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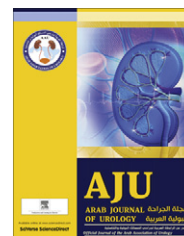


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REVIEW

Surgical complications of laparoscopic urological surgery

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KEYWORDS

Complications;
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ABBREVIATIONS

LUS, laparoscopic urological surgery; LPN, laparoscopic partial nephrectomy; IVC, inferior vena cava; FDA, US Food and Drug Administration

Abstract Objectives: To describe the incidence, identification and management of common intraoperative complications, including vascular, urological, bowel and visceral complications, of laparoscopic urological surgery.

Methods: We searched the databases of PubMed and Medline for relevant English language reports, using the keywords 'laparoscopy', 'urologic' and 'complication'.

Results: The search yielded 967 papers in all, and a review of these yielded a total of 42 relevant papers.

Conclusion: Despite its advantages, laparoscopic urological surgery is associated with complications having rates as high as 22%. As surgical volumes increase, the incidence and magnitude of complications have increased progressively. Meticulous surgical technique, surgeon experience, and a high degree of suspicion are necessary throughout the surgical endeavour. The intraoperative recognition and management of complications is mandatory.

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Introduction

Minimally invasive approaches to urological surgical pathology have become commonplace. Numerous studies show the decreased blood loss, shorter hospital stay and convalescence, and lower patient morbidity of laparoscopy when compared with open surgery [1–6].

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Laparoscopic surgery has its advantages but, like all surgical therapeutic interventions, carries a risk of complications. In fact, with increasing laparoscopic surgical experience the incidence and magnitude of complications increase because more complex procedures are increasingly tackled laparoscopically [7]. Meticulous dissection along with prompt identification and management of complications is of paramount importance, as delay can lead to significant patient morbidity.

There are inherent medical complications of laparoscopy that can arise as a result of the physiological effects of laparoscopy. CO₂ insufflation and its cardiovascular and pulmonary consequences represent one significant area of concern. Also, positional and neurological complications can arise from various patient positions used in urological laparoscopy to enhance exposure and facilitate certain procedures.

It is impractical to mention all potential complications of laparoscopic urological surgery (LUS) in this review. Consequently we focused on surgical and actual procedure-related complications. We describe the incidence, identification, and management of common intraoperative complications including vascular, urological, bowel and visceral complications of LUS. For the purpose of this review we chose to detail the complications of the transperitoneal laparoscopic technique. Despite this, however, many of the complications detailed here also apply to the retroperitoneal approach.

Vascular complications

Intraoperative vascular injuries are some of the most troubling and perilous complications encountered. A review of the non-urological reports shows a vascular injury rate of $\approx 0.05\%$. Despite their infrequency, the consequences can be great, with mortality rates as high as 17% [8].

In comparison, a review of urological reports gives a vascular complication rate of 0.03–2.7% [9–11]. A recent review reported an intraoperative complication rate for LUS of $< 5\%$, with haemorrhage during and after LUS accounting for 40% of all perioperative complications [10,12]. The elevated rate of vascular injury during LUS is not unexpected, as urological procedures often incorporate dissection, isolation and division of major vascular structures. During surgery these insults tend to occur either at the time of access or in the course of vascular dissection.

Access-related vascular complications

These are considered a rare entity; analysis of all trocar-related injuries reported to the USA Food and Drug Administration (FDA) from 1993 to 1996 identified 629 reports. Nearly 70% of access-related injuries were vascular. Additionally, 81% of access-related deaths

had a vascular cause, with aortic and inferior vena cava (IVC) injuries being the most common [13]. An additional study of 103,852 laparoscopic procedures identified a trocar-related vascular injury rate of 0.05%, with a 17% mortality rate [14].

