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Contents

Robotic-Assisted Laparoendoscopic Single-Site (RLESS) Pyeloplasty

Jeffrey C. Gahan, Jeffrey A. Cadeddu

Introduction

The performance of the first laparoscopic nephrectomy in 1991 marked a new surgical era in urology [1]. Since that time, urologists have continued to embrace the advantages of laparoscopic surgery, while continuing to push its boundaries through the use of fewer and smaller trocars. The report of the first laparoscopic nephrectomy through a single fascia incision ushered in yet another era of urologic surgery. This approach, dubbed laparoendoscopic single-site surgery or LESS, was promoted to offer better cosmetic results as well as quicker convalescence compared to conventional laparoscopy [2]. However, since its inception, LESS has proven to be technically demanding due to a loss of triangulation, instrument clashes, and limited instrument articulation.

With the introduction of the da Vinci robot, laparoscopic surgery was again revolutionized. The robot recreated the wristed action of the human hand, while at the same time maintaining the minimally invasive nature of laparoscopic surgery. These advantages naturally led to its application in LESS surgery, with the first robotic LESS (RLESS) pyeloplasty reported in 2008 [3]. Since then, RLESS strategies have continued to improve both through advances in single-site platforms and newly designed robotic arms.

For a number of reasons, pyeloplasty has been identified as a rational application of LESS. As a non-extirpative surgery, it does not require specimen extraction and thus the incision can remain small. LESS pyeloplasty can also be performed through the umbilicus, allowing the incision to stay hidden and maximizing cosmetic results. In addition, many of the patients presenting with ureteropelvic junction obstruction (UPJO) are young and have a greater concern for favorable cosmesis. Lastly, the majority of these individuals have not had previous abdominal surgeries, making them ideal candidates for LESS. However, the extent of intracorporeal suturing needed

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during LESS pyeloplasty tended to make these surgeries prohibitive to most surgeons. With the inception of the robot, LESS pyeloplasty has become a more ergonomic and technically feasible operation. The strategies involved in setting up and performing RLESS pyeloplasty will be discussed in this chapter, along with the key points for patient selection and a brief discussion of the reported outcomes.

Diagnosis and Planning

The most common presenting symptom of UPJO is flank pain, which can be associated with nausea and vomiting, although other symptoms may include hematuria, recurrent episodes of pyelonephritis, recurrent stone formation, or vague abdominal pain. In some instances, UPJO may not present with pain, but may be identified surreptitiously on abdominal imaging, although this presentation is rare.

The work-up for UPJO is generally no different for RLESS pyeloplasty than for standard pyeloplasty and should be performed with the goal of identifying the anatomic site and functional significance of the obstruction. A CT scan is often performed when the adult patient presents with flank or abdominal pain and usually shows a dilated pelvicalyceal system with a normal caliber ureter. If the diagnosis is already suspected, a CT angiography can help to identify a crossing vessel etiology. A CT further can delineate the extent of perinephric fat, a large amount of which may significantly hinder the ability to perform RLESS pyeloplasty. The diagnosis can be confirmed with a diuretic renal scan, with a T ½ >20 min considered conclusive for the presence of obstruction [4, 5, 6]. In addition, the renal scan can give an estimation of the differential function of the kidney. While there is no well-defined cutoff, a kidney with less than 15–20 % function should be considered for nephrectomy. If there is concern for stricture length, a retrograde pyelogram may be helpful in planning a more extensive repair.

Additional considerations must be made when considering RLESS pyeloplasty compared to conventional pyeloplasty. In the author's opinion, BMI plays the primary role in patient selection. All series in the RLESS literature report an average BMI between 22 and 25, with many using a BMI >30 as exclusionary criterion for surgery [7, 8, 9]. Further, because RLESS pyeloplasty is often performed through the umbilicus, greater abdominal girth can increase the working distance from the fascial incision which may create difficulties with reach and visualization. Also of concern is previous abdominal surgery. Not only may port placement be compromised, but lysis of medial adhesions may not be possible in RLESS given the difficult working angles. Previous operations to the kidney, including endoscopic procedures, may cause significant fibrosis, which can cause difficulties when using single-site approach. Lastly, we advise ureteral stents to be removed at least 4 weeks prior to pyeloplasty to allow for a reduction in inflammation at the UPJ.

Other considerations for RLESS include the administration of a partial bowel preparation to reduce bowel volume due to the limited camera mobility. This can be performed with a bottle of magnesium citrate given the night prior to surgery. Sterile urine is also mandatory prior to any pyeloplasty.

Surgical Procedure

In most cases of RLESS, a ureteral stent is placed prior to the patient being placed in the flank position as LESS does not afford favorable angles when placing a stent in an antegrade manner. Stent placement may be performed under fluoroscopic guidance to give an idea of the location and extent of the UPJO and will ensure proper stent positioning. Conversely, other authors have reported using a flexible scope at the time of surgery to place a stent in a retrograde fashion in an effort to save time and avoid repositioning [8]. We have also positioned a stent antegrade over a guidewire introduced through a 14-gauge angiographic catheter inserted into the abdomen in the midclavicular line below the costal margin. Of note, it is encouraged to upsize the stent length by approximately 2 cm to ensure that it is not displaced from the bladder during manipulation of the anastomosis.

Patient Positioning

The patient is positioned in a manner similar to conventional pyeloplasty. The patient is placed in a modified or full flank position. It is the author's preference to use a modified flank position which eliminates the need for an axillary role. The arm can be secured safely at the side as shown with the table in slight flexion (Fig. 1). Alternatively, the arm can be draped over the face and supported with a pillow or Krause arm support. A Foley catheter should be placed prior to the start of surgery and remain accessible to the circulating nurse throughout the case as clamping and unclamping may be necessary. The bed is then maximally rotated away from the side on which the robot docks.

Fig. 1: The patient is positioned in a modified flank position with the arm secured to the ipsilateral side of the body undergoing surgery. The bed is rotated to the patient's left in this case.

Abdominal Access and Port Placement

A curvilinear 2–3 cm incision is made at the umbilicus, and dissection is carried down to the rectus fascia. Once exposed, the fascia is cleaned of fat and two 0-Vicryl stay sutures on a UR-6 needle are placed on each side of the fascia. These are then used to lift the fascia as it is divided. Once the muscle layer is separated, atraumatic forceps are used to lift the peritoneum and scissors are used to divide this sharply. Once peritoneal access has been achieved, the fascial incision is extended to accommodate the single-site platform of choice.

Our preference is to use the GelPoint access platform (Applied Medical, Rancho Santa Margarita, CA, USA). This is placed in the standard manner through the fascial incision. Care must be taken when the device is secured, ensuring no bowl loops become pinned between the device and abdominal wall. This can be verified with a finger sweep outside the device and confirmed with a 30° lens in the upward position. The gel portion of the device is then attached and insufflation is started. The ports are positioned as shown in Fig. 2. A 12 mm camera port is placed at the top or on the most lateral portion of the gel, and the gel ports are positioned in a triangular pattern as shown.

The robotic 5 mm cannulas are placed through the gel ports, and the camera is placed through the most lateral port in the 30° upward position. The upward angle keeps the extracorporeal portion of the camera arm away from the other robotic arms. The robot is then docked and the 5 mm arms are brought through the trocars (Fig. 3).

The remote center of the robot ports is positioned just above the fascial level, and the arms are crossed inside the patient (Fig. 4). The master control is then reprogrammed so that the right hand controls the left instrument and the left controls the right. This is done so intuitive control is gained by the surgeon once the arms are crossed. Once inside the body, the point at which the arms cross cannot be seen unless the camera is pulled back. The advantage of this method is that articulating instruments can still be used; however, the arms must be continually crossed and uncrossed depending on the retraction needed.

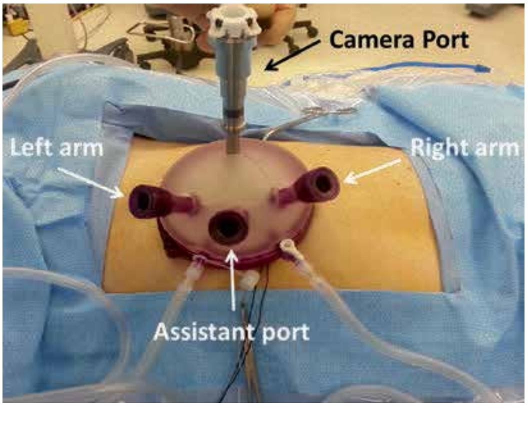

Fig. 2: Trocar placement using the GelPoint for RLESS pyeloplasty.

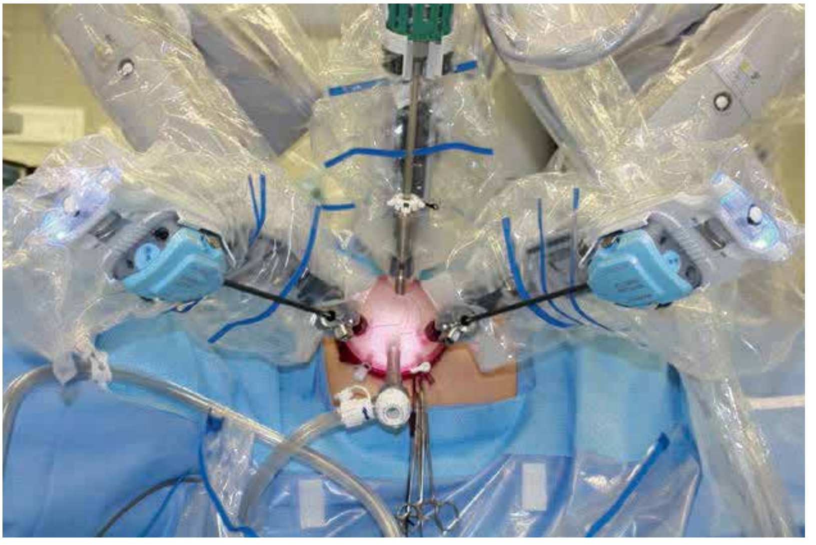

Fig. 3: Robot docked for RLESS pyeloplasty with robotic instruments and cannulas placed through the GelPoint trocars. The camera trocar is placed directly through the GelPoint.

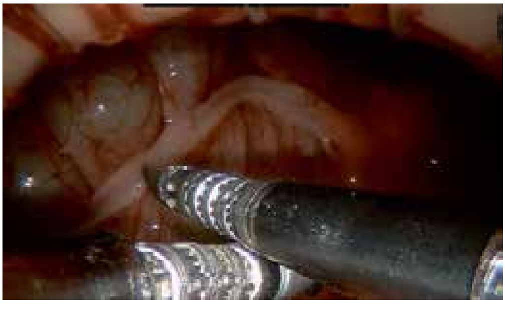

Fig. 4: Ports are positioned with their remote center at the level of the fascia, and the robotic arms are crossed inside the abdomen.

Fig. 5: Da Vinci single-site surgical platform.

An alternative to the GelPoint used by other centers is the da Vinci single-site platform (Intuitive Surgical, Sunnyvale, CA, USA) (Fig. 5) [10]. This surgical platform is specifically designed for RLESS. It is a multichannel, single-site port that accommodates two curved robotic cannulas which allow for semirigid instruments to cross inside the patient. Similar to the setup described previously, the master control is reprogrammed so that the left and right are reversed. One disadvantage to this system is that the semirigid instruments do not have articulating abilities. The camera is placed in the 30° downward position. Currently, this platform is FDA approved only for single-site cholecystectomy and hysterectomy.

Initial Steps

The operation is started by reflecting the colon medially. This is performed by grasping the mesenteric fat just lateral to the colon and lifting this off from the kidney (Fig. 6). A plane of loose areolar tissue between the colon/mesentery and Gerota's is encountered. This can be dissected through using the hook cautery with blunt or hot dissection. It is the author's preference to perform the majority of the dissection with the Maryland graspers and hook cautery, as the 5 mm scissors do not have cautery capability.

Once the colon is mobilized medially, the ureter is then identified. This is accomplished by grasping Gerota's fascia just inferior to the lower pole of the kidney and lifting this upward. The gonadal vein is identified and an incision is made in the fascia just above it, dropping it medially (Fig. 7). The ureter is located in nearly all cases just lateral and posterior to the gonadal vein. The ureter can be easily identified if a stent has been preplaced.

Alternatively, other centers have described a transmesenteric approach to locate the ureter, although this approach is not widely used [9]. This approach may offer the advantage of decreased bowel manipulation and quicker identification of the ureter. However, this approach does lend itself to consequences if a mesenteric vessel is inadvertently divided.

Once isolated, a grasper is then placed under the ureter and is lifted up toward the abdominal wall (Fig. 8). Circumferential access to the ureter is gained so that it can be placed on traction. The dissection of the ureter is then carried out cranially, with care taken to conserve as much periurethral tissue as possible so as to not devascularize the ureter. Care must also be taken to avoid crossing vessels as the dissection progresses toward the renal pelvis, as these may be encountered even in situations where they are not the etiology of UPJO.

If a crossing vessel is identified, the ureter below the crossing vessel and the renal pelvis above should be dissected free, rather than trying to dissect out the vessels themselves (Fig. 9). In addition, it is always prudent to dissect the renal pelvis to a greater degree than what is thought needed, as this will aid in sewing the anastomosis. Once clearly dissected and the cause of the UPJO determined, the method of reconstruction must be chosen.

Anderson-Hynes Dismembered Pyeloplasty

The dismembered pyeloplasty is the surgery of choice in most instances of UPJO. It is an effective repair given a number of etiologies including crossing vessels, strictured segments, or high

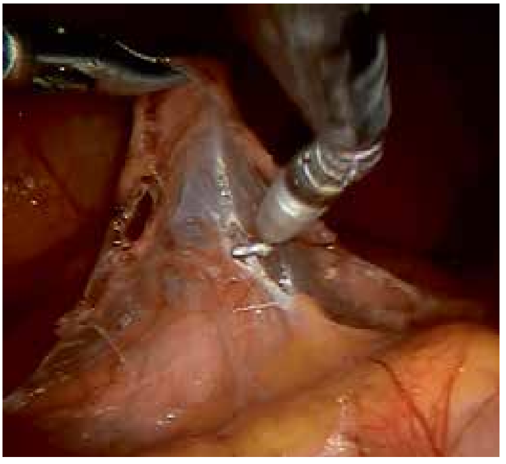

Fig. 6: The tissue lateral to the colon is elevated to reveal the loose, areolar tissue which is dissected off of Gerota's fascia.

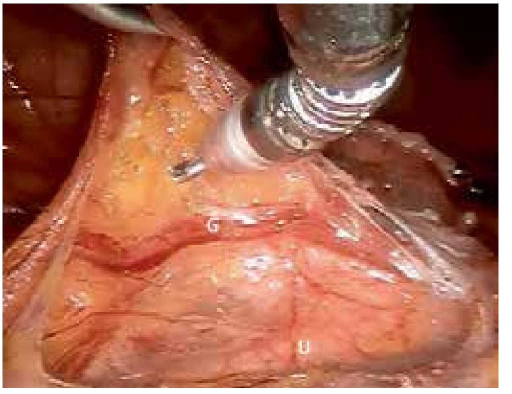

Fig. 7: The Gerota's fascia just caudal to the lower pole is lifted and incised, dropping the gonadal vessels (*G*) to expose the ureter (*U*).

Fig. 8: The ureter (*U*) is dissected free and elevated to provide tension for subsequent dissection. *G* gonadal vessels.

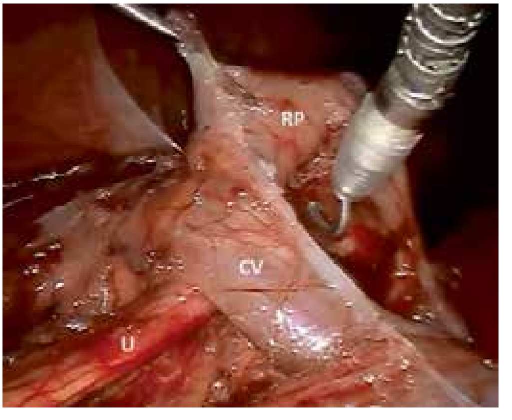

Fig. 9: The dissection of the ureter (*U*) is carried up to the crossing vessels (*CV*) at which point the renal pelvis (*RP*) is further dissected. The pelvis can be manipulated safely with a grasper, so long as the portion undergoing the anastomosis is not damaged.

insertions. Further, it allows for a reduction pyeloplasty to be performed. It also allows for anterior or posterior transposition of the UPJ and, unlike the flap techniques, allows for the removal of strictured segments.

Once the renal pelvis and ureter have been completely mobilized and dissected, the point of division must be decided. In the case of a crossing vessel, it is recommended that the dismemberment occur at the renal pelvis above the UPJ, as this etiology is rarely associated with internal stricture (Fig. 10). This allows for a more wide open anastomosis.

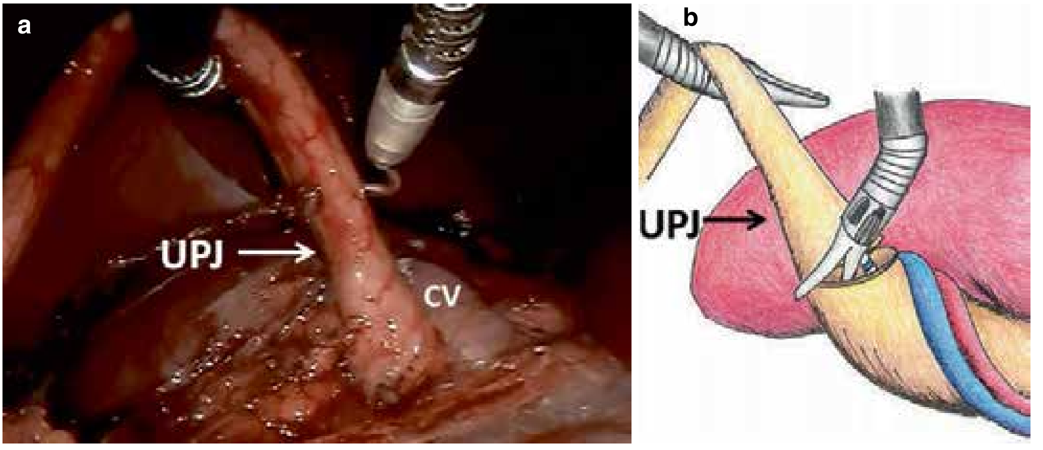

Fig. 10: (**a**) The UPJ can be brought below the crossing vessels with sufficient mobilization (**b**) and the renal pelvis divided proximal to the UPJ to facilitate a wide anastomosis. *UPJ* ureteral pelvic junction, *CV* crossing vessel

Fig. 11: The ureter is rolled using the periureteral tissue to facilitate spatulation along its lateral edge.

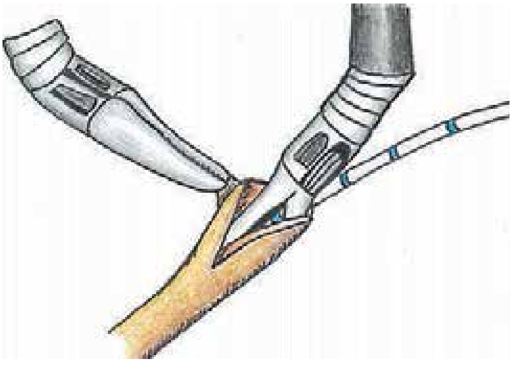

Fig. 12: The ureter is calibrated with the robotic scissors to ensure the lumen is widely patent.

Care must be taken to avoid cutting the preplaced stent. Once divided, the ureteral portion should spatulated along the lateral aspect and then cannulated with an instrument to ensure its patency (Figs. 11 and 12).

The ureter and renal pelvis are then transposed over the crossing vessel and the anastomosis is performed. We prefer to use a 4-0 Vicryl suture. The ureteral stitch is always thrown "in-to-out" to ensure the mucosa is obtained and the back wall is not inadvertently incorporated into the anastomosis (Fig. 13). Once the posterior aspect is completed, the ureteral stent is placed in the renal pelvis and the anterior anastomosis is completed.

A drain is placed either through a lateral stab incision or through the umbilicus and Gerota's fascia reapproximated over the anastomosis using Hem-o-lok clips. The LESS platform is removed and the fascia and skin are closed. The end result is shown in Fig. 14.

