Complications in Robotic-Assisted Laparoscopic Radical Prostatectomy: Prevention and Management

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Abbreviations

CK	Creatine kinase
CO_2	Carbon dioxide
CT	Computerized tomography
DVT	Deep venous thrombosis
ICP	Intracranial pressure
PE	Pulmonary embolism
RALP	Robot-Assisted Laparoscopic Radical Prostatectomy

Complications of Patient Positioning

Patient positioning has been widely studied due to its critical role in preventing complications even before the surgical procedure has started [1]. The surgical team must have a deep understanding of the potential complications from various positions. To increase effectiveness, having the same team position the patient for every surgery is recommended [2].

Postoperative complications due to positioning can go as high as 13% of patients undergoing robotic-assisted laparoscopic radical prostatectomy (RALP) [1]. Most of them being postoperative pain and neuromuscular injuries [3]. In an extensive multi-center review, the most common injuries identified were abdominal wall neuralgia, sensory and motor nerve deficit, rhabdomyolysis, shoulder pain, and back pain [4].

During RALP, lithotomy and 30° Trendelenburg position are required to allow adequate pelvic exposure. This steep head-down position for several hours can cause significant changes in cerebral hemodynamic physiology and increase intracranial pressure (ICP). Postoperative corneal abrasions have been observed in 0.1–0.6%, together with postoperative ischemic optic neuropathy (Fig. 48.1). Careful monitoring should be done to prevent delirium as well as short-term cognitive changes postoperatively [5, 6].

Safe fixation of the patient by increasing support and well-distributed friction using a soft mattress is mandatory to avoid sliding. Vacuum mattresses may also be used. However, unnoticed gas leakage may lead to compression injuries [7]. Sliding-associated complications include incisional wound tear, postoperative incisional hernia, and increase postoperative pain due to overstretching of the abdominal wall. Other maneuvers used in the past to prevent sliding, such as shoulder and body straps, restraints, or headrests, should be avoided.

During the preoperative assessment, protective padding is intended to protect the patient from peripheral neuropathies and muscle compression injuries (Fig. 48.1). In severe cases, muscle compression may lead to rhabdomyolysis and compartment syndrome, with incidence being particularly higher in patients with cardiovascular risk factors such as obesity, diabetes, hypertension, or peripheral vascular disease and those placed in Trendelenburg position for extended periods of time. These patients should be meticulously evaluated clinically and have an immediate assessment of serum creatinine and creatine kinase (CK) levels in order to prevent renal damage [8].

It is crucial to use well-padded armrests designed explicitly for Trendelenburg positioning to distribute the patient's weight evenly. Generally, these cushions have a notch stabilizing the patient's head without compression and limiting rotation or lateral flexion of the neck, preventing brachial plexus neuropathies [9].

The arms should be in an anatomically neutral position, limiting abduction of the arm to 90° and flexion/extension of the elbows and hands, preventing any excessive nerve stretching [10, 11] (Fig. 48.1).

Sciatic nerve injury has been reported in up to 1% of cases due to lower extremity overextension and separation of 30° during extreme lithotomy [12]. Considering the sciatic

