Robot-Assisted Pelvic Lymphadenectomy

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Kris E. Gaston and John W. Davis

Introduction

Robot-assisted pelvic lymphadenectomy for bladder cancer has developed in the past decade in the setting of fairly established literature from open surgery outcomes that promote the extended template method. The practice pattern of extended versus more limited templates may be inconsistent, but the data from high volume centers certainly point to specific oncologic gains from the former. Therefore, the surgeon setting out to learn this technique should consider three key questions for their learning objectives: (1) What is the background of the extended template? (2) What are the key anatomic considerations for the extended template from the robotic surgery view? And (3) are there remaining concerns about the ability of a robotic surgeon to provide high quality retrieval of lymph nodes at the time of robot-assisted radical cystectomy?

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K.E. Gaston
Department of Urologic Oncology, Carolinas Medical Center, Levine Cancer Institute, Charlotte, NC, USA

J.W. Davis, M.D. (✉)
Urology Director, Urosurgical Prostate Cancer Program, MD Anderson Cancer Center, 1515 Holcombe Blvd., Unit 1373, Houston, TX 77030, USA
e-mail: johndavis@mdanderson.org

Development of the Extended Template Pelvic Lymph Node Dissection at the Time of Radical Cystectomy

Approximately 25 % of patients undergoing surgery for muscle-invasive bladder cancer are found to have lymph node (LN) metastases at the time of surgery [1–6]. The incidence of lymph node positivity increases with increasing tumor stage with a range of 2–5 % in pT1 tumors, 16–22 % in pT2 tumors, 34–51 % in pT3 tumors, and 41–50 % in pT4 tumors [1–9].

Many authors have contributed to the understanding of the lymphatic drainage from the bladder, but this was well summarized by Leadbetter and Cooper [8] who described lymphatic drainage of the bladder to six distinct areas: (1)the lymphatic plexus within the bladder wall, (2) the anterior collated lymph nodes (nodes in the perivesical fat and surrounding the bladder), (3) pelvic collecting trunks–which are the medial lymph nodes of the external iliac and hypogastric lymph nodes, (4) regional pelvic lymph nodes which included the external iliac, hypogastric and sacral lymph nodes, (5) lymphatic trunks to the regional pelvic lymph nodes, and (6) the common iliac lymph nodes.

There has been much controversy over the limits of pelvic lymphadenectomy in regard to adequate bladder cancer surgery. Whitmore and Marshall described the standard lymph node dissection for bladder cancer [9]. In the 1970s, Dretler et al. reported the benefit of lymphadenectomy with

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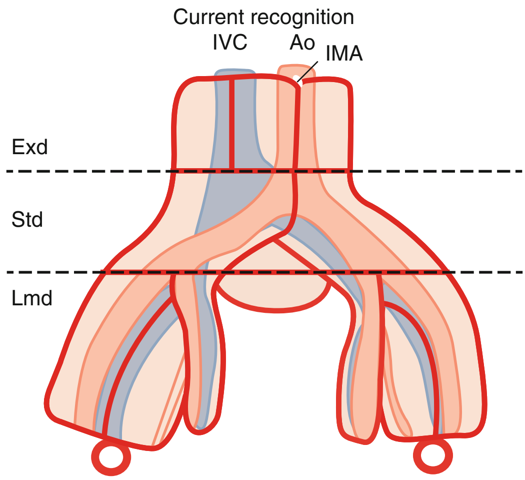

Fig. 9.1 Pelvic node dissection templates—limited (LMD), standard (Std), and extended (Ext)

