Urinary tract injuries in laparoscopic gynaecological surgery; prevention, recognition and management

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Key content
• Injury of the urinary tract is the most common major complication of gynaecological laparoscopic surgery.
• Injury to either bladder or ureter results in significant morbidity for the patient and may lead to litigation.
• Knowledge of pelvic anatomy, training and meticulous technique are of paramount importance in reducing the incidence of urinary tract injury.
• Ideally an injury should be identified and repaired during the primary operation, but vigilance in the immediate postoperative period may result in early recognition and intervention.

Learning objectives
• To understand the common risk factors of urinary tract injury at laparoscopy.
• To learn strategies to prevent injury where possible.
• To learn strategies for intraoperative and postoperative recognition and repair of such injuries.
• To understand the significance of multi-disciplinary management of such injuries.

Ethical issues
• Limited evidence shows that laparoscopic hysterectomy may carry a higher risk of urinary tract injury compared with abdominal hysterectomy. Should patients be counselled accordingly?

Keywords: bladder injury / laparoscopy / major complications / pelvic surgery / ureteric injury

Introduction
Since its introduction in the 1970s, operative laparoscopy has shown itself to be one of the most significant developments in surgery.1 The benefits of shorter hospital stay, quicker recovery, superior exposure and enhanced visualisation of the pelvic organs, make minimal access surgery attractive to patients, hospitals and surgeons. Yet the development of the technique has not reduced the incidence of visceral injuries; instead it has introduced some new ways by which these may occur. Urinary tract injuries, when pooled together, represent the most common type of major complication of laparoscopic pelvic surgery. A Canadian study reported that women who have sustained a urinary tract injury in benign gynaecologic surgery are 91 times more likely to resort to litigation compared with those who have had another complication or problem following the same kind of surgery.2 Collecting and reporting the knowledge and experience accumulated over years by clinicians who have dealt with such problems is invaluable. In this article, we review the evidence on the incidence, prevention, recognition, and management of urinary tract injuries that occur during laparoscopic gynaecological surgery.

Methods
The following electronic databases were used to perform a literature search for material published between 1980 and 2013: PubMed, Embase, and the Cochrane Database of Systematic Reviews. Search items included: laparoscopy, urinary tract injury, bladder injury, ureteric injury, gynaecological surgery and laparoscopic complications. The search retrieved a total of 482 references. After exclusion of duplicate and irrelevant studies, 49 studies published in English were identified and used to write this review.

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Urinary bladder injury

Incidence and risk factors

The urinary bladder is at risk of injury during laparoscopic gynaecological surgery, either due to the entry process (for example during suprapubic port insertion) or due to its close association with the operating field (for example during hysterectomy). In complex cases the bladder can also be at risk because of its direct involvement in the disease process (uterine endometriotic nodule). The reported incidence varies greatly. Injury rates range from 0.02% to 8.3% placing bladder injury at the top of the list of visceral damage complications related to laparoscopic pelvic surgery.4,5

Most injuries occur during dissection of the bladder from the cervix and therefore the most common site is in the midline, above the inter-ureteric bar.6 Less often the bladder can be put at risk during insertion of the Veress needle or a trocar. Surgical experience, the type and complexity of the operation, and operating on normal or distorted pelvic anatomy are all factors accounting for different levels of risk and are likely to explain the wide differences in reported incidence. Indeed, Altgassen et al. found that experienced surgeons had almost half the complication rate compared with their less experienced colleagues.7 Certain types of procedures, such as laparoscopic-assisted vaginal hysterectomy (LAVH), appear to be associated with a higher frequency of bladder injury compared with others.8,9 Factors that distort pelvic anatomy may increase the risk of bladder damage (Box 1). These should be taken into account when planning a laparoscopic procedure and patients must be counselled and consented accordingly.10–12 Still, in a large number of cases bladder injuries occur in women without any identifiable risk factors.