Retroperitoneal structures can reside within 2 cm of the anterior abdominal wall in a thin patient [13]. The umbilicus is the most common site or reference point for access. When the patient is supine the aortic bifurcation can range from 5 cm cephalad to 3 cm caudal to the umbilicus, and from 3 cm cephalad to 3 cm caudal when in the Trendelenburg position [15]. Body habitus is also important in this regard. With increasing body mass index, the umbilicus is caudally displaced from the aortic bifurcation [16]. This anatomical variance had led some to suggest that the umbilicus is not always an ideal landmark. In fact, post-contrast CT has been used to show a more durable relationship between the anterior superior iliac spine and the aortic bifurcation [17].

Although numerous procedures have been described, the two most commonly used are the open Hassan and the Veress needle technique. The open technique has been found to minimise the incidence of vascular injury at the time of entry into the peritoneum [18,19]. Despite this the Veress needle is more often used clinically [20]. In our experience we have found the Veress needle technique to be a safe procedure. In patients with a history of intra-abdominal surgery in the area of access, the use of the open Hassan technique should be considered. Also, if any difficulty is encountered while placing the Veress needle a conversion to the open technique can avoid visceral injury.

If an injury is suspected at the time of access, the Veress needle or trocar should not be removed as it can aid in locating the vascular injury and might promote haemostasis by tamponading the bleeding. Also, to avoid CO₂ embolism, it is imperative that insufflation is not initiated. If CO₂ embolism occurs it is often heralded by hypotension, bradycardia, an abrupt decrease in end-tidal CO₂, and murmur. Treatment consists of left lateral decubitus positioning and aspiration of the CO₂ via a central line.

During the course of a laparoscopic procedure, bleeding at any trocar site should not be overlooked. Bleeding might be a harbinger of vascular injury. In this situation open suture ligation via the 'cut-down' technique, or fascial closure with the Carter–Thomason device, can be used to achieve vascular control.

Major vascular injury

Throughout the course of a laparoscopic procedure, injury to vascular structures might not become immediately apparent. If an injury is not recognised it can continue to bleed outside of the surgeon's field of view. Also, pneumoperitoneum allows for the compression of

venous bleeding and it is imperative that haemostasis be assessed at intra-abdominal pressures of 5 mmHg before completing the procedure.

It is imperative that the surgeon has a firm grasp of surgical anatomy and collateral circulation. Major vessels such as the aorta, IVC, common iliac and external iliac vessels, must obviously be repaired. Most major vessel injuries require open conversion and repair. Vascular surgical consultation should be obtained for large-vessel injuries. In very selected scenarios, when the injury is adequately visualised, located and isolated, vascular repair can be attempted by the laparoscopically adept surgeon. In addition to these well-known major vascular structures, if adequate collateral circulation is present, additional vessels can be occluded. These include the internal iliac artery, inferior mesenteric artery, and the coeliac axis [21].

However, when there is poor circulation due to previous vascular injury or vascular disease, certain vessels must not be ligated. Also, the collateral circulation of the superior mesenteric artery is tenuous and thus repair of this vessel is mandatory. Superior mesenteric artery injury has been reported; the outcome is often disastrous, leading to bowel necrosis and death [9,11,22].

In addition to direct vascular injury, significant bleeding can occur when a vascular stapler malfunctions. Stapler malfunction is reported in 1–1.7% of cases [23,24]. If a vessel is partly occluded an additional stapler load can be used to complete the vascular closure and transection. If complete malfunction is recognised before releasing the stapler, vascular repair might be possible laparoscopically. Open conversion is necessary in 20–60% of such cases. Judicious application of the stapling device is of paramount importance. In the renal hilum the original stapling is best applied to some distance from the ostium of the renal vein or artery. This allows for the possibility of proximal vessel control with a vessel clip or another stapler if the original device fails.

All laparoscopic operative suites must be fully capable of conversion to open surgery. Despite the plethora of devices available to the laparoscopic surgeon, the individual surgeon's experience, degree of vascular injury, and patient stability must be considered when intervention is determined. The judicious use of open conversion is advocated when major vascular injury is encountered.

