Robotic Pyeloplasty

5

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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

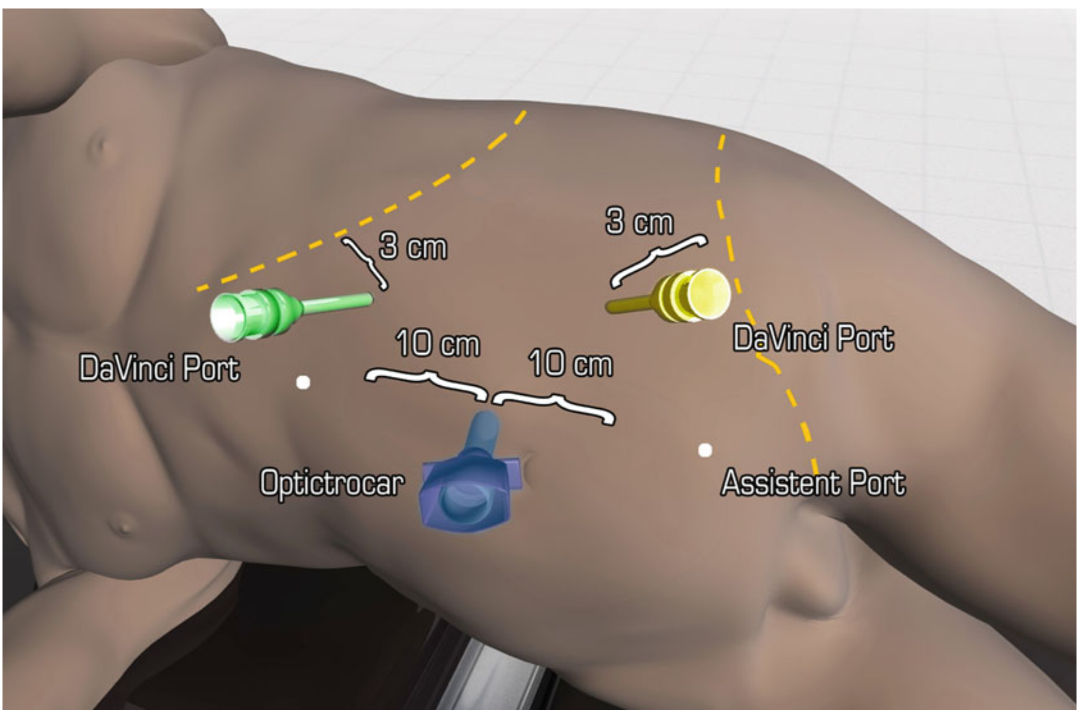

Fig. 5.3 The port placement

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.

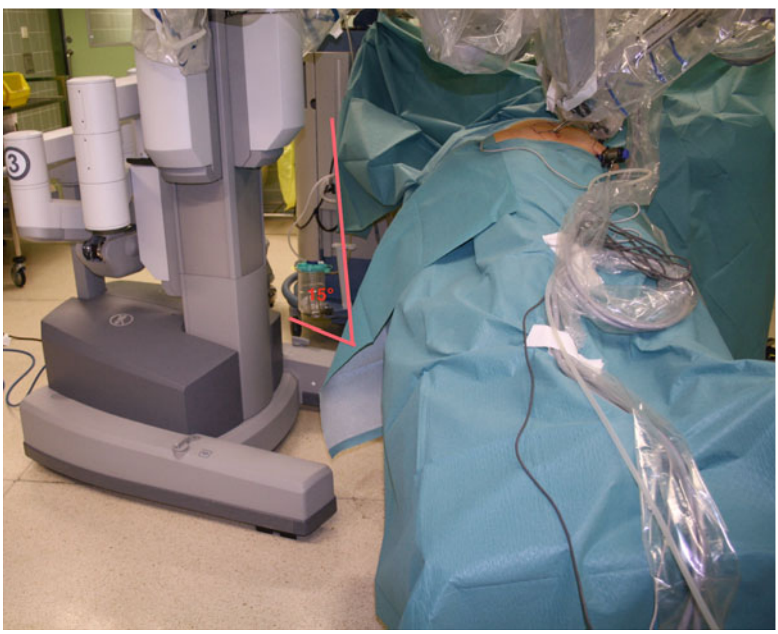

Fig. 5.5 The patient cart is moved in an angle of 15° from the back of the patient