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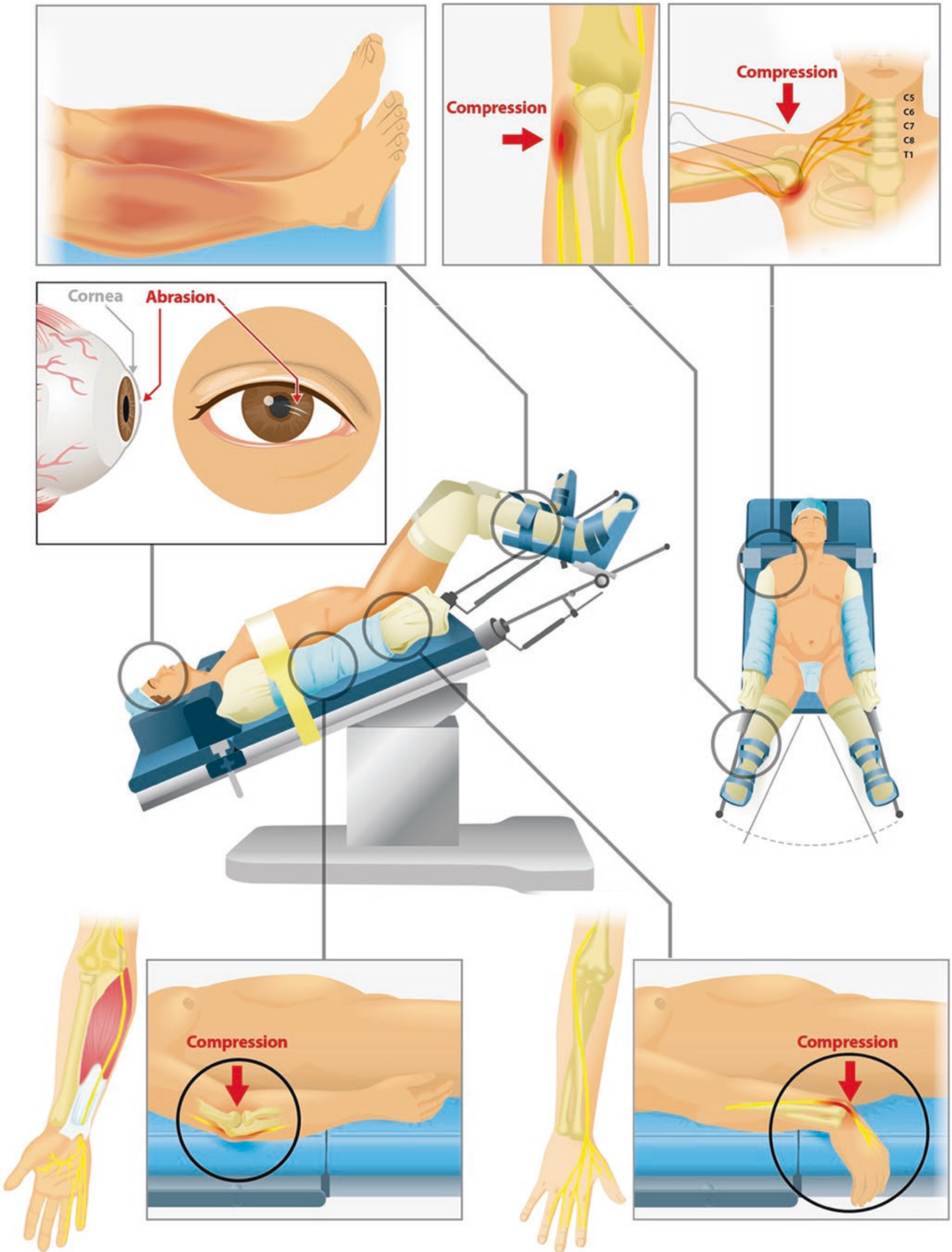

Fig. 48.1 Complications of Patient Positioning. Schematic drawing represents patient positioning-related complications, including corneal abrasions, muscle compression injuries, and brachial plexus, ulnar, radial, and common peroneal neuropathies

nerve or its branches cross both the hip and the knee joints, it is important to assess these joints' extension and flexion when determining the degree of hip flexion. When possible, excessive stretch of the hamstring muscle group should be avoided. Most nerve injuries are caused by stretching rather than direct nerve transections during the surgery itself [4]. In addition, specific padding to limit the pressure of a hard surface against the fibular head may be used to decrease the risk of peroneal neuropathy (Fig. 48.1).

Periodic perioperative assessments may be performed to ensure maintenance of the desired position. Of note, postoperative pain in the areas described should serve as a warning sign.

Care must be taken with the position and movement of the robotic arms during surgery, especially when one of the arms is placed outside the field of view. The drape must be kept free of surgical instruments as unrecognized compression injuries can occur, leading to intramural hematomas or thrombosis due to blood stasis.

Face masks, metallic bars, foam pads, and glasses can be used to protect the patients from any injury on the face and eyes due to the robotic ports' proximity.

Complications During Port Positioning

An essential component for performing a safe and effective robotic surgery is optimal port placement. Although complications associated with port-site placement are rare, devastating consequences can be seen, with most injuries involving either visceral or vascular organs. Ideally, the best method to manage those complications is prevention [13].

A pre-incisional checklist should be done to rule out any equipment malfunctions and the availability of all necessary resources, including preparation for open conversion [14].

Access Complications

Blind Veress needle insertion and insufflation followed by the blind camera trocar placement is the technique most widely used. Abdominal wall scars should be avoided as excessive force may be required, and adhesions can be present beneath these scars. The Veress needle should be inserted by bracing the hand on the patient to avoid pushing too deep, commonly at 2 cm above the umbilicus. The angle of insertion can vary from 45° in non-obese patients to 90° in those who are obese. The double-click test indicates the two resistance points (anterior and posterior rectus fascia). After passing through the second point, an aspiration and hanging drop test are used to identify any vascular or visceral lesions and verify the intraperitoneal position [14].