Haemorrhage after partial nephrectomy

Laparoscopic partial nephrectomy (LPN) carries a significant risk of bleeding. When haemorrhage occurs in these patients it is most commonly after surgery, and often after the patient has been discharged [25]. Patients may present with pain, malaise, syncope, haematuria, vomiting, and/or fever. Additional signs that should be recognised include bloody drain output, anaemia, hypotension, tachycardia and renal insufficiency. When there

is a clinical suspicion, abdominal CT with contrast is the first test used in the diagnostic evaluation. Stable patients with a perinephric haematoma can be monitored, whereas those with signs of active bleeding require further assessment with possible angiography or exploration.

Two unique complications that can arise in the post-operative setting are arteriovenous fistula and renal artery pseudo-aneurysm. The latter occurs in 1.7–2.4% of patients and tend to present \approx 12 days after surgery [26,27]. These complications often coexist and tend to precipitate from injury to proximal segmental renal arteries and veins. Meticulous examination of the partial nephrectomy bed after tumour resection, along with the

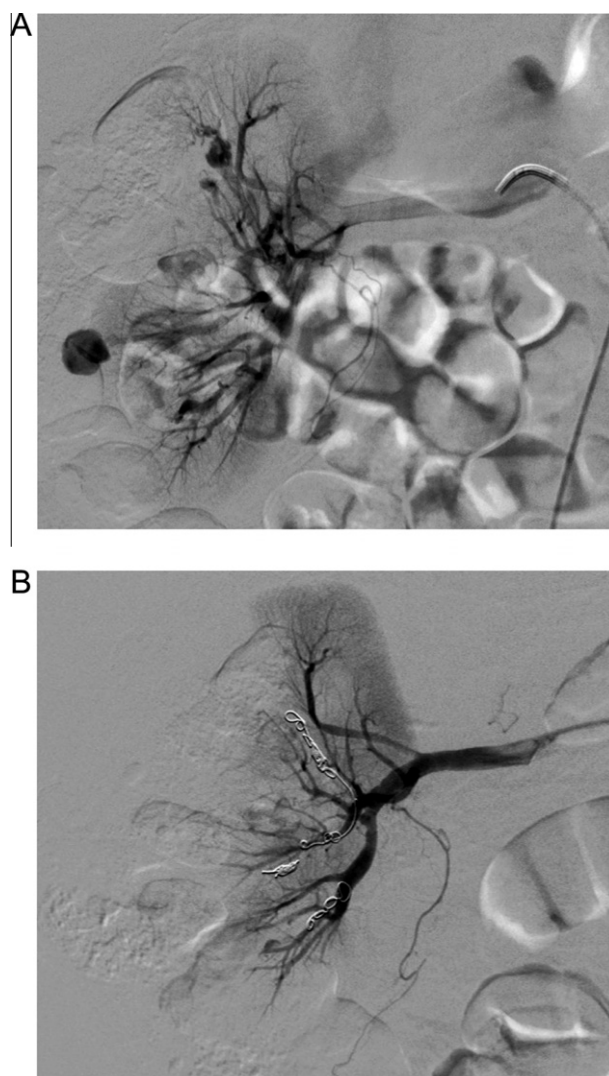


Figure 1 A patient presenting after LPN, with haemorrhage. (A) A renal angiogram showing an arteriovenous fistula and several pseudo-aneurysms. (B) A renal angiogram after intervention with selective angio-embolisation.

judicious use of sutures within the renal parenchyma, can help to reduce their occurrence.

CT during the arterial phase, an angiogram, or Doppler ultrasonography can reliably identify these complications [28]. When their presence is suspected, renal angiography has the added advantage of providing both better anatomical detail and a therapeutic intervention with selective angio-embolisation (Fig. 1). This is the least invasive therapy and should be routinely implemented as the initial intervention. If angio-embolisation is not available or fails to provide adequate vascular control, surgical intervention with either renorrhaphy or nephrectomy is warranted.

Urinary tract complications

Urinary tract injury during LUS can be divided anatomically into upper and lower urinary tract complications. Also, nearly all laparoscopic procedures carry a risk of bladder or ureteric injury. In large series of LUS the incidence of urinary tract injury is low, at <1% [10,12]. A review of non-urological reports gives ureteric injury rates of 0.09–14% [29–31].