**Box 1. Risk factors for urinary tract injury due to distorted pelvic anatomy**

- Endometriosis
- Cancer
- Adhesions (previous surgery/infection/inflammatory disease/radiation)
- Severe genital organ prolapse
- Obesity
- Pregnant uterus

Prevention

Knowledge of the anatomy, thorough understanding of electrosurgery and meticulous technique are prerequisites for a safe laparoscopic surgeon. A review of the literature revealed a number of strategies aimed at preventing bladder injury at laparoscopy.

The Royal College of Obstetricians and Gynaecologists advises that suprapubic insertion of the Veress needle should be avoided as it puts the dome of the bladder at risk of injury, and carries a high failure rate.13 Similarly, insertion of secondary trocars should be performed under direct view. Although not evidence-based, bladder catheterisation prior to peritoneal insufflation and insertion of trocars is recommended to avoid injury to a bladder distended by urine.14 Kyung et al.14 also advise insertion of an indwelling catheter in long procedures. Keeping the bladder empty during surgery will protect it not only because its decreased size will keep it out of the surgeon’s operating field, but also because an empty bladder cannot be penetrated as easily as a distended one.14,15

Laparoscopy offers a magnified view of the pelvic organs. Surgeons should use this feature to their advantage to identify the boundaries of the bladder during surgery. Maheshwari et al. suggest filling the bladder with saline while keeping it under direct vision to better define its borders in cases where this is proving difficult.16 Alternatively, 200–300 mL of dye-stained Ringers lactate may delineate both the bladder edges during difficult dissection and help recognise an injury if it occurs.17 Cystosufflation with carbon dioxide can be used for the same purpose.18 The bladder, however, should be decompressed before lateral and inferior dissection to decrease the chance of injury.

Specific attention is drawn to the risk associated with LAVH, and particularly to those cases where the bladder is dissected laparoscopically and the cuff is then closed vaginally. Kadar and Lemmerling19 suggest that the caudal direction of the laparoscopic dissection places the bladder in close proximity to the vaginal cuff and thus at increased risk during distal cuff closure performed vaginally. Contrarily, vaginal dissection of the anterior peritoneum displaces the bladder cephalad and then closure of the cuff vaginally may be safer. These authors therefore recommend laparoscopic closure if the majority of the dissection is done laparoscopically (i.e. performing a total laparoscopic hysterectomy) and vaginal closure if the majority of the dissection is done vaginally.17 When a total laparoscopic hysterectomy is performed, the bladder should be dissected adequately off the upper part of the vagina to avoid injury during closure.

Finally, it is important to be aware of and adhere to the rules of safe electrosurgery.20 There are four causes of inadvertent laparoscopic electrosurgical injuries, namely inadvertent tissue contact, insulation failure, direct coupling and capacitive coupling. The above apply to all visceral injuries that may occur during laparoscopic surgery. Such injuries may be difficult to identify, as they can occur at a site distant to the surgeon’s view, and/or present as delayed tissue breakdown several days following the primary insult. Safety measures to prevent such complications are listed in Box 2.21
Box 2. Safety measures to prevent laparoscopic electrosurgical complications

- Inspect insulation carefully before use
- Use the lowest possible effective power setting
- Use available technology; newer tissue response generators and active electrode monitoring technology eliminate concerns about insulation failure and capacitive coupling
- Use a low-voltage waveform for monopolar diathermy (cut).
- Use bipolar electrosurgery when appropriate
- Use brief intermittent activation
- Do not activate in close proximity or direct contact with another instrument
- Ensure that both the heel and the tips of the bipolar forceps are kept under direct view when activating

Recognition (intraoperatively)

When a visceral injury is suspected or identified, a multidisciplinary team of specialists will usually need to be involved to provide appropriate care to the patient. In some cases the operating surgeon may have the skills to conclusively diagnose and manage an injury of the urinary tract. In any other case a urologist should be consulted. A radiologist may also offer valuable assistance in terms of both diagnosis and management (this is covered in more detail later in the article). Intraoperative recognition and repair of a bladder injury will reduce morbidity and is less likely to lead to litigation. It is thought that approximately half of bladder injuries remain unrecognised during the primary operation.