radical cystectomy and found that survival of node positive patients improved by lymphadenectomy without increasing the morbidity and mortality [10]. Skinner reported in the 1980s a 36 % 5-year survival in patients who underwent a "meticulous" lymph node dissection [3]. A limited pelvic lymphadenectomy traditionally included dissection posteriorly to the obturator nerve, anteriorly to the external iliacs stopping the proximal dissection at the bifurcation of the iliac vessels, and distally to the arcus tendineus of the pubic bone at Cloquet's node. Historically, the standard lymphadenectomy included removal of the lymphatic tissue from the obturator region with the limits of the obturator nerve posteriorly, external iliac vessels up to the common iliac vessels including tissue from the fossa of Marcille cranially, and distally to Cloquet's node at the arcus tendineus of the pubic bone and circumflex vein. Extended pelvic lymph node dissection has varying definitions according to high-volume centers which typically includes the standard dissection in addition to dissection with the cranial limits being the aortic bifurcation plus or minus to the inferior mesenteric artery and inferior vena cava and posteriorly with resection of the hypogastric tissue including presacral lymph nodes (Fig. 9.1). Some authors call the cranial dissection to the IMA and the hypogastric regions a super-extended lymph node dissection [12].

What is considered adequate pelvic lymphadenectomy for bladder cancer and is there a therapeutic benefit in LN positive disease? Smith and Whitmore demonstrated that the obturator and external iliac lymph node regions were the most common sites for lymph node metastases at 74 and 65 %, respectively [11]. Additionally in this study it was found that 19 % of positive lymph nodes were along the common iliac chain. This was one of the first studies indicating that a standard lymph node dissection was likely an inadequate for removal of regionally involved lymph nodes. Leissner et al. performed a study in 447 patients who underwent pelvic lymphadenectomy and found that there was a statistically significant survival advantage in patient who underwent a more extended lymphadenectomy with equal or greater than 16 lymph nodes removed [5]. There was a significant correlation between the number of lymph nodes removed and the 5-year cancer-specific survival in pT1-3 tumors. In a later multicenter study by Leissner et al. that involved 290 patients who underwent radical cystectomy with extended pelvic lymphadenectomy found that approximately 28 % have positive lymph nodes and the percentage of metastases at different sites range from 14.1 % in the right obturator nodes to 2.9 % in the paracaval nodes above the aortic bifurcation [6]. Their analysis found that the incidental LN metastases was 21 % for nodes inferior to the bifurcation of the common iliac artery and 18.6 % at the common iliac and presacral nodes. They also showed that 10 % of primary sites of lymphatic spread were at the common iliac nose, and tumor spread to the contralateral side of the pelvic nodes was also found. They also report reported that 16.5 % of lymph node positive metastases were found between the level of the IMA and the aortic bifurcation suggesting the necessity for dissection of this region especially for the purpose of staging. However, a separate study by Zehnder et al. compared the extended lymphadenectomy data from Skinner's series at the University of Southern California which included superior boundary of the IMA to the

University of Bern with the boundary being the uretero–iliac crossing [12]. The USC group compared to the University of Bern group had a higher number of lymph nodes taken (38 versus 22, $p<0.0001$) and a higher incidence of lymph node metastases (35 versus 28 %, $p=0.02$). However, patient survival and recurrence was almost equivocal between these two large institutions suggesting no additional survival benefit from dissecting more cranial than the level of the ureteroiliac crossing at the common iliacs. Thus, the cranial extent of the dissection remains controversial in regard to survival.

Many authors have made the argument about the increased potential for staging with ePLND in regard to stratification of patient who may need adjuvant chemotherapy after surgery. However, to date there is no level I evidence that strongly supports adjuvant chemotherapy affecting survival in the postoperative setting. However a small retrospective series from Steinberg et al. that demonstrated that patients with lymph node metastases who received chemotherapy lived six times longer than patient who did not receive chemotherapy (48 versus 8 months, $p<0.0001$) [13]. The benefit of adjuvant chemotherapy remains controversial; however, extended staging lymphadenectomy may be important for identifying patients at high risk patients for recurrence. The incidence of patients with nodal positive disease likely increases with a total of number of lymph nodes removed [12]. USC popularized the concept of lymph node density, which was defined as the total number of positive lymph nodes divided by the total number of lymph nodes taken. Lymph node densities greater than 20 % demonstrated an increased risk of death versus patients with a lymph node density less than 20 % (17 versus 43 % 10-year recurrence-free survival) [14]. It has been well established in the literature that the number of lymph nodes that will be reported is dependent on the pathologic processing [15–17]. A number of studies have demonstrated that increased node counts will be reported along with increased positive node detection with the increased number of specimens packet sent [15–17]. There is the potential concern that extended lymph node dissection increases the potential complication rate with radical cystectomy. Brössner et al. performed a prospective study looking at 92 consecutive patients who underwent radical cystectomy with 46 undergoing a standard LND versus 46 undergoing an extended LND. There was no difference in 30-day morbidity between the two groups. The extended lymphadenectomy clearly increases the operative time; however, this is not translated to increase morbidity or mortality in the literature [18]. Nevertheless, the oncologic gains from the extended template must be balanced against the additional time required that may relate to overall anesthetic time and subsequent thromboembolic risk, accumulation of lymphoceles, risk for vascular injury, and temporary or permanent lower extremity edema.