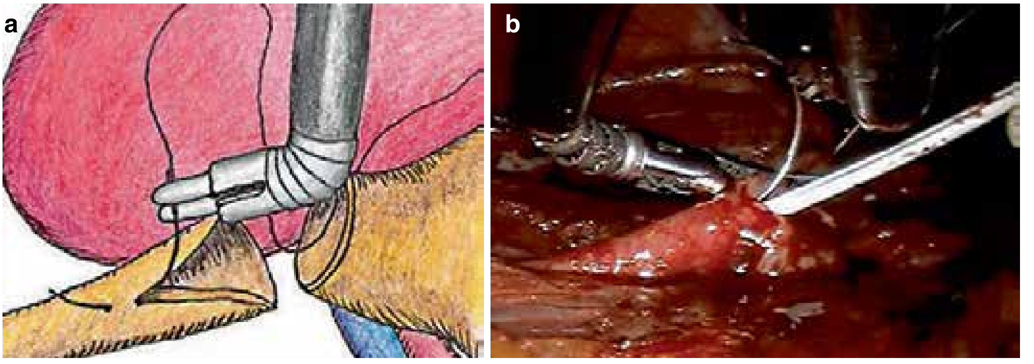

Fig. 13: (**a**) The renal pelvis is transposed over the crossing vessels and the first stitch is placed out-to-in through the renal pelvis, followed by (**b**) a stitch placed in-to-out through the ureter. A needle driver and Maryland grasper are used.

Fig. 14: The resulting skin incision of an RLESS pyeloplasty.

In situations where a strictured UPJ is encountered, a dismembered pyeloplasty can be performed with excision of the strictured segment. Unlike a crossing vessel etiology, this requires division both above and below the strictured segment. Spatulation and anastomosis are then performed as previously described. For cases where a large, redundant renal pelvis is associated with a UPJO, a reduction pyeloplasty is sometimes warranted. This is performed by simply removing a greater portion of the renal pelvis and sewing this portion to itself.

Foley Y-V Pyeloplasty

The Foley Y-V plasty was originally implemented to treat UPJO resulting from a ureter inserting high in the renal pelvis. This technique currently has a somewhat limited role as it is not efficacious when treating UPJO due to crossing vessels or when there is a redundant renal pelvis requiring reduction. It further is not useful when treating a strictured UPJ.

To perform a Y-V plasty, a wide inverted "V" incision is made to the point of high insertion on the medial aspect of the renal pelvis. The incision is then carried down the lateral aspect of the

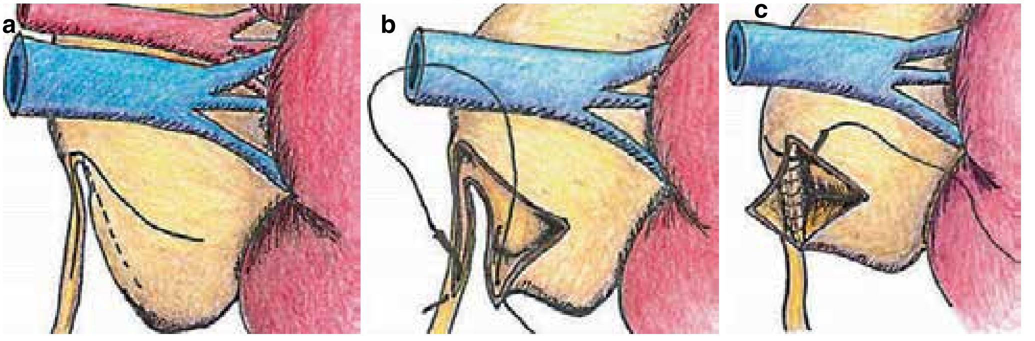

Fig. 15: (**a**) An outline depicting of the incision to be used in a high-insertion Y-V plasty. (**b**) An out-to-in stitch is placed in the renal pelvis, followed by in-to-out stitch at the apex of the ureteral incision. (**c**) The anterior wall is closed after the back wall of the Y-V plasty has been completed.

proximal ureter incorporating several millimeters of normal caliber ureter creating a "Y" (Fig. 15a). The apex of the generated flap is then sutured to the apex of the spatulated ureter (Fig. 15b). The posterior aspect of the anastomosis is completed in a running fashion followed by a running closure of the anterior component (Fig. 15c).

Fenger Non-dismembered Pyeloplasty

Focal stenosis of the ureter at the UPJ may be treated with a non-dismembered Fengerplasty. This assumes no crossing vessels or high insertion of the ureter. This is performed by making a 2 cm incision through the stenotic area extending approximately 1 cm on either side of the strictured segment. The incision is then closed transversely over a ureteral stent effectively increasing the luminal diameter at the strictured point. The advantage to this procedure is its relative ease and shorter operative time due to less reconstruction and intracorporeal suturing.

Vertical and Spiral Flap Pyeloplasty

In cases where the strictured segment is long, a vertical or spiral flap may be used. For this to be performed, the ureter must be inserted at the dependent portion of the renal pelvis. One disadvantage to this approach is that the strictured segment is not removed. Additional length may be gained from spiraling the flap around the renal pelvis. This is performed by making a ureterotomy into normal ureter approximately 1 cm distal to the ureteral stricture and caring this incision to the renal pelvis as shown in Fig. 16. The flap is then taken medially with the amount of renal pelvis incised directly related to the length of the ureter stricture to be repaired. The back wall is then closed with a running 4-0 Vicryl suture, followed by a repair of the front wall. Although this is a more complex reconstruction technique, this repair is possible because of the wristed action of the robotic instruments.

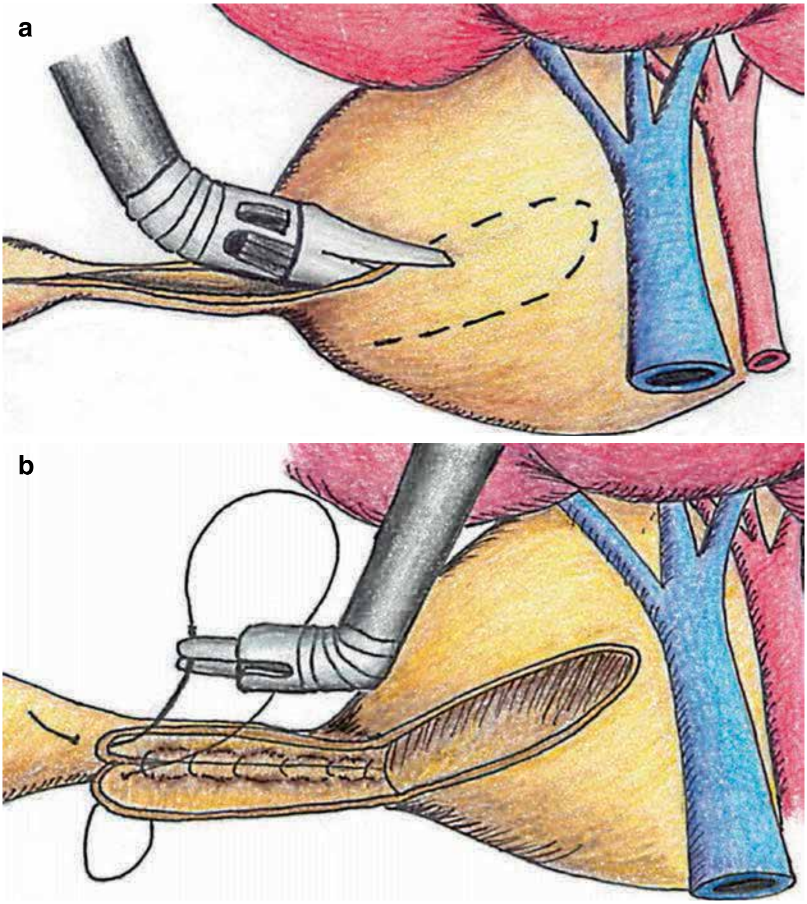

Fig. 16: (**a**) The creation of a vertical flap is shown, (**b**) followed by the running repair of the back wall once the flap has been created (Note: the stricture is not excised).

Postoperative Management

The care for patients undergoing RLESS pyeloplasty is no different than patient undergoing other forms of pyeloplasty. Typically, a Foley catheter and drain are left in place. The Foley catheter is typically removed the night after surgery and the drain output monitored until the next morning. If the drain output dramatically increases, the Foley catheter is replaced and the patient is discharged with the drain and catheter in place. If there is no significant increase in output, and the 24 h drain volume is minimal, the drain is removed prior to discharge. If there is a concern for leak due to equivocal drain output, or there are concerns with the integrity of the anastomosis, the drain fluid can be sent for creatinine level. The stent is left in place for 4 weeks and removed in the clinic with cystoscopy. A diuretic renal scan is obtained 6 weeks after stent removal to evaluate kidney drainage.

Outcomes

LESS pyeloplasty is a highly technical surgery and therefore is often associated with an increased learning curve when compared to traditional laparoscopic pyeloplasty or even extirpative LESS surgeries. Indeed, this has been shown in a multi-institutional study focusing on LESS procedures, whereby the majority of complications were identified in the LESS reconstruction cohort compared to the extirpative cohort (27.1 vs. 7.8 %) [11]. Demonstrating this steep learning curve, Best *et al*. reported that 71 % of their complications occurred in the first ten cases of their 28 case series of conventional LESS (CLESS) pyeloplasty. However, it is hypothesized that RLESS pyeloplasty can shorten the learning curve and minimize complications compared to CLESS. One study comparing these two approaches concluded there was in fact a shortened learning curve for RLESS based on common surrogates such as conversion rates and complications [7]. This study also reported a reduction in the number of accessory ports used [7]. It is the author's opinion that RLESS does in fact offer significant advantages compared to CLESS for the following reasons: (1) there is enhanced visualization using a 3-D high-definition camera; (2) the endowrist affords greater maneuverability and facilitates sewing; (3) intuitive control is gained by reprogramming the robot; and (4) removal of the surgeon from the crowded extracorporeal working space yields improved ergonomics (Table 1).

Table 1: Outcomes of selected RLESS pyeloplasty series.

	N	BMI (kg/m^2)	OR time (min)	Conversions	Complications (Clavien grade)	Success[a]
Harrow *et al*. [4]	22	22.0	208	0/22	2–3a	22/22
Olweny *et al*. [7]	10	21.8	226	0/10	1–3a	8/8
Tobis *et al*. [9]	8	24.0	181	0/8	1–3a	8/8
Cestari *et al*. [8]	9	22.5	169	0/8	1–2	5/5
Khanna *et al*. [15]	7	26.4	247	2/7	2	6/7

[a] Success defined as resolution of clinical symptoms

Despite these advantages, RLESS pyeloplasty remains a relatively new and infrequently performed operation, and as such, the literature concerning outcomes is limited. Currently, most RLESS pyeloplasty series demonstrate clinical success (defined as resolution of pain) in greater than 90 % of patients. This rivals the success of conventional robotic and laparoscopic series [12–14]; however, the RLESS series are small with limited follow-up (Table 1). There are also no series directly comparing RLESS to conventional laparoscopic or robotic pyeloplasty, making conclusions regarding its true efficacy difficult. Another limitation to the RLESS data is the relatively short follow-up. Published series report follow-up ranging from 3 to 12 months, although longer-term failures are known to occur with pyeloplasty. Despite these inadequacies, as RLESS technology continues to evolve both with the improvement of current equipment and the development of new devices such as the Titan robot (Titan Medical Inc., Toronto, Canada), RLESS pyeloplasty will undoubtedly have an increasing role in the management of UPJO.

Key Points

- Patient selection is critical for RLESS pyeloplasty: ideal patients are those with BMI <30 and with no previous abdominal surgeries.
- Success rates for RLESS do not appear to differ from conventional laparoscopic pyeloplasty, although complication rates may be higher initially as learning curve develops.
- RLESS may shorten the learning curve for LESS pyeloplasty in terms of complication and conversion rate, although the data is limited.

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Tips and Tricks for Difficult Ureteral Stent Insertion

Asif Raza

Abstract

Stents are widely used in urology to relieve obstruction or bypass strictures. In order to simplify stent insertion in difficult situations it is essential to have a wide range of endourological equipment available including guidewires, ureteric catheters, rigid and flexible ureteroscopes, ureteral dilatation equipment including serial and balloon dilators, baskets, ureteric access sheaths, various stent types and sizes and an image intensifier. An excellent assistant, scrub nurse and theater staff who are familiar with endourological equipment and techniques is also vital. In cases where a retrograde approach fails an antegrade approach should be attempted.

Keywords: Endourology, JJ stents, Guidewires, Baskets, Image intensifier, Dilators, Ureteroscopy, Hydronephrosis

Introduction

Stents are used to relieve collecting system obstruction secondary to benign or malignant causes. Stents can also be used for prostatic obstruction or urethral stricture disease.

Stents are usually placed intracorporeally although can be used extra anatomically when the obstruction is impassable by a standard stent. Routine stent insertion is usually performed retrogradely under general or spinal anesthesia. When a patient is not fit for this a stent may be inserted under local anesthesia with a flexible cystoscope.

Stents are inserted under fluoroscopy however when radiation exposure is contraindicated e.g., pregnant female, a stent may be inserted retrogradely or antegradely with ultrasound guidance.

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Fig. 1: Insertion of ureteric catheter and retrograde in tortuous ureter – guidewire removed to allow retrograde study.

Routine stent insertion is performed in standard lithotomy position. A rigid cystoscope is inserted into the bladder and ureteric orifice identified. A standard guidewire (0.035 or 0.038 inches) is inserted through the ureteric orifice under direct vision and fluoroscopy used to confirm its correct placement.

A 5/6 Fr ureteric catheter is passed over the guidewire just beyond the vesicoureteral junction. The guidewire then is removed and a retrograde performed with a 50/50 mix of contrast and saline.

Stent insertion without a retrograde should be avoided, as occasionally a guidewire may appear to be in the collecting system but be in a tortuous dilated ureter rather than in the kidney (Fig. 1).

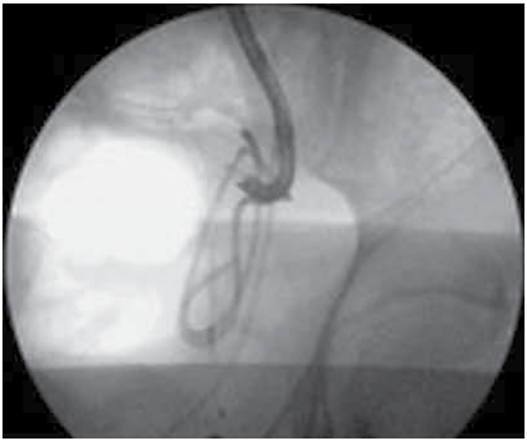

Fig. 2 Antegrade removal of a stent, stenotic VUJ secondary to previous ureterolithotomy.

After the retrograde a guidewire should be inserted through the ureteric catheter into the collecting system and the ureteric catheter exchanged with a stent. A stent inserted with a string (tether) that is left outside the patient can be removed without a further cystoscopy [1].

Difficult Stent Insertion

Vesicoureteric Junction (VUJ)

A tight VUJ may be due to a stenosis or impacted stone. If a standard guidewire will not pass beyond this a sensor wire (Boston Scientific) with a nitinol hydrophilic end or a hydrophilic guidewire (Terumo) can be used. Occasionally the stenosis needs to be dilated to allow access. This can be performed with a 6/7 Fr semi-rigid ureteroscope over a guidewire, a balloon dilator (Uromax, Boston Scientific) or with serial ureteric dilators.

Balloon dilators come in varying lengths. A 4 cm balloon should be used for the VUJ. The maximal balloon inflation pressure should not be exceeded. Dilatation is best performed over a super stiff guidewire. After wire insertion a JJ stent is passed. The VUJ may also be incised with a laser, Collins knife, bugbee electrode or occasionally resected if necessary to gain access. Dilatation is contraindicated in the septic patient with an obstructed system. An urgent nephrostomy with an interval antegrade/retrograde stent should be considered.

If the VUJ is still impassable the procedure should be abandoned and an antegrade approach used (Fig. 2). If the guidewire passes through the VUJ but not past the obstruction in the distal ureter I pass a short 6/7 Fr semi-rigid ureteroscope over the wire to the stone and fragment this with a holmium laser. This creates space for the wire to be placed beyond the stone and aid subsequent JJ stent insertion. The size and length of JJ stent to be inserted is dependent on the diameter of the stricture/stenosis that has been dilated and the length of the ureter [3, 6].

Fig. 3: Insertion of a rigid ureteroscope up tortuous ureter to help guidewire and stent insertion.

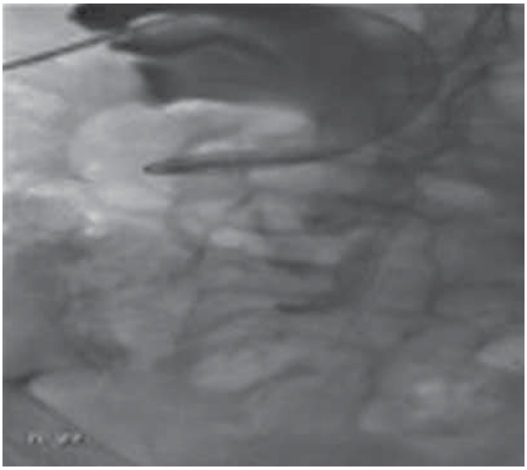

Fig. 4: Antegrade guidewire insertion in tortuous ureter after failed attempt at retrograde.

Another described technique involves inserting a small (7 Fr) occlusion balloon tip catheter under direct vision to the point of curvature and inflating this and pulling the balloon distally to straighten the ureter [2].

Once a ureteric catheter is advanced into the kidney over a hydrophilic wire, the wire should be replaced with a stiffer teflon-coated wire before the ureteric catheter is removed. If these methods fail an antegrade approach will be necessary (Fig. 4).

The Duplex Ureter/TUU

On occasion it may be difficult to insert a guidewire and subsequent stent into the affected moiety of 2 ureters that join before entering the bladder. An ureteroscope can be passed to the junction of the 2 ureters and the guidewire inserted under direct vision into the affected moiety. The position of the wire can be confirmed with a retrograde through the ureteroscope. If it is difficult to enter the affected moiety because the guidewire preferentially enters the other moiety or the angle to the affected moiety is too acute a ureteric catheter inserted into the unaffected moiety can prevent the entry of the second guidewire into this space again. A similar technique can be tried with a trans uretero–ureterostomy. If it is not possible to stent the obstructed moiety an antegrade approach may be necessary.

Reimplanted Ureter or Ileal Conduit (Bricker)/Wallace Anastomosis/ Congenital Anomaly/Transplant Kidney

An ileal conduit may be formed using a Bricker technique (Fig. 5) (2 ureters joined separately) or Wallace (2 ureters joined together to the ileal loop) with a refluxing or non–refluxing anastomosis.

Retrograde stenting will require the use of a flexible cystoscope inserted into the conduit (Fig. 6). Methylene blue/indigo carmine can be given intravenously to identify the ureteric orifices

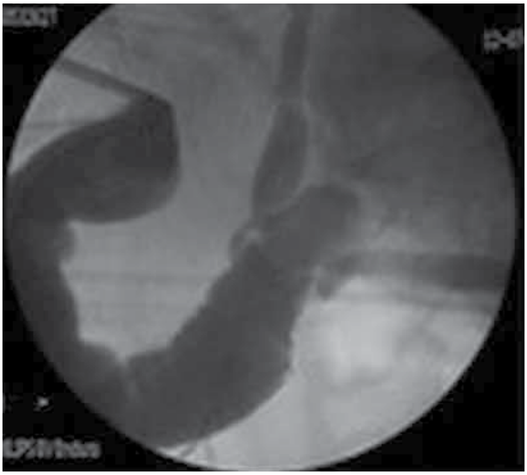

Fig. 5: Ileal conduit with Bricker anastomosis.

prior to guidewire insertion. A ureteric catheter (straight or curved tip) can be inserted through the flexible cystoscope to help direct the guidewire into the re-implanted ureter. A stent is inserted over the wire. The length of the stent may need to be longer in the left ureter due to its longer length in a right-sided conduit. Occasionally a flexible ureteroscope may be used to identify the ureteric orifices.

If the re-implanted ureters cannot be entered retrogradely an antegrade approach will be required. Similar principles apply to the re-implanted ureter or transplant kidney.

Fig. 6: Ileal conduit with flexible cystoscope with retrograde guidewire insertion into collecting system.

Dealing with a Stent Where Distal End Positioned in Ureter

Occasionally the distal end of a stent may be pushed completely into the ureter. If the VUJ is accessible an ureteroscope is inserted into the ureter and a 3 pronged or steel wire basket is used to grasp the end of the stent and reposition this in the bladder. Others have used a partially deflated ureteric balloon placed alongside the stent to bring the distal end back into the ureter [4].

Stenting in Children

Stenting in children may be more difficult due to the size of the ureter and ureteric orifice however VUJ dilatation or stenting is not always necessary post ureteroscopy. A small diameter, short adult ureteroscope (6 Fr) can be used in most children [8]. Pediatric stents are available and the appropriate length can be selected according to the child's age [7]. In cases of proximal placement of a stent in the ureter the stent may be removed with an Amplatz goose neck snare [5].