Next, the needle is attached to an insufflator, and the CO_2 opening pressure should be <10 mmHg if it is appropriately placed. Flow rate must be low until a symmetrical distention is well-documented. Then a 12–15 mmHg pneumoperitoneum is established. The camera trocar is then carefully introduced, and immediate camera inspection is done for early injury identification.

In patients with history of previous abdominal surgeries with presumed adhesions, an open laparoscopic trocar placement is recommended.

Vascular Injuries

The incidence of vascular injuries during access is low, with an estimated incidence of 0.03–0.3% [15]. Major or unrecognized vascular injury may cause a significant increase in morbidity and mortality. Most vascular injuries are caused by the Veress needle or the initial trocar placement, as these are often performed without visual confirmation. The most common vessel injuries are those located in the abdominal wall, particularly epigastric vessels. Otherwise, intra-abdominal vascular injury sites include the iliac vein, greater omental vessels, inferior vena cava, aorta, pelvic vessels, superior mesenteric veins, and lumbar veins [16].

Trendelenburg position should be avoided until port placement is completed because it causes promontory rotation and places the aortic bifurcation closer to the umbilicus, increasing the likelihood of vascular injury.

Direct compression of the bleeding site is the quickest and safest way to gain initial control of blood loss, especially with a venous injury. Small, non-expanding lesions can be managed with clips or pinpoint electrocautery. Increasing pneumoperitoneum pressure by up to 5–10 mmHg higher can be helpful, but frequent monitoring during the entire procedure is recommended as lesions partially controlled can rebleed. In those cases where cautery or clips are not sufficient, a figure-of-eight suture should be placed for adequate control.

If the hematoma expands, additional trocars should be placed, and the system docked. Robotic-assisted immediate repair with exploration and bleeding site exposure should be the preferable approach. Alternative strategies include compression, gauze insertion, and U stitches using a suture passer. Also, a Foley catheter can be inserted and inflated, doing gentle traction to tamponade the bleeding site [13] (Fig. 48.2). If the robotic attempt is not successful, the bleeding site is challenging to detect, or the patient is unstable, a prompt laparotomy should be performed.

Of note, at the end of the procedure, all ports should be visualized after trocars removal to ensure that there is no bleeding that was tamponade by the trocar itself.

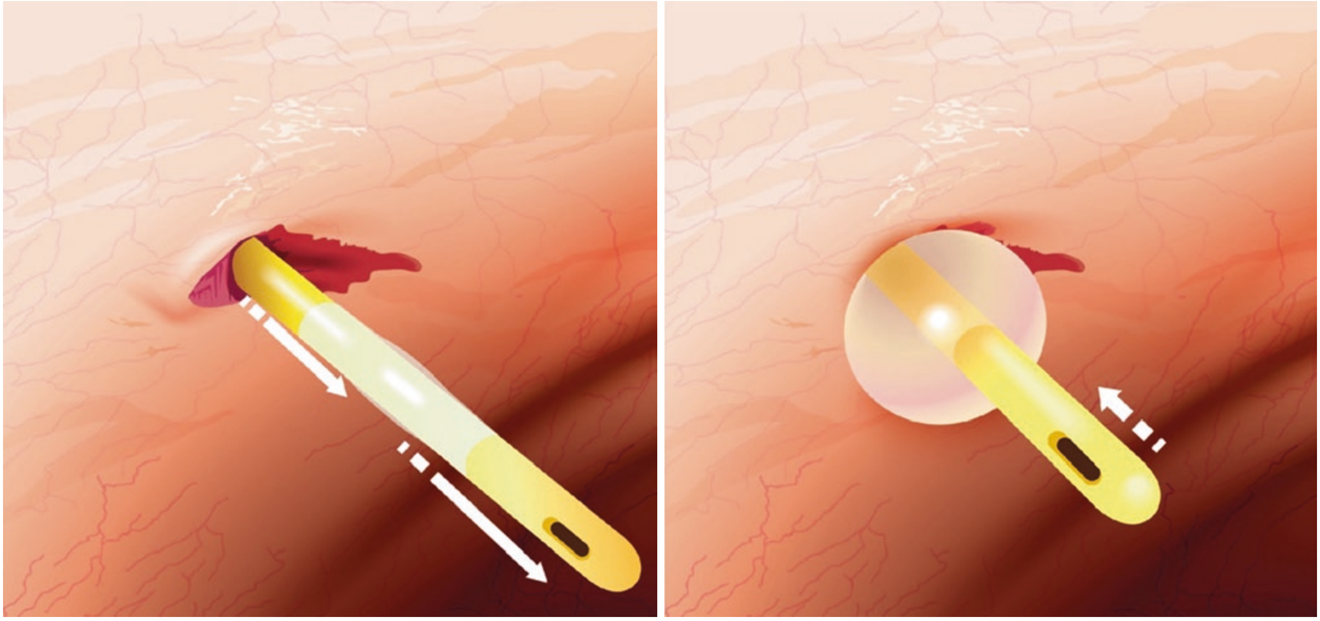

Fig. 48.2 Foley Catheter Balloon Tamponade. Schematic drawing shows balloon tamponade for temporary bleeding control after an abdominal wall vessel injury

