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Review

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Urological injuries following gynecologic surgery: clinical manifestations, diagnosis and management

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Abstract

Iatrogenic urinary tract injury constitutes a rare but serious complication of gynecologic surgery, occurring in 0.3% to 1.5% of all procedures. Delayed diagnosis and repair are associated with increased postoperative morbidity, mortality and a long-term negative impact on the quality of life. Intraoperative detection of urinary tract injuries allows for prompt repair, facilitates management and speeds up recovery. Bladder injuries are 3 times more common than ureteral injuries, and usually are recognized and repaired immediately with minimal complications. Undetected ureteral injuries lead to severe postoperative complications such as the formation of genitourinary fistulas, sepsis, renal loss and death.

In this review we aim to describe the postoperative clinical manifestations, the diagnostic methods and therapeutic strategies for the management of urinary tract injuries, whether in the acute or delayed setting, in an effort to reduce the potential impact of subsequent complications to both patient and surgeon. Timely and effective repair of urinary tract injuries is critical to improve patient outcome, mitigate litigation risk, and allow an uneventful postoperative recovery in a careful manner.

Key words: Urological injuries, gynecologic surgery, postoperative complications

Introduction

The most common complications after major gynecologic surgery are hemorrhage, urinary tract injury and bowel injury. Iatrogenic urinary tract injuries constitute rare but potentially devastating complications during elective or emergency abdominopelvic surgical procedure[1], that occur in 0.3% to 1.5% of cases[2]. Missed diagnosis and repair are associated with increased healthcare expenditures as well as higher morbidity, mortality and medical costs consequent to high litigation rate[3]. It is reported that gynecologic colorectal and urologic

surgical procedures account for 64%, 26% and 11% of urinary tract injuries, respectively[4], with a rising proportion now attributed to ureteroscopy[5,6]. The majority (50-70%) of these injuries are detected postoperatively with a median delay of two weeks or at a later juncture[7,8]. Unrecognized urinary tract injuries or missed diagnosis and repair failure may lead to severe postoperative complications such as urinoma, intraabdominal abscess, ureteral strictures or fistulas, uroperitoneum, resulting to renal auto-transplantation, renal loss, sepsis or death[9,10]. Additionally, urinary tract injuries may contribute to the development or deterioration of acute renal damage, which is noted in 17.4% of patients undergoing major emergency abdominal surgery[11]. In contrast, intraoperative detection of these injuries permits prompt repair and generally leads to more favorable outcomes[12].

Etiology

Gynecologic surgery is the second most common cause of iatrogenic urological injuries, following urological surgery. Urinary tract injuries may result from a wide variety of mechanisms, including ligation or kinking with a suture, sharp incision and transection (complete or partial), crushing from a clamp, thermal injury or ischemia from devascularization[13,14]. Obstruction or laceration of the urinary tract are the principal mechanisms of injury.

Among the most significant risk factors for urinary tract injuries are the amount of blood lost during surgery (specifically an amount larger than 800ml), lower BMI, larger uterine size as well as prolonged length of surgery[13]. Occurrence of these injuries also depends on the type of surgery performed. Notably, in a study by Donnez et al., a higher percentage of ureteral injuries was observed in transvaginal procedures (0.33%) in comparison to abdominal procedures (0%). However, regarding bladder injuries the percentage was higher in abdominal rather than transvaginal procedures[14]. Laparoscopy is generally considered safer and more beneficial in regards to urological injuries than transvaginal or abdominal procedures; studies have demonstrated a lower rate of both ureteral injuries and cystotomies when laparoscopically assisted techniques were applied[13]. The majority of injuries following laparoscopic methods were due to thermal damage; thus, surgical expertise and careful application of safety rules minimize the rates of these injuries[14].