A bladder injury may be directly recognised during laparoscopy because of an obvious cystotomy or visualisation of urine leakage. A suspicion of a not so obvious injury may be raised by noting haematuria or a distended catheter bag because of gas leaking through the defect into the bag. Therefore, it is always worth inspecting the catheter and its bag, near the end of a complex laparoscopic pelvic operation and before closure. Intraoperative cystoscopy and/or instillation of 200–300 mls of coloured saline (such as methylene blue or indigo carmine) into the bladder will identify the site and extent of the injury.

Care is advised when instillating coloured saline to look for an injury, as this may not be seen leaking intra-abdominally in cases where the bladder injury opens to the retro-pubic space (space of Retzius) (Figure 1). Such an injury may occur for example during a difficult suprapubic trocar insertion (previous suprapubic incision) which is accomplished by repeated attempts. In such a case, an initial unsuccessful attempt to insert the trocar may injure the bladder dome in a retro-peritoneal fashion. A second successful intraperitoneal entry achieved by repositioning the trocar may ‘miss’ the bladder dome and thus enter the peritoneal cavity in a misleadingly uneventful manner. The result will be a bladder injury that will communicate with the space of Retzius and might go unnoticed, as opposed to a more commonly expected laparoscopic injury that communicates with the
intraperitoneal cavity. Therefore, an intraoperative cystoscopy is advised in all cases where a bladder injury is suspected.

In fact, routine cystoscopy after major gynaecologic surgery has been suggested by some authors but not supported by others. An injury involving or occurring near the trigone carries a risk of potential ureteric injury. This can be assessed cystoscopically, but it is also useful to remember that the bladder mucosa can be accessed and inspected laparoscopically by inserting the laparoscope through the bladder injury. If the injury is not large enough for a 10 mm scope, then a 5 mm can be used and a 30-degree angled lens will allow inspection of the trigone and ureteral orifices.

Recognition (postoperatively)

Recovery following laparoscopic surgery is usually rapid. Any patient who is not recovering as expected should raise the suspicion of a visceral injury. Often, in cases where a bladder injury is suspected postoperatively, assessment for possible ureteric injury will also be required (see next section).

Clinical evidence of a bladder injury includes suprapubic pain, haematuria, leakage of urine per vagina and oliguria. Sterile urine does irritate the peritoneum, causing a form of chemical peritonitis (uroperitoneum). Symptoms and signs are misleading and subtle compared to peritonitis caused by contaminated material such as bowel content or infected urine. Uroperitoneum can present with diffuse abdominal pain, distension and ileus. Characteristically, tenderness may be absent. The above symptoms and signs usually appear within the first 48 postoperative hours unless a thermal injury has occurred. Thermal injuries may present after 10–14 days with uroperitoneum or vesico-genital fistula. Biochemistry investigations aid the diagnosis as serum creatinine levels will be abnormally elevated due to reabsorption of urine creatinine through the peritoneal membrane. A computed tomography (CT) scan with contrast may confirm the presence of uroperitoneum and/or show direct evidence of an injury. Retrograde cystography will confirm the diagnosis and cystoscopy will assess the injury and help decide whether conservative management is appropriate, depending on the extent of the damage (Figure 1). In cases of late presentations where a fistula is suspected the diagnosis will be supported by filling the bladder with dye (such as methylene blue) and demonstrating vaginal leakage. Magnetic resonance imaging (MRI) provides good tissue contrast and can be diagnostic for a vesico-vaginal fistula.

Management

In the majority of cases where a bladder injury occurs during laparoscopic surgery, repair can be achieved by either a gynaecologist or a urologist with advanced laparoscopic skills, thereby avoiding the additional morbidity of a laparotomy. Conversion to laparotomy should be reserved for cases where the injury or the surgeon’s experience is such that does not allow repair by laparoscopy.

