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## Urological injuries in gynecological surgery: A review

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### Abstract

Due to close anatomical proximity of urogenital systems to female reproductive system, urological complications are common in gynecological surgeries. In fact most of iatrogenic urinary tract injuries are due to gynecologic surgeries. Previous pelvic surgery, endometriosis, gynecological malignancy, pelvic radiation, abnormalities of ureter, and presence of adhesion were found to be significant risk factors. Urinary bladder injury was the most common urinary tract injury during gynecologic surgery and usually recognized and repaired immediately with minimal complications. However, ureteral injuries which mostly happens in distal one third of the ureter usually are not recognized immediately and have the potential to be life-threatening or to result in permanent kidney damage. The most reliable way for surgeons to avoid ureteral injury is to clearly identify the ureter. Aim should be of early diagnosis and management of urological injury to avoid the life threatening complications.

**Keywords:** Hysterectomy, ureteral injury, bladder injury, complications, vesicovaginal fistula

### Introduction

The reproductive and urinary tracts in women are closely related anatomically and embryologically. Hence operative injuries to the urinary tract are common in gynecological surgery due to the proximity of the urogenital organ systems. In fact 75% of iatrogenic urinary tract injuries are due to gynaecological surgeries; bladder injuries being the most common urologic injury. They are usually recognized during surgery and repaired immediately with minimal complications. However, ureteral injuries are typically not recognized immediately; hence they have the potential to be life-threatening or to result in permanent kidney damage.

The primary objective of this study was to identify risk factors associated with urologic injuries and to review the management.

### Material & methods

**Incidence:** The overall rate of urinary tract injury associated with pelvic surgery in women ranges from 0.3 to 1 percent<sup>[1, 2]</sup>. Bladder injury is approximately three times more common than ureteral injury<sup>[1, 3]</sup>. Up to 2.4 percent of patients may require concomitant urological intervention after hysterectomy-related injury to the urinary tract<sup>[4]</sup>. In a large population based analysis which included over 223,872 patients, ureteral injury occurred in 1,753 patients (0.78%) and was unrecognized in 1,094 patients (62%)<sup>[2]</sup>. While there was no significantly increased risk of acute renal failure or death for recognized ureteral injuries compared with no injuries, unrecognized injury was associated with significant increased risk of acute renal failure and death.

**Impact of procedure route:** The incidence of urinary tract injury at gynecologic surgery varies by the type of procedure and route of surgery: Of ureteral injuries from gynecologic surgery, roughly 50 percent are from radical hysterectomy (Laparoscopic assisted Radical hysterectomy does more injury followed by open Radical hysterectomy), 40 percent are from abdominal hysterectomy and less than 5 percent result from vaginal hysterectomy.

**Risk factors:** These are conditions that distort pelvic anatomy, obscure tissue planes, make visualization of urinary tract structures difficult, or make the urinary tract more vulnerable to injury<sup>[4, 6]</sup>. These include prior pelvic surgery, endometriosis, urinary tract abnormalities (eg, duplicated ureter, pelvic kidney), history of pelvic irradiation, obesity, large pelvic mass, fibroids including in the cervix and broad ligament. Specific to pelvic surgery, prior laparotomy

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or cesarean delivery was associated with higher rates of bladder and/or ureteral injury in studies of hysterectomy with 1000 or more women; the rates were compared with patients who had not previously undergone these procedures [7]. Previous laparotomy – 2.1 versus 0.5 percent, Previous cesarean delivery – 2.9 to 4.7 versus 0.7 to 1.1 percent. A large population-based study reported black race as a risk for bladder injury [6]. This is attributed to a greater incidence of large uteri and uterine fibroids among black women undergoing hysterectomy [6].