Ureteral catheter placement during gynecological surgery

In high-risk procedures, prophylactic ureteral stents may be used according to the European Association of Urology (EAU) guidelines on urological trauma[15]. However, the efficacy of ureteral stending remains controversial. Current evidence indicates that prophylactic ureteral stents have the advantages of reducing ureteral injury, shortening the operative time and reducing the amount of bleeding. A randomized controlled trial comparing preoperative stents in major gynecological procedures found no difference in injury rate between those with or without prophylactic stending[16]. Several authors have suggested that preoperative stending may increase the risk of ureteral injury by moving the ureter away from its normal anatomical location and reducing its mobility. The use of trans- illuminating stents has also been reported to help identify the ureter during laparoscopy; however, their use has been limited by costs, as well as by the additional equipment required[17]. The EAU guidelines state that prophylactic double-J stending may help identify and facilitate dissection of the ureters but does not reduce risk of injury. Conversely, the American Urological Association (AUA) guidelines on urotrauma do not address prevention of ureteral injuries[15,18].

Diagnostic methods for the detection of urinary tract injury

Intraoperative Diagnostic methods for the detection of urinary tract injury

The preferred diagnostic approach for detecting such injuries is intraoperative cystoscopy with a retrograde pyelogram, which is recognized as the diagnostic "gold standard". Intraoperative cystoscopy, used to document the presence of bilateral ureteral efflux, is controversial and success rates vary greatly in the literature; however detection rates may be improved by combining it with the use of intravenous indigo carmine during intraoperative cystoscopy. The AUA and EAU mention that the use of intravenous or intra-ureteral dyes such as methylene blue, indigo carmine, and retrograde pyelography may be useful[15,18]. Although cystoscopy exhibits low sensitivity for both bladder and ureteral injuries, it remains more effective in detecting urinary tract injuries compared to visual inspection alone, especially ureteral injuries[19-21].

Visual inspection is commonly used for diagnosing bladder injuries intraoperatively[22,23]. A prospective study including 800 women that underwent hysterectomy revealed that visual inspection detected 38% of bladder injuries, whereas only 7% of ureteral injuries were diagnosed[13]. Meanwhile, randomized controlled studies have demonstrated that the use of prophylactic stents in gynecological procedures has yielded inconsistent results when it comes to reducing the likelihood of ureteral injury[11,24,25]. It may, however, minimize the diagnostic delay and potentially decrease postoperative morbidity[26]. Indicators of urinary tract injuries include the presence of urine in the operative field, blood in the urinary catheter, as well as defects in the ureter or bladder such as transection or laceration. While transient bleeding may result from minor trauma, persistent hematuria necessitates further evaluation for urinary tract injury. Ureteral peristalsis, if observed, can help identify the ureter, but is not necessarily a sign of ureteral integrity. Based on a retrospective study, peristalsis was observed in 5 out of 6 women during total abdominal hysterectomy, to whom cystoscopy was performed and ureteral lesion was detected[27].

Bladder injury as well as urine efflux from the ureteral orifices can be confirmed using intraoperative cystoscopy; if either blood efflux, or abnormal/absent flow from one or both ureters is observed, this prompts the need for additional evaluation for the presence of ureteral obstruction or transection. However, it is important to note that cystoscopy is not sufficient for detecting all ureteral injuries, as partial ureteral obstructions, transections or thermal lesions might be overlooked. Particularly thermal injuries have been shown to be more challenging to detect than direct transections, which in turn delays the diagnosis[28].

In addition to cystoscopy, ureterography may be used to detect a ureteral defect, with contrast extravasation confirming its presence. Another diagnostic method is the intraoperative dye test, during which an intravenous injection of indigo carmine is performed[29]; however adverse side effects have been observed such as hypoxia, severe hypotension, subcutaneous erythema and cardiac arrest[30,31]. Contraindications to this method include hemodynamic instability and renal failure with a creatinine clearance level below 10 ml/min. Out of all available methods, retrograde cystogram remains the "gold standard" for the detection of bladder injuries[32]. The injection of a dyed saline solution via an indwelling urinary catheter can be used as an alternative method and may enhance the detection rate of bladder injuries[33,34].