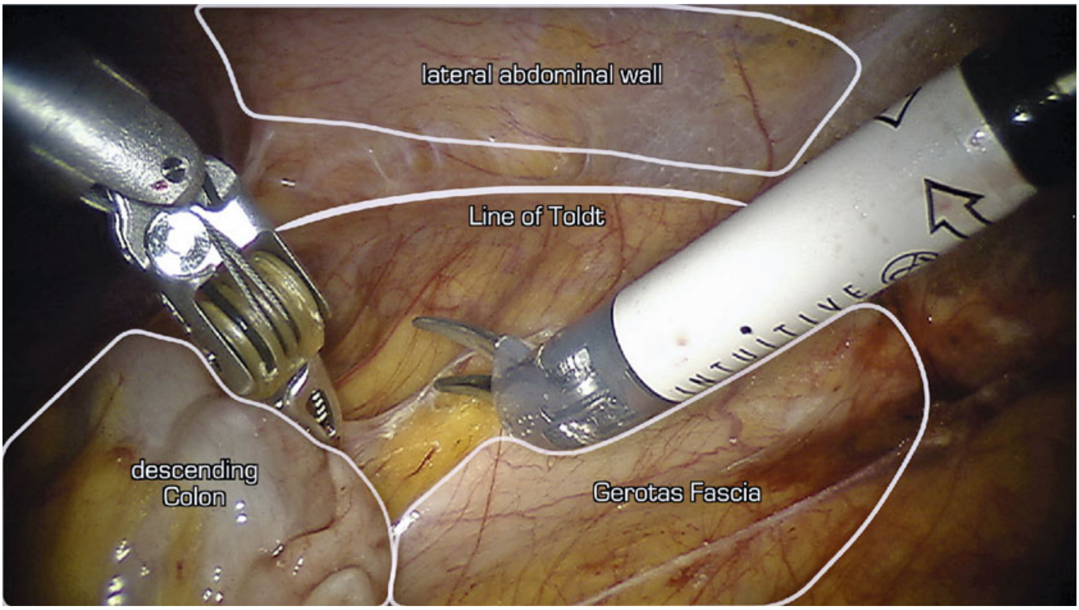

Fig. 5.6 The illustration shows the dissection line to enter the retroperitoneum on the left side

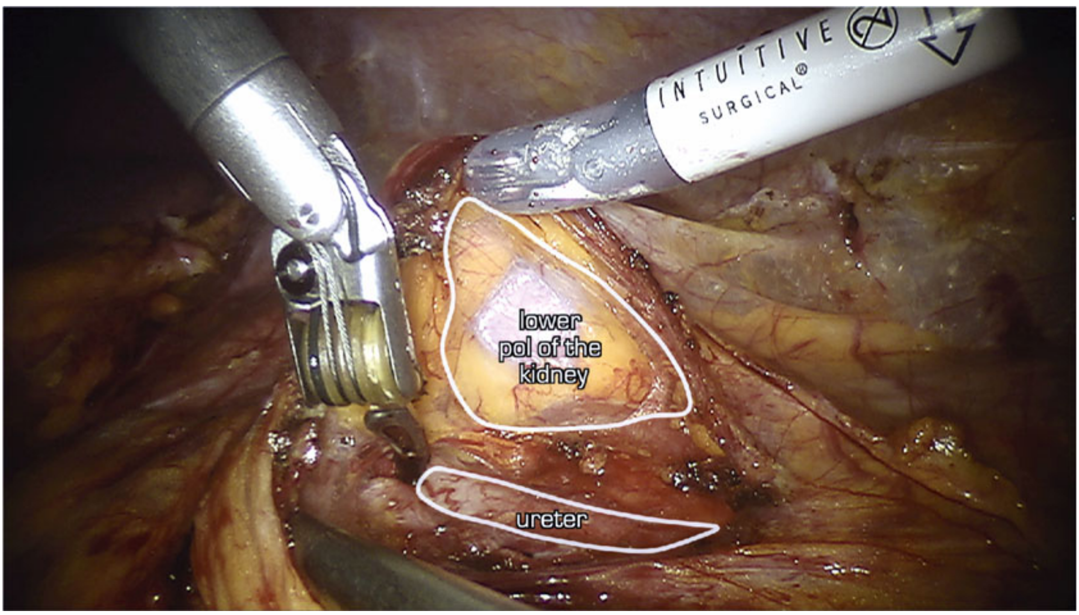

Fig. 5.7 The ureter is identified and traced proximal to the UPJ

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 mediocranially through the anterior wall (Fig. 5.9). The ureter is then stabilized through the still

