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Iatrogenic Thermal Energy-Induced Distal Ureteric Injury and Its Management by Laparoscopy Ureteroureterostomy

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ABSTRACT

Background and Objectives: Most thermal energy-induced distal ureter injuries are missed intraoperatively as they are caused by delayed ischemia-induced necrosis of the affected part leading to fistula, and a delayed presentation. The injuries of the distal ureter are commonly managed by ureteroneocystostomy, which has long-term complications related to vesico-ureteric reflux (VUR). We present our experience of management of distal ureter injury due to thermal energy by laparoscopy ureteroureterostomy and the role of various methodologies for its diagnosis.

Methods: It is a retrospective, single-center study that was conducted from January 1, 2020 – December, 31 2022.

Results: A total of 8 cases were enrolled in the study. All cases had an uterovaginal fistula (UVF) post-laparoscopic gynecology surgery. The bilateral ureteric injury was observed in 2 cases. The median post-surgery time to diagnose UVF in the study was 10 days. All cases were managed by laparoscopy ureteroureterostomy (LUUS). Six cases underwent immediate surgery after the diagnosis; whereas 2 cases had initial double-J stent placement as treatment, which subsequently failed following which the LUUS was performed. There were not any immediate or long-term complications such as leakage, stenosis, fistula, or any requirement for revision surgery.

Conclusion: The management of thermal energy-induced ureteric injury is exceptional as compared to other types of ureteric injury. Our approach should be toward immediate surgical management rather than a conservative one to avoid long-term complications and sequelae. Iatrogenic lower ureteral injury can be managed successfully by LUUS, maintaining the normal anatomy and physiology of VUR.

Key Words: Double-J stent, Laparoscopy ureteroureterostomy, Reimplantation of the ureter, Thermal energy-induced ureter injury, Uretero-vaginal fistula, Vesico-ureter reflux.

INTRODUCTION

Ureteral injuries are an ordeal for the surgeon as it is difficult to diagnose intraoperatively in pelvic laparoscopic procedures which require a high index of suspicion, surgical expertise, and a detailed knowledge of ureteric anatomy in the pelvis. Varied grave complications like urinoma, ureteral stricture, ureteral obstruction, and probable loss of renal function can arise from an unrecognized or delayed presentation of ureteral injury. The literature cites that most intraoperative ureteral injuries occur during gynecologic surgery (52–82%), in which hysterectomy accounts for most cases. Hysterectomies for any benign pathologies had 0.33–1.7%[1,2] associated risk of genitourinary injury. The rest of the ureteric injuries have been documented during urologic (25%), colorectal (15%), and vascular surgical procedures (5%).[3]

The ureteric injury, during any laparoscopic gynecologic surgery, usually occurs following over-cauterization while achieving hemostasis, or due to lateral thermal energy spread. Presently, ureteric injuries during operative laparoscopic gynecologic procedures are on the rise owing to its wide availability.[4] Among various inflictions on the ureter, the thermal injury-induced insult is supposedly different from other injuries like crushing, ligation, transection, avulsion, resection, or angulation. While all the other injuries to the ureters will be limited to the site of the injury, the thermal-induced injury will be more widespread than

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the initial inflict due to a lateral spread and causing devascularization. The proposed mechanism for any post-laparoscopic ureteric fistula is devascularization following which ischemic ends undergo necrosis and fibrosis, and further, retract and lead to fistula formation.[5,6] This is the reason for the delayed presentation of ureteric fistula, approximately 7–21 days post-surgery, following any thermal injury. The suggested maneuvers for immediate intraoperative detection in any ureteric injuries post thermal injury as the presence of bilateral ureteric jet on intraoperative cystoscopy, intraperitoneal visualization of ureteric peristalsis after surgery, and peroperative injection of phenazopyridine or sodium fluorescein dye to see for any leakage were not useful.