Most bladder injuries can be sutured in one or two layers using a 2-0 or 3-0 absorbable suture (such as polyglactin). A running non-locked repair with the sutures placed 0.5 to 1 cm apart and 0.5 to 1 cm lateral to the cystotomy angles is suggested. Alternatively, if extra-corporeal knotting is preferred, interrupted sutures can be used at 0.5 cm intervals, whereas a ‘figure of 8’ suture may be enough to close a small defect. Injuries involving the trigone require additional attention. Repair should aim to avoid obstructing the ureters or the urethra and in most cases should be performed by a urologist. In such cases ureteral stents must be inserted and the patency of the urethra and ureters confirmed following repair. A thermal injury to the bladder will require debridement before repair, whereas an injury that pierces the bladder through the space of Retzius alone may be managed conservatively by an indwelling catheter for 2 weeks.

Ideally, bladder repairs should be watertight and leakage from the suture line should be tested (for example with methylene blue or indigo carmine). A bladder catheter must be inserted and continuous postoperative bladder drainage should be allowed for 2 weeks. The above two measures (watertight closure and indwelling catheter) will improve healing and reduce the risk of subsequent vesico-vaginal fistula formation. Prior to catheter removal, complete repair without leakage should be confirmed by retrograde cystography (Figure 2). If contrast escape is noted then the catheter should be left in situ and the test repeated in 1 week. Despite these measures, a fistula can still form with an approximate incidence of % (of the cases where an injury occurred). Even though management of these late presentations will usually be by open or vaginal route, several cases of successful laparoscopic repair of vesicovaginal fistulas have been reported to date.

When a bladder injury is diagnosed postoperatively, conservative management may be appropriate, provided that the wound is not extensive. Cystoscopic examination can assist in the decision. Antibiotics should be administered for 5–7 days and an indwelling catheter kept for 2 weeks. In cases where surgical repair is required, the principles are similar to those described above.

Ureteric injury

Incidence and risk factors

Just like the bladder, the ureter’s proximity to the female genital tract puts it at risk of injury during pelvic surgery. Most published studies quote a range of ureteric injury rates at laparoscopic gynaecological surgery from <1% to 2%.
Rates as low as 0.06% (large series of laparoscopic subtotal hysterectomies),\(^{37}\) and as high as 21% (deep infiltrating endometriosis associated with hydronephrosis)\(^{38}\) have been reported. A Cochrane review\(^{39}\) reported a higher incidence of ureteric injuries associated with laparoscopic hysterectomies compared to abdominal and possibly vaginal hysterectomies. These observations were largely based on the eVALuate study which involved two parallel randomised trials comparing laparoscopic with abdominal and laparoscopic with vaginal hysterectomies. The study found a 9.8–11.1% incidence of major complications in the laparoscopic hysterectomy groups.\(^{40}\) However these conclusions have been criticised by other authors on the grounds of bias. Donnez et al. suggested that the unusually high complication rates reported by the eVALuate study were probably due to the relative inexperience of the surgeons in laparoscopic hysterectomy than to the technique itself.\(^{41-43}\) In the absence of further well-designed sufficiently-powered trials this debate remains unresolved to date.

The most common sites of ureteric injury in laparoscopic surgery are at the pelvic brim (where the ureter comes into close proximity with the infundibulo-pelvic ligament which contains the ovarian vessels)\(^5\) and lateral to the cervix (during division or coagulation of the uterine artery or the uterosacral and cardinal uterine ligaments).\(^{44}\) Less often, injuries may occur at the ovarian fossa, for example during resection of endometriosis or ovarian remnants. Risk factors due to distorted anatomy are essentially the same as those described above for bladder injuries (Box 1). Electrocautery may be involved in up to one quarter of ureteric injuries.\(^5\) Interestingly, video analysis of laparoscopic procedures where a ureteric injury occurred in a patient with severe endometriosis concluded that unconscious acceleration of surgery, possibly caused by fatigue, contributed to a judgement error that led to the injury.\(^{45}\) Hurd et al.\(^{46}\) showed that the ureter passes lateral to the cervix with an average distance of 2.3±0.8 cm. Analysis of CT images of 52 women with apparently normal pelvic anatomy, showed that in 12% of the patients the distance was less than 0.5 cm. In addition, the higher the body mass index the closer the ureter was found to be to the cervix.\(^{46}\)

