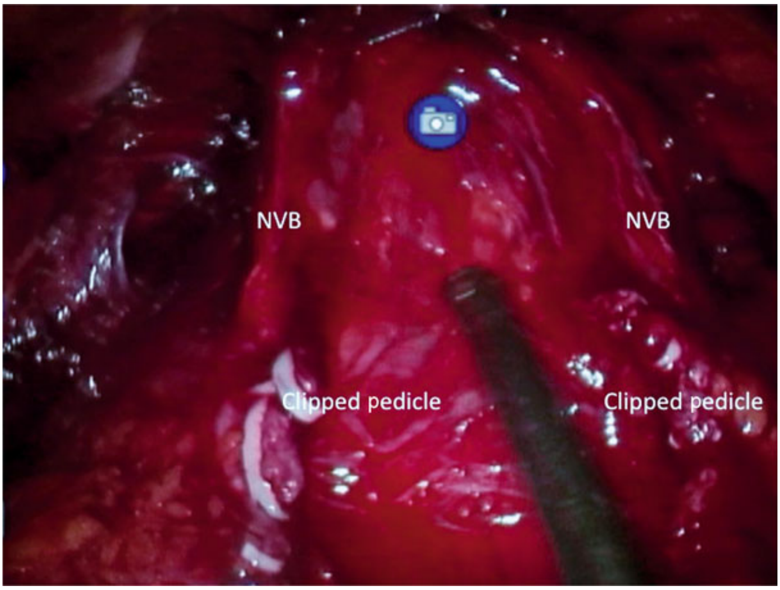

Fig. 23.7 Bilateral complete preservation of NVB

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Antegrade Robot-Assisted Radical Prostatectomy: Factors Impacting Potency Preservation

24

Thomas E. Ahlering, Anthony Costello,
and Douglas Skarecky

24.1 Introduction

In the early 1980s, the presentation of an anatomical dissection of the neurovascular bundles (NVBs) described by Walsh and Donker [1] is one of the most significant landmark findings in urology. Preservation of sexual function continues as a formidable quality of life issue with this surgery. However, how to maximize preservation of sexual function remains a controversial and heated topic largely casting anatomic preservation versus surgical trauma or inflammation versus patient-related factors such as age, medical and psychological conditions, and others. In this chapter, we stepwise examine our results in an effort to identify and stratify factors for their relative impact in preserving sexual function.

24.2 Cavernous Neuroanatomy

Walsh and Donker described the tortuous path of the parasympathetic nerves that run from the pelvic plexus past the seminal vesicles and then along the posterolateral aspect of the prostate between the true capsule and the lateral prostatic fascia (the supralevator pathway). The nerves continue posterior and lateral to the urethra where they pierce the urogenital diaphragm and continue on below the pubic bone (the so-called infralevator pathway) where there are delicate neural interconnections at the penile hilum between the cavernous and dorsal nerves [2, 3]. Recently, Tewari and associates [4], Takenaka and associates [5], and Costello and associates [6] have described precise gross and histologic dissections of male cadavers defining the cranial and caudal paths of the cavernous nerves (Fig. 24.1).

In 2005, Costello and associates reported a detailed description of the plexus of nerves running within the NVB based upon a series of elegant microdissections in human cadavers [6]. They found multiple nerve branches (6–16 in number) that emanated from the pelvic plexus and spread significantly, with up to 3 cm separating the anterior and posterior nerve fibers, much like the findings of Takenaka and associates [5]. Importantly, they found in all 24 dissections, the NVB ran 0.5–2 cm inferior to the tip of the seminal vesicle. Similar to Menon, Costello noted that the NVB courses along the posterolateral border of the prostate within the

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bounds of lateral pelvic fascia, the pararectal fascia, and Denonvilliers' fascia (Fig. 24.2). However, in distinction to Menon and associates, they feel that the nerves located within the veil of Aphrodite innervate the prostate and are sympathetic in nature. They also noted branches to the levator ani and anterior rectum. Similar to Takenaka, Costello found that the nerves converge at the mid-prostate, forming a more condensed bundle and then diverge again when

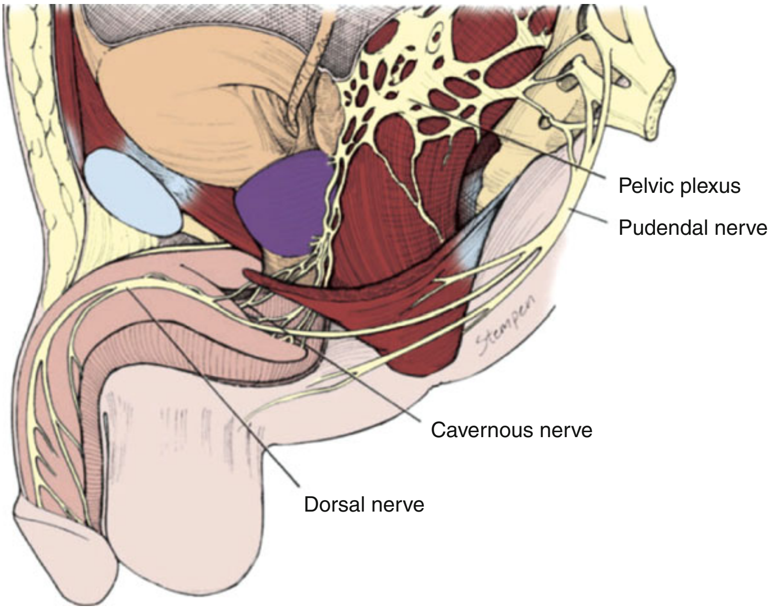


Fig. 24.1 Supralevator and infralevator neural pathways of the cavernous nerves (Reproduced with courtesy of Springer)

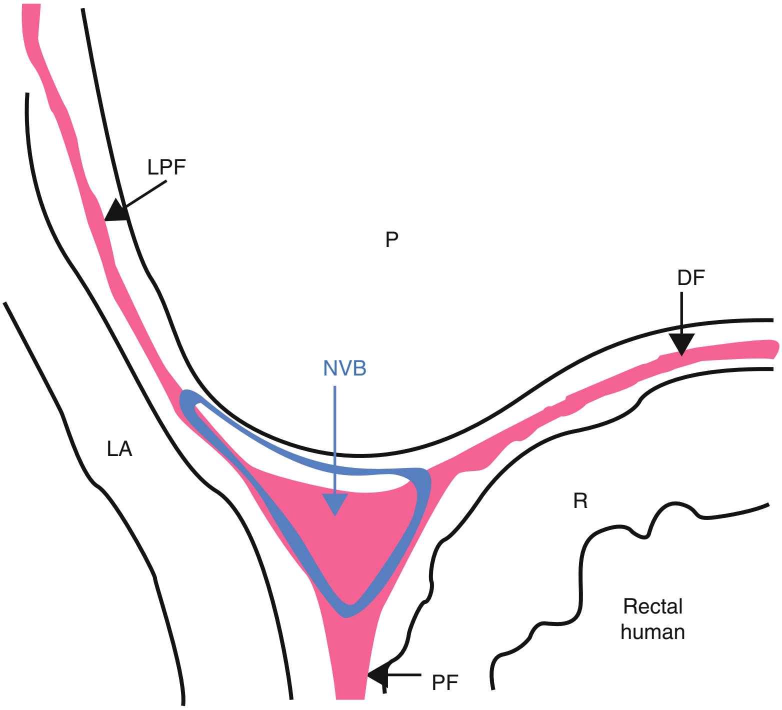


Fig. 24.2 The NVB courses along the prostatic posterolateral border with the lateral pelvic, the pararectal and the Denonvilliers fascial boundries

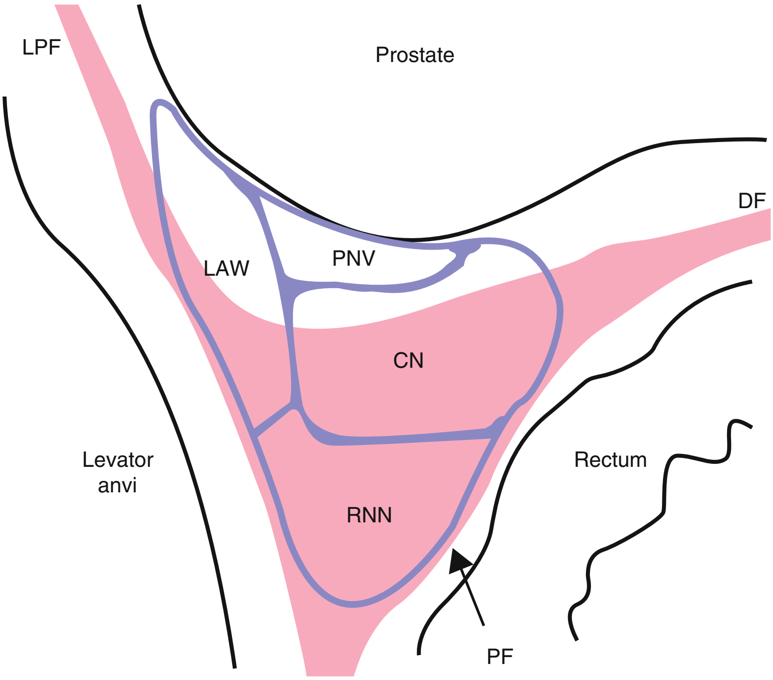


Fig. 24.3 Functional organization of the Neurovascular Bundle

approaching the prostatic apex, where they divide into numerous small branches that descend along the posterolateral aspect of the membranous urethra before penetrating the corpora cavernosa. Figure 24.3 demonstrates Costello's findings regarding the functional organization of the NVB.

However, there is no question that although we have a reasonable understanding of the neuroanatomy of the cavernosal nerve, the results of potency preservation following radical prostatectomy are immensely disappointing. This suggests that although preservation of the nerves is a critical component, other factors must play important roles accounting for the wide variability of "potency outcomes" experienced by individual surgeons. The issue of "potency outcomes" sparks two questions. First, why do some patients recover immediately and others take a year or longer? And secondly, what factor or factors impact who recovers? To address the first question on timing of recovery, we present our "timeline" observations we have seen over the years.

24.3 Observations on Recovery of Sexual Function with Reference to Peripheral Nerve Injury and Recovery

Early in 2004, we began to evaluate recovery of sexual function using "timelines." Figure 24.4 depicts expected slow and steady decline in potency in a hypothetical group of 100 potent (IIEF-5 22–25 and 65 and under) men over 24 months assuming no interventions. One would expect some level of decline which we have estimated at about 1–2 % per 2–3 years. In this figure, we also have included anticipated return of sexual function assuming no attempt to spare the NVBs. However, in distinction to non-nerve sparing, wide excision (either uni- or bilateral) is likely a very different physical outcome as compared to "non-nerve sparing." Studies indicate as little as 7 % return of function to as high as 35 % for "non-nerve sparing" [7, 8]; we have for the sake of compromise selected 20 % as a fairly neutral result. Beginning in 2002, with our initial experience (cases #1–125), we typically used cautery to

Fig. 24.4 Theoretical decline of potent men 24 months after radical prostatectomy (*large circle*) versus men with non- nerve sparing RARP (*small circle*)

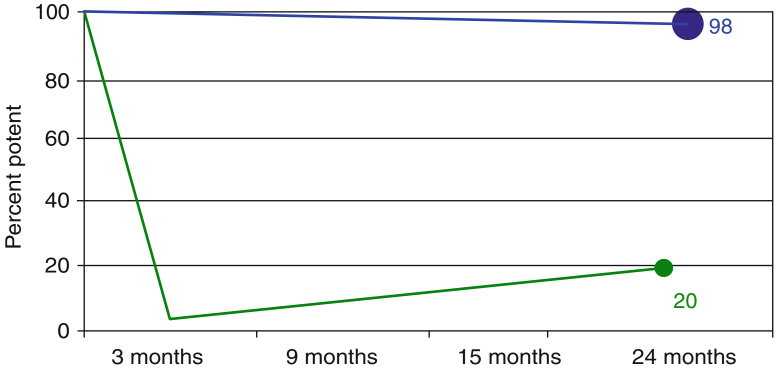
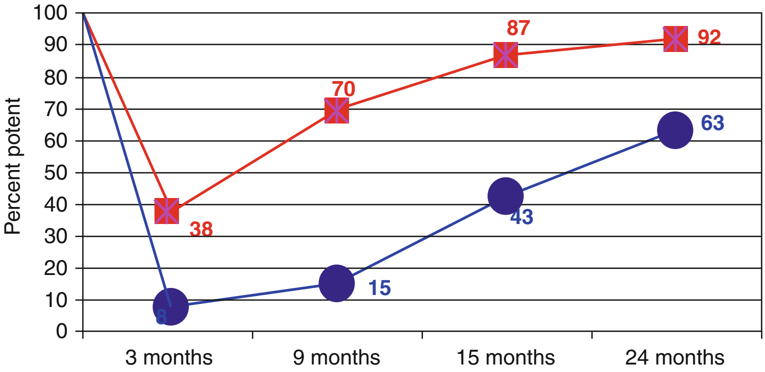


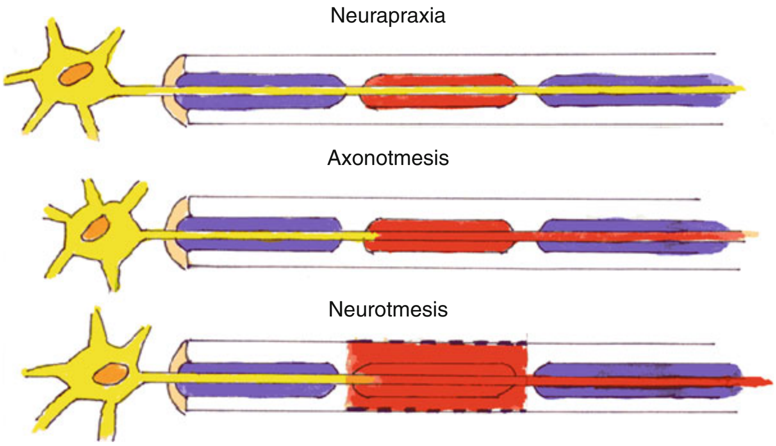
Fig. 24.5 Recovery of sexual function for potent men, aged ≤ 65 years using cautery (circles) versus Athermal NVB sparing (squares). [9,11]



fully control the prostatic vascular pedicle (PVP), and Fig. 24.5 depicts timeline recovery seen in the lower curve. After 18 months, or in early 2004, although the nerves appeared to have been physically well preserved, we feared cautery was responsible for potency rates only slightly better than what we would have expected for a non-nerve-sparing procedure. At this time, we adopted an athermal technique to control the PVP and NVB [9]. Over the next several months, we noted two important findings. We immediately saw a dramatic increase in recovery of potency at 3 months from 8 to 38 % [10]. However, remarkably we saw a slow and steady recovery of potency over 2 years in the cautery group [11]. Our best explanation for the 1–2-year delay was that although some injury to the NVB occurred, the injury was not permanent, and a relatively high percent of men (68 % in bilateral NVB preservation) recovered by 2 years. Additionally, there were two observations with the athermal group. First, the obvious improvement with the elimination of thermal injury improved outcomes (nearly fivefold at 3 months) to nearly 40 %. Additionally, the athermal technique seemed to indicate three levels of injury. Transient or no obvious injury where men were potent on their initial attempts to have intercourse (nearly 40 %) versus a second group who after a relative long period of impotence recovered (usually fairly abruptly) around 9–15 months. The third group was patients who had a permanent injury and never recovered.

In May of 2007 at the American Urological Association meeting, we presented these timeline findings to the Engineering and Urology Society meeting. We asked physiologically if and how these findings could be explained. It did not take long to find an answer as these observations are put in appropriate perspective when explained by established mechanisms of injury to peripheral nerves (as opposed to central or spinal cord injuries). Peripheral nerve injuries were initially classified by Sir Herbert Seddon in

Fig. 24.6 Classification of nerve injury according to Seddon [12]



1943 [12]. According to his initial and simplified classification of injury, three categories of severity occur: *Neurapraxia* is a mild injury due to nerve contusion from blunt impact or stretch injury to the nerve with no structural damage (Fig. 24.6). A concussion-like state results in a transient conduction block from which full recovery occurs within days to weeks. The second level of injury, *axonotmesis* is a moderately severe injury, which results in axonal disruption and Wallerian degeneration. In these injuries, the axon is disrupted, but the perineurium is preserved (Fig. 24.6). The nerve or axon will regenerate or regrow from the point of injury to the end organ assuming the perineurium is intact. Regrowth of the axon progresses at approximately one mm/day to in. per month and recovery takes 8–24 months. The last level, *neurotmesis* occurs after severe injury or laceration that transects the axon and perineurium completely with no capacity for regrowth of the axon. A neuroma or scar usually results. During radical prostatectomy, injury to the pelvic nerves and neurovascular bundles such as excision, incision, severe stretch, or thermal injury occurs according to these mechanisms resulting in a spectrum of nerve injury.

24.4 Nerve Redundancy

A very intriguing and important question is what evidence exists for a critical volume or percentage of nerve required for preservation of potency. Simply put, what impact does widely excising one of the NVBs have on potency? The fact that there is any recovery speaks to "systems redundancy." We compared potency outcomes in patients in whom we spared both nerves to those who had only one excised [13]. We queried what percent of recovery results following preservation of one versus two nerves (i.e., a doubling of nerve volume) and were there any differences in the quality of erections? We were quite specific about the definition of unilateral nerve sparing; we only included patients with a wide excision as unilateral. Any partial excisions were included in the bilateral preservation. In the first group, there were 38 (ten were unilateral) men who had cautery used during transection of the PVP and dissection of the NVB. In the second group, cautery-free technique was used and included 58 (19 were unilateral) men. The important findings were that when we doubled the nerve volume (2×), there was only a 15 % improvement (1.15×) in the cautery-free group and 36 % (1.36×) demonstrating a remarkable amount of redundancy. Further, of the men reporting potency recovery, both groups showed that qualitatively the erection with one nerve was the similar as two nerves.

The average postoperative IIEF-5 scores of both the uni- and bilateral were groups were similar (19.6 vs. 18.9, respectively, for cautery and 21.0 vs. 22.0, respectively, in the cautery-free group). In similar fashion, Walsh and associates [14] and Kundu and Catalona and associates [15] have reported their experience with unilateral nerve-sparing (UNS) surgery. In 1987, Walsh reported that 69 % of men potent before RP who had unilateral wide excision were potent after RP, compared to 85 % who had BNS. Kundu and associates reported a similar trend in overall potency rates at 18 months, of 53 and 76 % after UNS and BNS RP, respectively. A unifying theme among these reports is that 2× volume of nerve tissue improved potency rates by about 1.23–1.43×. This data speaks very strongly to the existence of redundancy and also explains in part why there is such poor subjective correlation of quantity of nerve sparing to the quality of nerve recovery.

24.5 Thermal Injury

The use of thermal energy on or near the nerves is a well-recognized and major mechanism of damage leading to delayed or impaired recovery of potency. Temperature elevations of as little as 4 °C (to 41 °C) can produce neural injury [16–18], and elevations to 45–55 °C coagulation occurs [16]. As temperatures continue to rise beyond that point, cell death occurs, with denaturation occurring at 57–60 °C and protein coagulation at 65 °C [17]. Donzelli and associates demonstrated that both monopolar and bipolar cautery causes primarily thermal injury to nearby neural tissue [18].

The role of the importance of thermal injury was nicely demonstrated in a landmark paper by Ong and associates that described the effects of electrocautery, and thermal injury on cavernous nerves was performed in a canine model [19]. In this study, monopolar electrocautery, bipolar electrocautery, and harmonic shears were compared to standard suture ligatures for unilateral NVB dissection. The contralateral bundle was not dissected and acted as an internal control. Upon cavernous nerve stimulation, only the energy-free (suture ligature) group maintained similar-to-baseline intracavernosal pressure responses immediately after dissection and 2 weeks later. The other modalities using thermal energy all resulted in a >95 % decrease in cavernosal pressures. Histologic studies comparing the individual groups confirmed an increased amount of inflammation associated with the use of heat and/or electrocautery. Because of these findings, transection of the vascular pedicles should be accomplished without thermal energy, unless neutralizing thermo-protective simultaneous cold irrigation is used.

It has been demonstrated that electrocautery produces temperature elevations and thermal energy effects beyond the site of cautery. In essence, standard laws of thermodynamics apply. A nice study by Mandhani and colleagues measured temperature changes at the NVB during RARP with monopolar and bipolar cautery [20]. The average temperature rise with monopolar and bipolar cautery at the NVB during distant (>1 cm from the NVB) anterior bladder neck incision was 43.6 and 38.8 °C, respectively, after approximately 60 s of cautery. During NVB dissection itself using both cautery modalities, the mean temperatures within the NVB measured within 1 cm of the cautery rose to 53.6 and 60.9 °C, respectively. The average time for the temperature to return to baseline with each modality was 3.4 and 6.4 s, respectively. The findings indicate that both mono- and bipolar electrocautery raises temperatures fairly equally but monopolar cautery appears more efficient and hence shorter periods of application and lower temperatures. Another interesting study by Khan and associates [21] demonstrated the thermodynamic impact of heat-sink effect or adjacent arteries and veins. In a porcine model, they demonstrated that active blood flow through arteries and/or veins reliably dissipated heat as long as blood flow was present in the vessels. The moment the vessels were clipped stopping blood flow, the adjacent thermal spread through muscle was exactly the same when vessels were not present. Zorn and colleagues have also nicely demonstrated that application of cold irrigation when applied concomitantly with cautery that thermal spread can be measurably reduced [22]. We recommend that the simplest solution is to avoid thermal energy altogether near the NVB; however, there is much evidence that if the laws of thermodynamics are observed thermal spread can be applied while keeping thermal spread to a minimum. If one keeps in mind simple thermodynamic principles such as low wattage, short bursts, distance, etc., thermal spread will be minimized.

24.6 Traction Injury

Traction or stretch injury is perhaps the most recognized means of nerve injury studied in animals and seen all too frequently in the human complications such as traumatic injury or more urologically familiar femoral nerve stretch injuries. In 2008, we published our findings looking specifically at 3-month potency outcomes in 139 men (preop: age < 66 with IIEF-5 scores 22–25) [23]. Of note 53 % or 38 % were potent and 86 % were not. We felt that some factor should or at least might be found accounting for such a stark difference in 3-month potency outcomes. We evaluated a large host of factors such as age, BMI, medical comorbidities, medications, social factors (marital status, partner age, etc.), and perioperative factors. In univariate analysis, age and prostate weight were significant but in multivariate analysis, only prostate weight remained significant. We felt the likely explanation was traction as our data demonstrated the lowest risk of impotence for the smallest prostate and a stepwise increase in impotence at 3 months over five increasing quintiles. The fact that a traction injury usually recovers (usually 9–15 months) explains why prostate size is not a significant factor for recovery at 12 months. Recently, these findings have been reported by V. Patel and colleagues (2010, abstract presented Southeastern Section of the AUA, personal communication).

24.7 Impact of Patient-Related Factors and Inflammatory Damage

It is well known that younger and healthier men with normal sexual function (IIEF-5 of 25) will have a much greater chance of potency recovery following surgery than older men (>65 years) regardless of surgeon or technique [24]. This begs the question why? One logical answer is acute surgical trauma and inflammation. There is no evidence that the trauma generated in a 70 year old is or should be greater than a 45 year old. Rather the likely explanation is that for any given trauma, younger and healthier men will resist and or recover better. Again, this simple concept explains the ubiquitous surgical finding why clinical outcomes deteriorate with age in any given surgeon using a defined technique.

Following surgery and its attendant traumatic injury to nerves, muscles, and other tissues, there is overwhelming clinical and animal research of a secondary wave of inflammatory damage that ensues leading to additional delays in functional recovery. Support of a role of inflammation was published by Fracalanza and associates in 2008 [25]. This group demonstrated significantly higher levels of inflammatory levels of IL-6 and C-reactive protein in men undergoing open RP as compared to RARP.

The inflammatory cascade includes activation of coagulation factors, proinflammatory cytokine formation, hypoxia, and microcirculatory impairment from endothelial damage, acidosis, free radical production, and apoptosis [26]. Neutrophil and macrophage infiltration with subsequent release of proteolytic enzymes further contributes to tissue destruction [27, 28]. Theoretically, this secondary inflammatory cascade might be blocked (or at least mitigated) with the use of local tissue hypothermia. Application of hypothermia preemptively (before dissection starts) prepares tissues for imminent damage by lowering their metabolic rate and oxygen demands. With sufficient temperature reduction, the cell enters into a quiescent state of low energy utilization. When injury ensues, energy reserves are available for repair without going into anaerobic metabolism. As a result, less lactate formation occurs, protein synthesis is preserved, and most importantly, the inflammatory cascade is blunted. With less proinflammatory molecules and free radical species generated, the risk of apoptotic cell death is reduced. Tissue damage from leukocyte infiltration is further reduced because cooling also blocks adhesion molecule transcription and inhibits neutrophil adherence [29].

Hypothermia has been demonstrated to have a dramatic protective impact in numerous experimental injury models of the central and peripheral nervous systems. The use of mild to moderate hypothermia (i.e., 33 to 28 °C) has been shown to be effective in shielding neurons from damage. In a rabbit model of spinal cord ischemia, Isaka and colleagues applied trans-vertebral cold packs and infused cold saline into a cross-clamped aorta to produce spinal cord cooling [30]. A modest reduction in spinal cord temperature of just 4.3 °C completely prevented paraplegia compared to complete paraplegia in all of the control rabbits.

We have been exploring regional local hypothermia to help prevent trauma-induced inflammatory injury to the external urinary sphincter for continence and the neurovascular bundles for sexual function [31–33]. Although still preliminary, we have demonstrated significant evidence for the concept with improvement in overall 12-month "no pad" continence of 86.6 % in our initial 670 patients (control group) versus 96.3 % in our initial 109 hypothermia patients. With regard to potency, we have also seen some improvement. When we compared our 15-month potency recovery in men with IIEF-5 scores of 22–25 aged 40–78, our potency rate was 83 % compared to 66 % in similarly aged controls. Consistent with the hypothesis that hypothermia reduces inflammatory injury particularly in older patients, we saw our greatest improvement in men over the age of 65 (hypothermia 70 % vs. controls 30 %).

Conclusion

The present understanding of the neuroanatomy of the cavernosal nerves and efforts to technically preserve the nerves during radical prostatectomy appears to be nearly maximized. Further, evidence for and an understanding of redundancy strongly dilutes substantial impact of further "nerve" preservation schemes significantly improving potency outcomes. Rather, we believe that focusing on technically mitigating injury will play an increasing role on our path to improve outcomes. Care should be taken to avoid or minimize heat spreading to the NVBs as well as focusing on methods to reduce traction. Lastly and potentially, most importantly, we believe in the need to explore novel therapies to help protect the NVBs before, during, and after surgery such as hypothermia.

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Allogenic Nerve Interposition During Non-Nerve-Sparing Robot-Assisted Radical Prostatectomy

25

Christian Vollmer and Hubert John

The primary aim of radical prostatectomy is an optimal local cancer control as well as preservation of the postoperative urinary continence and erectile function if possible. Various authors use the term "trifecta" for this [1, 2].

The neurovascular bundle (NVB) should not be spared at radical prostatectomy (RP) when the prostate cancer is intermediate or high-rate (cT3 and/or Gleason score ≥7 [3+4 and 4+3] and/or PSA ≥ 20 ng/ml). The inevitable consequence of this is a complete postoperative erectile dysfunction (ED). In addition to the erectile function (EF), the postoperative urinary continence also suffers from the excision of the NVB as nerve fibres to the m. sphincter externus urethrae also run through here [3, 4].

Postoperative erectile function sufficient for satisfactory sexual activity can often be achieved by nerve-sparing surgical techniques on the one hand and by bridging the excised nerve gap of the NVB on the other. The success rates in various studies of nerve interposition (NI) at radical prostatectomy in previous years are however very contrary. To date, most publications are uncontrolled, retrospective and/or display low cohort numbers. It remains unclear whether postoperative erections following unilateral nerve-sparing with contralateral grafting are the result of the nerve-sparing or the graft. Therefore, the true benefit of the nerve interposition remains uncertain.

In the early 1990s, the feasibility of NI (n. genitofemoralis) for the restoration of the EF was shown in rats [5]. Hereby, it is critical to note that the NVB differs in the human and rats. In rats, the NVB is a well-defined structure and as such ideal as a model for NI. In humans, the NVB is more like a mesh that cannot be completely replaced by a single, solid nerve. Such a nerve can however serve as a bridge for the regeneration of the nerve fibres of the NVB [6].

In 1991 and 1992, in an experimental study, Walsh et al. implanted n. genitofemoralis to the contralateral side in unilateral nerve-sparing procedures. Twelve patients were randomised equally into the study and control groups. In a follow-up of 5 years, there was no difference in the rehabilitation of the EF between the study and the control group [6]. It was supposed that the n. genitofemoralis did not have an adequate diameter.

The first implantation of n. suralis was carried out in 1997 by Kim et al. [7]. After an extensive bilateral excision of the NVB in nine men, an autologous suralis nerve was implanted. The follow-up was up to 14 months in one patient. The first spontaneous erection was documented at 5 months after the procedure, but this was not sufficient for penetration until 11 months postoperatively. With the use of a vacuum pump and MUSE®, erections capable of penetration

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were possible at 14 months postoperatively. This patient was continent 1 month after the procedure. Sensory loss at the donor site of the n. suralis was described.

In 2001, Kim et al. reported on a further 12 men by whom a bilateral suralis interposition following wide excision of the NVB was carried out during retropubic radical prostatectomy (RRP) [8]. Thirty-three percent (four men) had spontaneous, penetration-capable erections 14–18 months postoperatively, without medication supplements. A further 42 % (five men) had spontaneous erections, but the rigidity was not sufficient for sexual intercourse. Therefore, spontaneous erections were reported by 75 % (nine men). In a follow-up of 23 ± 10 months, Kim et al. reported on a further 11 men with bilateral suralis implantation during RRP [9]: 26 % (6 men) had spontaneous, penetration-capable erections without medication supplements. A further 26 % (six men) had spontaneous erections, but the rigidity was insufficient for sexual intercourse. Forty-three percent (ten men) had intercourse using Sildenafil.

Between 1998 and 2000 in a prospective study with a total of 30 patients, Chang et al. carried out a bilateral suralis interposition during RRP [10]. The follow-up was up to 33 months. Sixty percent (18 men) had spontaneous erections after an average of 13.6 months; in 43 % (13 men), the erections were sufficient for sexual intercourse.

In 2000, Turk et al. carried out the first laparoscopic suralis interposition [11]. This study was designed to show the feasibility of the laparoscopic nerve interposition. In 15 men, n. suralis was implanted following a unilateral or bilateral excision of the NVB. All 15 procedures were completed laparoscopically, the additional OR time for the nerve excision and grafting was between 30 and 60 min. There were no clinical data for the functional outcomes in this study.

The first NI with robot-assisted laparoscopic radical prostatectomy (RALP) was done in 2002 by Kaouk et al. [12]. In three preoperatively potent men, a suralis-interponate was implanted using the da Vinci® Surgical System (Intuitive Surgical, Sunnyvale, CA). In two patients, the implantation was bilateral, in one patient unilateral. In one patient, the whole operation was done using the da Vinci robot; in the other two, the robot was used only for the NI and the urethravesical anastomosis whilst the prostatectomy was done conventionally laparoscopically. The average operating time was 6.5 h with an average blood loss of 216 ml. Two patients had an R1 resection with positive margins at the apex. In a follow-up of maximal 7 months, one patient reported penile tumescence using Sildenafil but insufficient for penetration, one patient had no indications of erection at all; the patient, by whom the unilateral nerve-sparing was done, had penetration-capable erections without the use of medication. This study showed the feasibility of using the da Vinci robot for nerve interposition. Due to the improved, magnified and three-dimensional visualisation of the surgical field, the precise anastomosis of the nerve graft was possible [13].

The interposition of autologous nerve grafts is to date the only clinical reconstructive procedure following excision of the NVB. The essential advantage of autologous nerve grafts is that the vital Schwann cells in the graft provide a growth medium for the regeneration of the axons. As autologous nerve grafts are taken from the patient's own body, there are no autoimmune reactions to be expected. The axon regeneration is delayed however as the transplanted axon fragments have to go through the Wallerian degeneration. Better results can be achieved using pre-degenerated grafts by which the axons are enzymatically treated before implantation [14]. The autologous nerve transplantation has further disadvantages as in the additional surgical procedure and the morbidity of the nerve excision or the risk of the development of a neurinoma after the implantation in the pelvis. In their study on the functional and oncological long-term results following suralis implantation during RALP, Zorn et al. reported a neurinoma incidence of 4 % [15].

The additional surgical intervention necessary for autologous grafts is avoided by using artificial nerve conduits. The length and diameter of artificial conduits can be chosen at will and adapted exactly to the defect. The tubular form allows the nerve ends to be placed into the graft which reduces uninhibited growth and the formation of neurinomas [16]. Silicon conduits are amongst the most used experimental splints. As silicon splints are impermeable, neurotropic substances, which are produced at the nerve endings, are concentrated into the lumen. Good clinical results were achieved in the reconstruction of defects of the n. medianus and n. ulnaris by a relatively short defect length of 5 mm [17]. If the defect length is longer, then the use of silicon splints is limited.

Significantly better results in comparison to acellular matrices were achieved in the reconstruction of longer defects with the implantation of Schwann cells into the artificial conduits [18]. In a preclinical study, May et al. were able to show the influence of the transplanted Schwann cells in the regeneration of cavernosal nerves [19]. In the animal model, a significantly higher erectile function could be found 3 months after the interposition of the conduits with the Schwann cells in comparison to the acellular splints and autologous nerve grafts.

In 1998, Zou et al. described the inhibiting influence of chondroitin sulphate proteoglycans on the regeneration of peripheral nerves [20]. Krekoski, Neubauer et al. could show that the axonal regeneration in decellularised nerve grafts following purification with chondroitin sulphate proteoglycan was improved and that the effective length of a nerve graft could hereby be extended [21, 22].

Whitlock et al. compared in 2009 in an animal model autologous nerve grafts with the type I collagen conduit Integra from Neuragen® and a decellularised allogenic nerve graft in the reconstruction of peripheral nerves [23]. In a 14-mm defect of the n. ischiadicus, the number of myelinated nerve fibres in the middle and at the end of the grafts was counted after 6 and 12 weeks. After 6 weeks, the autologous nerve graft was superior to the decellularised allogenic nerve graft and the type I collagen conduit Integra. This difference was nullified after 12 weeks. The autologous nerve graft was superior at 6 and 22 weeks in a nerve defect of 28 mm. This supremacy of the autologous grafts was confirmed in the functional tests. It was however also shown that the target tissue was innervated by the decellularised allograft, but that there was no innervation over the conduit Integra.

Connolly et al. researched the use of decellularised allografts in the regeneration of the NVB in animal models [24]. In comparison to the control group, the animals that were implanted with the decellularised allograft after excision of the NVB showed a significantly better erectile function and 87.6 % higher intracavernosal pressures were measured. Although the results of this preclinical study are promising, there have been to date no clinical studies carried out.

At the Clinic for Urology, Kantonsspital Winterthur in Switzerland in the context of a prospective, randomised and single blind clinical phase IV study, the allogenic nerve graft Avance® is being implanted during non-nerve-sparing robot-assisted radical prostatectomies. Avance® is an allogenic medical product of decellularised and purified extracellular matrix of human nerves, whereby the nerve specific structures have been preserved. It is purified through an enzymatic process (chondroitinase) using chondroitin sulphate proteoglycan.

The NI can be used in patients diagnosed with an intermediate or high-risk prostate cancer and who demonstrate a preoperative IIEF≥21 (International Index of Erectile Function).

Essentially, the NI can be carried out via the trans-peritoneal as well as the extra-peritoneal access.

The nerve interpositions to date in this study have been done via the trans-peritoneal approach with a bilateral extended lymphadenectomy that extends from the ramus superior ossis pubis along the v. iliaca externa, dorsal to the n. obturatorius and cranially over the area of the a. iliaca externa. The lymph node packets of the obturatorial, iliaca externa and interna are extracted and sent for histopathology separately (Fig. 25.1).

After extra-peritonealisation and separation of the bladder from the prostate, the retro-vesicle space is prepared, the ductus deferens transected and the seminal vesicles freed completely. For oncological reasons, a bilateral descending (antegrade), non-nerve-sparing approach is made. The prostate is excised leaving a long urethral stump (Fig. 25.2).

Before implantation, the Allograft Avance® must be prepared. The grafts are stored at −80 °C.

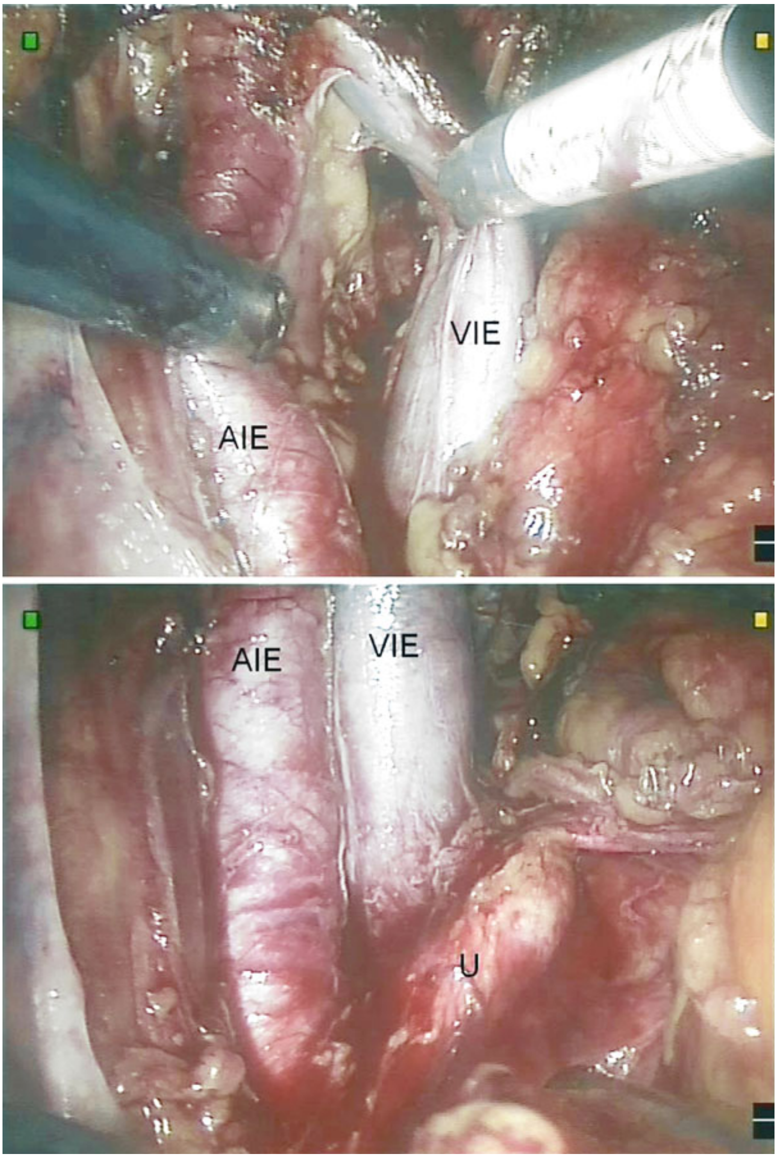

Fig. 25.1 Intra-operative video documentation after extended lymphadenectomy *top* (*AIE* a. iliaca externa, *VIE* v. iliaca externa, *U* ureter)

The product must be thawed 5–10 min before use. For this, a special container is provided and filled with sterile saline or Ringers solution. When the graft is completely thawed, it is soft and pliable (Fig. 25.3).

The Allograft Avance® is then inserted through the 12-mm assistant port and brought into position using the prior-attached monofilament suture. This suture is attached only through the epineurium. Excessive traction or shear force must be avoided at all cost. Using the fine instruments, the positional suture is removed; again only grasping the epineurium (Fig. 25.4).

The graft is first fixed ventrally with three 7-0 Premilene sutures (Fig. 25.5).

After shortening the graft to the required length using the Potts scissors, the left dorsal anastomosis is made to the NVB; again using 7-0 Premilene (Fig. 25.6).

This procedure is repeated on the right side (Fig. 25.7).

Finally each of the four neuro-neoneuronal anastomoses is secured using 1 ml Tissucol (Fig. 25.8).

The bilateral nerve interposition extends the operation by about 30 min.

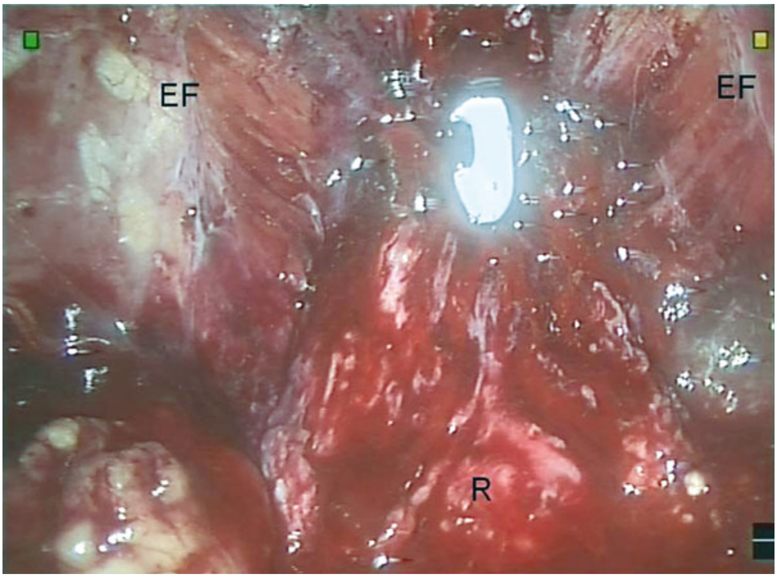

Fig. 25.2 Intra-operative video documentation after complete bilateral dissection of the neurovascular bundle (*R* rectum, *EF* endopelvine fascia)

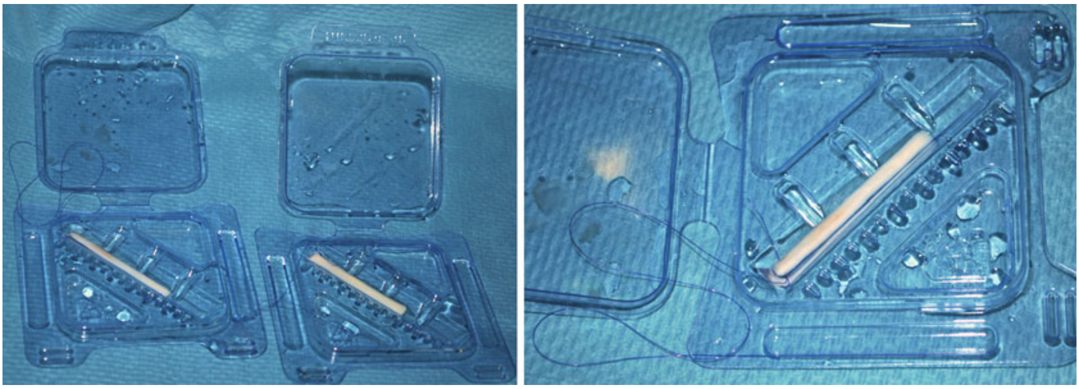

Fig. 25.3 Showing the nerve grafts in the thawing reservoirs. Both grafts have a 7-0 Premilene suture attached as positional aid

Conclusion

An optimal local tumour control as well as the preservation of the continence is the primary goal of the radical prostatectomy. The preservation of the erectile function completes the trifecta, which affords the patient the best postoperative quality of life. With the introduction of the robot-assisted laparoscopic radical prostatectomy and the development of the nerve-sparing technique, it is now possible to achieve very good postoperative results in respect to the erectile function. If the preservation of the NVB is untenable for oncological reasons, then the implantation of an allogenic nerve graft could make satisfactory postoperative sexual activity possible. Results for the Allograft Avance implantation by RP are not yet available, but with the background of the experience and positive results by implantation of decellularised allogenic nerves in the reconstructive peripheral surgery and in the context of preclinical studies, it would seem that this is a reasonable step. The feasibility of the implantation has been shown. The functional results of this and further implantations will be the objects of future analyses.