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Source: Asif Raza. Tips and Tricks for Difficult Ureteral Stent Insertion. In: A. Rané, B. Turna, R. Autorino, J.J. Rassweiler (eds). Practical Tips in Urology. 1st ed. London: Springer-Verlag; 2016, pp 399-407. DOI 10.1007/978-1-4471-4348-2_42.

Extraperitoneal Robot-Assisted Radical Prostatectomy

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Patient Selection

During robot-assisted radical prostatectomy (RARP), one may gain access to the prostate transperitoneally or extraperitoneally, and certain patient and/or disease factors may favor a given approach. With similar safety profiles, surgeons are encouraged to add both techniques to their armamentarium in order to most effectively individualize patient care [1, 2].

In patients who have had extensive prior intra-abdominal surgery, a transperitoneal RARP often requires early adhesiolysis, risking visceral injury. Such an injury may occur in the surgical field or away from the operative site during blind passage of instruments through an assistant trocar. Thus, an extraperitoneal approach can be quite advantageous in this setting. Further, this approach risks the development of de novo intra-abdominal adhesions, which can cause mechanical bowel obstruction and complicate future intra-abdominal surgery.

With the extraperitoneal approach, the peritoneum serves as a natural retractor of the bowels such that steep Trendelenburg may be avoided. This can be quite beneficial, especially in the obese, and in patients with chronic obstructive pulmonary disease [3, 4]. Urine leaks and bleeding become less of a concern after extraperitoneal RARP as an intact peritoneum can limit their spread and hasten their resolution. This technique may also decrease postoperative ileus [5, 6].

In the patient with a history of prior extraperitoneal surgery, particularly mesh herniorrhaphy, an inflammatory reaction may ensue and obliterate the extraperitoneal space. This can make both the RARP and concomitant lymph node dissection difficult, if not impossible when performed extraperitoneally [7, 8]. Patients who have had prior abdominal surgery with incisions extending to the pubic symphysis might also be best served with a transperitoneal RARP as the extraperitoneal space may be scarred or obliterated. Other noted challenges with the extra-

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peritoneal approach include a limited working space and difficulty creating space laterally to use the fourth arm. The confined space keeps the specimen bag in the operative field, potentially impairing visibility during the vesicourethral anastomosis stage [2, 9]. Moreover, lymphocele formation after pelvic lymphadenectomy may be more common with extraperitoneal RARP [10]. Inadvertent peritoneotomies made during the procedure may cause transperitoneal insufflation, further compressing the extraperitoneal space and rendering the procedure more difficult.

Preoperative Preparation

All patients receive a bowel preparation consisting of one bottle of magnesium citrate, doses of neomycin, metronidazole, and an enema the day before surgery. They are admitted to the hospital 2 h prior to surgery. Broad-spectrum intravenous antibiotics and 5000 U subcutaneous heparin are administered 1 h before incision. We do not recommend routine donation of autologous blood since our transfusion rate is insignificant.

Operative Setup

The location of the surgical console, bedside surgical cart, and the assistants are as shown (Fig. 1).

Patient Positioning

The patient is placed supine on a split-leg bed on top of a surgical bean bag. The legs are abducted slightly and secured to the table. The arms are internally rotated, placed parallel to the long axis of the patient, and secured in foam to avoid pressure sores or neuropraxia. Any hair on the patient's abdomen within the surgical field is trimmed with an electrical shaver. The surgical bean bag is manually molded to conform to the patient's body shape and air is suctioned from the device to secure the patient in place (Fig. 2). A digital rectal examination is performed for intraoperative clinical staging and to help with planning for subsequent nerve sparing. An Opium and Belladonna rectal suppository is administered to help prevent bladder spasms postoperatively. Orogastric tube and sterile urethral catheter placement are done prior to trocar insertion. Trendelenburg positioning is generally at about 10°. The patient's abdomen, genitals, and perineum are prepped and draped to provide a sterile field.

Trocar Configuration

Once the extraperitoneal space is developed and insufflated (see step 1 below), additional trocars are placed laparoscopically. A total of six trocars are used in a "W" shaped configuration as shown (Fig. 3). An 8-mm camera trochar is placed in the paraumbilical location and a 12-mm assistant trochar is placed 5-cm cephalad and just medial to the right anterior superior iliac spine. Three 8 mm trochars are placed under direct vision: one approximately 5-mm cephalad and just medial to the left anterior superior iliac spine, two in the middle of each rectus belly about 3 cm caudad to

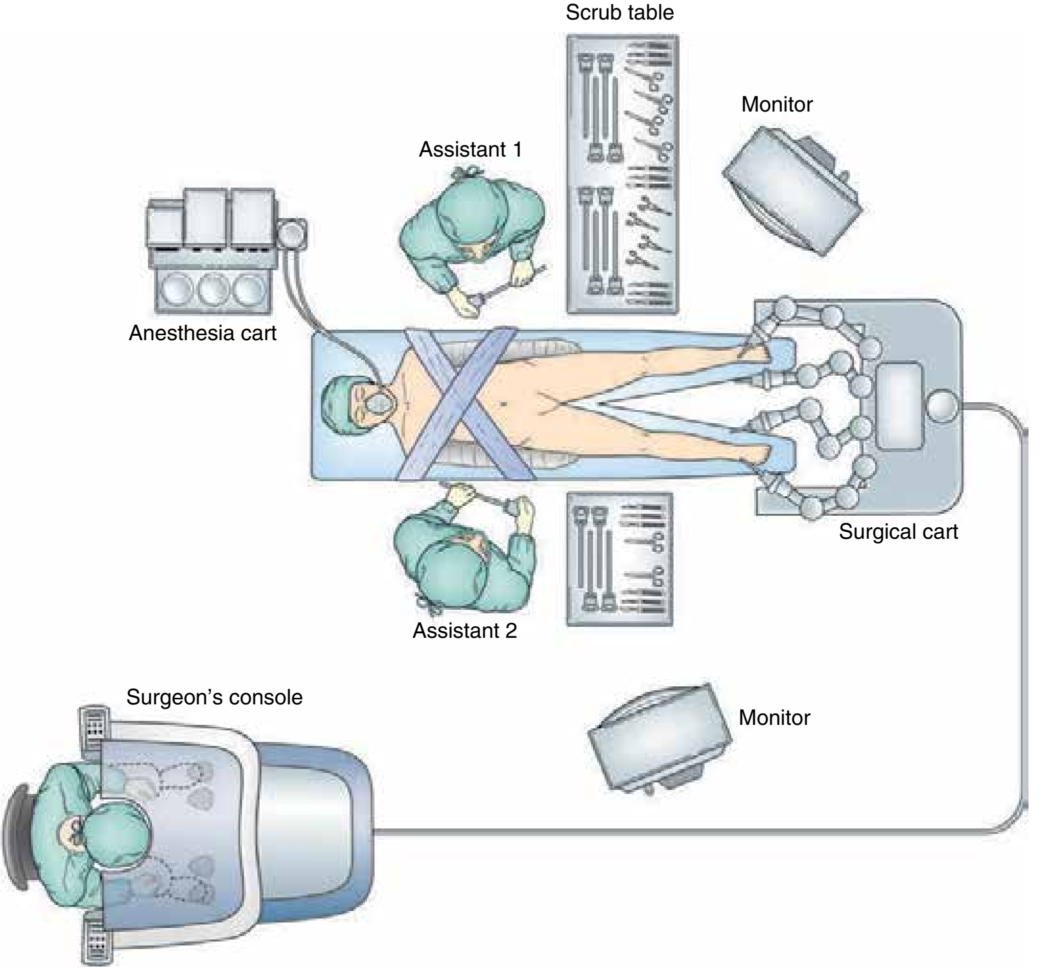

Fig. 1: View of operative setup.

the umbilicus (taking great care to avoid injuring the epigastric vessels). A 5-mm assistant trochar is placed between the umbilicus and the right 8 mm trochar, approximately 3 cm cephalad to the umbilicus. The following technique will be based upon this operative arrangement and personnel.

Instrumentation and Equipment List

Equipment

- da Vinci® S Surgical System (4-arm system; Intuitive Surgical, Inc., Sunnyvale, CA)
- EndoWrist® Maryland bipolar forceps or (Intuitive Surgical, Inc., Sunnyvale, CA)
- EndoWrist® curved monopolar scissors (Intuitive Surgical, Inc., Sunnyvale, CA)
- EndoWrist® ProGrasp™ forceps (Intuitive Surgical, Inc., Sunnyvale, CA)

Fig. 2: The patient is secured to the table with a surgical bean bag and placed in mild Trendelenburg. The legs are taped below the knees to the abducted limbs of the split-leg surgical bed.

Fig. 3: "W" configuration of trocars are shown. Numbers marked on patient's abdomen refer to size of trocar size (in French units) placed after insufflation.

- EndoWrist® needle drivers (2) (Intuitive Surgical, Inc., Sunnyvale, CA)
- InSite® Vision System with 0° and 30° lens (Intuitive Surgical, Inc., Sunnyvale, CA)

Trocars

- 12 mm trocar (1)
- 8 mm robotic trocars (4)
- 5 mm trocar (1)

Recommended Sutures

- Ligation of the deep dorsal vein complex (DVC): 2-0 Covidien V-Loc™ barbed suture (Medtronic, Minneapolis, MN) cut to 9 in., and 2-0 polyglactin suture on an RB1 needle cut to 6 in. (if necessary)
- Vesicourethral anastomosis: 2 (2-0 polyglactin) sutures (9 in. each) on an RB1 needle
- Posterior reconstruction stitch: 2-0 polyglactin suture on an RB1 needle cut to 9 in.
- Anterior bladder neck closure (if necessary): 2-0 polyglactin suture on an RB1 needle cut to 9 in.

Instruments Used by the Surgical Assistant

- Laparoscopic scissors
- Blunt tip grasper
- Suction irrigator device
- Hem-o-lok® clip applier (Teleflex Medical, Research Triangle Park, NC)
- Large Hem-o-lok® clips (Teleflex Medical, Research Triangle Park, NC)
- 10 mm specimen entrapment sac
- EnSeal® device 5 mm diameter, 45 cm shaft length (SurgRx®, Redwood City, CA) (optional)
- SURGICEL® hemostatic gauze (Ethicon, Inc., Cincinnati, OH)
- 20 Fr silicone urethral catheter
- Jackson–Pratt closed suction pelvic drain

Step-by-Step Technique (Videos 1, 2, 3, 4, 5, 6, 7, 8, and 9)

Step 1: Creation of Extraperitoneal Space

The initial step of extraperitoneal robot-assisted laparoscopic radical prostatectomy (RALP) is creation of the extraperitoneal space. A 2.5-cm paraumbilical skin incision is made down to the level of the anterior rectus sheath. A 1-cm incision is made in the latter to expose the rectus muscle. A 0-polyglactin suture is placed through the two apices of this incision and the free ends are secured with a snap (Fig. 4). The muscle fibers are pushed laterally using a clamp, exposing the posterior rectus sheath. A balloon dilator (Extra View™ Balloon, OMS-XB 2, Tyco Healthcare, Norwalk, CT) is inserted just above the posterior sheath and advanced down to the pubic symphysis in the midline (Fig. 5). A 0° scope is placed in the balloon trocar to allow direct visualization of the space being created. Care should be taken not to overstretch or tear the epigastric or iliac vessels from overinflation. Once the space is created, the balloon dilator is replaced by a 10/12 mm Dilating Tip Ethicon Endopath 512XD (Ethicon Inc. US, LLC., Somerville, NJ) trocar. It is necessary to use a transparent trocar such as this so that the retropubic space can be developed under direct vision. The retroperitoneum is insufflated up to 12–15 mmHg. The beveled tip of the trocar is used to further create the extraperitoneal space laterally, facilitating placement of the assistant trocars as mentioned above. The loose areolar tissue is swept laterally and cephalad, bluntly pushing the peritoneum off the abdominal wall. The epigastric vessels are left attached to the anterior abdominal wall to avoid bleeding from branches entering the rectus muscle (Fig. 6). If a da Vinci® Xi Surgical System is used, the 12-mm paraumbilical Ethicon Endopath 512XD trocar must be replaced with a 12-mm da Vinci® trocar with a reducer placed on its hub to accommodate an 8-mm, 0° laparoscopic camera. A petroleum jelly-impregnated gauze is wrapped around the trocar at the level of the anterior rectus sheath and the previously placed 0-polyglactin is tied tightly around the trocar to avoid leakage of CO_2. The additional trocars are then placed under direct vision as described above.

Step 2: Endopelvic Fascia Dissection (Table 1)

Table 1: Endopelvic fascia dissection: surgeon and assistant instrumentation.

Surgeon instrumentation			Assistant instrumentation
Right arm	**Left arm**	**Fourth arm**	• Suction-irrigator
• Curved monopolar scissors	• Maryland bipolar grasper	• ProGrasp™ forceps	
Endoscope lens: 0°			

A 0° lens is used throughout the entire operation. Monopolar and bipolar electrocautery settings are set to 90 and 30 W, respectively. Accessing the retropubic space by the extraperitoneal approach described above eliminates the bladder "take-down" step required during the transperitoneal approach, and allows rapid visualization and access to the prostate, endopelvic fascia, and puboprostatic ligaments (Fig. 7). The fatty tissue overlying the endopelvic fascia is easily swept away exposing the prostate. We routinely incise the endopelvic fascia, freeing the prostate from its lateral attachments. Accessory pudendal vessels, if present, are identified and

Fig. 4: A 2.5-cm paraumbilical skin incision is made down to the level of the anterior rectus sheath. A 1-cm incision is made through the anterior rectus sheath and a 0-polyglactin suture is placed through the two apices and secured with a snap.

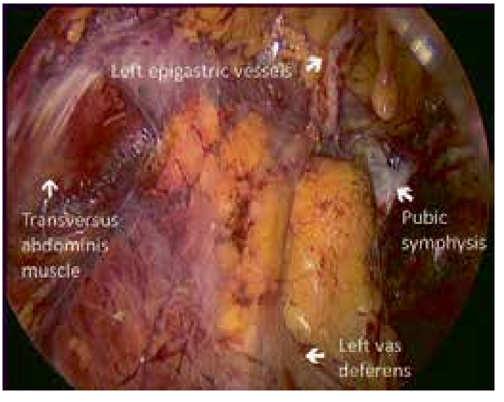

Fig. 5: View of left pelvis following balloon dilation of extraperitoneal space.

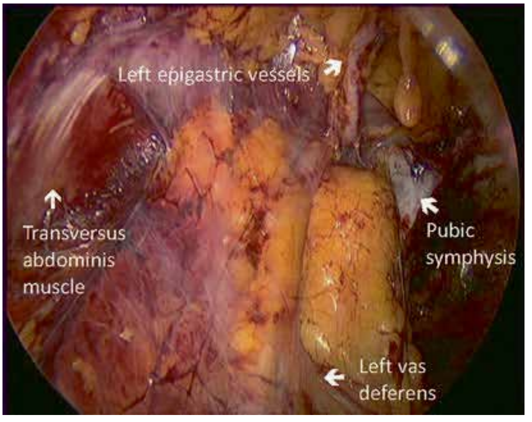

Fig. 6: View of right pelvis following balloon dilation of extraperitoneal space. *Asterisk* denotes loose alveolar connective tissue where blunt dissection is carried out in an anterior cephalad direction to push the peritoneum away and expose the transversus abdominis muscle.

preserved. We routinely incise the puboprostatic ligaments to allow adequate mobilization of the prostatic apex. Superficial vessels encountered are cauterized.

Step 3: Dorsal Vein Ligation (Table 2)

Table 2: Dorsal vein ligation: surgeon and assistant instrumentation.

Surgeon instrumentation			Assistant instrumentation
Right arm	**Left arm**	**Fourth arm**	• Suction-irrigator
• Needle driver	• Needle driver	• ProGrasp™ forceps	• Laparoscopic scissors
			• Laparoscopic needle driver
Endoscope lens: 0°			

A 2-0 Covidien V-Loc™ barbed suture is used to ligate the dorsal venous complex (DVC). With medial retraction of the prostatic apex, a groove is visualized between the DVC and the anterior urethra. We routinely pass the needle three times through this plane and suspend the complex to periosteum of the pubic symphysis after the first and third pass. A Hem-o-lok® clip is applied to the distal end of the suture and used to further cinch it to the pubic symphysis (Fig. 8).

Step 4: Bladder Neck Dissection (Table 3)

Table 3: Bladder neck dissection: surgeon and assistant instrumentation.

Surgeon instrumentation			Assistant instrumentation
Right arm	**Left arm**	**Fourth arm**	• Suction-irrigator
• Curved monopolar scissors	• Maryland bipolar grasper	• ProGrasp™ forceps	
Endoscope lens: 0°			

With cephalad tension on the bladder, the loose areolar connective tissue crossing the bladder neck is removed allowing identification of the bladder neck (Fig. 9). With the magnification afforded by the da Vinci® robot, the plane between the prostate and bladder neck is easily

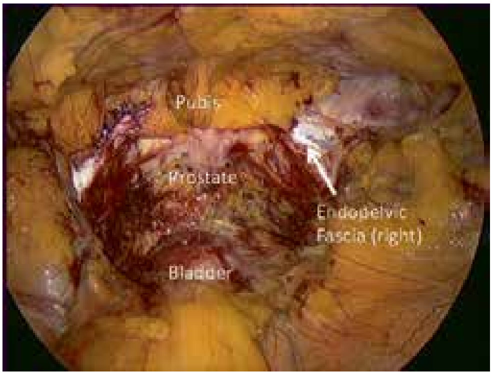

Fig. 7: Complete view of the pelvis including the pubis, prostate, bladder, and endopelvic fascia following balloon dilation of the extraperitoneal space.

Fig. 8: Control of the DVC with a 2-0 Covidien V-Loc™ barbed suture.

identified. A combination of electrocautery and blunt dissection allows separation of the bladder from the prostate. Judicious use of electrocautery is necessary to avoid excessive charring and obliteration of the tissue planes. Given the lack of tactile feedback, following the tissue planes allows an accurate anatomical dissection, without violation of the prostate capsule. Once the longitudinal urethral fibers are identified, the bladder neck is transected (Fig. 10). The previously placed urethral catheter is removed allowing access to the posterior bladder neck. The transection is done sharply, with no significant bleeding encountered. If a bleeding vessel is present, it can be selectively cauterized avoiding the bladder neck mucosa. The anatomical groove between the bladder and prostate is further dissected, pushing the bladder cephalad. The bladder neck dissection is completed with the identification of the longitudinal muscle fibers coursing posterior to the bladder, covering the seminal vesicles (SVs) (Fig. 11).

Step 5: Seminal Vesicle Dissection (Table 4)

Table 4: Seminal vesicle dissection: surgeon and assistant instrumentation.

Surgeon instrumentation			Assistant instrumentation
Right arm	**Left arm**	**Fourth arm**	• Suction-irrigator
• Curved monopolar scissors	• Maryland bipolar grasper	• ProGrasp™ forceps	• Hemoclip applier
Endoscope lens: 0°			

Once the longitudinal fibers are transected, the ampullae of the vasa and attached SVs are identified. These fibers need to be incised transversely in the midline allowing identification of both vasa. Once the ampullae are fully identified, the fourth arm can also be used to elevate the attached SVs. Optimal traction is achieved by pulling the vas toward the contralateral pubic bone. The dissection should be carried cephalad to the tip of the SVs. Dissecting in a caudal direction will inadvertently enter the posterior aspect of the prostate. It is helpful to avoid directly grasping or traumatizing the SVs, since that will alter the dissection plane. Instead, leaving the SVs attached

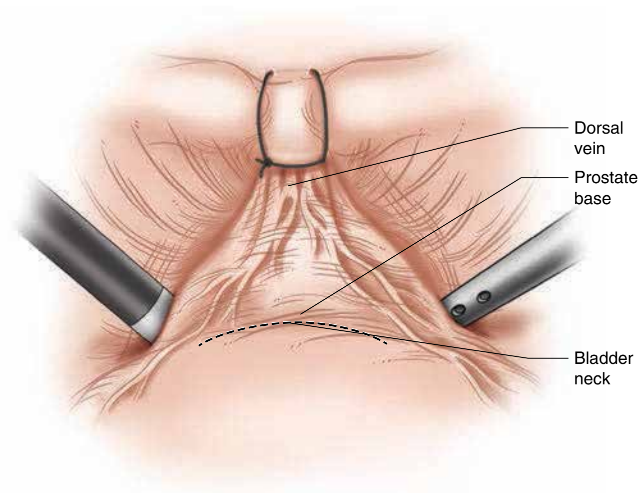

Fig. 9: View of bladder neck (*dashed line*) following control of distal DVC, with traction placed on the perivesical fat.

Fig. 10: View of longitudinal urethral fibers prior to bladder neck transection.