Figure 2. Retrograde cystography 2 weeks following conservative management of the case shown in Figure 1. (a–d) The contrast fills the bladder gradually as shown in the x-ray series. The balloon of the Foley catheter can be seen. Healing is confirmed by absence of leakage.
Prevention

The principles of bladder injury prevention (knowledge of the anatomy, safe electrosurgery and meticulous technique) apply here as well. Instruments such as virtual reality models of pelvic anatomy are now at the disposal of modern surgeons and complement traditional textbooks and learning anatomy ‘on the job’. Preoperatively, an MRI with or without an intravenous urogram (IVU) may help the surgeon plan a complex procedure, for example, in cases of endometriosis with suspected ureteric involvement; however, this investigation offers no benefit in routine cases. Intraoperatively, the detailed vision offered by the magnified laparoscopic view should be used to identify ureteric peristalsis and thus localise and follow the course of the ureter. Patience is needed to keep the laparoscope still until peristalsis is seen. This process may be repeated as many times as necessary during the course of a complex procedure. On occasion it may be easier to identify the ureter if one starts looking for it at the pelvic brim where it crosses the bifurcation of the common iliacs.

In complex cases which carry increased risk of ureteric injury (for example extensive pelvic endometriosis, large ovarian cysts, pelvic adhesions, cervical fibroids) it is useful and often mandatory to dissect and expose the ureter (ureterolysis) (Video S1). Mobilisation of the ureter should be performed through a peritoneal incision using a medial to lateral blunt sweeping technique. The ureter is an organ that carries its own blood supply system within a layer of adventitia that surrounds it. Provided that this vascular plexus is preserved, the ureter can be mobilised over a length of 15 cm (approximately half its total length) without compromising viability. It follows that electrosurgery should be used with caution and, if possible, avoided in close proximity to the ureter. Ureterolysis performed through dense surrounding pathology, such as severe endometriosis, is an advanced laparoscopic skill and should normally only be performed in centres with the appropriate expertise.

Ureteric stenting (including lighted stents) is useful only in very select cases, where the pelvic anatomy is severely distorted and/or usual methods of ureter identification have failed. De Cicco et al. suggest that in cases of severe endometriosis associated with ureteric obstruction and hydronephrosis, preoperative stenting is mandatory. This practice is not evidence-based and care must be taken when mobilising a rigid stented ureter. In such cases, where the ureter travels through dense disease, an alternative trick is to identify it laparoscopically while illuminating by ureteroscopy. To achieve this, the surgeon has to keep the laparoscope still in a position close to where the ureter is expected to be seen. The laparoscopic lighting is then turned down and the ureteroscope is advanced inside the ureteric lumen. When transillumination is seen laparoscopically, the position of the ureter may be identified.

Finally, adequate reflection of the bladder off the uterus and the cervix during total laparoscopic hysterectomy will move not only the bladder, but also the ureters away from the uterine vessels and the cervix, thus reducing the risk of injury.

Recognition (intraoperatively)

There are seven types of ureteric injury (Box 3), with transection the most commonly reported at laparoscopy. Only a third of such injuries are recognised intraoperatively therefore any uncertainty about the integrity of the ureter should prompt intraoperative investigation and involvement of a urologist. Cystoscopy allows visualisation of the ureteric orifices and urine jets which rules out obstruction, but does not exclude other types of injuries. Presence of blood or air suggests injury. Intravenous administration of indigo carmine colours the urine blue within 5 to 10 minutes and will assist a cystoscopic assessment as well as potentially allow the surgeon to identify a urine leak laparoscopically. Stents inserted without resistance, under direct laparoscopic visualisation to ensure they do not exit through a possible injury, can also rule out obstruction. Occasionally, insertion of a stent alone can be therapeutic if the problem was angulation (kinking) of the ureter. Ureteroscopy may locate the approximate height and extent of injury. Retrograde, antegrade and/or intravenous uretero-pyelography can confirm or refute the diagnosis and determine the location of an injury.