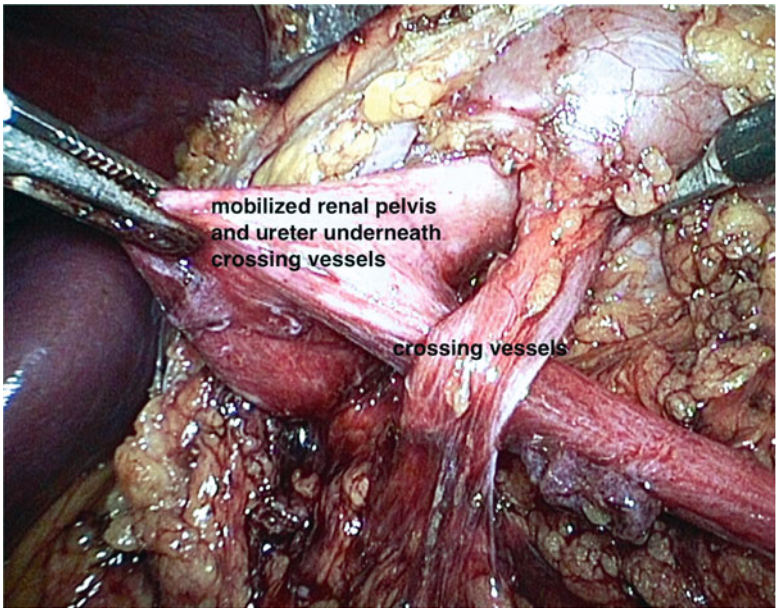

Fig. 5.8 The renal pelvis is circumferentially freed and detached from the obstructing crossing vessels. Ready to transpose them posterior to the anastomosis later on

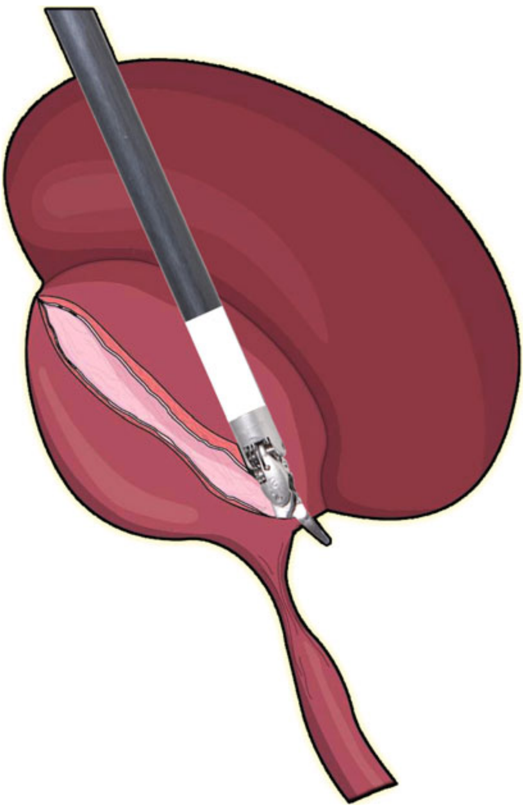

Fig. 5.9 The resection starts by only incising the ventral wall of the renal pelvis. From the caudal end of this incision, the spatulation of the ureter is done, while the posterior wall stabilizes it so that the lateral circumference of the ureter can be clearly identified

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

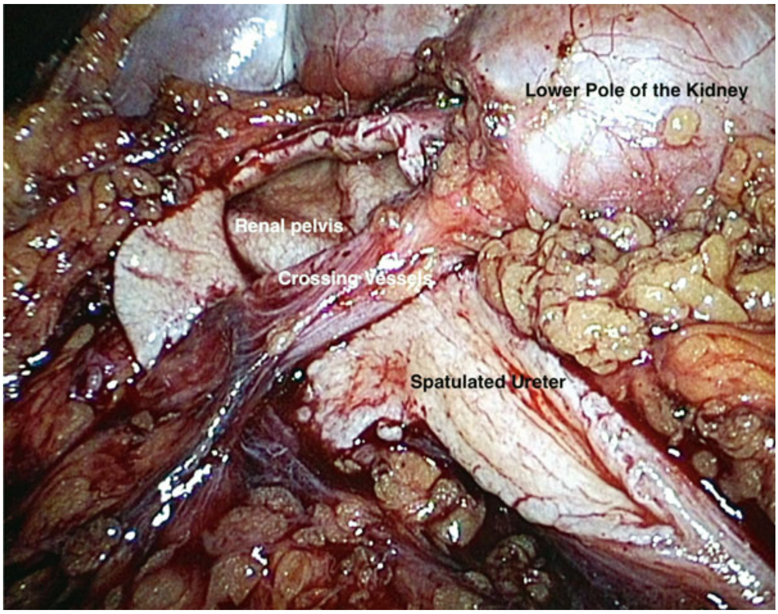

Fig. 5.10 The renal pelvis is opened, and the spatulation is done below the crossing vessels, while the posterior wall of the pelvis is still intact