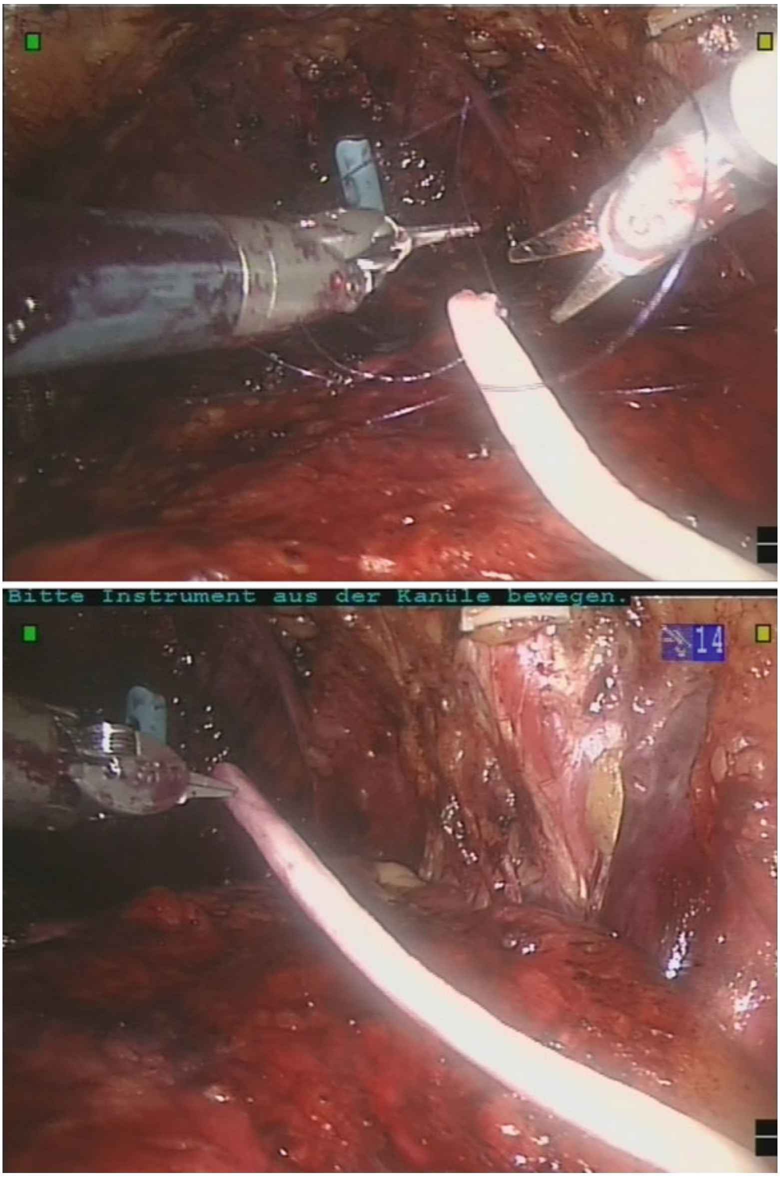

Fig. 25.4 Positioning the Allograft Avance® in the surgical site using the 7-0 Premilene suture

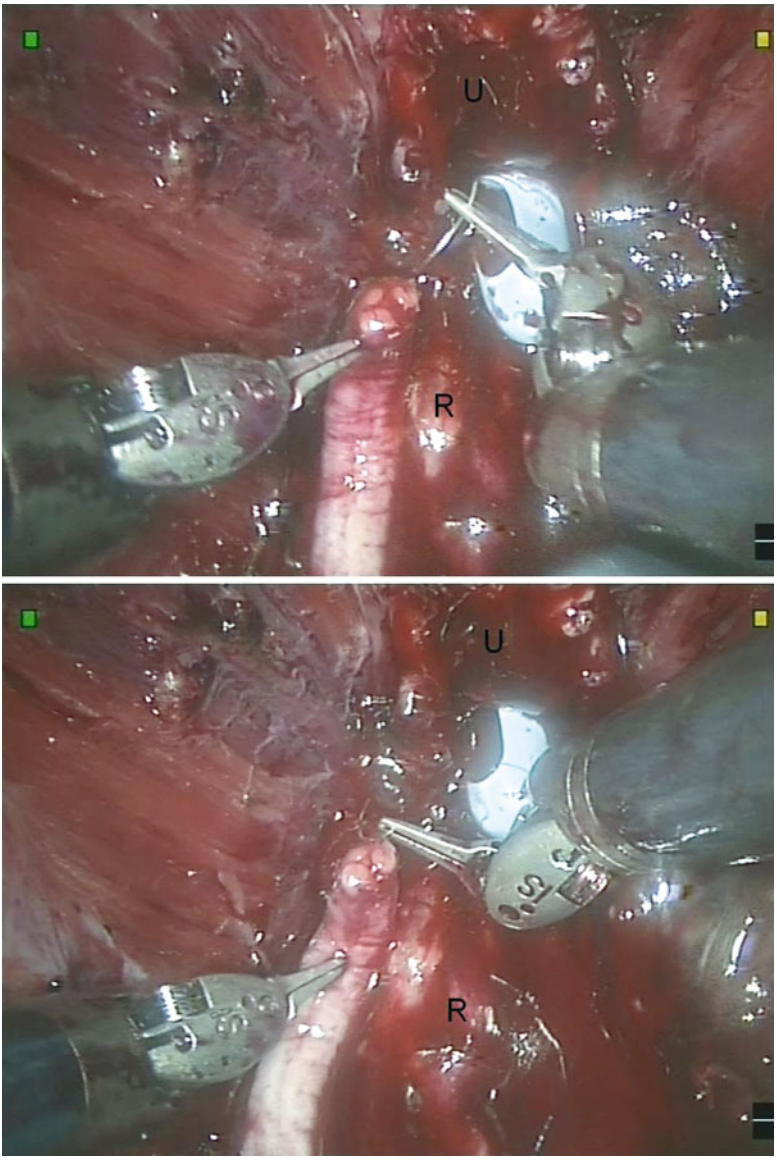

Fig. 25.5 The epineural suture technique by the anastomosis of the Allograft Avance® to the *top* ventral neurovascular bundle (*R* rectum, *U* urethra)

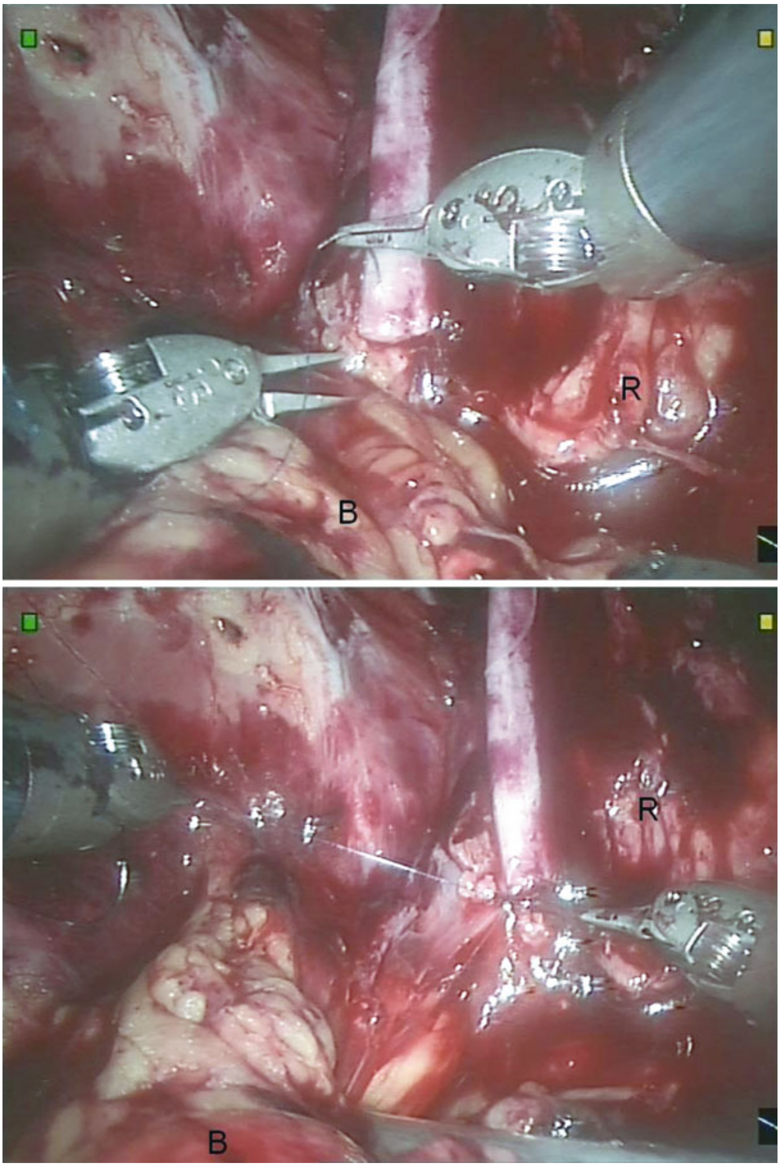

Fig. 25.6 Anastomosis of the Allograft Avance® to the neurovascular bundle dorsal *top* (*R* rectum, *B* bladder)

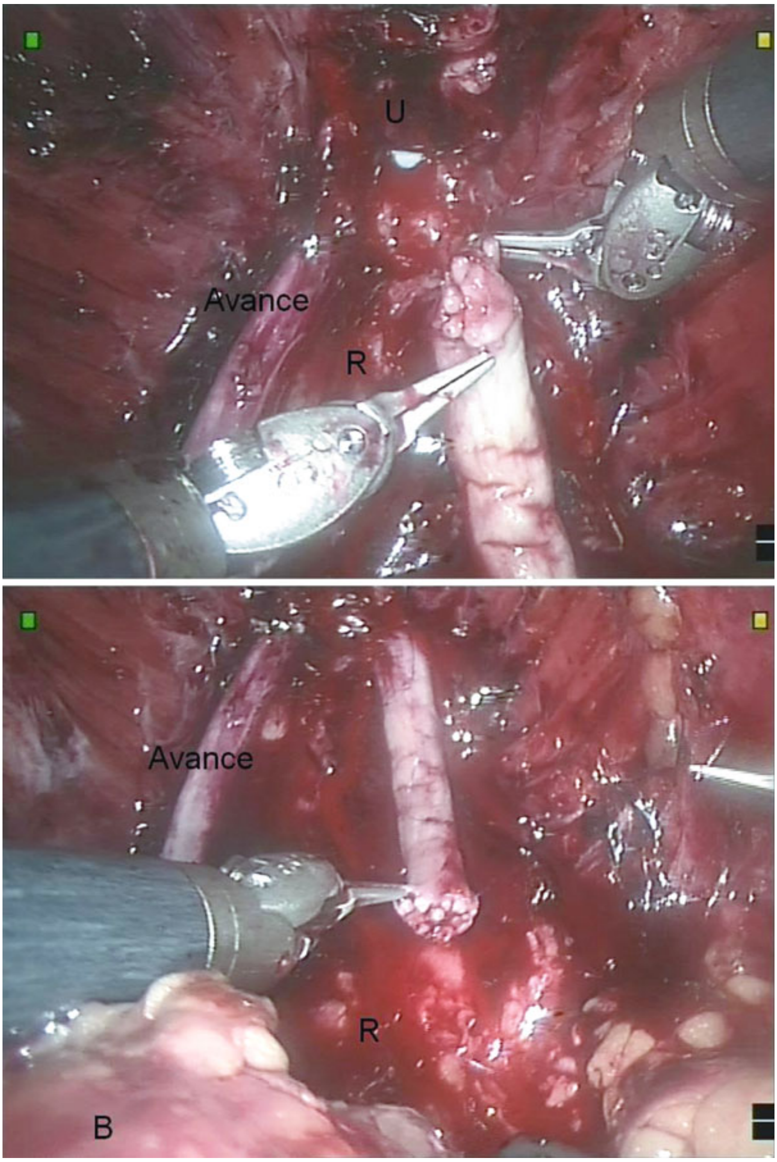

Fig. 25.7 Implantation of the Allograft Avance® *bottom* (*R* rectum, *B* bladder)

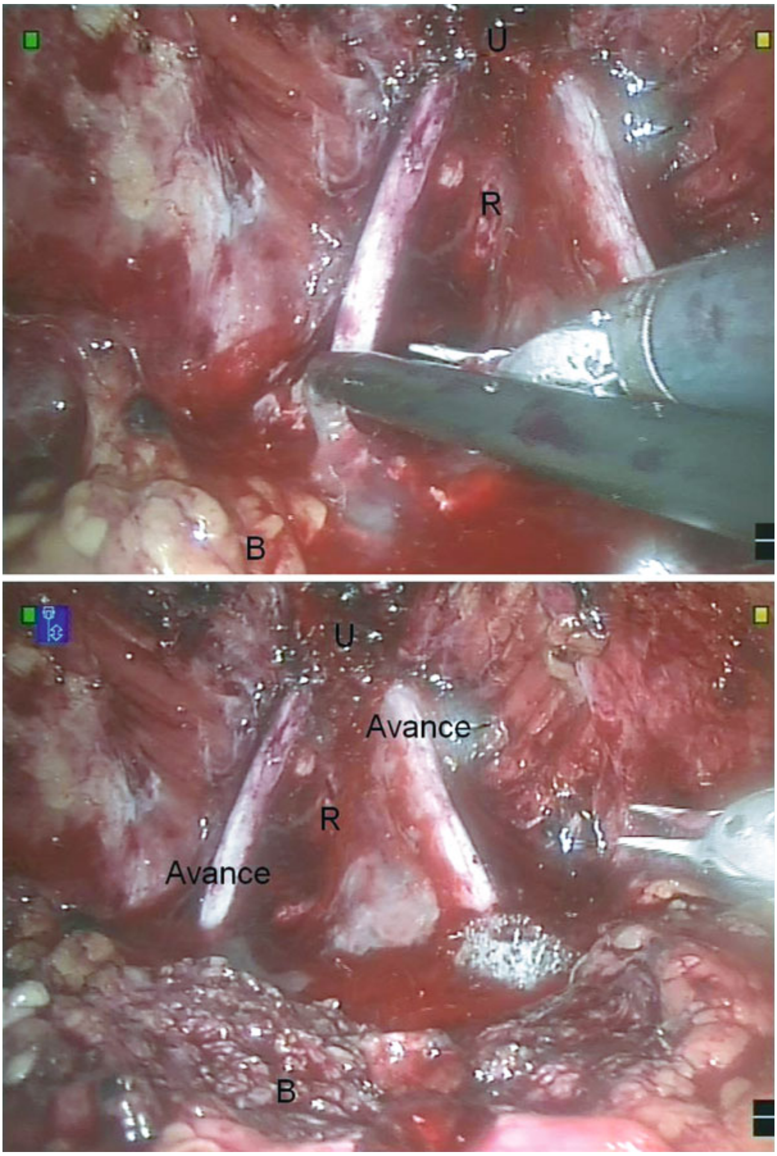

Fig. 25.8 Injection of the Tissucol (*photo top*), final situation after bilateral implantation of the allografts (*photo bottom*) (*R* rectum, *U* urethra, *B* bladder)

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The Apical Dissection

26

Walter Artibani

26.1 Introduction

Prostate apex dissection during radical prostatectomy is a critical step in order to assure proper oncologic and functional outcomes. Full knowledge of the surgical anatomy of the prostate apex (shape variations, attachments to pelvic floor musculature, peri-prostatic fasciae, junction with membranous urethra, neural and vascular anatomy) is a prerequisite to achieve an effective surgical dissection.

The goals of a proper prostate apex dissection are the following: (1) radical removal of prostate apex, without any prostatic tissue left behind, and with negative apical margins; (2) maximal preservation of the membranous urethra both in its length as well as in its anterior, lateral and posterior segments; (3) a nerve-sparing procedure, whenever possible, gently dissecting out from the apex the neurovascular bundles concentrated at 5 and 7 o'clock; and (4) the careful sparing of any accessory/aberrant pudendal artery. An efficient and successful management of the dorsal vascular complex (Santorini plexus) is instrumental to attain perfect vision of the surgical field.

Robot-assisted laparoscopic radical prostatectomy (RALP) represents nowadays a reliable procedure in order to consistently achieve those goals. Actually, RALP has contributed to redescribe details of surgical anatomy of the prostate and surrounding structures as a result of the tenfold magnified tridimensional depiction: some anatomical features were never seen formerly with comparable accuracy [1–4].

A variety of techniques have been described, via intraperitoneal or extra-peritoneal approach, using three or four-armed da Vinci equipment, with different stepwise sequential approaches (for instance, sewing the dorsal venous complex as a first step, or leaving its section and suture as one of the last steps of the procedure).

We describe here our technique with a specific focus on apical dissection.

Patients selection was based on clinical staging (prostate biopsy outcome: Gleason score, number and location of positive cores; PSA; DRE; when indicated, prostate MRI). A nerve-sparing procedure was planned in patients with low/intermediate risk according to D'Amico. The size of the prostate, the presence of a median lobe and the apex shape were also taken into account [5–11].

26.2 Clip-Less RALP

We use routinely the three-armed da Vinci S™ system (Intuitive Surgical, Sunnyvale, California), via a six-port intraperitoneal approach.

The patient is padded at pressure points, fixed to the table, placed in lithotomy position with steep Trendelenburg (30–33°). An 18-F Foley catheter is inserted in the bladder.

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One bedside assistant trained in laparoscopy assists at the patient's right side and a nurse on the left side. A para-umbilical 12-mm trocar is used for the robotic camera. Two 8-mm robotic trocars are placed lateral to the rectus muscles halfway from the umbilicus and the pubic bone and halfway between the umbilicus and the anterior superior iliac spine, 9 cm from the camera trocar. A 12-mm trocar is placed 2 cm right/left to the anterior superior iliac spine. A 5-mm trocar port for the suction device is placed 3 cm lateral to the camera port.

We use the following instruments: a monopolar curved articulated scissors in the right robotic arm, an EndoWrist PK™ in the left robotic arm, suction device, two needle drivers, two Johann graspers.

We use a 0° lens throughout the entire procedure.

Our procedure is clip-less; we do apply monopolar pinpoint precise punctual short-term (less than 1 s) diathermy (25–30 W) using one open branch of the scissors.

The following steps are sequentially performed before apical dissection.

After careful exploration of the abdominal cavity and release of any sigmoid or ileal adhesions, we enter the Retzius by a transverse peritoneal incision side-to-side from the right to the left umbilical ligament, transecting the urachus in the midline and extending the dissection laterally down along the umbilical ligaments until the vas deferens. The bladder is bluntly mobilised downwards, developing adequate space at the prostatic area.

We then carefully remove the adipose tissue delineating the anterior surface of the prostate, the endopelvic fascia and puboprostatic ligaments, observing carefully for accessory pudendal arteries (which if present should be preserved whenever possible). The fat tissue is easily detachable from the prostate and the endopelvic fascia, while it is more fixed to the bladder wall: this can help identify the prostato-vesical junction.

The superficial dorsal vein is coagulated and divided.

We immediately approach the bladder neck without opening the endopelvic fascia or suturing the dorsal vein complex. We outline the prostate-bladder junction by moving the catheter balloon and grasping the anterior bladder wall in the midline. The catheter balloon is then deflated in order to avoid anatomic distortion. We transect the detrusor apron with an inverted V incision, opening the anterior bladder neck from 10 to 2 o'clock.

The catheter tip is attracted out and grasped by the right-side assistant; a firm traction is applied internally and externally in order to elevate the prostate and expose the open bladder neck.

The posterior bladder neck lip is explored, checking for median lobe and position of ureteric orifices. The spatial direction of the trigone is variable and can differ based on prostate size and shape: usually it is slightly oblique, but it can appear horizontal due to prostate hypertrophy, or can be deformed by a median lobe; sometimes it is vertical or, in the case of a very small prostate, a caudal indentation can be present, producing an acute caudal angle. The spatial direction of the trigone is important in planning the direction of the posterior transection of the bladder neck and the separation by sharp and blunt dissection of the trigone from the cranial posterior base of the prostate.

The posterior bladder neck and the trigone are dissected away from the prostate, dividing the vesico-prostatic muscle and the fibro-adipose tissue layer laying beneath (often incorrectly described as anterior layer of Denonvilliers' fascia) exposing the vasa and the seminal vesicles.

Posterior bladder neck dissection is a difficult step: the key points to be considered are the thickness of the bladder wall and the direction/conformation of the trigone. The vesico-prostatic muscle is composed of longitudinal muscle fibres going from the outer bladder wall towards the base of the prostate. After dividing transversally this longitudinal muscular tissue, a deeper fibro-adipose layer must be divided in order to see the vasa.

Each vas is dissected carefully and mobilised as much as possible, separated from the vesicle which is simultaneously dissected medially and laterally. The vas is transected and its cranial edge is grasped by the assistant and retracted upwards with a twisting manoeuvre which facilitates the exposition and dissection of the tip of the seminal vesicle. We never spare the seminal vesicle tip. The dissection is done very close to the vesicle's wall in order to spare all the surrounding tissue which is notoriously rich in nervous fibres. The vesiculo-deferential arteries are coagulated (pinpoint short-term cautery) and divided.

Both seminal vesicles are grasped and retracted upwards. The space between the prostate and the rectum is developed following a plane anterior to the Denonvilliers' fascia. The midline plane is avascular and usually very easy to dissect bluntly; the plane is developed as lateral as possible taking care not to damage the medial edge of the posterolateral neurovascular bundle.

We then perform a so called 'high anterior release', incising the prostatic fascia anterolaterally (10 and 2 o'clock position) and detaching the anterolateral tissue surrounding the prostate. We search for contact with the prostate following an intra-fascial or inter-fascial plane. Counter-traction from the assistant on the opposite seminal vesicle facilitates this manoeuvre. The dissection goes millimetre per millimetre down towards the apex of the prostate.

We then approach the supero-lateral pedicle of the prostate, precisely cauterising and transecting small vessels entering the prostate. The correct plane is found and followed alternating between a superior, lateral and medial approach: the posterolateral neurovascular bundles are fully released towards the prostate apex. After intra-/inter-fascial dissection, the preserved tissue appears covered with a whitish 'fascial' thin layer. The didactic distinction between intra-fascial and inter-fascial dissection is not always feasible in reality: there are individual variations of the multilayered peri-prostatic fasciae, and often it is difficult to follow exactly the same plane from the base to the apex of the prostate.

At this point, prostate and seminal vesicles are completely released from the bladder, the vascular pedicles, the neurovascular bundles and the rectum: the only remaining attachments are the dorsal vascular complex, the apex and the membranous urethra.

Therefore, Santorini plexus control and apical dissection are the last steps in our procedure.

26.3 Apical Dissection

The assistant provides adequate cranial traction grasping the prostate base.

The two anterolateral incisions of the ventral peri-prostatic fascia are well visible (Fig. 26.1a, b). A midline side-to-side transversal incision joining their medial edges divides the dorsal vascular complex (Fig. 26.2a, b). Inconstantly one or two small arteries are encountered and coagulated. The venous bleeding is usually minor, thanks also to the temporary increase, the CO_2 pressure (up to 15 mmHg) controlled hypotension and minimised suction.

The plane between the dorsal vascular complex and the fibro-muscular stroma of the ventral prostate is meticulously dissected anteriorly and anterolaterally. The shape of the prostate is carefully exposed, identifying notches and lips.

Laterally, the apex is dissected from the antero-medial components of levator ani (levator prostatae, Muller/Walsh ligaments, levator urethrae) (Fig. 26.3a, b).

Due to the high transverse incision of prostatic fascia in the midline, the puboprostatic ligaments are fully preserved. Therefore, the urethral suspensory mechanism of the urethra to the pubic bone is left intact.

The muscle fibres, covering as a cup the anterior and lateral segment of the apex, are bluntly pushed towards the urethra. The prostato-urethral junction is now delineated anterolaterally, and the pubo-perinealis muscle is smoothly dissected.

A gentle rotation of the prostate on its axis provides a perfect view of the posterolateral and posterior segments of the apex, allowing ultraprecise circumferential dissection. The posterior attachments to the end of Denonvilliers' fascia are swept out from the prostatic apex. Great attention is applied on avoiding apical fissures or lacerations as well as on respecting all the surrounding structures because at this level the distal neurovascular bundles and nerves to the external urethral sphincter complex are very close and easily damageable.

At this moment, the prostate is almost completely released, attached only to the membranous urethra (Fig. 26.4).

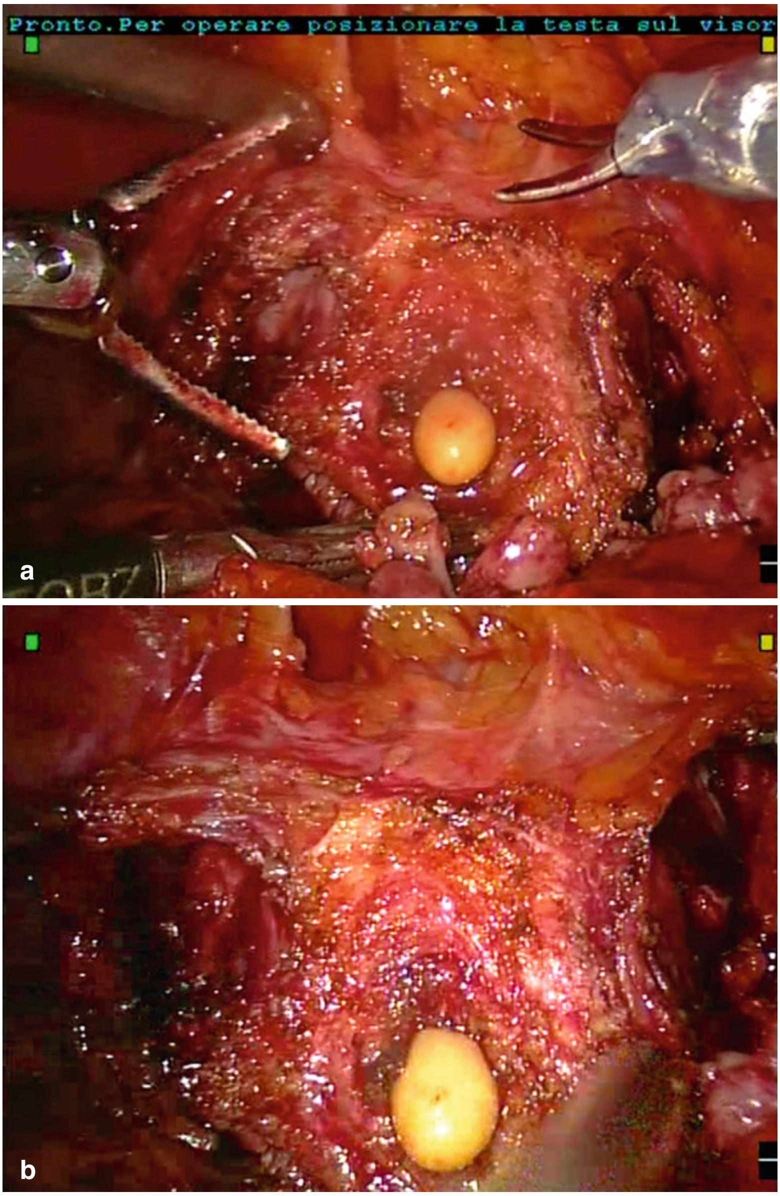


Fig. 26.1 (**a**, **b**) The two anterolateral incisions of the ventral peri-prostatic fascia are well visible

Robotic instruments are changed, introducing two needle drivers. A vertical ultraprecise overrunning suture of the dorsal vascular complex is accomplished (Polisorb 3-0 needle ½ 22 mm). The manoeuvre is facilitated by cranial traction on the prostate and external upwards pressure on the perineum by the assistant. The CO_2 pressure is lowered to zero, and the absence of any bleeding is tested. The field is cleaned by alternate irrigation and suction (Fig. 26.5).

The robotic instruments are changed again reinserting scissors on the right and PK on the left.

Following the individual apex shape, further 'intra-prostatic' dissection of the membranous urethra is pursued in order to maximise its length and preservation, without jeopardising radicality. Initial urethral transection is performed with a catheter inside, which allows a better outline of the border between the urethra and the apex. The

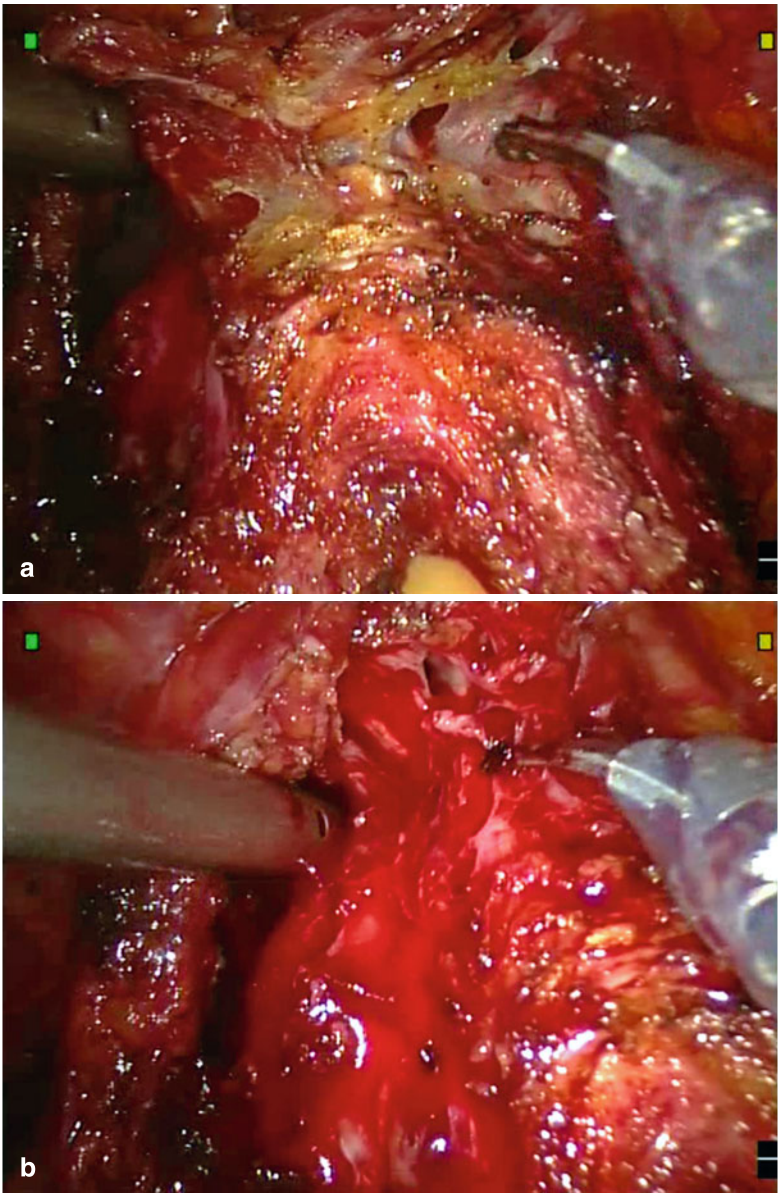


Fig. 26.2 (**a**, **b**) A midline side-to-side transversal incision joining their medial edges divides the dorsal vascular complex

anterior/superior wall of the urethra is transected from 2 to 10 o'clock, leaving a safe 1–2-mm margin on the prostate apex: the thick rhabdosphincter is visible and underneath the longitudinal fibres of the smooth sphincter. The catheter is now visible and is retracted in order to visualise the lumen of the posterior urethral wall: the 'crista urethralis' and 'plicae colliculi' are visible (Fig. 26.5b). The lateral and posterior transection is facilitated by the seven degrees of freedom of the scissors allowing ultraprecise division at a 90° angle. This is particularly important in some variations of the prostatic apex with posterior apical overlap or with lateral asymmetry. The perfect view of the different texture of urethral and prostatic tissue and the ideal motion capacity of scissors allow a meticulous and effective performance of this delicate manoeuvre, without applying undue traction.

Finally, the so called recto-urethralis muscle is transected following a cranial horizontal direction

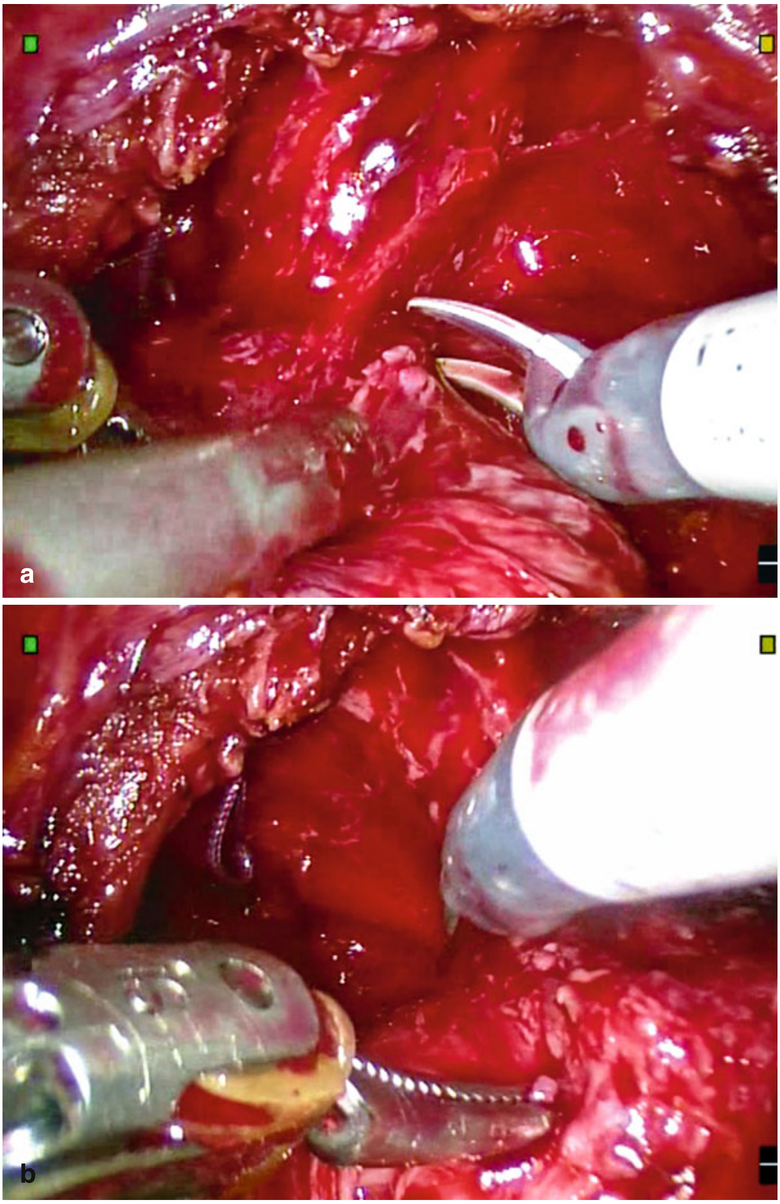


Fig. 26.3 (**a**, **b**) The shape of the prostate is carefully exposed identifying notches and lips; the apex is dissected laterally from the antero-medial components of levator ani

in order to preserve the posterior support to the urethra.

The completely released prostate is stored in an endo-bag inserted through the left 12-mm trocar.

The haemostasis is controlled and any bleeder is selectively sutured.

The urethro-vesical anastomosis is performed with a standard van Velthoven technique (Monocryl 3-0 needle 5/8, 18 + 18 cm) on a 22-F catheter.

No anterior or posterior reconstruction is performed. Actually, anterior reconstruction is not needed because the anterior suspensory mechanism is fully preserved (pubo-urethralis ligaments were untouched). The anastomosis starts with three posterior passages per side, which include in adjunct to the urethral and bladder neck walls,

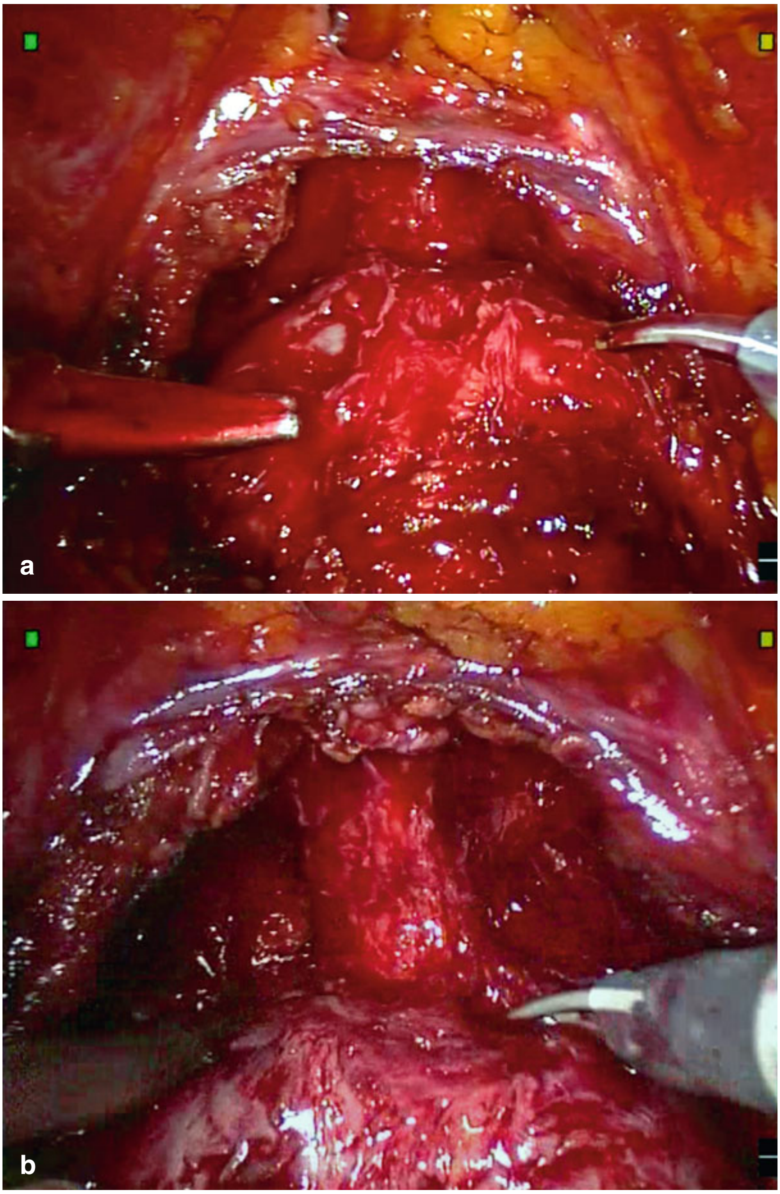


Fig. 26.4 (**a**) After selective suture of the dorsal vascular complex, the prostate is almost completely released, (**b**) attached only to the membranous urethra

on the urethral side the recto urethralis muscle and the fibrous tissue beneath the urethra, and on the bladder neck side the edge of Denonvilliers' fascia lying behind the trigone. The passages are meticulous at 5 and 7 o'clock positions preventing as much as possible damage to the neurovascular bundles.

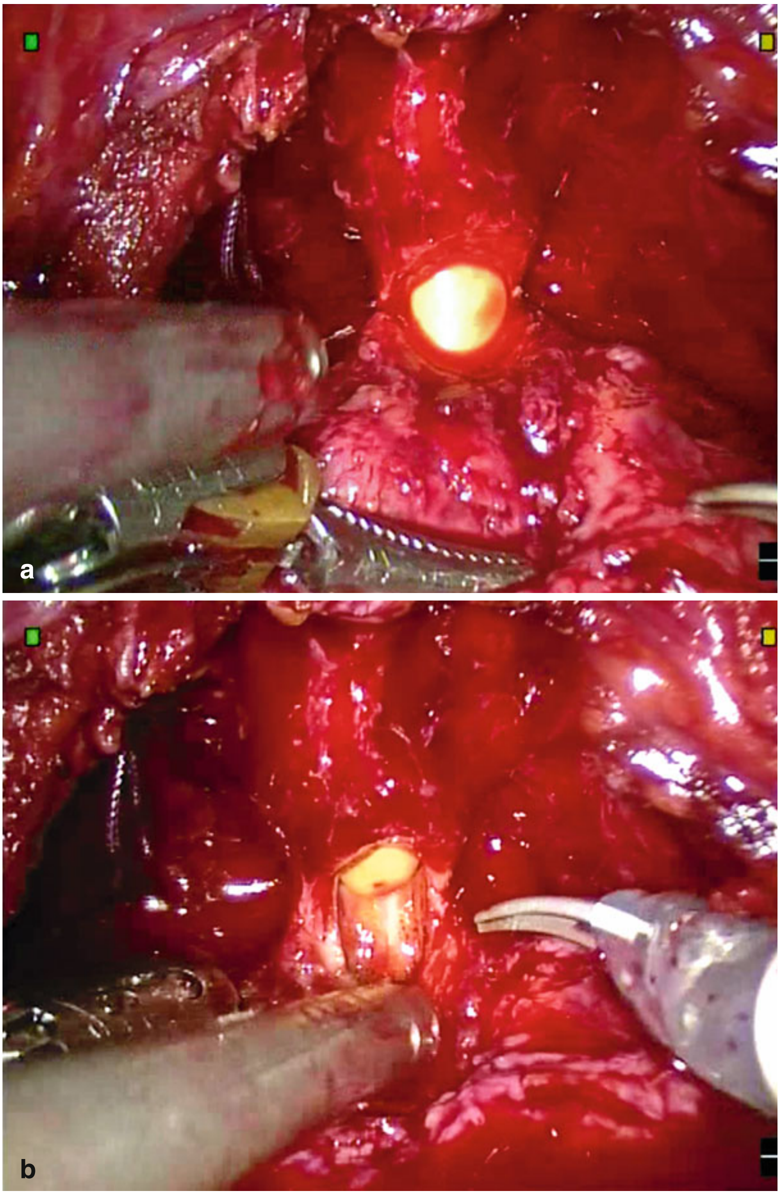
The bladder is filled with 150 ml of coloured solution in order to verify whether the suture is watertight.

A Penrose-type drainage (easy flow) is inserted in front of the anastomosis through the right 12-mm trocar, usually removed after 24 h.

No heparin is administered if there are no risk factors and lymphadenectomy was not performed.

Early mobilisation (after 6 h) and elastic compression stockings are adopted. The catheter is removed on the fourth/fifth day after X-ray confirmation of no leakage.

Fig. 26.5 (**a**) Anterior transection of the urethra; (**b**) the ‘crista urethralis’ and ‘plicae colliculi’ are visible; (**c**) posterior transection of the urethra



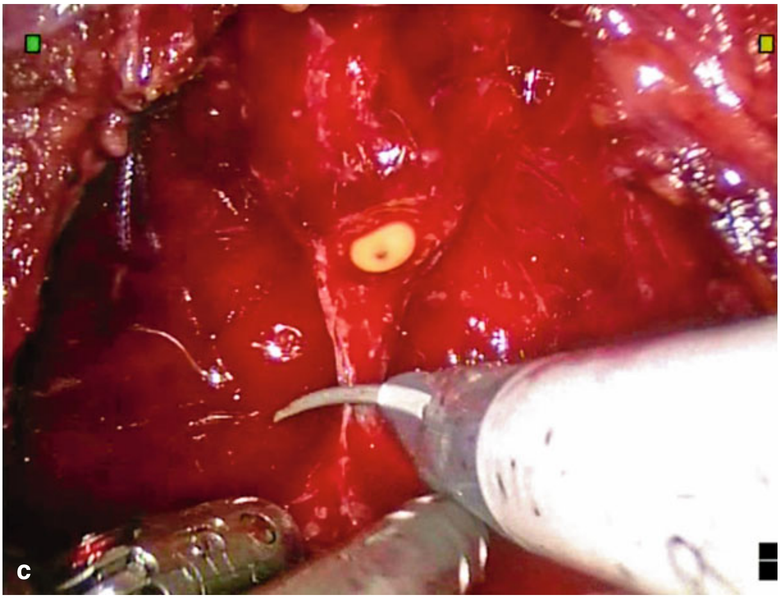


Fig. 26.5 (continued)

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Posterior Reconstruction of the Rhabdosphincter

27

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Pietro Acquati, and Francesco Rocco

27.1 Introduction

Urinary incontinence is still one of the major drawbacks following radical prostatectomy. It is considered even more bothersome than erectile dysfunction, even if its incidence is lower. According to the EAU guidelines, the incidence of definitive incontinence is about 7.7 % [1] whereas according to the AUA guidelines, the reported risk of urinary incontinence following prostate cancer therapies ranged from 3 to 74 % for radical prostatectomy [2].

Furthermore, the time for continence recovery remains a major issue, and most of the series consider a definitive evaluation of continence not before 12 months [3, 4].

Stress incontinence is the type of incontinence most frequently observed after radical prostatectomy, even if a considerable number of patients present a mixed urge and stress syndrome [3, 5].

Only a limited number of patients have been found to suffer from urge incontinence alone [4, 6].

The anatomical basis of stress incontinence after radical prostatectomy is not completely clarified even if many authors agree that a sphincter deficiency may be considered one of the most relevant causes of postoperative incontinence.

In 2006, based on accurate anatomical studies, our group described a technical modification of the original Walsh technique focused on faster continence recovery: the posterior reconstruction of the rhabdosphincter [7].

27.2 Anatomo-Physiological Background and Surgical Concept

The sphincter is shaped like a horseshoe and surrounds about two-thirds of the urethra, anteriorly and laterally. The sphincter muscle fibres, therefore, spread over both the anterior face and the sides of the prostate. On the dorsal side, according to Myers, Oelrich, Strasser [8–10], there is little or no muscular component, it being made up of connective tissue supporting the medial fibrous raphe (Fig. 27.1).

Particularly, the caudal part of the sphincter appears with greater amount of muscular fibres in the anterior lateral aspects, whereas posteriorly it seems markedly thinner or absent. In our studies, few striated muscular fibres seem present in the posterior portion of the sphincter as well [7].

Burnett and Mostwin [11] claim that the striated sphincter together with the pubo-urethral ligaments have a tonic effect, compressing the

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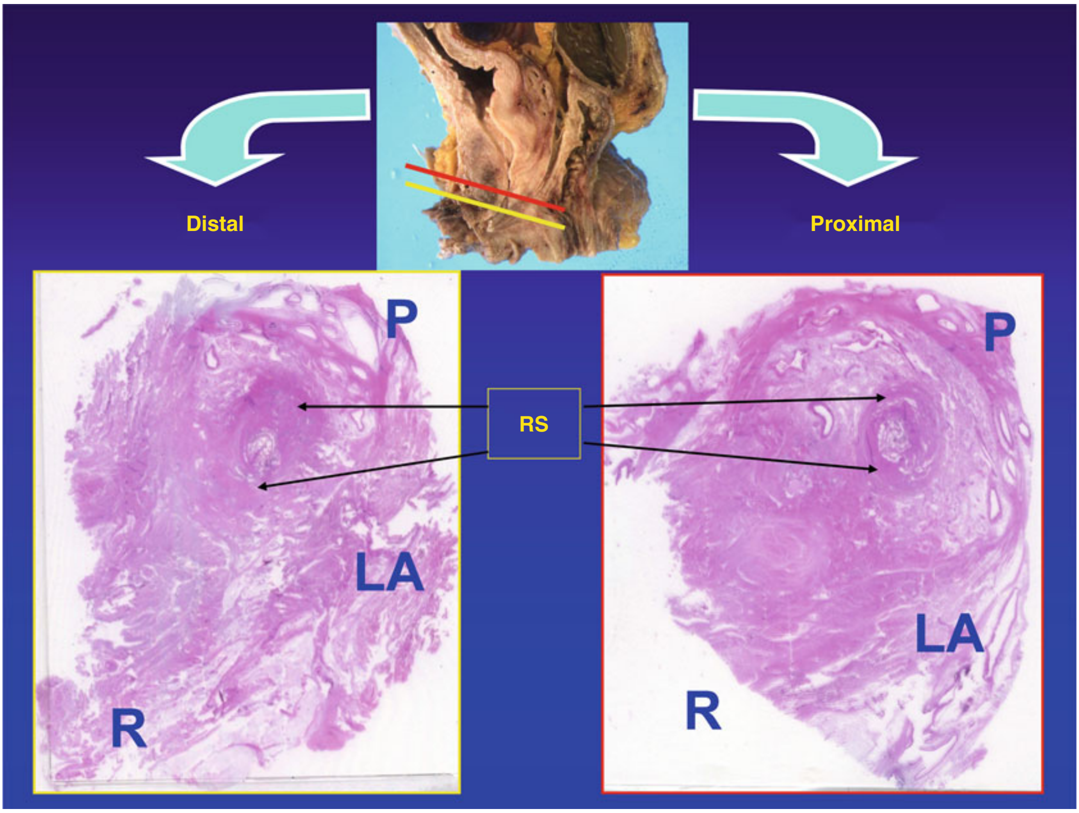


Fig. 27.1 Anatomical e pathological studies showing the relationship between the rhabdosphincter (*RS*), the prostate (*P*), the levator ani (*LA*) and the recturm (*R*)

urethro-prostatic complex towards the pubis during the period of urine collection in the bladder and releasing the complex towards the perineum during micturition.