Visceral Injuries

Bowel injuries during port placement are uncommon, ranging from 0.04% to 0.09%. However, 30–50% of them are not recognized intraoperatively, leading to a mortality rate of up to 30% [17, 18]. Once identified, it must be repaired. The trocar should be left in place, and another trocar should be inserted to explore and determine the extent of injury (Fig. 48.3). Depending on surgeon expertise and defect size, a primary intracorporeal closure can be done with a purse-string or double-layer suture. Alternatively, the bowel can be externalized and repaired through a small incision. Major injuries requiring bowel resection can be managed by stapling or may require laparotomy.

Colon injuries should be immediately treated by primary repair, in which case drainage is always recommended. The decision to perform primary anastomosis or colostomy should be individualized considering the patient's condition and the primary procedure to be performed.

Liver or spleen injury management includes compression primarily using an instrument or by introducing gauze into the abdominal cavity. Increasing the pressure of the pneumoperitoneum may help control hemostasis in venous injuries. The use of dry hemostatic agents or thrombin sealants should be considered if bleeding control is not achieved. Suture use should be carefully assessed as it could cause larger tears.

Bladder injuries may also occur. The use of a Foley catheter may reduce the risk of injury and allow early diagnosis by air or blood in the collection bag. The diagnosis is made by instilling dye into the bladder. If the damage was caused by a Veress needle and is less than 5 mm, it can be managed by leaving a Foley catheter up to 10 days. More extensive injuries will require primary two-layer closure.

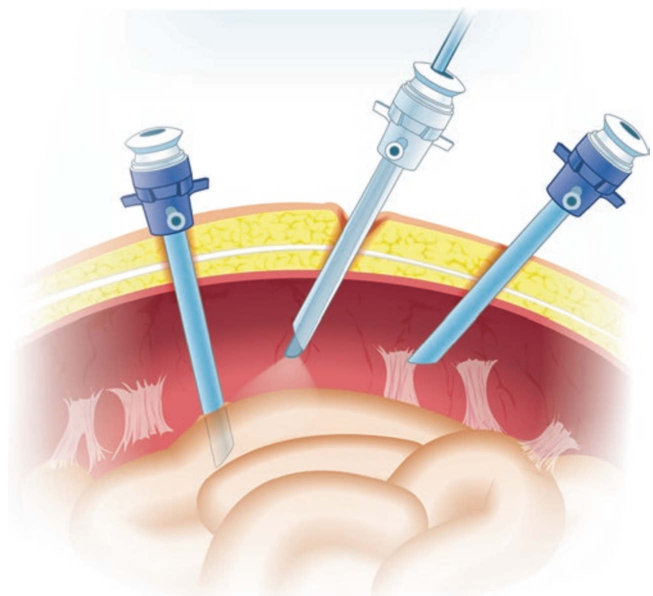

Fig. 48.3 Visceral Injury. Schematic drawing depicts trocar visceral injury, and secondary trocar placement to explore, and determine the extent of injury

Secondary Trocar Placement Complications

Subsequent trocars must always be placed under direct vision. The optimal sites of trocar placement should be marked after a full pneumoperitoneum has been established.

Transillumination may help visualize subcutaneous vessels; however, the epigastric vessels at the rectus muscle's lateral border are often undetectable.

After placement of the camera, adhesions are identified and avoided. The degree of adhesions is unpredictable, ranging from extensive after previous minor surgeries to nonexistent despite major abdominal interventions. If adhesions are present, subsequent trocars are placed in a position that allows manual laparoscopic adhesiolysis.

Despite direct port placement visualization, vascular injury can still occur. Lower abdominal wall vessels, notably inferior epigastric vessels, and intra-abdominal (aorta or iliac vessels) can be involved in 35% and 30% of cases, respectively [19].

Intraoperative Complications

Bowel Injury During Instrument Exchange

Robotic-assisted surgery occurs with the primary surgeon working on the console, apart from the operating table. Therefore, many steps must be synchronously performed with the bedside team, generally, another surgeon, scrub nurse, or surgical physician assistant. Most surgical procedures require a variety of instruments to accomplish each step. Hence, a constant exchange between the instruments has to occur [20].