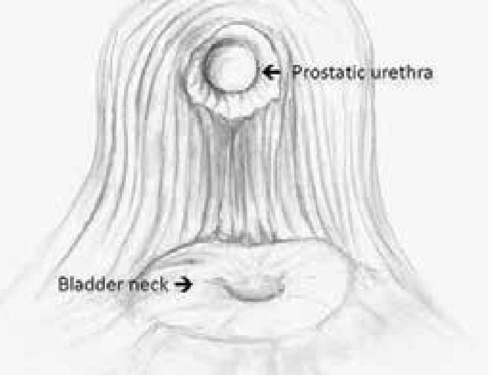

Fig. 11: View of bladder neck following transection.

to their respective ampullae helps with retraction of both structures by grasping only the ampulla. The artery to the vas located between the SVs and the vas deferens is clipped en bloc. When performing a nerve-sparing procedure, electrocautery is avoided to prevent damage to the nerve plexus traveling near the tip of the SVs.

Step 6: Posterior Prostate Dissection

Once the SVs are completely dissected, both ampullae are retracted anteriorly exposing Denonvilliers' fascia (Fig. 12). The latter is incised transversely, exposing the yellow perirectal fat. The assistant uses the suction to gently retract the rectal wall in a cephalad direction. The rectal wall is pushed bluntly from the posterior aspect of the prostate all the way to the prostate apex. If the latter is not possible due to a very enlarged gland, this step can be carried out once the posterior prostate pedicles are mobilized. It is important to note that the rectal wall is being pulled anteriorly with the traction on the prostate or SVs. The caudad dissection should be carried out parallel to the posterior prostate to avoid injury to the rectal wall. A rectal bougie or an assistant's finger can be used to help delineate the rectal wall if necessary. This dissection is carried out primarily in the midline, avoiding trauma to the laterally located neurovascular bundles (NVBs).

Step 7: Neurovascular Bundle Dissection

The ampullae and SVs are pulled medially in the opposite direction from the side being dissected. Using the suction, the assistant can place traction on Denonvilliers' fascia posterior to the bladder, allowing better visualization of the bundles. In patients selected for nerve sparing, the prostate capsule is exposed bluntly using graspers to push off the overlying fat and periprostatic fascia. With further lateral dissection, arterial pulsations from the cavernous vessels within the NVBs are easily noted. These vessels are preserved by gently pushing them posterolaterally towards the rectum. Dissecting in a cephalad direction helps identify the main neurovascular trunks, bifurcating in anterior branches entering the prostate, and the posteriorly located NVBs coursing towards the pelvic diaphragm and toward the corpora cavernosum.

Prior to clipping the prostatic branches, the levator fascia is incised allowing improved identification of the lateral aspects of the NVBs. As for the posterior dissection, this can be carried out bluntly with minimal bleeding encountered. Dissection in a medial direction leads to the previously dissected anterior rectal space, with the NVBs mobilized posteriorly. Clips can be selectively applied, in lieu of electrocautery, to the vascular branches of the prostatic pedicles prior to their transection (Fig. 13). Once the prostatic pedicles are transected, the periprostatic fascia encompassing the NVBs can be detached bluntly from the prostate, in a caudal direction all the way to the prostatic apex.

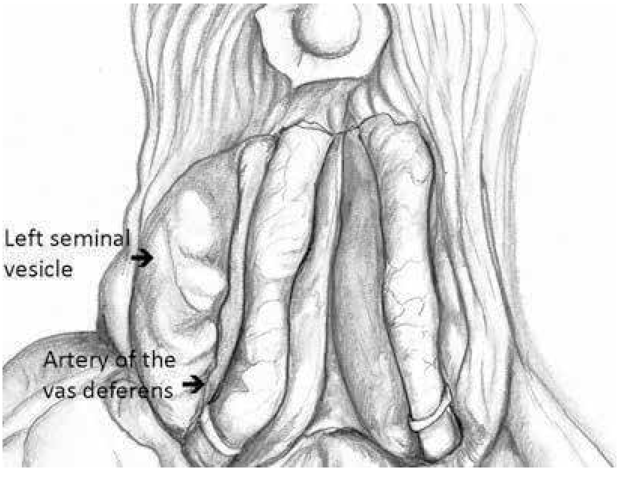

Fig. 12: Seminal vesicles with clipped ampulla.

In non-nerve-sparing cases, the periprostatic fascia is incised next to levator ani. The bundles and their investing fascia are left attached to the prostate capsule, allowing for wide excision of the NVBs along with the prostate.

Step 8: Apical Dissection

With the prostate retracted in a postero-cephalad direction, the DVC is transected (Fig. 14). A urethral catheter should be inserted in the urethra to facilitate identification of the urethral stump. Electrocautery should be avoided in order not to damage the NVBs coursing lateral to the prostatic apex. Care should be taken not to enter the prostate at this point. This is best achieved by following the normal curvature of the apex, transecting the vein in a caudal direction. A perpendicular dissection plane inevitably will enter the prostate gland. If bleeding is encountered or the previously placed DVC suture is dislodged, additional sutures are placed on the DVC, using 2-0 polyglactin suture on an RB1 needle, to achieve hemostasis. Temporary increase in intra-abdominal pressure up to 20 mmHg facilitates completion of the DVC transection when profuse bleeding from venous sinuses is present.

Step 9: Urethral Transection

With the urethral catheter in place, the longitudinal anterior urethral fibers can be identified. The urethra is dissected cephalad, close to the prostate and transected. Urethral length should be preserved without compromising cancer control at the apex. Once the urethral catheter is exposed, it is retracted by the assistant, facilitating visualization and transection of the posterior urethra (Fig. 15). We prefer cutting the urethra sharply to avoid ischemic mucosal injury that can occur with the use of electrocautery.

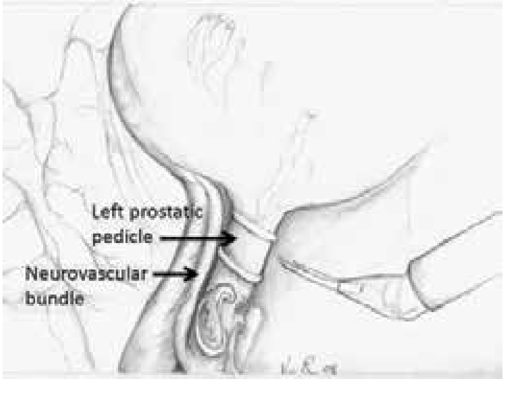

Fig. 13: Hem-o-lok® clips used to control the prostatic pedicle, while leaving the NVBs intact, coursing posterior to the prostate to enter the pelvic diaphragm.

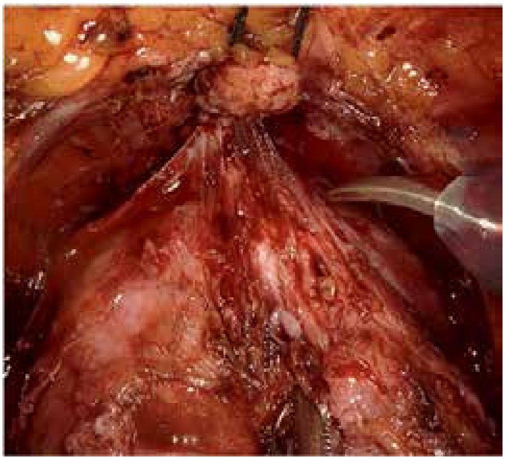

Fig. 14: View of prostatic apex following DVC transection, prior to urethral transection.

The prostate is then retracted in an anterior and cephalad direction to allow visualization of the posterior apex. The NVB should be thoroughly dissected, pushed in a posterolateral direction prior to transecting the remaining posterior apical attachments. The prostate is placed in a 10-mm ENDO CATCH™ bag (Covidien, Mansfield, MA), which is pulled out of the pelvis and stored out of the operative field in the abdomen until the end of the operation. The prostate fossa is irrigated and inspected for hemostasis and integrity of the rectal wall. When arterial bleeding is noted from the NVB, the bleeding vessel is selectively controlled using 2-0 polyglactin suture ligatures. If a rectal injury is suspected, a finger or rectal bougie is placed to tent the rectal wall to allow a thorough examination.

Step 10: Posterior Reconstruction (Table 5)

Table 5: Posterior reconstruction: surgeon and assistant instrumentation.

Surgeon instrumentation			Assistant instrumentation
Right arm	**Left arm**	**Fourth arm**	• Suction-irrigator
• Needle driver	• Needle driver	• ProGrasp™ forceps	• Laparoscopic scissors
			• Laparoscopic needle driver
Endoscope lens: 0°			

A posterior reconstruction is routinely performed prior to completing the vesicourethral anastomosis. In one step, the posterior layer of the rhabdosphincter is sewn to Denonvilliers' fascia and the posterior aspect of the bladder using two interrupted Covidien V-Loc™ barbed sutures. The posterior bladder tissue encompassed is the longitudinal fibrous layer which previously covered the anterior aspect of the SVs (Fig. 16). The insufflation pressure in the retroperitoneum is lowered to 8–10 mmHg, while pressure is applied to the perineum to facilitate tying of these two interrupted sutures. This reconstructed layer helps bring the bladder and urethra in close proximity in preparation for the vesicourethral anastomosis. After cinching these sutures, the bladder is brought in close proximity to the transected urethra, greatly reducing tension on the anastomosis. The needle ends of the two Covidien V-Loc™ barbed sutures are left loose and temporarily tucked away lateral to the bladder for later use.

Step 11: Vesicourethral Anastomosis

The anastomosis is completed using two separate sutures (2-0 polyglactin suture on an RB1 needle). The first suture is placed at the 5 o'clock position approximating the bladder neck and urethra using the right hand (forehand on both bladder and urethra). Urethral sutures are placed while the assistant withdraws the urethral catheter exposing the urethral mucosa. Initially, the anastomosis is carried out in a clockwise fashion to the 7 o'clock position when the needle placement is done using right hand (backhand) on the urethra, and left hand (forehand) on the bladder. This suture is tied to itself at the 11 o'clock position. The second suture is carried out in a counterclockwise direction completing the anterior wall of the anastomosis. The 5–1 o'clock locations are

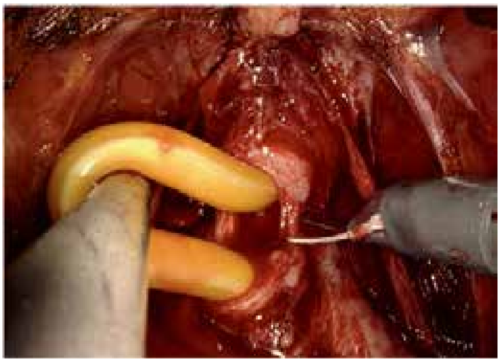

Fig. 15: View of the posterior urethra prior to transection.

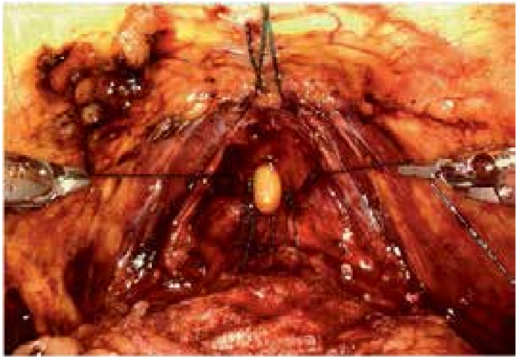

Fig. 16: The bladder is pulled towards the transected urethra using as part of the posterior reconstruction.

done using the right hand (forehand) on the bladder, and the left hand (backhand) on the urethra. The anterior-most aspect of the anastomosis (1–11 o'clock) is accomplished using the right hand (backhand) on the bladder, and the left hand (backhand) on the urethra. The second suture is also tied at the 11 o'clock position. Bladder neck mucosa is encompassed into every suture to facilitate mucosal apposition. Care should be taken for the suture not to pass through the posterior bladder neck mucosa, while placing the anterior bladder sutures. Once the anastomosis is completed, a new 20 Fr urethral catheter is inserted into the bladder under direct vision, prior to cinching the second counterclockwise anastomotic suture (Fig. 17). When cinching this suture, it is best to pull on the urethral side of the anastomosis, in a direction perpendicular to the longitudinal urethral fibers. This maneuver avoids shearing the urethral wall, while achieving water tightness of the anastomosis. The urethral catheter is irrigated verifying absence of anastomotic leakage. Once the vesicourethral anastomosis is complete, the catheter is flushed both to confirm the absence of a significant leak and to irrigate clots from the bladder. Attention is then turned to the two needle ends of the previously placed posterior reconstruction Covidien V-Loc™ barbed sutures. These needles are passed through the pectineal ligament, approximately 3 cm lateral to the midline, the sutures are held with a moderate amount of tension and two Hem-o-lok® clips are applied to the distal ends of both in order to cinch them down firmly (Fig. 18). Our group believes that this step may aid in the prevention of postoperative urinary incontinence by acting as a prophylactic male urinary sling.

Step 12: Delivery of the Specimens and Exiting the Abdomen

The surgical cart is disconnected from the trocars and wheeled away from the patient. The specimen bag is retrieved from the periumbilical camera trocar at the end of the procedure (Fig. 19). A 19 Fr Jackson-Pratt (JP) drain is placed in the retropubic space via the 10 mm lateral assistant trocar site and subsequently secured to the skin. The robotic trocars are removed under vision, verifying hemostasis from the exit sites. The anterior rectus sheath adjacent to the midline fascia is incised to allow withdrawal of the bag. The anterior rectus fascia opening is closed using absorbable

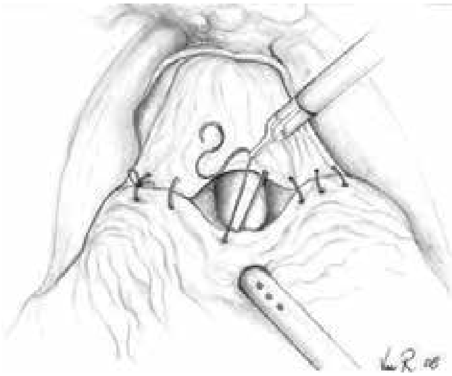

Fig. 17: View of the vesicourethral anastomosis. Final urethral catheter is passed into the bladder prior to cinching the anterior anastomotic suture.

Fig. 18: After completion of the vesicourethral anastomosis, the two previously placed posterior reconstruction sutures are passed through the pectineal ligaments bilaterally and cinched with Hem-o-lok® clips.

sutures. All skin openings are later closed in a similar manner. With the extraperitoneal approach, no other fascial closure is necessary. In conditions where air is trapped into the peritoneal cavity, it is evacuated with a small opening in the posterior sheath and peritoneum, which is later closed.

Postoperative Management

Postoperative pain management consists of ketorolac, and morphine sulfate for breakthrough pain. We do not use ketorolac in patients with bleeding diathesis or abnormal renal function. Two additional doses of 5000 U of subcutaneous heparin are administered postoperatively following the initial preoperative dose. Patients are ambulated and fed once they fully recover from anesthesia. They are generally discharged within 23 h of surgery. Jackson–Pratt drains are removed before discharge if the output remains low with less than 30 cm^3 in an 8-h shift. The urethral catheter is removed in the outpatient setting 7–10 days after surgery. We perform cystograms only in patients with gross hematuria, or prolong JP drainage, to verify the integrity of the anastomosis prior to instituting a void trial.

Special Considerations

Obesity

In the obese patient, we favour an extraperitoneal approach to RARP for a variety of reasons. The peritoneum serves as an excellent natural retractor which keeps the bowels out of the operative field. Furthermore, the steep Trendelenburg position, which may be associated with anesthetic complications in an obese patient due to diaphragmatic splinting, is not necessary laryngeal and facial edema associated with the steep Trendelenburg position may otherwise lead to delayed extubation and a prolonged recovery.

Fig. 19: Specimen retrieval through the previously created periumbilical incision.

Large Prostate Gland

A large gland may be difficult to manipulate during extirpation, especially when associated with a narrow pelvis. The posterior apical dissection may be challenging due to inability to lift the prostate anteriorly to reach the posterior aspect of the prostate apex. Anterior mobility of the prostate is limited by the pubic symphysis. In such cases, the posterior dissection is best completed following dissection of the apex and transection of the urethra.

Steps to Avoid Complications

Bleeding is the most common complication encountered during the development of the extraperitoneal space. Balloon insufflation should be carried out under direct vision to avoid stretching or tearing of the epigastric or iliac vessel. The epigastric vessels give off several perforators entering the rectus muscles which can be injured during creation of the extraperitoneal space. Occasionally this may result in tearing of a branch of the epigastric artery which may necessitate clipping. Increasing the pressure in the preperitoneal space may help decrease the bleeding until an additional trocar is inserted to allow clipping of the bleeding vessel. If mild venous bleeding is encountered, which can be from perforating veins or vessels behind the pubic symphysis, it is easily controlled with preperitoneal insufflation. Overcompression of the iliac vessels, impairing flow from the lower extremities, should be avoided.

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Robotic Pelvic Lymphadenectomy: Standard and Extended Techniques

Nishant D. Patel, Christopher J. Kane

Introduction

Robotic pelvic lymphadenectomy is a routine staging procedure performed at the time of robotic radical prostatectomy for men at risk for nodal metastases. The procedure is safe and reproducible with limited complications and provides important risk stratification information that helps stratify patients by risk of biochemical and clinical progression. Patients with limited lymph node metastases may do well after surgery alone and be observed closely. Those with higher volume lymph node metastases or N1 disease and biochemical recurrence may benefit from androgen deprivation therapy or radiation therapy or the combination.

Traditionally pelvic lymphadenectomy has been limited to the obturator and external iliac lymph nodes; however, more modern series suggest that with a more extended lymphadenectomy a much greater proportion of men will be recognized with lymph node metastases. The extended dissection should incorporate the internal iliac lymph nodes along with the obturator and external iliac lymph nodes to the common iliac artery. Some authors include presacral lymph nodes as well.

We perform extended lymphadenectomy for all D'Amico high-risk patients. The technique involves a peritoneal incision over the common iliac artery, identification, and medial reflection of the ureter to identify the iliac artery bifurcation. We begin the dissection at the bifurcation, dissecting the nodal tissue from the bifurcation distally along the external iliac artery and vein to the node of Cloquet medially and the ilioinguinal nerve laterally. The nodal tissue along the distribution of the internal iliac artery is then removed. The obturator lymph nodes are then dissected from the obturator nerve proximally to the internal iliac artery. Lymphostasis is obtained with small hemo-lock or titanium clips and monopolar electrocautery.

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The extended lymphadenectomy takes 10–30 min of operative time per side and yields 10–20 lymph nodes per side. The risk of lymphocele formation is 1–5%. Major complications are exceedingly rare; however, lymphadenectomy may increase the risk of thromboembolic events and therefore may warrant greater DVT prophylaxis.

We believe extended lymphadenectomy is an important staging procedure for men undergoing radical prostatectomy for high-risk prostate cancer; that the procedure can be done safely and efficiently robotically, with similar oncologic outcomes to an open pelvic lymph node dissection.

Patient Selection

Indications

In the PSA era, 1–3% of men will have positive lymph nodes (LN) at the time of radical prostatectomy and, of those, 50% will have a clinical recurrence within 10 years of prostatectomy [1]. Traditionally, the indication for pelvic lymph node dissection (PLND) in prostate cancer was that of a staging procedure, as CT or MRI preoperative imaging has low sensitivity (39–42%) for detecting nodal metastases if <11 mm [2]. However, more recent data suggest that a more extended pelvic lymphadenectomy can improve staging accuracy and potentially provide a therapeutic benefit in biochemical recurrence-free survival and prostate cancer-specific mortality [1, 3]. Extended PLND (E-PLND) is thought to confer a therapeutic benefit by decreasing the burden of histologically undetectable metastatic disease, i.e., micrometastatic disease.

Per NCCN guidelines, pelvic lymphadenectomy is recommended in low and intermediate risk categories (Table 1) when the predicted probability of nodal metastases is >2%. Several nomograms are available to calculate this risk including the MSKCC Kattan nomogram, UCSF CAPRA score, and the updated Partin Tables [4]. The EAU and NCCN recommend performing PLND using an extended template. The AUA 2013 Guidelines state that PLND “may not be necessary” in low-risk patients with PSA ≤10 ng/mL, clinical stage T1 or T2, and Gleason score ≤6 with no Gleason pattern 4 or 5. The AUA mentions the extended template as an option. At our institution, very low and low-risk patients do not receive a PLND, intermediate-risk patients receive a standard PLND (S-PLND) if the risk of LN metastases is ≥2%, and all high-risk and very high-risk patients receive E-PLND. The paradox is that although intermediate-risk patients have a relatively low risk of lymph node metastases at PLND, in order to adequately determine if LN metastases are present a more extended node dissection is required. So many authors now recommend extended node dissections for intermediate-risk patients as well. Compared to open or laparoscopic PLND, robotic PLND can be performed with a comparable nodal yield [5, 6].