Postoperative diagnostic methods for the detection of urinary tract injury

When ureteral injury is suspected postoperatively, CT scan with delayed excretory phase is considered

the best diagnostic tool according to the EUA and AUA with a reported sensitivity of 85-100%[35]. Findings on CT urogram include: ureteral contrast extravasation, urinoma, hydronephrosis and ascites. Retrograde or anterograde pyelography are also sensitive radiographic tests for ureteral injury while also allowing simultaneous placement of a stent.

Clinical Manifestations

Following gynecologic surgery, individuals with urinary tract injuries typically manifest symptoms within the initial two weeks postoperatively or at a later stage. Clinical signs and symptoms include abdominal or flank pain (unilateral or bilateral), abdominal distention, nausea with or without emesis, fever that may be accompanied with leukocytosis, urine leakage from the vagina or abdominal incision, hematuria, oliguria or anuria and elevated serum creatinine and BUN levels[36].

In accordance with existing literature, an analysis of 126 cases of ureteral injuries revealed that 17 were identified intraoperatively, 50 within a week postoperatively, 47 within one month and 17 at a later juncture[37]. Notably, lesions in 5 patients remained undetected until two years post-surgery[37].

While partial ureteral obstruction is often asymptomatic, it may progress to complete obstruction and result in renal failure and loss. Complete ureteral obstruction and subsequent urine stasis predisposes to pyelonephritis and may be indicated by ipsilateral flank pain within 24 hours postoperatively. A ureteral or bladder lesion coupled with urine leakage into the peritoneal cavity, may present as ascites with or without abdominal pain. In instances where an abdominal drain was inserted during surgery, intraperitoneal urinary leakage can be identified by the analysis of urea nitrogen and creatinine levels in the peritoneal fluid[38]. Normally, reference values for urea nitrogen and creatinine levels in the peritoneal fluid should be equivalent to the corresponding values in the serum and significantly lower than urine levels[38]. A collection of urine in the retroperitoneum may evolve into anurinoma, increasing the risk of infection and inflammation and resulting in fever development.

Anuria is indicative of bilateral ureteral obstruction, transection, or other structural or intrinsic renal processes. Oliguria, while plausible in the context of ureteral obstruction, lacks specificity as it may result from a variety of different potential postoperative causes. In unilateral complete ureteral obstruction, the contralateral, healthy kidney compensates partially for the loss of renal function, thus only a transient minimal increase in creatinine levels may be observed. A case-control study involving 15 women with unilateral ureteral obstruction following gynecologic surgery reported an increase in creatinine levels 36 to 48 hours post-surgery, with recorded preoperative creatinine levels between 0.8 and 1.4 mg/dl[39].

In cases where uroperitoneum is suspected, biochemical analysis of peritoneal fluid is deemed necessary and the ensuing results are interpreted as follows:

- The concordance of values in the serum and peritoneal fluid is reassuring for the absence of uroperitoneum, although further evaluation is warranted if there is still high suspicion of urinary tract injury. Moreover, if significant non-urine ascites is present, additional evaluation for alternative aetiologies becomes imperative.
- Normal BUN and creatinine levels in the serum coupled with elevated levels in the peritoneal fluid, comparable to the levels in urine, suggest the likelihood of urinary tract injury, and warrant confirmation through cystoscopy and/or imaging.
- Elevated values in both serum and peritoneal fluid may signify both acute renal failure and uroperitoneum, possibly resulting from urinary tract injury. Such outcomes mandate further assessment of renal function as well as the use of

cystoscopy and/or imaging for urinary tract injury.

In instances where ureteral injury is suspected, ultrasonography proves beneficial in assessing hydronephrosis or excluding retroperitoneal collections and computed tomography with renal contrast or cystoscopy with retrograde intravenous pyelography may be performed. The insertion of a nephrostomy tube represents an alternative initial approach for the management of acute renal injury, while further classification can be achieved with the use of computed tomography or magnetic resonance imaging.

