4 Robot-Assisted Radical Cystectomy: Room Setup, Patient Positioning, Instrumentation, and Anesthetic Considerations

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Room Setup

Robot-assisted radical cystectomy (RARC) can be performed in the same operating theater as robot-assisted prostatectomy. The limiting factor in all robotic surgery with regard to operating room setup is space. Care must be taken to secure as much space in the room as needed for robot cart docking/undocking, surgeon console, and sterile tables sufficient for robotic instruments as well as those necessary for open cystectomy/urinary diversion. Sufficient anesthesia working space is also required. There should also be sufficient space to allow for the flow of anesthesia personnel, blood products, and other items to the patient's bedside. Our current robotic suite is 750 sq. ft (25 ft × 35 ft), and we find it offers sufficient space to safely perform the operation.

It is important that all assistants be able to clearly see the operative monitors. Since our surgical assistant is on the patient's right-hand side, it is imperative that a monitor be placed directly across from the assisting surgeon/technician (Fig. 4.1a). It is easiest if the assistant does not have to torque his or her neck or trunk to get a clean view of the monitor. Some OR suites have a large monitor mounted on the wall across from the assistant position. Others have mobile ceiling-mounted booms available to move the assistant's monitor directly into view. It is also important that nonassisting technicians and nurses also have a view of the operative field either through large mounted monitors or boom-mounted mobile monitors (Fig. 4.1b). Some of our assistants find it more comfortable to sit on a high stool while assisting during the operation.

Patient Positioning

Proper patient positioning is a big key to safe and effective performance of robot-assisted radical cystectomy. Proper positioning is necessary to allow for full range of motion of the robotic arms as well as to prevent harm to the patient in the form of neuropraxias and compartment syndromes. Proper positioning must also be used to secure safe, effective access to the abdomen for the bedside assistant. Given the implications for positioning in RARC, the surgeon should be actively involved in patient positioning for the procedure. All patients should have appropriate intravenous access and possibly even central line access before positioning is completed. We adduct the patient's arms in a tuck position in all our cystectomy patients using foam pads and the patient's draw sheet (Fig. 4.2a–c). Leaving the arms out in a "crucifix" position carries the risk of brachial plexus injury in prolonged robotic cases [1]. Care is taken to cushion all pressure points with padding. The arms should be low

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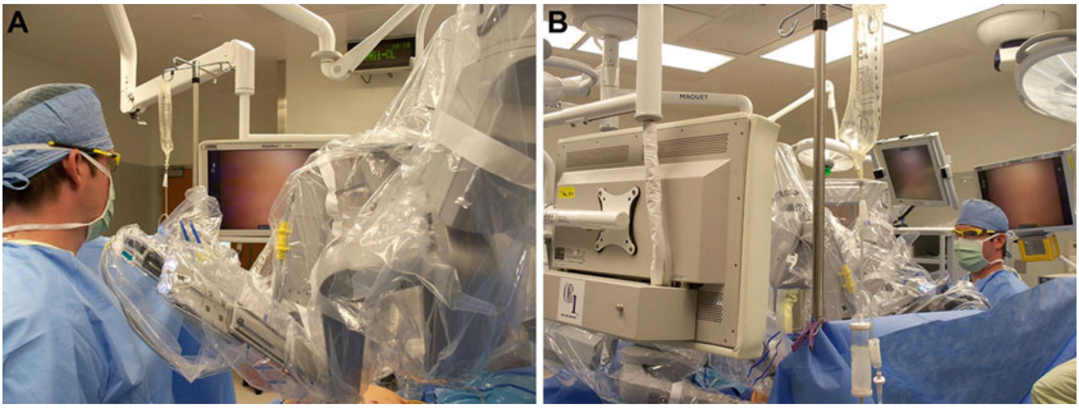

Fig. 4.1 Room monitors. (**a**) Demonstrated the assistant on the patient's right-hand side with a monitor directly across from their position to prevent neck and trunk torque during the case. These monitors are on mobile booms anchored from the ceiling. Certainly, large monitors can be anchored to the wall. (**b**) Demonstrates that other monitors are available on both sides of the bed to allow surgical techs and assistants to view the intra-abdominal events

enough on the patient's sides to not interfere with the robotic working arms and to allow the surgical field to be prepared lateral to the patient's anterior-superior iliac spine (ASIS).