Imaging

As stated earlier, preoperative CT and MRI imaging has poor sensitivity for detecting LN mets <11 mm. New technologies are emerging that may improve the accuracy of MRI including restriction spectrum imaging (RSI), in addition to diffusion weighted imaging (DWI) [7]. Novel methods are emerging to preoperatively detect LN metastases and subsequently detect these LNs intraoperatively. In one study, fluorescent-labeled tilmanocept was injected into male dogs, a pelvic PET/CT scan was performed for sentinel lymph node mapping, and robotic-assisted sentinel lymph node dissection using a fluorescence-capable camera system was completed [5].

Table 1: Risk categories.

Very low risk[a]	PSA < 10		Gleason ≤ 6		
	PSAD < 0.015	&	No pattern 4 or 5	&	Clinical stage T1c
			< 50% cancer/core		
			≤ 2 positive cores[b]		
Low risk	PSA < 10	&	Gleason ≤ 6	&	Clinical stage T1 or T2a
Intermediate risk	PSA 10–20	or	Gleason = 7	or	Clinical stage T2b or T2c
High risk	PSA >20	or	Gleason ≥8	or	Clinical Stage T3a
Very high risk	Any PSA	&	Primary Gleason	or	Clinical Stage T3b–T4
			Pattern 5	or	
			>4 cores with		
			≥ Gleason 8		

PSA prostate-specific antigen, *PSAD* PSA density (PSA/prostate volume)
[a] All criteria are required
[b] Two or less cores that show cancer using a biopsy template taking ≥ 10 cores

Preoperative Preparation

The same preoperative preparation instruction and orders used for robotic-assisted laparoscopic prostatectomy are given for pelvic lymph node dissection. One important consideration is the administration of pharmacologic venous thromboembolism (VTE) prophylaxis prior to surgery. VTE rates following robotic-assisted radical prostatectomy range from 0.2 to 8%. In a large series of 2572 robotic-assisted prostatectomies, a 0.7% prevalence of VTE was observed; however, the addition of a pelvic lymph node dissection increased the risk of deep venous thrombosis (DVT) and pulmonary embolism (PE) by eight- and six-fold, respectively [8]. Pelvic lymphocele is thought to be a contributing factor to VTE because compression of large pelvic veins can worsen lower extremity stasis and associated pain may result in immobility. While lymphocele formation may be related to surgical technique and extent of PLND, there is some evidence to suggest that pharmacological VTE prophylaxis may increase the risk of lymphocele formation—anticoagulation may increase the drainage of lymph by preventing lymphatic coagulation. For the surgeon, the decision to administer preoperative VTE prophylaxis should be based on patient risk factors for VTE and need for PLND, as well as its extent. At our institution, we do not routinely administer preoperative VTE prophylaxis beyond sequential compression devices and early ambulation unless the patient is high risk (i.e., previous history of VTE) and we routinely use hemo-lock or titanium clips extensively to occlude lymphatic vessels and minimize the risk of lymphocele formation.

Operative Setup and Patient Positioning

At the time of PLND, the patient will already be positioned appropriately in steep Trendelenburg and the same trocar configuration for transperitoneal robotic-assisted laparoscopic prostatectomy is utilized.

Instrumentation and Equipment List

Equipment

- da Vinci® Si HD Surgical System (4-arm system; Intuitive Surgical, Inc., Sunnyvale, CA)
- EndoWrist® ProGrasp™ forceps (Intuitive Surgical, Inc., Sunnyvale, CA)—left robotic arm and third arm (left)
- EndoWrist® curved monopolar scissors (Intuitive Surgical, Inc., Sunnyvale, CA)—right robotic arm
- InSite® Vision System with 0° lens (Intuitive Surgical, Inc., Sunnyvale, CA)

Trocars

- 12 mm trocar (1—assistant)
- 8 mm robotic trocars (3)

Instruments Used by the Surgical Assistant (Table 2)

Table 2: Surgeon and assistant instrumentation.

Surgeon instrumentation			Assistant instrumentation
Arm 1 (right)	Arm 2 (left arm)	Arm 3	• Suction irrigator
• Curved monopolar scissors	• Prograsp dissector	• Prograsp dissector	• Blunt tip grasper
			• Clip applier
			• Endo Catch™ bag

- Blunt tip grasper
- Suction irrigator device
- 5-mm Small Hem-o-lok® clip applier and clips (Teleflex Medical, Research Triangle Park, NC)
- 10 mm Reusable Endo Catch™ specimen retrieval bag

Step-by-Step Technique

Step 1: Port Placement and Radical Prostatectomy

We use a *five-port technique with a single 12 mm assist port* and four 8.5 mm robotic trocars (for the Xi robot) or three 8 mm trocars with a 12 mm camera port (for the Si robot). The access and camera trocar is supraumbilical. The right 8.5 mm trocar is 15–18 cm to the right of the umbilicus with the 12 mm assist port 7–8 cm to the right of the umbilicus (between the right robotic arm and the camera trocar). We place two left-sided robotic trocars, one about 3 cm medial and superior to the left anterior superior iliac spine and one about 10 cm to the left of the umbilicus (Fig. 1).

We then perform the robotic prostatectomy. The peritoneal incision to release the bladder anteriorly is brought laterally to the edge of the bladder and brought down to the level where the vas deferens crosses the external iliac artery. I also routinely reflect the sigmoid colon left lateral peritoneal attachments so the peritoneum overlying the left common iliac artery is free of sigmoid attachments.

At the end of the prostatectomy and prior to the vesicourethral anastomosis, we perform the pelvic lymphadenectomy. The reasoning for that timing is that performing the prostatectomy exposes the obturator fossa and distal iliac vein well. If the PLND is performed prior to prostatectomy, medial retraction is required on the medial edge of the peritoneum. Finally, I prefer to perform the PLND prior to the anastomosis so that any required retraction isn't placing tension on the anastomosis. So I prefer the PLND after the prostatectomy and prior to the vesicourethral anastomosis.

Step 2: Peritoneal Incisions and Retraction

For the purpose of this chapter, we will describe the right-sided dissection. The incisions, landmarks, and surgical steps are identical for the left-sided dissection. We identify the right ureter,

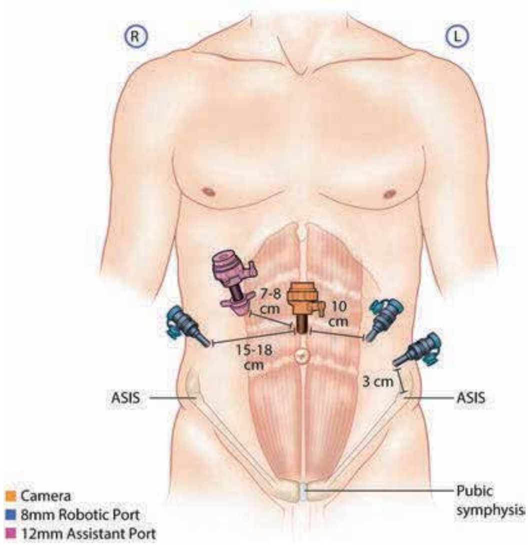

Fig. 1: Five-port placement and a single 12 mm assist port. Camera place is supraumbilical. The 8 mm right robotic port is 15–18 cm laterally from the camera port and along the level of the umbilicus. The 12 mm assist port is inserted superiorly and 7–8 mm right lateral to the camera port. The 8 mm left robotic port is placed 10 cm laterally from the camera port along the level of the umbilicus. The fourth arm robotic port is placed 3 cm superomedially to the left anterior superior iliac spine.

which can usually be seen under the peritoneum at the level of the common iliac artery. I make a longitudinal incision in the peritoneum with monopolar electrocautery, just lateral to the ureter. With the prograsp forceps in my left-handed instrument, I retract the peritoneum medially and continue the incision in the peritoneum up in the direction of the vas deferens as it is crossing the external iliac vein (Fig. 2). When the peritoneum is completely incised, I commit my third robotic arm to medical retraction on the peritoneum and bladder.

Step 3: Identification and Medial Displacement of the Ureter to Identify the Common Iliac Artery Bifurcation

Medial retraction of the peritoneum allows the ureter to be easily visualized as it will typically move medial with the peritoneum. The ureter can also be visualized by placing superior traction on the obliterated umbilical artery at the edge of the bladder peritoneal junction and the ureter passes medial to the obliterated umbilical artery. At this point the external and internal iliac artery junction is visualized. I then pick up the nodal tissue over the external iliac artery and split it with

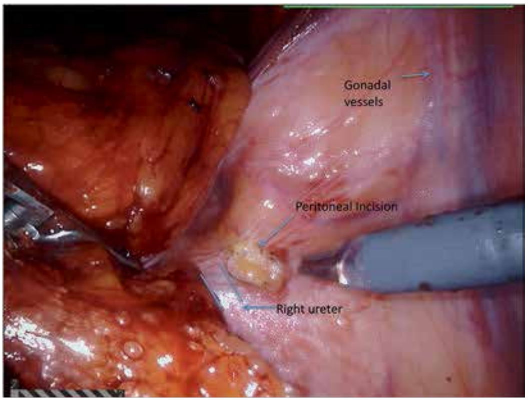

Fig. 2: A peritoneal incision is made just lateral to the ureter with medial retraction by the left robotic arm of the bladder.

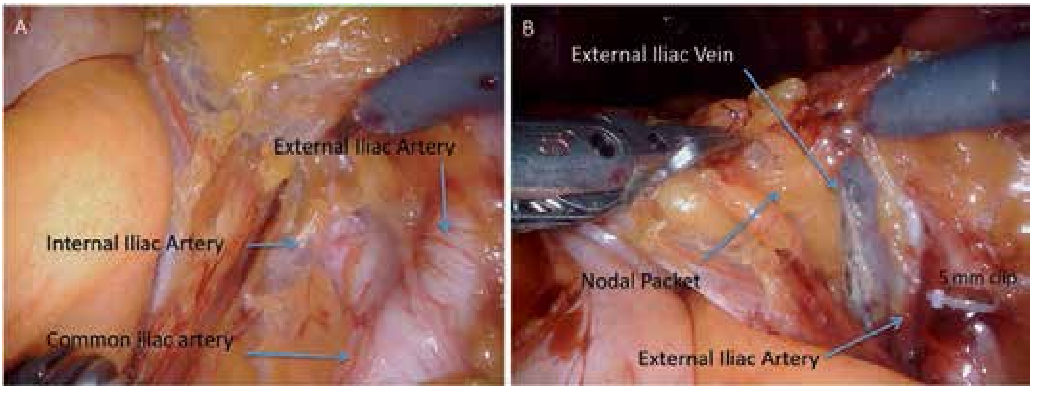

Fig. 3: (**a**) Junction of the internal and external iliac artery. (**b**) Nodal tissue dissected off the medial edge of the external iliac artery and external iliac vein.

monopolar cautery identifying the adventitial surface of the artery. I then dissect this nodal tissue medially off the edge of the artery and the proximal portion of the external iliac vein (Fig. 3).

Step 4: Dissection of the External Iliac Artery Lymph Nodes

I then continue the dissection of the nodes over the external iliac artery distally to the inferior epigastric artery. I remove the nodal tissue lateral to the external iliac artery to the level of the genitofemoral laterally (Fig. 4).

Step 5: Dissection of the Internal Iliac Artery Lymph Nodes

We then dissect the nodes from the surface of the internal iliac artery. Typically the obliterated umbilical artery will be visualized first, then the obturator artery, and then the superior vesical artery. The nodal tissue lateral to the internal iliac artery is swept medially exposing the artery and its branches (Fig. 5).

Step 6: Dissection of the External Iliac Vein and Obturator Lymph Nodes (Standard or Limited Dissection)

I then move distally to perform the external iliac vein dissection taking the nodal tissue off the medial portion of the external iliac vein and dissecting distally to the inguinal canal (Fig. 6). The circumflex iliac artery is visualized and preserved. There are often medial veins coming from the external iliac vein and joining the obturator vein. I clip the distal limit of the node of Cloquet. I then retract the nodal tissue medially and superiorly and clip and divide the small lymphatics that go to the pelvic sidewall, and the obturator nerve is visualized and protected (Fig. 7).

At the proximal limit of this dissection, the previously dissected internal iliac lymph nodes and artery will be visualized. The final clips typically go on lymphatics that are just medial to the obturator nerve and adjacent to the internal iliac vein.

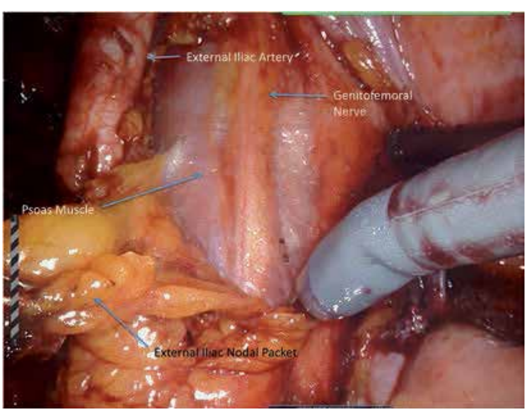

Fig. 4: Dissection of the external iliac artery nodal packet away from the psoas muscle with the genitofemoral nerve seen coursing laterally.

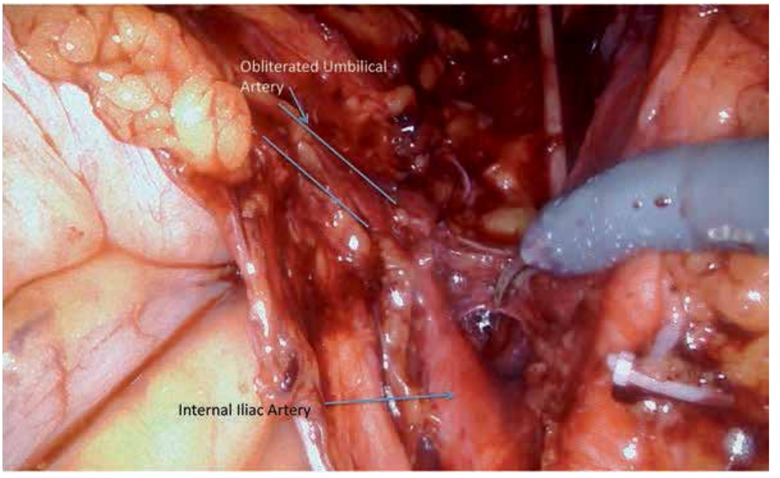

Fig. 5: Internal iliac nodal dissection with the first branch of the internal iliac artery, the obliterated umbilical artery.

Step 7: Lymph Node Dissection Specimen Retrieval

The lymph node packet is typically in one or two large pieces. I favor using a reusable Endo Catch™ bag to remove the specimen through the 12 mm assist port (Fig. 8). The assistant may need to expand the incision and remove and replace the trocar as the specimen is often quite large. The other option is to remove the specimen with grasping forceps through the assist port; however, this typically fractures the specimen and may diminish the pathologic assessment.

Step 8: Vesicourethral Anastomosis and Prostate Specimen Retrieval and Close

These portions of the procedure proceed as usual practice. If a reusable Endo Catch™ bag was used for lymph node specimen retrieval, it can also be used for prostate specimen removal.

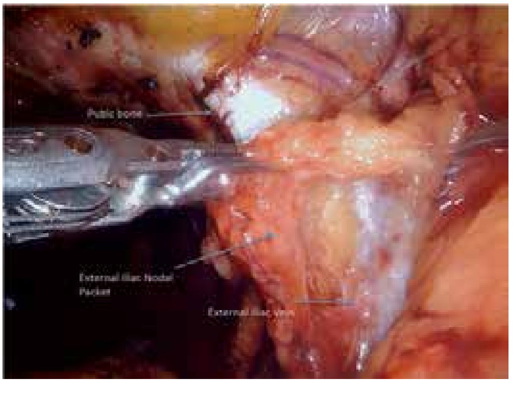

Fig. 6: External iliac nodal tissue dissected directly from the surface of the external iliac vain.

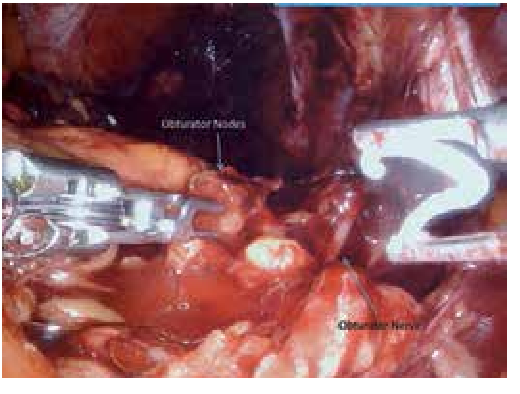

Fig. 7: Obturator nodes retracted medially to allow for lymphostasis with a 5-mm small Hem-o-lok® clip.

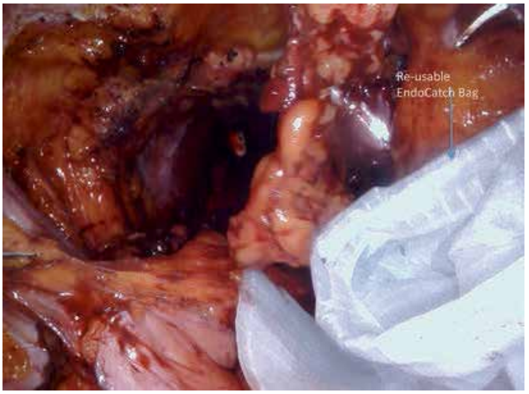

Fig. 8: A 10-mm Reusable Endo Catch™ specimen retrieval bag.

Postoperative Management

The postoperative management for PLND is the same as for RALP. Our institution has moved away from placement of JP drains and 90% of our patients are discharged postoperative day 1. The Foley catheter remains in place for 7 days prior to removal and a voiding trial is performed in clinic—no cystogram is performed.

Common Complications and Steps to Avoid Them

In order to avoid injuries to surrounding key structures, a thorough understanding of pelvic anatomy is requisite. The median umbilical ligament should be identified and dissection carried laterally to avoid injury to the ureter, which enters the pelvis in the region of the bifurcation of the common iliac artery. Repair of a ureteral injury proceeds with mobilization of the proximal end of the cut ureter with reimplantation into the bladder over a ureteral stent. To avoid vascular injury, separation of nodal packets should be directly between the plane of the nodes and vessels to prevent unnecessary traction. Injuries to the major vessels (external and internal iliac artery and vein) are rare events. Small lacerations to the external iliac vein may be repaired with increase in insufflation pressure and nonabsorbable suture (4-0 polypropylene), while larger injuries may require vascular surgery consultation, and possibly open conversion.

The most common nerve injury during PLND is the obturator nerve (reported rates 0–1.8%), which provides sensory cutaneous innervation of the medial thigh and motor innervation of the adductor muscles, responsible for adduction of the thigh [9]. When the injury is recognized intra-operatively, an epineural approximation can be performed with fine nonabsorbable suture (5-0 or 6-0 polypropylene or nylon). Alternatively, for larger defects an interposition nerve graft may be necessary. Postoperatively, intensive physical therapy should be instituted to regain and maintain function.

Lymphoceles are lymph fluid-filled collections without a distinct epithelial lining. They comprise the majority of postoperative complications following PLND and are caused by disruption of the efferent lymphatics during dissection. Reported rates of symptomatic lymphocele formation vary from 2.6 to 15% [10]. Contributing factors to lymphocele include excessive use of diathermy, extent of PLND (extended > limited), disruption of the lymphatics overlying the external iliac artery, prior radiation, and subcutaneous heparin (see Preoperative Preparation). We advocate minimizing use of thermal injury and placing a 5-mm small Hem-o-lok® clips to ensure thorough hemostasis and lymphostasis. Symptomatic lymphoceles may present with pelvic pain, lower extremity pain or edema, fevers from infected lymph fluid, or storage lower urinary tract symptoms from mass effect upon the bladder. A lower extremity ultrasound should be performed to rule out deep venous thrombosis. Simple aspiration by interventional radiology colleagues can provide symptomatic relief, although fluid reaccumulation may occur. We advocate for aspiration and temporary drain placement, especially in the setting of suspected infection. Sclerotherapy has been described using various chemical agents including povidone–iodine, ethanol, bleomycin, talcum, and doxycycline with varied results. Surgical treatment involves marsupialization or unroofing of the lymphocele into the peritoneal cavity. Our approach has been laparoscopic marsupialization when approaching persistent or bilateral lymphoceles.

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Complications of Robot-Assisted Radical Prostatectomy

Christian Wagner, Jorn H. Witt

Introduction

While there are numerous possible side effects of prostatectomy (no matter which approach, open, perineal, laparoscopic or robot-assisted) like urinary incontinence and erectile dysfunction, there are some more or less specific complications of the surgery that need to be addressed.