Extended Pelvic Lymph Node Dissection Technique: Making the Transition with Robot-Assisted Platforms

Surgical training for robot-assisted radical cystectomy with extended pelvic lymph node dissection is best rooted in robot-assisted radical prostatectomy [19], first starting with cases that require only a limited node dissection and progressing to an extended template for high risk disease. The latter requires an understanding of the familiar obturator fossa anatomy in which the main task is to retrieve the lymph nodes from under the iliac vein from the distal landmark of the node of Cloquet and proximally to somewhere near the hypogastric artery. Laterally the border is the pelvic sidewall, and inferior is the obturator nerve, which must be preserved. From observing other surgeons and personal experience, it is clear that the distal node of Cloquet is often visible and fairly easy to obtain but likely drains the leg and less often involved with pelvic cancers. However the more proximal tissue in and around the obturator nerve as is passes lateral to the iliac vein is much more difficult to retrieve, and there is tremendous variability in how persistent surgeons are in working for these lymph nodes. These nodes, however, are very close to the hypogastric artery and a common landing site for prostate and bladder cancers.

Expansion of the template to the hypogastric artery zone, as described by Bader et al. [20] requires a more advanced skill set. The obturator fossa is fairly avascular, and the main potential complication is injury to the obturator nerve from blind clipping or errant cutting/coagulating. In the hypogastric template, there are multiple fine arterial/venous branches from the hypogastric and other feeding sources. The surrounding lymph nodes will not lift into the specimen until the vasculature holding them down is controlled with either a bipolar sealant or clip/cut. Furthermore, the exposure of the hypogastric artery requires some work. The peritoneum over the iliac vessels and psoas muscle needs to be divided, and the ureter identified and gently pulled medial—generally in the vicinity of its crossing over the common iliac artery. Within 3–5 cm of the takeoff of the hypogastric artery, the large caliber obliterated artery abruptly turns medial to the bladder. The ureter always passes inferior to this landmark. In prostatectomy, this artery can be preserved, while in cystectomy it must be taken. From this point distally, the hypogastric is a complex structure that dives deep within pelvic spaces, sending out varied patterns of branches medial to the bladder, and distally into the obturator space—some named structures and some not. Dissection along the hypogastric artery at this point occurs for a centimeter or two medially and would stop at the bladder. Lateral to the hypogastric artery, there is ample lymph node tissue present inferior to the obturator nerve all the way to the pelvic sidewall. Again, this region is rich in small caliber vascular branches requiring effective seal. In general, one distinct recommendation for extended pelvic lymphadenectomy for prostate cancer is to limit the lateral/high dissection to the junction between the iliac artery and vein. Thus some external iliac nodes are taken, but the lateral tissue from the artery to the genitofemoral nerve is left alone to decrease the incidence of postoperative lower extremity edema.

Continued evolution of technique from a prostatectomy to radical cystectomy requires expansion of the template. Based upon Bochner et al.'s lymph node mapping study from 2004 [21], we studied our learning curve with this procedure by adopting this template: right and left external iliac, right and left obturator/hypogastric, right and left common iliac, pre-sacral, and para-caval/para-aortic. This map, therefore consists of six paired zones and two midline zones. Initially we performed a protocol with robotic e-PLND to all zones and during the open diversion performed a second look open EPLND. The overall robotic times were a median 117 min (range 89–152) and retrieved a median of 43 nodes (range 19–63). Additional lymph nodes (median 4) were retrieved by second look open, but a majority of zones were completely cleared (67 %) or retrieved non-lymph node tissue (13 %) [22].