**Anatomy:** The ureters are retroperitoneal, 25 to 30 cm long structures that run from the renal pelvis to the bladder and can be injured during pelvic surgery at any point along their distal course. Most common sites of injuries are-1) infundibulopelvic ligament where ureter runs just medial and inferior to the ovarian vessels. 2) at internal cervical os, the ureter passes under the uterine arteries in the cardinal ligament through a tunnel of areolar tissue, 3) The ureters then pass close to the anterolateral fornix of the vagina and enter the posterior aspect of the bladder. Bladder is positioned anterior to the vagina, cervix, and lower uterine segment. The base is opposed to the cervix and vagina with the vesicocervical and vesicovaginal fascia. The bladder is divided into the dome superiorly and the base inferiorly [8]. The base contains the trigone, including the ureters, which enter posteriorly, and the urethra which exits at the most inferior aspect of the bladder.

**Mechanisms of injury:** Injuries with energy sources: Thermal damage from electrosurgery, laser or harmonic scalpel, is becoming a more frequent cause of injury to the urinary tract [9, 10]. The expected thermal spread from devices ranges from 2 to 22 mm. In a systematic review of 90 studies, electrosurgery was the most common cause of ureteral injury (33 percent) while lysis of adhesions was the most common cause of bladder injury (23 percent) [4]. Other modes of intraoperative ureteral injury include: crushed with a clamp, kinked or ligated with a suture or staple, lacerated or transected during sharp/blunt dissection or while using an energy source, devascularization or denervation. Additional mechanisms of intraoperative bladder injury include: Trochar or Verres needle injury during laparoscopic surgery, laceration of the bladder wall with or without breach in the bladder wall, devascularization or denervation, accidental placement of an intravesical suture or staple.

**Sequelae of injury:** Potential consequences of lower urinary tract injury include ureteral obstruction (resulting in hydronephrosis and possible irreversible injury which, if bilateral, can lead to renal failure), genitourinary fistula and urinoma [11]. Any of these consequences can lead to readmission, sepsis, and death [2]. When bladder injuries present postoperatively, genitourinary fistulas appear to be the most common presentation (74 of 76 in one series). Fistulas are more often associated with hysterectomy, particularly radical hysterectomy.

### Diagnosis & management

**Preoperative:** When a bladder injury is found during pelvic surgery, it should be repaired in 2 layers with prolonged indwelling catheter, and it is wise also to investigate the possibility of an accompanying ureteral injury. If the patient had received prior pelvic irradiation, the bladder repair should be covered with omentum or peritoneum (two types of abdominal membrane), if available, to prevent possible formation of a fistula. A suction drain is placed until the drainage is minimal. If drainage output remains high, the drainage fluid should be sent for creatinine level test. Creatinine levels higher than normal serum levels indicate a urine leak; whereas levels equal to serum indicate

peritoneal or lymphatic fluid. Persistent urinary leakage typically resolves with an additional two to four weeks of bladder drainage [16]. In laparoscopic surgeries bladder may get penetrated by placement of the Veress needle or trocar. Trocar injuries are typically to the bladder dome and have an entry and exit wound. Bladder injuries occur most often with midline and lower abdominal trocar placement. A full bladder or one with distorted anatomy from previous pelvic surgery, endometriosis or adhesions is more likely to be injured laparoscopically [17]. During the operation, the diagnosis of bladder injury is suggested by the presence of gas filling up the Foley bag or visibly bloody urine in the Foley bag. Veress needle injuries and other small injuries to the bladder can be successfully managed conservatively by catheter drainage for seven to 14 days followed by cystography. Large bladder injuries, such as from 5 or 10 mm trocar or surgical dissection, often require suturing the injuries closed (either laparoscopically or by open repair) with prolonged catheter drainage.