Regardless of the procedure used, intraoperative detection of urinary tract injury is of the utmost importance. When these complications are identified during LUS it is possible to repair them directly, sparing the patient significant morbidity. If these injuries escape detection they tend to present after a delay and thus a high level of suspicion is mandatory.

Upper tract

Upper urinary tract complications can be classified by procedure. For this purpose we examined the complications of LPN and laparoscopic pyeloplasty. Both of these procedures incorporate delicate reconstruction of the urinary tract and therefore can be complicated by urinary leakage.

The two most common complications of LPN are haemorrhage and urinary leak. In a comparison of open PN and LPN cohorts by Porpiglia et al. [32] the former was associated with a higher urological complication rate. This was hypothesised to be a consequence of the propensity for surgeons to manage more complex tumours via an open approach. Similarly, Campbell et al. [33] found a higher rate of leakage during PN in those patients with tumours of >4 cm, endophytic tumours, and those requiring urinary tract reconstruction.

Previous reports show a rate of urinary leak after LPN of 0.5–21% [33–36]. Patients tend to present with abdominal distension, low-grade fevers, ileus, or elevated drain output. If suspected, the ideal imaging method for diagnosis is CT with intravenous contrast, or a pyelogram at the time of stenting or percutaneous nephrostomy placement.



Figure 2 Percutaneous drainage of a urinoma after right robot-assisted LPN.

Resolution of the urinary leak depends on the lack of obstruction to antegrade urinary flow and maintenance of a low-pressure system. In a recent review, urinary leakage after LPN lasted on average 20 days [36]. In that series, placing a percutaneous nephrostomy or ureteric stent led to resolution of the urinary leak. It is important to recognise that placing a urethral catheter with a ureteric stent further diminishes the collecting system pressure. Also, when the urinary leak fails to resolve, imaging should be obtained to ensure proper drain placement, to avoid active siphoning of urine. The drain can then be placed ‘off suction’ and advanced sequentially. The formation of an urinoma might necessitate percutaneous drainage (Fig. 2).

Complications involving the urinary tract occur in 2.3–5% of laparoscopic pyeloplasties [12,37,38]. These complications include urinary leak, clot obstruction of the indwelling ureteric stent, and stone formation.

Patients with a urinary leak require a plain abdominal film to assess the stent position. In those with a suspected stent obstruction, renal ultrasonography can be used to identify a renal pelvic blood clot. When ureteric stent obstruction mandates stent exchange, the use of a hydrophilic guidewire is imperative to minimise anastomotic trauma. Placing a urethral catheter can diminish the collecting system pressure, and thus facilitate closure.

While the presence of a urinary leak might be secondary to stent failure, it can also be caused by insufficient suture tension or the use of interrupted sutures during urinary tract reconstruction. It is this aspect of pyeloplasty that can be most amenable to a robot-assisted laparoscopic technique.

Ureteric injury

While non-urological reports show ureteric injury rates of 0.09–14%, it is a rarely encountered during LUS [29–31]. In a review of 2775 procedures by Permpongkosol et al.

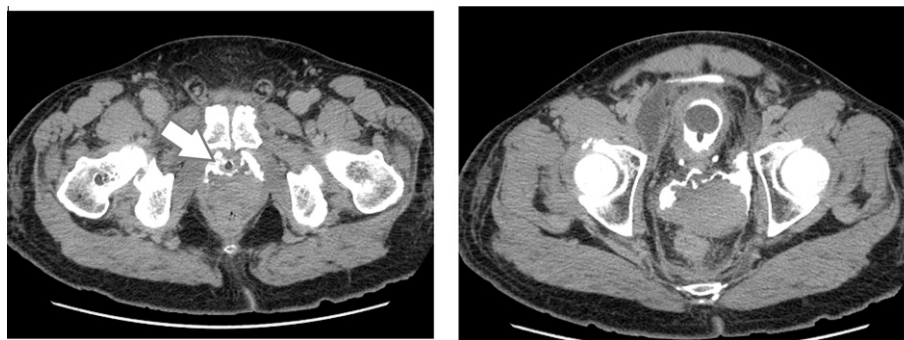


Figure 3 A urethrovesical anastomotic urinary leak after robotic prostatectomy.