According to Lowe [12], the action of the sphincter involves the contraction of the horseshoe-shaped fibres ventrodorsally so that the anterior face of the urethra comes against the posterior face; the posterior wall of the urethra is set on a strong dorsal support plane, the medial-posterior raphe inserted 'hanging' in the aponeurosis of Denonvilliers cranially and in the central tendon of the perineum caudally: this structure which forms a solid posterior support plane of paramount importance for the action of the rhabdosphincter (Fig. 27.2).

Denonvilliers' fascia, the prostate dorsal aspect and the posterior median raphe with the connected rhabdosphincter dorsal wall form a unique musculofascial plate extending from the peritoneum of the pouch of Douglas to the perineal membrane and the central tendon of the perineum. The musculofascial plate is an important support structure in the pelvis that appears to serve as a fixation point for the muscle fibres of the rhabdosphincter [7]. The musculofascial plate is a dynamic suspensory system for the prostatomembranous urethra. The rhabdosphincter has the shape of a non-coaxial cylinder wrapping the urethra in craniocaudal sense. This description supercedes the idea of a mainly horizontal structure as previously described [8, 9].

As a result of the resection of the cranial end of the striated sphincter and the urethra, at the moment of the apical dissection, the urethro-sphincteric complex which has lost its cranial anchorage, tends

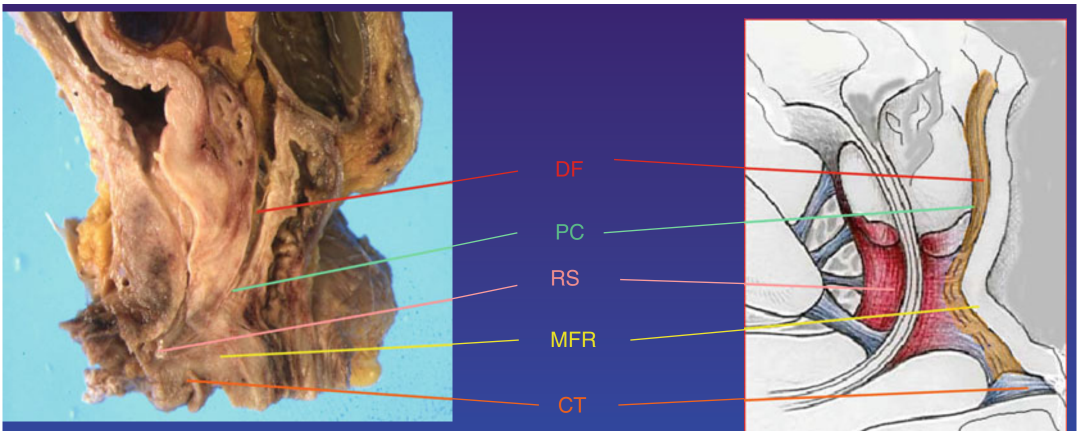


Fig. 27.2 Anatomy and function of the rhabdosphincter (*RS*). Median fibrous raphe (*MFR*) is the fulcrum of the contraction of anterior walls of RS. The posterior wall of RS and the median fibrous raphe are in line with: Denonvilliers fascia (*DF*), posterior aspect of the prostatic capsule (*PC*), cranially, and central tendon (*CT*) of perineum, caudally. These structures constitute a fibrous septum extending from peritoneum to central tendon providing support to the static system of the pelvis (Burnett and Mostwin [11] and Rocco et al. [17])

to retract elastically in a caudal direction due to the action of the longitudinal muscular fibres of the urethral wall, thus causing the anatomical shortening of the complex itself: it has been commonly observed that, after removal of the prostate gland, to make it easier to trace the urethra and construct the urethro-vesical anastomosis, it is necessary to push back the perineum with a swab to find the urethral stump.

The degree of shortening of the urethro-sphincteric complex is not equal if the antero-lateral and posterolateral faces of the complex are considered: ventrally, the complex is fairly firmly attached to the pubis by the anterior, middle and posterior pubo-urethral (puboprostatic) ligaments which support the complex for its full craniocaudal length; many authors affirm that the conservation of the posterior pubo-urethral or puboprostatic ligaments during apical dissection improves the state of post-operative continence [13].

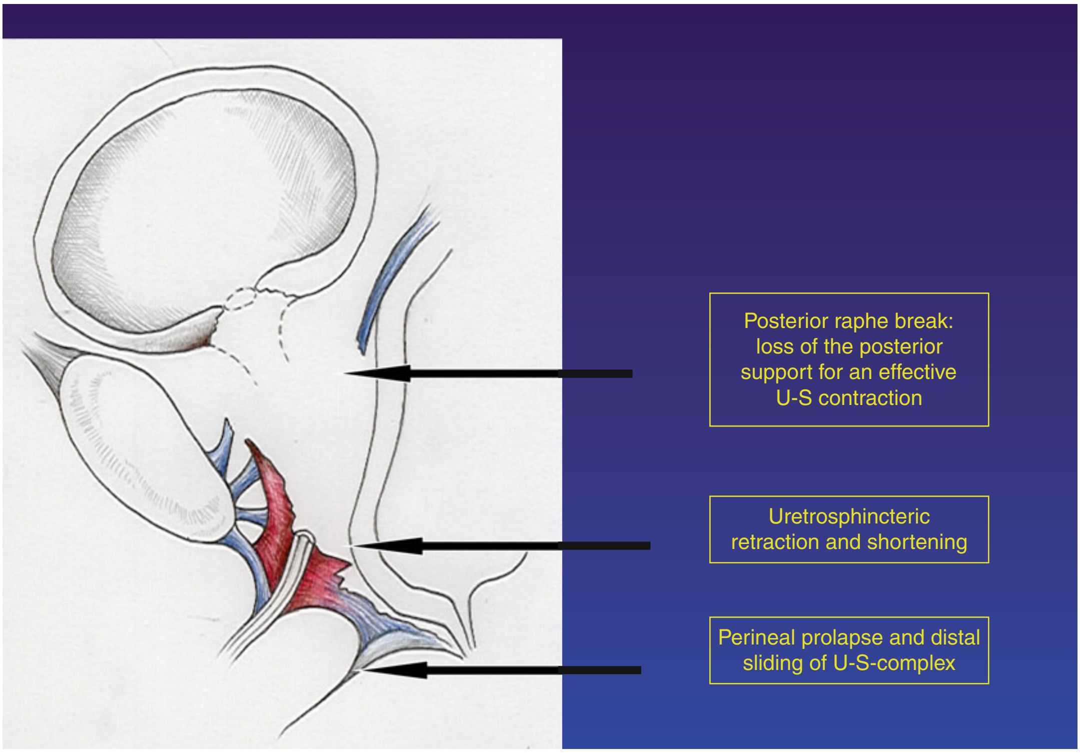
Dorsally, the complex is 'hooked on' like an elastic band at its cranial extremity by means of the connexion with the prostrate and with the aponeurosis of Denonvilliers : it tends, therefore, to slide towards the perineum due to the retraction of the smooth longitudinal fibres. The extent of the caudal slipping of the urethro-sphincteric complex is probably linked to the method of preparation and level of incision of the urethro-prostatic fascia on which, on each side, are the insertions of the lateral fibrous muscle ramifications of the rhabdosphincter.

The overall effect on the male pelvis of the removal of the prostato-vesicular block, with extirpation of the urethro-prostatic fascia reflexion and detachment of the medial fibrous raphe from the aponeurosis of Denonvilliers, is represented by the postero-caudal prolapse of the perineal membrane and the caudal sliding and anatomical shortening of the urethro-sphincteric complex, especially on the dorsal side.

In summary, the effects of prostate removal are the following (Fig. 27.3):

1. Posterior raphe break: loss of the posterior support for an effective U-S contraction
2. Urethro-sphincteric retraction and shortening
3. Perineal prolapse and distal sliding of U-S-complex

To overcome the effects of prostate removal, we designed a new surgical technique aimed to (Fig. 27.4):

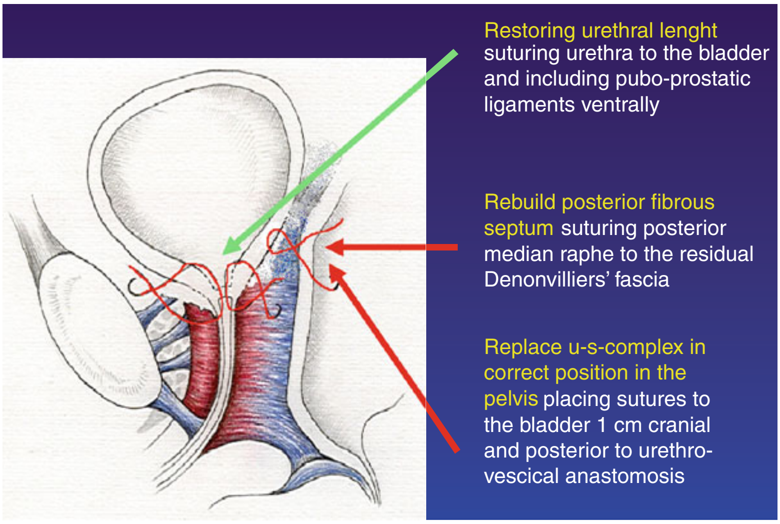


Posterior raphe break: loss of the posterior support for an effective U-S contraction

Uretrosphincteric retraction and shortening

Perineal prolapse and distal sliding of U-S-complex

Fig. 27.3 Consequences of the removal of the prostate on the static system of the pelvis



Restoring urethral lenght suturing urethra to the bladder and including pubo-prostatic ligaments ventrally

Rebuild posterior fibrous septum suturing posterior median raphe to the residual Denonvilliers' fascia

Replace u-s-complex in correct position in the pelvis placing sutures to the bladder 1 cm cranial and posterior to urethro-vescical anastomosis

Fig. 27.4 Aims and steps of the present technique

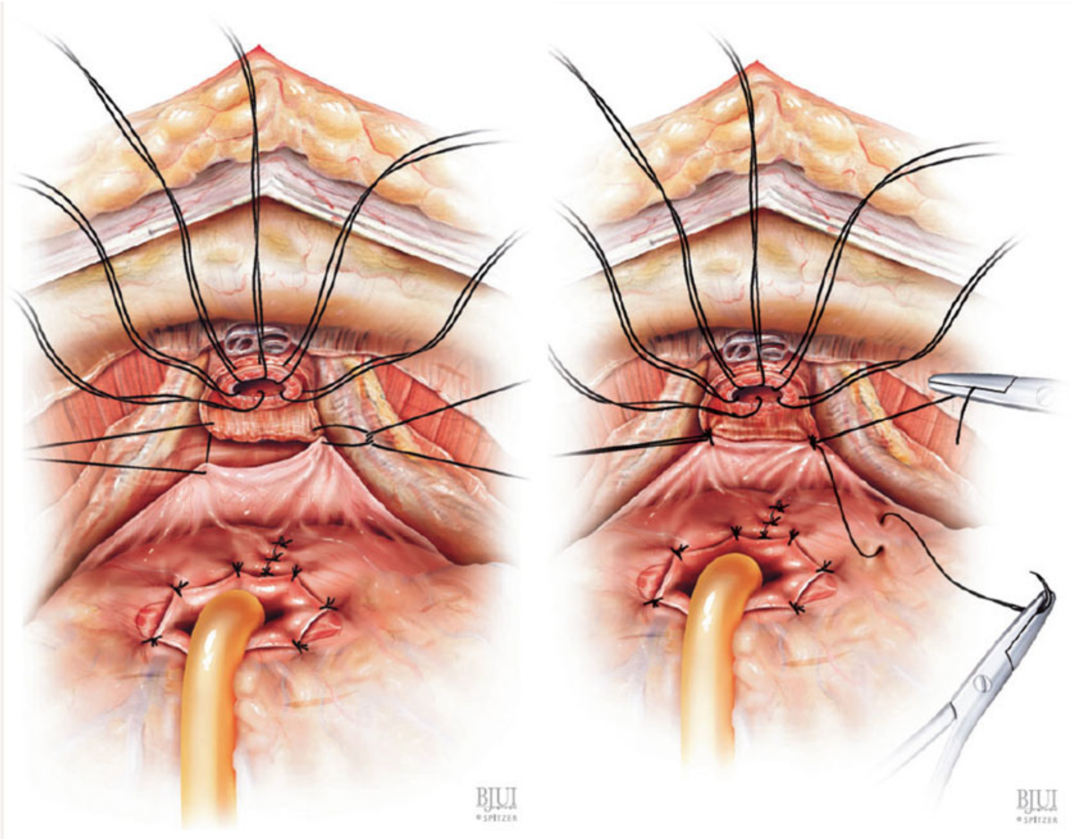


Fig. 27.5 The posterior reconstruction technique. First the remnant of the Denonvilliers' fascia is sutured to the urethra, and to bladder, about 2 cm below the bladder neck

- Restore urethral length, suturing the urethra to the bladder and including puboprostatic ligaments ventrally
- Rebuild posterior fibrous septum suturing posterior median raphe to the residual Denonvilliers' fascia
- Replace U-S-complex in correct position in the pelvis placing sutures to the bladder 1 cm cranial and posterior to urethro-vesical anastomosis

27.3 Description of the Original Technique of Posterior Reconstruction and Its Development

The original technique was published in 2006, and it was presented as a modification of the radical retropubic prostatectomy, with two simple steps:

1. Before proceeding to vesicourethral anastomosis, the posterior median raphe is fixed to the residual Denonvilliers' fascia using two previously placed marking sutures. By doing this, the posterior wall of the sphincter is elongated cranially; the urethral circumference is not involved by these sutures.
2. To suspend the urethral sphincteric complex from the bladder, the posterior median raphe joined to Denonvilliers' fascia is now attached to the posterior bladder wall with two sutures applied about 1–2 cm cranial and dorsal to the new bladder neck. Thus, the dorsal aspect of the bladder is used as the new cranial insertion of the sphincter and posterior median raphe, serving as an anchor for sphincter fixation (Fig. 27.5).

Subsequently, the new bladder neck is anastomosed to the urethra with six to eight polyglactin 3-0 sutures. The anterior sutures include the puboprostatic ligaments, and the posterior sutures join the urethra to the new bladder neck without involving the posterior median raphe.

In 2007, the technical modification for the laparoscopic approach was presented with the cooperation of Dr. Gaboardi: the remnant of the Denonvilliers' fascia was joined to the posterior portion of the rhabdosphincter and immediately tightened with two separate stitches. A further step was done subsequently anchoring the new posterior plane 1–2 cm dorsally and cranially to the bladder neck with the previously passed sutures. The anastomosis was then performed with six separate stitches [14].

In 2008, Coughlin and Patel presented a modification of the laparoscopic technique for the robotic setting: two running sutures tightened together by the tail instead of two separate sutures; the first suture was used to join Denonvilliers' remnant with the posterior part or the rhabdosphincter, whereas the second was used to join the new plane to the usual position 1–2 cm cranially to the bladder neck. A subsequent modified van Velthoven anastomosis was performed [15].

Coelho and Patel published a further modification of this technique subsequently in 2010. In fact, even if the double running suture was useful to perform a more robust approximation of the structures involved in the reconstruction, the drawback was that most of the time the second layer was responsible for the creation of a 'step' between bladder neck and urethra, with a somewhat odd approximation and difficult anastomosis.

They modified the second layer with a suture that included posterior bladder neck and posterior urethra. Such reconstruction, allowed for a more even approximation of the structures, allowing for a much easier and robust van Velthoven anastomosis [16] (Fig. 27.6).

Further modifications have been described, conceptually based on the Rocco principle, with controversial results.

27.4 Results

Since its description, in 2006, the technique of posterior reconstruction has been studied and modified by several authors; Table 27.1 summarizes some of the most relevant studies.

In the update of the original study by Rocco et al. [17] with the open technique, a significant difference in terms of early continence recovery was found (62, 74 and 85 % were continent at 3, 30 and 90 days, respectively, with posterior reconstruction of the rhabdosphincter (PRORS) versus 14, 30 and 46 %, respectively, in the control group). Study design was a retrospective comparison with historical controls, and continence evaluation was done with third part interviews; continence definition was 0–1 safety pad. This is the only published study in the open setting.

The subsequent study [14] tested the PRORS with laparoscopic approach in a comparative study with a small sample size 31 versus 31 and found a significant advantage performing the posterior reconstruction. Similarly, in this study, the definition of continence was 0–1 safety liner/day and a third part interview was the method used to obtain information from the patients.

Nguyen et al. [18] who found a significant advantage in laparoscopic setting performing PRORS in terms of continence recovery at 3 days and at 6 weeks, confirmed these results.

In 2008, Tewari published data on the experience made in the robotic setting with a procedure combining their own technique of anterior support (preservation puboprostatic ligaments and reconstructing the anterior urethral support structures by suturing arcus tendineus and puboprostatic ligaments to the bladder neck) [19], with a modification of the posterior reconstruction. They studied a cohort of 700 patients and found a significant advantage combining the anterior support technique with PRORS.

In 2009, Woo et al. published an interesting case control study on 132 patients comparing posterior reconstruction versus control and found different outcomes according to the different definition used for continence recovery; defining continence as 0–1 safety, they also found advantages in terms of earlier continence recovery, whereas a more strict definition (no use of pads) failed to demonstrate advantages compared to controls [20].

In the only randomized control trial published on this topic, Menon et al. studied 116 consecutive patients undergoing robotic prostatectomy at a single institution-randomized patients to either

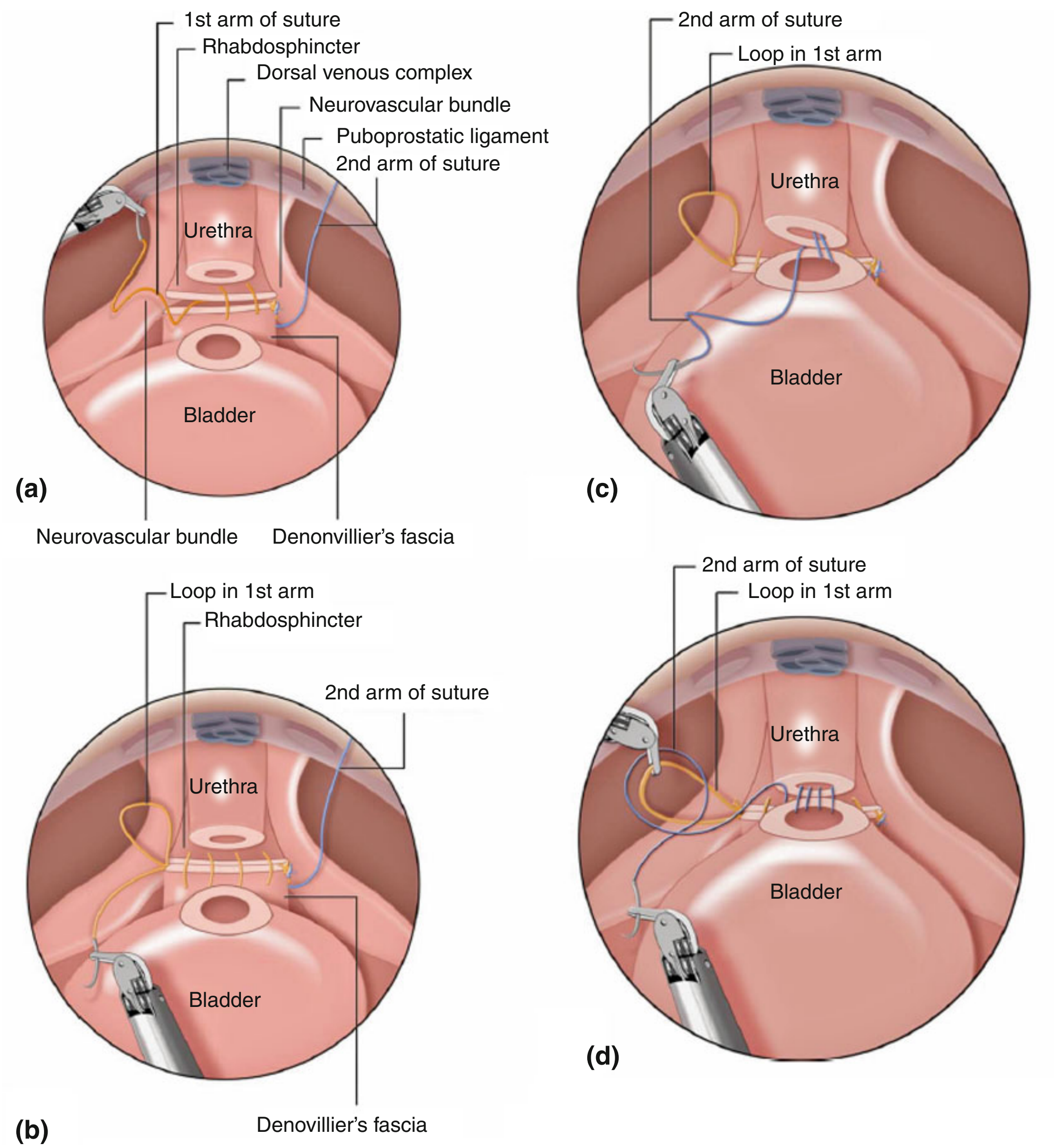


Fig. 27.6 (**a**) First layer of posterior reconstruction. (**b**) The free edge of the remaining Denonvillier's fascia is approximated to the posterior aspect of the rhabdosphincter. (**c**) Second layer of posterior reconstruction. (**d**) The posterior lip of the bladder neck and vesicoprostatic muscle are sutured to the posterior urethral edge

single- or double-layer urethro-vesical (UV) anastomosis and found that although patients with single-layer anastomoses were more likely to have a leak at 1-week cystogram and longer duration of catheter placement, their reconstruction technique did not lead directly to bladder neck contracture or incontinence [21]. It is noteworthy to underline the differences between the surgical approach proposed by Menon and the original posterior reconstruction technique [22], as also reported by Dr. Stein [23].

Further published experiences by Joshi, Kalisvaart and Kim have led to controversial results [24–26].

In 2010, Coelho et al. presented the results of the technical refinements of robotic adaptation of the posterior reconstruction from Dr. Vipul Patel's group, with the largest sample size ever, analyzing

Table 27.1 Studies comparing cohorts of patients who underwent *RP* with or without posterior reconstruction of the rhabdosphincter

Author	Study design	Setting	Sample size	Definition	Evaluation	Outcome	Leakage
Rocco et al. [17]	Historical control	Open	300	0–1 pad	Third part interview	$p < 0.05$	n.v.
Rocco et al. [16]	Prospective	Laparoscopic	62	0–1 pad	Third part interview	$p < 0.05$	n.v.
Nguyen et al. [18]	Historical control	Laparoscopic	62	0–1 pad	Q	$p < 0.05$	n.v.
Menon et al. [21]	RCT	Robotics	106	0 pad	Q	N.S.	$p < 0.05$
Tewari et al. [19]	Historical control	Robotics	700	0–1 pad	Third part interview + validated instruments	$p < 0.05$	n.v.
Joshi et al. [25]	Alternate assignment parallel group study	Robotics	107	0 pad	Q	NS	n.v.
Kalisvaart et al. [24]	Historical control	Robotics	100	0–1 pad	Q	$p < 0.05$	No difference
Woo et al. [20]	Historical control	Robotics	62	0–1 pad	Q	$p < 0.05$	n.v.
Kim et al. [26]	Historical control	Robotics	50	0 pad	Q	N.S.	n.v.
Coelho et al. [16]	Historical control	Robotics	802	0 pad	Q	$p < 0.05$	$0 < 0.05$

803 consecutive patients who underwent RARP by a single surgeon over a 12-month period: 330 without performing PR and 473 with PR. The modified PR technique resulted in significantly higher continence rates at 1 and 4 week after catheter removal ($p = 0.048$ and 0.016, respectively). The median interval to recovery of continence was also statistically significantly shorter in the PR group. Moreover the confirmed reduced incidence of cystographic leaks in PRORS group [16].

27.5 Comments

The assumptions upon which the PRORS technique is based have been accurately anatomically investigated; the shape of the sphincter and its insertion, the structures involved in the posterior backboard were previously thoroughly analyzed by relevant authors, such as Myers, Oelrich, Strasser, Burnett and Mostwin [8–11]. The key principle of the reconstruction are to reattach the Denonvilliers' fascia and the posterior part of the rhabdosphincter, originally connected through the prostatic fascia. Second, to reposition the urethro-sphincteric complex in the right anatomical position to allow a correct contraction mechanism.

The technique has been described in an open surgical environment with significant benefit on early continence recovery. Nevertheless, the impact on earlier continence recovery of PRORS techniques have been progressively less evident as the surgical approach to prostate cancer moved from the open setting to the robotic approach through laparoscopy. The better preservation of the periprostatic tissue and fasciae due to a more conservative surgical approach can be a partial explanation. Furthermore, the evidence of controversial results has to be related with several methodological flaws of most of the studies addressing the issue of PRORS outcomes, including ours: study design, continence definition and continence assessment make of utmost difficulty to clearly evaluate the impact of the technique on early continence recovery that is its main goal. Moreover, individual modifications can omit some of the basic clues of the technique: for example, Menon et al. only performed the first step of reconstruction originally described [20]. After reconstructing the Denonvillier's fascia and the posterior wall of the striated sphincter, it is mandatory to suture the reconstructed sphincter to the posterior bladder wall or to the bladder neck. This is really important because it increases the functional length of the posterior urethra and stabilizes the sphincteric complex in its anatomic position in the pelvic floor. In the same way, in the recent study published by Joshi et al. [25], only the first step of the reconstruction was performed, suturing the distal cut of the Denonvillier's fascia and the median fibrous raphe to the rhabdosphincter. At the present time, the technique that we consider more appropriate for the robotic setting and that we currently perform is the one described by Coelho et al. in a recent publication on European urology.

If there are controversial results on PRORS impact in terms of continence recovery, both the studies by Menon and Coelho dealing with this topic agree on a significant reduction in terms of anastomotic leakage and time to catheter removal. A further advantage, according to some authors is the possibility of performing a completely tension free anastomosis with a double posterior layer. Finally, at least to our knowledge, no specific complication related this technique has been published so far.

Conclusion

PRORS is a surgical modification of the original Walsh technique that has been suggested to reduce time to continence recovery. Over the years, it has been modified to be adapted to different surgical techniques due to the minimal invasive approach, laparoscopy first and then robotics. Notwithstanding many articles and different studies performed by several authors on this technique, conclusive results cannot be drawn, because of methodological flaws and lack of surgical standardization.

Beyond continence recovery, other possible advantages are tension free anastomosis, reduced anastomotic leakage and absence of reported complications. Whether a definitive conclusion on the impact of PRORS on continence recovery is strictly advisable, a multicenter randomized control trial with a standardized surgical approach needs to be carried out.

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The Urethrovesical Anastomosis

28

Ahmed Ghazi and Jean V. Joseph

28.1 Introduction

The urethrovesical anastomosis (UVA) is one of the most critical and technically demanding steps during a radical prostatectomy. An optimal anastomotic closure involves creating a watertight, tension-free anastomosis with mucosal apposition and correct realignment of the bladder and urethra, without compromising the integrity of the external sphincter [1]. Before the advent of minimal invasive laparoscopic surgery, the UVA was performed with difficulty as a result of suboptimal vision of a retracted urethral stump under the pubic symphysis, in addition to unfavorable ergonomics. This was generally accomplished by placing four to eight interrupted sutures between the bladder neck and urethra, which were subsequently tied after all sutures were positioned [2].

28.2 The Urethrovesical Anastomosis in the Era of Laparoscopic Surgery

The introduction of laparoscopy in the early 1990s allowed the surgeon to perform the anastomosis under direct vision through the laparoscope, unlike open surgery where the surgeon could not view the anastomosis once the bladder was brought down to the urethra. However, the skills required for intracorporeal suturing rendered the anastomosis a very tedious task during laparoscopy. The initial publication of laparoscopic radical prostatectomy (LRP) by Schuessler et al. in 1992 stated that the anastomosis required the greatest amount of time, taking twice as long as the removal of the prostate [3]. This was largely responsible for the abandonment of the technique. Nearly 7 years later, Vallancien et al. resurrected LRP reporting reasonable outcomes estimating their learning curve to be at 50–60 cases [4]. They used 6–8 polyglactin 3-0 interrupted sutures tied intracorporeally over an 18Fr Foley catheter. In their view, the UVA was difficult for a number of reasons. These included suture placement in both the bladder neck and the urethra and the need for multiple intracorporeal knots. Of concern was that the anastomosis occurred late in the procedure when surgeon fatigue was more problematic. It was apparent that for both ergonomic reasons and exceedingly time-consuming endoscopic knot tying, the techniques used in open surgery were not optimal for laparoscopic surgery. The difficulties encountered in completing the UVA during laparoscopic surgery prompted the innovation of other techniques with minimal intracorporeal knot tying. Hoznek et al. [5] described a running-suture technique during LRP (Figs. 28.1 and 28.2), which incorporated two hemicircle sutures with three intracorporeal knots. The bladder neck was approximated to the urethra at the

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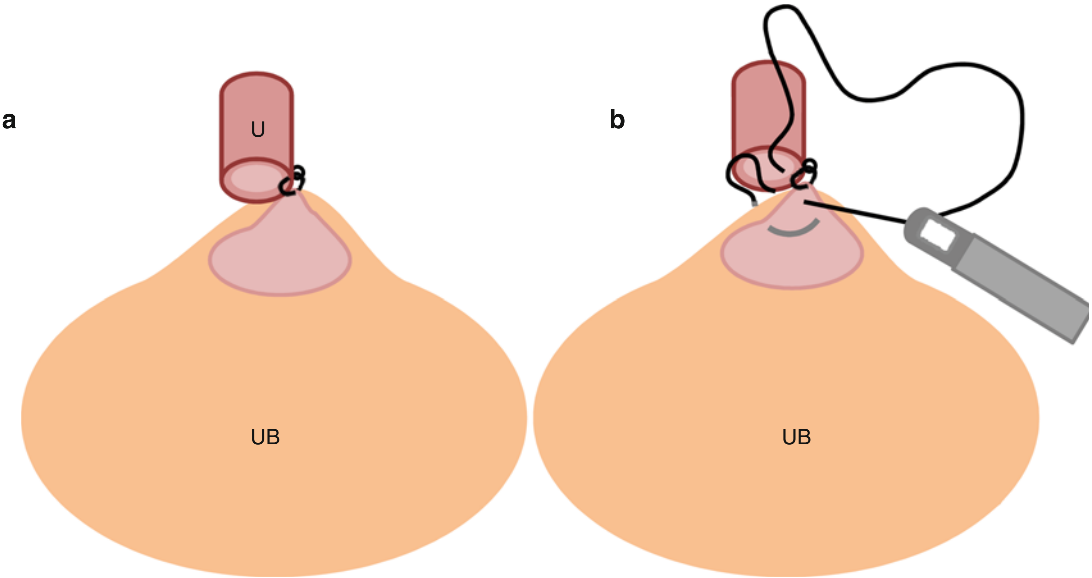

Fig. 28.1 Vesicourethral anastomosis with posterior and anterior hemi-circumferential running suture. (**a**) Starter knot at 3-o'clock position, (**b**) start of posterior running suture (bladder outside in and urethra inside out) at 4 o'clock. *UB* urinary bladder, *U* urethra

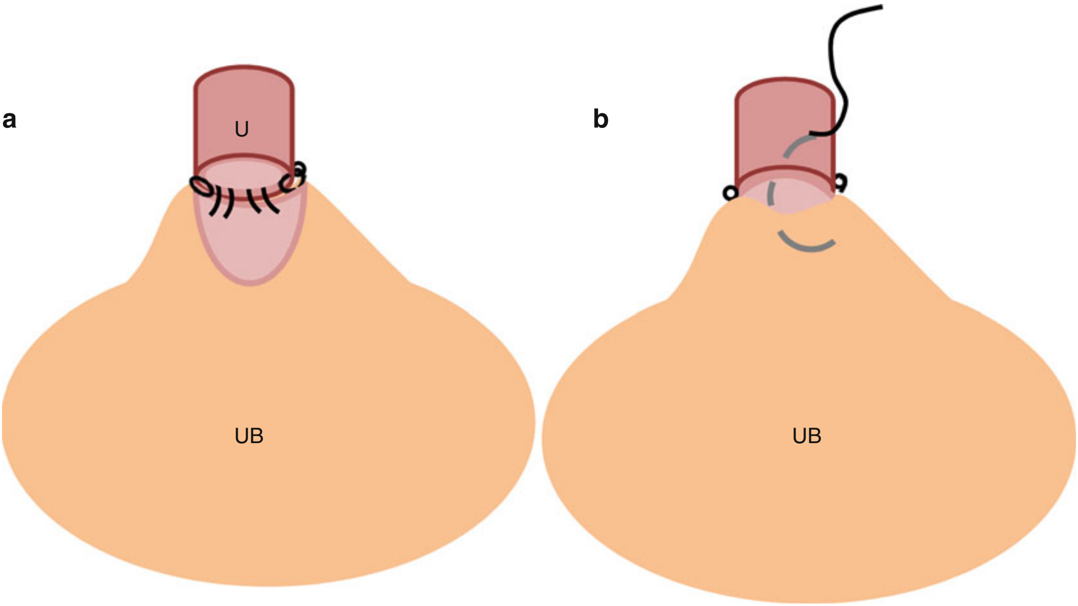

Fig. 28.2 Vesicourethral anastomosis with posterior and anterior hemi-circumferential running suture. (**a**) Extramural completion of posterior suture line, (**b**) placement of second running suture. *UB* urinary bladder, *U* urethra

3:00-o'clock position with an initial suture, followed by two running sutures for the posterior and anterior wall, respectively, each ending with an intracorporeal knot.

The introduction of the running, double-armed, single-knot suture technique revolutionized the UVA during radical prostatectomy. Van Velthoven et al. [6] described using two 6-in. monofilament sutures of polyglycolic acid (one dyed and one undyed for identification purposes) tied together prepared extracorporeally (Fig. 28.3). Both sutures are passed through the posterior bladder neck (outside in, at the 5:30–6:30-o'clock positions) and subsequently placed in their corresponding position in the urethra. One end of the suture is continued in a clockwise direction and the other in the opposite direction in a continuous manner. As the posterior aspect of the anastomosis is completed on each side, the surgeon gently pulls on both sutures parachuting the posterior bladder neck to the posterior urethra. The sutures are continued until both ends meet and are tied together at the 12-o'clock position. This solitary intracorporeal knot, like the initial knot, rested on the exterior of the bladder. This technique offered a watertight, reproducible, and efficient anastomosis that was less time-consuming. Although it was rapidly adopted by other laparoscopic surgeons, the novice laparoscopic urologist standing at the patient's bedside still struggled with the difficulty of negotiating complex angles using non-articulating instruments.

28.3 The Vesicourethral Anastomosis in the Era of Robot-Assisted Surgery

The introduction of robotic assistance offered the benefits of improved dexterity, precision, and control during minimally invasive laparoscopic surgery, providing the surgeon with a magnified, stereoscopic view of tissue planes [7]. The da Vinci Robotic System's proprietary EndoWrist technology allowed suturing of the UVA with tremor filtration facilitating placement of each suture. This enabled surgeons with limited suturing experience to master a difficult technical step, at the end of a challenging procedure. Furthermore, the surgeon was now seated at the console, with head and forearm rested comfortably which minimized fatigue.

Ahlering et al. reported their initial eight cases of robot-assisted radical prostatectomy (RARP) [6] followed by a series of 45 patients [8] using the continuous single-knot suture technique. Anastomosis times ranged from 21 min in the last ten cases to 50 min in the first five cases. The authors concluded that 8–12 cases were sufficient to successfully transfer a laparoscopically naive yet experienced open surgeon to a laparoscopic environment using the robotic interface. This simple technique was later popularized by Menon and coworkers [9] from the Vattikuti Urology Institute in Detroit, following an early experience with the interrupted technique. The authors reported technical tips for dissecting the prostatic apex and prostatovesical junction during RARP as well as a modified single running-suture UVA, with subtle differences in execution from the original technique (Fig. 28.4). Modifications included running one arm on the posterior bladder wall starting at the 4-o'clock position with the right assistant "following" to maintain tension on the suture. After the posterior urethral wall is approximated to the bladder neck in its entirety, the direction of the suture is then changed from outside in on the bladder to inside out. The suture is run clockwise up to 11-o'clock position and handed to the left assistant to hold with gentle, approximating traction. The undyed arm is then run counterclockwise from 4 to 11 o'clock, where both arms of the suture are tied to each other. The mean time for the UVA was 13 min. Twenty percent of patients had mild leak on cystography and were treated by prolonged catheterization up to 7 days. Two patients had urinary retention within a week of removing the catheter and had to be re-catheterized. Ninety-six percent were continent at 3 months, and the remaining 4 % used a thin pad for security. These reports and several others [10, 11] cemented the single running suture as one of the main techniques for performing the UVA during RARP.

28.4 Modifications to the Single-Knot, Running Suture

Modifications to this technique have been made in pursuit of increased efficiency while preserving safety and anastomosis integrity. A major drawback of this technique is the need to maintain

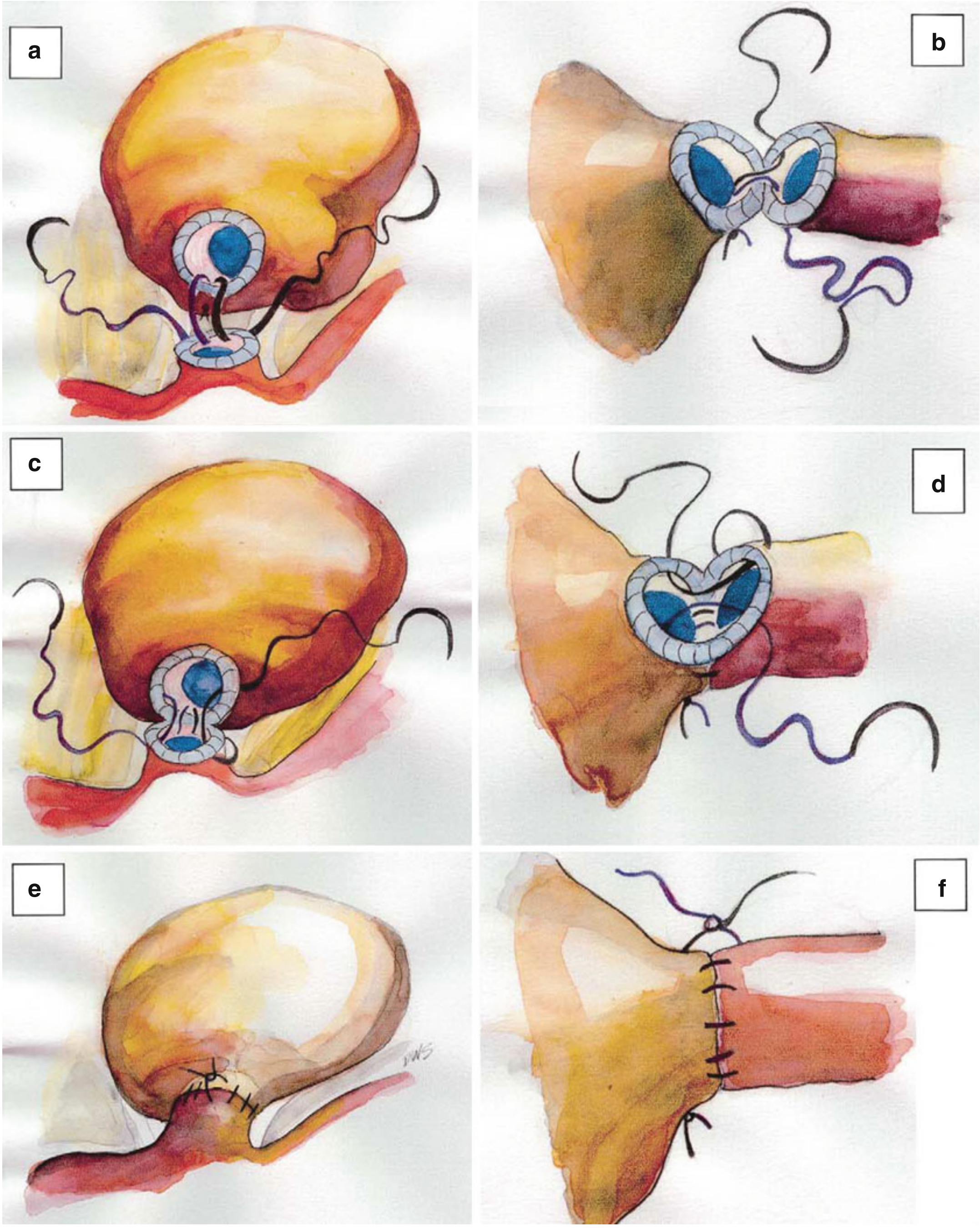

Fig. 28.3 Technique for performing the running single-knot anastomosis. (**a**) The two sutures have been passed outside in on the bladder and inside out on the urethra at the 5:30 and 6:30-o'clock position, respectively; the extracorporeal knot joining both sutures together sit at the 6:00-o'clock position. (**b**) Transverse view highlighting the single knot at the 6:00-o'clock position. (**c**) One suture is run clockwise, and the opposite suture is run counterclockwise to the 9:00 and 3:00-o'clock positions, respectively. (**d**) A transition suture taken in the background suture, such that the suture now runs outside in on the urethra and inside out on the bladder. A similar transition stitch will be done with the suture in the foreground. At this point, the catheter can be placed in the bladder. (**e**) As a result of the transition stitches, the single intracorporeal knot resides on the outside of the bladder at the 12:00-o'clock position. (**f**) Side view showing the two knots, one at the 6:00-o'clock and one at the 12:00-o'clock position, both lying on the extravesical surface (Printed with permission from reference [6])

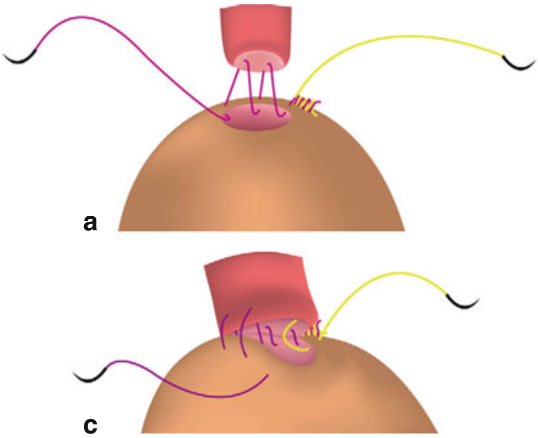

Fig. 28.4 (**a**) Posterior wall with anticlockwise dyed Monocryl arm of suture. (**b**) Change of direction of needle passage at transition of anterior and posterior walls. (**c**) Clockwise stitches with undyed Monocryl arm of suture. (**d**) Completion of anastomosis (Printed with permission from reference [9])

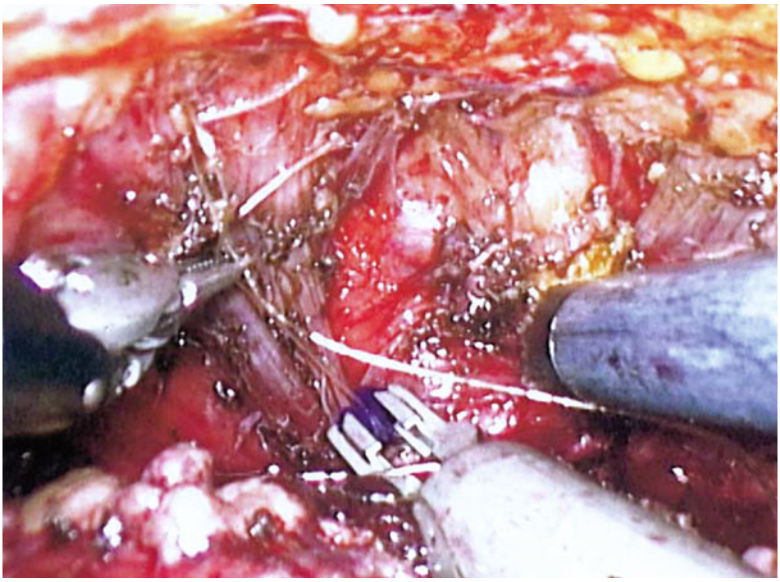

Fig. 28.5 Lapra-Ty placement to secure anastomosis (Printed with permission from reference [12])

tension on the suture line to keep the opposing edges of the bladder and urethra approximated following cinching of the posterior bladder lip to the urethra. In addition, a traditional monofilament suture has a tendency to slip, forcing the surgeon to retighten the anastomosis with every throw and revisit each throw several times throughout the anastomosis to ensure integrity and avoid potential anastomotic leaks. Assistants have been used to holding the suture in place between throws [9], but this necessitates experienced assistants performing delicate retraction. To avoid posterior slippage, tearing of urethral tissue, suture breakage, prolonged anastomotic times, and postoperative urinary leakage several modifications were described. Ball and colleagues [12] described using a Lapra-Ty to hold the posterior approximation tight (Fig. 28.5). Berry and coworkers [13] described using three posterior interrupted sutures for the same purpose (Fig. 28.6). Unlike sutures secured with standard surgical knots, the Lapra-Ty clip can be further cinched if needed,

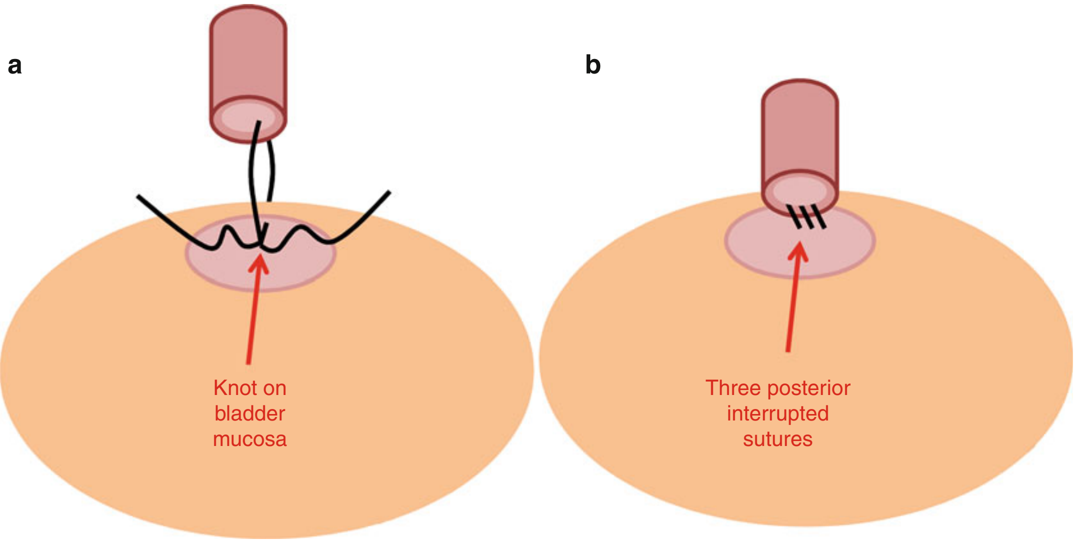

Fig. 28.6 UVA combining running and interrupted sutures. (**a**) Posterior suture placed on bladder mucosa. (**b**) Completion of left lateral posterior urethra suture with three knots on posterior bladder wall

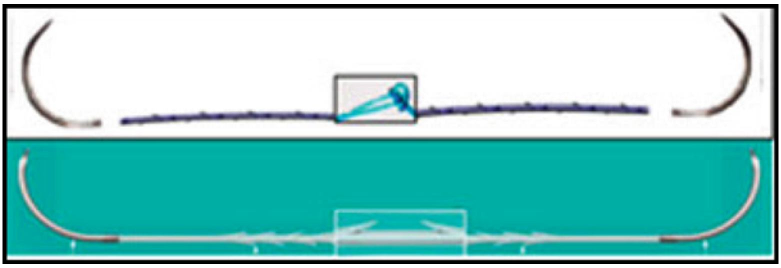

Fig. 28.7 The unidirectional (V-Loc, glycolic acid-trimethylene carbonate, Covidien, Norwalk, CT, USA) above and bidirectional (Quill SRS, polyglycolic acid-polycaprolactone, Angiotech pharma, Vancouver, Canada) barbed sutures below (Printed with permission from reference [27])

by pulling the suture and placing an additional clip under the previous one in cases of suboptimal closure [14, 15]. Drawbacks of the preceding techniques include reliance on the assistant, a foreign body adjacent to the UVA, and sutures tied within the bladder, respectively.