During instrument insertion, a bowel injury can occur as previously mentioned; this is preventable by following the simple rule of inserting any instrument always under direct visualization. Some robotic platforms have instrument exchange memory where the instrument returns to just short of its previous location, but this may not always be reliable. Manual repositioning of the robotic arm resets this memory when the new instrument is inserted, causing it to go further than expected and cause an organ lesion, most commonly a bowel injury. If a bowel injury is suspected, careful inspection of the bowel surface must follow. If it is recognized, it must be properly managed depending on the extent of the damage.

Vascular Lesions

Arterial injuries are prevented by understanding the dissection boundaries and the specific risky steps that involve the iliac vessels. If an arterial injury occurs, immediate clamping with a grasper should follow. Gauze can be passed through one of the assistant ports for compression. Clip placement may be helpful, but this cannot be blindly placed, as it could represent a risk for a future complication. Suturing may be necessary if entry into a larger arterial vessel occurs. If hemostasis is not achieved by the described methods, the bedside team can apply external compression to momentarily control the bleeding while the surgical team prepares for conversion to open surgery.

Generally, a venous lesion can be controlled by increasing pneumoperitoneum up to 25 mmHg; this should be the first maneuver to attempt after recognition. If pneumoperitoneum alone does not resolve the bleeding, the following most crucial step is the visual identification of the vein's particular injury site to achieve hemostasis by clip or suture ligation. It is recommended to limit suction as this could significantly decrease pneumoperitoneum. In an iliac vein injury, ipsilateral sequential compression devices should be stopped to avoid worsening the bleeding and allow appropriate control. If it is difficult to determine the exact location of the injury, temporary clamping of distal branches may allow a window of no bleeding to determine the lesion location. Venous injury complications rarely go beyond this point. However, it is always recommended to be prepared to escalate the decision-making process in real time.

Rectal Injury

Rectal injury is an infrequent complication of RALP, generally reported in <1% of the procedures [21]. The vast majority occurred during the early phase of the surgeon's robotic learning curve. It can be avoided by limiting aggressive electrocautery and blunt dissection during the posterior plane dissection that occurs just above the rectum. If a rectal injury is recognized, closure of the defect with a 3-0 V-Loc suture in two layers is recommended as depicted in the picture (Fig. 48.4). It is crucial to make sure the edges of the injury are well vascularized, and this could be ensured using indocyanine green. It is also essential to be aware of the rectal lumen diameter during the repair as rectal stenosis and stricture are possible complications. A chest tube inserted in a retrograde fashion while placing the sutures can ensure proper diameter, or a rectoscopy can be performed by another team simultaneously. Some authors recommend the interposition of tissue between the rectum and the bladder to avoid the possibility of rectovesical fistula development, seen in 1% of the cases [22].

Obturator Nerve Injury

Obturator nerve injury is an uncommon complication of RALP reported in 0.2–5.7% of the cases [23]. The injury occurs due to the proximity of the nerve to the nodal packet. It can be preventable by clearly separating the bladder pedicle from the lateral pelvic wall and ensuring that the obturator nerve is always visualized. Generally, an obturator lesion