Patients can be positioned in one of four ways for RARC. The four variations in positioning depend on necessity of surgeon access to the perineum, patient anatomic limitations, and robot docking preference. All robot-assisted radical cystectomy operations require the patient to be in the steep Trendelenburg position and care must be taken to secure the patient to the bed to prevent patient movement towards the head of the bed during surgery. We tape the patient's chest over foam padding to prevent slippage in the steep Trendelenburg position (Fig. 4.3). Once the patient is secured to the bed, the position is tested by placing the patient in Trendelenburg to see if movement ensues before the patient is sterilely prepared and draped for the operation. If the patient's chest is secured to the bed with tape, it must not be so tight as to prevent chest wall movement during ventilation. Some have proposed using a desufflated "bean bag" (Olympic Vac Pac, Olympic Medical, Seattle, WA) under the patient to prevent slippage during steep Trendelenburg position as opposed to taping the patient's chest to the bed [1]. The patient should be sterile draped and prepared from the sub-xiphoid region down to the mid-thigh region including the perineum (Fig. 4.4). The genitals should be prepared in the field to allow for intraoperative manipulation and catheter placement. The sterile urethral catheter is placed once the patient is prepared and draped. Some surgeons require a Mayo stand over the patient's face to place instruments during the procedure and to protect the patient's face. We do not place a Mayo stand over the patient's face during the operation.

The standard robotic prostatectomy/robot-assisted radical cystectomy position is to have the patient in the low dorsal lithotomy position with the legs in Allen stirrups (Allen Medical Systems, Acton, MA). Once the patient is placed in steep Trendelenburg position, the robot is docked between the split legs. Success of this position requires that the patient's buttocks be directly at the break in the table. Prolonged dorsal lithotomy positioning is known to carry an increased risk of lower extremity neuropathies [2]. In fact, Warner et al. [2] noted that for each hour in lithotomy position, the risk of motor neuropathy increased 100-fold. Prolonged hip flexion, abduction, and external rotation, as well as pressure point injuries, are all thought to contribute to the morbidity of the dorsal lithotomy position. Care should be taken to secure all pressure points and to insure the legs stay bent at a 45° angle. Leg straightening during the procedure can lead to debilitating neuropathies. It is important to evaluate all pressure points

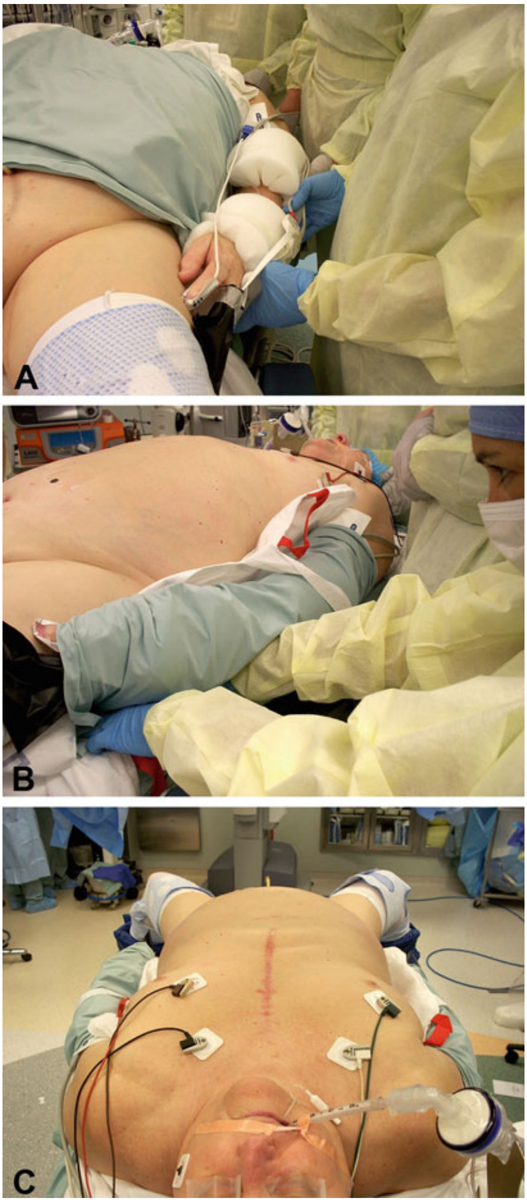

Fig. 4.2 Arm tucking. (**a**–**c**) Demonstrate how the patient's arms are tucked to their side with cushioning around the arms. The arms are tucked with the aid of the patient's draw sheet under their trunk