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<th>Box 3. Types of ureteric injury</th>
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<td>• Angulation</td>
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<td>• Crush</td>
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<td>• Transection</td>
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Recognition (postoperatively)

The principles of recognising a ureteric injury postoperatively are similar to those described earlier for bladder injuries. Any failure to recover as anticipated following major laparoscopic pelvic surgery must raise the suspicion of a ureteric injury. Flank pain and flank tenderness, haematuria, oliguria or watery vaginal loss may be present within the first 48 hours of an acute injury. Uroperitoneum will present clinically with the often misleading features discussed above. In a recent case report, van Ooijen et al. observed extensive cellulitis as an unusual first symptom of ureter lesion after laparoscopic hysterectomy. A urinoma may develop as a result of
retroperitoneal leakage of urine which leads to encapsulation by reactive fibrous tissue, such that a cyst containing urine is formed. This may develop into an abscess and present with sepsis and electrolyte imbalance. Like all visceral injuries, a thermal injury to the ureter may result to delayed necrosis and/or fistula formation that will often present clinically between 10 and 14 days postoperatively. Ultrasound and/or CT scans can evaluate hydroureteronephrosis, urinomas and abscesses, whereas a CT intravenous urogram (CT IVU) will locate the injury.

The consequences of an unrecognised injury can vary from spontaneous healing to fistula and/or stricture formation with associated deterioration of the function of the affected kidney. This may occasionally require nephrectomy. Up to 25% of unrecognised ureteral injuries result in eventual loss of the ipsilateral kidney.

**Management**

Traditionally ureteric injuries have been managed by laparotomy. There is now a growing body of evidence suggesting that both acute injuries, as well as late sequelae such as uretero-vaginal and uretero-uterine fistulas can be repaired successfully by laparoscopy.

There are a number of options when repairing a ureteric injury. Review of the literature suggests a general consensus that certain surgical principles must be respected and that the type of repair should be selected according to the site and type of injury.

Minor crush or needle injuries may be managed conservatively provided that the ureter’s integrity and viability have not been compromised, i.e. there is peristalsis and adequate perfusion present with no urine leak. Most authors agree that obstruction (more significant crush or ligature injuries) is best managed with ureteral stenting.

However, the recommended amount of time for which the ureter should be stented in such cases, varies in the literature between 2 to 6 weeks. Similarly, limited areas of thermal injury may require stenting to prevent stenosis and urine leakage during healing. Caution is required when more extensive deep thermal injury has occurred, in which case, excision of the affected part and ureteral re-anastomosis or re-implantation (as discussed below) might be needed. Ureteric lacerations appear to heal better when managed with suturing and stent rather than stent alone.

In cases of major ureteric injuries (transection, resection) the suggested techniques are site-specific. At the upper third of the ureter an end-to-end re-anastomosis of the ureter (uretero-ureterostomy) should be performed. At the middle third either a uretero-ureterostomy or a trans-uretero-ureterostomy (end-to-side anastomosis of the injured ureter with the contra-lateral healthy ureter) is appropriate for the management of injuries occurring at the middle-third of the ureter.

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**Box 4. Surgical principles of ureteric repair**

- Adequate but careful debridement to avoid shortening the ureter (debridement may be needed to enable the use of the healthy ureter for re-anastomosis)
- Adequate but careful dissection to avoid devascularisation (dissection/mobilisation may be needed to lengthen the ureter for anastomosis)
- Anastomosis must be:
  - water-tight
  - tension-free
  - spatulated or fish-mouth
- Use absorbable and intermittent sutures
- Avoid using too many sutures
- Use drainage (ureteral stents, bladder catheter, retro-peritoneal anastomotic site drain)
- Consider omental flap to cover the repair site and increase vascularity
- When possible, repair by laparoscopy