More recently, the introduction of a self-locking barbed suture for the UVA has proved to ameliorate drawbacks of traditional monofilament sutures during this technique for UVA. The barbed suture prevents slippage and obviates the need for assistance, as well as the frequent revisiting of each throw. The barbs also perform the function of Lapra-Ty clips without introducing a foreign body into the area of the anastomosis (Fig. 28.7). The barbs of these sutures are either unidirectional (V-Loc, absorbable wound closure device, Covidien, Mansfield, MA) or bidirectional (Quill Sutures, Research Triangle Park, NC). Moran and colleagues [16] used a bidirectional barbed suture to perform UVA in an inanimate model and demonstrated that anastomosis with the barbed suture was faster, with no difference in subjective assessment of the quality of the anastomosis. The barbed suture line held against disruption even with intentional cutting of every fourth and every other suture compared to complete disruption of a Monocryl suture line. Kaul et al. reported the use of a unidirectional barbed suture for UVA during RARP in 51 consecutive patients [17]. The anastomotic times were reduced to a mean of 11 min and to <10 min in 45 % of cases. There were no reports of intraoperative or cystography-detected urinary leak after removal of the catheter despite elimination of the final knot, and complete reliance on the barbs hold the suture in place. Tewari et al. [18] reported an improvement in surgical times by more than 40 %, using the same suture for UVA during RARP in 50 consecutive patients. Only one patient had a clinically insignificant cystogram-detected urinary extravasation that necessitated delayed catheter removal. A potential drawback of the barbed suture is the tendency to cause ischemia and tissue necrosis with overtightening. This was demonstrated in a prospective RCT [19], comparing a surgeon-specific RARP anastomosis (running technique using two sutures and three knots) using either barbed polyglyconate ($n = 45$) or polyglactin 910 ($n = 36$) sutures. The barbed suture group showed higher rates of cystogram-detected urinary extravasation (20.0 % vs 2.8 %) and longer catheterization times (11.1 day vs 8.3 day). On approximation, only to the point of bladder and urethral tissue approximation in the last 16 cases the rate of urine leak was reduced from 27.5 (first 29 cases) to 6.3 %. The authors recommend the use of a barbed suture only in specific cases (large bladder neck, novice surgeons, and in training settings) as the costs of the barbed suture (x6 of polyglactin 910) did not outweigh its benefits.

28.5 Anastomotic Techniques

In general, there are three types of vesicourethral anastomosis that have been described: interrupted, running or continuous, and semicontinuous.

We use a semicontinuous suturing technique. Two 2-0 Polygalactin sutures on and RB-1 needle (Ethicon) are used. This needle is small and allows full rotation in very tight spaces. The sutures are cut to about one and a half the trocar length. Two running sutures are used for the entire anastomosis, one for the anterior and the other for the posterior. The first suture is placed at the 5-o’clock position in the urethra and tied to its corresponding position at the bladder neck (Fig. 28.8). This suture is carried out in a clockwise direction approximating the bladder neck to the urethra ending at the 11-o’clock position (Fig. 28.9). The initial needle starts in the urethral lumen to obtain adequate urethral tissue, and the knot placed either inside or outside the bladder. These sutures are absorbable and dissolve quickly making the location of the knot inconsequential.

The posterior suture line must be completely secure, and all areas of suture looseness eliminated to prevent urine leakage. This area is inaccessible once the anterior anastomotic line suturing is begun. Three to five passes are generally necessary between the 5 and 7-o’clock positions to bring the posterior bladder neck in continuity with the urethra. The location of the DaVinci surgical cart makes access to the patient’s penis difficult to maneuver a rigid urethral sound. The latter is also potentially traumatic, causing us to prefer the soft Foley catheter used initially for bladder drainage as a urethral guide. Proper coordination is necessary between the surgeon at the console and the bedside assistant to avoid suturing the catheter in place. The Foley catheter is withdrawn as the surgeon advances the needle in the urethra (Fig. 28.10). When the sutures are placed correctly, the Foley catheter is seen coursing easily into the bladder. With poor approximation, the catheter may enter in the posterior bladder neck. This can be corrected if detected immediately. Following completion of the posterior suture line, the anterior aspect of the anastomosis is carried out starting from the 5 to the 11 o’clock in a counterclockwise direction, using the second suture. The first pass is made through the bladder (outside in) and into the corresponding position of the urethra (inside out) with the knot placed outside of the anastomosis. Six to eight passes may be necessary. Prior to tying the anterior suture at the 11-o’clock position, a new Foley catheter (20 Fr) is inserted into the bladder under direct vision (Fig. 28.11). Once the sutures are tied, the balloon is inflated to 30 cc. The bladder is irrigated to remove clots and ensure proper distension. Influx of fluid with bladder distension

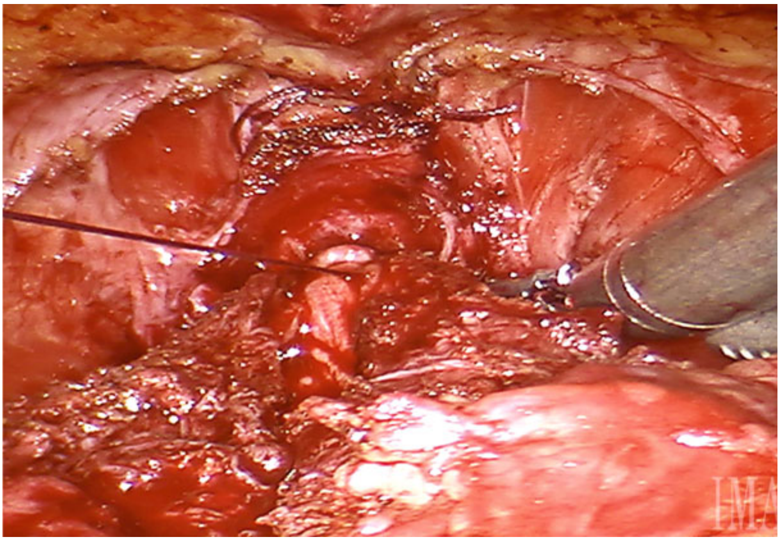

Fig. 28.8 Semicontinuous anastomosis, two separate sutures are used to complete the anastomosis. The posterior layer starts at the 5-o'clock position

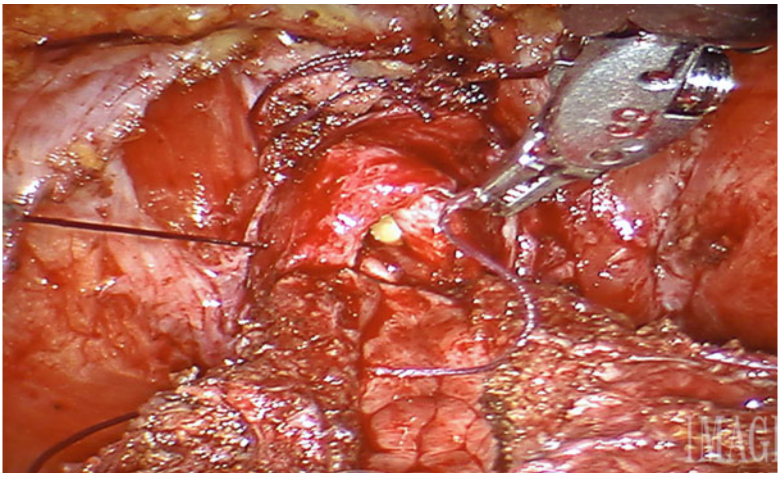

Fig. 28.9 The posterior layer is carried out in a clockwise direction from the 5-o'clock to the 11-o'clock position

indicates the presence of a leak. With a large influx of fluid, and absent bladder distension, improper catheter location must be ruled out. A total of 200 cc of saline is used to fill the bladder with the balloon of the catheter away from the anastomosis. Pulling the balloon to the bladder neck or placing the catheter on traction does not allow proper testing of the integrity of the anastomosis.

The semicontinuous technique is our preferred approach as it allows completion of the anastomosis in a very time-efficient manner. It avoids reliance on a single suture line, which can be broken leading to complete anastomotic disruption. Furthermore, it ensures tight approximation of the posterior lip of the anastomosis under direct vision before staring the anterior anastomosis.

On the other hand, a continuous anastomosis is often perceived as the fastest way to complete the UVA. It, however, has a number of shortcomings, which can lead to significant complications both intraoperative and postoperatively. As the posterior aspect of the anastomosis is completed on each side, the surgeon often pulls on the two sutures, parachuting the bladder neck to the posterior urethra. This can be associated with disruption of the urethral passes. Bladder neck

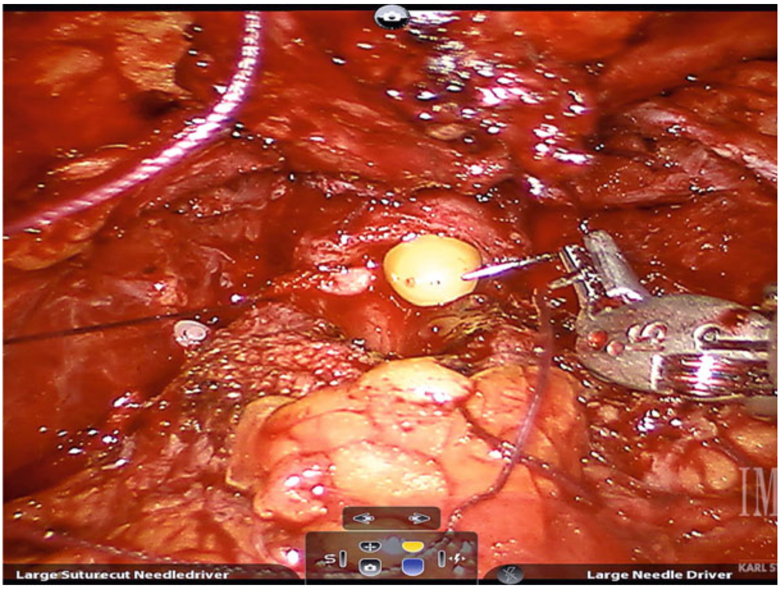

Fig. 28.10 Foley catheter is withdrawn by assistant as surgeon passes needle into urethra encompassing all layers

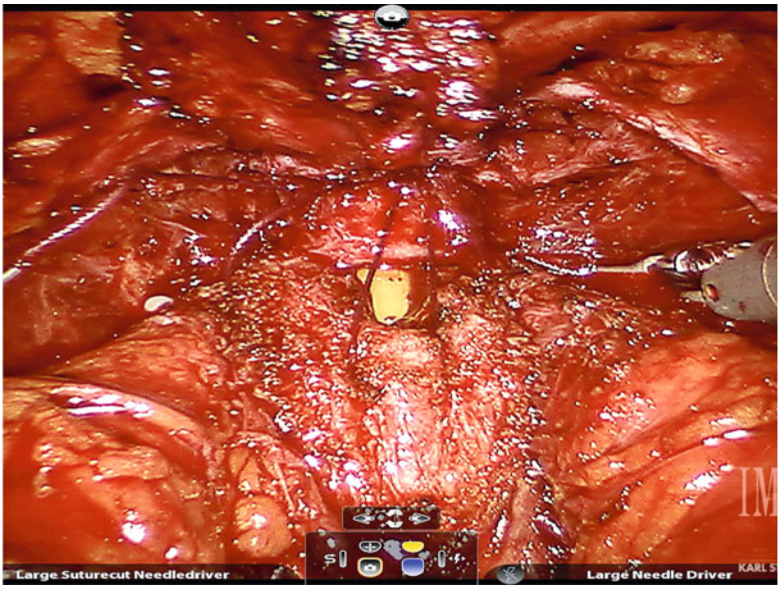

Fig. 28.11 Completion of UVA. Foley entering bladder under direct vision

approximation must be ensured with each pass to eliminate urethral disruption. The circular anastomosis is associated with potential tissue ischemia which can lead to bladder neck contracture in the postoperative period. Tissue approximation is the goal as opposed to tissue tightness. An accordion-like tension can result from a circular running anastomosis and must be avoided to lessen the risk of leakage.

The interrupted technique ensures tissue approximation with each suture. Loosening of the suture line which can be seen with the semi-continuous and continuous approaches is avoided, limiting the potential for urinary leakage. This method of suturing, however, is lengthy and requires the use of several needles to carry out the procedure. Alternatively, a single needle on a long suture can be used, but this increases the complexity of the procedure, as the surgeon maneuvers an excessively long suture. The main advantage of this technique is that it eliminates the potential for radial force disruption inherent in approximating different tubular structures of different consistency and diameter.

28.6 Reconstruction of Periprostatic Tissues

Several periprostatic reconstruction techniques have been described. One of the most widely used is the posterior rhabdosphincter reconstruction, advocated by Rocco and colleagues [20, 21]. This reconstruction will be discussed in details in a chapter dedicated to its original description and evolution. Based on cadaveric studies, the concept of preserving the "puboprostatic collar" (puboprostatic ligament and fascial tendinous arch of the pelvis) and "puboperineoplasty" (approximation of the puboprostatic ligaments to the anterior aspect of the UVA and reattachment of the arcus tendineus to the lateral aspect of the bladder neck) was introduced in 50 consecutive men undergoing RARP [22]. UVA was performed in a continuous running fashion using 9-in. dyed and undyed 3-0 Monocryl sutures in a running manner. Reconstruction of the arcus tendineus was achieved using a running suture approximating the bladder to the arcus tendineus, puboprostatic ligaments, puboperinealis muscle, and midline connective tissue on either side, using a 2-0 Vicryl on an RB1 needle (Fig. 28.12). The authors reported continence rates after catheter removal of 29 % within the first week, 62 % within 4–6 weeks, 88 % within 12 weeks, and 95 % within 16 weeks. The drawback of this technique was the theoretical higher risk of apical positive margins, which the authors did not encounter. Taking it one step further, the authors further combined ventral re-suspension of the anastomosis and distal bladder neck to Rocco's posterior reconstruction, a complex seven-step technique they coined the "total reconstruction of the vesicourethral junction" [23]. In this study, 700 patients were prospectively evaluated in which 214 patients served as a control group, 304 underwent only the previously described anterior reconstruction, and 182 received a total reconstructive procedure. Using standardized questionnaires, the total reconstruction group had continence rates of 38, 83, 91 and 97 % at 1, 6, 12, and 24 weeks, respectively. At all the follow-up intervals, the continence rate was significantly less in the control group than in the anterior reconstruction and the total reconstruction group ($p<0.01$). In contrast, another group [24] showed no improvement in continence rates with reconstruction of the posterior rhabdosphincter and puboprostatic collar. They randomized 116 consecutive patients undergoing RARP to UVA with or without periprostatic reconstruction. They found no statistical difference in the urinary continence rates at 1, 2, 7, and 30 days after the procedure. However, they did note a decreased in the incidence of urinary leak, which is a known risk factor for developing bladder neck contracture and urinary incontinence. The technique utilized 2, 3-0 double-armed monofilament sutures. The first suture was used to create a posterior plate (posterior reconstruction) from right to left, after which the suture was tied or locked and held with gentle traction by the second assistant. The UVA (inner layer) was then completed as previously described [9]. Finally the outer layer was completed by suturing the puboprostatic ligament to the anterior pubovesical collar (Fig. 28.13). Cystograms were done at 7 days after surgery, and the catheter was removed if there was no leak or a small contained extravasation. At long-term 2-year follow-up, no statistical significance existed among both groups of the same cohort regarding continence or development of bladder neck contracture [25]. Recently [26], a periurethral suspension technique was evaluated in 94 RALP patients. This was found to have statistically significantly higher continence rates 3 months postoperatively than in patients without the suspension suture (92.8 % vs 83 %; $p=0.013$). The suture is passed between the urethra and the dorsal vein complex and through the periosteum of the pubic bone, providing support to the posterior urethra (Figs. 28.14, 28.15, and 28.16). The interval to recovery of continence was also statistically significantly lower in the suspension group.

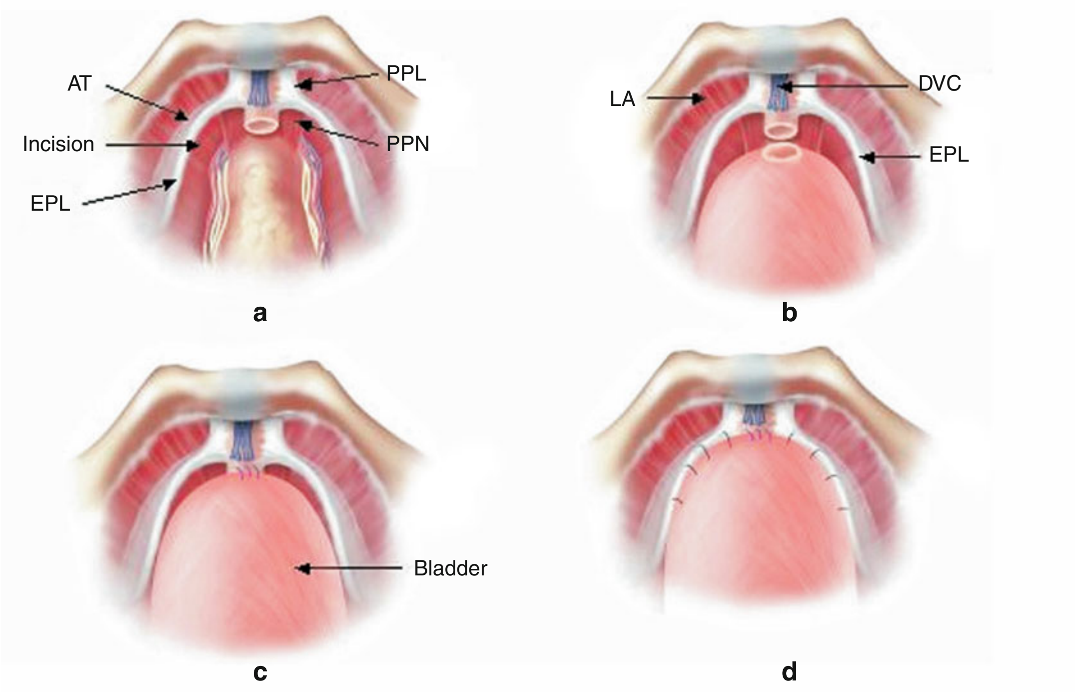

Fig. 28.12 (**a**) Incision of endopelvic fascia (*EPL*) medial to white line. *AT* arcus tendineus, *PPL* puboprostatic ligaments, *PPN* puboperinealis muscle. (**b**) Preserved collar of tissues around urethra after removal of prostate. This collar comprises the puboprostatic ligaments, endopelvic fascia (*EPL*), and arcus tendinous, which form the fascioligamentous component of the puboprostatic musculoligamentous complex. *DVC* dorsal vein complex, *LA* levator ani. (**c**) Vesicourethral anastomosis with 3-0 sutures. (**d**) Final picture after anastomosis is suspended by three 3-0 sutures on either side (Printed with permission from reference [22])

28.7 Complications

Complications associated with the UVA, however, can be associated with significant morbidity, lengthening the recovery period. These complications can be divided into intraoperative and postoperative.

28.7.1 Intraoperative

Blood loss can be a significant intraoperative problem that can complicate the completion of the anastomosis. Toward the end of the procedure, adequate hemostasis is required for proper recognition of the anatomy and adequate suture placement. Uncontrolled dorsal vein bleeding can result from dislodgement of the dorsal vein suture or placement of the anterior sutures through the overlying dorsal vein bundle. Avoiding a large needle sweep or using a small needle (e.g., RB-1) can generally avoid encompassing the dorsal vein in the anastomotic suture.

Urethral closure is possible without a proper guide for the needle entering the urethra. Two sides of the urethral wall can be caught with the suture, effectively closing the urethral lumen. Difficult insertion of the Foley catheter should alert one to such possible complication. As described above, the needle is inserted in the urethra under guidance of a urethral sound or Foley catheter. Similar to urethral closure, the anastomotic needle can encompass more than one side of the bladder neck. This is more likely with closure of the anterior wall, when the tip of the needle is poorly visualized as it courses away from the camera view.

Ureteral injury can occur both during the bladder neck dissection and the UVA. During

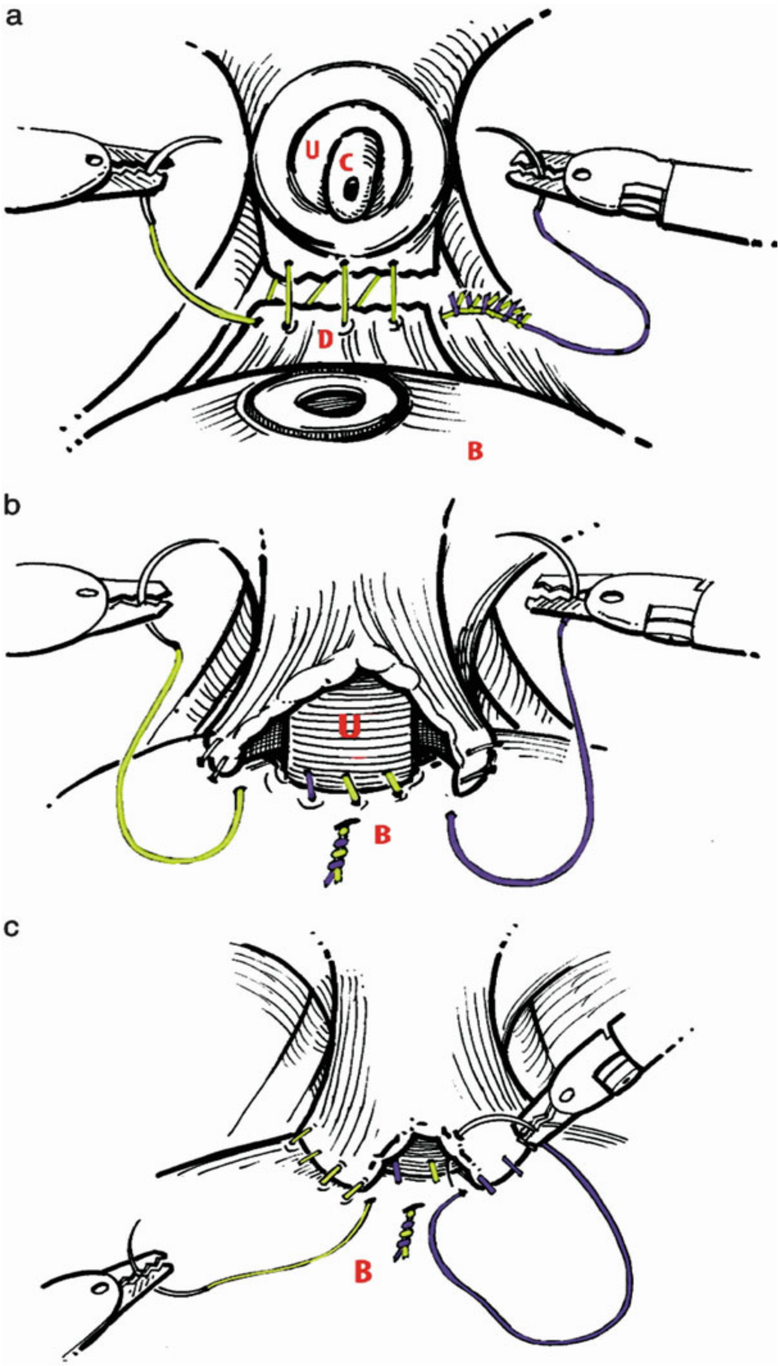

Fig. 28.13 (**a**) Posterior external layer approximating Denonvilliers fascia and posterior rhabdosphincter. Following reconstruction between 5 and 8-o'clock positions formal urethrovesical anastomosis (or internal layer) is begun. (**b**) After completion of urethrovesical anastomosis lateral aspects of external layer are completed in stepwise fashion from 8 to 11-o'clock position on left side and from 5 to 1-o'clock position on right side. (**c**) Anterior pubovesical collar reconstruction is completed approximating puboprostatic ligaments to midline anterior bladder tissue. *B* bladder, *U* urethra, *C* Foley catheter, *D* Denonvilliers fascia (Printed with permission from reference [24])

either step, visualization of the trigone with efflux of urine from both ureters is necessary to avoid such complication. To facilitate ureteral visualization, we recommend the administration of intravenous indigo carmine (5 cc) when ureteral compromise is suspected. Additionally, the absence of urine with proper hydration, or accumulation of urine outside of the bladder, should raise one's suspicion of a ureteral injury during the earlier parts of the procedure. With

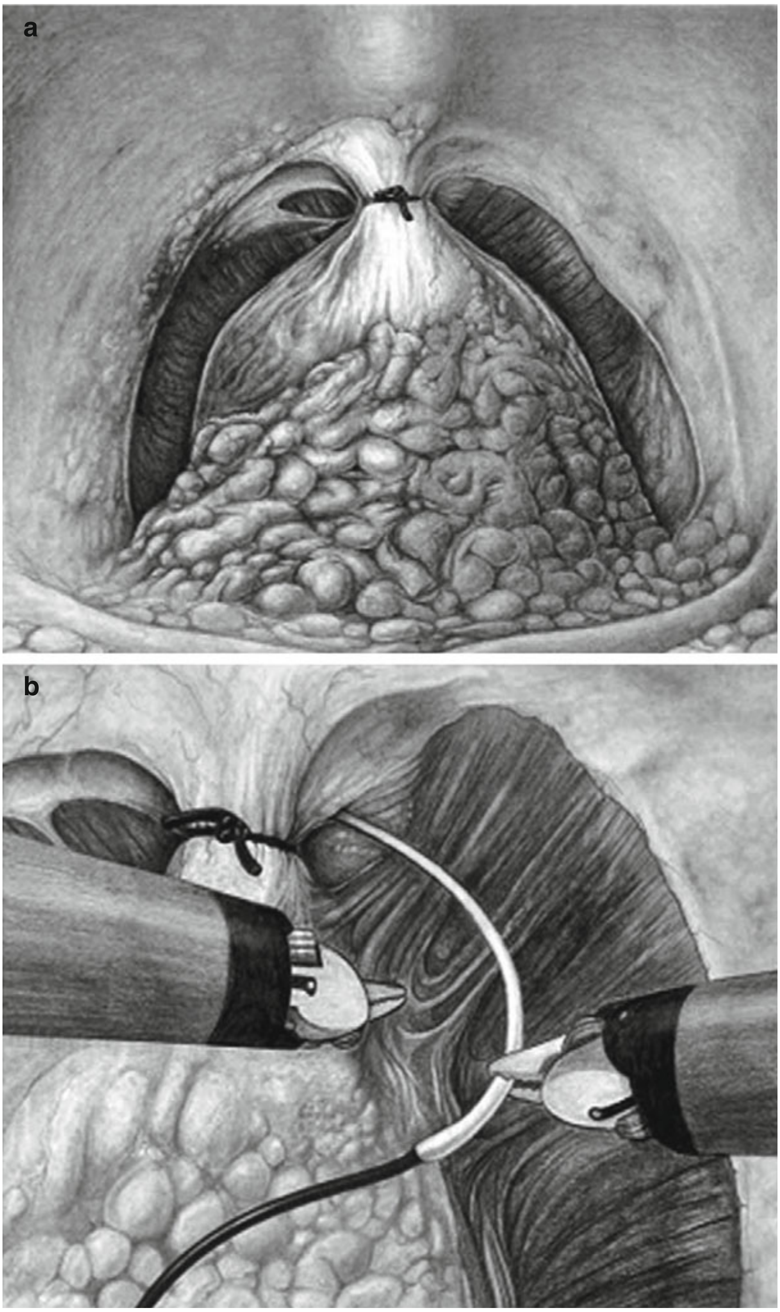

Fig. 28.14 (**a**) Vision after the endopelvic fascia has been opened and the dorsal venous complex ligated; (**b**) CT-1 needle held at a 908 angle passed from right to left between the urethra and dorsal venous complex (Printed with permission from reference [26])

identification of an injury, ureteroneocystostomy should be considered prior to the completion of the UVA. Intraoperative recognition of a ureteral injury is the most important aspect of management. One should take the necessary steps to ensure ureteral integrity prior to proceeding with placement of the posterior anastomotic sutures.

Rectal injury can occur with the posterior suture placement. This can be due to poor visualization of the bladder neck. It can also occur if a large needle is used to capture the posterior urethra. Sutures encompassing the adventitial layer of the rectal wall can be of no consequence. A suture, however, involving all layers

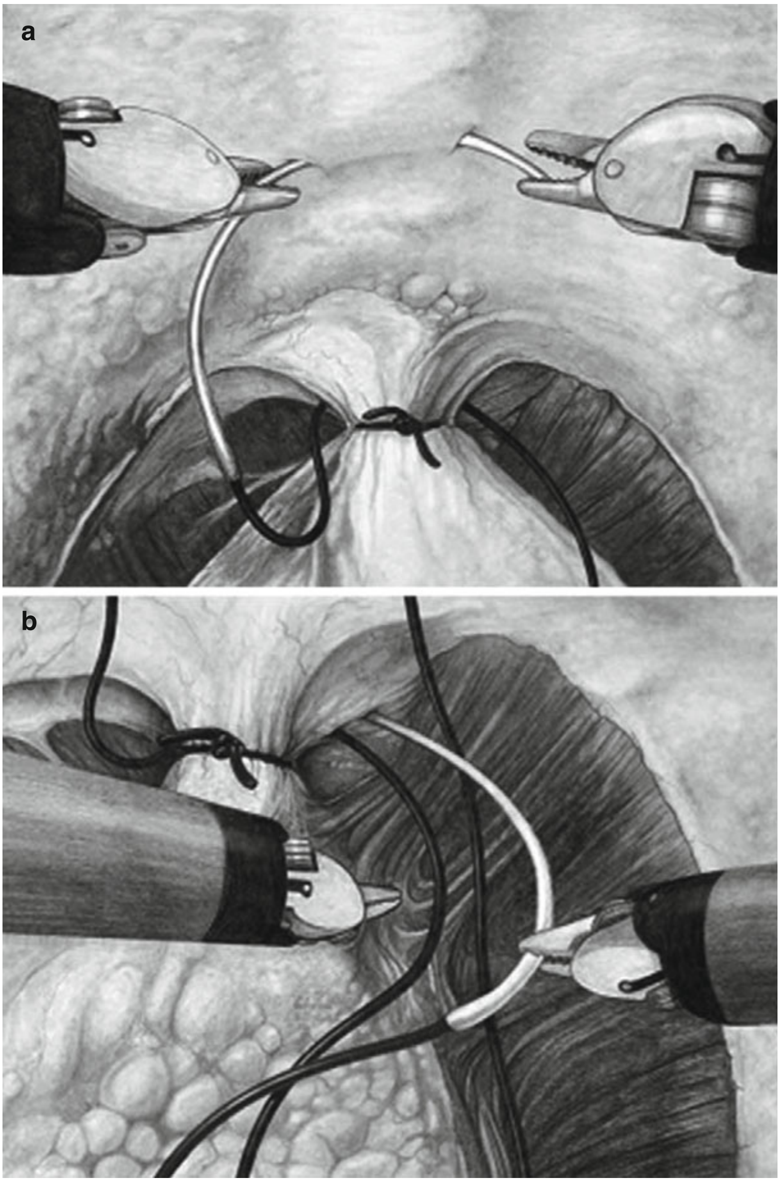

Fig. 28.15 (**a**) Stitch placed through the periosteum on the retropubis; (**b**) second pass through the dorsal venous complex (Printed with permission from reference [26])

of the rectum can potentially lead to devastating infectious complications or rectourethral fistula.

Improper Foley placement can result from poor approximation of the posterior bladder neck to the posterior urethra. Inflation of the balloon in that location can lead to further disruption of the bladder neck. When detected intraoperatively, a catheter guide can be used to push the catheter anteriorly through the bladder neck. In the postoperative period, flexible cystoscopy may be necessary to help visualize and access the bladder neck. Once identified, a guide wire can be inserted into the bladder over which a catheter is inserted. This complication is best avoided by adequately visualizing entrance of the catheter into the bladder prior to the completion of the vesicourethral anastomosis. Irrigating the bladder under laparoscopic visualization helps ensure proper positioning of the Foley catheter.

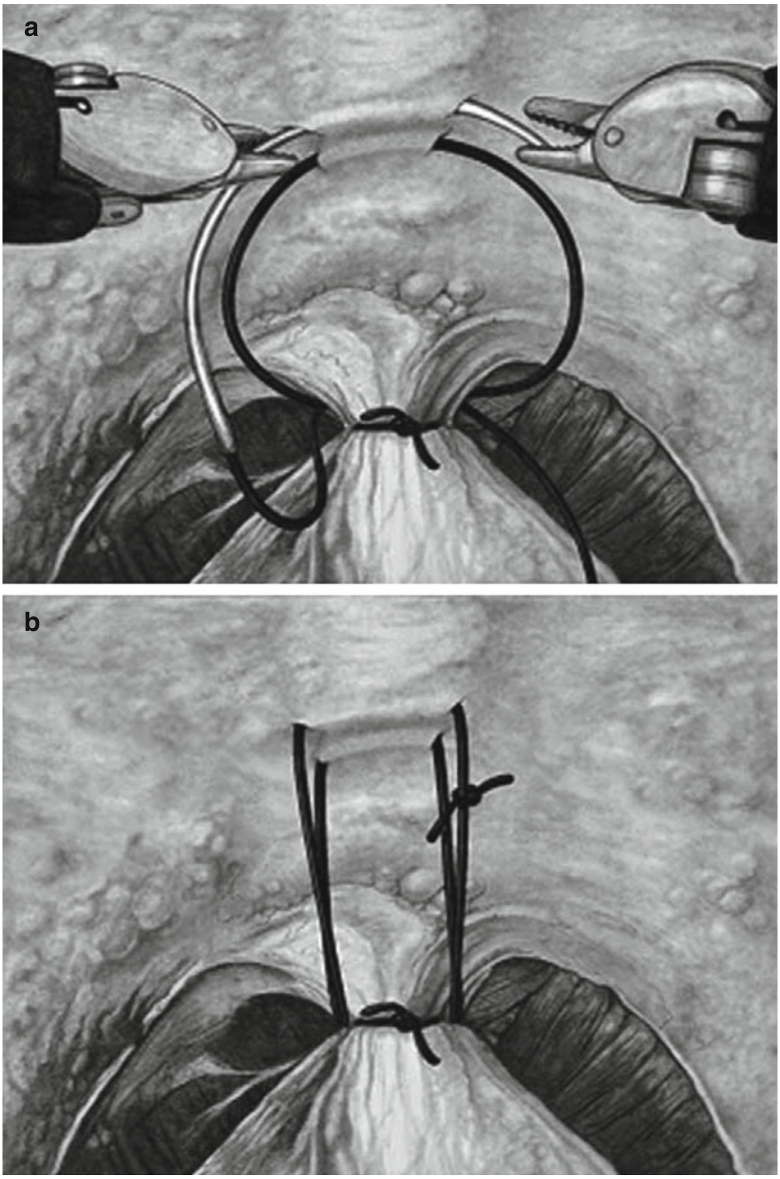

Fig. 28.16 (**a**) Second pass through the dorsal venous complex and the periosteum on the retropubis; (**b**) the final stitch is tied (Printed with permission from reference [26])

28.7.2 Postoperative

Bleeding can result in the postoperative period as a result of an anterior anastomotic suture placed through the dorsal vein. This is often not a problem intraoperatively as the pneumoperitoneum serves to tamponade the site of the injury. With reversal of the pneumoperitoneum, this can present as brisk bleeding via the Foley catheter. If unsuspected, it may result in a significant pelvic hematoma compromising the healing process. Inflating the Foley balloon with about 30 cc of fluid and placing the Foley catheter on traction generally suffice to control such bleeding.

Urine leakage can present as high drain output in the postoperative period. A high drain output, with a low urinary catheter output often indicates urinary leakage. A high creatinine content of the drain fluid is diagnostic of this condition. When a drain is not placed, if the leak is significant, it often presents as a urinoma, when the procedure is done via an extraperitoneal route. Urine ascites can ensue with the transperitoneal technique.

Urine leakage results from a poorly constructed or disrupted anastomosis. Inadequate suture placement can lead to poor tissue apposition with overriding tissue edges. This can cause leakage which is generally self-limiting in nature and evident only with high pressure. Bladder irrigation can easily demonstrate breaches in the water tightness of the anastomosis, to help decide on corrective measures. With urethral catheter obstruction postoperatively, mild leakage at sites of poor tissue apposition can become significant, resulting in high urine output via the drain.

In the long term, a disrupted anastomosis can lead to urinary incontinence, the most feared and disabling complication associated with prostatectomy. In the setting of a large urine leak, the edges of the bladder neck and urethra are not in continuity to facilitate healing. With the two edges far from one another, the healing phase is prolonged and rather occurs via “secondary intention.” Urine leakage is also associated with fibrosis of the bladder neck, limiting its compliance, impacting subsequent continence recovery.

Bladder neck contracture is another postoperative complication that can develop at anytime during the postoperative period following catheter removal. Ischemia at the bladder neck and urethral edges are the likely culprit, in the face of a tension-free mucosa to mucosa anastomosis. We recommend transecting the bladder neck and urethra sharply without the use of cautery to avoid tissue ischemia. Management of this complication is beyond the scope of this chapter.

Neurovascular bundle injury can occur during completion of the anastomosis. The visualization afforded by the robot allows proper dissection and delineation of the neurovascular bundles, decreasing the incidence of postoperative impotence. The latter, however, can result from poor anastomotic suture placement on the urethra. The proximity of the neurovascular bundles to the urethra places them at significant risk for injury. A poor urethral stump, retracting in the pelvic diaphragm with the pneumoperitoneum, can lead to this complication. The needle can be inadvertently placed through the bundle, as the surgeon attempts a large sweep through the urethra. Using a smaller needle and a urethral guide can help avoid such complication, with a previously well-preserved neurovascular bundle.

28.8 Summary

RARP is fast becoming a preferred way to manage localized cancer of the prostate, in men who are suitable surgical candidates. The technology offers great advantages. Its proper use in skilled hands remains the only way for men affected by prostate cancer to receive the greatest benefits. The UVA is a key reconstructive step of the procedure which the robot facilitates. The different techniques used offer both advantages and disadvantages. With continued technological improvements and refinement of surgical skills, achievement of the triad of cancer control, preservation of continence, and erectile function will maintain radical prostatectomy as the most effective option for most men faced with this common disease.

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29

Robotic-Assisted Laparoscopic Radical Salvage Prostatectomy

David Y. Josephson and Timothy G. Wilson

29.1 Introduction

Radiation therapy (RT) is an accepted treatment for the management of localized prostate cancer [1], and it is estimated that up to one-third of the prostate cancer patients undergo radiotherapy treatment including external radiotherapy, brachytherapy, or a combination of the two [2]. However, following RT, up to 50 % of patients develop biochemical recurrence (BCR) [3], and RT fails in 20–50 % of men [4] with persistent neoplastic cells found in postirradiation prostate biopsies. Based on these outcomes, approximately 30,000 men will experience recurrent disease following RT each year in the United States [5]. Treatment options for these patients include watchful waiting, androgen deprivation therapy (ADT), or additional local salvage therapy such as radical prostatectomy (RP), radical cystoprostatectomy (CP), cryotherapy, high-intensity focused ultrasound (HIFU), and brachytherapy. Of these options, salvage RP has consistently demonstrated a benefit for long-term disease-free survival [5–9] and is currently the only treatment approach with curative potential for these patients [10]. Salvage RP has historically been performed as an open technique. Here, we review salvage RP for recurrent prostate cancer and compare the open RP approach to minimally invasive robotic-assisted laparoscopic radical prostatectomy (RALP), describing the technique, patient morbidity, and oncologic outcomes.

29.2 Historically Open Salvage RP

Historically, salvage RP has been shown to offer the greatest likelihood of secondary local control in prostate cancer. Indeed, studies have demonstrated that salvage RP provides long-term cancer control (≥10 years) in a substantial proportion of patients [5–9], with 5 and 10-year PSA progression-free probability ranging from 47–69 % to 25–43 %, respectively [5, 7]. Many series have demonstrated that patients who undergo open salvage RP early in the course of recurrent disease, when PSA levels are low, have substantially better outcomes. Among open salvage RP patients with preoperative PSA levels ≤10 ng/ml, up to two-thirds of patients have organ-confined disease, and an estimated 70 % are free of progression at 5 years post surgery [4, 5, 8, 11]. Bianco et al. showed 5-year progression-free probabilities after open salvage RP of 86, 55, and 28 % for patients with preoperative PSA levels <4, 4–10, and >10 ng/ml, respectively [6]. The authors further showed a 5-year PSA progression-free probability of 77 % after open salvage RP for those

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patients with organ-confined disease, 71 % with isolated extracapsular extension, and 24 % for those men with seminal vesicle invasion and/or regional lymph node metastases.

29.3 Oncologic Outcomes: Open Salvage RP

In 1980, Carson and colleagues were the first to report on open radical retropubic prostatectomy after RT. Planned salvage surgery was used with the rationale of downsizing the tumor for the improvement of obstruction after primary RT [12]. In 1985, Mador et al. reported the first series of RP and CP with the intent of salvaging patient cases in whom RT failed [13]. In these patients, 5-year biochemical disease-free survival (DFS) ranged from 50 to 60 %. The earliest large-scale published series of open salvage RP is from the Mayo clinic. Investigators there reported on a total of 199 patients undergoing salvage surgery over a 20-year period (138 patients underwent RP, and 61 underwent CP). They found that such surgery resulted in an overall 10-year cancer-specific survival (CSS) of 65 %. Patients undergoing salvage RP fared better than those undergoing salvage CP (10-year CSS of 77 % [RP] versus 38 % [CP]), and the 5-year DFS for patients undergoing salvage RP was 63 % [8]. Another large-combined salvage RP series from Memorial Sloan-Kettering Cancer Center and Baylor School of Medicine involving 100 patients demonstrated 30 % DFS and 73 % CSS at 10 years post surgery [6]. More recently, one of the largest studies on open salvage RP was a retrospective, international, multi-institutional cohort analysis of 404 patients treated at high-volume tertiary centers from 1985 to 2009. With a median follow-up of 4.4 years, 195 patients experienced BCR, 64 developed metastases, and 40 died from prostate cancer. Ten years after salvage RP, the rate of BCR-free survival was 37 %, metastasis-free survival was 77 %, and CSS was 83 %. Multivariate analysis revealed preoperative PSA and Gleason score at postradiation prostate biopsy to be the best predictors of BCR and metastasis [14].