Bladder injuries

Iatrogenic bladder injuries are predominantly identified intraoperatively,primarily through visual inspection, in contrast to ureteral injuries, which are often detected postoperatively[40]. A study involving over 200,000 women that underwent hysterectomy revealed that, in comparison to patients without ureteral injury, those with delayed diagnosis of ureteral injury exhibited significantly lower 1-year overall survival rates (99.7% vs. 91.7%)[9]. Bladder injuries may occur during adhesiolysis or bladder dissection at hysterectomy, or during anterior cul-de-sac entry at vaginal hysterectomy. The dome, the trigone as well as the infra- and supratrigonal areas are all potential injury sites. Clinical manifestations include hematuria and abdominal tenderness, progressing to abdominal pain, abdominal distention, peritonitis, and sepsis in the presence of coexisting urine extravasation[41]. Intraoperatively, suggestive signs of bladder injury include urine extravasation, distinguishable bladder laceration, visible bladder and catheter, clear fluid in the surgical field, and the presence of blood and/or gas in the urine collection bag during laparoscopy.

In cases where bladder injury is suspected, cystoscopy is essential for assessing the extent of injury and evaluating ureteral efflux. A prospective study involving 840 women revealed abnormal ureteral efflux without detectable injury in 2% of cases following cystoscopic examination[13]. After the administration of bolus intravenous fluids in all instances of abnormal flow, the urine flow rate normalized, with or without the addition of a diuretic. If cystoscopy is not feasible, a cystogram may be used for the evaluation of bladder injury, albeit with limitations in identifying more subtle findings such as transmural sutures or bladder mucosa attenuation, compared to lacerations or large foreign bodies which may easily be detected. In cases where intraoperative injury is undefined or challenging to localize, instillation of methylene blue dye into the bladder, followed by careful observation for extravasation, may aid in further management[42]. A mere 35.3% of bladder injuries are detected intraoperatively at hysterectomy before cystoscopy is performed, whereas visual cystoscopy has been shown to yield a 94% intraoperative detection rate[43,44]. Notably, routine implementation of cystoscopy does not impact postoperative detection rates, while incurring an additional cost of $83 per hysterectomy and presenting false positive findings in up to 2% of cases[13,22]. Moreover, ultrasound examination in the context of ureteral injury may reveal a characteristic triad of hydronephrosis, ascites, and the absence of a ureteral jet into the bladder[4,45].

In terms of delayed urinary tract injury detection, CT cystoscopy allows for the concurrent evaluation of both the bladder and the ureters, and is the optimal diagnostic tool presenting an accuracy of up to 85-100%[46,47]. Postoperative management and surgical repair of bladder injuries depend on lesion localization (intraperitoneal or extraperitoneal), taking into account that intraperitoneal injuries typically necessitate prompt operative repair to avert infection and sepsis[48]. Simple decompression with a Folley urine catheter may be adequate for managing small bladder injuries (<1cm). Full-thickness bladder injuries larger than 1 cm should undergo primary repair; based on current data 35% of such