The lack of an accepted standardization for reporting complications concerning robot-assisted radical prostatectomy (RARP) leads to numerous different reports about types and incidences, which makes it difficult to summarize overall complication rates. In the available literature, the most common complications were perioperative hemorrhage/bleeding, blood transfusions, lymphoceles and anastomotic leakage.

Generally speaking, complications can be divided into intraoperative, postoperative, and technical complications and errors.

Unfortunately, in contrast to more emotionally positive topics, complications is a topic which is generally talked about and especially published about less frequently; one of the reasons may be the growing fear of medico-legal implications about "confession". However, it is of crucial importance to not only talk about the possible complications, but also to give tips and tricks how to manage them—and, perhaps even better, how to avoid them in the first place.

Some of the surgical complications may appear to be "standard surgical complication", like hemorrhage, but there are issues to it that go a little further.

Intraoperative Complications

Intraoperative Bleeding/Hemorrhage

Usually, due to Trendelenburg position during pelvic cases and the intraabdominal insufflation pressure, venous bleeding during RARP is quite little, especially venous oozing is less intense in

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comparison to open surgery. Sometimes, especially in case of inflammation, an increased tendency of general bleeding can be encountered, in this case the intravenous administration of tranexamic acid (at least in our experience) can be considered. However, when opening up veins of a larger diameter, like the puboprostatic plexus or the iliac vein, repair is necessary. Arterial bleeding in case of smaller branches of the prostatic arteries can usually be avoided by ligating or clipping them beforehand. Unlike upper tract surgery, major vessel injuries fortunately occur less often. An injury of the iliac artery is quite uncommon, maybe because of the arterial wall thickness, or the fact that it lies to the lateral borders of the surgical field. Avoiding major vessel injury can be achieved by applying only gentle traction on the structures, and being careful with electrocautery, bearing in mind that the insulation sheath of the instruments may break and thus lead into an electric current flowing to unwanted places. Also, one has to keep in mind the assistant has to be able to locate his instruments three-dimensionally, because the typical "poking movements" of less experienced assistants in search of the scissors or other instruments may result in perforation of other structures.

In our experience the first step in case of bleeding (just like in open surgery) should always be pressure and tamponade, followed by exploration and repair if necessary. Compression with the robotic instruments should be always used with gentle force only. Especially the needle driving instruments have a strong closing force, that could potentially result in perfusion problems of the gripped tissue. A surgical sponge/bolster appears to be the most appropriate means of applying temporary pressure, and simultaneously can help to clear the field. Reduction of suction, instead using gentle irrigation, and an intraabdominal pressure above the central venous pressure (capnoperitoneum between 10 and 15 mmHg) are additional measures. In case of a major venous injury (Fig. 1), it is not advisable to raise the pressure, since it may result in a gas embolism, a potentially much more dangerous complication in comparison to hemorrhage. Closure of vessel injuries usually can be performed safely with a suture (Fig. 2), which should be always favored in comparison to clips (that may slip off). For beginners, we recommend to have a "safety suture" at hand, a medium sized needle on a medium length thread, that has a knot at the end and is preloaded with a clip (Fig. 3). This suture can be used for gaining control even in stronger bleeding sources, thereby offering a dryer field for the definitive closure of the injury. A conversion to open surgery is a possible and considerable solution—however we believe that if you are not a very beginner in the robotic console, control can be achieved in most cases much easier with robotic assistance. If the surgeon's robotic experience level is low however, conversion is always an appropriate possibility. In the inevitable case of conversion, consider leaving one robotic arm in place that applies pressure with a bolster, it could serve as the "finger on the wound" and save some units of blood during the conversion process, and may also indicated the site of the vessel injury.

Bowel Injury

In big contrast to retropubic prostatectomy, small bowel injury much more frequent in transperitoneal RARP. Especially in patients with prior major abdominal surgeries, and/or a history of inflammatory diseases and reactions, like peritonitis, or perforated bowels (sigmoid

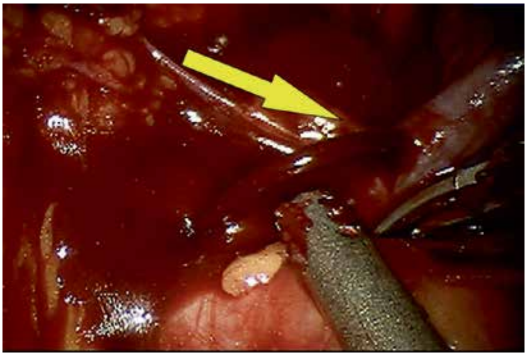

Fig. 1: Venous bleeding (*arrow*) from external iliac vein after puncture with the scissor tip.

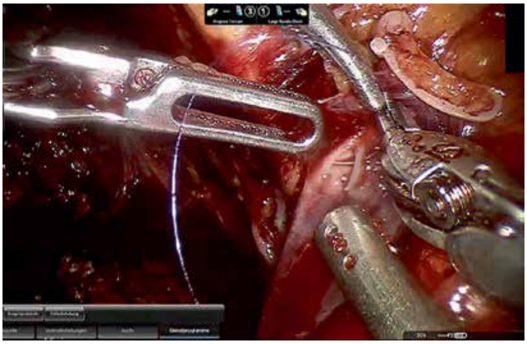

Fig. 2: Suturing of the venous lesion.

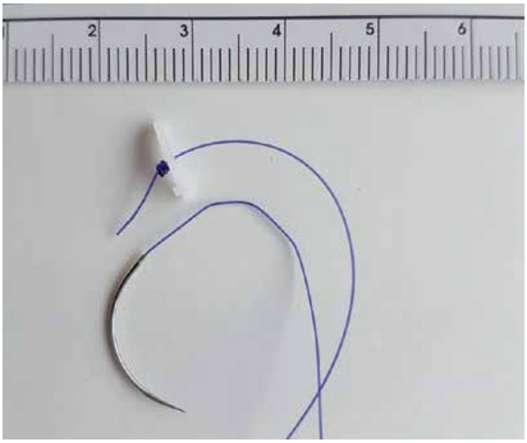

Fig. 3: "Safety suture" with a knot at the end and preloaded with a clip.

colon, appendices), the probability to encounter severe adhesions usually is much higher. To avoid this, extraperitoneal RARP may be a viable option, however developing the extraperitoneal space in case of major scarring sometimes is quite challenging and may result in a peritoneal tear with possible harm to the bowel, too. In the beginning of the learning curve, it is strongly advisable to make a good patient selection; in case of a high experience in laparoscopic surgery, usually adhesions can be managed laparoscopically. In our institution, we barely ever make use of a Verees needle insufflation, because entrance under vision (Hasson technique) is known to cause less bowel injuries in the first place, and since there is the need of an incision to extract the specimen anyway, we prefer using a ring wound retractor (Alexis® by Applied Medical) or a Hasson balloon trocar.

In case of expected peritoneal scarring, we use the most distant part of the abdomen for prior insufflation, one should not be afraid to make use of an additional trocar to gain access, having a better overview adds to the safety and efficiency of the adhesiolysis. One advantage of smaller cameras (like the da Vinci Xi/X System's 8 mm Scope) is the possibility to swap between trocars during adhesiolysis. Another option is switching between 0° and 30° (upward) lenses. Open adhesiolysis also is a viable option in those cases where access is otherwise impossible. A temporary closure of the wound after completion of adhesiolysis enables to perform RARP afterwards, still offering the benefits of robotic surgery.

In case of a serosal tear in the bowel, suture repair is strongly advisable, either marking the site for later robotic repair, or primary closure. In case any bowel lesion especially with a full thickness lesion (Fig. 4), advice from the general surgeons should be considered, mostly because of medico-legal reasons. A primary repair without compromising the diameter of the bowl lumen (suturing transverse to the bowl direction) with a monofilament running suture (e.g., 3/0 or 4/0) is our standard technique. A partial resection of the bowel sometimes is inevitable.

It is crucial to avoid thermal energy whenever possible because of the delayed bowel necrosis. Moreover, traction force should be reduced to a minimum, and direct grasping of the bowel should only be reserved to atraumatic graspers. When the robotic ports are placed, the remaining adhesions can usually be taken down robotically.

Rectal Injuries

In comparison with open retropubic surgery, rectal injuries appear to happen much less often, likely because of the improved vision and spatial orientation that is offered by the robotic technique, especially during the dorsal parts of the dissection. In advanced tumors, which should only

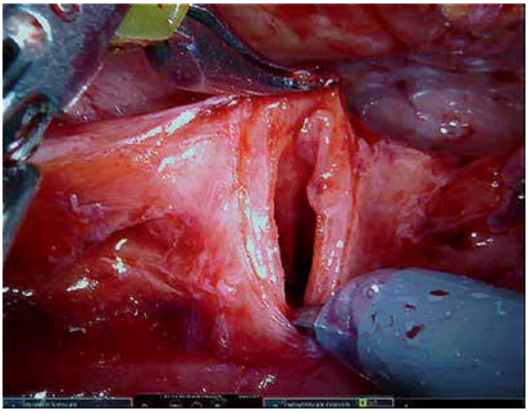

Fig. 4: Robotic exploration of a lesion in the small bowel after initial laparoscopic adhesiolysis.

be operated on by more experienced surgeons, the possible higher risk of rectal injuries should always be considered. We do not bowel prep our patients, however we advise to insert a rectal tube in advanced tumors and make use of the underwater insufflation test (bubble test) after resection of the prostate (Fig. 5); furthermore, inserting a scope with a light source rectally and reducing the robotic lights (diaphanoscopy) can show a thinned-out rectal wall even if there is no complete hole yet. A rectal injury (Fig. 6) can usually be repaired easily and efficiently with sutures (Fig. 7) robotically; a colonic diversion should be reserved to major rectal injuries only. In case of a recognized rectal injury with sufficient repair, we do not alter the postoperative management or medication, and we have seen no problems with it so far. An additional single-shot dose of a broad spectrum antibiotic like metronidazole is routine in our institution, but we would refrain from using a longer therapy course. Also, keeping the patient on non-per-os postoperatively, or leaving the rectal tube offers no advantages, and does not go in compliance with the standards and benefits of fast-track surgery. The recognition of a rectal injury is crucial, because it is typically the unrecognized injury that cause the worst effects. In order to lower the probability of a rectal fistula, an additional interposition of tissues can be performed. The easiest way is a dorsal reconstruction using the posterior prostatic fascia, other possibilities are options are: omental flap; a vesical fat flap; a modified dorsal reconstruction using the vesicoprostatic muscle; or sacrificing the neurovascular tissues for a transposition.

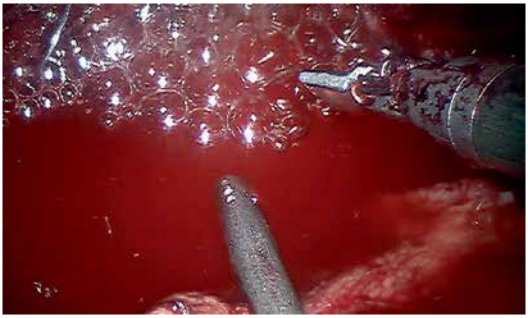

Fig. 5: Positive rectum insufflation test (bubble test).

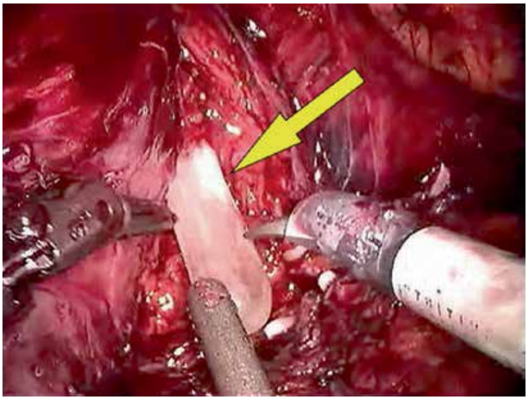

Fig. 6: Rectal injury, inserted rectal tube clearly visible, penetrating through the gap.

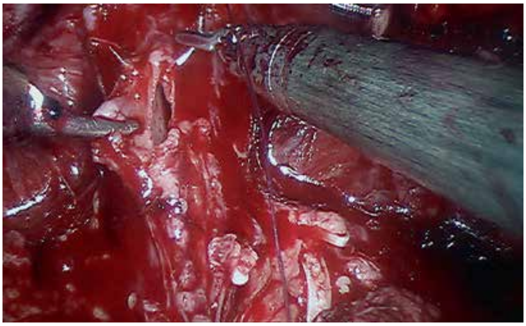

Fig. 7: Rectal injury, primary suture closure.

Nerve Injury

The most frequent injury to adjacent nerves (apart from the nerves of the neurovascular structures) is the obturator nerve injury. This usually happens during lymphadenectomy. To avoid it, a clear identification of the nerve is mandatory before transecting or clipping the lymphatic tissues.

In case of a (partial) transections (Fig. 8), a suture repair can be performed (using 8–0 or smaller sutures). Sutures smaller than 6/0 has to be manipulated with a micro needle driver (Black Diamond Micro Forceps). Hemolok™ Clips that were accidentally placed on the nerve can be opened either by using the specific removal tool, or better (less manipulation and cheaper) by cutting the non-locking end of the clip with a hooked scissor (Figs. 9 and 10). If we encounter an obturator nerve injury, we recommend extended physical therapy and a course of B-vitamins, even though this lacks evidence.

Ureteric Injuries

In general, ureteric injuries are a quite rare condition, but if they occur, they are often recognized quite late. Especially, prolonged secretion of large amounts of high-creatinine fluid from the drains and increasing abdominal symptoms like distension (because of chemical urine peritonitis) are warning signs, and should point to checking the ureters with retrograde ureteropyelogram or IVP. One can easily be misled to consider an anastomosis insufficiency to be the cause for it, but in our experience, this usually does not cause a high-volume drain output. Usually the ureteric damage occurs during extended lymphadenectomies, so it should be considered mandatory to clearly identify the ureter before transecting or clipping of lymphatic tissues, and of course avoiding a denudation of the ureter off its surrounding tissues, too. A different danger point is during the dissection of the dorsal bladder neck and the seminal vesicles, especially in more advanced tumors, or during a dorsal approach, when the ureters are not far away from the surgical field. One trick is to avoid cautery during dissection of the tips of the seminal vesicles, not only to avoid damage for the neurovascular structures, but also for the ureters. A third possible reason for damage is an unrecognized duplex system, or a transection of the ureteric orifice during dorsal bladder neck dissection. This sometimes can be challenging in cases of one or more median lobes, care has to be taken to make sure the interureteric ridge is left in place.

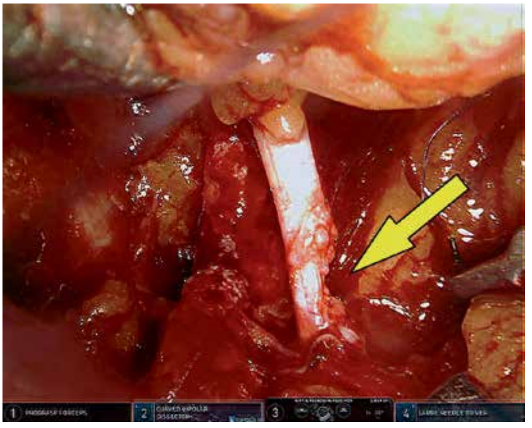

Fig. 8: Partial transection of the obturator nerve after accidental clipping.

Fig. 9: Opening of a clip with a hooked scissor on the opposite sit of the lock.

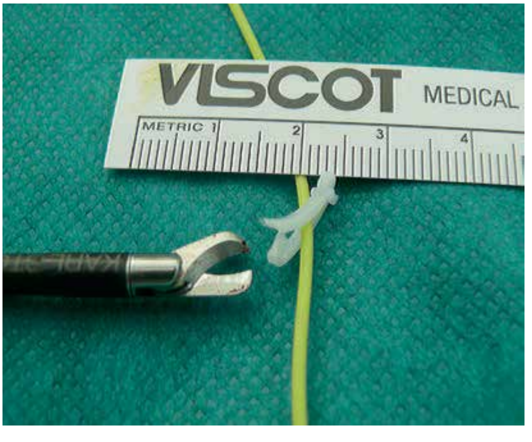

Fig. 10: Opening of a clip with a hooked scissor on the opposite sit of the lock.

Visible continuous clear urine output from the ureteric orifices (easiest to visualize with a 30° down scope during anastomosis) is the first checkpoint to assure the ureter has not been transected. However thermal damage causing long term necrosis or stenosis cannot be excluded like this. Placing DJ Stents over a hydrophilic guidewire during RARP despite the lack of haptic feedback is usually easy to perform, and in case of doubt of ureteric damage we recommend to do so. In case of suspected injury to ureteral blood supply, the use of intravenous indocyanine green (ICG) fluorescence (FireFly™) can be helpful to identify a sufficient blood supply. In case of major injury to the ureters or a complete transection, a ureteroneocystostomy, e.g., in a psoas hitch technique, can be performed.

Bone Injury

In situations with a narrow pelvis, most likely in black or small patients, the robotic instruments can cause a constant bruising to the pubic bone. Care has to be taken to avoid touching the periosteum, since contact with infected urine in case of an anastomotic leak can lead to a severe periostitis. Lowering the robotic instruments dorsally, or even repositioning the patient to a deeper Trendelenburg position may be necessary. Also, the periurethral suspension stitch can be a potential entrance point for bacteria, leading to inflammation of the symphysis ossis pubis, a rare but devastating and excruciatingly painful condition that requires long-term antibiotic and analgesic treatment.

Positioning Damage

The Trendelenburg position is an unphysiological position that requires some safety measures to assure the patients to not slip from the table, and does not suffer from pressure point damage. We use 35° Trendelenburg, measured with an inclinometer (a smartphone app can be used alternatively to standardize the tilt degree). In order to offer a safe position, we use a three compartment vacuum mattress, that is modelled onto the patient, and spread the padded legs. Specifically, for expected longer operating times, we do not recommend placing the patient in lithotomy position using spreader bars or pneumatic compression devices or stirrups, because of the even more unphysiological position of the legs and hips, which may result in a compartment syndrome after prolonged cases. It is key to try to keep operating times below approximately 4 h, which may be considered a cutoff time to decrease the risk of compartment syndrome.

Another devastating, yet rare complication (we haven't seen this in more than 11,000 robotic cases) of the Trendelenburg position has been reported only in case reports so far: posterior ischemic optic neuropathy (PION), leading to significant vision loss or even blindness after surgery. All reported cases had in common a long operating time (8–10 h), so keeping the time for the case short should be advisable in respect to this infrequent problem.

Although one might think the quite steep Trendelenburg position may result in other problems, usually after a short period of compensation (causing a short drop in blood pressure and heart rate that can be effectively managed by anesthesia), the body seems to compensate the position. Restricted fluid management during surgery is mandatory and should be standard for the anesthesiologist today. However, we recommend that patients with a high intracerebral pressure (hydrocephalus) or previously untreated glaucoma should be checked up before surgery. Furthermore, in patients with a history of cardiopulmonary problems, we recommend cardiologic preoperative checkup.

Postoperative Complication

Can be structured into early and late complications.

Early

Hemorrhage

Postoperative hemorrhage requiring intervention is an infrequent, yet considerable complication after RARP. With an estimated peak time during the first 24 h up to 3 days after surgery, patients usually present with a decrease in blood pressure and increased heart rate, and a drop in hemoglobin. In our institution, a decrease of postoperative hemoglobin for more than three points on the first morning after surgery has been a sufficient cutoff to figure out potential patients requiring reintervention. Also clinical observation of the patient is critical to identify possible bleeding situations. Due to the mostly used transperitoneal access, early reintervention is highly advisable, because unlike retropubic approach, bleeding usually does not tamponade itself. Providing adequate transfusions may result in many units of blood, leading to a potential additional risk for the recipient. Furthermore, larger amounts of blood collections are a potential source of superinfection, and can cause a secondary rupture of the urethrovesical anastomosis or inflammatory problems like peritonitis. Regular checkup of the patient is required, there are unspecific clinical warning signs that should ring a bell, such as hiccup, nausea, unusually strong pain and ongoing mobilization problems such as dizziness. Using a drain usually is not a sufficient tool to recognize bleeding, since most parts of the blood can drain to the abdominal cavity. When in doubt, we perform an ultrasound and in case of a suspected hemorrhage we bring the patient back to the OR as early as possible. An additional CT scan can be performed, but in most cases does not provide crucial information that leads to a change in the proceeding, yet only leads to a further delay or reintervention. In our experience, an open revision is usually not required, since most bleedings can be managed laparoscopically by suction of the fluid collections, and a mix of irrigation and suction using a larger diameter suction device can effectively clear the field. Inability to clear the field has been reported in the literature to be one of the main reasons for conversion to open revision—in our opinion this is an avoidable step. Some bigger blood clots can be extracted with a spoon forceps. Sometimes coagulated blood may hamper clearance by clogging the suction tube, which can easily be overcome by using a syringe to wash it free. Smaller bleedings can be take care of by cautery or placement of clips, in case of a bleeding source which is difficult or impossible to control with standard laparoscopy techniques (such as a source from the common or internal iliac vessels for example), we would rather switch to a conversion to robot-assisted revision surgery than to an open approach. Even though the cost may be higher, it offers a very effective minimally invasive treatment option that causes only little delay in the healing process for the patient with all the benefits for both the surgeon and the patient.