If injury to the ureter is suspected during the operation, the ureter must be meticulously examined as direct exploration and visual inspection are the most common and accurate methods for diagnosis. If no obvious urine leak is noted at the suspected injury site then to help identify the ureteral injury, indigo carmine can be injected into the ureteral opening or injected directly into the ureter. The injection of indigo carmine into a vein coupled with Lasix diuretic, which colors the urine blue, is also helpful. The blue-tinged urine helps confirm injury. A ureter with a bruised appearance can have significant trauma from either a crush or ischemic injury. To determine whether a ureter has lost blood supply are to note wall discoloration and absence of refill of the capillaries. A ureter that visibly can contract, unfortunately, is not a clear indication of normal ureteral function or of adequate blood supply. The method of ureteral repair is determined by many factors, including the location and length of ureteral injury or type of injury. Partial ureteral lacerations or thermal injuries that are diagnosed during the operation can be managed by endoscopic placement of a stent. When the ureter has been cut completely, an immediate, open surgical approach is typically needed.

### Delayed bladder & ureter injury/diagnosis

Undiagnosed injuries to the bladder that occur during surgery typically become evident days to weeks after surgery. In patients with previous pelvic irradiation, fistulas can occur months to even years after hysterectomy. Typical delayed bladder complications are various forms of fistulas. Cystography with a post-drainage X-ray will enable the surgeon to assess injury inside and/or outside the abdominal membrane. Injuries inside the abdominal membrane require surgical closure and drainage, whereas injuries outside the abdominal membrane can be successfully managed through prolonged Foley catheter drainage. Decreased urine output, absent or defective urine excretion, an excess of urine, elevated blood urea nitrogen, the presence of blood in the urine, bruising and abdominal swelling suggest a bladder injury has been missed.

Initially, a ureter that is cut produces no symptoms until a cyst collecting urine causes abdominal swelling, bowel obstruction, infection, fever or low back, or abdominal pain. Persistent blood in the urine, increase in white blood cells and/or urinary (fluid) leakage from the vagina are other reliable signs of injury. Absorption of the urine by the abdominal membrane will often cause a rise in the serum urea nitrogen. Such injuries have been managed successfully by a variety of methods, from ureteral stent placement for minor injuries to open surgical repairs. When the injury is not detected for more than two to three weeks, the patient requires proximal urinary diversion (PCNL and, if possible, ureteral stenting), as well as drain placement

into the urine-containing cyst. The discharged urine also may cause fibrosis severe enough to cause ureteral obstruction. At two to three weeks after surgery, re-exploration is typically difficult and fraught with danger because of inflammation, fibrosis, adhesions, blood clotting and distorted anatomy. Intravenous urography findings suggestive of ureteral injury are delayed visualization or the inability to visualize the involved kidney, hydronephrosis, or incomplete visualization of the entire ureter. Retrograde urography is typically the most sensitive radiographic method to evaluate the integrity of the ureter, and to determine if it has been damaged. CECT can identify a hematoma (clotted blood), a cyst containing urine or hydronephrosis, ureteral leak, all suggestive of ureteral injury. Definitive repair is performed in a delayed/staged fashion.