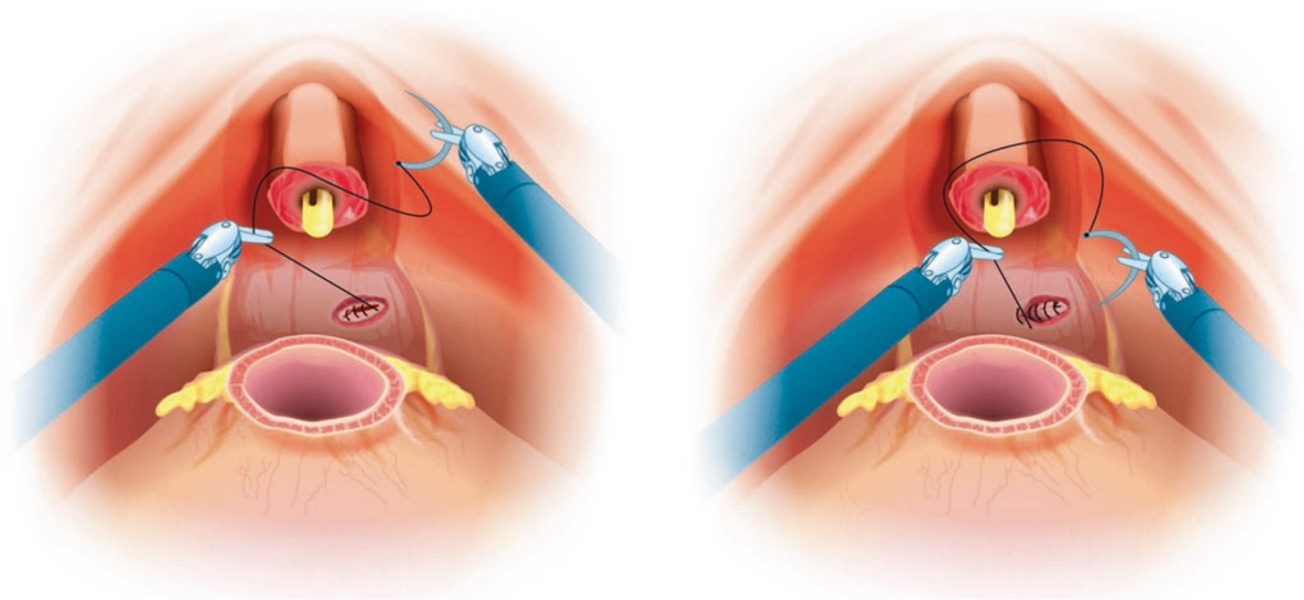

Fig. 48.4 Rectal Injury Repair. Schematic drawing exhibits a rectal repair in a two-layer running fashion with 3-0 V-Loc suture after iatrogenic injury during posterior plane dissection

could be caused by direct thermal injury, stretching, or transection.

In pelvic lymph node dissection, visual identification at every step is critical to avoid blind use of electrocautery and direct thermal damage. Stretching nerve injury generally occurs due to forceful traction of the tissues. Therefore, gentle management of them is encouraged. A total or partial transection could happen as the lymph node dissection occurs.

All these lesions may result in neuropraxia, characterized by gait disturbance, weakness, and atrophy of the adductor muscles. If identified intraoperatively, the best way to manage is by approximating and suturing both ends of the nerve together. In some circumstances, they will not reach each other if the patient is supine and extended; for these cases, thigh flexion may help reduce tension. Otherwise, a neural graft has to be used.

Urinary Tract Injuries

The incidence of ureteral injury during RALP is reported in <1% of cases [24–26]. Some steps pose a risk for unintentional ureteric injuries to occur. During the downward dissection between the prostate and the bladder in the anterior approach, the bladder neck can be injured if the detrusor muscle thickness is reduced. Therefore, it is crucial to constantly check detrusor muscle thickness while performing this dissection. If a bladder neck lesion happens, it is recommended to close the defect with a 3-0 V-Loc suture and do not remove the urethral catheter before a cystogram is performed to rule out any urinary leak. Less frequently, a large defect could compromise the ureteric orifices. In this case, both ureters should be stented with double J stents to remain in place for at least 21 days. Again, a cystogram is mandatory before catheter removal.

The posterior approach for radical prostatectomy described by Guillonneau et al. poses a significant risk to the distal ureter during the seminal vesicles' dissection. If there is no proper identification of the structures, the distal ureter can be confused for the seminal vesicles as they lie posterior to the vas deferens. Distal ureteral injuries can be partial or complete. If a partial ureteral injury is intraoperatively identified, a ureteral stent placement followed by suture with 5-0 Monocryl is recommended. If there is a complete transection of the ureter, ureteral reimplantation will be the next step.

Lastly, during extended lymph node dissection of the pelvic lymph nodes, the middle third of the ureter can be injured. This type of injury occurs as the ureter runs with the psoas muscle and crosses anterior to the common iliac vessels at the bifurcation level. To prevent this, it is vital to visualize the ureter at all times during pelvic lymph node dissection.

Complications from Technical Errors and Robotic Malfunction

Electrocautery or Thermal Energy Injuries

A robot is still a machine with mechanical parts and accessories, and their errors or malfunction can cause significant injuries. Monopolar instruments failure such as tip cover