Fig. 4.3 Chest tape to prevent patient slippage. Demonstrates the patient's chest taped to the table over foam padding to prevent slippage during steep Trendelenburg positioning. Care must be taken not to make the tape so tight as to prevent chest wall motion for ventilation

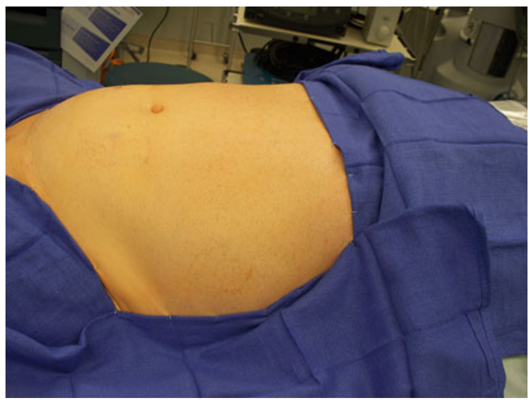

Fig. 4.4 Patient draping. The operative field should be the xiphoid process down to the mid-thigh region with the genitals prepared into the field. The field should be wide enough to include the patient ASIS to allow for lateral port placement

and leg positioning before the patient is draped because operative drapes will hide the patient's true position once the case begins (Fig. 4.5a, b). Regardless of approach used, pneumatic compression boots should be placed. The popliteal region should be inspected following positioning to insure that there is no pressure in this region from stirrups. Rosevear et al. wisely noted that a potential pressure point exists between the robotic fourth arm and the patient's left leg [3]. They reported a case of lower extremity compartment syndrome secondary to the pressure exerted by the robotic fourth arm on a patient's left leg. The authors concluded that surgeons should maintain a high level of suspicion for compartment syndrome or potential neuropathies in all patients exposed to

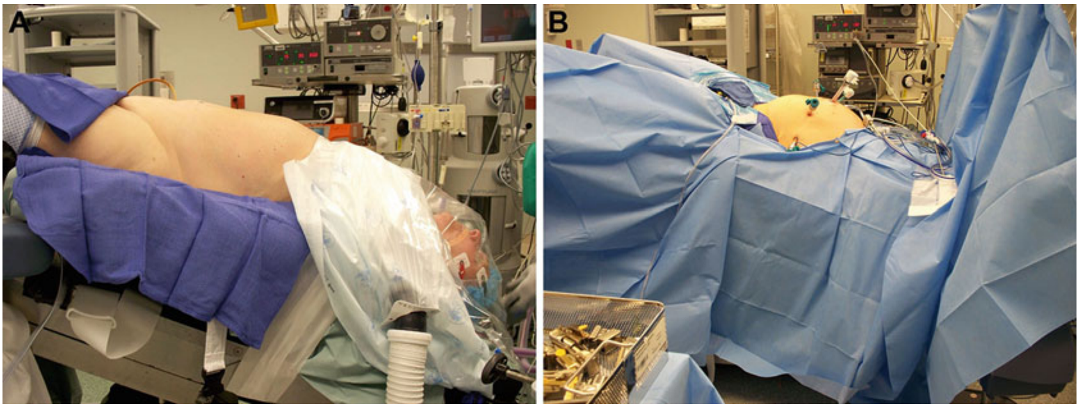

Fig. 4.5 Importance of position check before patient draping. (**a**, **b**) Are pictures of the same patient in Trendelenburg position and it demonstrates how drapes can hide abnormalities in positioning

Trendelenburg positioning for long periods of time, especially if the operating room time is prolonged.