### Discussion

Most ureteral injuries (80 to 90 percent) occur in the part of the ureter that is in the pelvis, the segment of ureter closest to the bladder. In fact, more than 75 percent of ureteral injuries due to gynecologic surgeries occur during uncomplicated and routine procedure where pelvic anatomy is normal [10]. Hemorrhage (extensive bleeding) during the operation is a clear and main risk factor for ureteral injury. Sudden hemorrhage should never be treated with blind cautery (searing of tissue) or suturing, but rather direct pressure, sharp dissection and exposure of the bleeding vessels followed by accurate and precise suturing [2, 10]. Abdominal hysterectomy is the most common cause of ureteral injury inadvertently caused by a surgeon. Here, the potential for ureteral injury is greatest during the ligation and division of the uterine arteries, followed by division of the ovarian vessels in infundibulopelvic ligament. In radical hysterectomy, the ureter can be skeletonized when removing an adjacent tumor, and this can result in a lack of blood supply and delayed death of tissue. Radical hysterectomy also may require en-bloc resection (removal as a unit) of a ureteral segment (in order to achieve a tumor-free margin). Prior irradiation can compromise ureteral blood supply, make wounds heal poorly and increase the risk of ureter injury during pelvic surgery (after hysterectomy by three to fourfold). Cancers can directly invade and can fix the ureter or distort its course. Severe pelvic prolapse also can increase the risk of ureteral injury. Infected or inflamed tissues are other important contributing factors for ureteral injury [14]. The method of ureteral repair is determined by many factors, including the location and length of ureteral injury, the time of diagnosis (during the operation, early postoperative or delayed), the type of injury and the presence of associated medical or surgical illnesses. Clearly, the optimal time for repair of a ureteral injury is during the operation, when it initially occurs. Immediate recognition and repair allow for better results and fewer complications compared with that in a delayed fashion. Unfortunately, most ureteral injuries from gynecologic surgery (more than 80 percent) are discovered in a delayed fashion. Injuries that are detected after an operation tend to be more complex, require more complex repairs and multiple procedures, and have more complications than those detected and repaired during the operation. Rates for surgical removal of the kidney resulting from delayed diagnosis, overall, are seven times as common as when the ureter injury is diagnosed during surgery. Urine leakage also can cause abscess formation and scarring of the ureter, leading to obstruction and formation of abnormal passages.

### Preventive measures

**Informed consent** - Counseling about the risk of urinary tract injury is part of the informed consent process prior to pelvic surgery. **Medical history** - Important history are prior pelvic surgery, radiation, or infection and known or suspected endometriosis. Congenital anomalies of the urinary tract (eg,

duplicated ureters, pelvic kidney) may be suspected if there is a personal or family history of congenital anomalies of the urinary tract or reproductive tract, since these abnormalities often coexist. Imaging studies - Contrast studies of the ureters may be useful in patients with known or suspected urinary tract anomalies. Preoperative imaging with computed tomography or urography can be helpful in demonstrating structural abnormalities in the urinary tract [12]. Magnetic resonance imaging can be helpful in confirming the presence of cervical fibroid, broad ligament fibroid, and/or retroperitoneal cysts or masses that increase the risks of urinary tract injury.

### Operative setup

**Patient positioning** - Patient positioning in the dorsal lithotomy rather than supine position for pelvic surgery provides better access for evaluation of the urinary tract with cystoscopy or other methods that require access to the urethra. This setup allows a second surgical assistant to stand between the patient's legs, which improves their ability to assist. **Bladder catheter** - Placement of a Foley catheter may be helpful in procedures in which there is a potential for urinary tract injury. If there is an increased risk of injury, a triple lumen (three-way) catheter can be used, which will allow instillation of contrast material if bladder injury is suspected. Persistent blood-tinged urine in the catheter output should prompt evaluation for urinary tract injury. **Prophylactic ureteral catheters** - Universal use of prophylactic ureteral catheters is not recommended [13, 14]. A randomized trial that assigned 3,141 women with no prior pelvic surgery who were undergoing major gynecologic surgery to bilateral ureteral catheters versus no stents reported similar incidences of ureteral injury in the groups (1.2 versus 1.1 percent) [14]. Ureteral catheters are potentially helpful for selected women with known or suspected periureteral fibrosis or scarring, such as those with severe endometriosis, large cervical fibroids, or prior pelvic irradiation. **Surgical Technique** - The most important principle for prevention of urinary tract injury is to develop and divide tissue planes to identify and isolate the structures of the lower urinary tract before operating on other pelvic structures. Anatomic variation and pelvic pathology may obscure tissue planes, thereby increasing the risks of an injury [1]. **Avoiding ureteral injury** - Identification of the ureter at each step in a procedure avoids injury [12]. The highest risk of denervation and/or devascularization is during ureterolysis; therefore, removal of all tissue surrounding the ureter should be avoided during gynecologic surgery performed for benign indications. During gynecologic surgeries the steps of the procedure in which the ureter is most likely to be injured are: **Ligation of the ovarian vessels** - To avoid ureteral injury when the ovarian vessels are ligated during oophorectomy, there are several methods of identifying the ureter; however, opening the retroperitoneum and visualizing and/or palpating the ureter prior to isolating, clamping, and ligating the ovarian vessels is the method that best ensures accurate identification and protection of the ureter. **Ligation of the uterine vessels** - At the level of the uterine arteries, the uterine vessels are skeletonized before ligation to visualize the ureter. If the vessels have been isolated, it is not required to completely dissect out the ureter. When placing a clamp prior to ligating the vessels, care must be taken that only the vessels are included in the clamp. Mobilizing the bladder from the anterior cervix and displacing it inferiorly will also shift the ureters inferior to the uterine arteries prior to clamping. The ureters pass below the uterine vessels, and once these vessels are ligated, the ureter will pass just inferior and lateral to this pedicle. Thus, to protect the ureter during subsequent dissection of the cardinal ligament, the clamp is placed medial to the uterine artery pedicle. **Vaginal cuff closure** - The ureters enter the bladder posteriorly, along its interface with the anterior vaginal wall. As the bladder is dissected off the