The oncologic outcomes from reported series of open salvage RP that have been published since 1990 are shown in Table 29.1. The 5-year biochemical DFS rate typically ranges from 50 to 60 % in most salvage RP series. In the past, most salvage RP series included a high proportion of men with locally advanced disease, as reflected by the presence of seminal vesicle invasion (SVI) and/or lymph node involvement (LNI) in 45–70 % of patients.

29.4 Morbidity: Open Salvage RP

The advantage of open salvage RP in term of efficacy must be balanced against the risks of complications. Historically, open RP has been fraught with high complication rates and poor functional outcomes. These risks are greater in the salvage RP setting than in the de novo setting, because RT induces fibrosis merging the tissue planes used for dissection and results in poor wound healing. Early series on the open approach reported intraoperative rectal injuries in up to 19 % of patients, as well as urinary incontinence in up to 73 % of patients, and bladder neck contracture rates of up to 30 % [7, 11, 20, 26]. More recent studies have shown an improvement in the morbidity from this procedure [5–9]. This has likely resulted from improved surgical technique in combination with newer technologies and more precise targeting of newer RT modalities (including intensity-modulated and proton therapy), thereby decreasing damage to periprostatic tissues.

Vaidya and Soloway performed salvage RP on six men with curative intent. They reported no rectal injuries or anastomotic strictures, and five of the six patients were continent with a mean follow-up of 27 months [20]. Stephenson et al. evaluated 100 consecutive patients who underwent open salvage RP between 1984 and 2003. The major complication rate decreased significantly from 33 to 13 % in patients who underwent treatment prior to and after 1993, respectively, including a rectal injury rate that improved from 15 to 2 %. The authors attribute the high complication rate in their early salvage

Table 29.1 Oncologic outcomes of salvage prostatectomy since 1990

Series	*n*	Treated	Preoperative median PSA, ng/ml (% <10 ng/ml)	Treatment	Organ-confined disease (%)	Follow-up, months median/mean	5-year FFS (%)
Link and Freiha [15]	14	1984–1988	15 (29)	–	36	18	43
Stein et al. [16]	13	N/A	N/A	RP: 11; CP:2	46	<12	43
Rogers et al. [11]	42	1984–1992	N/A	RP: 40; CP:2	20	39	82
Gheiler et al. [17]	40	1992–1997	14; 9.4	RP: 30; CP:10	53;10	36;34	50 (RP); 30 (CP)
Garzotto and Wajsman [18]	29	1985–1993	8.4	RP: 9; CP: 20; ADT	28	61	69
Amling et al. [19]	108	1966–1996	6.2	ADT (44 %)	39	N/A	56
Vaidya and Soloway [20]	6	1995–2000	N/A	–	67	2	83
Pisters et al. [21]	13	1995–1999	4.9 (92)	RP and UC	54	25	69
Ward et al. [8]	199	1967–2000	5.2 (78);3.6 (29)	RP:138; CP:61	39;17	92;67	63 (RP); 19 (CP)
Bianco et al. [6]	100	1984–2003	5.9 (59)	–	35	60	55
Sanderson et al. [9]	51	1983–2002	8 (64)	–	25	86	47
Darras et al. [22]	11	1989–2004	3.7 (82)	–	82	63	55
Dall'Oglio et al. [23]	9	1996–2002	13 (33)	–	44	30	78
van der Poel et al. [24]	27	1997–2005	8.6	Perineal RP	41	43	31
Heidenreich et al. [25]	55	2004–2008	7.8 (81.8)	RP and ePLND	72.3	23	87.3
Chade et al. [14]	404	1985–2009	4.5	RP and ePLND	53	52.8	48

UC urinary reconstruction, *RP* radical prostatectomy, *CP* cystoprostatectomy, *NA* not available, *ADT* androgen-deprivation therapy, *ePLND* extended pelvic lymph node dissection, *FFS* failure-free survival

RP experience to the fact that most patients underwent pre-RT pelvic lymph node dissection and/or retropubic interstitial RT, thereby causing extensive pelvic fibrosis. These techniques fell out of favor by 1993, and the morbidity associated with salvage RP decreased. Their overall anastomotic stricture rate and 5-year continence rate were 30 and 68 %, respectively. Interestingly, these values did not improve over the 20 years of their study [27]. Ward et al. reported on 138 patients who underwent open salvage RP with a median follow-up of 7 years. Rectal injury occurred in 4 % of cases, with urinary extravasation and bladder neck contractures developing in 15 and 22 % of cases, respectively. Continence was reported in 67 % of patients [8]. The persistent 30–50 % incontinence rates in these studies may result from RT-induced sphincteric dysfunction, as continence rates did not improve significantly over time despite better patient selection, reduced pelvic fibrosis, and improvements in surgical techniques [5].

The morbidities associated with open salvage RP reported since 1990 are shown in Table 29.2. Unfortunately urinary incontinence remains high in this population, likely due to loss of the normal properties of the rhabdosphincter, surrounding pelvic muscular support, and membranous urethra secondary to RT-induced fibrosis. In addition to sphincteric deficiency, loss of compliance can make secondary changes to RT common, resulting in decreased bladder capacity. Rectal injuries are less common than generally perceived (0–15 %). The high rate of bladder neck contracture may be explained by the decreased tissue vascularity which occurs after RT, with consequent diminished healing. Vasculogenic changes associated with prostate irradiation make erectile dysfunction universal, even when excellent cavernous nerve-sparing techniques are used. However, it is important to note that nerve-sparing should not be a primary objective in this population as cancer control is the primary objective of this procedure.

29.5 Minimally Invasive Salvage RP: Morbidity and Outcomes

29.5.1 Laparoscopic Salvage RP

The most concerning complication after open salvage RP is rectal injury which requires patients to have a temporary diverting colostomy. Laparoscopic salvage RP improves visualization of the cul-de-sac and the posteriorly scarred plane between the rectum and the prostate and can help avoid this significant complication. Vallancien et al. reported the results of seven patients who underwent laparoscopic salvage RP. Utilizing the Montsouris technique, the laparoscopic prostatectomy was performed using a transperitoneal approach. For the dissection between the prostate and the rectum, transrectal finger guidance was used; the so-called finger-assisted laparoscopy. With a mean operative time of 190 min and average blood loss of 387 ml, no postoperative transfusions and no conversions were noted. Five patients in their series were continent, and all patients were impotent. They reported a longer catheterization time of 13 days compared to open salvage RP. After a mean follow-up period of 11.2 months, PSA level was <0.1 ng/ml in five patients [28].

Liatsikos et al. reported the results of 12 patients who underwent extraperitoneal laparoscopic salvage RP. Average operative time was 153 min. Mean blood loss was 238 ml. There was no need for conversion to open surgery or transfusion. Mean total urethral catheterization time was 7.2 days. After a mean follow-up of 20 months, ten patients were completely continent, and two patients needed one to two pads per day. Three patients were potent before the surgical treatment, but no patients reported potency postoperatively. Biochemical recurrence was observed in only one patient 12 months after surgery [29].

Nunez-Mora et al. reported the results of nine patients who underwent laparoscopic salvage RP. The average operative time was 170 min. There was no need to convert to open surgery or transfusions. There were no cases of rectal injury. Over half of the patients had extraprostatic extension, and two patients had nodal metastasis. Postoperative PSA was undetectable in seven of the nine patients. Two patients experienced BCR at 16 and 13 months after surgery. After a minimum follow-up period of 15 months, these patients were free from recurrence. There were no cases of urethrovesical anastomotic strictures. Three patients manifested severe incontinence (>2 diapers per day), which required artificial urethral sphincter implantation in two cases. The remaining six patients required zero to one pads per day. Of the patients who were potent before surgery, only one of the five maintained his erectile function [30].

29.5.2 Robotic Salvage RP

With the rapidly expanding application of robotics for urologic surgery, RALP has become a standard surgical treatment modality for localized prostate cancer. The known advantages of RALP include reduced blood loss and a shorter hospital stay with a more rapid convalescence, with comparable oncologic, continence and potency outcomes compared to the open approach [31–35]. As more experience has been gained with robotic techniques, expert minimally invasive surgeons have abandoned the pure laparoscopic technique in favor of the robotic approach given the lack of tremor, increased degrees of movement, and 3D visualization. Naturally, the application of robotic technology has also been expanded to more technically challenging procedures. Initial case reports described the feasibility and safety of salvage RALP in appropriately selected patients with encouraging early functional outcomes that were at least equivalent with historical open salvage RP series [36–38]. Kaouk published a series of four patients who underwent salvage RALP. The mean operative time was 125 min, mean blood loss was 117 ml, and mean hospital stay was 2.7 days. Two of the four patients had positive surgical margins. At a mean follow-up of 9 months, three patients were continent and one patient had developed BCR [37]. Boris et al. recently reported data on 11 patients who underwent salvage RALP. The operative

Table 29.2 Morbidity of salvage prostatectomy since 1990

Series	*n*	Treated	Duration (h)	Incontinence (%)	Rectal injury (%)	Bladder neck stricture (%)	Median/mean follow-up (months)	Postoperative mortality (%)
Link and Freiha [15]	14	1984–1988	N/A	55	0	7	18	0
Stein et al. [16]	13	N/A	N/A	64	8	18	<12	0
Rogers et al. [11]	42	1984–1992	4.4	58	15	27.5	39	0
Gheiler et al. [17]	40	1992–1997	N/A	50	3	17	36;34	0
Garzotto and Wajsman [18]	29	1985–1993	N/A	67	7	29	61	0
Amling et al. [19]	108	1966–1996	N/A	51	6	21	N/A	0
Vaidya and Soloway [20]	6	1995–2000	N/A	17	0	0	2	0
Pisters et al. [21]	13	1995–1999	N/A	17	0	N/A	25	0
Ward et al. [8]	199	1967–2000	N/A	48	4;10	22	92;67	0
Bianco et al. [6]	100	1984–2003	4.05	36	7	30	60	0
Sanderson et al. [9]	51	1983–2002	N/A	27	2	41	86	0
Darras et al. [22]	11	1989–2004	N/A	55	0	18	63	0
Dall’Oglio et al. [23]	9	1996–2002	N/A	22	0	22	30	0
van der Poel et al. [24]	27	1997–2005	N/A	38	4	4	43	4
Heidenreich et al. [25]	55	2004–2008	2	18.2	3.6	10.9	23	0

NA not available

duration was 183 min with an estimated blood loss of 113 ml and a mean hospital stay of 1.4 days. With a mean follow-up of 20.5 months, 27 % of patients experienced BCR. One patient experienced an anastomotic leak, and one developed an anastomotic stricture that required surgical intervention. In short-term follow-up of 2 months, they reported that eight of ten patients were continent [38].

We recently reported the results of 18 patients who underwent salvage RALP for biopsy-proven prostate cancer after primary RT treatment. Median preoperative PSA was 6.8 ng/ml, and three patients had a PSA of ≥10 ng/ml before undergoing therapy. Median operative parameters for estimated blood loss, surgery length, and length of hospital stay were 150 ml, 2.6 h, and 2 days, respectively. No patients required conversion to open surgery, blood transfusion, or experienced rectal injury. Perioperative complications occurred in seven patients (39 %); the most common of which was urine leak identified by postoperative cystogram. Five patients (28 %) had a positive surgical margin. Although some patients had limited follow-up, six (33 %) were continent, and 67 % were free of biochemical progression [39]. Another recent series reported by Strope el al. included the results of six patients who underwent RALP after definitive RT. Functional status of patients before salvage RALP was compromised; three of the six patients had extremely poor sexual function before surgery (EPIC sexual domain <50), and 75 % had significant irritative symptoms (mean EPIC urinary irritation score 60.5). The mean preoperative PSA level was 9.3 ng/ml. The mean operative time was 356 min. No rectal injuries or other intraoperative complications were experienced. Mean estimated blood loss was 280 ml. No patients received blood transfusions. Patients stayed a mean of 2 days in the hospital. One patient had a partial nerve-sparing procedure, and the rest were non-nerve-sparing. Two patients experienced transient urine leaks after surgery which resolved by postoperative day 2 with conservative management. Late complications were experienced by two of the six patients, with the patients experiencing a bladder neck contracture and posterior urethral distraction, respectively. Of the six patients, four (75 %) remain free of disease; however, incontinence and erectile dysfunction are evident in all, to some degree [40].

Salvage RALP is a technically feasible operation with decreased operative morbidity and functional and oncologic outcomes comparable to those of large series of open salvage RP. A benefit of this surgical approach compared to open salvage RP is the magnified 3-dimensional vision in the deep pelvis. The mean estimated blood loss during surgery is significantly lower than open salvage RP due to the positive abdominal pressure caused by the pneumoperitoneum and the preemptive control of any vessels. An additional advantage of salvage RALP arises from the antegrade dissection of the prostate, which allows for the early separation of the anterior rectum from the prostate. A well-defined plane can often be established, thereby minimizing the risk of rectal injury. Nonetheless, continued refinement of both patient selection and surgical technique is necessary to improve the functional and oncologic outcomes of salvage RALP. The morbidity and outcomes associated with laparoscopic and RALP salvage RP are shown in Tables 29.3 and 29.4, respectively.

29.6 Minimally Invasive Salvage RP: Patient Selection and Indication

The greatest challenge in selecting a patient with PSA failure after primary local treatment for further local therapy is determining whether the rising PSA represents distant disease, local disease, or both. Although several features have been associated with a higher likelihood of systemic rather than local disease, including a rapidly rising posttreatment PSA level, short PSA doubling time (PSA-DT), poorly differentiated cancer (Gleason score 8–10), and a short disease-free interval after RT, no individual factor is definitively associated with metastatic progression nor eliminates the possible benefit of local salvage therapy. Biochemical failure after irradiation is defined according to the American Society of Therapeutic Radiology and Oncology criteria [41].

Table 29.3 Oncologic outcome of salvage laparoscopic RP and RALP

Series	*n*	Preoperative median PSA, ng/ml (% <10 ng/ml)	Treatment	Organ-confined disease (%)	PSM (%)	Median/mean follow-up (months)	BCR-free (%)
Salvage laparoscopic RP							
Vallancien et al. [28]	7	N/A	Transperitoneal; Preop-ADT (5)	0	28.5	11.2	71.4
Liatsikos et al. [29]	12	12.7	Extraperitoneal	66.6	25	20	91.7
Nunez-Mora et al. [30]	9	9.1	Transperitoneal	44.4	22.2	26.8	55.6
Salvage RALP							
Kaouk et al. [37]	6	3.85	RP:4;CP:2	25 (1/4)	50 (2/4)	5	75 (3/4)
Boris et al. [38]	11	5.2	–	27.3	27.3	21	72.7
Eandi et al. [39]	18	6.8	–	50	28	18	67
Strope et al. [40]	6	9.3	–	83.3	16.7	3	66.7

RALP robotic-assisted laparoscopic radical prostatectomy, *RP* radical prostatectomy, *CP* cystoprostatectomy, *NA* not available, *ADT* androgen-deprivation therapy

Table 29.4 Morbidity of salvage laparoscopic RP and RALP

Series	*n*	Duration (h)	Incontinence %	Rectal injury (%)	Bladder neck stricture (%)	Median/mean follow-up (months)	Postoperative mortality (%)
Salvage laparoscopic RP							
Vallancien et al. [29]	7	3.1	28.6	0	0	11.2	0
Liatsikos et al. [30]	12	2.6	16.7	0	0	20	0
Nunez-Mora et al. [31]	9	2.8	33.3	0	0	26.8	0
Salvage RALP							
Kaouk et al. [38]	4	2.1	25	0	0	5	0
Boris et al. [39]	11	3.1	20	0	9	21	0
Eandi et al.[40]	18	2.6	66.6	0	17	18	0
Strope et al. [41]	6	5.9	100	0	0	3	0

RALP salvage robotic-assisted laparoscopic radical prostatectomy, *RP* radical prostatectomy

All recurrences should be based on three consecutive increases in PSA. Patients with documented PSA recurrence should undergo a thorough evaluation prior to biopsy by CT/MRI (abdomen/pelvis) and bone scan to rule out regional or distant spread of disease. A Prostascint exam and endorectal MRI should be obtained at the discretion of the physician if extraprostatic disease is suspected but not evident on initial imaging. Systematic transrectal ultrasound-guided prostatic biopsies should subsequently be performed to document persistence of cancer in the prostate prior to discussion of salvage modalities.

PSA-DT can help to determine which patients will most likely benefit from salvage therapy. Zagars et al. presented 7-year distant metastases rates after RT. They found 54 % of patients with a PSA-DT of <8 months had metastases compared to 7 % for patients with a PSA-DT of >8 months [42]. This suggests that the optimal candidate for salvage local therapy after RT should ideally have a PSA-DT of >8 months and, ideally, >12 months.

In case of BCR after RT, Buyyounouski et al. reported an interval to BCR of <18 months as a prognostic factor for distant metastases and prostate cancer-specific mortality [43]. Zagars and Pollack reported that men who developed metastases after RT experienced PSA failure at a median of 9 months compared with a median time to failure of 18.4 months for men who failed but did not develop metastases [42]. The optimal candidate for salvage local therapy should also have an interval of >2 years between RT and PSA failure. In general, patients being considered for salvage RP should have the same characteristics as those being considered for primary radical surgery: life expectancy of ≥10 years, no significant comorbidities putting them at risk for surgical complications, highly motivated (i.e., those patients who accept increased surgical morbidity). In addition, patients should have favorable risk profiles including initial low-risk disease (PSA < 10 ng/ml, Gleason score ≤ 7, clinical T1c or T2a tumor status), pretreatment PSA velocity < 2.0 ng/ml/year at the time of initial presentation, interval to PSA failure >2 years, PSA-DT > 12 months, negative bone scan and imaging studies, and positive re-biopsy.

29.7 Minimally Invasive Salvage RALP: Operative Technique

29.7.1 Patient Preparation

Patients typically undergo an outpatient mechanical bowel preparation without antimicrobial coverage on the day prior to surgery. At this time, patients are also instructed to remain on a clear liquid diet until midnight. An intravenous line for hydration is typically not necessary. On the day of surgery, we routinely type and crossmatch patients for two units of packed red blood cells, and preoperative intravenous antibiotics are given. An arterial line and large-bore intravenous catheters are placed under general endotracheal anesthetic, and a nasogastric tube is placed to decompress intestinal contents and gas during the procedure.

29.7.2 Patient Positioning

Intermittent pneumatic compression devices are applied, and the patient is positioned in low lithotomy position with the legs in Allen stirrups. The arms are abducted using padded sleds, and the table is placed at its lowest height and subsequently placed in maximal Trendelenburg position. We prefer to use a Kendall Devon OR table pad (Covidien, Mansfield, MA, USA) without an additional bed sheet to prevent a gravitational slide during the procedure. Once the patient is prepared and draped, a 16-French Foley catheter is inserted to empty the bladder and is left to gravity drainage for the remainder of the procedure. Pneumoperitoneum is obtained by elevating the anterior abdominal wall, using penetrating towel clamps and the introduction of a Veress needle at the umbilicus. The abdomen is inflated to 15 mmHg, where it remains for the laparoscopic portion of the procedure. Once the abdomen is fully distended, we mark out our port sites. We prefer to use bipolar Maryland forceps in the left robotic arm, while the monopolar scissors and harmonic scalpel are interchangeably used in the right arm to dissect small vessels. A Prograsp instrument is utilized in the robotic third arm to assist in traction and elevation. The assistant uses an extra-long suction/irrigator in the left hand through the epigastric port and a locking grasper safe handling bowel through the right iliac port.

29.7.3 Operative Details

29.7.3.1 Step 1: Posterior Dissection

All salvage RALP at our institution are performed transperitoneally with our institutional modifications to the Montsouris technique [44]. The fourth arm utilizing the Prograsp retracts the sigmoid colon out of the pelvis to expose the cul-de-sac. A curvilinear incision is made in the pouch of douglas at the reflection of the peritoneum. The vas deferens and seminal vesicles can be targeted directly at the bottom of the peritoneal reflection under the bladder. The plane between Denonvillier's fascia and the rectum is incised sharply. The posterior wall of Denonvillier's fascia is swept off the anterior aspect of the rectum as distally as possible and ideally to the posterior aspect of the prostatic apex. Care must be taken to avoid blunt dissection as postradiation scarring can eliminate normal tissue planes and result in rectal injury. If we encounter a significant reaction on the anterior rectal wall with fear of iatrogenic perforation, the bedside assistant can insert a rectal budgie to aid in the dissection. As the peritoneum is retracted superiorly by the assistant with the sucker/irrigator, the vas/seminal vesicle complex is dissected out using a combination of sharp and cautery dissection. The vas deferens is clipped and divided at the tips of the seminal vesicles. The ampulla of each vas deferens along with each seminal vesicle is dissected up to their insertion in the prostatic base. The entire complex is again grasped by the assistant and retracted anteriorly and cephalad to expose the posterior prostatic plane. We believe that iatrogenic rectal injury can be minimized by dissecting as much of the posterior plane as possible with this type of approach.

29.7.3.2 Step 2: Anterior Approach: Dropping the Bladder

The bladder is completely mobilized by bilaterally incising the peritoneum lateral to the medial umbilical ligaments. The medial umbilical ligaments and urachus are divided as cephalad as possible. The endopelvic fascia is opened to gain access to the prostatic apex and expose the deep dorsal venous complex. The fat is mobilized off the prostate, and the superficial dorsal vein is divided by bipolar energy. The endopelvic fascia is incised to expose the levator attachments. The levators are swept off the prostatic apex to the level of the puboprostatic ligaments. The dorsal vein complex is controlled either by suture ligation or application of a 45-mm endoscopic stapler using a tissue load cartridge. Prior to applying the stapler, the indwelling catheter is moved back and forth by the bedside assistant to assure that the urethra has not been incorporated into the stapler load.

29.7.3.3 Step 3: Bladder Neck Dissection

The fatty and vascular soft tissue overlying the junction of the prostate and the bladder is initially divided at the 12 o'clock position using cautery, and the fatty tissue overlying the lateral aspect is divided down to the base of the prostate. The posterior dissected retrovesical space is identified on the patient's right-hand side using blunt dissection, and the prostate and bladder are then separated using scissors, dissecting in a posterior-to-anterior manner. A Harmonic scalpel or curved monopolar scissors are typically used for this portion of the case. This is repeated in exactly the same manner on the patient's left-hand side, until only the urethra remains attaching the prostate to the bladder. This is then divided in a 270° manner anteriorly to expose the indwelling deflated Foley catheter. The catheter is retracted into the prostate, and the posterior urethra is also subsequently divided, completely detaching the prostate from the bladder. A bladder neck-sparing approach should be avoided if the vascularity of the tissue just proximal to the prostatic urethra appears to be compromised from RT. Lack of vascularity or blanched tissue can be a sign of poor healing postoperatively and can cause post-prostatectomy stricture/contracture. We also advocate using sharp dissection and limiting cautery on the mucosal surface to maximize vascularity of the tissues.

29.7.3.4 Step 4: Dissection of Pedicles and Neurovascular Bundles

We then retract the seminal vesicle complex to the patient's left-hand side medially and anteriorly.

Positive margins at the base are best avoided by widely resecting the pedicles and neurovascular bundles. A thermal scissors with clips or Harmonic scalpel can be used to divide the prostatic vascular pedicle and the bundles. Once better mobility is achieved on the prostate, the gland is turned to expose the most distal and posterior aspect near the apex. Dissection at this point is again carried out with scissors to avoid iatrogenic rectal injury. Depending on the extent of RT-induced fibrosis, preservation of the neurovascular bundles may be attempted; however, it should be noted that most patients who have salvage RP suffer from erectile dysfunction requiring adjunct measures for return of potency.

29.7.3.5 Step 5: Apical Section

With the apex of the prostate and membranous urethra exposed, the prostate is placed on retraction both posteriorly and in a cephalad fashion. The anterior urethra is divided in a 270° manner. The Foley is then withdrawn into the bulbar urethra, and a tethering suture is placed at the 6 o'clock position of the urethra. The posterior urethra is then divided sharply, and the specimen is moved to the superior aspect of the pelvis. The prostate is visualized and secured using an Endocatch bag. The prostatic fossa is examined for hemostasis, and irrigation of the pelvis is carried out.

29.7.3.6 Step 6: Pelvic Lymphadenopathy

We then perform an extended bilateral pelvic lymph node dissection by skeletonizing the lymphatic tissue from both the left and the right external iliac veins using combination of monopolar and bipolar cautery. Boundaries of our dissection include the anterior aspect of the external iliac artery at the bifurcation of the common iliacs superiorly, the lymph node of Cloquet and Cooper's ligament distally, and the obturator fossa inferiorly. During this dissection, the obturator nerve is identified on each side and kept out of harm's way.

29.7.3.7 Step 7: Urethrovesical Anastomosis

A posterior reconstruction is carried out by reapproximating the cut edge of the rectourethralis muscle to the cut edge of Denonvillier's fascia using a series of absorbable 3-0 sutures. The urethral anastomosis is facilitated by passing the tethering suture at the 6 o'clock position to oppose the bladder mucosa and the urethra. Two additional posterior urethra sutures are placed at the 5 and the 7 o'clock positions, and these are run up to the 12 o'clock position and then tied off. A new 18-French Foley catheter is inserted, and the bladder is irrigated using a total of 120 ml of normal saline to rule out extravasation from the anastomosis. It is imperative to leave a pelvic drain in postoperatively.

29.7.4 Postoperative Care

Patients are monitored in a regular surgical bed for 24 h. The patient is kept NPO until the morning after surgery, at which point clear liquids are initiated. The patient is discharged home with an indwelling Foley catheter once he is tolerating full liquids, has adequate pain control on oral narcotics, and has acceptable stable labs. The pelvic drain can be removed if the output is less than 100 ml per shift. We prefer to use a standardized postoperative care pathway with preprinted order sets in all patients. In addition, all patients are started on routine venous thromboembolism-event prophylaxis with subcutaneous low-molecular-weight heparin as soon as their hematocrit is deemed stable. The catheter is typically left in for 2–3 weeks, and we perform a cystogram on all patients to evaluate urinary extravasation prior to catheter removal. If urinary extravasation is seen, the catheter is left indwelling and the process is repeated 1 week later.

Conclusion

Although a large number of patients develop BCR following RT therapy for localized prostate cancer, very few patients undergo local salvage treatment. Salvage prostatectomy represents an established option for these patients with curative potential. Salvage RALP is a technically feasible operation with decreased operative morbidity compared to open salvage RP and comparable functional and oncologic outcomes. Advantages for salvage RALP include the documented benefits of robotic-assisted surgery such as enhanced visualization in the deep pelvis and the use of instruments capable of the same degree of movement as the human hand. These factors combine to allow for a more precise dissection compared to an open approach. The presence of a pneumoperitoneum also results in minimal blood loss, further improving visualization in such critical areas of dissection as the prostatic apex. An additional advantage for salvage RALP arises from the antegrade dissection of the prostate, which allows for the early and relatively easy separation of the anterior rectum from the prostate. A well-defined plane can often be established, thereby minimizing risk of rectal injury. We hope that with the increased application of robotic-assisted surgery and the demonstrated safety and feasibility, urologists will consider more patients for this potentially curative surgical treatment of radio-recurrent prostate cancer

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Outcome Measures After Robot-Assisted Radical Prostatectomy

30

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30.1 Introduction

Prostate cancer is the third most common cancer in men with half a million new diagnosis worldwide yearly and the second most frequent cause of cancer death in American men [1]. Open radical retropubic prostatectomy (RRP) is being challenged for the gold standard treatment for organ-confined disease.

The first laparoscopic radical prostatectomy (LRP) was reported by Schuessler, Clayman, and Kavoussi [2] via a transperitoneal approach in 1992. Almost a decade later, the technically challenging demands of pure LRP lead Menon, Tewari, and Ahlering to transition to the new robotic surgical systems. So far robot-assisted laparoscopic prostatectomy (RARP) has generated great enthusiasm among surgeons and patients alike due to its minimally invasive nature and its excellent short-term outcomes compared to the open and standard laparoscopic approach; but we must ask ourselves seriously – has the robot fulfilled the promise to be equivalent or better than open surgery?

This chapter will discuss operative, perioperative, quality of life, and oncologic outcome measures with RALP.

30.2 Operative Results

30.2.1 Blood Loss and Transfusion

The pneumoperitoneum induced in RARP provides a significant reduction in intraoperative blood loss. Benefits for the patient are improved operative field visualizations for more precise anatomical dissection. The reported estimated blood loss (EBL) in robotic series ranges from 75 to 800 mL (overall series mean of 271 mL) with most series reporting <200 mL EBL (Table 30.1). Blood transfusion rates now average 1–4 % (range 0–17 %) for RARP versus 32 % (range 3–67 %) for RRP, thus greatly reducing the risks of hepatitis B and C or HIV infection, transfusion reaction, or anaphylaxis associated with transfusions [3, 4]. Menon et al. reported that EBL in open as well as in RARP decreases as surgery time decreases [51]. A precise measure and comparison of estimated blood loss during robotic or open prostatectomy is difficult due to the inherent subjectivity. Furthermore, the pneumoperitoneum can tamponade bleeding venous channels that otherwise may continue to ooze during standard open surgery.

30.2.2 Convalescence

The length of hospital stay (LOS) is often used as an instrument to measure recovery as it generally correlates with the patient's time to return to basic activities. As LOS is also driven by other factors

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Table 30.1 Pathologic outcomes of robotic radical prostatectomy series

Authors	*N*	Age (years)	Method	OR time (h)	EBL (ml)	Tx. rate	Anastomosis	Open conv. rate
Rassweiler et al. [34]	33	68	Robotic intraperitoneal ascending	7.5[a]	na	na	Interrupted	0 %
Pasticier et al. [35]	5	58	Robotic intraperitoneal descending	3.7	800	na	Interrupted	0 %
Menon et al. [36]	40	60.7	Robotic intraperitoneal descending	4.6	391	0 %	Interrupted	2.5 %
Tewari et al. [37]	100	na	Robotic intraperitoneal descending	na	na	na	Interrupted	na
Menon et al. [38]	100	60	Robotic intraperitoneal descending	3.3	149	0 %	Running	na
Bhandari et al. [39]	300	60.3	Robotic intraperitoneal descending	2.96	109	0 %	Running	0 %
Patel et al. [18]	200	59.5	Robotic intraperitoneal descending	2.35	75	0 %	Running	0 %
Ahlering t al. [40]	60	62.9	Robotic intraperitoneal descending	3.9[b]	103	0 %	Running	0 %
Borin et al. [11]	200	60.3	Robotic intraperitoneal descending	na	108	na	Running	na
Menon/ Tewari [20]	200	59.9	Robotic intraperitoneal descending	160 min	153	0	Running	
Patel et al. [41]	1,500	60.7	Robotic intraperitoneal descending	105 min	111	0	Running	0.6 %
Murphy et al. [15]	400	60.2	Robotic intraperitoneal descending	186 min	na	2.5 %	Running	0.25 %
Menon et al. [15]	2,766	60.2	Robotic intraperitoneal descending	154 min	100	1.5 %	Running	0.1 %
Menon [15]	1,384	60.0	Robotic intraperitoneal descending	na	na	na	Running	na

OR time operative time, *Tx rate* transfusion rate, *RRP* radical retropubic prostatectomy, *EBL* estimated blood loss

[a] Includes pelvic lymph node dissection in 27/33 patients

[b] Excludes robotic setup

Margin positive rate							Gleason <7/≥7	Mean F/up (months)	PSA progression-free rate (<0.1 ng/ml)	Cost
Overall	pT2a	pT2b	pT2c	pT3a	pT3b	pT4				
18 %	na	na	na	na	na	na	na	na	na	na
20 %	0 %	33 %	na	na	na	na	na	na	na	na
17.5 %	na	na	na	na	na	na	na	6.5	na	na
na	na	na	na	na	na	na	na	na	na	na
15 %	10.6 %			40 %		na	14 %/16 %	5.5	na	na
na	na	na	na	na	na	na	na	na	na	na
10.5 %	5.7 %			28.5 %	20 %	33 %	na	9.7	95 %	na
16.7 %	4.5 %			47 %		100 %	na	na	na	na
7.5	na			na		na	na	na	na	na
6.0 %	na			na		na	na	na	na	na
9.3	4.0			34		40	na	na	na	na
19.2	9.6			42.3		na	na	22	86.6 %	na
na	13.0			35		na	na	22	84 % 5 year	na
25.1	na			na		na	na	60.2	86.6 %	na

such as cultural differences, healthcare systems, patient socioeconomics, and surgeon practice patterns, it is difficult to compare LOS particularly between countries. In the United States of America, most RARP series report a LOS of 0.96–1.2 days, while the average hospitalization after open RRP is between 2 and 3 days. A shorter hospital stay is truly advantageous to a decreased risk of nosocomial infections and decreased hospital costs. In a Swedish study, Hohwue et al. [5] reported that patients who underwent RARP had shorter postoperative hospital stay and less need for paid sick leave than patients who underwent an RRP. The average time to return to work was 11 days for RARP versus 49 days undergoing open RP.

30.2.3 Complications

As in open surgery, complications in laparoscopic prostatectomy are related to surgeon's experience and occur more readily during the learning curve. Minor and major complication rates of open, standard laparoscopic, and robotic prostatectomy series are listed on Tables 30.1, 30.2, 30.3, and 30.4. As not every series reports all complications, meaningful comparisons are rare. Nonetheless, the complication rates appear to be less in the robotic series.

A multi-institutional study [6] evaluated perioperative and late complications of 1,130 RLPs performed by three surgeons. Overall complication rates varied from 8.8 to 13.9 %, and the average for all patients was 11.3 %. There were no mortalities and only one conversion from RARP to open RRP for the whole series. Overall there were 17 *major complications* (1.5 %): 6 rectal injuries (0.5 %), DVT (0.2 %), 5 pulmonary embolus (0.4 %), 3 bleeding (0.3 %), and 1 (0.1 %) myocardial infarction. There were 81 *minor complications* (7.2 %): 21 anastomotic disruptions (1.9 %), 19 clotting/urinary retentions (1.7 %), 13 acute urinary retentions (1 %), 11 ileus (1 %), 3 blood transfusions (0.3 %), 2 wound infections, 1 urinoma, and 11 others (1 %). There were 30 *late complications* (2.6 %): 16 fossa strictures (1.4 %), 7 incarcerated/incisional hernias (0.6 %), 5 anastomotic strictures (0.4 %), and 2 lymphoceles (0.2 %). Major perioperative complications dropped significantly to less than 0.7 % when surgeon experience exceeded 200 cases.

Coehlo et al. [7] reported the early complications of a single-surgeon outcome of 2,500 RARP. Rates for Clavien grades 1 and 2 were 4 % and grades 3 + 4a were 1 %. No Clavien 4b or 5 complications were observed in the entire cohort. Overall complication rate varied from 9.3 % in the initial 300 cases and fell to 3.3 % for cases 2,100 and above. Anastomotic leakage varied similarly from 4 % in the early cases to 0.3 % in the later cases.

Rectal injuries most commonly occur during the dissection of the prostatic apex. If not completely mobilized off of the posterior aspect of the prostate, the rectum that remains adherent to the apex is at risk of injury during transecting of the urethra, or when performing non-nerve-sparing RARPs for aggressive high-risk prostate cancer, and lateral rectal injuries may occur while performing wide resection of the NVBs particularly at the apex. Historic rates for open RP were as high as 9 %, although contemporary rates were near 0.5 %. The key is to use the perirectal fat as a guide to stay in the correct plane, dissecting close to the prostatic surface. Menon et al. reviewed their single institutional outcome of 4,400 men undergoing RARP and found the average rate of rectal injury to be 0.2 % [67].

The van Velthoven single knot stitch originally reported by Ahlering and van Velthoven in 2003 [8] allowed for the creation of a running urethral anastomosis in a tension-free fashion. The critical benefit of this technique is that the initial tension of approximating the bladder to the urethra is dispersed over ten needle holes rather than two with interrupted techniques. It is simple and creates a watertight anastomosis with only one intracorporeal knot required. We applied the van Velthoven technique from case 1 onward, and the bladder neck contracture (BNC) rate for all men was originally <1 %.

A high incidence of fossa strictures has been reported to be an iatrogenic effect of using larger caliber (>18Fr) catheters during stapling of the

Table 30.2 Functional outcomes of laparoscopic radical prostatectomy series

Authors	*n*	Age (years)	Method	# hospital days	# days with catheter	Time of assessment from surgery (months)	Continence rate	Criteria	Erectile function (bns/uns)	Complication rate total, major/minor
Rassweiler et al. [34]	33	68	Robotic intraperitoneal ascending	na	6.8	na	na	na	na	na
Pasticier et al. [35]	5	58	Robotic intraperitoneal descending	na	5.5	na	na	na	na	0 %
Menon [36]	40	60.7	Robotic intraperitoneal descending	na	na	1.5	na	na	29 %/na	15 %, 0 %/15 %
Tewari et al. [37]	100	na	Robotic intraperitoneal descending	na	na	6	na	na	58 %[a]	na
Menon et al. [38]	100	60	Robotic intraperitoneal descending	0.96[b]	4.2	6	92 %	0 or pad use for protection only	na	8 %
Bhandari et al. [39]	300	60.3	Robotic intraperitoneal descending	1.2	6.9	na	na	na	na	5.7 %
Patel et al. [18]	200	59.5	Robotic intraperitoneal descending	1.1	7.9	12	98 %	0 pads	na	na
Ahlering et al. [40]	60	62.9	Robotic intraperitoneal descending	1.1	7	3	75 %[a]	0 pads	na	6.7 %
Borin et al. [12]	200	60.3	Robotic intraperitoneal descending	1	na	3	91 %	0 pads	na	na
Menon/Tewari et al. [20]	200	59.9	Robotic intraperitoneal descending	1.2	7	6	96 %	0 or pad use for protection only	<60 year 64 % >60 year 38 %	4.0 %
Patel et al. [41]	1,500	60.7	Robotic intraperitoneal descending	1 (97 %)	6.3	na	na	na	na	4.3 %
Murphy et al. [15]	400	60.2	Robotic intraperitoneal descending	3.1	8.2	12	91.4 %	0 pads	62 %	15.75 % 10.5 %/5.25 %
Menon et al. [15]	2,766	60.2	Robotic intraperitoneal descending	1.14	10	28	93 %	≤1 pad	79.2 %	na
Menon et al. [43]	1,384	60.0	Robotic intraperitoneal descending	na	na	na	na	na	na	na

[a] Assessed with validated patient questionnaire

[b] Length of hospital stay for 95/100 patients

Table 30.3 Open radical prostatectomy series

Institution	*n*	Age (years)	Method	Oper. time (h)	EBL (ml)	Transfusion rate	# hospital days	Margin post rate	Follow-up (months)	Continence rate	Criteria	Erectile function (bns/uns)	PSA progression-free rate (<0.2 ng/ml)	Complication rate total, major/minor
Johns Hopkins [12]	64	57	RRP	na	na	na	na	1.5 %	18	93 %[a]	0 pads	86 %[a, c]	na	na
Johns Hopkins [45]	2,404	59	RRP	na	na	na	na	na	75	na	na	na	74 %	na
NYU [46]	1,000	60.3	RRP	na	819	9.7 %	2.3	19.9 %	na	na	na	na	na	7 %
NYU [47]	621	58.7	RRP	na	na	na	na	na	24	82.4 %[a]	0 pads	na	na	na
Washington Univ. [48]	1,342	na	RRP	na	na	11.5 %	na	na	na	na	na	na	na	7.4 %, 2.4 %/5.0 %
Washington Univ. [49]	1,870	63	RRP	na	na	na	na	na	18	92 %	0 pads	68 %/47 %	na	10 %
Washington Univ. [50]	3,477	61	RRP	na	na	na	na		18	93 %	0 Pads		na	9 %
Mayo Clinic [51]	3,170	66	RRP	na	600–1,030	5–31 %	na	24 %	60	na	na	na	52 % at 10 year	na
Baylor [52]	1,000	62.9	RRP	na	na	na	na	12.8 %	53.2	na	na	na	75 % (<0.4 ng/ml)	na
Baylor [53]	472	62.2	RRP	3.0	na	28.6 %	6.2	na	na	na	na	na	na	27.8 %, 9.8 %/18.0 %
Baylor [54]	314	60.5	RRP	na	na	na	na	na	25.4	na	na	70 %/26%[d]	na	na
Baylor [55]	581	63	RRP	na	800	na	na	na	24	91 %	0 pads	na	na	na
Columbia Univ. [56]	480	62.6	RRP	na	na	na	na	na	39.6	91.8 %[b]	0 pads	na	na	na
Memorial Sloan-Kettering Cancer Center, New York [57]	1,746	na	RRP	na	na	na	na	12 %	72	na	na	na	75 % at 15 year	na

University of Padu, Italy [58]	985	64.5	RRP	na	750	na	na	13.7 %	95.5	79.9 %	0 pads	na	na	na
Memorial Sloan-Kettering Cancer Center, New York [59]	1,577	58	RRP	na	na	na	na	11 %	23.5	94 %	0 pads	67 % 3 year	91 % at 5 year	na
Memorial Sloan-Kettering Cancer Center, New York [60]	818	59	RRP	188 min	1,267	49 %	3.3	11 %	18	82.8 %	0 pads	58.5 %	95 % at 1.5 year	na
Mayo Clinic, Rochester [61]	588	61.0	RRP	204 min		na		17 %	12	88.0 %	0 pads	62.8 %	92.2 % at 3 year	4.8 %

RRP radical retropubic prostatectomy, *RPP* radical perineal prostatectomy, *EBL* estimated blood loss, *bns* bilateral nerve sparing, *uns* unilateral nerve sparing

[a] Assessed with validated patient questionnaire

[b] Assessed with non-validated retrospective questionnaire

[c] 89% of men underwent bilateral nerve-sparing procedure

[d] Men age 60 years or younger, for 60.1–65 years = 49 %/15 %, for age >65 years = 43 %/13 %

Table 30.4 Comparison of complication rates between recent large studies with long-term follow-up for assessing late complications

	Constantinides et al. [61]	Carlsson et al. [62]	Rabbani et al. [63]	Rabbani et al. [63]	Hruza et al. [64]	Agarwal et al. [65]	Carlsson et al. [62]	Ahlering
Year	2008	2010	2010	2010	2010	2011	2010	2011
Surgery	OPEN	OPEN	OPEN	LAP	LAP	RARP	RARP	RARP
N total patients	995	485	3,458	1,134	2,200	3,317	1,253	1,000
N complications	268	159	950	442		326	197	105
% Patients w/ complications[a]	26.9	32.8	27.5	39.0	32.4	10.4	15.7	10.5
FU	36.8 months	30 months	36.9 months	36.9 months	50 months	24.2 months	19 months	40 months
Complications by Clavien score category								
% Minors								
1	3.4 %	7.4 %	23.2 %	44.2 %	6.8 %	*7.2 %*	0.5 %	1.3 %
2	3.9 %	24.3 %			14.9 %		4.8 %	1.7 %
% Majors								
3	15.4 %	13.5 %	16.5 %	13.0 %	9.8 %	*3.8 %*	4.0 %	6.6 %
4	3.8 %	1.4 %			1.5 %		0.2 %	0.8 %
5	0.3 %	0.2 %			0.1 %		0 %	0

[a] Multiple complications within one patient counted only as one

DVC. It is noteworthy that using a smaller 18F catheter size eliminated these strictures.

RARP has historically used a vertical incision for the camera port above or below the navel. The camera incision is also the port used to extract the prostate. The incidence of incisional hernias (IH) has low reported rates in literature but with incomplete or short follow-up. Beck et al. [9] proposed a simple modification to reduce the incidence of incisional hernias and improve cosmesis. The rate of IH in midline incision varies with the method of reporting, as low as 4.9 % (36/735) relying on patient ad hoc self-reporting or as high as 9.4 % (18/192) if queried by email. Only one incisional hernia occurred in the transverse group – 0.6 % (1/165), although the average follow-up is much shorter in this group (2.8 year vs 0.8 year), with no difference in baseline factors between groups. Midline incisions conferred a *risk hazard of 11.0* compared to transverse incision. Baseline factors that appear to influence the development of incisional hernias in vertical incisions at the camera port include direction prostate weight, older age, IIEF-5, and BMI. Transverse closures had much smaller scar width (Fig. 30.1), which we feel reflects less tension on the skin and hence the fascial closure which reasonably appears to have resulted in fewer incisional hernias.

30.3 Oncological Control

30.3.1 Surgical Margins and PSA Recurrence

Regardless of surgical approach, the cornerstone oncologic principle of radical prostatectomy is the complete removal of the prostate gland. Cancer control can be assessed by margin status of the surgical specimen and presence of PSA recurrence.

Caution is advised when interpreting these results as positive surgical margin rate is subjective and not standardized to allow a qualitative comparison between institutions. Therefore, comparisons should only be performed after adjustment of relevant covariates. It is best to compare pT2 to pT2 rates to capture the rate of "surgeon error" which is significantly less than pT3 rates. Comparing combined pT2 and pT3 rates of differing groups can be very misleading if the ratios are biased to greater inclusion of pT2 cases and hence lower rates.