There has been a notable shift in the treatment approach for ureteric injury from laparotomy to minimally invasive treatment by laparoscopy or robotics. As early as 1991, Gomel and James[7] and Nezhat et al. in 1992[8] published a case report on the laparoscopy repair of ureteric injury. Since then various kinds of complex urological surgeries have been performed laparoscopically, including bladder reimplantation as well. A considerable incidence of vesicoureteral reflux (VUR) with laparoscopic ureteroneocystostomy (LUN) with subsequent progression on long-term to recurrent urinary tract infection (UTI), pyelonephritis, renal scarring, and renal failure is disapproving.[9] Laparoscopy ureteroureterostomy (LUUS) has been a promising surgical alternative with commendable outcomes,[10] but it is a strenuous surgical exercise to get an adequate length of the distal end along with diligent intracorporeal suturing to prevent ureteric stricture and the risk of recurrent fistula. The decision of repair depends on the site of ureteric injury and its timing of identification. The general proposition is to do immediate surgical repair, if there is an early presentation (within 72 hours), at least with a less invasive procedure with a double-J (D-J) stent insertion with a therapeutic intent into the affected ureter for 6 weeks. If there is a delayed presentation, any surgical intervention is warranted for 6 weeks to 3 months for the tissue edema, inflammation, and fibrosis to subside.[11] In contrast, there are studies in the literature advocating similar surgical outcomes following an immediate or delayed surgical management for a ureteric injury.[12] We present our experience in the management of thermal energy-induced iatrogenic ureteral injury at the distal pelvic ureter and its laparoscopic repair by end-to-end ureter-ureter anastomosis. The role and importance of various preventive and diagnostic methods as prophylactic D-J stent placement before surgery for ureteric identification or the role of immediate endourological treatment by stenting has also been discussed in detail.

MATERIAL AND STUDY DESIGN

This is a retrospective study conducted at a single center from January 1, 2020 – December 31, 2022 (36 months). A total of 8 cases were enrolled in the study, who were referred to our center for further definitive management. All the cases were managed by laparoscopy ureteroureterostomy through a three-dimensional (3D) laparoscopy set-up performed by a single surgeon. The data were retrieved from the patient's case sheets, operative notes, videos, and follow-up medical records.

Diagnostic Approach

Symptoms and Presentation

Ureteric injury due to thermal energy usually presents with delayed presentation. A characteristic symptom of continuous watery discharge through the vagina from day 7 and onwards after the surgery is characteristic of UVF. Flank pain may present due to occlusion of the ureter or its fistulization into the peritoneal cavity or retroperitoneal space presenting as a flank mass. Hematuria is present only in 25–30% of patients, and its absence is not a reliable sign.[13] In the early postoperative period patients' complaints (including abdominal and flank pain, hematuria, fever, or paralytic ileus) should have one differential diagnosis as urinary tract injury as it mimics the same as postoperative symptoms. Evaluation should be done if symptoms do not improve.

Computed tomography with intravenous pyelogram (CT-IVP) is the preferred imaging technique for a definitive pre-operative diagnosis. A CT-IVP provides a better 3D delineation of the relevant anatomy and continuity of the whole urinary tract as well as the site of ureteral injury through the extravasation of contrast material at the location. Delayed scans using CT-IVP reveal an enhancement of fluid collection due to contrast leaking from a ureteric injury, outlining a track connecting the vagina to the distal ureter. Several other findings on CT imaging studies that are suggestive of a ureteral injury include the absence of contrast material distal to the injury due to the transection or complete obstruction, ipsilateral hydroureter, hydronephrosis, and incomplete visualization of the entire ureter.[14] There are chances of false positive results when the lesion is too close to the vesico-ureteric junction owing to a dye leak in the bladder. Low ureteric injury cases are usually associated with vesicovaginal fistula in 12–25%.[15] A pre-operative clear diagnosis regarding the different sites of involvement along with any fistulous connection is imperative for definitive management. Thus, a detailed

intraoperative exploration and dissection of the ureter and the bladder will further substantiate the pre-operative diagnosis. Patients with renal failure or with contraindications for CT may utilize a pre-operative magnetic resonance imaging for the diagnosis of the same.