Another positioning option is to have the patient on a split leg table. This allows the legs to stay straight without lithotomy positioning. The robot is docked in between the split straight legs. If this option is elected, it is preferred to have straps at the level of the calves and mid thighs with padding between them and the patient [3]. The theoretical advantage of this positioning is to allow the patient to lie in a more anatomical position with the absence of popliteal pressure exerted by stirrups as seen in low lithotomy positioning. However, the lack of lithotomy positioning does not guarantee absence of lower extremity neuropathies. Koc et al. [4] reviewed 377 consecutive robot prostatectomies completed with the split leg table and found five (1.3 %) lower extremity neuropathies. Three of the five had neuropathies relating to the femoral nerve distribution. After adjusting for all variables, prolonged operative time was found to be the only risk factor for the lower extremity neuropathies. Interestingly, elevated BMI was not associated with lower extremity neuropathies in the split leg table studies, despite increased BMI being associated with lower extremity neuropathies in dorsal lithotomy patients [3, 5, 6]. This may suggest an advantage for the split leg table in those with elevated BMI who are facing prolonged operative times associated with RARC. Warner et al. [2] reviewed close to 200,000 lithotomy patients, noting the most common nerve distributions injured with dorsal lithotomy position were the peroneal, sciatic, and femoral nerves. The split leg table injuries tend to involve the femoral nerve most commonly. It is proposed that the hip hyperextension necessary to allow the robot to be docked with the split-leg table may lead to femoral nerve compression as it courses beneath the inguinal ligament [4, 7].

Another option for patient positioning is to have the patient in lithotomy positioning in preparation for docking the robot from the side of the patient. The robot is docked beside the patient as opposed to in between the patient's legs. This allows unfettered access to the patient's perineum without undocking the robot, which may be important in females requiring simultaneous transvaginal access for urethral dissection. Transvaginal access may also allow for any uterine mobilization or vaginal cuff mobilization that may become necessary during surgery. Side docking removes the perceived symmetry created by docking the robot from between the legs in the patient's midline. Port placement remains the same as the standard procedure. The robot is docked at a 45° angle to the lower torso and aligned with the outer border of the left leg stirrup [8]. Colon surgeons and gynecologists have utilized this technique for pelvic surgery with a learning curve of three to five cases and no increase in instrument clashing [8, 9]. All authors have noted that this can only be completed with the second and third generation robotic systems (S and Si units). The first generation systems do not have enough arm mobility for this type of maneuver.

A final option for patient positioning involves side docking the robot with the patient's legs flat (no lithotomy positioning or split leg). Uffort and Jensen noted this technique to be advantageous in patients with limited hip abduction, such as patients with bilateral hip implants [10]. The authors extended this technique to all robotic prostatectomies at their institution and compared the traditional robotic prostatectomy setup times to those of the above technique. They found that the side docking technique resulted in a 4.5 min improvement in setup time compared to the standard low lithotomy position. This technique did not result in increased robot arm clashing or increased operating room time. This position would not be optimal for any patient that needed perineal/vaginal access during RARC.

Instruments

Intuitive Surgical Corporation (Sunnyvale, CA, USA) offers numerous surgical instruments for their three generations of robotic systems. Most of the instruments are equipped with Intuitive Corporation's patented Endowrist® technology. Endowrist technology allows for 7 degrees of freedom, 90° of articulation, motion scaling, and tremor reduction [11]. The company divides their operative instrument selection into five categories—energy, forceps, needle drivers, retractors, and specialized instruments.

Energy instruments include monopolar and bipolar cautery instruments (electrical energy), Harmonic ACE™ (mechanical energy), PK™ dissecting forceps (advanced bipolar), and laser [12].

Standard needle drivers are available as well as devices that have internal suture cutting blades. Forceps include devices for grabbing tissue in an atraumatic fashion. Retractors are devices used to retract tissue. These instruments are usually used in the third robotic arm. Specialized instruments would include hemostatic clip appliers.

Fig. 4.6 Cobra grasper demonstrates the Cobra grasper used to manipulate the bladder to one side or another once it is mobile. This grasper is used almost exclusively in the third robotic arm. The tips can be very traumatic and we only use this on tissue that will be removed. This instrument should not be used to retract bowel

Despite the plethora of robotic instruments available, our selection is relatively simple for RARC. The cystectomy portion is almost entirely performed with monopolar scissors in the right hand and bipolar dissecting forceps in the left hand. The third robotic assistant arm usually has large Prograsp® forceps present. These instruments are seldom exchanged during cystectomy. The Cobra® grasper may be helpful when used in the third robotic arm to retract the bladder as it becomes more mobile during the operation (Fig. 4.6) The Cobra teeth are very strong and can be traumatic. We only use this device on tissue that will be removed. This device should never be used to retract bowel. The dorsal vein is sutured with standard needle drivers, although the drivers with internal suture cutting would suffice.