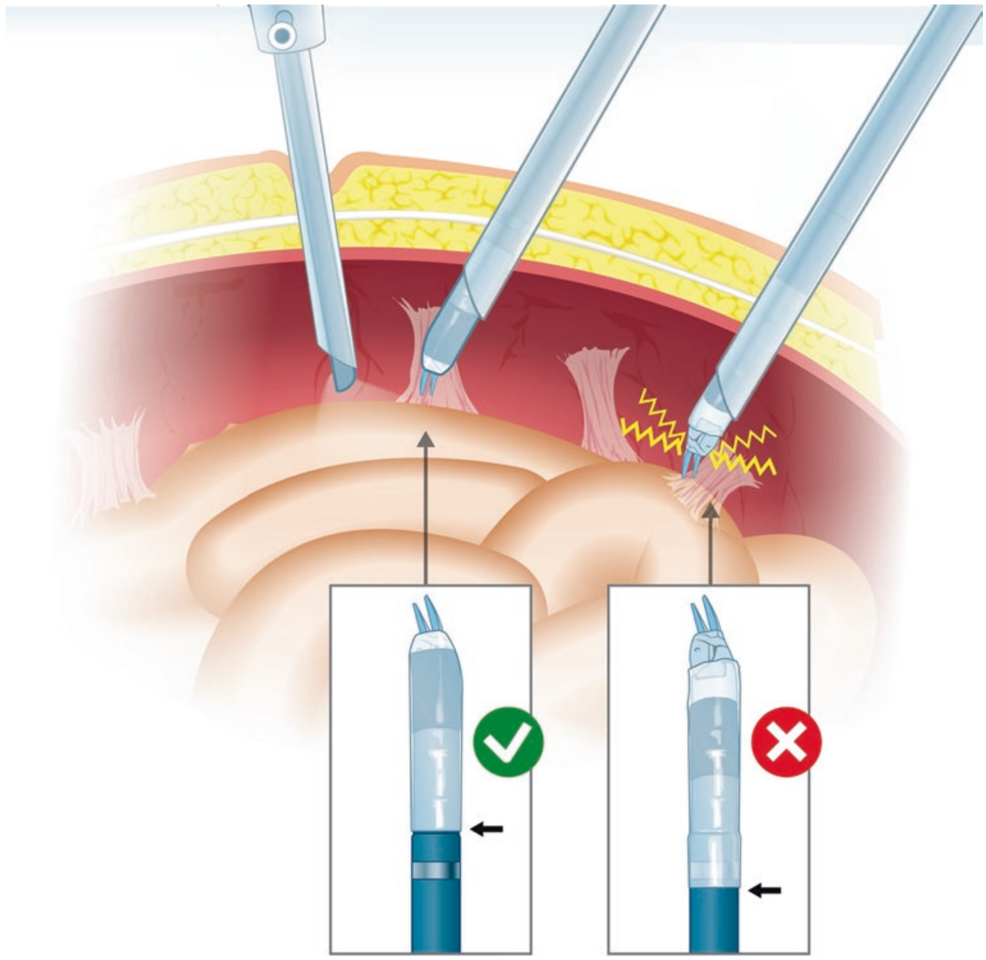

Fig. 48.5 Electrocautery or Thermal Energy Injuries. Schematic drawing represents a thermo-electrical injury due to cover tip failure

failure can result in dissipation of monopolar electrical current leading to significant damage [27]. Blood vessels and intestinal injury can be caused directly by electrosurgical arcs and thermal energy (Fig. 48.5). These electrical arcs may go over from the tip of the scissor to the non-isolated parts of the instrument or to a suction cannula, leading to visceral or bowel injury. Therefore, surgeons must take greater care and ensure the insulation's integrity, preventing broad dissipation of monopolar electric current, allowing a safe dissection in proximity to blood vessels, nerves, and bowel.

Instrument Malfunction

Different events of instrument malfunction can occur before or during surgery. Breaking of the endo-wrist wire and instrument jaws is the most common scenario of instrument malfunction. In cases where this happened, the instrumentation can be removed without difficulty [28]. Other common events that can be encountered are broken or disintegrated instruments, which can get lost intra-abdominally during surgery. In many cases, the broken instrument is easily retrieved with graspers. If the instrument cannot be simply visualized, imaging techniques as fluoroscopy can facilitate the location. Lastly, if fluoroscopy fails or is unavailable, open conversion is necessary to retrieve the part [29].

Needle Loss

Intraoperative retained instruments have been reported in up to 0.11% of the surgical cases. One in five surgeons will encounter needle loss during surgery over their entire professional career [30]. For this reason, needle loss is an important matter. Needle loss during robotics procedures can occur, and the retrieval can pose a challenge due to laparoscope visual field limitation.

In order to avoid this situation, preventive measures can be followed. Ideally, only one needle at a time inside the cavity, except in cases when double-armed sutures are used. Besides, a needle holder must be used instead of a grasper for needle insertion or retrieval. Needle retrieval and counts should be confirmed verbally; therefore, clear communication between the surgical team is essential in these scenarios.

In cases of needle loss during surgery, it is imperative to avoid any instrumental movement that may lead further hiddenness of the needle. During the searching process, examination of the surgical field by quadrants must be performed, starting in the last area manipulated. If there is no presence of the needle, a systematic inspection of the rest of the abdominal quadrants is done. If still not found, a searching process outside the abdominal cavity, including the operating room floor, is done. On the other hand, the trocar's lumen and suction devices should be inspected and, in some cases, even X-rayed. Lastly, fluoroscopy imaging or abdominal X-ray can be used. Moreover, magnetic searching devices have been reported to locate and aid in needle retrieval [30, 31].