An antegrade pyelogram is an imaging modality for the upper urinary tract. It may be used as a preliminary investigation for the detection of UVF in a limited resource setting. The positive findings suggestive of a fistulous tract may be extravasation of dye outside the ureter, leakage of contrast media into the vagina, or features of hydronephrosis and hydroureter without vaginal drainage. Though this has a very low sensitivity for UVF detection (33%). In case of a dilemma, retrograde pyelography can be performed as a definite test. This technique additionally has the benefit to differentiate between a ureterovaginal fistula from a vesicovaginal fistula. Alternatively, an examination of the fluid leaking through the vagina for the urea and creatinine levels can diagnose urine, if the findings are too close to normal urine (urine creatinine: > 10 mg/dL).[16]

Pre-operative Preparation

Patients provided informed written consent after hearing the explanation of the complexity of the procedure and the possibility of leaking post-surgery. The chances of performing redo implant surgery (uretero-neo cystostomy) along with its long-term complications were also explained in detail. All baseline investigations, especially urine routine/microscopy and urine culture/sensitivity were done pre-operatively. Antibiotics were given according to the sensitivity reports or as routine. All patients underwent a CT urogram (abdomen, pelvis, intra-venous pyelography).

Surgical Steps

All cases were operated using a 3D laparoscopy system by a single surgeon. The patients were placed in a low Trendelenburg position. The various port position was as routine with a supra-umbilical primary 10-mm port for the camera along with 3 accessory 5-mm trocars inserted, two on the surgeon's left side and one on the right side. The head's low position was provided adequately to keep the bowel away from the pelvic cavity. Cystoscopy was routinely performed to visualize the bilateral ureteric orifice and for the evaluation of the bladder wall. Coexisting vesicovaginal fistula were also looked for as there were incidences of combined vesicovaginal fistula along with ureterovaginal fistula.

Initially, the first endo view is visualized with a detailed inspection and analysis of the site of the injury, associated positive findings, and most importantly the tissue health for regenerative surgery. The first endo view of a case of right UVF is shown in **Figure 1**. The surgery is started with a retroperitoneal dissection, in which the overlying peritoneum is incised starting from the level of sacral promontory towards the round ligament followed by tracing the ureter in the medial fold of the peritoneum from its entry into the pelvic cavity. The ureter is then lateralized from its medial attachment with a meticulous dissection keeping its adventitia layer intact (**Figure 2**). The proximal end is adequately mobilized to get an adequate length for tension-free anastomosis. The surgery is usually performed using a cold scissor as a dissector and suction, as required, using the energy sources as minimally as possible. The distal end of the injured ureter can be identified by concomitant use of cystoscopy and laparoscopy by placing guide wire by cystoscopy and tracing its tract intra-peritoneally (**Figure 3**). Under laparoscopic guidance, a guidewire (0.635 mm in diameter) is introduced into the proximal cut end of the ureter through the rail-road technique (**Figure 4**). Further, over this guidewire, the surgeon inserts a size 5 French D-J stent (**Figure 5a**). Subsequently, dissection of the