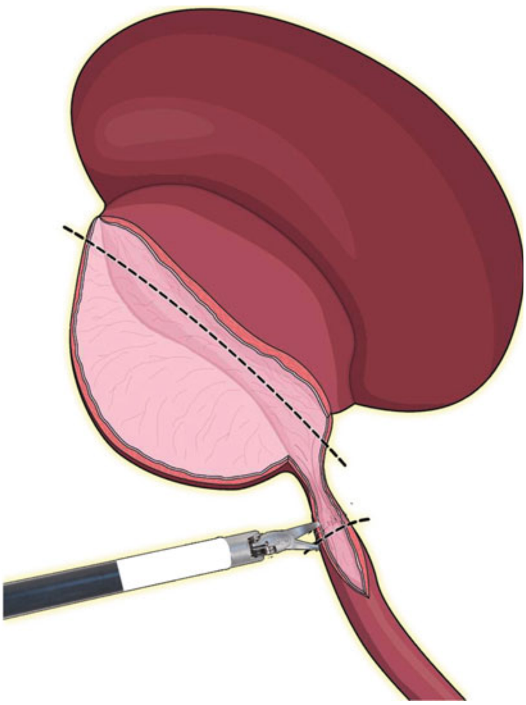

Fig. 5.11 The resection of the renal pelvis and the stenotic ureter segment is done after the spatulation

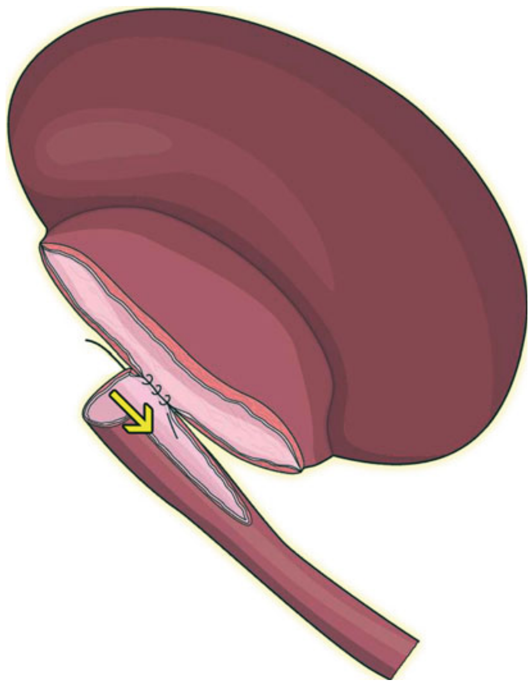

Fig. 5.12 The anastomosis starts at the cranial portion of the ureter and is directed to the tip of the spatulation

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

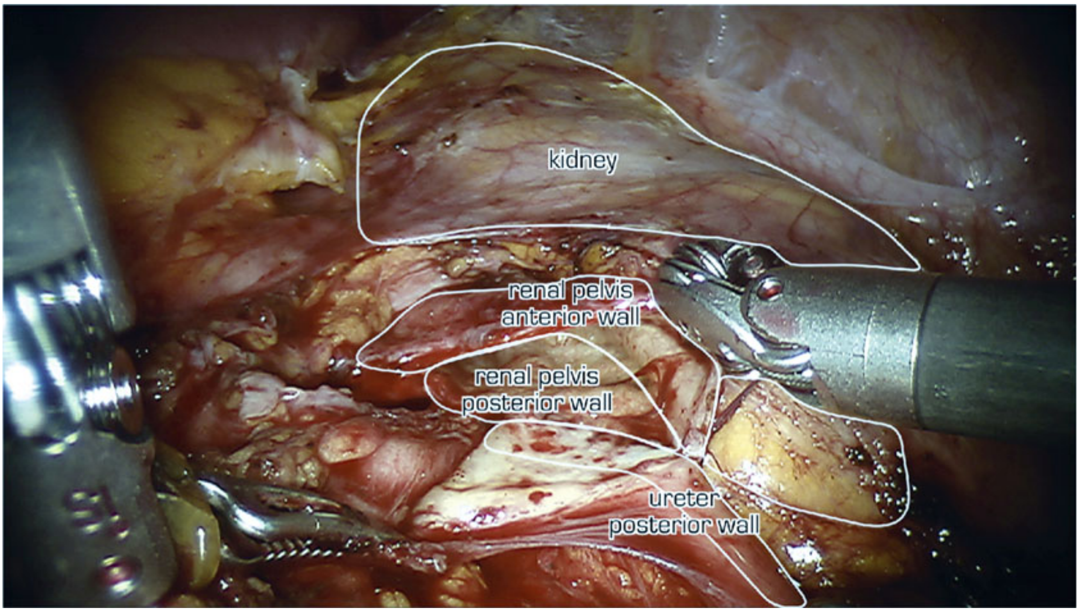

Fig. 5.13 The anastomosis of the posterior wall is completed showing an entire mucosa to mucosa adaptation