An important aspect of radical prostatectomy is the reduction of iatrogenic positive surgical margins (PSM) in otherwise organ-confined prostate cancer. The goal of a "zero" pT2 margin positivity rate reflects a difficult technical challenge, but it represents a theoretical perfection of iatrogenic-free surgical technique. With surgical experience and refinement of technique, the frequency of PSMs should decrease. Ahlering et al. [10] reported several technical methods to aid in the apical dissection and minimize the risk of positive surgical margins: removal of all fat overlying the dorsal venous complex (DVC) and prostate, division of the puboprostatic ligaments, dissection of the levator fibers to expose and increase the DVC length, and division of the DVC using a laparoscopic vascular stapler. With implementation of these techniques, Ahlering reduced his overall PSMs from 36 to 16.7 % and reduced pT2 PSMs from 27.3 to 4.7 % ($p = 0.003$). We continued to refine meticulous apical dissection in reducing PSMs at the apex. Borin et al. [11] reported a more aggressive urethral resection resulted in marked reduction in overall positive surgical margin rates without a significant change in time to continence or overall continence.

Walsh and colleagues [12] reported overall PSMs of 1.5 % for RRP, while most other open prostatectomy centers reported rates from 12.8 to 43.1 %, with an overall average of 21.6 % (Table 30.3). The overall positive surgical margin frequency in RARP series with at least 20 patients is similar to the open literature with a range of 10.5–20 % and an average of 15 % (Table 30.1). For organ-confined disease (pT2), PSMs range from 4.5 to 10.6 %, while for T3 disease they range from 20 to 47 %.

In an excellent review and meta-analysis by Ficarra et al. [13] comparing PSMs between RRP and RARP within institutions in five studies, RRP rates averaged 22.4 % versus 14 % in RARP, with

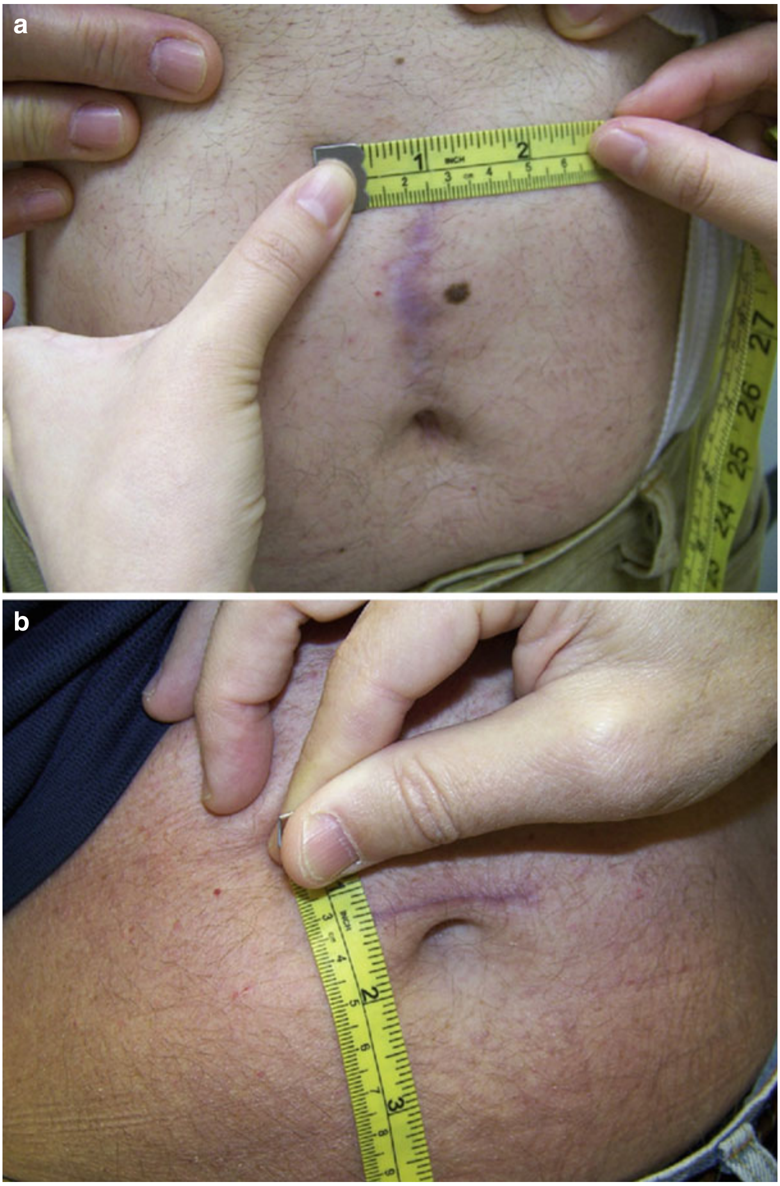


Fig. 30.1 Examples of a transverse versus midline incision scar

a relative risk of 1.6. For noncomparative studies, RRP PSM rates ranged from 12 to 37 % and RARP 9.4–21 %.

It has been shown that surgical margin status decreases with operative experience and is affected by clinical stage, serum PSA, and biopsy Gleason score [14].

Assessment of long-term biological progression (PSA) after RARP is fledgling at this time, in contrast to the more numerous but relatively short follow-up of reported series thus far. Menon et al. [15] reviewed their experience of 1,384 men with a median follow-up of 5 years, with 29 % of the men >5 years out. The actuarial biochemical recurrence-free survival (BCRFS) at years 1, 3, 5, and 7 was 95, 91, 87, and 81 %. The median time for PSA recurrence was 20.4 months, with ~2/3rds of men occurring within 3 years and 86 % by 5 years. Metastases occurred in 13 men, seven died of prostate cancer, and 29 died of other causes. Similar to open RRP, the greatest hazard ratios were for Gleason score 8–10

(HR = 5.4), pathological staging of pT3B/T4 disease (HR = 2.7), and positive surgical margins (HR = 2.4). Short-term follow-up results appear promising.

Initial short-term oncologic control outcomes with RARP are at least comparable to the open approach. However, in order for RARP to gain widespread acceptance as the alternative to the current gold standard, oncologic outcomes cannot be compromised. Longer follow-up with larger numbers and standardized review methods will help confirm the efficacy of robot assistance in treating organ-confined prostate cancer.

30.4 Quality of Life

30.4.1 Continence

The return of urinary continence after radical prostatectomy is of paramount importance for the patient's quality of life and to the surgeon as a marker of operative technique.

Caution should be exercised when comparing continence rates between series, as there is a lack of standardization in continence definition. The large discrepancy in continence rates between centers can be attributed to multiple variables including the use of different continence questionnaires, data collection and interpretation, patient and surgeon subjectivity, patient demographics, and surgical experience. Self-administered questionnaires consistently report poorer outcomes compared with the clinical interview which many institutions use to report their results [16]. Maybe the most important point that RARP has emphasized is the importance of defining continence as the need for no pads. Another RARP-associated change is the emphasis on how long it takes to attain pad-free continence. As we all know, older publications usually defined continence as 0–1 pads at a fixed time usually 1 year.

The impact of urinary continence on quality of life for men following RRP based on how many pads they wear (0, security, 1, 2, 3+) was reported by Liss et al. [17]. For men requiring no pads, the mean urinary QOL was rated one (pleased), whereas men wearing either a security pad or one pad had a mean QOL of about three (mixed). Fig. 30.2a depicts pad-free men have 75 % rate of total urinary control or occasional drippage, while the rates were ≤10 % for any type-pad user, leaving >90 % of pad users with frequent dribbling or no urinary control. The results are similar for bother score in Fig. 30.2b; ~75 % of pad-free men delighted or pleased versus ≤15 % for any pad user. Fifty percent of security and 75 % of single pad users had mixed to terrible bother scores. We also saw that clinically speaking, men did not see a clinically relevant difference between a security pad and one pad. The mean urinary QOL of wearing a security pad versus one pad was 2.8 versus 3.2 ($p = 0.03$).

Simply put any studies of continence which includes pad use will include men with frequent leakage and negative bother scores. A standardized "no-pad" continence definition and more rigorous standardized data collection and interpretation methods with validated questionnaires will be instrumental in making accurate comparisons. The continence rates of various open and robotic prostatectomy series are listed in Tables 30.2 and 30.3. Although no standard definition of continence was used, most open contemporary series report continence rates ranging from 69.9 to 96 % (Table 30.3). Walsh and co-workers [12] reported pad-free continence rates of 54, 80, and 93 % at 3, 6, and 12 months postoperative, respectively.

With ≥6-months follow-up, the urinary continence rates in reported RARP series range from 85 to 98 %. Patel and co-workers [18] reported no-pad continence rates of 27 % immediately after catheter removal, 47 % at 1 month, 82 % at 3 months, 89 % at 6 months, 92 % at 9 months, and 98 % at 1 year. Menon and associates [19] reported similar results, with a 96 % pad-free continence rate at 3 months. In a single-institution prospective comparative study, Tewari and colleagues [20] noted a faster return to continence in the RARP group compared to the open RRP group (50 % continence rate at 44 days vs 160 days, respectively). In our initial experience of 185 RALPs, 80 % were pad-free and 15 % used a security pad or one pad per day at 3 months. The

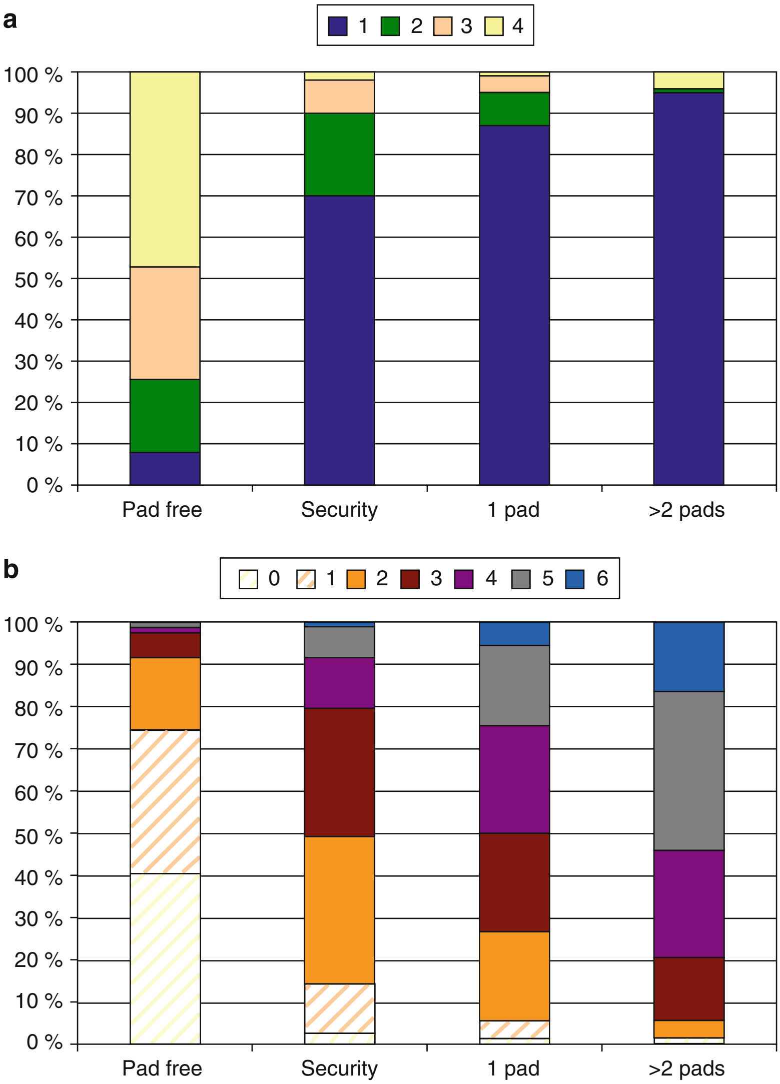


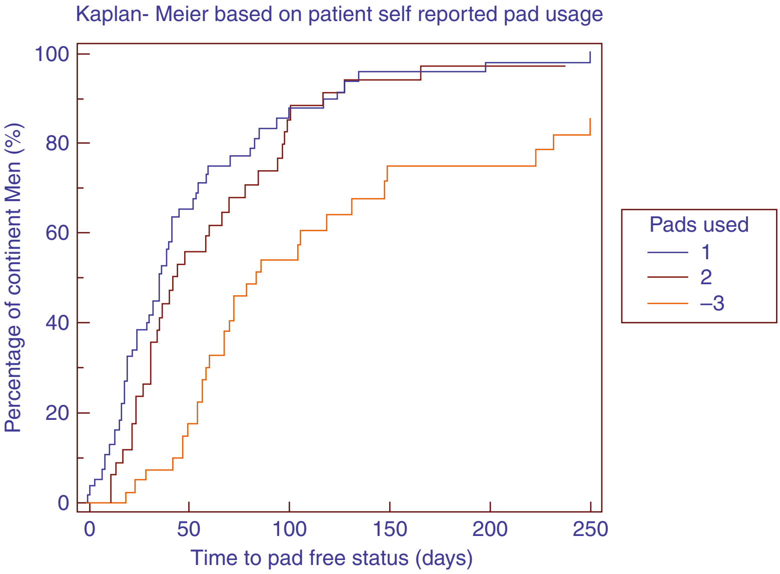
Fig. 30.2 (**a**) Percentage of men who experience total control or urinary leakage by self-reported pad usage: *1* no control, *2* frequent dribbling, *3* occasional dribbling, *4* total control. (**b**) Distribution of bother scores by patient self-reported pad usage: *0* delighted, *1* pleased, *2* mostly satisfied, *3* mixed, *4* mostly dissatisfied, *5* unhappy, *6* terrible [17]

overall pad-free continence rate was 85 % at 6 months and 92 % at 1 year [21].

A second critical improvement to the reconstruction of the bladder to the urethra is the Rocco stitch first described in 2006 [22]. The Rocco stitch is an extremely valuable addition by markedly improving the ease of performing the van Velthoven stitch by reducing tension, and is very hemostatic, greatly reducing ER and clinic visits for hematuria and clot retention. Incorporating the second addition of the Rocco stitch has lead to a very low bladder neck contracture rate (2/500).

We believe that maintenance of continence is improved with the robotic surgical system. Improved magnification, and superb visualization and decreased blood loss, allows the surgeon to better identify and preserve the urethral sphincter and levator muscles. This allows a more precise anatomical dissection of the prostatic apex and the urethral stump, and assists in performing a watertight urethrovesical anastomosis with mucosa-to-mucosa approximation. There appear to be patient characteristics like age, SHIM, and BMI which can independently influence postoperative continence results [23, 24]. But these influences have

Fig. 30.3 Time to attaining pad-free urinary continence based on patient self-report of number of urinary pads used on days 3–4. Men using ≥3 pads per day experience significant delays in returning to continence [67]



low hazard rates and are more global than specific in predicting an individual patient's outcomes. A more important approach may be simply assessing the pad weight or simply the number of standard urinary pads during the 1st week post catheter removal, as shown in Fig. 30.3.

A novel investigational technique has introduced locoregional hypothermia to the pelvis during robot-assisted radical prostatectomy (RARP) to reduce inflammatory injury. Regional pelvic cooling (<30^{0}C) was achieved with a prototype endorectal cooling balloon (ECB) during the course of RARP (Fig. 30.4). Continence was defined as no pads. Median time to zero pad use was 39 days versus 62 days (hypothermic vs controls, $p = 0.0003$). At 1 year, overall pad-free continence was 96.3 % (105/109) versus controls of 86.6 %, $p < 0.001$ [25] (Fig. 30.5). A randomized multicentered clinical trial will be needed for validation, after cooling parameters have been optimized.

30.5 Potency

Preservation of sexual function has significant impact on quality of life in men undergoing radical prostatectomy. These days, most radical prostatectomies are indebted to the anatomical principles described by Walsh in the early 1980s [26, 27], for a greater anatomical understanding which drastically reduced postoperative impotence. This conceptual work has been extended by RARP as noted in the previous potency chapters. An important caveat is that reporting variability makes true comparisons between series and operative technique a daunting task. Postoperative potency is greatly influenced by preoperative patient characteristics, with younger patients, and higher baseline sexual function having better outcomes. Intraoperative factors such as number of neurovascular bundles (NVB) preserved, surgeon experience, and nerve injury also influence potency. Therefore, to adequately compare potency rates between series, all of these factors must be accounted for. In addition, the use of pre- and post-validated questionnaires such as the 5-item International Index of Erectile Function (IIEF-5) also known as the Sexual Health Inventory for Men (SHIM) are not uniformly used. Centers should stratify patients who are potent with and without the aid of medications or erectile dysfunction devices. In this regard, the use of validated questionnaires and standardized reporting algorithms are essential to the acquisition of accurate data which can then be used to correlate erectile function with operative technique.

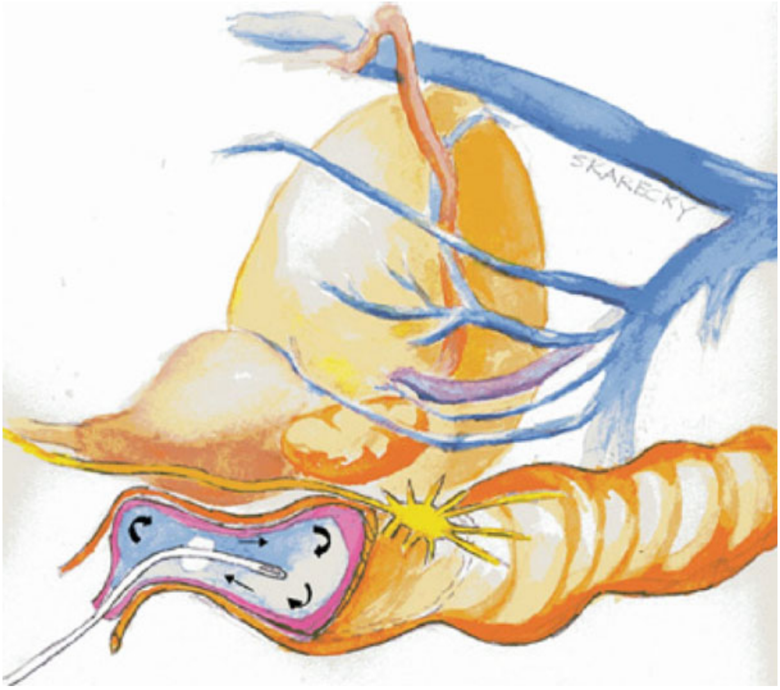


Fig. 30.4 Localized hypothermia induced via an endorectal balloon positioned below the prostate and nerve plexus and cooled via recycling cool saline [21]

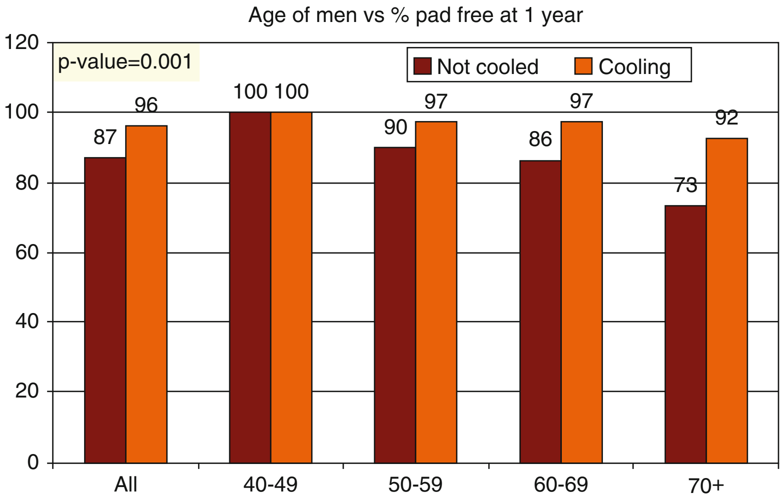


Fig. 30.5 Comparison of rates of pad-free continence at one year for men of increasing decades of age for men either cooled with hypothermia during surgery or not cooled. The impact of cooling during surgery is greatest in the older cohorts [25]

Notwithstanding the above, potency rates after open RRP range from 8.2 to 86 %, with higher volume centers obtaining better outcomes (Table 30.3). Walsh and co-workers reported potency rates of 38, 54, 73, and 86 % at 1, 3, 12, and 18 months following RRP, respectively. When stratified by age, patients under age 50 had a 90 % potency rate with either unilateral or bilateral NVB preservation [12].

Techniques such as bipolar electrocautery, harmonic scalpel, and Ligasure have been introduced in an attempt to reduce thermal and stray electrical injury to the neurovascular bundles. However, in a dog model, Ong et al. [28] demonstrated significant decreases in erectile response when using monopolar and bipolar hemostatic cautery in close proximity to the NVBs. We previously described [29] the cautery-free, clip-free

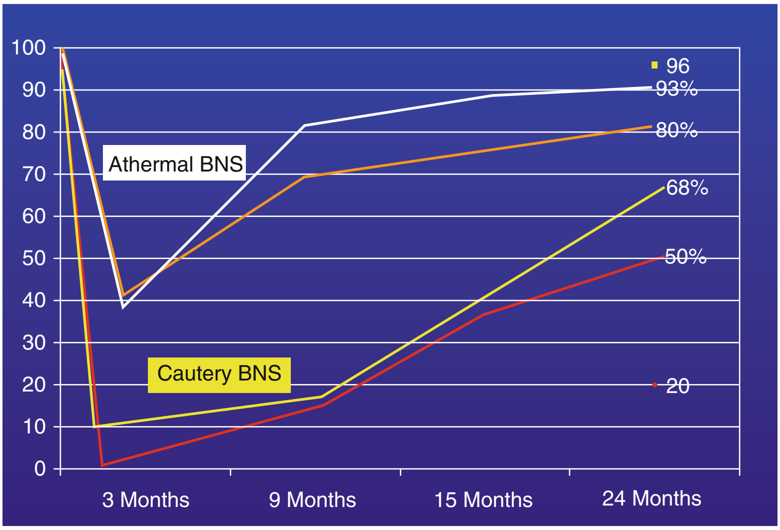


Fig. 30.6 Time to recovery of sexual function for bi- and unilateral nerve sparing using either bipolar cauter (*thermal*) or bulldog (*athermal*) technique for men with IIEF-5 ≥22 and age ≤65 with RARP [30]

dissection of the cavernous nerves to decrease nerve injury during RARP and hence improve potency. That technique involves placing a bulldog clamps on the lateral pedicles prior to cautery-free, sharp dissection of the pedicles and the NVBs of the prostate. Figure 30.6 shows a more comprehensive 2-year follow-up of prepotent men aged ≤65. We saw a dramatic short-term improvement over our previous technique, in which we used bipolar cautery to control the vascular pedicle; 43 % versus 8 % of men (≤65 years and preoperative IIEF-5 of 22–25) have return of erectile function with the cautery-free technique at 3 months with or without 5-PDE inhibitors. Additionally, only 18 % of patients with the cautery-free technique failed to have partial erections compared to 68 % in the bipolar group [30]. By year two, potency rates for men with thermal cautery (68 %) approach athermal rates of ~90 %, implying transient nerve damage inflicted by thermal techniques. Regardless of the specific surgical technique used to preserve the NVBs, to help maintain sexual function, electrocautery should be minimal or avoided to prevent thermal spread and injury of the nerves.

The mainstay to nerve preservation is avoiding nerve transection followed by reduction of traumatic or thermal injury. In their literature review, El-Hakim and Tewari reported that at an average of 7.7 months post RALP, 49.5 % of patients were having intercourse and 79 % had return of erections, with or without medical assistance [31]. Menon and colleagues identified an accessory lattice of nerves on the ventral and lateral prostatic fascia (the veil of Aphrodite) which they hypothesize may be critical in the return of erectile function after RARP. In a selected subset of 35 patients in which the veil of Aphrodite was preserved, 95 % had erections strong enough for intercourse at 1 year and presented in an earlier chapter [32].

30.6 The "Trifecta"

A recent concept combines three elements into the "trifecta" score: progression-free PSA, continence, and potency are combined into one scorecard and success rated when all three are attained. As a "gold standard," it has several weaknesses. Impotent or men with ED generally are excluded. Additionally, men not having bilateral nerve sparing, who are at higher risk of extra prostatic extension and BCR, skew Trifecta results. This leaves a percentage of men analyzed for a "trifecta" score. Note the majority of the men at risk for QOL failure presenting for RARP are excluded from the trifecta, leading to inflated "excellent" and misleading results for the "average" men considering treatment. Guillionneau also questions the validity of whether QOL outcomes are truly equal in value to survival [33]. Most importantly, PSA progression-free rates decline with time as noted in Menon et al., BCR free rates from 95 %, 91 %, at years 1, 3, to 87 % and 81 %, 5 and 7 years [15]. Hence, trifecta overstates success at 1–2 years as BCR rates deteriorate with time.

Conclusion

Robotic-assisted radical prostatectomy has shown to be a more easily acquired laparoscopic technique, with shorter learning curves, and now rivals the open procedure as best practice. We are witnessing a paradigm shift from open to robotic radical prostatectomy as the procedure of choice worldwide. When compared to the open approach, early studies indicate that robotic prostatectomy has equal outcomes in short-term oncological control, potency and continence, and potentially favorable perioperative outcomes such as in blood loss and transfusion rates, minor complications, narcotic use, convalescence, and length of hospital stay. However, robotic-assisted laparoscopic radical prostatectomy has now matured and comparable to open radical prostatectomy. Experienced urologic oncologists with open radical prostatectomy have set high standards in oncologic and functional outcomes. In light of present day open radical prostatectomy, in order to determine the true place of robotics in the surgical pantheon, validated questionnaires and analog assessment scales are essential to determine true functional results and need to be combined with careful long-term follow-up of oncologic outcomes. Prospective cooperative interinstitutional studies of this nature are beginning to be reported by some centers. Now almost a decade old, the long-term outcomes of robotic prostatectomy are now beginning to emerge, and evidence-based accounting of this and other robotic techniques will bear out, if this is a true technical advance in oncologic and quality of life outcomes.

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Urinary Incontinence After Robotic-Assisted Laparoscopic Radical Prostatectomy

31

Kevin G. Chan and Timothy G. Wilson

31.1 Introduction

Urinary incontinence following radical prostatectomy continues to be a significant problem despite improving surgical techniques. Robotic surgical techniques have the potential to improve urinary outcome measurements even more than their open predecessors. Improved visualization and precision of dissection with robotic technology offer a truly anatomic approach. The main purpose of this chapter is to summarize the status of urinary outcomes following robotic-assisted laparoscopic radical prostatectomy as well as to discuss the most current therapies used in the treatment of post-prostatectomy urinary incontinence. We also discuss the etiology of post-prostatectomy urinary incontinence, contributing risk factors, and the evaluation for incontinence as they are intimately related to prostatic surgical technique and incontinence interventions.

31.2 Incidence of Urinary Incontinence Following Radical Prostatectomy

The incidence of urinary incontinence following radical prostatectomy varies widely depending on the definition of incontinence used, era in which that data was collected, and variations of surgical technique. Open radical retropubic prostatectomy continues to be the gold standard by which all other techniques are compared. To examine the incidence of urinary incontinence following robotic-assisted laparoscopic radical prostatectomy (RALRP), one must evaluate outcomes in relation to the established open standards. Table 31.1 summarizes representative reports of urinary continence rates following radical retropubic prostatectomy, radical perineal prostatectomy, laparoscopic radical prostatectomy, and robotic-assisted laparoscopic radical prostatectomy.

As open and laparoscopic techniques have been refined, two areas of urinary continence continue to improve, overall continence rate and time to continence. These are the two areas that may ultimately demonstrate the benefit of robotic technology in radical prostate surgery. When evaluating overall continence rate, it is most accurate to compare 2-year outcomes. Multiple long-term reports have shown a relatively small but statistically significant improvement in continence from the 1-year- to the 2-year follow-up [1, 2]. Time to continence is an outcome in radical prostatectomy series that has only been recently assessed with the development of competing techniques.

Table 31.1 summarizes radical prostatectomy continence outcomes from large contemporary open retropubic and perineal series as well as laparoscopic and robotic-assisted laparoscopic series. Regardless of approach, we observe high

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Table 31.1 Incidence of urinary incontinence following radical prostatectomy

Author	Approach	Year	No. of cases	Definition of continence	% Continent at 1 month	% Continent at 3 months	% Continent at 6 months	% Continent at 12 months	% Continent at 24 months
Rocco et al. [85]	Retropubic	2007	250	One pad or less/day	74	85	NR	94	NR
Marien and Lepor [20]	Retropubic	2008	610	"Total urinary control" or "occasional urinary dribbling"[a]	NR	NR	NR	NR	97
Harris [86]	Perineal	2006	704	No pads	52	71	85	94	NR
Martis et al. [87]	Perineal	2007	100	No pads	NR	NR	74	NR	96
Goeman et al. [88]	Laparo scopic	2006	550	No pads	NR	NR	NR	83	91
Takenaka et al. [88, 89]	Laparo scopic	2009	135	No pads	13	41	63	79	NR
Stolzenburg et al. [90]	Laparo scopic	2009	2,400	No pads	NR	72	81	95	NR
Potdevin et al. [91]	Robotic	2009	147	No pads	47	76	93	NR	NR
Reynolds et al. [92]	Robotic	2009	198–679[b]	One pad or less/day	20	52	75	88	90
Menon et al. [93]	Robotic	2007	1,110	One pad or less/day	NR	NR	NR	95	NR

NR not reported
[a] University of California Los Angeles Prostate Cancer Index
[b] Sample size was variable at different intervals of follow-up

overall continence rates as well as high early continence rates. Overall, 2-year continence rates ranged from 90 to 97 %. More remarkable are the 3-month continence rates in these series which range from 41 to 85 %. Time to continence is an exciting and intriguing area of study when evaluating the various radical prostatectomy techniques.

31.3 Mechanism of Urinary Incontinence Following Radical Prostatectomy

To evaluate the mechanism of urinary incontinence following radical prostatectomy, we must rely on data obtained from open radical prostatectomy series. The three major causes of urinary incontinence following radical prostatectomy include bladder dysfunction, sphincteric dysfunction, and overflow incontinence, although a combination of mechanisms may be present.

Most evidence supports the idea that post radical prostatectomy urinary incontinence is primarily due to sphincteric dysfunction. While bladder dysfunction, either a loss of compliance or detrusor overactivity, may be present in a significant number of patients after radical prostatectomy, its influence on urinary incontinence is debated.

Several studies have urodynamically evaluated radical prostatectomy patients preoperatively and postoperatively. Majoros et al. evaluated their patients at a relatively early period postoperatively (2 months) and found sphincteric dysfunction in 90 % of their incontinent patients. Isolated bladder dysfunction was rarely a cause of incontinence [3]. Kleinhans et al. also urodynamically evaluated radical prostatectomy patients preoperatively and postoperatively (mean 7.6 months after surgery) and found that all incontinent patients had sphincteric weakness [4]. A similar study by Pfister et al. showed sphincteric dysfunction in 85 % of incontinent patients at 3 months after surgery [5].

Ficazzola et al. prospectively evaluated 60 incontinent patients with video urodynamics at least 6 months following radical retropubic prostatectomy. Sphincteric dysfunction was detected in 90 % of patients. Forty-five percent of patients were found to have some component of bladder dysfunction, but only 3 % of incontinent patients had bladder dysfunction alone [6]. Leach et al., evaluating incontinent patients following one of a variety of prostate procedures, reported that 56 % of prostate cancer surgery patients had a "major component of high-pressure bladder." However, in this same group of patients, 82 % had a component of sphincteric dysfunction. In addition, anticholinergic medication alone rarely cured a patient (4.7 %).

The mechanism of post radical prostatectomy urinary incontinence has also been studied at the neuroanatomical level. These studies have been performed under the basic premise that the male rhabdosphincter is the primary source of continence in men following radical prostatectomy. It has long been known to be innervated by somatic branches of the pudendal nerve. Several groups have proposed additional neural pathways to the rhabdosphincter that could potentially be damaged during radical prostatectomy.

Narayan et al. demonstrated a neural branch to the rhabdosphincter that arises from the dorsal nerve of the penis and enters the infraprostatic urethra at the 9–12 o'clock positions and 1–3 o'clock positions [7]. While the dorsal nerve of the penis does arise from the pudendal nerve, its function is primarily sensory, and this branch to the rhabdosphincter may be a part of the urinary guarding reflex pathway [8]. Hollabaugh et al. demonstrated that parasympathetic fibers arising from the inferior hypogastric plexus, continuing as the pelvic nerve, course inferolateral to penetrate the prostate and rhabdosphincter [9]. These branches may also play a role in the urinary guarding reflex pathway but may also be damaged during radical prostatectomy. Further supporting this theory, John et al., measuring sensory thresholds at the bladder neck and proximal membranous urethra, showed a significantly higher sensory threshold in incontinent patients after radical prostatectomy [10]. This suggests that potential damage to branches leading to the rhabdosphincter during radical prostatectomy decreases afferent nerve conduction that may be part of a reflex pathway.

Overflow incontinence secondary to anatomic obstruction from a urethrovesical anastomotic stricture is not uncommon. Its incidence has been reported to be 4.5–27.9 % [2, 11, 12]. Sacco et al. additionally found a 33.8 % stricture rate among their incontinent patients [2]. Our series of laparoscopic and robotic-assisted laparoscopic radical prostatectomies showed a bladder neck contracture rate of 2.2 and 0.6 %, respectively, suggesting a possible advantage with a robotic technique [13]. Nonetheless, this evidence supports the multifactorial nature of incontinence following radical prostatectomy and supports the need for diligent and complete evaluation of all incontinent patients after radical prostatectomy.

31.4 Risk Factors for Urinary Incontinence Following Radical Prostatectomy

While the data regarding risk factors for urinary incontinence following radical prostatectomy is rapidly accumulating, it remains difficult to draw many definite conclusions. Even the most commonly identified risk factors remain controversial. Age and nerve sparing status continue to be the most debated predictors for post-prostatectomy urinary incontinence. We will also discuss several other factors that may ultimately be found to influence continence rates after radical prostatectomy including previous prostatic surgery, certain urethral and prostatic measurements, presence of a urethrovesical anastomotic stricture, obesity, and prostate size.

Age was identified by Eastham et al. in a multivariate analysis to significantly influence continence rates, and this finding was reproduced by others [2, 14]. Eastham had reported that 15 % of their patients were over the age of 69 which is a somewhat higher proportion than most series. Another multivariate analysis of 742 patients, including 26 % of whom were older than 70 years old, did not find age to be a risk factor [15]. The two series, however, are truly not comparable. Eastham's group only had 10 % non-nerve sparing patients, whereas Wille's group had approximately 90 % non-nerve sparing patients. Another recent report by Burkhard et al. did not demonstrate age to be significant risk factor in a series of 536 patients. While the proportion of non-nerve sparing patients was similar to that of Eastham's, it is unclear how many patients over 70 there were in the Burkhard group [16]. Interestingly, Twiss et al. showed that patients under the age of 50 did not experience an improved continence rate, suggesting that the age threshold, if it exists, is beyond 50 years old [17]. The literature specifically regarding robotic-assisted laparoscopic radical prostatectomy (RALRP) also supports age as a risk factor for post-prostatectomy urinary incontinence. Novara et al. evaluated 308 consecutive patients who underwent RALRP, and age was identified as an independent predictor of 12-month continence on multivariable analysis [18]. Ultimately, the evidence suggests increased rates of urinary incontinence with advancing age following radical prostatectomy, but the data is not conclusive.

Nerve sparing status is another controversial risk factor for urinary incontinence. Eastham identified nerve sparing status as a risk factor at a period within which nerve sparing was relatively newly established [14]. Other large contemporary open series have subsequently reproduced these findings [2, 16]. Most reports that have contradicted these findings have either been small in size or had a disproportionately small number of non-nerve sparing patients [1, 15, 19, 20]. In a contemporary radical perineal prostatectomy series, nerve sparing proved to be an independent predictor of earlier recovery of continence on multivariate analysis [21]. With specific regards to RALRP, Berry et al. evaluated 628 patients undergoing open, laparoscopic, or robotic radical prostatectomy, and regardless of technique, the bilateral nerve sparing cohort demonstrated improved 3-month continence rates ($p = 0.007$) and no significant differences at 6 months and longer [22]. The evidence suggests that nerve sparing status may at least improve early continence rates and may ultimately improve total continence rates.

Several urethral measurements have been identified as potential risk factors for urinary incontinence following prostatic surgery. Coakley et al. found that patients with longer preoperative membranous urethral lengths, measured by MRI, were shown by multivariate analysis to have a significantly shorter time to stable postoperative continence [23]. Paparel et al. recently corroborated these results finding that both preoperative and postoperative membranous urethral length were significantly associated with time to recovery of continence [24]. Another multivariate analysis, by Oefelein, found that longer prostatic urethral length, measured by transrectal ultrasound, was significantly associated with a prolonged time to urinary continence [12]. Finally, Lee et al. demonstrated that patients with a prostatic apex that did not anteriorly or posteriorly overlap the membranous urethra, as shown by preoperative MRI, had a significantly earlier return of urinary continence [25]. While each of the urethral parameters evaluated were different, they all related to an improved intraoperative ability to preserve membranous urethral length during surgery which may ultimately be shown to shorten time to continence.

Contemporary open and laparoscopic radical prostatectomy series suggest a relationship between prostate gland size and time to urinary continence. This may be related to increased operative difficulty in nerve and sphincter preservation. In a multivariable analysis of 1,422 patients who underwent open or laparoscopic radical prostatectomy, there was a small but not statistically significant relationship found between pathologic prostate weight and 1 year continence rates ($p = 0.08$) [26]. Konety et al., utilizing the CaPSURE national disease registry of men with prostate cancer, found that men with prostate volumes greater than 50 g on transrectal ultrasound had lower rates of continence at 6 months and

1 year after radical prostatectomy, but at 2 years, this difference equalized [27]. Milhoua et al. reported in 137 patients undergoing laparoscopic radical prostatectomy that patients with pathologic prostate weights of greater than 70 g had a significantly delayed time to continence [28]. Thus, while prostate size may not influence final continence status, the evidence suggests it may influence time to continence.

The relationship between obesity, as measured by body mass index (BMI), and post-prostatectomy urinary incontinence remains to be defined. Ahlering et al., in a robotic radical prostatectomy series of 100 patients, found that patients with a body mass index (BMI) of <30 had a significantly improved continence rate compared to those with a BMI of 30 or greater [29]. Wolin et al., in a report specifically evaluating the role of obesity in post-prostatectomy incontinence, found that at 58 weeks, the rates of incontinence were higher in obese (BMI > 30) men (31 %) than in nonobese men (18 %) ($p = 0.05$) [30]. However, there are a robust number of reports in both the open and robotic radical prostatectomy series that demonstrate no correlation between BMI and postoperative continence status [18, 20, 31].

Previous transurethral prostate surgery has been examined in numerous series. While it always appears to be mentioned in any discussion of risk factors for urinary incontinence, the evidence does not really support this. The majority of series demonstrate that previous prostate surgery does not significantly influence continence outcomes [2, 14, 15]. Colombo et al. reported a series of 109 radical retropubic prostatectomy patients who underwent previous transurethral (71 patients) or open prostatectomy (38 patients) for benign disease. The continence rates at 6 and 12 months were 74 and 86 %, respectively. There did not appear to be a statistically significant difference to their retrospectively matched controls [32]. Previous transurethral prostate surgery does not appear to be a risk factor for urinary incontinence following radical prostatectomy.

The presence of a urethrovesical anastomotic stricture appears to be a significant risk factor for urinary incontinence [2, 14]. This may ultimately be due to the fibrosis incorporating the external sphincter or related to the treatment of the stricture. Interestingly, it has also been suggested that anastomotic stricture may be related to surgical technique. Hu et al. reported on an analysis of 8,837 patients from the United States Surveillance, Epidemiology, and End Results (SEER)-Medicare data, and found a significantly lower anastomotic stricture rate in patients undergoing minimally invasive radical prostatectomy (with or without robotic assistance) compared with those undergoing open radical prostatectomy [33]. This finding was also corroborated in a single surgeon series of 200 consecutive radical prostatectomies, 100 open, and 100 robotic, where there were no anastomotic strictures in the robotic group compared to 9 patients in the open group [34]. This may potentially be explained by the improved vision and precision of the anastomotic technique provided with minimally invasive approach. However, with the relatively small numbers of patients with both incontinence and anastomotic strictures, this correlation of surgical approach, anastomotic stricture, and continence status may be difficult to demonstrate.

31.5 Evaluation for Urinary Incontinence Following Radical Prostatectomy

Evaluation of post radical prostatectomy urinary incontinence is based on the etiology of the incontinence as well as the treatment options available. Our standard evaluation includes a thorough history to elicit the volume of incontinence, type of incontinence, storage symptoms, and voiding symptoms. A voiding diary and questionnaire such as the International Consultation on Incontinence Questionnaire-Short Form (ICIQ-SF) will help in quantifying the problem. The history will commonly paint a clinical picture of classic stress urinary incontinence, urge incontinence that may be related to overflow incontinence or detrusor overactivity or a mixture of stress and urge incontinence. The standardized 1-h pad test is also useful in assessing the incontinence.

Objective evaluation, in addition to physical examination, includes flexible cystourethroscopy and multichannel urodynamic evaluation. Cystourethroscopy is critical to evaluate the degree and sustainability of volitional external sphincter coaptation which can aid in identifying those patients who may be a candidate for a male sling procedure. Cystourethroscopy is also important to rule out urethrovesical anastomotic strictures. In addition, other less common findings of an obstructing bladder neck stone, urethral stricture, or bladder mass may be identified as the etiology of the incontinence.

A multichannel urodynamic evaluation including the minimum of a complex cystometrogram, pressure-flow study, and electromyelogram is also performed. The main purpose of this evaluation is to evaluate for detrusor hypoactivity or detrusor overactivity. With male slings as a major part of the armamentarium for incontinence treatment, it is important to demonstrate normal detrusor function prior to placement or risk permanent urinary retention. If the urodynamic evaluation demonstrates evidence of detrusor overactivity, this may direct treatment toward a trial of anticholinergic therapy before considering surgical intervention.

31.6 Management of Urinary Incontinence Following Radical Prostatectomy

There is a range of therapies available for the patient with post radical prostatectomy urinary incontinence. Ultimately, treatment options depend on the results of their incontinence evaluations.

31.6.1 Detrusor Overactivity

If a component of detrusor overactivity is identified by either subjective or objective assessment, it is most reasonable to offer a trial of anticholinergic therapy prior to possible surgical intervention [6, 35]. If isolated detrusor overactivity is identified with no evidence of stress urinary incontinence, and that patient fails medical therapy, one may consider second-line therapies for overactive bladder such as sacral neural modulation or intravesical botulinum toxin injection.

31.6.2 Urethrovesical Anastomotic Strictures

If a urethrovesical anastomotic stricture is identified, transurethral incision of the stricture is indicated. We generally perform this with either a holmium laser or cold knife. The patient then undergoes repeat cystoscopy in 6 months to ensure that the stricture is resolved and stable prior to any incontinence intervention. Often, treatment of these strictures leads to subsequent stress incontinence or unveils stress incontinence that was not assessable with the stricture present. Managing this incontinence with surgical intervention can be very troublesome because of the possibility of recurrent stricture which would then be difficult to treat.

Management of urinary incontinence associated with problematic recurrent urethral stricture has been attempted by a range of interventions. The simplest measure would be clean intermittent catheterization or a self-dilation regimen. We have found that hydrophilic catheters do well for this particular problem. Multiple groups have described the method of Urolume™ stent (American Medical Systems) placement followed by placement of an artificial urinary sphincter 6 weeks to 3 months later [36–38]. This is performed in patients with a completely obliterated urethral lumen who fail at least one recanalization and self-calibration course. This technique has achieved moderately good results with intermediate follow-up. Complex abdominoperineal, transpubic, and perineal approaches to these troublesome strictures have also been described with good success and sometimes required a subsequent artificial urinary sphincter [39, 40]. Ultimately, a supravesical continent or incontinent urinary diversion may be required if other means fail.

31.6.3 Post-prostatectomy Stress Urinary Incontinence

Once urinary incontinence due to sphincteric dysfunction has been identified by subjective or objective assessment, a range of treatment options are available. Stress urinary incontinence identified within the first year after radical prostatectomy is generally treated with noninvasive behavior therapy techniques.

There can be significant improvement seen in the first to the second year postoperatively [1]. If one sees slow but gradual improvement, it would not be unreasonable to continue observing the patient up to 2 years. If there is a significant degree of incontinence or patient dissatisfaction at 1 year despite completing a course behavioral therapy, we would proceed with evaluation for incontinence and surgical intervention.

31.6.3.1 Behavioral Therapy

Behavioral therapy for urinary incontinence includes pelvic floor exercises (PFE) with or without biofeedback (BFD) and with or without electrical stimulation (ES). Pelvic floor exercises generally include multiple sessions of formal instruction by a physical therapist. Biofeedback is performed by using either an anal pressure probe or patch electrode to transmit a visual display to the patient that the appropriate muscular contraction is being performed. In theory, this visual reinforcement is thought to improve the patient's quality of exercise. Electrical stimulation utilizes an electric current sent to the pelvis to stimulate contraction of the pelvic floor musculature. In theory, this is helpful in patients who are initially unable to volitionally contract the appropriate pelvic floor muscles or to improve awareness of the muscles they should be working.

There have been numerous reports on the role of behavioral therapy in post-prostatectomy stress urinary incontinence. Multiple studies have shown an improvement in time to continence with the use of PFEs, but not an overall change in long-term continence outcome [41–43]. The adjunctive use of biofeedback or electrical stimulation does not appear to add any benefit over PFEs alone [43–45].

31.6.3.2 Medical Therapy

At this time, there is no pharmacologic treatment approved for stress urinary incontinence in men. However, duloxetine has been approved for use in women for the treatment of moderate and severe stress urinary incontinence by the European Medicines Agency since August of 2004. Duloxetine is a balanced and potent inhibitor of serotonin and norepinephrine reuptake. Duloxetine has been found to increase bladder capacity and increase periurethral striated muscle electromyographic activity in cats through a central neural mechanism [46]. The increased concentration of serotonin and norepinephrine is thought to raise the activity of pudendal motor neurons, leading to an increase in striated urethral sphincter tone and detrusor relaxation.