injuries are repaired by laparoscopic suturing, 19% through vaginal access, and 15% require conversion to laparotomy for successful repair[49]. The standard approach for bladder injuries consists of a two-layer closure including the mucosa, using absorbable suture material[41]. Running or interrupted suture may be used for the second layer, incorporating the serosa in an imbricating fashion for additional integrity. Larger or more complex injuries may occasionally require additional layers or coverage with an omental flap. Isolated intraperitoneal injuries, however, with no signs of infection or ileus may be managed postoperatively without operative intervention[50]. It is recommended to keep the bladder drainage for at least 7 days postoperatively and to perform a cystogram prior to catheter removal so as to exclude contrast extravasation and to validate the potency of repair, with many protocols advocating the use of a plain CT cystogram[50]. Voiding cystourethrogram (VCUG) after urinary tract injury repair has been shown to reveal abnormal findings in up to 2.9% of cases, as well as modify clinical management; a study assessing the characteristics of VCUG after lower urinary tract repair showed that in all instances with abnormal VCUG findings a change in management of the patient took place (e.g. extended use of an indwelling catheter)[51]. Discomfort or bladder spasm post-repair may develop and may be attributed to the temporary presence of the indwelling Folley catheter or the suture itself. Anticholinergic agents such as oxybutynin or belladonna-opium suppositories are usually effective in treating this condition if need be. In uncomplicated cases, the use of prophylactic antibiotic administration is generally not recommended for short-term indwelling Folley catheter use.

On top of urinary catheterization, percutaneous drainage of the peritoneal cavity, has been described as safe and efficient adjunctive treatment option in cases of intraperitoneal bladder perforation[52]. Lastly, bilateral nephrostomy in addition to urinary catheterization is the preferred approach for patients with bladder injury that are deemed unfit for surgery[53,54]. Contraindications to non-operative management include but are not limited to: large extraperitoneal bladder injuries, bladder neck injuries, injuries associated with other lesions requiring operative management and cases involving adjacent orthopedic implants such as external pelvic fixators[55,56]. Direct repair of extraperitoneal bladder injuries is preferred in such circumstances[53]. Trigonal or infratrigonal injuries may involve the ureters or urethra and are more challenging to repair than dome or supratrigonal injuries [Table 1]. Assessment of ureteral and urethral integrity is essential in cases of trigonal injury, with potential need for ureteral stent

Table 1. Methods of Cystotomy Repair and Follow-Up According to Type of Injury57

INJURY TYPE	MANAGEMENT	FOLLOW-UP
Pinpoint full-thickness serosal injury only	Expectant management	Routine
Non-trigonal ≤1cm	Primary repair or expectant management	Urinary catheter decompression ×1 week
Non-trigonal >1cm	Primary repair, 1-2 layers ± closed suction drain	Urinary catheter decompression ×1-2 weeks ± cystogram
Trigonal complicated, necrotic or infected injury	Specialist consultation repair, possible stenting or reimplantation, closed-suction drain	Urinary catheter decompression ×1-2 weeks, Possible stenting CT cystogram

placement. Urethral injuries, commonly observed during pelvic surgery for urinary incontinence or pelvic organ prolapse, may lead to the formation of urethrovaginal fistula, particularly in association with anterior colporrhaphy or obstetric forceps rotations.

Ureteral Injuries

Ureteral injuries encompass a variety of signs such as ureteric obstruction, hydronephrosis, contrast medium extravasation, ascites and localized fluid collections, such as urinoma[4,45]. Intraoperative diagnosis of such injuries is commonly facilitated through retrograde pyelography or ureteroscopy. The optimal diagnostic tool for detecting ureteral structure or contrast extravasation remains cystoscopy with bilateral retrograde pyelography[4]. In the event that retrograde pyelography results are equivocal, ureteroscopy may be used to achieve direct visualization of the ureters. Suspicion of ureteral transection may prompt the administration of intravenous indigo carmine or methylene blue together with furosemide to observe for blue-tinged urine extravasation. In cases of suspected ureteral ligation, it is recommended to dissect the target-area in order to directly identify and visualize the ureter. Another option would be a retrograde ureteral catheterization; unhindered passage to the renal pelvis indicates no or incomplete transection or occlusion.

Overall, CT urography with both nephrographic and excretory phases (the latter is performed 5-20 minutes after contrast administration), emerges as the "gold standard" method for suspected ureteral injuries[58]. In rare instances where the ureter is sutured despite the absence of transection, attempting balloon dilation of the ligated portion may obviate the need for surgery[59,60]. Partial ureteral transection is preferably managed through percutaneous nephrostomy tube placement, wire recanalization of the ureteral lumen and stent placement[10]. In patients with high risk of retrograde stent placement failure or following a failed attempt, percutaneous nephrostomy with anterograde stent placement may be considered as a more optimal choice[53].