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

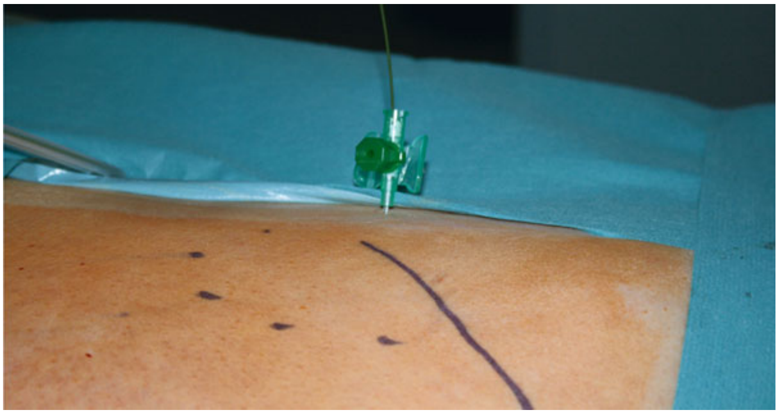

Fig. 5.14 The venous cannula is inserted percutaneously, and a guide wire is brought into the abdomen through this access

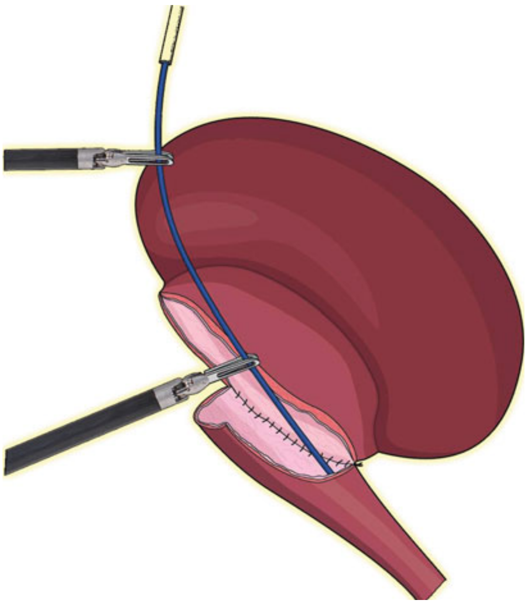

Fig. 5.15 The percutaneously inserted guide wire is directed with the robotic instruments into the proximal ureter and then further down to the bladder, followed by the JJ catheter in an antegrade fashion

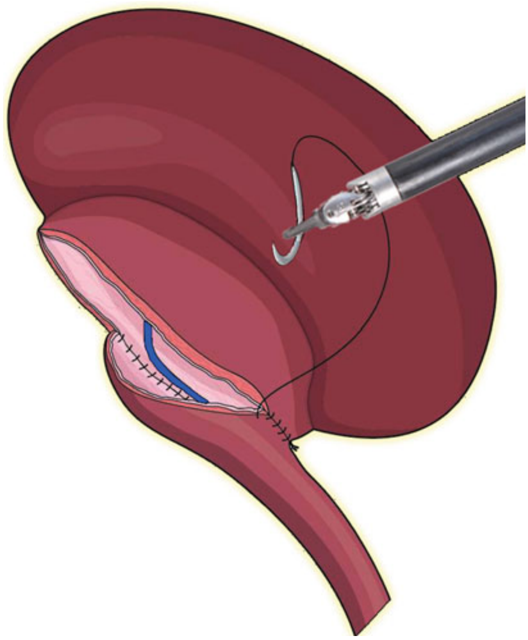

Fig. 5.16 After the JJ catheter is placed, the ventral part of the anastomosis is carried out, starting from caudal to cranial

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.