Sequence and Exposure

The pelvic lymph nodes can be done first or second. Doing them first leaves the urine drainage intact longer in the case and can setup the pedicles for the cystectomy as second step. The lymph nodes can be organized into 1–2 bags using surgical to separate the different zones. More recently, we have utilized the Anchor Tissue Retrieval System (Anchor Products Company, Addison, IL, USA), which can be reused, however, limiting the extraction to what can fit through a port. We avoid pulling large amounts of unprotected lymph nodes through ports to minimize risk of tumor seeding.

With a lymph node first approach, it is helpful to go ahead and divide the Pouch of Douglas and free up the posterior planes. For a nerve-sparing case, divide/mobilize the seminal vesicles as they will be valuable landmarks for the nerve sparing. To start the nodes, divide the peritoneum over the medial umbilical ligament and then across the iliac vessels and psoas muscle. Leave the midline intact so the bladder is easier to expose at the pedicles—see Video 9.1 and Fig. 9.2.

Instrumentation

The robotic surgeon utilizes the monopolar scissors, bipolar Maryland, and in the third arm the Prograsp or Cautier. The assistants need a

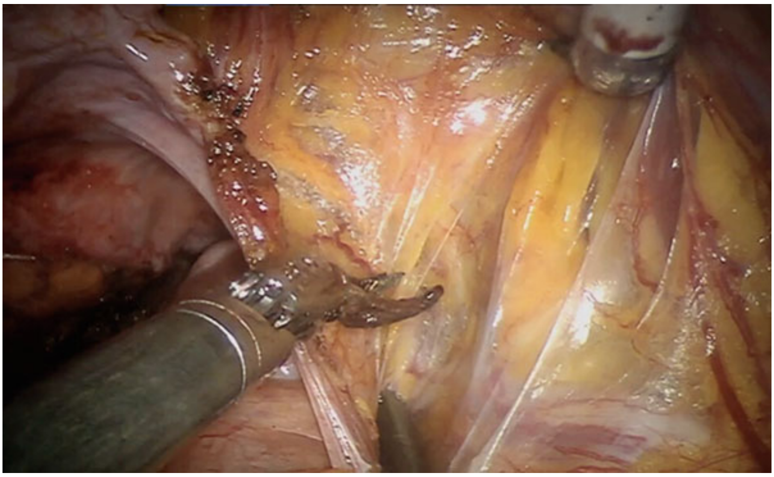

Fig. 9.2 Division of the peritoneum from the medial umbilical ligament and over the iliac vessels permits identification of the ureter and vessels

bowel-friendly grasper such as a laparoscopic Debaky and the suction. The position of the assistant varies by surgeon preference, however, if planning a robotic ileal conduit, the technique presented by Castle [23] calls for a left-sided assistant with two 12-mm port access to allow ideal stapling angles to the bowel.

In terms of dissection style, the monopolar scissors is efficient at dividing tissues and sealing very small vessels <2–3 mm. Vessels any larger require a bipolar and larger than 5 mm may require a clip. Most split/roll lymphatics can be simply divided with cautery, however, the proximal and distal extent of dissection should probably be clipped to decreased lymphatic collection, even though the operation is transperitoneal. Cautery use near the obturator nerve will likely induce a muscular contraction and should be avoided.

Vascular Injury

Any significant effort to clear an entire zone of lymph nodes in the retroperitoneum or pelvis will eventually lead to a vascular injury that needs repair. The iliac vessels are fairly robust and pliable enough to move around for dissection. However an errant use of cautery with the tips pointed into the vessels will likely cause an injury. In general pressure against the vessel to the side wall can control it without needing full circumferential clamping. It is important to recover from the adrenalin surge and carefully articulate repair plans with the staff. Specifically, give very clear instructions as to which instruments will be replaced for suturing and when so as to maintain control of the injury. For small vein lacerations a 3-0 Vicryl figure of eight can work. For an artery, 4-0 prolene figure of eight.