Three phase three double-blind, placebo-controlled studies involving 1,635 women in North America, South America, Europe, Australia, and Africa all showed significant improvement in stress urinary incontinence versus placebo [47–50]. While efficacy was clearly demonstrated in these studies, there were two other notable findings, a high discontinuation rate and a high placebo response. The common side effects were nausea, fatigue, insomnia, dry mouth, and constipation. The discontinuation rate due to side effects ranged from 17 to 24 %. With regards to placebo response, 33–43 % of patients who received placebo had 50–100 % decreases in incontinence episode frequency.

There have been some early studies looking specifically at the off-label use of duloxetine for the treatment of post-prostatectomy urinary incontinence. Filacamo et al. evaluated 112 patients undergoing radical prostatectomy and randomized patients to pelvic floor muscle training with or without duloxetine [51]. There appeared to be some benefit from duloxetine up to 16 weeks, but the results reversed at the 20th week. Shortly after discontinuing the medication, continence rates were actually worse in the duloxetine treatment group at 20 and 24 weeks. A more recent prospective, placebo-controlled, double-blind, randomized, superiority study in men with mild to moderate stress urinary incontinence at least 1 year after surgery showed significantly reduced incontinence in patients taking duloxetine compared to placebo at 12 weeks of follow-up [52]. Unfortunately, the data regarding duloxetine in men with post-prostatectomy

Table 31.2 Outcomes for collagen injection for post-prostatectomy urinary incontinence

Author	Year	No. of patients	Mean follow-up (months)	Median follow-up (months)	% Cure/improved	Mean duration of response (months)
Aboseif et al. [55]	1996	72	10	NR	66 %	NR
Faerber and Richardson [56]	1997	47	38	NR	15 %	NR
Smith et al. [57]	1998	62	NR	29	39 %	17.5
Westney et al. [58]	2005	322	40	NR	44 %	7.3

NR not reported

urinary incontinence remains limited to small, off-label, short-term studies.

The central acting role of duloxetine, the relatively high discontinuation rate due to side effects, and the high placebo responses in the three phase three studies will likely play an important role in determining the efficacy of duloxetine in men with post-prostatectomy urinary incontinence. The proposed central acting mechanism of duloxetine requires intact innervation of the external sphincter. The integrity of this neural pathway after radical prostatectomy is uncertain. Secondly, high discontinuation rates due to side effects will make a potential prophylactic role after surgery difficult. Finally, most radical prostatectomy patients recover their urinary control within 1 year. The presence of a large placebo response in previous studies necessitates large randomized, double-blind, placebo-controlled trials in men to accurately evaluate the efficacy of medical therapy.

31.6.3.3 Transurethral Injection Therapy

Transurethral injection therapy for post-prostatectomy urinary incontinence has been described using polytetrafluoroethylene, polydimethylsiloxane (Macroplastique®), zirconium carbon-coated beads (Durasphere™), and glutaraldehyde cross-linked collagen. Animal studies demonstrating granuloma and emboli formation led to the discontinuation of polytetrafluoroethylene injections in the United States of America [53]. While Durasphere™ and collagen are equally available, most of the long-term published reports utilize only collagen.

Skin testing is required 1 month prior to collagen injection. Then using either local or general anesthetic, collagen is injected submucosally under direct vision at the urethra proximal to the external sphincter at the right and left sides or using a four-quadrant technique (at the 2, 4, 8, and 10 o'clock positions) [54, 55]. Side effects are usually minor but include self-limiting hematuria, transient urinary retention, and urinary tract infection [56].

Urinary continence outcomes using transurethral collagen have been disappointing in terms of overall continence rate as well as durability of response as shown in Table 31.2. Short-term reports have demonstrated cure/marked improvement rates as high as 66 % or 75 % social continence [54, 55]. However, reports with longer follow-up have demonstrated a 2 % cure rate at 1 year and 15–44 % cured/greatly improved rate overall [56–58]. Despite its overall poor outcomes, transurethral collagen does have a role in the select patient. These include patients with significant comorbidities that would not tolerate general anesthesia and patients with detrusor hypoactivity and mild incontinence.

31.6.3.4 Male Slings

The concept of upward compression of the bulbous urethra for the treatment of post-prostatectomy urinary incontinence was initially introduced in 1972 by Joseph Kaufman [59]. However, it was not until the late 1990s that male slings were revisited with Schaffer et al. presenting their series of bulbourethral slings in men with post-prostatectomy urinary incontinence. Since that time, there has been a rapid resurgence in the development of male slings. Currently, there are three types of slings available in the treatment of post-prostatectomy urinary incontinence:

compressive slings, functional slings, and adjustable slings. Male slings play an important role as an intermediate alternative to the artificial urinary sphincter. There are two important caveats when considering a male sling. First, there is a strong body of evidence that shows patients with a history of previous radiation have significantly worse outcomes with slings, regardless of sling type [60–62]. The second important caveat is that there should be no evidence of detrusor areflexia. In such cases, an artificial sphincter should be considered, or one could proceed with a sling as long as the patient has the expectation for the high possibility of permanently requiring clean intermittent catheterization.

The technique of bulbourethral sling utilizing retropubic needle passage was originally described by Schaeffer [63]. Briefly, it involves placement of a suprapubic catheter and two separate incisions. Three tetrafluoroethylene bolsters are placed beneath the bulbar urethra through a perineal incision. Nonabsorbable sutures attached to each end of the bolsters are then passed from the perineal incision to a suprapubic incision using a modified Stamey needle. The sutures are then tensioned to 60 cm of H_2O and tied over the rectus fascia. Retightening involves reopening the suprapubic incision and retying the nonabsorbable sutures. Similar slings using a strip of polypropylene or a composite of polypropylene and porcine skin collagen as the sling material instead of tetrafluoroethylene have also been described [64, 65]. Complications for the bulbourethral sling using retropubic needle passage include prolonged perineal pain (12–100 %), urethral erosion/infection requiring removal (8–11 %), urinary retention requiring tension release (6 %), transient retention (2 %), and unrecognized suture in bladder (2 %) [63, 65–67].

The technique of the bone-anchored sling, also known as the InVance™ male sling, was originally described by Comiter [68]. Briefly, it involves an approximately 4-cm incision in the perineum. The urethra is minimally dissected down to expose fat around the bulbospongiosus or to expose the bulbospongiosus muscle itself. A 2-cm dissection of the medial aspects of the descending pubic rami is performed, and titanium bone screws loaded with a pair polypropylene sutures are inserted on the pubic rami symmetrically using either a four or six-suture technique. The sutures are then used to tie down either a synthetic, absorbable, or composite piece of mesh that compresses the bulbar urethra to a pressure of 60 cm of H_2O. Complications for the bone-anchored sling include transient perineal pain/scrotal numbness (19–73 %), transient urinary retention (4–12 %), infection/urethral erosion (2–8 %) requiring removal, screw dislodgement requiring reoperation (4 %), and perineal hematoma (rare) [60, 68–73].

The first functional retrourethral transobturator sling was described by Rehder and Gozzi and is available as the AdVance® sling (American Medical Systems, Minnetonka, MN) [74]. This sling utilizes a polypropylene mesh placed through a perineal incision and passed bilaterally through a transobturator route. This “functional” sling is thought to reposition the bulbar urethra into the pelvis, reestablishing support to the external sphincter previously provided by the prostate. There also appears to be a passive compressive component that likely contributes to its effectiveness. Common complications include transient urinary retention (21 %) and mild perineal discomfort for 4–6 weeks. (2 %) Major complications appear rare. In a series of 230 patient treated with the Advance sling, three patients (1 %) required reoperation due to complication (unrecognized urethral injury, urethral obstruction, and pubic syphilitic) [75] . Other male transobturator slings are in development, but their data is still preliminary.

There are three adjustable slings currently available for the treatment of post-prostatectomy urinary incontinence: the Adjustable Continence Therapy (ProACT®; Uromedica, Plymouth, MN), the Remeex® sling (Neomedic International, Barcelona, Spain), and the Argus® (Promedon SA; Cordoba, Argentina) adjustable bulbourethral sling.

The ProACT sling utilizes two silicone balloons placed on both sides of the bladder neck, with each balloon connected to a titanium port placed in the scrotum. Open and ultrasound-guided percutaneous placement techniques have been described [76, 77]. Adjustments are made percutaneously by using the percutaneous ports in the scrotum, typically requiring an average of 3.3–3.6 adjustments to achieve a satisfactory result [62, 78]. The common complications with the ProACT sling in more contemporary series include intraoperative bladder perforations (2–2.5 %), device migration (4.8–5 %), erosions (3.2 %), wound infections (8 %), and temporary urinary retention (1–6 %) [62, 78].

The Remeex sling utilizes a monofilament suburethral sling (placed perineally) that is attached to a regulator with monofilament tensioning sutures (placed suprapubically). Adjustments are made by reopening the suprapubic incision under local anesthesia and changing the tension using a screwdriver-type device. Common complications include intraoperative bladder perforation (10 %), device infection (4 %), mild perineal hematoma (6 %), and urethral erosion (2 %) [79]. Bladder perforations are managed by simply performing an additional suture passage at the time of surgery. Device infection and urethral erosion require device removal.

The Argus system is also placed with a combined suprapubic and perineal approach utilizing silicone cushions to compress the urethra, tensioning silicone columns brought from the perineum to the suprapubic incision, and silicone washers maintain tension. Loosening is performed under general anesthesia, and tightening is performed using local anesthesia. Common complications include urethral erosion (13 %), transient perineal discomfort (15 %), device infection (3 %), and bladder perforation (5 %). The urethral erosions and device infections are treated with explantation.

In terms of outcome, Table 31.3 summarizes intermediate-term results for the various slings. Although the definition of "cure" may vary somewhat between studies, we observe relatively high cure rates with all the male slings, ranging from 52 to 81 %. Dikranian et al. demonstrated an improved performance with synthetic, nonabsorbable mesh over absorbable mesh with the bone-anchored sling [80]. Synthetic, nonabsorbable components appear to be important concepts in male sling material.

Currently, there appears to be a trend away from the bone-anchored sling in favor of the functional transobturator sling. This may due to high rates of prolonged perineal pain seen in most series. This pain is thought to be related to perineal nerve compression, a problem that seems to be avoided with the transobturator sling. The experience with adjustable slings is still early, but the concept of adjustable urethral tensioning combined with minimally invasive approaches make adjustable slings a promising option. Overall, the male sling has established itself as a first-line surgical intervention in the treatment of post-prostatectomy urinary incontinence.

31.6.3.5 Artificial Urinary Sphincter

The artificial urinary sphincter (AUS) has long been the gold standard for the treatment of post-prostatectomy urinary incontinence. Research has moved toward finding alternative, less invasive methods at treating incontinence, but the artificial urinary sphincter continues to be one of the mainstays of urinary incontinence treatment.

Table 31.4 summarizes urinary outcomes with the artificial urinary sphincter. The number of cured patients (19–20 %) appears to be somewhat low for a treatment considered the "gold standard." However, improvement rates (70–72 %) seem to bring patient satisfaction rates to an impressive 90 %.

The well-known complications with the AUS include infection/urethral erosion (3–12 %) and mechanical malfunction (1–9 %). Additionally, the reoperation rate for the AUS ranges from 18 to 36 %. There appears to be a 50 % 5-year revision-free rate [81–84]. Even with the high need for revision, Litwiller et al. still found a 90 % patient satisfaction rate in patients undergoing revision [81].

The emergence of the male sling has brought forward a nice intermediate option for those patients suffering from mild urinary incontinence, or those with moderate to severe urinary incontinence that are hesitant to undergo an artificial urinary sphincter. The higher degree of complexity associated with the AUS combined with its high reoperation rate make it a much less attractive option than a male sling. However, the AUS

Table 31.3 Outcomes for male slings for post-prostatectomy urinary incontinence

Author	Year	Type	Sling material	No. of patients	Mean follow-up (months)	Median follow-up (months)	% Cured	% Improved	% Social continence
Dikranian et al. [80]	2004	Perineal bone anchored	Porcine	20	18	NR	56	31	NR
		Perineal bone anchored	Synthetic	16	18	NR	87	13	NR
Comiter [71]	2005	Perineal bone anchored	Synthetic	48	NR	48	65	15	NR
Guimarães et al. [60]	2008	Perineal bone anchored	Synthetic	62	28	NR	65	23	NR
Giberti et al. [73]	2009	Perineal bone anchored	Synthetic	40	35	NR	55	13	NR
John [65]	2004	Retropubic needle passage	Porcine/synthetic composite	19	NR	14	69	6	NR
Stern et al. [66]	2005	Retropubic needle passage	Synthetic	71	48	NR	81	NR	NR
Migliari et al. [67]	2006	Retropubic needle passage	Synthetic	49	32	NR	NR	NR	63
Cornu et al. [61]	2009	Transobturator	Synthetic	102	13	13	63	18	NR
Bauer et al. [94]	2010	Transobturator	Synthetic	126	27	27	52	24	NR
Gilling et al. [78]	2008	ProACT®	Synthetic	33	52	NR	62	NR	NR
Gregori et al. [62]	2010	ProACT®	Synthetic	62	25	NR	66	26	NR
Sousa-Escandón [79]	2007	Remeex®	Synthetic	51	NR	32	65	20	NR
Hübner et al. [95]	2010	Argus®	Synthetic	101	25	26	79	NR	NR

NR not reported

Table 31.4 Outcomes for artificial urinary sphincter for post-prostatectomy urinary incontinence

Author	Year	No. of patients	Mean follow-up (months)	Median follow-up (months)	% Cured	% Improved	Social continence	Patient satisfaction (%)
Litwiller et al. [81]	1996	65	28	NR	20	72	NR	90
Klijn et al. [82]	1998	27	35	NR	NR	NR	81 %	NR
Walsh et al. [84]	2002	98	44	47	19	70	NR	89–92

NR not reported

will continue to have its role in the post-prostatectomy patient with severe urinary incontinence, those with incontinence refractory to a sling, patients with a history of pelvic irradiation, and those with detrusor areflexia or hypoactivity.

Conclusions

Urinary outcomes following robotic-assisted laparoscopic radical prostatectomy are remarkably good. It will be exciting to track the course of overall continence rates and time to continence parameters to accurately measure the benefit of robotic technology in the execution of the anatomic radical prostatectomy. Related to this are preoperative risk factors for urinary incontinence that may ultimately be counteracted with improved surgical technique. Incontinence intervention has made great progress. Behavioral therapies accelerate the recovery of urinary continence. The developments of the suburethral and transobturator male slings provide an excellent option for surgical correction, not readily available a few years ago. While time to continence rates continue to improve following RALRP, there remains a stable subgroup of patients that will benefit from the advances we make in incontinence surgery.

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Part VIII

Reconstructive Urology

Paediatric Pelvic Exenteration

32

Magnus Annerstedt

Pelvic exenteration is a major surgical procedure which, in the paediatric population, most commonly is associated with genitourinary rhabdomyosarcoma (GU-RMS). Initially surgical resection was the only option in treatment of GU-RMS, but advances in treatment including a combination of radiation, polychemotherapy and surgery have led to improved survival rates. Today organ preservation strategies are often possible. However, when disease is refractory to initial treatment or as a salvage procedure, pelvic exenteration is a good option with defendable survival rates [1].

32.1 Genitourinary Rhabdomyosarcoma

Soft tissue sarcoma represents the fifth most common type of childhood solid tumour. Rhabdomyosarcoma (RMS) is the single most common sarcoma in infants and children, and it accounts for almost half of all soft tissue sarcomas. RMS can arise at virtually any site in the body, except bone, because of its origin from embryonal mesenchymal cells. Intergroup Rhabdomyosarcoma Study Group (IRSG) was formed in 1972 in an effort to use a multidisciplinary approach to the treatment of RMS. Today IRSG has enrolled more than 3,000 patients and has enhanced survival rates for RMS. IRSG has devised a pathology classification with three major histologic groups. Embryonal RMS is the most frequent subgroup and accounts for most of the genitourinary tumours. It can occur in a solid form or as the so-called sarcoma botryoides that develops in hollow organs like the bladder or vagina. A third form of embryonal RMS is the spindle cell variant which like the sarcoma botryoides is associated with good prognosis. In IRS-IV (Intergroup Rhabdomyosarcoma Study), 883 patients were analysed between 1991 and 1997, and the distribution of the primary tumour was the following: genitourinal 31 %, parameningeal 25 %, extremities 13 %, orbit 9 %, head/neck 7 %, trunk 5 %, all other sites 3 % [2]. RMS is characterised by a male predominance. The male to female ratio in IRS-III is 1.5:1. The same study showed that two thirds of the cases of RMS occurred under 10 years of age. The clinical outcomes of the disease are tumour stage [3], localization [2] of primary tumour, histological subtype [4] and age [5] at diagnosis. Patients with localised disease have a better prognosis. Metastatic spread is usually to the lungs. Currently, RMS is categorised in two systems: the TNM staging system and the clinical grouping system. The staging relies on clinical examination and imaging studies including chest CT, CT or MRI [6] of the primary site and regional lymph nodes, a bone or PET scan and

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bone marrow aspiration or biopsy. Intraoperative findings and final pathology should not affect stage but will define the clinical group. The clinical group correlates closely with long-term survival and prognosis [5]. MRI is considered to be superior regarding the tumour and surrounding tissues and is preferable for pelvic lesions. As a matter of fact, the progress in imaging over the last decades has been credited with improving the survival of children with soft tissue sarcomas [7]. The initial procedure for most patients is a biopsy, usually performed open, to obtain tissue for analysis in order to plan the treatment. Clinically suspect lymph nodes should be confirmed pathologically. Since lymph node resection is diagnostic but not therapeutic, a prophylactic radical lymph node dissection is not necessary in paediatric RMS.

32.2 Treatment

Initially the effective treatment of RMS was radical surgery. Total pelvic exenteration was the procedure for genitourinary RMS, and of course this was performed as open surgery. However, more recent studies have shown that the now used multimodality approach can justify an organ preservation strategy, and tumours in prostate, bladder or vagina can be locally resected or managed by anterior resection hereby sparing the rectum [1, 8]. In RMS of prostate and bladder, approximately 50–60 % can be managed with bladder salvage [9]. RMS in the bladder has a better prognosis than in the prostate probably due to the fact that bladder tumours are more easily resected. But still an abdominoperineal approach is used when the pelvic floor or urethra are involved. RMS arising from vulva, vagina and uterus is usually of the botryoid variant with good prognosis and survival over 90 % [10]. They usually respond well to chemotherapy, and therefore an organ-preserving strategy often can be performed. RMS was found to be radiosensitive, but high doses are required for local control when used alone, and radiotherapy is therefore considered as one of several options in the now preferred multimodality treatment regime. Polychemotherapy is now routinely used in the treatment of RMS, since it has been shown that this strategy significantly improved survival in childhood [11, 12]. Commonly used drugs used are vincristine, topotecan, carboplatin, actinomycin D or ifosfamide. Chemotherapy alone is seldom sufficient to cure RMS, and complete surgical resection is of utmost importance considering local control and survival [13]. Combined chemotherapy and radiation have been used after surgery, enhancing the results. Some of the international rhabdomyosarcoma groups have advocated primary treatment with chemotherapy in order to either downstage the tumour to be surgically resectable or allowing an organ-sparing approach, CWS-2002 P (Cooperative Weichteilsarkom Studie).

Oncological paediatric surgery has until recently been performed with an open approach. Advocated reasons are based on the traditional surgical technique, good access to the tumour through a laparotomy and ability to detect affected lymph nodes with your fingers. The introduction of minimally invasive surgery has naturally become a substantial part of paediatric surgery. A wide range of different procedures have been done with conventional laparoscopy. However, in more complex surgery, robot assistance may improve minimally invasive surgery by 3D vision, 12 times magnification, tremor reduction, motion scaling and enhanced dexterity. The first reported case of a robot-assisted radical cystoprostatectomy in a child with embryonal RMS in his urinary bladder and prostate was published in 2008 [14].

32.3 Surgical Technique of Robot-Assisted Cystoprostatectomy and Total Pelvic Exenteration

32.3.1 Extirpation

Depending of the size of the patient, a four to six port approach is used (Fig. 32.1). The author prefers a zero-degree lens. In the right robotic arm, a monopolar scissors is used, and in the left robotic arm, the Maryland bipolar grasper (Intuitive Surgical®). Both ureters are dissected, clipped and divided close to the bladder. The proximal cut of each ureter is clipped with the Hem-o-Lok® ligation system in order to facilitate hydrostatic distension. In cystoprostatectomy, a transverse incision is created in the pouch of Douglas, and the vasa deferentia are divided bilaterally.

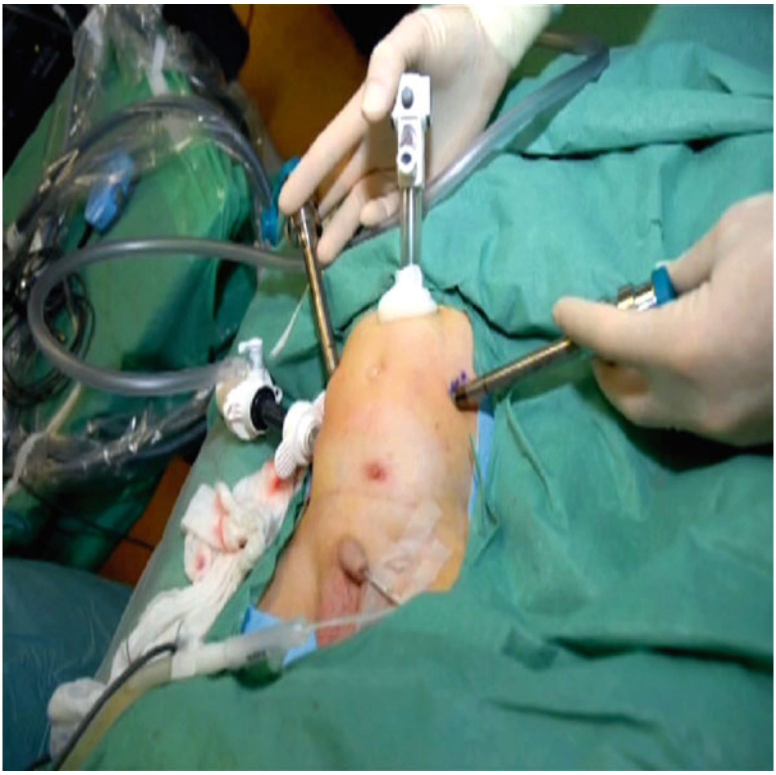

Fig. 32.1 Illustrates the four port approach. Instruments from left to right: 12 mm assistant port, 8 mm robotic port, 12 mm camera port balloon blunt tip, 8 mm robotic port

Dissection continues between the rectum posteriorly and the bladder, seminal vesicles and prostate anteriorly. The pedicles to the bladder and prostate are ligated with Hem-o-Lock clips. An inverted U-shaped incision is made from the urachus and continuing lateral to the medial umbilical ligaments on both sides down to the previously made posterior peritoneotomy. The anterior surface of the bladder and the perivesical fat is mobilised down to the endopelvic fascia which is incised bilaterally and the prostate is released from the pelvic side wall. The dorsal vein is secured with a stitch and divided. The urethra is dissected free, and a Hem-o-Lok clip is placed towards the bladder neck in order to avoid tumour spillage before being divided. The specimen is immediately entrapped in an Endocatch™ bag.

In total pelvic exenteration, the sigmoid colon is mobilised, and dissection is performed at the presacral fascial plane down towards the anal canal. Depending on the extent of tumour, the rectum is divided or amputated through the perineum at the end of the procedure. A colonic anastomosis or colostomy is performed either through a minilaparotomy or intracorporeally. The lateral and anterior dissection is the same as for cystoprostatectomy.

32.3.2 Reconstruction of the Urinary Canal

Reconstruction of the urinary canal is a challenging part after radical cystoprostatectomy or total pelvic exenteration and should be tailored to the need for each patient. Following cystectomy, urine can either be diverted into an incontinent stoma, into a continent urinary reservoir catheterised by the patient or controlled by the anal sphincter, or into an orthotopic bladder substitute so that the patient voids per urethra. Simon was the first to describe a urinary diversion, using intestinal segments in 1852 [15]. There are several options regarding urinary reconstruction after anterior or total pelvic exenteration. Previous irradiation is a risk factor for complications, i.e. anastomotic leakage and fistulae, and therefore a bowel segment not exposed to irradiation should be used [16]. Age has also to be taken into consideration since a more definite solution is preferred in older patients. Ureterocutaneo anastomosis, ureteroenterocutaneo anastomosis and ureteroenterourethro anastomosis can be performed totally intracorporeally as well as with a minilaparotomy. Continent cutaneous diversion using an ileocecal segment or transverse colonic segment is a safe and well-tolerated reconstruction especially in older children.

32.4 The Intracorporeal Technique

32.4.1 Intracorporeal Ileal Conduit

Twenty-centimetre intestine is isolated from the terminal ileum, leaving at least 15 cm to the ileocecal valve, using an Endo-GIA™ with a 60-mm intestinal stapler. The assisting surgeon, using the 15-mm port on the left side, inserts the stapler. The continuity of the small bowel is restored by using Endo-GIA with a 60-mm intestinal stapler, positioning the distal and proximal end of the ileum side to side with the antimesentery parts facing each other. An additional transverse firing of the Endo-GIA stapler is used to close the open ends of the ileal limbs. The left ureter is tunnelled under the sigmoid mesentery to the right side. The ureters are then incised and spatulated 2 cm. Two baby feeding catheters are pulled through the ileal segment and separately pushed up each ureter. The catheters are then secured to the mucosa using 4-0 Vicryl Rapid™.

The anastomosis between the ureters and the afferent limb is performed using the Wallace technique suturing the posterior walls side to side with a running 4-0 monofilament or the Nesbit version implanting the ureters separately into the bowel segment. This plate is then sutured to the proximal end of the conduit. At the end of the procedure, the stoma is constructed at its appropriate location.

32.5 Orthotopic Neobladder, Intracorporeal Technique

32.5.1 Anastomosis Between the Urethra and Ileum

The first step is to perform an anastomosis between the ileum and the urethra. The ileum is sufficiently mobilised in order to reach down to the urethra. This is important for two reasons, first, the anastomosis between the neobladder and urethra can be performed without tension, and second, the neobladder will be placed correctly in the small pelvis during the whole procedure. This will help during construction of the neobladder by running suture. An opening is made in the antimesenteric site of ileum, using robotic scissor. The anastomosis is performed according to the Van Velthoven technique with a two times 18 cm 4-0 Biosyn→ suture, allowing for 10–12 stitches. Two needle drivers are used to establish the anastomosis.

32.5.2 Isolation of 50-cm Ileum

The orthotopic neobladder is fashioned from a 50-cm segment of terminal ileum. The intestine is isolated using laparoscopic Endo-GIA with a 60-mm intestinal stapler. The stapler is inserted by the assisting surgeon, using the 15-mm port on the left side. The ileum is stapled 40 cm proximal to the urethral-ileal anastomosis. The continuity of the small bowel is restored by using Endo-GIA with a 60-mm intestinal stapler, positioning the distal and proximal end of the ileum side to side with the antimesentery parts facing each other. An additional transverse firing of the Endo-GIA stapler is used to close the open ends of the ileal limbs. Stay sutures may be used to attach the intestines before stapling them together.

32.5.3 Detubularization

The distal 40 cm of the isolated ileal segment is detubularized along its antimesenteric border with cold scissors, leaving a 10 cm intact proximal isoperistaltic afferent limb. Care is taken not to interfere with the sutures used for the anastomosis to the urethra, and one should keep closer to the mesenteric line posteriorly in order to avoid this.

32.5.4 Formation of Neobladder

After detubularization, the posterior part of the reservoir is closed using multiple-running sutures (25-cm 3-0 Biosyn™ or Vicryl™) in a seromuscular fashion, avoiding suturing the mucosa.

After the posterior part is sutured, the distal half of the anterior part of the reservoir is sutured, using the same sutures. The 0° or 30° lens can be useful for this part of the procedure. The proximal half of the anterior part of the reservoir is left open in order to handle the stents for the ureters and is closed in the last part of the procedure.

32.5.5 Ureteric Enteroanastomosis

The anastomosis between the ureters and the afferent limb is performed using the Wallace technique. The left ureter is tunnelled under the sigmoid mesentery to the right side. The ureters are then incised and spatulated 2 cm. The posterior walls of ureters are sutured side to side, using 15-cm running 4-0 Biosyn™ suture. Before the anastomosis between the ureters and the intestinal loop is performed, two Single-J ureteric stents are introduced with Seldinger technique through two separate 4-mm incisions at the lower part of the abdominal wall. The stents are pulled through the afferent limb and pushed up into the ureters on each side. Alternatively two baby feeding catheters can be sutured to the tip of the urethral catheter and then inserted into each ureter in the same fashion. With this technique, there is no need for external stents. The ureters are then sutured to the afferent limb of the Studer pouch, using a two times 15-cm 4-0 Biosyn™ suture. External stents are then sutured and fixed to the skin.

32.5.6 Closure of the Reservoir

The remaining part of the reservoir is then closed with a running 3-0 Biosyn™ or Vicryl™ suture. The balloon of the indwelling catheter is filled with 10 cc of sterile water. The neobladder is then filled with 100 cc of saline to check for leakage. If leakage is observed, extra sutures will have to be considered. An 18 Ch passive drainage is introduced and placed in the small pelvis.

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33

Robot-Assisted Laparoscopy for Genital Organ Prolapse

Jan Persson

33.1 Introduction

Support of the anterior and posterior vaginal wall is related to the support and position of the vaginal apex. Therefore, support of the vaginal apex, with or without a concomitant procedure to prevent the formation of an enterocele, is the base for prolapse surgery. A number of surgical approaches, vaginal, open or laparoscopic have been described with or without preservation of the uterus. The use of type I mesh for anchoring of the vaginal apex to the sacral promontorium has lowered the complication rate for these kinds of procedures. As women with urogynaecological problems rarely present with one symptom in isolation combined procedures for stress urinary incontinence or concomitant pelvic floor compartment defects are often necessary.

Even though many of the procedures currently are performed with traditional laparoscopy, the complexity of this approach has hindered a general adoption. Robotic surgery has numerous surgical advantages over traditional laparoscopic surgery. It is mainly in the context of facilitating a more general use of minimally invasive techniques within the field of prolapse surgery robotic surgery may play a role. So far, robotic surgery in this field is considered less cost efficient than traditional laparoscopy and open surgery.

33.2 Sacrocolpopexy

The use of graft material between the vagina and sacral promontory was first described in 1958 [1]. Over time, nonabsorbable synthetic graft materials, despite an increased risk of erosion, have gained increased popularity since biologic grafts may be hampered by a reduced longevity. Nonabsorbable synthetic grafts are classified in four types (I–IV) based on filament type and pore size [2]. Nowadays most authors advocate the use of type I polypropylene mesh. Usually, a Y-shaped or a double-strap configuration of the mesh is recommended to secure anchoring of the mesh to the anterior as well as posterior aspects of the vaginal apex.

Sacrocolpopexy may be performed as an open, laparoscopic or robot-assisted laparoscopic procedure. Apart from surgeons' experience with different surgical approaches, the selection of a certain approach should take into consideration various factors such as need for concomitant procedures, previous pelvic floor surgery, body mass index, previous abdominal surgery, known intra-abdominal adhesions and comorbidity that will affect time for surgery or limit the duration of anaesthesia.

33.2.1 Robot-Assisted Sacrocolpopexy

The patient is placed in the dorsal lithotomy position allowing access to the vagina and manoeuvring of a vaginal probe. Ideally the

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probe is egg-shaped and of a durable non-conducting material. The patient is placed in a steep Trendelenburg position. Ideally, the robot is docked at the side of the patients' right or left leg (only convenient with the da Vinci S or Si system) to facilitate vaginal access during surgery. Ports are placed routinely for pelvic surgery but may be varied at surgeon's discretion. A 10–12-mm assistant's port is needed for insertion of mesh and needles. Initial instruments are a bipolar grasper, a monopolar scissors and, in the fourth arm, a retracting grasper. To reduce instrument cost, the later needed needle holder may be used for grasping instead of a separate grasper. General surgical technique for robot-assisted surgery includes proper exposure and tension of tissue, a careful and usually blunt dissection in anatomic planes and a careful vessel by vessel coagulation to achieve a bloodless surgery and best possible visualisation.

If indicated, a concomitant hysterectomy may be performed, and the vagina is closed. There is conflicting evidence whether or not a concomitant hysterectomy increases the rate of graft erosion. A supracervical hysterectomy may decrease that risk as the remaining cervix may act as a barrier against infection [3]. To facilitate access to the operative field, the sigmoid colon may be temporarily approximated to the left abdominal wall by the use of sutures in the cut peritoneum or sigmoid epiploicae. Landmarks such as the ureter, the iliac vessels and the aortic bifurcation are identified. Then the peritoneum over the sacral promontorium is opened to identify the anterior longitudinal ligament and the presacral vessels. Other important landmarks are the sacral foramina, the sympathetic chain and the superior hypogastric nerve plexus. However, in case of a clear anatomic overview, the latter structures are not necessary to dissect and visualise.

The peritoneum is incised down to the pelvic cul de sac, alternatively left intact in between the openings in the space of Douglas and presacral area. This way, with the mesh tunnelled under the peritoneal bridge, later closure of the peritoneum is facilitated. The vaginal cuff is lifted in a cephalad position with the use of the vaginal probe before the peritoneum over the vaginal apex is opened. The vesicovaginal and rectovaginal spaces are opened symmetrically, and the vagina is exposed approximately 4–6 cm from the vaginal apex. As widely as possible, the mesh is sutured to the anterior and posterior aspects of the vaginal cuff with multiple single nonabsorbable sutures. Then, the mesh is pulled back to the sacral promontorium for proper tensioning and anchored with 3–4 nonabsorbable sutures to the anterior longitudinal ligament. Finally, the peritoneum is closed to ensure a complete covering of the graft to prevent small bowel adhesion. A total peritonealisation of the space of Douglas usually makes a separate culdoplasty unnecessary.

The surgical principles for a sacrocolpopexy are the same regardless of a previous supracervical or total hysterectomy, the former allowing additional reinforcing sutures in the cervical stump. Any concomitant prolapse or anti-incontinence procedure may be performed at surgeon's discretion.

33.2.2 Surgical Outcome of Sacrocolpopexy

Following an abdominal sacrocolpopexy, still considered the gold standard for vaginal vault prolapse surgery, a 78–100 % cure of vaginal apex prolapse is reported. Recurrences are reported in the range of 0–18, 2 % [4, 5].

A recent review of laparoscopic sacrocolpopexy summarising the results of more than 1,000 procedures reports a satisfaction rate of 94.8 %, a reoperation rate of 6.2 % and a mesh erosion rate of 2.7 % at a mean follow-up of 24.6 months. Median time for surgery was 158 min [6]. Relief of related symptoms such as urinary retention is reported in 90 % of patients. Reported effects on bowel function and sexual activity are not consistent.

Patients with a history of stress urinary incontinence should be investigated before surgery to assess the need for a concomitant robotic colposuspension or a midurethral sling procedure.

Available literature on robotic sacrocolpopexy is limited and restricted to usually smaller case series and cohort studies. Surgical times are reported in the range of 186–328 min, conversion rates between 0 and 5 % and recurrence rates for most series approximately 5 % [7–12]. Geller et al. compared the results from 73 robotic and 105 open sacrocolpopexies and report a similar short-term vaginal vault support [11]. Akl et al. report that time for surgery is reduced by 25 % following the first ten procedures [13]. Complications following robot-assisted sacrocolpopexy are reported in the range of 0–7, 5 % and include cystotomy, ureteral damage, small bowel damage, postoperative ileus, pelvic abscesses and sacral osteomyelitis [7–12, 14].

The costs for robot-assisted sacrocolpopexy have been evaluated in comparison with open and traditional laparoscopic surgery. Time for surgery, the risk of conversion, blood transfusions and length of stay were used as denominators [15, 16]. Robot-assisted surgery had the longest operative time, an equal conversion rate and transfusion rate but the shortest length of stay and compared with laparoscopy. Robot assisted was considered the most expensive surgical approach. Open sacrocolpopexy was deemed to be the most cost-effective method [16]. However, one should bear in mind that results for robotic sacrocolpopexy reflect an initial phase.

33.3 Colpoperineorrhaphy

The colpoperineorrhaphy is a modification of a sacrocolpopexy. The procedure includes an extension of the posterior graft down to the level of the perineal body in order to restore the rectovaginal septum in case of a posterior wall defect and/or a perineal descent. The mesh is anchored laterally to the fascia of the levator ani muscles and distally in the perineal body. Traditionally the procedure is initiated vaginally with the distal part of the dissection. With the properties of the da Vinci robot, the procedure may in selected cases be performed entirely as an abdominal procedure which may result in less risk of infection and mesh erosion. The procedure usually includes a vaginal reconstruction of the perineal body at the end of the procedure.

33.4 Hysteropexy

An increasing proportion of women request a preservation of the uterus due to individual preference, fertility reasons or a wish to minimise morbidity and impact on sexual function. However, the surgical treatment of uterine prolapse with preservation of the uterus presents a challenge for the surgeon. Vaginal, open or laparoscopic approaches have been described with a variety of suspension and anchoring techniques [17–21]. Krause et al. described a sacral suture hysteropexy whereby a permanent suture is run through the right uterosacral ligament between the posterior part of the cervix and the sacrum [17]. Cutner et al. used a mersilene sling run through both uterosacral ligaments with ends anchored to the sacral promontorium [18]. Maher used helical sutures through each uterosacral ligament and the posterior aspects of the cervix [19]. Most other techniques utilise mesh similar to the ones used for sacrocolpopexy but with different shape and anchoring in the cervix and vagina [20–22]. Costatini et al. describe the use of two meshes: one Y-shaped mesh sutured to the anterior vagina and cervix before being passed through an avascular area of the broad ligaments and a second rectangular mesh sutured to the posterior vagina and cervix [20]. The rationale for using an anterior mesh is the prevention of later recurrence of cystocele. However, an anterior mesh with arms surrounding the cervix may inherit problems in case of future pregnancy and childbearing. Therefore, alternatively Gadonnier et al. describe an anterior unilateral curvilinear mesh in addition to a posterior mesh [21]. The use of a posterior mesh only may be an alternative [22]. The latter two techniques are advocated in case women have a desire to conceive.

For robotic hysteropexy, only two publications are available, one of them performed in conjunction with surgery for classical bladder extrophy, an example of application of robotic surgery for a very rare and complex procedure [10, 23].

The results of different surgical approaches are difficult to compare due to various follow-up times, definitions and a large proportion of women with conjunct procedures. Nevertheless, the overall cure rate and proportion of women with recurrence seem similar to the results reported for sacrocolpopexy [10, 20–24].

33.5 Anterior and Posterior Wall Defects

Laparoscopic surgery of anterior vaginal wall defects is proven effective and safe only for repair of lateral defects. Following opening of the space of Retzius, the lateral retropubic space is dissected to visualise the obturator internus and levator muscles as well as the obturator neurovascular bundle. Then, the vaginal wall is sutured to the arcus tendineus fascia pelvis. In isolated cases, an anatomic cure rate is reported in 95 % of cases [25].

Reported experience of laparoscopic repair of isolated rectoceles is scarce. Lyons and Winer report the use of a polyglactin mesh in 20 patients with an 80 % relief of prolapse symptoms [26]. Robotic surgery for posterior wall defects may play a role as an alternative to commercially available prolapse mesh kits with the aim of reducing mesh erosions, the main complication associated with the use of the latter products.

33.6 Summary

Robot-assisted surgery may be used for all types of abdominal genital prolapse surgery. The properties of the robot may facilitate a more general implementation of minimally invasive surgery within this field. So far, robot assistance is not proven to result in superior surgical outcome, and the technique is hampered by associated costs although available publications report data from an introductory phase.

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Robot-Assisted Laparoscopic Repair of Supratrigonal Vesicovaginal Fistulae with Peritoneal Flap Inlay

34

Michael Kurz and Hubert John

34.1 Introduction

Vesicovaginal fistulae have always been a highly problematic complication. Nowadays, most cases are complications after hysterectomy or obstetric surgery, whereas obstructed labour is the main aetiology in underdeveloped countries. The localisations and dimensions of the fistulae are very different dependent on their aetiology. Obstructed labour leads to necrosis of the anterior vaginal wall and consequently to a lower, urethrovaginal, vesicovaginal or combined fistula. After hysterectomy, we know that fistulae occur in about 1/1,800 cases [1]. At a rate of 600,000 hysterectomies in the United States in 2003 [2], we can assume approximately 330 fistulae had to be treated in that year. This makes it not only a social but also an economic issue. These fistulae are usually found to be supratrigonal and sometimes located high on the bladder dome. This fact makes it very demanding or even impossible to operate transvaginally. They occur after inadvertent lesion of the bladder or ureters, operation-site infection or tumourous diseases. The success rate of either repair is between 75 and 97 % [3–5] depending on the method and complexity. Smaller fistulae can be treated by transurethral drainage and sometimes by transurethral coagulation of the bladder wall, depending on their aetiology. However, the long-term results are not very impressive (7–12.5 %) [6, 7]. A valuable alternative to conservative treatment is the use of fibrin glue [8]. In case of failure, the operative access is still available.

34.2 Materials and Methods

34.2.1 Patients

From July 2006 until February 2011, we treated three cases aged 40–64 year. All were diagnosed with a supratrigonal fistula as a complication of abdominal hysterectomy with no malignancy. In all cases, a conservative treatment was not an option since the fistulae were too large and the symptoms were almost devastating for the patients.

The fistulae could be diagnosed and localised by cystoscopy and conventional cystography.

They all suffered from continuous incontinence 3 months following the hysterectomy. One patient showed large adhesions after an old uterus fixation operation in 1971 and a sigma diverticulitis. These adhesions were also in the spatium vesicovaginale including an omentum attached to the bladder dome. Altogether, there were no postoperative complications besides the occurrence of the fistulae. The patients had no significant concomitant diseases that could be responsible for wound healing disorders.

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One patient suffered from acute intermittent porphyria. During the hospitalisation, we did not see any problems as she did not suffer any acute episode. The fistula repair was done immediately after being diagnosed, 3 months after primary operation on average.

34.2.2 Operative Technique

The patients received 2 g (Cefazolin) Kefzol® when anaesthesia was begun. We started with the vaginoscopy in lithotomy position. First, we inserted a 5 F Fogarty catheter through the fistula into the bladder using a vaginal speculum. Then, a cystoscopy was performed to verify the position of the Fogarty and to insert DJ catheters to protect the ureters and the ureteric orifices. For easier identification of the vagina intraoperatively, a sponge stick was inserted. Thereafter, we continued in a low lithotomy position with a Trendelenburg tilt. The complete abdomen and the genitals were disinfected using povidone-iodine. After establishing the pneumoperitoneum via the 12-mm camera port, all ports could be installed according to the scheme of the radical prostatectomy. One 8-mm da Vinci port left and right to the umbilicus, one 12-mm Versaport ™ in the right lower quadrant (ca 3-cm craniomedial of the anterior iliac spine) and one 5-mm port was installed right of the camera port, ca. 3 cm proximally.

Initially we had to perform adhesiolysis due to postoperative, intra-abdominal scarring. We continued sharp and blunt dissection using the PK bipolar forceps and monopolar curved scissors to expose the abdominal surface of the bladder and the vaginal stump. After getting a good exposition, we opened the vagina and localised the Fogarty catheter and thereafter searched for the fistula (Fig. 34.1). We subsequently opened the bladder and prepared it towards the fistula to finally resect it completely including peri-fistular scar and inflammation tissue. Sharp dissection is used in order to protect the ureteric orifices and to prevent wide excisions (Fig. 34.2). The next and very important step was to mobilise the bladder dorsally to get a tension-free suture. The closure of the vagina was performed using 2-0 Vicryl®. Before the closure of the bladder, we mobilised the adjacent peritoneum to use it as a vital layer between the vaginal and bladder sutures (Fig. 34.3). The bladder was finally closed using 4-0 Biosyn® (Fig. 34.4). After performing a leakage test of the bladder, we removed all the ports.

The mean operation time was 240 min including DJ insertion and transfers. There was no significant blood loss.

34.2.3 Postoperative Management

The wound drain was removed after 24–48 h as there was no evidence of bleeding or leakage. The patients were discharged after 5 days with the indwelling Foley catheter. After 14 days, cystography was performed prior to the catheter removal. 100 % of the patients showed no leakage of the bladder suture. Sexual intercourse was prohibited for 4 weeks. The DJ catheters were cystoscopically removed after 4 weeks.

34.3 Follow-up and Results

After a follow-up period of 4–42 months, all the patients stayed continent, and we saw no evidence of a recurrent fistula. One patient was hospitalised and treated with antibiotics due to a left-sided pyelonephritis 3.5 weeks following the operation. The DJ catheter could be removed under successful antibiotic therapy. We did not have to change the DJs. No patient complained about pollakisuria, low bladder volume or discomfort during sexual intercourse.