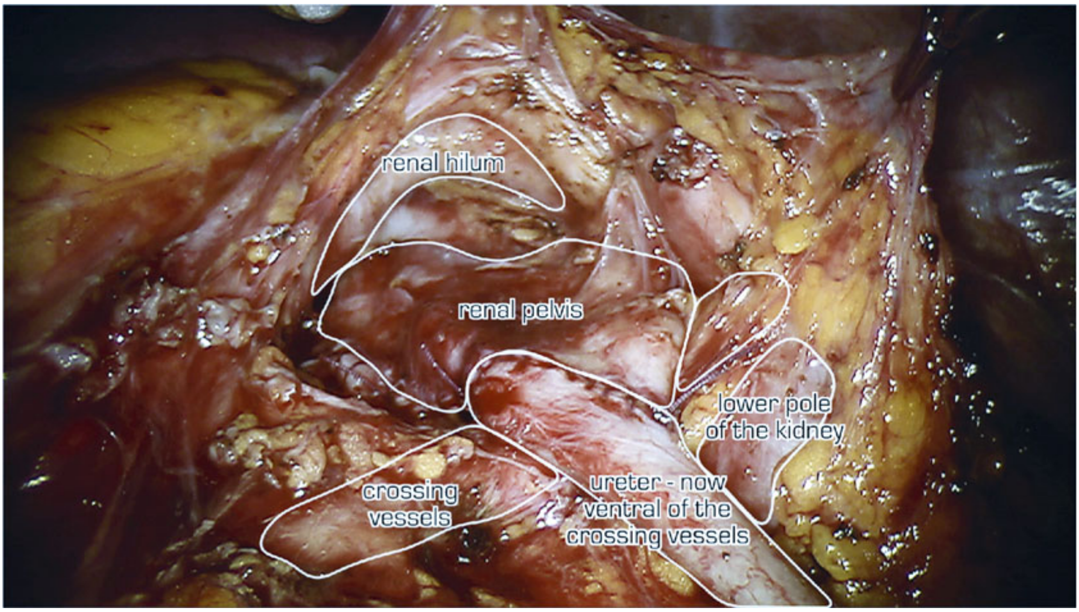

Fig. 5.17 The final anastomosis should be watertight and funnel-shaped and should be positioned ventral to the crossing vessels

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

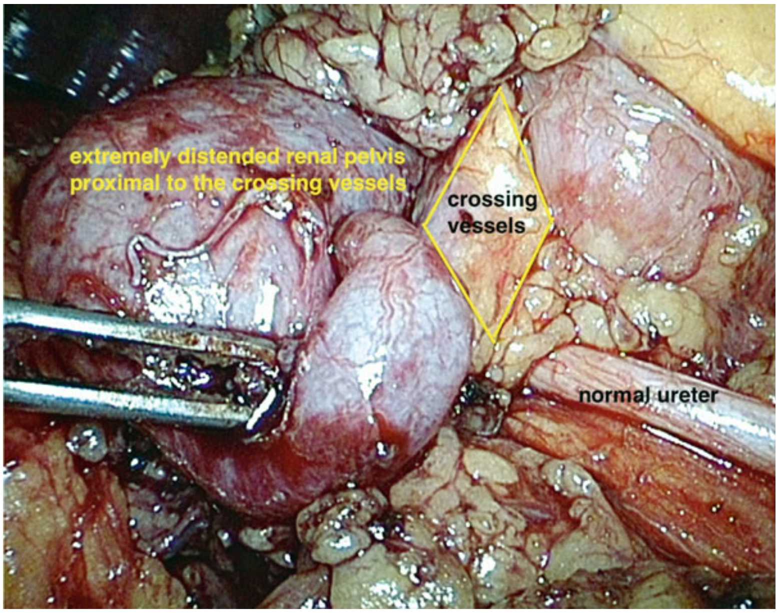

Fig. 5.20 Especially with a very distended renal pelvis, crossing vessels can be difficult to handle