Typical bleeding sites we check are: the prostatic pedicles, the dorsal vascular complex, neurovascular bundles, ventral bladder surface, epigastric vessels, accessory pudendal arteries, pelvic wall, port sites and the lymphadenectomy areas. An example of a laparoscopic revision within a bleeding situation from the right lymphadenectomy region is shown in the Fig. 11 (initial view of the hematoma) and (Fig. 12) (bleeding source). In many cases, a specific bleeding source cannot be identified, which may represent a spontaneous resolving of the bleeding in the meantime.

If hemorrhage is recognized early, transfusions can be avoided in the majority of the cases, if the patient is fit and has a low cardiovascular comorbidity profile. As auxiliary measures, we recommend using intravenous tranexamic acid and the use of local hemostatic agents such as fibrin products or starch powder.

To avoid bleeding complications it is advisable to take care of the vessels during the case using clip or ligation, and a meticulous check for a dry field at the end of the case. Therefore, we lower the intraabdominal pressure to zero, using one of the robotic arm to elevate the abdominal wall to emulate gasless laparoscopy, in order to simulate the postoperative situation, to make sure we are not missing venous bleeding that would be otherwise compressed by the capnoperitoneum. During this procedure at least one insufflation port has to be in an open position to maintain a zero capnoperitoneum. This avoids a negative pressure in the surgical cavity during suction with a resulting collapsed surgical field. This lowered pressure has to be maintained for a while, because the vessels may be still reflectively contracted, so at least a minute or two of desufflation is advisable. In addition, to check a sufficient closure of the puboprostatic venous complex, intermittent external perineal pressure is applied, so the possibly retracted veins are pushed in again, and open veins can be sewed with selective sutures. Extraction of the trocars should occur under vision,

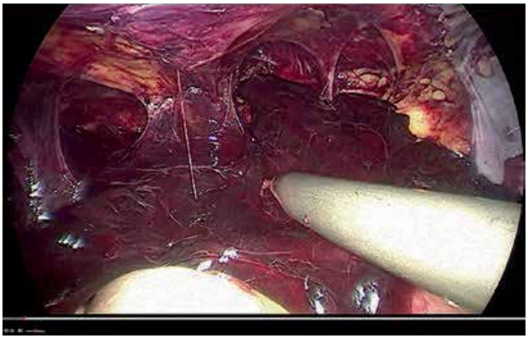

Fig. 11: Laparoscopic revision of a postoperative hemorrhage, initial overview shows partial clotting of the hematoma ventrally to the bladder and laterally right side.

Fig. 12: Laparoscopic revision of a postoperative hemorrhage, bleeding source in the right lymphadenectomy region.

since the trocar may have injured a vessel during insertion, but during the case may have compressed the bleeding.

Incisional/Port Site Hernia

Laparoscopic trocars of more than 8 mm in diameter have been proven to be a possible site for port site hernias. Therefore, they should be closed effectively. We recommend using an all-layer suturing technique under vision, for example using dedicated trocar closure devices like the Carter-Thomason needle or Busche device. Alternatively, external suturing can be performed, too.

Patients with port site hernias present with unusual wound pain and unspecific abdominal symptoms. A bulging is sometimes not visible, especially in obese patients this can lead to a delay in diagnosis. Ultrasounds and/or CT scan confirm the diagnosis. For treatment, a primarily laparoscopic approach with extraction of the herniated bowel segment is usually sufficient enough, however in case of a prolonged herniation, sometimes a bowel resection can be required.

Ileus

Problems with bowel function are quite common problem after every lengthy transperitoneal laparoscopic procedure, usually resulting in only mild symptoms and delay in bowel movement. Measures like bowel prep and feeding restrictions have been used in the past a lot to overcome these issues. However, there is no convincing evidence to support this; it is more likely that these approaches have a negative influence. Instead, it is advisable to keep surgery time as short as possible, an also trying to keep the intraabdominal compartment as physiological as possible. One major point for this is keeping the capnoperitoneum as low as possible, since it has been shown that using a 15 or 12 mmHg pressure has significant impact on the bowel. Therefore, we advise to bring the pressure down to 8 or 10 mmHg, with high flow, and have the assistant use the suction only in short periods. Moreover, we apply a gas warming device.

An actual ileus can be caused by mechanical problems like a herniation or compression by adhesions, which require surgical treatment. A subileus can usually be treated conservatively, with auxiliary measure like chewing gum, early mobilization of the patient, early feeding, and administration of medication to stimulate bowel movement postoperatively. An upper gastrointestinal X-ray series can be performed in a situation of a delayed bowl movement, with the contrast medium also working as a very effective stimulant.

Anastomotic Leak

In contrast to retropubic prostatectomy, transperitoneal RARP shows the potential problem of urine draining into the peritoneal cavity. This can cause a significant chemical peritonitis, resulting in ileus symptoms. Therefore, a sufficient vesicourethral anastomosis should be achieved. With the versatility of the robotic technique, this is generally possible even in difficult cases. Even if bladder neck reconstruction is necessary, a sufficient closure of the anastomosis is feasible. To avoid urine spill during surgery, it can be recommended to only open the bladder neck when the bladder is empty, and to suck away remaining urine portions. If one places a suprapubic tube (which may lead to an improved postoperative patient comfort), we recommend closing the insertion site at the bladder, and attaching it to the anterior abdominal wall. We try to keep the time for the indwelling catheter on a minimum, because longer times may result in higher infection rates and a prolonged time of or urinary incontinence. If the cryptogram shows no leakage, the Foley catheter can be removed. In case of a primary insufficiency, the catheter should be kept longer. 3 weeks after surgery the catheter can be removed also in cases with a remaining insufficiency if there is no contrast medium reaching the peritoneal cavity. A sudden pain during voiding, followed by gross hematuria should be signs for a secondary anastomotic leak, and it is advisable to place a new catheter and check the urethrovesical anastomosis once again.

Only in few cases of prolonged anastomotic leak is it necessary to drain the urine through ureteric stents, here one option is the placement of extra-long mono-J stents, and fixing them together with the Foley. Alternatively, a transvesical placement with open revision surgery is also an option.

Late Complications

Lymphocele

During RARP, a pelvic lymphadenectomy in many cases is performed, and with an increasing number of lymph nodes removed, the incidence of lymphoceles is known to rise, too.

In order to avoid lymphoceles, many measures can be undertaken to try to decrease the risk, however so far, there is no convincing evidence which is the best technique to avoid lymphocele formation. Generally discussed measures are: using cautery, placement of clips, avoiding clipping of nodes but only the lymphatic strains, using hemostatic agents, peritoneal fenestration and avoiding heparin injection to the lower extremities. Even though one might think that due to the transperitoneal access, there may be a natural lymphatic drainage, the incidence of pelvic lymphoceles is lower in comparison to retropubic prostatectomy, but not zero. This may be explained for one by the earlier mobilization of the patient, resulting in higher lymphatic fluid output, and secondly to the early closure of the peritoneal incision during the healing process. One interesting technique to overcome this problem described lately is the suture-fixation of the bladder at the obturator fossa, to keep the peritoneal incision at the lymphatic region open.

In our intuition, we use meticulous clip ligation (small clips) of the lymphatic strains to the external limit of dissection, and we avoid administering heparin to the lower extremities or the lower abdominal wall.

In case a lymphocele is encountered, one has to bear in mind that many of those resolve spontaneously. Only symptomatic lymphoceles require intervention, for example if a lymphocele causes compression of the iliac veins or the bladder thus resulting in the inability of the bladder to adequately fill up or a possible formation of a deep venous thrombosis. Of course, painful or infected lymphoceles or compression of the obturator nerve require treatment, too. In uninfected lymphoceles, a laparoscopic or robot-assisted fenestration is the most effective way to provide a fast cure, with only littles chances of recurrence. Figure 13 shows the identification of a left side lymphocele followed by the fenestration (Fig. 14). In infected lymphoceles we recommend a stepwise approach with antibiotic treatment and a percutaneous ultrasound-guided drainage, followed possibly by administration of local sealing agents like gentamicin. If drainage does not lead to a sufficient and lasting collapse, laparoscopic revision is the next step. We do not advise primary laparoscopic intervention in infected cases, because of the possible spread of infected fluid/pus into the peritoneal cavity. In experienced laparoscopic hands, an open lymphocele resection is usually not necessary.

Anastomotic Stricture/Bladder Neck Contracture

With the benefit of improved dexterity and vision of the robotic platform, and the widespread use of the running van Velthoven anastomosis technique, the formerly (in the times of retropubic prostatectomy) not uncommon long-term complication of anastomotic stricture has virtually become a thing of the past. In our experience of more than 10, 000 RARP it only occurred in three patients.

Venous Thrombosis

Due to the advent of enhanced recovery protocol, in combination with early patient mobilization and an improved understanding of the necessity to administer low molecular heparins, the incidence of deep venous thromboses has dramatically decreased, and hence the incidence of potentially lethal lung arterial embolism has diminished consecutively. Current guidelines recommend postoperative medical treatment with low-molecular heparins for 4 weeks postoperatively.

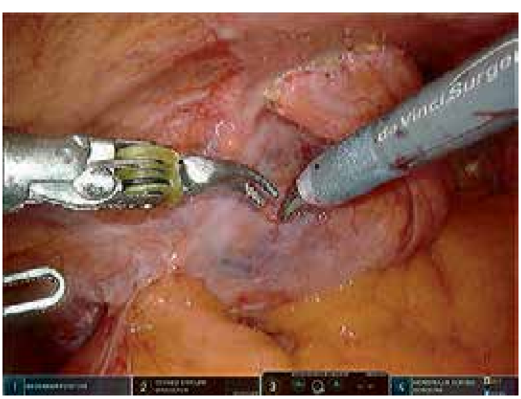

Fig. 13: Robotic identification of left pelvic lymphocele.

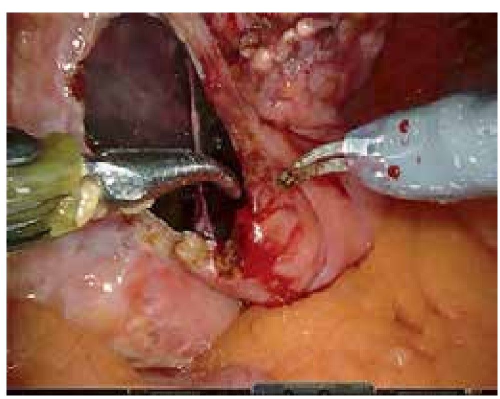

Fig. 14: Robotic incision of left pelvic lymphocele.

Lymph Edema

Generally, an infrequent long term problem, short-term mild lymphedemas of the groin region, especially in patients with pelvic lymph node dissection, are quite common. Most postoperative lymphedema resolve over time, a long term problem should always be checked for an obstruction, e.g., a lymphocele. Lymphatic drain problems of the legs are extremely rare.

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Difficulties in Anesthesia for Urologic Laparoscopy

Amr M. Sayed

Laparoscopic techniques have rapidly increased in popularity because of multiple advantages: smaller incisions compared with traditional open techniques, reduction in the postoperative pain, lower postoperative pulmonary complications, lower incidence of postoperative ileus, and early ambulation. All of these aspects carry substantial medico-economic advantages [1].

Urologic laparoscopy techniques are minimally invasive and have rapidly gained acceptance [2]. Laparoscopic procedures performed in urology include diagnostic procedures for evaluating undescended testis, orchiopexy, varicocelectomy, bladder suspension, pelvic lymphadenectomy, nephrectomy, partial nephrectomy, nephroureterectomy, adrenalectomy, prostatectomy, and cystectomy. The physiological consequences of laparoscopy are related to the combined effects of elevated intraperitoneal pressure following carbon dioxide (CO_2) insufflation to create a pneumoperitoneum, effects of systemic absorption of carbon dioxide, and alteration of patient position [3]. The lengthy operative duration, unsuspected visceral injury, and the difficulty in evaluating the amount of blood loss are additional factors that contribute in the complexity of anesthetic practice for laparoscopic surgery. Understanding of the pathophysiologic consequences of elevated intra-abdominal pressure (IAP) is crucial for the anesthesiologist in order to prevent or adequately respond to changes in the perioperative period [4].

Pulmonary Changes in Laparoscopy

Pneumoperitoneum is created by insufflation of carbon dioxide (CO_2) – which is currently the routine gas used for laparoscopy – results in ventilatory and respiratory changes. Changes in pulmonary function during abdominal insufflation include reduction in lung volumes, decrease in pulmonary compliance, and increase in peak airway pressure [5].

Reduction in functional residual capacity (FRC) and lung compliance associated with supine positioning and induction of anesthesia would be aggravated by CO_2 insufflation and cephalad shift of the diaphragm during head-down tilt [6].

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Hypoxemia because of reduction in FRC is uncommon in healthy patients during laparoscopy. However, reduction in FRC may result in significant hypoxemia because of ventilation-perfusion mismatch and intrapulmonary shunting in obese patients or in patients with preexisting pulmonary diseases such as those in the American Society of Anesthesiologists (ASA) classes III and IV (Table 1) [7].

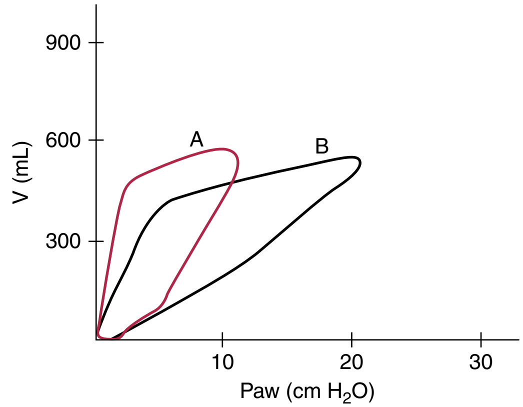
Table 1: Pulmonary changes associated with laparoscopy (Adapted from Schellpfeffer and Crino [42]).

Increased	Decreased	No significant change
Peak inspiratory pressure	Vital capacity	PaO_2 (in healthy patients)
Intrathoracic pressure	Functional residual capacity (FRC)	
Respiratory resistance	Respiratory compliance	
$PaCO_2$		

Carbon dioxide is the gas of choice for laparoscopic surgery. It does not support combustion as nitrous oxide (N_2O), and therefore can be used safely with diathermy. Compared with helium, the high blood solubility of CO_2 and its capability for pulmonary excretion reduces the risk of gas embolism. CO_2 insufflation into the peritoneal cavity increases arterial carbon dioxide tension ($PaCO_2$), which is anesthetically managed by increasing minute ventilation. Absorption of carbon dioxide depends on vascularity and the surface area, making absorption greater in pelvic extraperitoneal laparoscopic procedures than abdominal intraperitoneal ones. Mullet and colleagues examined end-tidal CO_2 ($EtCO_2$) and pulmonary CO_2 elimination during CO_2 insufflation for laparoscopic cholecystectomy and pelviscopy. CO_2 absorption reached a plateau within 10 min after initiation of intraperitoneal insufflation, but continued to increase slowly throughout extraperitoneal insufflation. The resulting rise in $PaCO_2$ is unpredictable, particularly in patients with severe pulmonary disease (Fig. 1) [8].

Cardiovascular Changes in Laparoscopy

The hemodynamic response to peritoneal insufflation depends on the interaction between many factors including the degree of IAP achieved [9], patient positioning [10], neurohumoral response [11], cardiorespiratory status of the patients and the intravascular volume status [6]. Principally, the physiologic responses include an elevation in systemic vascular resistance (SVR), mean arterial blood pressure (MAP), and myocardial filling pressures, accompanied by an initial fall in cardiac index (CI), with little change in heart rate. The rise in the IAP that occurs with pneumoperitoneum compresses vessels of the venous system, causing initially an increase in the venous return, which is then followed by a sustained decrease [12]. The decrease in cardiac output is a multifactorial phenomena, related to the decline in venous return [13] followed by a reduction in left ventricular end-diastolic volume when measured using transesophageal echocardiography (TEE) (Fig. 2) [14].



	TV	Ppeak	Pplat	C	PETCO2
A	522	12	9	56	31
B	525	21	19	27	39

Fig. 1: Change in total respiratory compliance during pneumoperitoneum for laparoscopic procedure. The intra-abdominal pressure was 14 mm Hg, and the head-up tilt was 10°. The airway pressure (Paw) versus volume (V) curves and data were obtained from the screen of a Datex Ultima monitoring device. Curves are generated before insufflation (A) and 30 min after insufflation (B). Values are given for tidal volume (TV, in mL); peak airway pressure (Ppeak, in cm H_2O); plateau airway pressure (Pplat, in cm H_2O); total respiratory compliance (C, in mL/cm H_2O); and end-tidal carbon dioxide tension ($PETCO_2$, in mmHg) (Adapted from Joris [4])

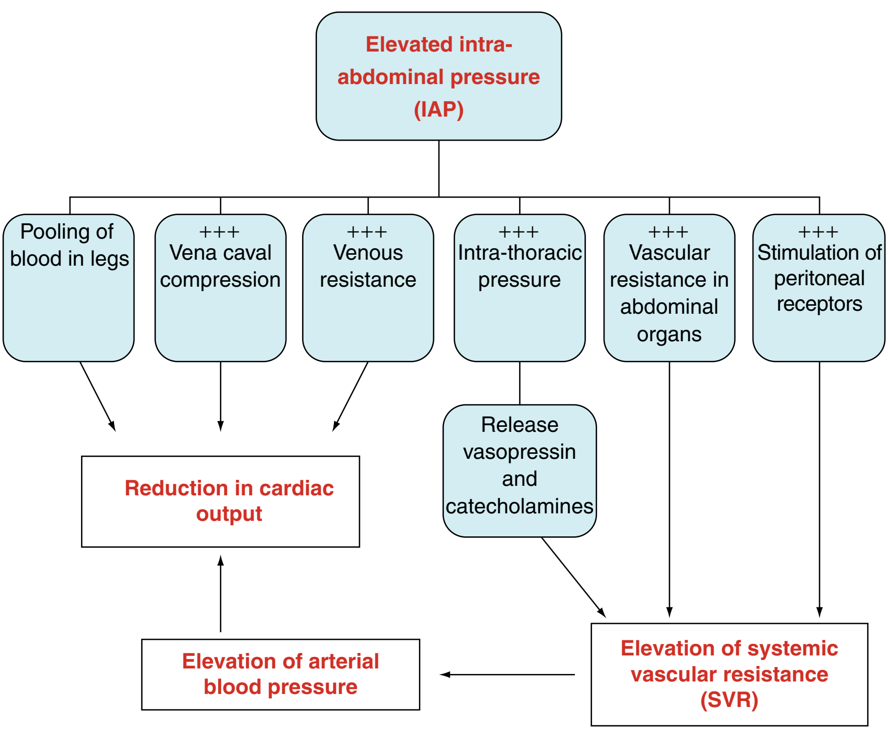


Fig. 2: Schematic representation of the different mechanisms leading to decreased cardiac output during pneumoperitoneum for laparoscopy (Adapted from Joris [4]).

The compression of the arterial vasculature increases afterload and hence the SVR [15]. Using flow-directed pulmonary artery catheters in healthy patients, Joris and colleagues[16] observed a significant (35–40%) reduction in CI with induction of anesthesia, which was further decreased to 50% of baseline following peritoneal insufflation. Branche and colleagues observed a similar phasic hemodynamic response to pneumoperitoneum [12]. These hemodynamic changes would carry a detrimental effect on patients with depressed ejection fractions. Pulmonary edema, perioperative myocardial ischemia, and arrhythmias could manifest during lengthy laparoscopic surgery. Ishizaki *et al*. reported that IAP ≤ 12 mm Hg had minimal hemodynamic effects, and recommend this pressure value to avoid cardiovascular compromise during CO_2 insufflation (Table 2) [10].

Table 2: Hemodynamic changes during laparoscopy (Adapted from Schellpfeffer and Crino [42]).