Final Steps Consideration

During case finalization, there are some considerations the surgeons should make. Subcutaneous emphysema should be assessed, as it can easily be misled with generalized edema. Pneumoperitoneum must be reduced by 5 mm Hg to inspect for bleeders masked by high levels of insufflation pressures. Finally, the scrotum should be free of gas to avoid epidermolysis and skin lesions.

Postoperative Complications

The first three hours postoperative are the most crucial to assess the patient exhaustively, owing to the fact that early postoperative complications are the most common complications encountered. The overall incidence of postoperative complications is 1.9–9% [24, 32].

Assessment includes:

- Vital signs
- Inspection of skin coloration
- Level of consciousness
- Character and volume of catheter and drain outputs
- Abdominal tenderness

Hemorrhage

The incidence reported for blood transfusions is less than 1.5% [24, 32]. Blood transfusions represent the most critical immediate complication seen in the open approach. Indications for transfusions and reintervention are based on clinical findings. This is particularly important in patients presenting with hypotension, tachycardia, and abdominal distension, where immediate reintervention is the standard of care.

A CT scan with contrast will aid in determining the urgency of reintervention for patients experiencing postoperative hemorrhage, evidenced by a decrease in hemoglobin levels. In cases when active bleeding is encountered, reintervention is imperative. In contrast to cases where active bleeding is not present, the necessity of re-intervention is decided by the hematoma's size and location.

Urinary Anastomotic Leakage

Vesicourethral anastomotic leaks are one of the most common short-term complications of radical prostatectomy, with an incidence reported of 0.3–15.4% [33]. Increased drain output is the initial sign of urinary leakage. However, increased output can be indicative of ureteral injury as well. Therefore, to differentiate the origin between anastomotic leakage or ureteral injury, cystography is the easiest assessment method. A cystography shows either partial or total disruption of the anastomosis. Furthermore, to differentiate urine leak from an anastomosis or a ureteral lesion, the gold standard is a CT urogram. In order to confirm the presence of urine drainage, drain fluid creatinine must be higher than serum creatinine.

Retrograde pyelogram is an alternative method that adds the benefit of identifying and treating ureteral lesions. In cases where the defect is minor, and guidewire passage is possible, ureteral stent placement for 4–6 weeks is the treatment to follow. But, if retrograde pyelogram shows a larger defect, or in cases when the passage of a guidewire is not achievable, reintervention, combined with percutaneous renal drainage, is imperative.

Port Site Hernia

Port site hernia is a rare but existing complication with an incidence reported ranging from 0.04% to 0.47% due to multiple incision sites and large trocars [34]. For this reason, fascia should be closed on ports larger than 10 mm as a preventative measure. However, 5–8 mm port-site hernias have been described in the literature due to a cone effect in the abdominal incision caused by the trocar's movement [14].

Stricture and Bladder Neck Contracture

Stricture and bladder neck contracture represent an uncommon, late complication following radical prostatectomy, with an incidence of 0.7–1.4%, presenting with symptoms of urinary retention [34–37]. To avoid the incidence of these complications, an ideal mucosa-to-mucosa, watertight, and tension-free anastomosis should be made.

Lymphoceles

Lymphoceles are considered the most common long-term complication, with an incidence of up to 50% in patients who underwent RALP with pelvic lymphadenectomy [38]. Pelvic pain, pressure, leg edema, thrombosis formation, and even abdominal distension are typical signs. Lymphatic collections are diagnosed with ultrasound. Doppler sonography of the lower extremities should exclude deep venous thrombosis (DVT) [39, 40]. The modality of choice to treat lymphocele is CT-guided percutaneous drainage. Those who do not resolve or continue to recollect after drainage, may require a laparoscopic fenestration [41].

Thromboembolic Events

Thromboembolic events refer to those complications caused by a triad of predisposing factors, such as Virchow's triad (hypercoagulability, venous stasis, endothelial injury), specifically DVT, which can lead to pulmonary embolism (PE). They have been reported in <1% of the cases [24]. Nonetheless, prophylaxis is recommended with low molecular weight heparin and compressive devices.

Conclusions

Robotic-assisted laparoscopic prostatectomy represents a safe and feasible procedure in experienced surgeons. Complications are inherent to surgery, yet immediate recognition and reporting contribute significantly to the prevention of complications during the surgeon's learning curve in addition to improving patient outcomes.

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