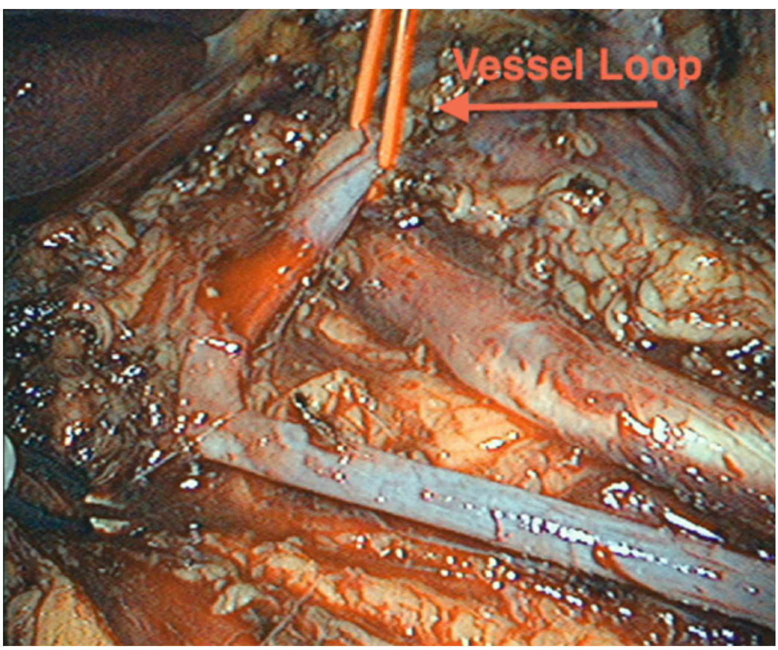

Fig. 5.21 Crossing vessels are encircled, and the ureter below is mobilized

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

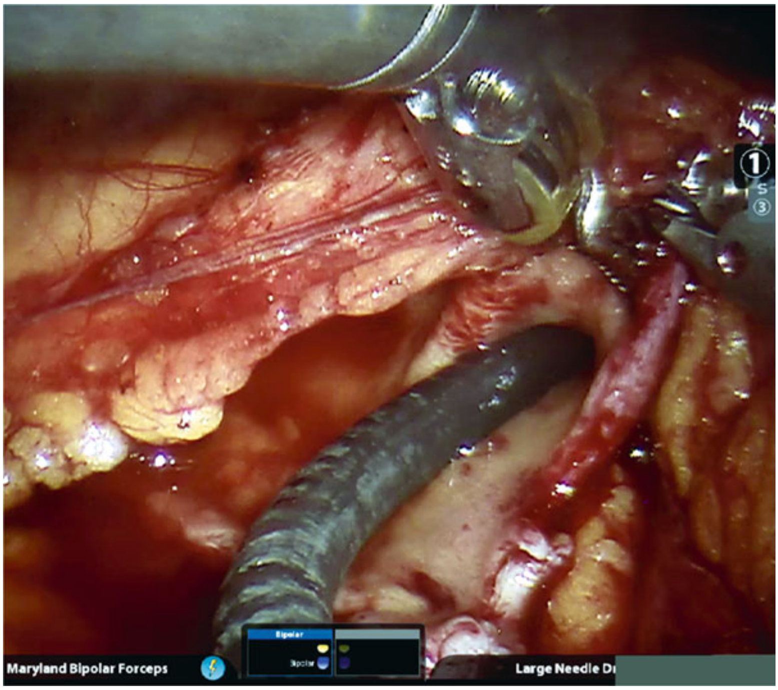

Fig. 5.23 The tip of the cystoscope is advanced into a calyx after the renal pelvis is opened

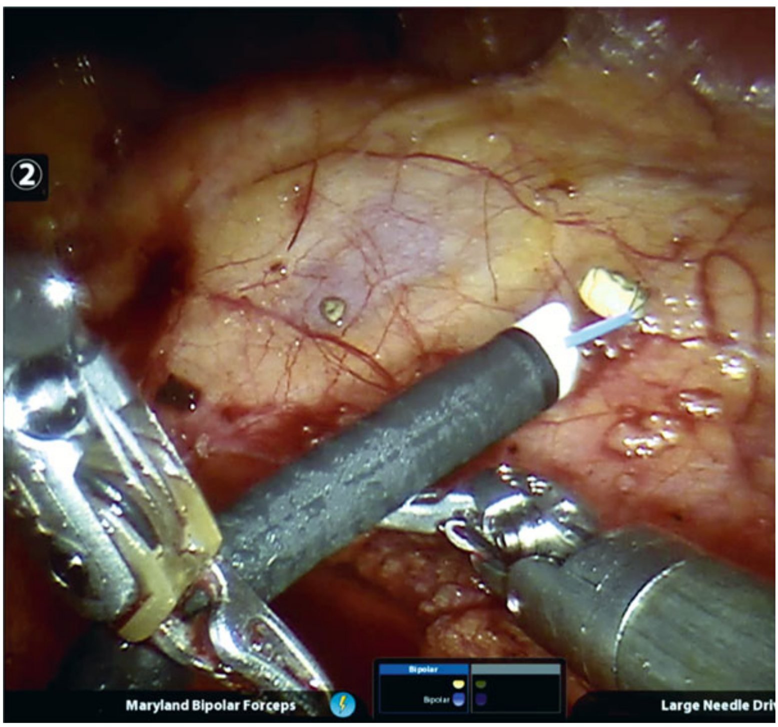

Fig. 5.24 After the stone is entrapped in the basket, it can be removed with the cystoscope

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.