Common locations of injury outside of a cautery injury are near the take off of the external iliac artery/vein—especially lateral common iliac vein.

Extended Pelvic Lymph Node: Zone by Zone Description and Video Illustration

External Iliac Zones

This step is a good starting point for e-PLND. With the monopolar scissors, split the lymphatics down the midpoint of the artery and start another division line with the scissors or bipolar down the far lateral border over the psoas to the genitofemoral nerve. As these two lines are split, the iliac artery/vein becomes more mobile and can be pulled medially to create a sizable groove

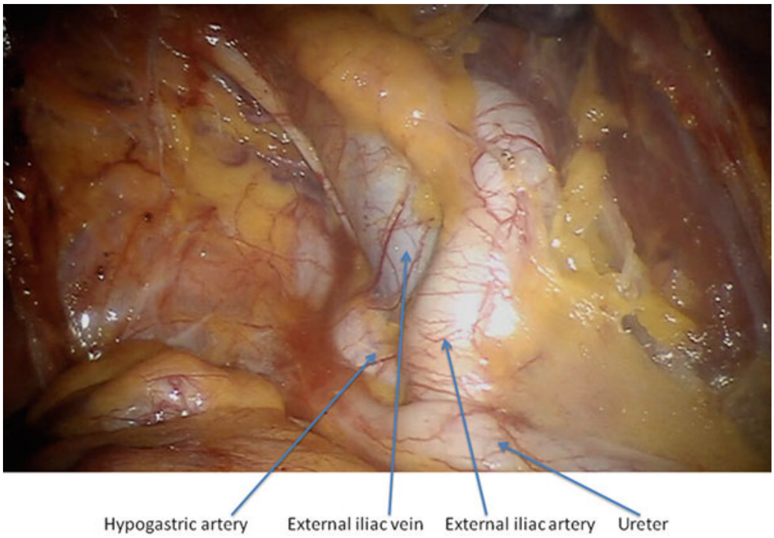

Fig. 9.3 Identification of the ureter and take-off of the hypogastric artery

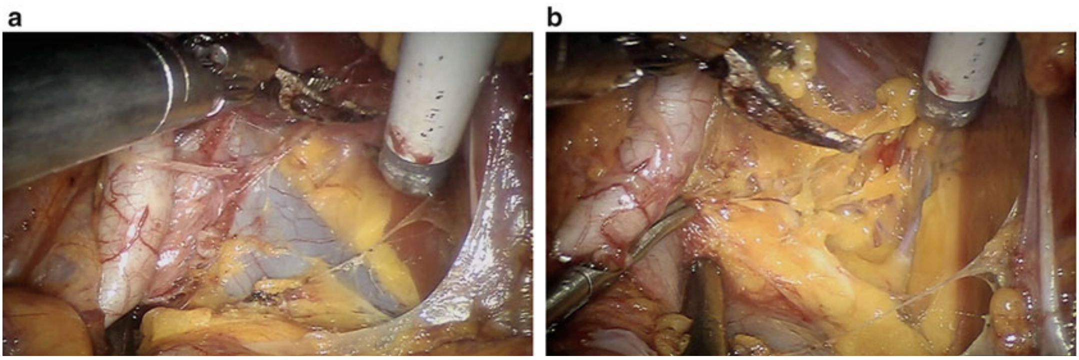

Fig. 9.4 External iliac zone. (**a**) The lymphatics are split down the artery and over the psoas muscle to the genitofemoral nerve. The common iliac vein is encountered (*right side*). (**b**) The right common iliac vein is retracted medially and the obturator nerve is identified. Lymphatics are separated from the many small vessels coming from the pelvic sidewall. On the *left side*, the common iliac vein approaches from a more medial angle and not seen in this space as much

between the vessels and the psoas muscle. Continue the dissection down the sidewall. As the space is cleared you will see the common iliac vein, which can also be retracted medially. Deep to this structure, you will see the obturator nerve as it passes from under the iliac vein to a more lateral position, headed to the sacrum. The lymph nodes are attached to varying micro vessels that often originate from the hypogastric branches but are heading into the pelvic side wall. These micro vessels can be sealed with the tips of the bipolar and the lymphatics mostly mobilized at this step. Doing the dissection in this sequence allows for a large bloc removal when you return from the medial approach through the obturator fossa. Of note, this most proximal nodal tissue that follows the obturator nerve often goes on and on and is difficult to completely clear of lymph and adipose tissue.