The bladder/prostate pedicle can cause troublesome bleeding during cystectomy, and the robotic approach is no different. When the pedicle can be thinned out nicely, Endo-GIA staplers with vascular loads do a nice job of securing the vascular pedicle. In experienced hands, Endo-GIA stapling devices can make cystectomy faster and demonstrate decreased blood loss compared to standard suturing techniques [13]. The one drawback to using Endo-GIA staplers in robot-assisted radical cystectomy is the requirement of the assistant to have sufficient experience with the device for safe application. The use of the

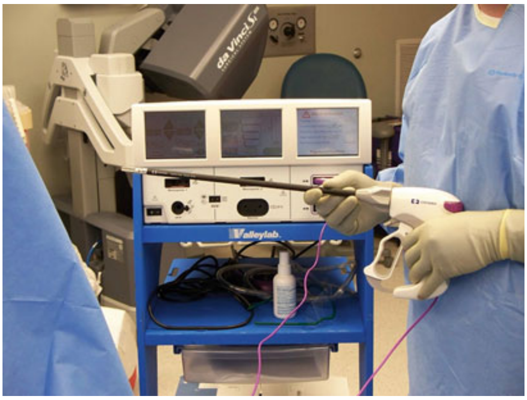

Fig. 4.7 Impact device. The Ligasure impact vessel sealing system is used to seal the bladder/prostate pedicles. It must be activated by the beside assistant

Harmonic scalpel has also been reported for control of the pedicle during cystectomy [14]. The Harmonic scalpel energy can now be utilized by the bedside assistant or via the operating surgeon with the Harmonic ACE instrument. It should be noted that the robot-mounted Harmonic ACE does not currently articulate like other Intuitive Corporation instruments. Certainly, the pedicle can be managed with clips and possibly even with bipolar cautery/monopolar cutting. Free bleeding vessels can be oversewn with suture following bladder removal.

We currently utilize the Ligasure Impact™ vessel sealing system to secure the pedicle during RARC (Fig. 4.7). The Ligasure™ vessel sealing system achieves hemostasis by reforming the collagen and elastin in vessel walls to form an autologous seal. Vessels up to and including 7 mm in diameter may be sacrificed with this technology [15]. The device is not available to the operating robotic surgeon and must be activated and the energy delivered by the bedside assistant. The Ligasure device has been shown to seal vessels with burst pressures over 400 mmHg in porcine models [16]. No matter what energy is used during the procedure, care must be taken to avoid contact with surrounding structures such as bowel. Kim et al. [17] noted that the Harmonic ACE, Ligasure device, and the Plasma Trisector all have significant residual thermal energy directly following application that could cause injury to peripheral structures if contact was made. On a similar note, a Canadian study evaluated robotic instruments and discovered that they all demonstrated stray electrical current along their shaft during use [18]. The stray electrical current was sufficient to cause unwanted bowel injury if contact occurred. The authors recommended cautious use of robotic instruments around surrounding bowel and agreed with Intuitive Surgical Corporation's recommended instrument replacement after eight to ten uses.

Anesthetic Considerations

As with all robotic surgeries, it is important that the anesthesiologist recognize the importance of complete relaxation and paralysis throughout robot-assisted radical cystectomy. Many anesthesiologists involved in robotic surgery recommend atracurium and cisatracurium for muscle relaxation given their predictable chemical breakdown and short half-lives [19]. Care should be taken to limit the use of nitrous oxide, as it may cause distension of the bowel, making visualization of the operative field difficult. As laparoscopic surgery enters its third decade, the effects of pneumoperitoneum on pulmonary physiology, cardiac output, and potential air emboli complications are well understood [19–21]. The prolonged operative time of radical cystectomy compared to robotic prostatectomy underscores the need for careful hemodynamic monitoring during surgery.

Radical cystectomy presents anesthetic challenges due to the risk of excessive blood loss, fluid shifts acquired with prolonged operative time, cardiopulmonary morbidity, and thromboembolic events. The addition of robotics to the cystectomy armamentarium adds to the morbidity associated with prolonged steep Trendelenburg positioning with lower extremities in lithotomy position and pneumoperitoneum. Comparison of anesthetic experiences acquired from robotic prostatectomy literature is difficult due to the typically younger, more physically fit population that receives robotic prostatectomy and shorter operative time associated with robotic prostatectomy compared to RARC.