[12], only six (0.2%) cases were identified. Of these six cases, one was identified during surgery. This is pertinent, as identifying ureteric injury during surgery allows for primary repair and can potentially spare the patient the morbidity of a second procedure.

The repair of a ureteric injury is tailored to the specific location injured (proximal, middle or distal ureter), cause of the injury (electrocautery, crush, ligation, transection), and length of ureteric loss. Proximal and middle ureteric injury is ideally managed with a spatulated, stented uretero-ureterostomy after debridement of devitalised tissue. Distal ureteric injuries mandate reimplantation secondary to the tenuous blood supply of this ureteric segment. In all situations, the use of a psoas hitch, Boari flap, or caudal renal mobilisation can provide additional length to facilitate a tension-free anastomosis.

Lower tract

Lower urinary tract injury is a rare occurrence during LUS. Throughout pelvic LUS the urinary organs are the centre of attention and, therefore, the major complication is that of anastomotic leakage, not urinary tract injury. Leakage is a known complication after laparoscopic prostatectomy, at the urethrovesical anastomosis (Fig. 3), and after transvesical procedures, at vesicotomy closure.

After laparoscopic prostatectomy anastomotic leakage is infrequent, but can have a devastating outcome. Patients tend to present with an elevated drain output, postoperative ileus, or fever, and are at risk of dense fibrosis with the resultant formation of bladder neck contracture. The periurethral fibrosis can involve the rhabdosphincter. This also places patients at risk of urinary incontinence.

In practice it is difficult to fully quantify the incidence of anastomotic leakage in patients undergoing laparoscopic prostatectomy. This is a result of poor uniform reporting and the lack of routine postoperative imaging. In a novel study, Menon et al. [39] retrospectively reviewed a total of 442 patients with a routine cystogram at 7 days after a robotic prostatectomy. In that review

the incidence of urinary leakage was 15.2%. Of those with a leak, only six (8.9%) were found to have extension into the peritoneal cavity.

To address the intrinsic bias of surgeon-reported complications Lasser et al. [40] prospectively assessed complications, using an independent third party. Urinary leakage was defined as an elevated drain output with the need for maintenance of indwelling drain for >48 h after surgery. In that series, seven (2.9%) patients were identified to have an anastomotic leakage after surgery.

Conservative management of anastomotic leakage is usually successful. Fortunately most leaks will eventually resolve with prolonged catheterisation. In these situations it is imperative that a cystogram is used to document the resolution of leakage before removing the catheter. If leakage persists, the drain should be taken 'off suction' and possibly advanced. For persistent high-volume urinary leaks the urethral catheter can be placed on gentle pneumovacuum suction for preferential urine drainage.

Bladder injury is a rare event during urological procedures, with an incidence of 0.7% [12]. Bladder injury is most often encountered during the course of laparoscopic gynaecological surgery, and is especially prevalent in patients with pelvic malignancy or a history of Caesarean section [41]. Bladder injury with lower tract LUS is a complication more prevalent during the learning curve, and is a rare occurrence for an experienced robotic or laparoscopic surgeon. The bladder can be repaired in two layers with absorbable sutures.

After surgery, the ideal imaging method for diagnosis is a CT cystogram [42]. The superior anatomical detail provided allows for a more accurate diagnosis of any intraperitoneal extension of the urinary leak. Whereas extraperitoneal leaks can be managed conservatively, intraperitoneal leaks mandate operative intervention and vesicotomy closure.

Visceral and bowel complications

During the course of any surgery there are many potential procedure-specific complications in addition to

those mentioned above. In addition to vascular and urological complications, bowel injuries are an area of concern, especially in transperitoneal LUS. Reports of LUS give a rate of intraoperative bowel injury of 0–0.9% [9,11,12]. Despite its rarity, bowel injury is a complication that is potentially debilitating and deadly if it is not recognised during surgery, resulting in an acute abdomen and sepsis.