Once the groove space developed between the iliac vessels and psoas is cleared, continue to split the tissue in and around the iliac artery, achieving a separation between the artery and vein—Figs. 9.3 and 9.4a, b. This plane is carried back to

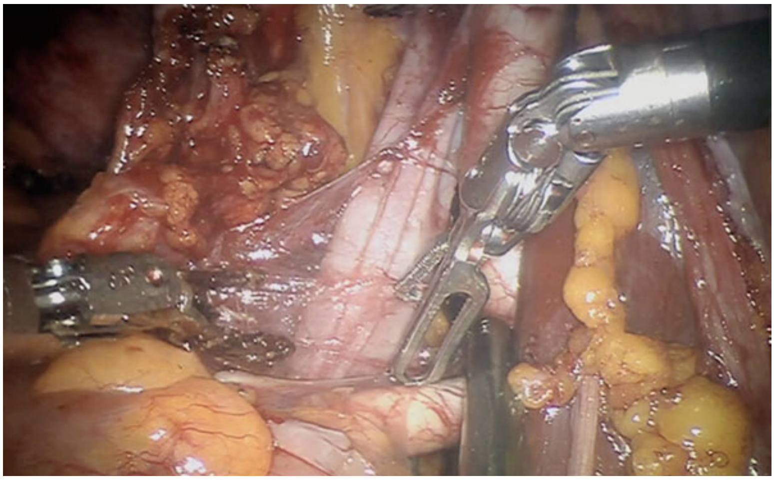

Fig. 9.5 External iliac zone. The dissection split continues in and around the artery creating space between. Once completed, this tissue can be sent as its own zone, and the dissection proceeds with the obturator/hypogastric. The lymphatic tissue seen to the *left* generally falls down and comes out en bloc with the obturator lymphatics

the common iliac artery. These combined nodes can then be extracted at this point. In our pilot study [22], the right external iliac zone took a median 11 min (range 7–20) and yielded a medina 5 nodes (range 2–8). For the left the time was 13 min (range 6–24) and nodal yield 4 (range 0–8). The range of nodes may vary by sequence. If, for example, the obturator packet is dissected first, some of the external nodes can easily be pulled into this bloc of tissue. By the same token, there is no anatomic separation between external iliac and common iliac, and these zone have to be manually separated.

Obturator/Hypogastric Zones

With the ureter mobilized medially, the hypogastric is cleared of tissue from its origin distally. The first major branch encountered will be the obliterated artery, which should be clipped and divided. Then the pattern varies with location and number of send off vessels into the obturator space versus more posteriorly. Often a clear superior vesicle artery is seen quickly and can be divided and clipped. Remaining tissue medially will often be captured in the pedicle dissection. By starting the procedure with the external iliac zone, much of the lateral obturator zone is freed up and comes out en bloc—Fig. 9.5. The tissue around the proximal obturator nerve was also mobilized and the remaining comes out in the obturator zone. Most of this zone can be completely cleared with the exception of the deepest tissue following distal hypogastric and the most proximal tissue along the obturator nerve. Additional tissue around the hypogastric tissue is easy to retrieve when completing the pre-sacral zone.

In our pilot study [22], the right obturator/hypogastric took a median 21 min (range 11–38) and retrieved a median 9 nodes (range 1–18). For the left side, the time was 20 min (range 11–29) and yield 6 (range 4–19). Figure 9.6 shows a post-dissection image of the obturator/hypogastric plane.