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**Figure 3. Trans-uretero-ureterostomy.** End-to-side anastomosis of the injured ureter with the contra-lateral healthy ureter. This technique is appropriate for the management of injuries occurring at the middle-third of the ureter.
ureter) can be performed (Figure 3). It follows that trans-uretero-ureterostomy involves intentional injury and therefore risk to the contra-lateral healthy ureter and should not be used as a first-line option. At the lower third uretero-neocystostomy (re-implantation of the ureter into the bladder) should be preferred. If a tension-free anastomosis cannot be achieved by simple re-implantation (due to a shortened ureter, for example), then a psoas hitch or a Boari flap can be performed.\(^6\) In these two techniques the bladder is mobilised and used to bridge the gap. A psoas hitch involves fixing the bladder to the iliopsoas muscle tendon (Figure 4). To create a Boari, an oblique flap from the dome of the bladder is cut and the cystotomy is closed vertically extending the flap to the ureter (Figure 5). The Boari flap technique can provide up to 12–15 cm of additional length.

Urinomas can often be managed by involving a specialist radiologist. A combination of percutaneous drainage of the urinoma, percutaneous nephrostomy, ureteral stents and bladder drainage may help avoid re-operation.\(^5\) When late presentation is associated with a septic unstable patient and/or abscess formation, conservative initial management similar to that described for urinomas plus aggressive antibiotic treatment is required. The patient should ideally be stabilised before considering a laparoscopic or open approach.

At the end of the healing period, an intravenous or retrograde urogram must be performed to confirm ureteral patency and integrity.

**Conclusion**

It has been quoted that to avoid all injuries to the urinary tract, one would have to stop operating near it – an unrealistic prospect for gynaecologists. Injuries will occur even in the best hands. Hence, it is important to be familiar with strategies that reduce the incidence of such complications and limit the resulting morbidity when they happen. The present review has brought together a number of recommendations on how to prevent, recognise and manage urinary tract injuries that complicate laparoscopic

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**Figure 4.** Psoas hitch. (a) The bladder is incised transversely and mobilised to reach the shortened ureter to achieve a tension-free anastomosis; (b) the bladder is fixed to the psoas muscle; (c) the incision repaired in a vertical manner which allows “elongation” of the bladder.

**Figure 5.** Boari flap. (a) A wide-based flap is developed by an anterior bladder wall incision; (b) the flap is brought towards the ureter to achieve a tension-free anastomosis; (c) the bladder incision is closed in a tubular manner to allow up to 12–15 cm of additional length.
pelvic surgery. Various confounding factors, including the relatively low incidence of these complications, make it particularly difficult to produce data from randomised trials. In the absence of such well-designed studies, evidence on the efficacy of the described techniques either originates from case series and cohort studies, or represents anecdotal clinical experience.

To conclude, it should be emphasised that laparoscopy offers us the unique ability to review our practice by recording our own operations. Through such a method Schonman et al were able to perform an accident analysis to determine factors that were associated with a ureteric injury.45 This process brings to mind the analysis performed in aviation using the aeroplanes’ flight data recorders, the ‘black box’. When adverse events occur in medicine, we reflect on our practice using our memory and medical notes. This process is considered an integral part of a clinician’s learning and continuous development. Laparoscopy gives the surgeon the opportunity to reflect by physically playing back and reviewing every single intraoperative decision and action. Perhaps this tool will prove valuable in the future in gradually gaining the experience and knowledge that a surgeon needs to maintain a low complication rate.

Contribution to authorship
VM performed the literature review and wrote the article. NG and DR conceived the subject of the article. NG, TA, MD, and DR critically revised the article and contributed to the written material. All authors approved the final version of the submitted article.

Disclosure of interests
The authors of this article have no conflict of interest to disclose.

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Supporting information
The following supplementary information is available for this article online:

Video S1. Video demonstrating ureterolysis in a case of overlying pelvic sidewall peritoneal endometriosis. The ureter is identified by observing peristalsis. An incision is made to the peritoneum above the level of the ureter and the ureter is mobilised by medial to lateral blunt sweeping movements.

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