34.4 Discussion

In fistula surgery, the effort should always be to heal at the first attempt. Therefore, a meticulous operative plan has to be established. In all cases, we should strive to operate effectively, safely and with the lowest morbidity possible. There are no consequent guidelines which way of access should

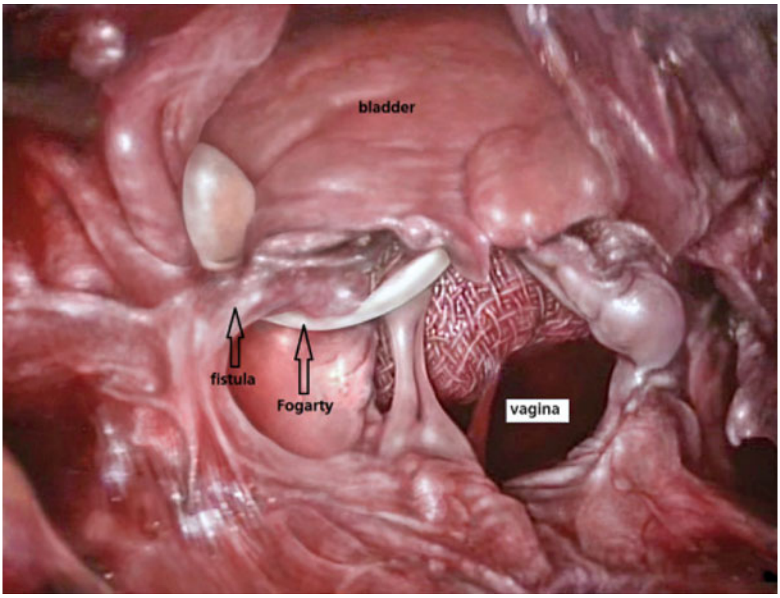

Fig. 34.1 View into the bladder and the opened vagina. The Fogarty catheter is seen with its balloon on the left side. It was inserted into the fistula and is still in situ. The excision of the fistula will follow next

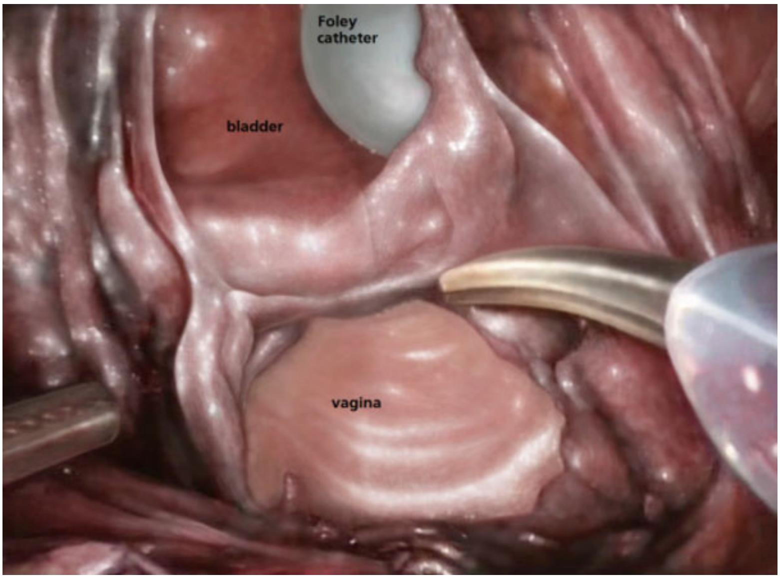

Fig. 34.2 After complete resection of the fistula and adherent scar tissue, the next step will be the bladder mobilisation

be taken while the surgeons experience is mainly what counts. Gynaecologists often choose the transvaginal way wherever possible. The advantage is the possible outpatient setting, low patient morbidity, low blood loss, minimal postoperative pain and low postoperative bladder irritability [4, 9, 10]. Some authors report that an equal success can be observed compared to abdominal approaches using a peritoneal flap when a Martius flap was not recommended [4, 11]. Exclusion criteria of the transvaginal access can be a circumferential induration at the fistula site thicker than 2 cm, a high fistula location where the transvaginal approach gives too little exposure, fistulae involving ureters, or when patients wish the transabdominal operation [10, 12]. Combined transabdominal and transvaginal operations have been reported [13].

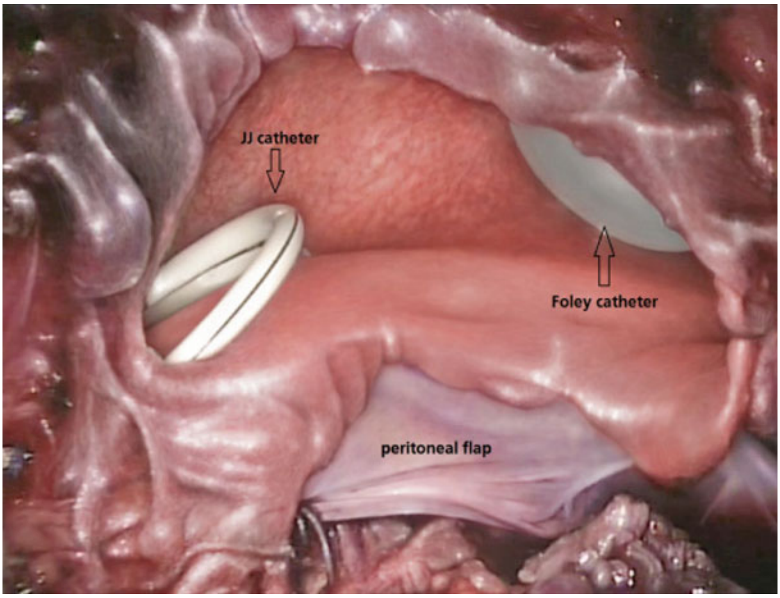

Fig. 34.3 The vagina is now closed and the peritoneal flap lies above its suture. A DJ catheter was inserted into both ureters before the operation. Here, the left one is seen in the picture

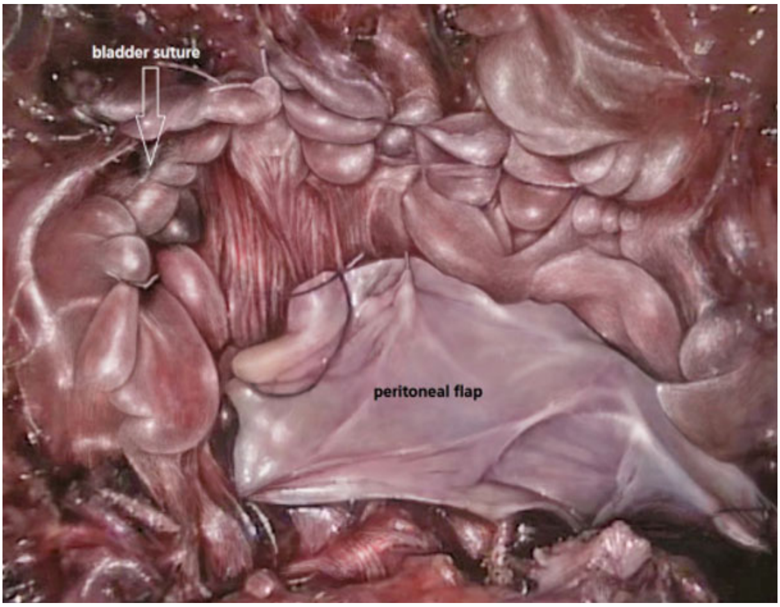

Fig. 34.4 View at the end of the operation. The bladder is now closed and watertight. The peritoneal flap is in situ and covers the vaginal suture

Where a safe transvaginal fistula repair cannot be granted, there remains only the transabdominal pathway. The transabdominal transvesical technique provides most space for exact and wide preparation of the bladder and vaginal wall, easier identification of scar and fistula tissue, and thus provides a good basis for the complete excision. More recent techniques have become less morbid than the historical O'Connor procedure even though there are "mini" variations [14, 15].

In recent years, laparoscopy could also establish itself in fistula surgery as an equivalent option to the open operation.

Nezhat was the first to perform and document this operation in 1994 [16], and it was developed continuously in the following years, and several case reports appeared [9, 17–26]. The technical advantages of laparoscopic surgery are the easier access to the deep pelvis with high illumination, magnification and easy coagulation. The patient suffers less pain, and mobilisation and release from hospital is faster. Unfortunately, many surgeons avoid this technique due to its technical demands (training curve, difficult fistula resection), and it is mainly performed in special centres [27]. Especially the closure of the bladder and vagina is time consuming but very efficient and safe [9]. Here, the da Vinci Surgical System can be a very helpful assistance.

The use of the da Vinci facilitates the most important steps in this procedure and helps the surgeon to lower operation time. This may also lead to a better outcome and lower complication and recurrence rates.

It gives a 3-dimensional magnification up to 15× with a superior view of all different structures including small vessels. It also filters the surgeon's tremor and gives up to seven degrees of freedom. Yet so far, only few reports can be found about robot-assisted fistula repair [28–32]. The first one was described in 2005 by Melamud et al. at the University of California [28].

The aim of this series is to show the feasibility of peritoneal flap inlays and the effectiveness of the da Vinci Surgical System as an advancement in the laparoscopic approach to treat this embarrassing and compromising complication after hysterectomies where a transvaginal procedure, i.e. after Latzko or a Martius flap is not the preferred choice.

The surgical advantages by the use of the da Vinci Surgical system are well known and need not be mentioned. In the case of fistula surgery, we observed that patients recovered almost immediately after surgery by using the laparoscopic access which is less morbid compared to the open operation. The most difficult steps during the procedures are likely the ones that keep urologic surgeons away from the laparoscopic approach. It is the tricky preparation of previously damaged tissue and the suturing. This is where the da Vinci Surgical System gives you the utmost assistance. Accessing through the vagina as a natural orifice gives you less space to work and to prepare precisely, not to mention that many high fistulae are out of reach.

In a few cases, ureters can be affected by the fistula or have to be partially resected. In such cases, the operation can also be performed laparoscopically while a transvaginal access is futile.

Besides small differences such as suture material or ports, there was no difference between our procedures compared to prior case reports besides the fact that we performed peritoneal flaps in all patients.

Colleagues used epiploic appendix of the sigmoid colon [31]; omentum, epiploic appendix of the sigmoid colon or a peritoneal flap [30]; omentum [29]; or fibrine glue [28]. We estimate a similar functional result in all these different ways. However, of major importance is the separation of the suture lines.

One disadvantage of the da Vinci System is its inflexibility when preparation of the omentum would be necessary. Therefore, we wanted to encourage the use of a regional flap as interposition graft with no need of omental preparation or even colon mobilisation.

Despite the small number of treated patients, we can assume that the da Vinci-assisted laparoscopic method in operating high fistulae is safe and highly effective. Three out of three patients are still satisfied with the postoperative results after regaining full quality of life. Recurrences after repair are usually seen within 3 months [6], so we can consider these patients to be healed.

Vesicovaginal fistulae are a rare but a devastating complication mainly after gynaecological operations, especially hysterectomy which is very often performed. Its repair can sometimes be even more demanding. By using the given technology, we believe that the da Vinci robot-assisted, laparoscopic approach is the most auspicious in most cases of high supratrigonal fistulae.

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Robotic Surgical Training: Imparting Necessary Skills to Future Urologic Surgeons

35

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35.1 Introduction

Over the last decade, training opportunities for aspiring surgeons have become increasingly limited. Advances in healthcare technology, the development of day-case surgery, and the setting of quality-assurance targets for informed patients have lowered resident exposure to patient-based surgery and created a new demand for alternative methods of surgical training [1]. Furthermore, restraints on the lengths of residency workweeks and the emphasis on operating room efficiency have mutually curtailed teaching time for surgeons-in-training [2]. Robotic surgery currently presents the greatest challenge for training programs and aspiring surgeons alike, for reasons of instrument cost and a lack of training alternatives outside of the operating suite. The field of urology has been a long-time leader in the application of robotic surgery, largely for the great advantages the interface offers within the tight confines of the human pelvis. Robotic-assisted radical prostatectomy (RARP) continues to be the most prevalently executed robotic procedure worldwide, with advantages offered to both surgeons and patients favoring rapid adoption. This multitude of advantages robotic-assisted (RA) surgery offers to patients—accelerated return to preoperative activity, shorter periods of hospitalization, decreased postoperative pain and dependence on analgesics, etc.—has fueled the rising popularity of minimally invasive procedures compared to alternatives [3–5]. Additionally, improvements of visual field, operative precision, and toll on fatigue have brought many surgeons to favor the RA approach. In 2011, it is estimated that over 80 % of all radical prostatectomies will be performed robotically. Despite this, the high expenditure and upkeep requirements make many hospitals and surgical urology practices reluctant to train inexperienced surgeons in the procedure due to a lengthy learning curve and the high surgical volume necessary to offset the cost of the technology [6]. As such, new and effective training modalities are dually necessary for patients and medical institutions alike.

In order to progress the surgical standard of care and meet today's rising expectations for improved patient outcomes, the technology for robotic surgical training must advance and simultaneously be made affordable for establishments of academic medicine. Although numerous training simulators for laparoscopic surgery are now used in medical

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school electives and residency programs, the high cost of such devices limit the universal availability at training institutions. Of greater issue is that, despite growing interest, a well-accepted, validated robotic simulator has yet to make significant headway into the marketplace. By generating a more effective and efficient means of training robotic surgeons before their introduction into the operating room, the incurred costs associated with the large learning curve of the robotic surgery can be reduced, and resident training can become more affordable for teaching institutions. In addition, improvements in robotic training will promote trainee familiarization with both the device and surgical procedure prior to any patient-based instruction, promoting safety and improved outcomes. Innovative measures, however, must be taken by medical technology organizations and teaching hospitals to ensure that the next generation of surgeons has the means to uphold elevating healthcare standards. In addition, there is a great need for the establishment of a centralized credentialing agency, specific curricula for teaching robotic procedures to naïve students, and a means of competency evaluation prior to granting surgical privileges. The goal of this chapter is to present the need for, the current state of, and the future of robotic surgical training; while RARP and urologic residency will be emphasized, this discussion is extremely pertinent to all surgical disciplines.

35.2 Evolution of Robotic Surgical Training

While practice makes perfect, there is bound to be error during any surgeon's initial cases. Surgical residency programs have allowed for this over the course of a 5–6-year program to institute slow, supervised clinical training. Over time, the Halstedian model of "see one, do one, teach one" has been applied to progress trainee exposure in a stepwise manner, as well as implement new surgical technology into practice, allowing such innovation to continuously offer increasing patient and surgeon benefits. This teaching methodology will be valuable to aspiring urologists in the upcoming 5–10 years as a large volume of experienced robotic surgeons become available as mentors; however, there is an immediate need for an effective means to educate postgraduate urologists who lack formal robotic training. Currently, the majority of the United States' surgical robots (>1,200) are being used by low-volume, nonacademic urologists who lack fellowship training. In order to properly train the next generation of surgeons under the Halstedian model, it is important that future mentors themselves are skilled, experienced, and trained in robotic surgery. Nevertheless, the training of physicians does pose unique challenges, and the foremost among these pertain to ensuring the safety of the patient. Multiple training methods have been proposed including the use of mini-fellowships, simulators, and proctoring and preceptoring. Outside of urological training centers, the expansive application of robotic surgery has created the need for adequate education programs for aspiring and practicing surgeons across a number of medical fields. During the 4 years after the induction of robotic surgery into one medium-sized city's healthcare system, the number of RARP performed increased by a monthly factor of five while the number of open prostatectomies became nominal. This rapid expansion of the RARP was attributed to the numerous benefits the robotic system offers to both patients and surgeons, as well as a concerted effort to properly train the surgeons in the area [7]. Although the RARP was one of the first procedures to widely make use of this new technology, robotic surgery is not limited to the urologist. The far-reaching nature of this breakthrough device has proven applicable to many surgical fields, and the number of surgical subspecialties that are currently taking advantage of this technology has grown substantially in the last 5 years. The robot has implemented itself in the surgical practices of cardiothoracic, colorectal, and general surgery, as well as otolaryngology, nephrology, gynecology, and pediatrics [8–10]. As a young innovation, however, robotic surgery is very much in the developmental period and is still expanding into the healthcare market.

As the world of surgical technology continues to advance, measures must be taken to ensure that education keeps pace. As mentioned previously, surgical education for robotic surgeons is a crucial aspect of the progression of robotic surgery and its safe implementation in the operating room. In 2006, despite many residents being exposed to robotics, only 38 % were satisfied with their laparoscopic training, and 31 % found it inadequate [11]. Clinical exposure to robotics has since improved with dedicated American Urological Association (AUA) robotic guidelines being implemented into the curriculum (see AUA website, http://www.auanet.org/content/homepage/homepage.cfm). However, robotic technology has yet to become standard in pertinent surgical training at all academic venues. Innovative practice tools to help prepare residents and fellows for robotic-assisted procedures are only in the production stages, and just a few have been introduced into the current curricula of select institutions. While there is increased awareness and effort, it is important that these training tools are quickly validated and globally incorporated into existing programs so that education programs have established universal objectives for adequate robotic competency [12].

35.3 The Learning Curve and Surgical Experience

Counterproductively during robotic apprenticeship, as humans, we are naturally flawed to forget over time (Hermann Ebbinghaus, German psychologist, 1850–1909). As such, evaluation methods are not only important and necessary for up-and-coming robotic trainees, but they are imperative for periodic and repetitious assessment of practicing surgeons' skills, especially for those with a smaller case load to attain a level of automation of the procedure.

Current training programs and residencies have shown the promising benefits that a formal education in robotic surgery can have for physicians; such benefits are not only important for patients and surgeons to consider but for investing healthcare institutions as well. Kwon et al. have shown that formally trained robotic surgeons have shorter operative times, which permit for a greater case volume over a given period [13]. In turn, a high surgical volume has been directly linked to improve patient outcomes and lower levels of complication [14]. In a 6 year, 2,666 patient study both complication and blood transfusion rates were inversely correlated with surgical experience (volume) during minimally invasive (MI) robotic prostatectomy [15]. As a larger surgical volume is naturally associated with a greater sense of procedure familiarity, instrumentation expertise, and motor memory of the surgical process, one should attain a great deal of experience prior to beginning robotic surgery on his/her own.

To date, even without the use of the dual console da Vinci® Si model (discussed below), the inclusion of robotics trainees has not generally been linked to poor patient outcomes or a decrease in program efficiency when a stepwise introduction to the surgical procedure is used. In a training assessment, Schroeck et al. determined that trainee presence did not impact a surgeon's own learning curve and further concluded that trainees' outcomes were comparable to those of their mentors [16]. In another study, Davis et al. showed that trainee introduction in the operating room had no negative impact on patient outcomes and necessitated no major or minor corrections by senior instructors [17]. They additionally illustrated that initial exposure to 40 RARP cases provided trainees with quality basic skills, although trainees did have significantly longer procedure times than instructing surgeons. Operative times have, however, been shown to continually decrease in mature surgeons even after hundreds of performed surgeries [16], which is likely attributed to improved surgical efficiency by both the surgeon and the robotic team.

Budäus et al. determined surgical expertise to be a primary factor in patient hospitalization period following minimally invasive (MI) prostatectomy [18]. Consistently, in another study, surgeon experience—measured by annual robotic prostatectomy caseload—was inversely related to associated hospital costs [19]. Such considerations may be crucial to institutions when initially trying to launch a robotics program in a cost-effective manner. Furthermore, a comparative evaluation of hospital charges based on surgical caseload for open versus MI prostatectomy showed a greater caseload effect for the MI approach. That is, a given increase in surgical experience reduced hospital costs by more for surgeons who utilized MI rather than open technique [20]; this further demonstrates the potential value of widespread, adequate robotic training.

Organized mentor-guided instruction, as opposed to informal individual practice, has proven beneficial for robotic naïve students in terms of technical skill achievement, especially for more advanced robotic skills such as suture placement and knot tying [21]. This study attests to the fact that some formal education is necessary to impart indispensible skills to surgeons-in-training prior to their introduction to actual patient surgery. In addition to more efficient operative times, formally trained surgeons boast better patient outcomes. Kwon et al. showed that RARP-trained surgeons had a better surgical margin rate and shorter procedure time than surgeons with no formal training [13]. With regard to formally trained surgeons adapting to a robotic platform, Tewari et al. reported no compromise of oncological safety in a study of over a 1,000 patients [22]. The data collected included positive surgical margin rate and video recordings of procedures. The study reasoned that the enhanced visual feedback offered by the robotic platform compensated for the lack of tactile feedback afforded during laparoscopic and open procedures. Published literature also suggests that a formally trained surgeon in robotics will benefit both the patient and the efficiency of a robotics program, while having no adverse influence on patient safety or operative time during the training process.

35.4 Unique Needs and Responsibilities of the Surgeon During Robotic Surgery

The youthful and unique nature of the robotic surgical platform further necessitates adequate surgical training. Perhaps the most frequently reported disadvantage of the robot is the lack of tactile feedback. Although the enhanced visual field has been said to make up for the deficiency in haptic control, the dissimilarity between the robotic instrumentation and previous technology sufficiently illustrates the need to accustom surgeons to the new interface through training and education [22]. In an international multicenter study that investigated the learning curve properties for RARP, prior open surgical experience had no reducing effect on positive margin rate during one's learning curve (200–250 cases in this study). Secin et al. concluded that surgical margin outcome was primarily a function of laparoscopic-specific training and experience [23]. Future robotic platforms (Titan Medical, Toronto, Canada) as well as adjuncts to the da Vinci® platform (Vibrosense, David Lee, U Penn) may soon help provide force feedback to the console surgeon. The most immediate advances in robotics will most likely come through incremental changes in the currently available systems. However, there are still many areas in which the current systems can be improved.

The physical parameters of the standard robotic operating suite layout also contribute to the challenge of these procedures. Robotic surgery is unique in that the surgeon console is physically removed and distant from the patient during the operation, presenting an additional element of challenge to bedside instruction of assistants. The separation that is forced between the surgeon and bedside trainee by the robotic console necessitates additional verbal coordination for the instruction of naïve students. Due to the surgeon's inability to see outside of the camera field of vision, clear and coherent communication between the console surgeon and bedside assistant is imperative. Bedside placement of clips, suture cutting, and other medical acts are also not performed by the surgeon, rather the assistant. Furthermore, because whoever is at the surgeon console has absolute control of the robot at that point in the procedure, simulation must be used to safely acquaint residents and fellows with the robotic approach prior to their exposure in the operating room.

On top of the physical differences imposed by the robotic interface, urologic robotic training faces another unique challenge. Some surgical fields have been able to use animal models to train residents on the robotic interface prior to further instruction via live-patient procedures—the pig heart, for example, is commonly practiced on in cardiology training and has proven to be an effective representation of the human model for trainees. Adding to the difficulties of training for RARP and other urologic surgical procedures is the lack of an adequate animal model that has human semblance in the pelvic and prostate region. Although porcine models are more readily available, the paucity of perirenal fat and lack of overlying intestine make these models very different from live human cases.

Cadaver labs, on the other hand, still present a variety of issues, most notably that of high cost. To run successful cadaver-based robotic training requires a physical lab space, a complete da Vinci® robotic system, that is, unlikely to be used to for any income-generating surgical cases, and an ongoing supply of nonrenewable, expensive cadavers. For all these reasons, cadaver-based training has thus far been financially and logistically unsound for robotic urologic surgery. To surpass these inadequacies of animal and cadaver models for surgical training in many specialties, the demand for surgical simulators and training alternatives has been and will continue to be on the rise. Robotic-assisted surgery has proven beneficial to patients on numerous levels; expanding the capacity to train surgeons in robotic procedures will extend these benefits to a greater patient population.

35.5 Present Robotic Training Modalities

As stated above, in recent years, a number of existing training programs have been greatly successful in their efforts to educate young robotic surgeons, which ought to provide encouragement, reassurance, and a model of action for new academic programs. Additionally, recent breakthroughs in training technology have begun to show promise for the future of preoperative robotic education.

35.5.1 Residency

Although residency exposure to robotic surgery is still generally considered inadequate, it has improved markedly, and the feasibility of implementing the means to higher levels of resident training has been demonstrated. High surgical volume is a key aspect of a robotics training program—it mutually serves to offset the cost of the capital investment of the robot, and it increases the number of teaching opportunities. Common patient features such as obesity, previous hormone therapy, and high-risk pathology may increase procedure complexity, and thereby significantly reduce the number of cases suitable for training in a small pool of patients [17]. Madeb et al. reported a parallel between growing robotic surgical volume and the incorporation of robotic-assisted surgery into a urologic residency program. In order to raise their rate of residency exposure while maintaining standards of patient safety, significant modifications of their training technique were made [7].

Robotic trainees are generally progressed from the bedside to the robotic console, where they are introduced to surgical tasks of increasing complexity [16, 17]. A three-part training model for educating urology residents in RARP has proven effective by the comparison of estimated blood loss measurements and positive surgical margin rates between mentors and trainees [16]. Shroeck et al. characterized three parts of RARP as follows: Part 1—bladder dissection, incision of the endopelvic fascia, and control of the dorsal venous plexus; Part 2—bladder neck incision, posterior dissection of the prostate, nerve sparing, transaction of the dorsal venous complex and urethra, and pelvic lymphadenectomy; and Part 3—suturing and testing the vesicourethral anastomosis [16]. Under the teaching program described, trainees were initially introduced to the robotic procedure by lecture, video, and literature review prior to receiving basic functional instruction with the robot from an Intuitive Surgical, Inc. (Sunnyvale, CA) representative. For roughly ten cases each, trainees would assist mentors at the bedside, followed by assisting with Parts 1, 3, and then 2 of RARP at the robotic console, in said order. Only after achieving proficiency in all discrete procedure sections would trainees begin to perform two or all three parts of the surgery. Throughout their study no implications of significantly different outcomes between mentors and trainees were seen, and trainees did experience a dramatic decrease in operative time throughout their instruction period, achieving comparable procedure times to their mentors by the end of the study [16]. This teaching model for RARP very well may prove safe, effective, and financially feasible for other institutions in their attempts to increase resident and fellow training in urologic robotic surgery. While a number of current training programs now offer sufficient robotic exposure to resident trainees, this offers no solution to practicing urologists in the community who wish to learn the robotic approach.

35.5.2 Fellowship and Mini-Fellowship

While exposure to robotics has increased in some residency programs, robotic “fellowship” is the common approach for practiced and naïve surgeons who seek additional training in robotic surgery. Currently available in many forms, “fellowships” in robotics may range from short 5-day courses to 2-year programs. Even the short courses have shown a positive impact on implementation of robotic assistance into surgical practice; the lengthier opportunities, however, are not feasible for the majority of practicing urologists. Altunrende et al. demonstrated that a 2-day robotic kidney course consisting of lecture and skills practice had an immediate impact on the number of robotic procedures performed by participating surgeons [24]. A 5-day robotic fellowship has also shown to have positive short- and long-term impacts on the incorporation robotic prostatectomy in surgeon practice [25]. Likewise, a 5-day postgraduate mini-fellowship on laparoscopic renal surgery reportedly allowed participating urologists to introduce and expand upon their practice of minimally invasive renal surgery [26]. Following such short periods of training, however, novice surgeons must immediately and frequently continue to use their newly acquired robotic skills—which is challenging in regions of low case volume—further attesting to the need for a validated simulation trainer for robotics. Current training programs and instruction models for the introduction of robotic procedures show promise for the future of the robotic surgical education. Expanding the number of institutions that offer training in robotics and developing stepwise teaching models for more procedures are a necessary progression to advance the education and application of the RA surgical approach.

35.5.3 Proctoring and Preceptorship

Proctorship, the current training approach implemented by Intuitive Surgical for all new users, has been widely criticized by urologic academia. Following a day-long hands-on porcine lab to familiarize one with the robotic platform and layout, the surgeon is proctored for a minimum of two surgical cases before becoming credentialed by their hospital institution. In robotic urologic surgery, a proctor functions to report his/her findings on a trainee’s competency level to the department head or medical staff of the surgeon-learner’s institution. The institution may then act on the proctor’s recommendation autonomously, and either grant surgical privileges or require additional training for the aspiring surgeon. Frequently, the proctor is a different surgeon from around the country for each case; as such, this method leaves novice surgeons without a role model or mentor figure who is able to evaluate and aid in their progression. Furthermore, in proctorship, the expert surgeon is unable to scrub in to actively coach the trainee through difficult parts of the case or to relieve them in an emergency.

Preceptorship is an alternative that allows the experienced surgeon to help at the console and attempt to transfer his/her skills to the trainee through an active “hands-on” approach. This method provides more direct feedback for the surgeon-learner and permits for a safer training environment during the steep part of the learning curve. While proctoring generally occurs at the trainee's home institution, preceptorship may occur at the location of either the surgeon-learner or expert, as well as within a mini-fellowship or mini-residency program [27].

While proctoring plays a crucial role in observing and certifying competency for robotic urologic surgeons, a common criticism of the system is the means by which surgeons currently earn proctor or preceptor status, as well as the inherently inconsistent skill and experience level between various "experts." Furthermore, proctoring presents practical difficulties for both the aspiring and instructing surgeon; either requires the proctor to take time out of his/her schedule to travel to the learner's institution or involves the surgeon-in-training to bring his/her patient to the proctor's location. To circumvent these difficulties, modern telemedicine technology has recently been put to use to allow an expert surgeon to observe, oversee, and actively supervise a surgical procedure being conducted by a trainee from a remote location. With the expansion of robotic facilities worldwide, the application of remote proctoring for robotic urologic surgery will enable the most expert surgeons to easily proctor and ultimately optimize patient outcomes and improve safety.

35.5.4 Virtual Reality and Laparoscopic Training Modules

Virtual reality (VR) simulation has been integrated into surgical curricula as an intuitive method to enhance preclinical training. According to *Lewis* et al., VR simulators may be the solution to the reduction of training opportunities faced by current surgical trainees [28]. They report that new VR technology allows aspiring surgeons to practice full-length, realistic procedures on electronic models where mistakes can be used as learning points and pose no risk to patients. Another study evaluated whether or not common laparoscopic simulators could be effectively adapted for training on a robotic platform. Feifer et al. illustrated that the joint use of a ProMIS® hybrid and the LapSim® VR simulator can improve robotic console performance in medical students; such an approach may offer a cost-effective alternative to early robotic training until a pure robotic simulator has been widely validated [29]. As robotic surgery continues to gain popularity among patients, surgeons, and residents, the need for an affordable and accepted robotic training device will persist. While popular laparoscopic simulators have proven effective for improving robotic console performance in naïve students, these training tools are far from inexpensive. The two commonly used laparoscopic training devices, the LapSim® and ProMIS®, average at a cost of $25,000 and $50,000, respectively [29]. Standard laparoscopic simulator technology is currently being remolded to better emulate the robotic surgical experience.

35.5.5 Robotic Surgery Simulation

Simulation training for the robotic surgical interface is likely the most feasible and effective means of providing trainees with a basis of tactile skill prior to introducing them to the actual robotic device. Through simulation, academic institutions may help surgeons-in-training overcome a portion of the learning curve without taking up valuable and expensive time in the operating suite, which will further promote patient safety and quality outcomes. To our knowledge, Mimic®'s dV-Trainer™ is currently the most widely accessible simulator model for the da Vinci® interface and is utilized at over 30 training sites. In collaboration with Intuitive Surgical Inc. (Sunnyvale, CA), Mimic Technologies used product development insight to incorporate accurate robot modeling kinetics, as well as realistic icons and instruments into the training modules. Exercises on the simulation program include instruction on EndoWrist® manipulation, camera and clutching, energy management, and needle driving. Mimic's MScore™ software also provides a comprehensive trainee evaluation and score reports for credentialing and privileging. In a recent comparison study on the effectiveness of simulation training on the dV-Trainer versus repeated exercises on the actual da Vinci® system, Lerner et al. found that each practice approach yielded similar improvements in the timing and accuracy of some drills [30]. They further concluded that the dV-Trainer may help bridge the gap between the acquisition of surgical skill and its live implementation on the operating table.

Virtual reality robotic simulators such as Mimic®'s dV-Trainer can now be leased by institutions to help immature robotic surgeons overcome the steep learning curve of the RA approach. Even though the lease option allows traditionally nonteaching hospitals and other academic programs to avoid permanent investment in an evolving piece of technology, it is by no means a cheap solution. In a Mimic® dV-Trainer presentation from May 2011, 3- to 4-year lease arrangements for the device ranged from roughly $110,000–$140,000, depending on the chosen plan of service. Another up-and-coming collaboration project is the Robotic Surgical Simulator (RoSS), codeveloped by Roswell Park Cancer Institute and the University of Buffalo's School of Engineering and Applied Sciences. This piece of equipment is said to transmit real-time feel and a highly realistic simulation to the surgeon-in-training and has been described as a "flight simulator" for robotic surgery.

In December of 2011, Intuitive Surgical Inc. (Sunnyvale, CA) released the da Vinci® Si Skills Simulator software. This technology allows residents and surgeons to learn and practice the use of the robotic device in a nonoperative fashion, as well as track their acquired proficiency. With a focus on the basic use of the system and its features, the Skills Simulator lets trainees accustom themselves to the interface through manipulation of the actual surgeon console controls. Compatible with any da Vinci® Si model, this additional software employs three-dimensional simulation visuals to provide the user with numerous skills exercises in virtual environments and task-specific metrics of varying difficulty—as described in Intuitive Surgical Inc.'s 2010 Annual Report. Having the option to undergo console-based simulation would provide trainees with unparalleled hands-on practice and allow them to gain an unmatchable level of comfort with the robotic platform prior to participating on any patient-based surgery. In addition to promoting safe training practice, having both the operative and training modules combined into a single device would prevent institutions from having to make separate expensive purchases. Surgeons-in-training would be able to observe procedures completed by their mentors, and then practice with the simulating software between cases and whenever the operating room is vacant.

Simulator cost, in concert with lack of validation for the simulators that are young on the market, still makes the investment difficult to justify for many institutions. Until further development of a well-accepted robotic training interface, laparoscopic VR simulators may be effective in helping trainees overcome an early portion of the learning curve of the robotic platform. As the technology for robotic surgical simulation improves and competing models are released to the market, hopefully these educational simulators become more affordable and accessible to aspiring robotic surgeons.

35.5.6 Da Vinci® Si Dual Console Model

In 2009, Intuitive Surgical Inc. (Sunnyvale, CA) began offering a dual-console da Vinci® Si model—envisioned both as a tool of operative assistance for the primary surgeon and to permit active instruction during surgeon-student training sessions. This equipment upgrade allows an experienced surgeon and trainee to share control of the robotic arms and simultaneously operate on a patient. While both surgeons easily communicate and share an equal field of vision, the trainee can proceed through the procedure with the input and guidance of the mature instructor. At any intraoperative juncture, the instructor may override the movements of the trainee to ensure patient safety and a quality procedure outcome. Additionally, the surgeons may control virtual 3D pointers, aiding visual communication and instruction. This dual-console approach is thought to be an effective means of late-stage training in robotic surgery; however, as the training model is a relatively new addition to the da Vinci® lineup, there has yet to be any validating study that shows it to be a cost-effective and efficient educational approach. The additional cost of the dual-console robot, $2.2 million compared to the $1.75 million of the standard device, may deter a number of academic institutions from the investment, thus limiting accessibility of the dual device to surgeons-in-training. The need for supporting literature regarding the value of the da Vinci® Si dual-console training model is needed to encourage its acquisition in more teaching hospitals.

35.5.7 What May Come in the Future

With the growing demand for robotic-assisted procedures in all specialties, the need to continually progress robotic training equipment and simulation technology is clear. In recent years many suggestions have been made to better the trainee experience and to make robotic surgery education less expensive; those proposals have included the modification of laparoscopic training devices, upgrades or add-ons to the current robotic platform, and the generation of a full-on robotic surgery simulator (the responses to which have just been described). In their study, Davis et al. also noted equipment upgrades of potential value during live surgical instruction, including enhanced visual technology for the bedside surgeon and two-way microphones for improved communication between the bedside and the robotic console [17]. Recent developments have certainly advanced the quality and depth of robotic surgical training; however, many of these new tools remain pricey and are not yet supported by published literature.

There is still ample room for technological innovation within the realm of robotic surgical training beyond the recent efforts. Advances in this area will hopefully enhance the convenience and quality of education for students of robotics and further promote the safe integration of patient surgery into the experiences of the novice surgeon. While the currently available training options should become more affordable and accessible to trainees over time, the need to parallel the pace of innovation for both surgical and training equipment will persist. As advances in operative technology are continuously being made, representative training models should follow to promote the greatest quality of surgical education. For instance, a near-infrared imaging system has recently been incorporated into the da Vinci® Si and utilized for indocyanine green-fluorescent imaging during robotic-assisted laparoscopic nephrectomy [31]. And, what may be the next generation of the robotic surgical platform, Titan Medical Inc.'s Amadeus®, is being designed to allow a surgeon force feedback for the first time. How well and how soon will training simulators come to emulate these groundbreaking technologies?

35.6 Concerns

From a technological standpoint, one must wonder whether the development of robotic surgical training devices will proceed fast enough to prepare the next generation of surgeons. With the application of robotic surgery still on the rise, academic medicine must provide an increasing supply of apt surgeons to meet the patient demand for the robotic approach. Supporting evidence of the effectiveness of currently available robotic simulators and training devices may serve to encourage investments by hospitals and educational institutions. However, for the most part, only a series of small studies with a lack of consistency have been performed, and further efforts are needed to validate a specific training tool. Whether or not the efficacy of these training devices is authenticated by literature, we must hope that the technology becomes available to more teaching institutions by ways of decreased cost. In addition, as patient demand and expectations continue to rise, is it imperative that not only the accessibility of but the quality of robotic surgical training be amplified by new equipment and inventiveness. The discrepant growth rates of robotic surgery's popularity and the advancement of its training approach over the past decade are becoming cause for concern. While RA surgical technology has undergone a rapid evolutionary expansion since the turn of the century, only recently has training technology mirrored this level of innovation. When planning for the future, healthcare industries must consider how to offer higher-quality robotic training to a greater number of aspiring surgeons, under a financially feasible and safe model of implementation.

Training programs for robotic surgery are also presented with a variety of limitations and concerns. Of utmost consideration in any hospital is the focus on patient safety, which complicates the dilemma on how to best educate and train aspiring surgeons. While many would argue that the best way to learn is by "doing," the need to gradually introduce residents to operating room participation is readily apparent. Rising expectations of patient outcomes have paralleled the evolution of robotic surgical technology. As a consequence, some institutions may feel reluctant to instruct naïve students in robotic surgery out of concern that expectations may not be met. Prematurely training surgeons on patients are considered unacceptable in any surgical field, making this concern equally pertinent across today's healthcare world. This challenge, in conjunction with the elevating expectations of patient outcomes, has served to decrease the operative exposure of many trainees. The laparoscopic nature of robotic-assisted surgery and the removed surgeon console have diminished the efficacy of bedside assistance for residents. While the new da Vinci® Si model does offer a second teaching console and an extra telestration monitor as training enhancements, these tools are not yet widely utilized or validated. While there are many hopes that training models for the robotic platform become more affordable as the technology does [32, 33], the current cost of the robot, as well as optional trainee console, leaves many institutions without a device to safely introduce patient surgery to residents and fellows.

Frequently it is this high cost of the operating room and educational training technology that presents the greatest obstacle for institutions in their willingness to train residents in patient-based robotic surgery. As the robotic surgical interface is a substantial capital investment, any hospital or university faces a great opportunity cost for all extra time the device is used for educational purposes rather than for additional surgical cases. As a solution, some academic programs have introduced students to only portions of a procedure at a time. The implementation of stepwise training curricula has effectively increased trainee exposure, while posing very limited inference to work flow, operative time, and surgical volume in a number of program models [16, 34]. The establishment of teaching approaches for specific procedures within robotic-surgical specialties would greatly benefit the effectiveness of residency and fellowship training in those fields. Furthermore, such procedural organization may make educational endeavors financially feasible for more teaching hospitals.

Another ongoing concern is the lack of consensus on robotic credentialing for the field of urology despite the numerous attempts to address these issues [35]. The American Urology Association (AUA) published Standard Operating Practice's (SOP's) for Urology Robotic Surgery intended for those seeking certification in 2010 [36]. These SOP's, however, do not include specific guidelines for granting privileges for individual surgical procedures; they rather describe the responsibilities of credentialing parties and outline the minimum experience requirements for the practice of urological robotic surgery. The AUA maintains that credentialing physicians for operative procedures are the responsibility of each teaching institution and that qualified committees or individuals at each site may formulate their own requirements for approving a surgeon's practice of robotic surgery. In addition to the completion of an ACGME-accredited urology residency program and American Board of Urology certification, one must have robotic surgical training in their residency and/or fellowship—indicating at least 20 completed robotic procedures. The AUA has deemed a structured training program appropriate for active urologists who wish implement robotic-assisted surgery into their practice, as well as for residents who received inadequate robotic exposure during their residency training. The requirements for the attaining privileges in robotic surgery for those in either of these scenarios include the following: completion of an online training module, certification in the open approach of the given procedure, hands-on experience and instruction with the robotic surgical interface, successful completion of the proctored procedure, procedure assistance by a certified robotic urologist until competency has been verified, the initial presence of adequate biomedical support in early performed cases, and a review of surgical outcomes.

Despite these experience requirements set forth by the AUA, the lack of any validated surgical training curricula and means of effectively evaluating skill and surgical competency leave the criteria for robotic certification ambiguous at many institutions. Furthermore, with the associated learning curve of the da Vinci® platform, 20 cases are not deemed an acceptable case volume to achieve surgical proficiency. The Society of Urologic Robotic Surgeons (SURS) maintains that proctoring is a critical component of the training process and should, therefore, be a prerequisite for all credentialed surgeons and robotic practice [37]. At the same time, the minimal criterion for becoming a proctor, which is currently set by the robotic industry, is also thought to be inadequate. SURS believes that the establishment of a centralized certification authority is crucial to establish and uphold the integrity of certification standards for robotic surgery and to further promote the safe implementation of RARP for patients, surgeons, and institutions alike. It is recommended that such an authority assumes responsibility for granting permission to proctor and for the development of a standardized means of evaluating surgeons-in-training. Also, SURS believes that the medicolegal implications of proctoring and preceptoring need to be minimized and better defined. A full series of recommendations put forth by the Society of Urologic Robotic Surgeons is listed in the Appendix.

Lastly, the use of more technology and instrumentation presents surgeons with additional venues for complication. While malfunction of the da Vinci® platform is quite uncommon, it has been noted in the literature. As part of the robotic training process, a surgeon must be taught how to deal with technical complications, especially those that may occur intraoperatively. According to a recent international survey, 56.8 % of responding surgeons performing RARP had encountered a technical problem that could not be resolved during the procedure [38]. In the event of a platform malfunction, a surgeon has the choice to proceed with a laparoscopic or open approach. The survey further illustrated that fellowship-trained surgeons were more likely to use laparoscopy, while there was no correlate to surgical volume [38]. Laparoscopic proficiency during robotic surgery is indispensable. As it has also been shown to complement the acquisition of robotic skill, laparoscopic training should be a part of, or a prerequisite to, a fellowship in robotic surgery.

35.7 Recommendations

Educating surgeons to achieve proficiency with the robotic platform is a multiple-step process. In order to ensure cost efficiency and patient safety, familiarization with the robotic interface must begin outside of the operating room. Lectures or online tutorials ought to be the first means for aspiring surgeons to attain knowledge about the new technology. Steps of video learning, observation, virtual reality simulation, and practice on cadavers or animal models should follow. Ideally, a surgeon's first surgical attempts will utilize a dual-console robot, during which a mature surgeon may regain control of the operation at any time. It is also advisable that a proctor remains present during a surgeon's initial individually executed procedures [39]. In the event of a complication, if a subspecialist is not available, assistance from an experienced robotic surgeon in a remote location may be transferred via teleproctoring [40]. Until residency programs begin to produce a larger supply of proficient robotic surgeons, it is recommended that more "mini-residency" training programs and regional preceptoring centers are established [37].

Conclusion

Despite the recent rise of surgical simulation and educational technology, the need for a structured and validated system to train and verify the competency of new users persists. As simulation can be utilized to both build and evaluate the skill set of aspiring physicians, it is likely the future not only of robotic surgery but of all medical training.

Consider the comparison of medicine and aviation, a field in which simulation has had an integral role in both training and skill maintenance for considerable time. A plane model cannot be sold without an accompanying simulator that has been established and validated. In contrast, the surgical robot was built and distributed without any pathway for patient-safety education models. If pilots and surgeons share a common responsibility for the safety of others, why has such discrepancy been tolerated? Should medical technology companies be permitted to release new products without a training simulator as its counterpart?

Beyond simulation, the development of proper and effective guidelines in robotic surgery is of utmost importance. The Society of Urologic Robotic Surgeons has recently published a consensus report on training, credentialing, and proctoring. In addition, the American Urological Association has distributed and approved standard operating practices for urologic robotic surgery. Together, these organizations have tried to outline safe practices for surgeons to follow in order to safely perform robotic urologic procedures.

Appendix

Suggested Recommendations for the Safe Implementation and Credentialing of RARP at an Institution: Society of Urologic Robotic Surgeons

1. The establishment of a national/international, centralized, certification authority which would institute and uphold standards for safe introduction of RARP in an institutional credentialing committee setup.
2. Credentialing of institutions and individuals to be based on these standard guidelines. The guidelines need to cover basic requirements with regard to training, certification courses, departmental staffing, and infrastructure.
3. Until residency programs provide an abundance of skilled robotic urologists (5–10 years), we recommend an increased number of regional centers to assist with preceptoring through mini-residency programs.
4. The central certification authority, rather than the robotic industry, should assume responsibility for identifying and promoting expert robotic surgeons. Only such designated experts, based on peer-support, submitted videos, and case logs, should be permitted to serve as a proctor.
5. The central certification authority will need to develop a standardized report for proctors to complete for each RARP, which will need to be submitted to the institutional robotic committee for review.
6. The first few (3–5) cases of the novice urologist will need to be proctored by an approved proctor, preferrably by the same proctor for all cases. Individualized requirements may be necessary for those with laparoscopic versus open radical prostatectomy experience and background. The proctor's report will then collectively be reviewed by the institutional departmental staff/credentialing committee prior to granting unrestricted robotic privileges.
7. Legal liability of the proctor/preceptor to be minimized by including the institutional legal counsel in the credentialing committee of the institution. He/she should be actively involved in the formulation of guidelines and their implementation.
8. The institution should indemnify the proctor against any possible legal implications while performing proctoring services for RARP.
9. Informed consent must be obtained from the patient with regards to the role of the proctor during the surgery and thereafter.
10. The role of the proctor should be clearly defined by the institutional credentialing

committee. Whether or not the proctor is expected to intervene in case of a possible intraoperative necessity should be clearly established and documented beforehand.

11. A system of periodic review by the institutional robotic committee of the performance of the surgeon including case selection, surgical competence, management of complications, and postoperative outcomes should be set in place. Continuance of robotic privileges should be subject to consistent performance in all of these criteria. Failure to perform adequately should result in a recommendation for a refresher training or additional preceptoring prior to continuity of these privileges.

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