surface of the vagina or cervix and displaced inferiorly, the ureters will descend with the bladder to a level safely below the superior aspect of the cuff but care must be taken during closure of the vaginal cuff to avoid both the ureters and bladder injury. *Avoiding bladder injury* - Injury to the bladder may occur while dissecting the bladder away from the lower uterus, cervix, and upper vagina during hysterectomy. This tissue plane is usually easy to find and dissect, whether a hysterectomy is being performed from a laparoscopic, abdominal, or vaginal approach. However, one or more previous cesarean deliveries may cause fibrosis and scarring. In this setting, there is increased difficulty in dissecting the tissue plane with a higher risk of bladder injury. Use sharp dissection, with or without electrosurgery, whether the dissection is easy or difficult, do not perform blunt dissection when developing this tissue plane. Blunt dissection may result in increased bleeding or tearing of the bladder. Bladder injury that occurs with sharp, rather than blunt, dissection can often be easier to repair. In laparoscopic surgery, injury to the bladder usually occurs during secondary trocar insertion. Bladder injury can be avoided by placement of the secondary trocar under direct visualization and by making certain that the bladder is emptied before trocar placement. *Intraoperative maneuvers* - At abdominal hysterectomy, having the first assistant constantly pulling the uterus up, while the surgeon mobilizes the bladder and ligates the uterine arteries and the cardinal/uterosacral ligaments, facilitates descent of the bladder and ureters away from these structures, decreasing the risk of injury. During laparoscopic hysterectomy, having the second assistant constantly pushing the uterus up accomplishes the same maneuver. At vaginal hysterectomy, placing clamps and suturing pedicles as close as possible to the cervix and uterus decreases the risk of ureteric injury. *Identifying a pelvic kidney* - A pelvic kidney, which occurs in from 1 in 500 to 1 in 3000 individuals, may be encountered during gynecologic surgery. They are usually unilateral, retroperitoneal, irregular in shape, and may occur anywhere below the pelvic brim. The blood supply is invariably anomalous, often with branches coming from the aorta, common, external or internal iliac vessels, and vessels may come from both sides of the pelvis. During laparotomy, identification of a pelvic kidney can be made by palpating the abdominal retroperitoneum to confirm that there is no abdominal kidney, and then by identifying the ureter which exits the pelvic kidney [15]. Intraoperative sonography may also be used to identify a pelvic kidney.

### Conclusion

Statistically urological injuries are rare, but are responsible for significant morbidity. Bladder injuries are more common than ureteric injuries but causes less morbidity due to early detection and repair. Ureteral injuries are, however, less frequent but associated with high morbidity. Early diagnosis and intervention are necessary to prevent the occurrence of life-threatening urological complications in gynecological surgery.

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