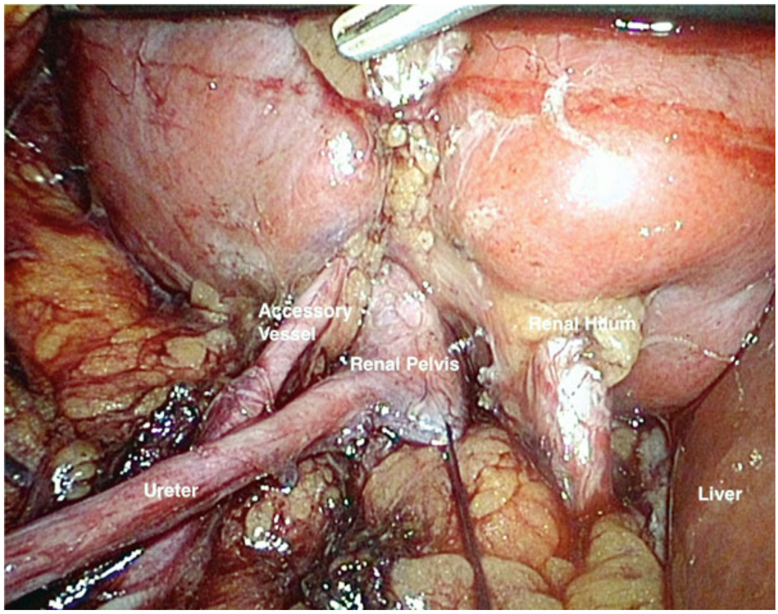

Fig. 5.25 A very small renal pelvis can lead to difficulties during the anastomosis by slipping into the hilum if a dismembered technique is chosen. A stay suture can be helpful for the exposure

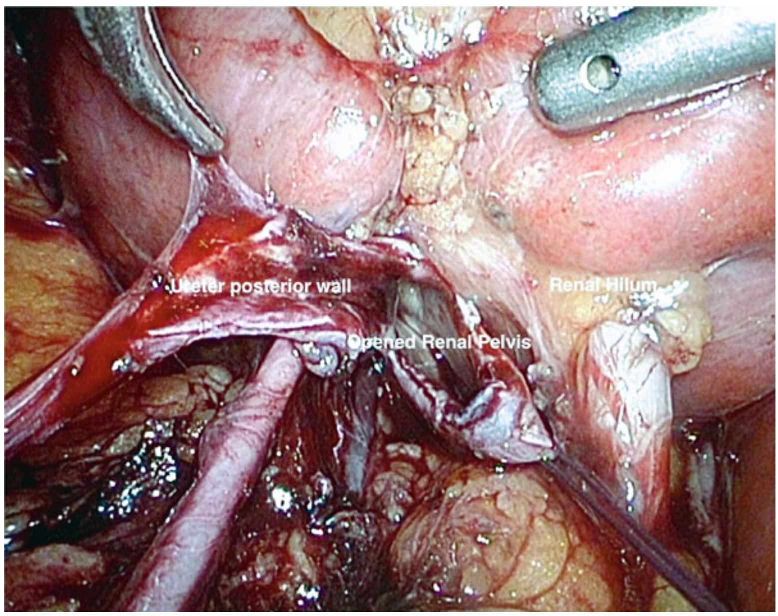

Fig. 5.26 The renal pelvis is opened in the shape of a V, and the stenotic part of the ureter is incised ready for the anastomosis

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,

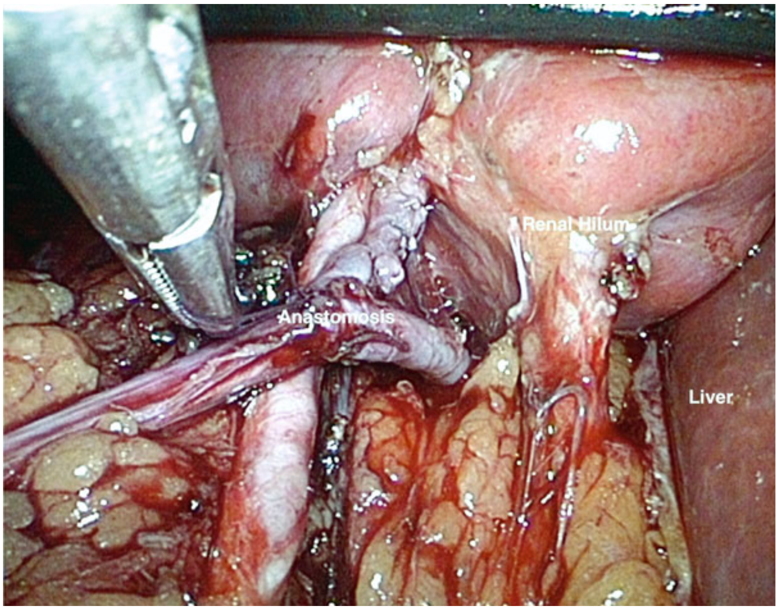

Fig. 5.27 The tip of the opened renal pelvis is sutured to the ureter below the incised stenotic part, resulting in a funnel-shaped anastomosis

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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