Bowel injury can occur at any time from access through to closure. Of 639 trocar-related complications reported to the FDA from 1993 to 1996, a total of 134 (21%) involved bowel injury [13]. Of these, six (4.5%) were unrecognised and eventually resulted in the death of the patient. Bowel injuries recognised at the time of surgery can be repaired using the same standards as in open surgery, using intracorporeal suturing techniques. Adequate and judicious use of a bowel preparation regimen is important in difficult laparoscopic cases where injury is anticipated.

A recent meta-analysis showed an incidence of gastrointestinal tract injury during laparoscopy of 0.13% [43]. The rate of bowel perforation was slightly higher, at 0.22%. The small intestine was the most commonly injured portion of the bowel, and the most prominent cause of bowel injury was access-related via either trocar or Veress needle (41.8%). The second most common cause of intraoperative bowel injury was via electrocautery (25.6%). Injuries related to thermal damage to the bowel are routinely unrecognised during surgery. The patient presents typically at 1–2 days after surgery with signs of sepsis and acute abdomen. The presentation is typically with trocar-site pain, leukopenia, fever and chills. The patient can deteriorate rapidly and a high index of suspicion is mandatory. The diagnosis can be confirmed with abdominal CT confirming extraluminal faeces and/or free air. Additional imaging methods such as a Gastrografin enema can be used for the diagnosis of rectal injury. Perhaps the most relevant bowel injury in LUS is rectal injury, which can occur, albeit rarely, in robotic or laparoscopic prostatectomy. The vast majority of these complications are ultimately managed successfully via a laparotomy and diverting colostomy, with a mortality rate of 3.6%. Early recognition of bowel injury can allow for prompt repair and diminished patient morbidity.

During laparoscopy the instruments can stray from the surgeon's field of view. It is imperative that care is taken to actively monitor the location of instruments with a potential to injure the viscera (electrocautery, needle, harmonic scalpel, etc.). Thermal coupling to metal trocars can occur, and thermal damage to bowel in areas remote from the tip of the laparoscopic instruments can happen when there is a breach in the insulation sheath of the shaft of the laparoscopic instrument. Therefore, adequate maintenance of the equipment and preoperative inspection of the instruments by the operating room staff is imperative.

For right-sided upper tract (renal and adrenal) procedures, care should be taken to avoid duodenal and liver injuries during mobilisation for exposure. Most liver lacerations can be managed with an argon-beam coagulator or a combination of biological surgical glue and Surgicel. Duodenal injuries require prompt recognition and free-hand suturing when identified.

On the left side, pancreatic and splenic injuries can occur. Pancreatic injuries can be managed by distal pancreatectomy when extensive. Another option is the use of fibrin glue and Surgicel. If diagnosed after surgery, drainage of the collection is mandatory. Any aspirated fluid should be sent for analysis to confirm a pancreatic source. Persistent drainage can be managed with somatostatin administration. Splenic injuries can be managed in a manner similar to liver lacerations. In the presence of extensive splenic injury a splenectomy might become a necessity.

It is important to recognise that assistance is available when complications occur. Appropriate general surgical consultation should be obtained in both the intra- and postoperative settings when extensive splenic, liver or pancreatic injuries are encountered.

Conclusion

Complications of LUS are rare but well documented. Despite their infrequency, they carry a risk of devastating consequences. Meticulous surgical technique, surgeon experience, and a high degree of suspicion are necessary throughout laparoscopic surgery. Intraoperative recognition and management are mandatory. It is the surgeon's responsibility to vigilantly seek and repair intraoperative complications in an attempt to spare the patient the morbidity of delayed detection of a complication. In the cases of unrecognised intraoperative injury, a high index of suspicion, and thus early recognition of the problem immediately after surgery, can allow prompt action to intervene in a timely manner and prevent further morbidity and potential mortality.

Conflict of interest

The authors have no conflict of interest to declare.

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