Increased	Decreased	No change
SVR MAP CVP	CO (initially, then increases) Venous return (at IAP > 10)	Heart rate (may increase due to hypercapnia or catecholamine release)
PAOP		
Left ventricular wall stress		
Venous return (at IAP < 10)		

SVR systemic vascular resistance, MAP mean arterial pressure, CVP central venous pressure, PAOP pulmonary artery occlusion pressure, IAP intra-abdominal pressure

Neurohumoral Response

Vasopressin and catecholamines are mediators activating the sympathetic nervous system. Joris and colleagues observed a marked increase in plasma vasopressin immediately after peritoneal insufflation in healthy patients and the profile of vasopressin release paralleled the time course of changes in SVR [16].

Patient Positioning

The patient's positioning may have significant effects on the hemodynamic consequences of pneumoperitoneum. By using transesophageal echo (TEE), Cunningham and colleagues reported a significant reduction in left ventricular end-diastolic area on assumption of the reverse Trendelenburg position, indicating reduced venous return. Left ventricular ejection fraction was maintained throughout in otherwise healthy patients. However, such changes in left ventricular loading conditions might have adverse consequences in patients with cardiovascular disease [11].

Miscellaneous Changes

Renal System

The renal system is affected by the mechanical compressive effects of pneumoperitoneum that accounts for almost 50% reduction in glomerular filtration rate, renal plasma flow, and urine output during laparoscopic interventions [17]. Urine output increases significantly following pneumoperitoneum deflation. Oliguria has been associated with prolonged duration of pneumoperitoneum during laparoscopic nephrectomy [18]. A possible mechanism for intraoperative oliguria during laparoscopic surgery is an increase in stress hormone levels, such as antidiuretic hormone (ADH) [19].Thus, oliguria during prolonged laparoscopic procedures does not reflect depletion in the intravascular volume.

Cerebral Circulation

Cerebral blood flow velocity and intracranial pressure both increase during CO_2 pneumoperitoneum, with implications for patients with intracranial mass lesions [20].

Splanchnic Circulation

The splanchnic circulation flow is reduced, but it is counterbalanced by the splanchnic vasodilating effects of carbon dioxide. The effects of pneumoperitoneum on the splanchnic circulation are not clinically significant [20].

Intra-operative Complications Throughout Laparoscopic Urologic Procedures

Various complications may possibly occur in laparoscopic procedures:

- *Pulmonary* complications include pneumothorax, pneumomediastinum, hypoxemia, hypercapnia, and pulmonary aspiration.
- *Cardiovascular* involvement could be in the form of dysrhythmias, hypotension, hypertension, venous gas embolus, and venous thrombosis.
- *Miscellaneous* complications include vascular injury, visceral perforation, oliguria, hypothermia, peripheral nerve injury, and surgical emphysema [21].

Anesthesia for Patients Undergoing Urologic Laparoscopic Surgery

The number of patients presenting for laparoscopic surgery is increasing, with a great percentage of them having cardiac, respiratory, or renal dysfunctions and other system affections. The changes that occur during abdominal insufflation prior to laparoscopic surgery and the hemodynamic consequences that take place turn these situations into great challenges anesthetically. The challenging aspect is that preoperative dysfunctions will still exist after the operation, needing further postoperative care; furthermore perioperative myocardial ischemia, infarction, and arrhythmias are the most common cause of morbidities following anesthesia and surgery for cardiac patients undergoing noncardiac surgery. In patients with severe pulmonary dysfunction, prolonged postoperative mechanical ventilation could delay the discharge of the patient from the operating room and may prolong the intensive care unit (ICU) stay. Elevated blood urea nitrogen (BUN), serum creatinine, history of renal dysfunction, left ventricular dysfunction, advanced age, jaundice, and diabetes mellitus are predictive of postoperative renal dysfunction.

Challenges in Cardiac Patients Undergoing Laparoscopic Surgery

The role of anesthetist in the preoperative period is divided into three stages: (1) the patient's risk assessment, (2) evaluation of functional capacity, and (3) determination of surgical risk; this is to help in patient selection for surgery and optimization of medical status.

Risk Assessment

In 2007, the American College of Cardiology and the American Heart Association (ACC/AHA) produced updated guidelines for perioperative evaluation for noncardiac surgery. These guidelines differentiate clinical predictors of increased perioperative cardiac risk into three categories (major, intermediate, and minor). For patients with major clinical risk predictors, their elective nonurgent surgical procedures, whether open or laparoscopic, should be postponed till they undergo preoperative evaluation and treatment, if needed (Table 3).

Table 3: Active cardiac conditions (major clinical risk predictors) for which patients should undergo evaluation and treatment before noncardiac surgery (class I, level of evidence: B) (Adapted from Fleisher *et al.* [22]).

Medical disorder
Unstable coronary syndrome Unstable severe angina (CSS class III or IV) Recent M.I. (recent MI as more than 7 days and less than or equal to 30 days)
Decompensated heart failure (HF) NYHA class IV worsening or new onset HF
Significant arrhythmias Mobitz II Third degree A-V block Symptomatic ventricular arrhythmias Supraventricular tachyarrhythmias (SVTs) Atrial fibrillation (A.F.) with uncontrolled ventricular rate
Severe valvular lesions Severe stenotic lesions

Functional Capacity

The patient's exercise tolerance is assessed by history and is expressed as metabolic equivalents (1 MET = 3.5 mL O_2/kg/min) on a scale defined by the Duke Activity Status Index that estimate patient's maximal oxygen consumption capacity. METs greater than 10 are classified as excellent, 7–10 METs are good, 4–7 METs moderate, and, lastly, METs less than 4 is a poor functional capacity. Activities that require more than 4 METs include moderate cycling, climbing two flights of stairs, and jogging.

Surgical Risk Factors

The type of surgery and the resultant degree of hemodynamic stress influences the risk to the patient. Some procedures previously counted as high risk are now categorized as intermediate risk, owing to improved perioperative management. The risks of not performing the surgery should be taken into account, and the experience and skill of the surgeon and anesthetist. Endoscopic and laparoscopic procedure ranges from low risk to intermediate risk surgery where reported cardiac risk generally less than 1% [22].

Preoperative Therapy

For patients undergoing laparoscopic urologic procedures, most cardiac medications should be continued preoperatively. There is evidence that continuation of angiotensin-converting enzyme (ACE) inhibitors may increase the incidence of hypotension and some physicians have recommended withholding them for 24 h preoperatively.

In goal-directed optimization, patients with high risk factors should be admitted preoperatively to a high-dependency or intensive care unit for invasive monitoring (including pulmonary artery catheter), manipulation of fluid, and inotropic therapy in order to achieve the optimal cardiac index, oxygen delivery, and consumption. Patients receiving antiplatelets present a challenge in management. Dual-antiplatelet therapy using aspirin and clopidogrel carries a 0.4–1.0% increased absolute risk of major bleeding compared with aspirin alone [23]. Increased blood loss in patients taking aspirin has been reported in noncardiac surgery, including general surgical, gynecologic, urologic operations, and in dermatologic surgery. Merritt and Bhatt concluded that monotherapy with aspirin need not be routinely discontinued for elective noncardiac surgery [24]. Burger *et al.* reviewed the surgical literature with regard to the risks of stopping low-dose aspirin versus the risks of bleeding and found that, in the majority of surgeries, low-dose aspirin may result in increased frequency of procedural bleeding (relative risk 1.5), but not an increase in the severity of bleeding complications or perioperative mortality due to bleeding complications [25].

Intraoperative Monitoring

Standard intraoperative monitoring is recommended for all patients undergoing minimal-access procedures. There may be hemodynamic consequences to the rise in the intra-abdominal pressure during laparoscopic interventions; invasive monitoring by arterial and pulmonary artery catheters may be useful in patients at high risk, especially if they have had a recent myocardial infarction with cardiac failure, provided that the anesthetist has the experience to insert them and interpret the data. The pulmonary artery catheter is most useful in monitoring volume status and cardiac performance, such as cardiac output/index, mixed venous oxygen saturation, systemic and pulmonary vascular resistances. Transesophageal echocardiography may be used to assess volume status and valvular disease and is the best way to detect ischemia early (segmental wall motion abnormalities), but requires expertise to interpret [26]. $EtCO_2$ is most commonly used as a noninvasive indicator of $PaCO_2$ in assessing the adequacy of ventilation during laparoscopic procedures. Temperature should be monitored throughout laparoscopic surgery.

Intraoperative Management

The oxygen supply/demand ratio must be maintained to avoid ischemia in coronary artery disease patients. During pneumoperitoneum, the rise of the systemic vascular resistance would impair oxygen supply/demand ratio. The maintenance of arterial blood pressure and reduction of heart rate should reduce the risk of ischemia [26].

Anesthetic Agents

In laparoscopic surgery, general anesthesia is the technique of choice, owing to the lengthy procedure and the diaphragmatic cephalad migration. The choice of anesthetic agents does not significantly affect the risks of perioperative complications, provided that hypertension, tachycardia, and hypotension are avoided. Anesthetic agent choice should be governed by the experience and skill of the anesthetist and their familiarity with the techniques and drugs. Etomidate has the fewest cardiovascular effects, but most people are more familiar with thiopentone or propofol, both of which should be titrated carefully to effect. Pretreatment with a dose of opioid (fentanyl and sufentanil, 1.5–5 and 0.25–1 μg/kg, respectively) reduces the required dose of induction agent and attenuates the hemodynamic response to intubation. Remifentanil is a new, potent, ultra-short-acting opioid, in a dose 0.05–2 μg/kg/min has great ability to produce hemodynamic stability and suppress the stress response. Concerns were previously raised that isoflurane might cause a "coronary steal" situation, but these have subsided. The concerns regarding the use of N_2O during laparoscopy, as it might lead to bowel distension and postoperative nausea and vomiting, has been a controversial issue. Clinically there is no significant difference in bowel distention and postoperative nausea and vomiting when N_2O-oxygen was compared to air-oxygen and no conclusive evidence suggesting N_2O cannot be used during laparoscopy [27]. The rise in the SVR that accompanies peritoneal insufflation leads to afterload elevation and increase in the left ventricular workload, adding more stress to the coronary circulation disrupting the oxygen supply/demand ratio. At this stage a vasodilator agent is of value in reducing the elevated SVR; inhalational anesthetic agents, especially isoflurane and sevoflurane, are the agents of choice, as the hemodynamic profile of sevoflurane resembles that of isoflurane [28]. In cardiac patients, sevoflurane had a cardiovascular outcome data equivalent to that of isoflurane [29]. When intravenous vasodilator agent is warranted, hydralazine is recommended for perioperative hypertension in a dose of 5–20 mg in a titrated intravenous (IV) boluses every 15–20 min until the desired blood pressure is reached. Fenoldopam mesylate is a selectively D_1-dopamine receptor agonist with moderate affinity for $\alpha(\text{alpha})_2$-adrenoceptors (infusion rates studied in clinical trials range from 0.01 to 1.6 μg/kg/min) reduces systolic and diastolic blood pressure in patients with malignant hypertension. It offers advantages in the acute resolution of severe hypertension compared to sodium nitroprusside, particularly in patient with preexisting renal impairment.[30] Esmolol is an ultra-short-acting selective $\beta(\text{beta})_1$-antagonist that reduces heart rate and to a lesser extent blood pressure. Successfully used to prevent tachycardia and hypertension in response to perioperative stimuli such as intubation, surgical stimulation, and emergence from general anesthesia, esmolol is given by infusion in a dose 50–300 μg/kg/min. Labetalol α(alpha)- and β(beta)-blocker for treatment of hypertension can be used as a bolus; the initial dose is 0.1–0.25 mg/kg IV over 2 min, then repeated every 10 min to a total of 300 mg. When used as a continuous infusion, it is usually started at 2 mg/min and titrated to effect [31]. Owing to their systemic vasodilatory effects, intravenous isradipine and nicardipine have been shown to be effective in the treatment of postoperative hypertension in cardiac surgical patients, with minimal side effects [32].

Challenges in Patients with Pulmonary Disease Undergoing Laparoscopic Surgery

Six risk factors predispose patients to postoperative pulmonary complications:

- Preexisting pulmonary disease
- Thoracic or upper abdominal surgery
- Smoking
- Obesity
- Age (>60 years)
- Prolonged general anesthesia (>3 h)

Chronic obstructive pulmonary disease (COPD) is the most common pulmonary disorder encountered in anesthetic practice. During preoperative assessment using a pulmonary function test, patients with a forced expiratory volume in the first second (FEV_1) less than 50% of predicted (1.2–1.5 L) usually have dyspnea on exertion, whereas those with an FEV_1 less than 25% (< 1 L for men) typically have dyspnea with minimal activity. The latter patients often exhibit CO_2 retention and pulmonary hypertension. Many patients have concomitant cardiac disease and should also receive a careful cardiovascular evaluation. Laparoscopic procedures commonly lead to elevation of $PaCO_2$; mechanical ventilation should be adjusted through manipulation of tidal volume and respiratory rate to achieve normocapnia and avoid hypercarbia. The use of arterial blood gas sampling and capnogram are helpful monitoring devices is such situations [33].

Challenges in Patients with Perioperative Renal Dysfunction and Renal Failure

Preoperative preparation is of benefit for patients with renal disease undergoing urologic laparoscopic procedures. Hemodynamic instability is common, especially on a lengthy laparoscopic extensive surgery such as laparoscopic nephrectomy. From the standpoint of renal dysfunction, there may be a varying degree of decreased ability to concentrate urine, decreased ability to regulate extracellular fluid and sodium, impaired handling of acid loads, hyperkalemia, and impaired excretion of medications as in end stage renal disease (ESRD). Renal impairment is confounded by anemia, uremic platelet dysfunction, arrhythmias, pericardial effusions, myocardial dysfunction, chronic hypertension, neuropathies, malnutrition, and susceptibility to infection. If a contrast study is definitely indicated, the patient should be well hydrated and the contrast dose limited to the minimum needed, plus the addition of *N*-acetylcysteine, which acts as a nephroprotective agent to prevent contrast-induced nephropathy [34].

Preoperatively patients must be euvolemic, normotensive, normonatremic, and normokalemic. Patients should not be acidotic or severely anemic, or without significant platelet dysfunction as this would carry deleterious bleeding consequences in a laparoscopic urologic procedure. Dialysis usually corrects uremic platelet dysfunction and is best performed within the 24 h before surgery, though 1-deamino-8-d-arginine vasopressin (DDAVP) may also be administered to correct platelet dysfunction.

Patients with ESRD who have left ventricular dysfunction undergoing laparoscopic urologic procedures would need invasive monitoring in the form of invasive blood pressure, pulmonary artery catheter (PAC) to measure pulmonary capillary wedge pressure (PCWP) and left ventricular functions. A sterile technique should be strictly followed when inserting any catheters to reduce risk of infection. Hyperkalemia should be considered in patients with ESRD who develop ventricular arrhythmias or cardiac arrest. Rapid administration of calcium chloride temporizes the cardiac effects of hyperkalemia until further measures (administration of glucose and insulin, hyperventilation, administration of sodium bicarbonate and potassium-binding resins, and dialysis) can be taken to shift potassium intracellularly and to decrease total body potassium [35].

Contraindications for Laparoscopic Procedures

Relative contraindications for laparoscopy include increased intracranial pressure, patients with ventriculoperitoneal or peritoneojugular shunts, hypovolemia, congestive heart failure or severe cardiopulmonary disease, and coagulopathy. Morbid obesity, pregnancy, and prior abdominal surgery were previously considered contraindications to laparoscopic surgery; however, with improved surgical techniques and technology, most patients with these conditions can safely undergo laparoscopic surgery [36].

Postoperative Pain Management in Laparoscopic Urologic Surgeries

Pain is a form of stress and produces an elevation in stress hormones and catecholamines. Good pain management results in shorter hospital stay, reduced morbidities (especially in patients with less physiologic reserve, such as those in the intensive care unit), and better immune function, less catabolism and endocrinal derangements, and fewer thrombo-embolic complications. Recent studies have shown the value of preemptive analgesia in some surgical situations. The blockade of the pathways involved in pain transmission before surgical stimulation may decrease the patient's postoperative pain. Balanced (multimodal) analgesia is the term applied for using two or more analgesic agents that act by different mechanisms to achieve a superior analgesic effect without increasing adverse events compared with increased doses of single agents. For example, epidural opioids can be administered in combination with epidural local anaesthetics; intravenous opioids can be administered in combination with NSAIDs, which have a dose sparing effect for systemically administered opioids.

Pharmacological Options for Pain Management

Postoperative pain management should be stepwise and balanced as mentioned before. Laparoscopic surgery is a minimally invasive surgery, hence producing mild intensity pain. Postoperative pain can be controlled by simple noncomplicated techniques, which adds to the list of advantages to laparoscopic procedures.

Non-opioid analgesics: Paracetamol, NSAIDs, including COX-2 inhibitors are considered an effective choice for postoperative pain, especially in low-intensity pain procedures.

Weak opioid analgesics: Including tramadol alone or in combination with paracetamol.

Strong opioids: Are useful in moderate to severe postoperative pain control, including morphine, meperidine, and oxycodone.

Adjunctive analgesics: Ketamine, clonidine, gabapentine, pregabaline [37].

Patient-Controlled Analgesia

Advances in computer technology have allowed the development of patient-controlled analgesia (PCA). By pushing a button, patients are able to self-administer precise doses of opioids intravenously (or intraspinally) on an as needed (PRN) basis. The physician programs the infusion pump to deliver a specific dose, the minimum interval between doses (lockout period), and the maximum amount of opioid that can be administered in a given period, and a basal infusion can be simultaneously delivered (Table 4).

Table 4: General guidelines for patient-controlled intravenous analgesia (PCIA) orders for the average adult (Adapted from Morgan et al. [37]).

Opioid	Bolus dose	Lockout (min)	Infusion rate
Morphine	1–3 mg	10–20	0–1 mg/h
Meperidine (Demerol)	10–15 mg	5–15	0–20 mg/h
Fentanyl (Sublimaze)	15–25 μg	10–20	0–50 μg/h
Hydromorphone (Dilaudid)	0.1–0.3 mg	10–20	0–0.5 mg/h

Studies show that PCA is a cost-effective technique that produces superior analgesia with very high patient satisfaction with reduced total drug consumption. Patients additionally like the control that is given to them; they are able to adjust the analgesia according to their pain severity, which varies with activity and the time of day. PCA therefore requires the understanding and cooperation of the patient; this limits its use in very young or confused patients. The routine use of a basal ("background") infusion is controversial.

Central Neuraxial Blockade

Epidural administration of local anesthetic–opioid mixtures is an excellent technique for managing postoperative pain following abdominal, pelvic, open, and laparoscopic surgical procedures. Patients often have better preservation of pulmonary function and are able to ambulate early, with the added benefit of early physical therapy and lower risk for postoperative venous thrombosis. In lengthy extensive laparoscopic urologic surgery such as cystectomy, nephrectomy, and prostatectomy, the preoperative insertion of epidural catheter provides titratable analgesia with extendable duration and level. The tip of the catheter should be placed as close as possible to the surgical dermatomes: T6–T10 for major intra-abdominal surgery, and L2–L4 for lower limb surgery. Diluted local anesthetic solutions combined with opioids shows synergistic effect. Bupivacaine 0.0625–0.125% (or ropivacaine 0.1–0.2%) combined with fentanyl 2–5 μg/mL provides excellent postoperative analgesia with lower drug requirements and fewer side effects. Patient controlled epidural analgesia (PCEA) is a term describing the patient-controlled administration of analgesic medications in the epidural space, to cover periods of increased discomfort.

Dosage of PCEA: A mixture of Bupivacaine 0.0625–0.125% (or ropivacaine 0.1–0.2%) combined with fentanyl 2–5 μg/mL

- Background infusion of 4–6 mL/h
- Controlled infusion bolus dose: 2 mL (2–4 mL) lumbar or thoracic
- Minimum lockout interval 10 min (10–30 min)

Epidurally administered, preservative-free morphine allows lumbar injection to provide proper analgesia in both thoracic and upper abdominal procedures, which is attributed to the rostral spread phenomena of hydrophilic opioids. Epidural clonidine in a dose of 3–5 μg/kg is an effective analgesic, but it can be associated with hypotension and bradycardia [37].

Ketamine

Ketamine is a noncompetitive, use-dependent antagonist of *N*-methyl-D-aspartate (NMDA) receptors; it reduces the postoperative pain in opioid tolerant patients, and postoperative nausea and vomiting. At a serum level of 0.1 μg/mL or higher, pain threshold is elevated [38]. Ketamine reduces opiate requirements by 30% postoperatively [39]. An intravenous dose of 0.1–0.2 mg/kg followed by a continuous infusion of 5–7 μg/kg/min is considered a sub-anesthetic dose effective in reducing morphine requirements in the first 24 h after surgery [40]. Central nervous system (CNS) excitatory effects included sensory illusions, sympathoneuronal release of norepinephrine, elevated blood pressure, tachycardia, elevated intracranial pressure (ICP), blurred vision, and altered hearing [41].

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