Common Iliac Zones and Pre-sacral

Moving higher to the common iliac zones used to be a challenge for the standard model robot due to the size/mobility of the arms. With daVinci S and Si models the access is greater for two reasons: longer instruments allowing higher port placement and greater range of motion by the arm itself. The exposure takes additional division of peritoneum above the location of the ureter crossing. The sigmoid colon generally needs

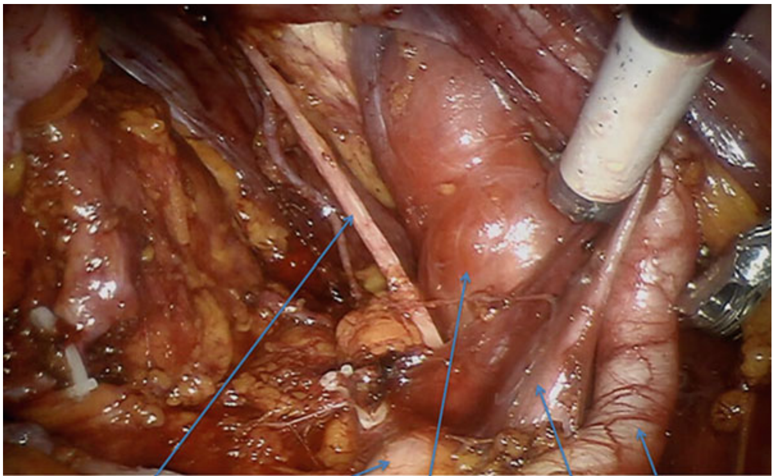

Fig. 9.6 Obturator/hypogastric zone. The obturator space clears easily due to the previous external iliac dissection. The dissection proceeds down the hypogastric artery and then laterally under the obturator nerve to the side wall

specific retraction by an assistant instrument or third robotic instrument. The lymphatics at the takeoff of the external iliac artery can be continued with split dissection to the point of the aortic bifurcation. An additional 3–5 cm of tissue can be split and retrieved in the para-caval right side and para-aortic left side. At some point, the arms lose range of motion. Once the common iliacs are split down the middle, the lateral tissue is mostly sent of designated as common iliacs—left and right. In the space between the common iliac artery, the tissue can be retrieved by retracting the sigmoid colon left and anterior to the abdominal wall. This maneuver with the third robotic arm should allow viewing from the aortic bifurcation to both sides of the common iliac arteries. The tissue between is then retrieved. The left common iliac vein will quickly be seen once lymphatics removed from the crotch of the aorta. Moving distally, the sacral bone is encountered and the tissue connects all the way back to the take off of the hypogastric artery. Moving back to the left side, the colon is push up and right, and the space connected in and around the left common iliac artery. Of note, the spaces around the lateral common iliac artery will often contain very friable common iliac vein branches that are hard to control if avulsed. Ideally, identify them early and seal them properly. Otherwise, packing with surgicel may be required.

Editors' Commentary

Erik P. Castle and Raj S. Pruthi

There are few things that will generate more emotion in the world of urological oncology than the debate regarding the adequacy of a robot-assisted pelvic lymphadenectomy. With the understanding that a complete pelvic lymphadenectomy may be curative in upwards of 30–40 % of cases, it is key that a thorough and complete lymphadenectomy is performed during RARC. The published literature currently supports that the numbers of lymph nodes removed and intermediate oncologic outcomes of RARC are equivalent to the open procedure (see **Chap. 14). In order to achieve this, it is key to adhere to the principles outlined in this chapter. Specific steps such as creating the space lateral to the external iliac vessels often referred to as the "Space of Marcille" as well as meticulous dissection of the lateral aspect of internal iliac artery posterior to the obturator nerve will allow the surgeon to complete a thorough pelvic lymphadenectomy. Extending the proximal extent past the common iliac vessels is based on surgeon preference. The benefits of the pneumoperitoneum will allow for great visualization as venous ooze is kept to a minimum. From a complication standpoint, one consideration is aberrant electrical energy from a compromised sheath on the monopolar scissors which has been described as well as "off screen" vascular injuries by the assistant. Keeping all of these considerations in mind, most surgeons who have undertaken robot-assisted pelvic lymphadenectomy agree that the robot in and of itself is not a deterrent to performing an equivalent and thorough lymphadenectomy. In fact, many believe that they may even be performing a more complete dissection today than they ever did before in their open cases.

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