Thromboembolic deterrent (TED) stockings are placed preoperatively on all patients. Pneumatic compression stockings are placed for the duration of the operation. We do not administer preprocedure fractionated heparin or subcutaneous heparin, although some have advocated this decreases intraoperative and postoperative thromboembolic risk. An arterial line is placed for hemodynamic monitoring. Large bore intravenous lines should be placed in preparation of possible blood loss anemia. A central venous catheter may be elected in cases with anticipated excessive blood loss or for advanced access in less healthy patients. All patients are covered with a forced air warming device over the upper body. All patients undergo general anesthesia with an endotracheal tube.

Trendelenburg positioning during RARC is necessary to pull the abdominal viscera away from the operative field. However, this position is nonphysiologic and may have significant physiologic effects if maintained for a long period of time. Trendelenburg positioning can cause significant changes in cardiovascular, respiratory, metabolic, and cerebral physiology [22]. The increase in intracranial pressure seen with steep Trendelenburg positioning combined with pneumoperitoneum is also seen with either event alone [23]. The $PaCo_2$ should be maintained in the normal range during RARC [22]. Mean arterial blood pressure (MAP) as well as central venous pressures (CVP) increase markedly during pneumoperitoneum with Trendelenburg position in both health patients and those with baseline cardiopulmonary disease [24]. A study of robotic prostatectomy patients of ASA physical status I–II noted two to threefold increases of right as well as left-sided filling pressures [24]. Systemic blood pressure changed during the surgery, but there was no change in cardiac output. Other studies have confirmed the absence of cardiac output change associated with robotic prostatectomy [25]. Lestar et al. propose that this maintenance of cardiac output during pneumoperitoneum with steep Trendelenburg position is maintained in healthy men due to their abundance of cardiac reserve [24]. Therefore, a patient with compromised preoperative cardiac function could experience heart failure due to excessive preload. It is not known if returning these cardiac compromised patients to horizontal position will improve the patients' normal heart function [24].

Urine production can be expected to be sluggish during robotic surgery as in other laparoscopic/robotic surgeries. The pneumoperitoneum associated with laparoscopy can be associated with a 50 % decrease in renal plasma flow and glomerular filtration leading to decreased urine output [26]. This should be considered when administering crystalloid fluid replacement. The sluggish urine output associated with this effect often responds to aggressive fluid loading, but care must be taken to avoid potentially dangerous fluid overload [27].

Serious ocular consequences, such as retinal detachment and blindness, have been associated with Trendelenburg positioning as early as 1952 [28, 29]. Visual loss secondary to posterior ischemic optic neuropathy has been reported following robotic prostatectomy [28, 30]. Impaired ocular perfusion pressure is thought to be the major contributor to visual loss following prolonged spinal surgery [31]. It is not know the impact that the addition of prolonged pneumoperitoneum has on intraocular pressures (IOP). Awad et al. [28] examined the IOP of 33 consecutive patients undergoing robotic prostatectomy. IOP was 13.3 mmHg higher after Trendelenburg positioning when compared to the supine position. Duration of surgery and tidal CO_2 were the only significant predictors of IOP increases during robotic prostatectomy. Robot-assisted radical cystectomy operative times are naturally longer than those for prostatectomy. To date there has not been reported cases of visual field loss following RARC. However, ocular consideration must be given if the case is prolonged. Due to the IOP changes associated with Trendelenburg positioning and the prolonged operative time of robotic cystectomy, glaucoma can be seen as a relative contraindication to robotic cystectomy. All patients with elevated IOP at baseline before surgery may benefit from consultation with an ophthalmologist.

Editors' Commentary

Erik P. Castle and Raj S. Pruthi

The authors have described the considerations and steps of one of the most important aspects of any robotic procedure: setup. The key to the success of any procedure is preparation. This concept is particularly true for robot-assisted radical cystectomy. The procedure has many more steps and considerations than its robotic counterpart, robot-assisted radical prostatectomy (RARP). Hence preparation is paramount to success. Room setup such as monitor placement and location of the assistant can impact the ease with which the team can support the surgeon. In cases where the surgical and anesthetic team are experience with robot assisted radical prostatectomy, setup and positioning should be relatively straightforward. However, the issue of longer operative times must be kept in mind. Even the most experienced robot-assisted radical cystectomy surgeons have operative times that range between 4 and 8 h. As was the case early on during the learning curve for RARP, long cases can translate into complications, particularly those associated with prolonged extreme positioning. Therefore, it is important that any steps to enhance efficiency and success are undertaken as are outlined within this chapter.

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