It should be noted that conservative management poses a risk of subsequent ureteral stricture, therefore surgical intervention is preferred for complete or extensive ureteral lesions. Repair approaches vary based on the location of the injury [Table 2]; lesions in the upper or middle third of the ureter are primarily repaired with uretero-ureterostomy, in which the distal and proximal ureteral ends are debrided to viable tissue and reconnected with a standard running or interrupted end-to-end anastomosis. Transuretero-ureterostomy serves as a second-line technique, particularly when primary reconstruction is not attainable[61]. Reportedly, transuretero-ureterostomy features a high potency rate; however its application is mostly limited to patients with unfavorable prognosis, given the concerning risk of injury to the contralateral healthy excretory axis[62].

Lower-third ureteral injuries necessitate direct reimplantation through uretero-neocystostomy[10].

Table 2. Types of surgical approach according to location and severity of ureteral injury

LOCATION/ SEVERITY OF URETERAL INJURY	OPTIMAL TREATMENT
Upper or Middle third of ureter	Uretero-ureterostomy Transuretero-ureterostomy as second line
Lower third of ureter	Direct reimplantation through uretero-neocystostomy
Complete resection or severe injury of the distal part of the ureter	Boari flap or the psoas hitch technique
Extensive or multifocal ureteral injuries	Ureteral substitution or nephrectomy

If there is a complete resection or severe injury to the distal part of the ureter and the remaining portion cannot reach the bladder for reimplantation, a boari flap or the psoas hitch technique is employed to diminish tension at the anastomosis[63]. The psoas hitch technique involves mobilizing the bladder prior to hitching it to the psoas minor tendon; the ureter is subsequently reimplanted, preferably using a tunnel technique[64]. This is the preferred option, although normal capacity of the bladder is essential. The boari-flap technique entails opening the bladder on its anterior surface, swinging a full-thickness bladder flap cranially, and tubularizing it so that an anastomosis with the proximal ureteral segment is performed[59]. Arguably, robotic platforms may offer assistance and optimize anastomosis construction[65,66].

The overarching goals of ureteral injury management are ensuring renal preservation and adequate drainage. However, salvage procedures such as auto-transplantation, ureteral substitution or nephrectomy may be inevitable in certain cases of extensive or multifocal ureteral injuries[59,67]. Renal auto-transplantation may be considered as a last resort to avoid renal loss when less invasive and complex options are deemed unamenable, although it carries a risk of renal perfusion injury. It involves reimplantation of the kidney in the pelvis following nephrectomy; the renal vessels are anastomosed with the iliac vessels and the ureter is anastomosed with the bladder[68]. In ureteral substitution, parts of the gastrointestinal tract such as the ileum, appendix, or colon, are used as a conduit for urinary diversion, with ileal substitution being the most commonly used technique. Contraindications to this method include azotemia, inflammatory bowel diseases, limited bowel, liver dysfunction or lower urinary tract disorders causing elevated bladder pressure[62]. Notably, malignancy represents one of the most crucial long-term risks following bowel substitution, with an incidence rate of 0.8%[69,70].

Conclusion

Urinary tract injury is a rare but crucial complication of gynecologic surgery. Surgeon's inexperience is considered to be the primary risk factor for such iatrogenic injuries. To that end, enhanced anatomical knowledge and familiarity with anatomical structures may well be the predominant preventive strategy, as commonly suggested. The delayed diagnosis of urinary tract injuries is intricately associated with escalated healthcare expenditures, higher morbidity and mortality rates, and legal ramifications. Timely diagnosis and intervention are imperative so as to avert the onset of potentially life-threatening urological complications during gynecological surgery.

Conflicts of interest

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