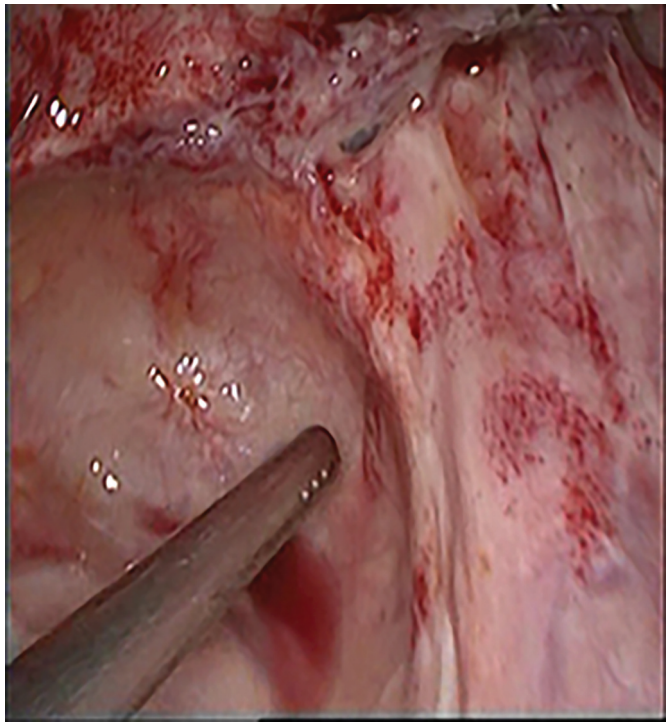

Figure 1. Inflamed pelvic peritoneum tissue with no frank intraoperative leak seen.

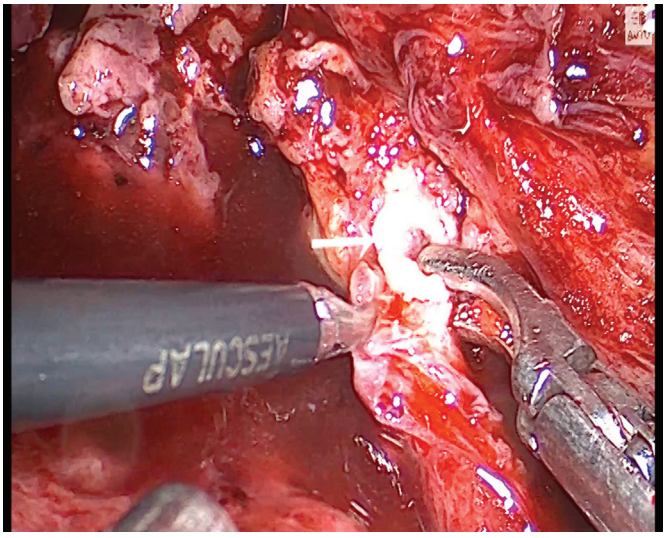

Figure 2. Right lower ureteric defect, identified after the retroperitoneal ureteric dissection.

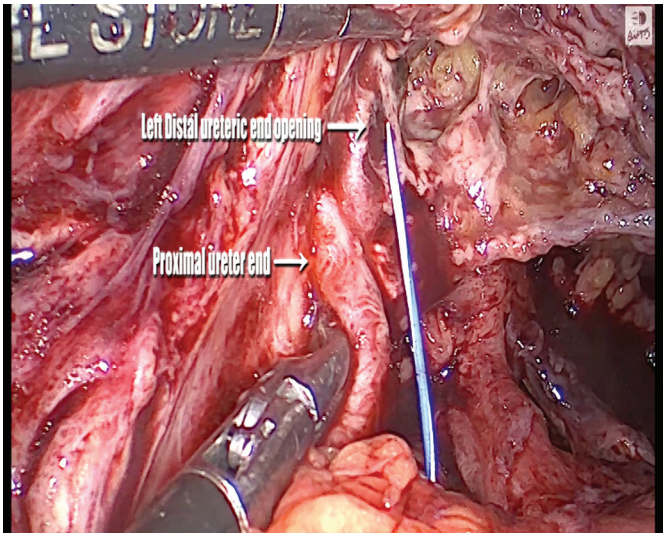

Figure 3. Endo view of identification of injured distal ureteric end with the help of cystoscopy guided insertion of guide wire.

lower end has further proceeded to get an adequate length for suturing along with the excision of devitalized tissue (**Figure 5b**). The repair alternatives depend on the availability of the length of the cut end of the distal ureter. A deliberate dissection with an adequate mobilization of the proximal ureter for tension-free anastomosis is justified.

The successful ureteral repair depends on the following principles:[10]

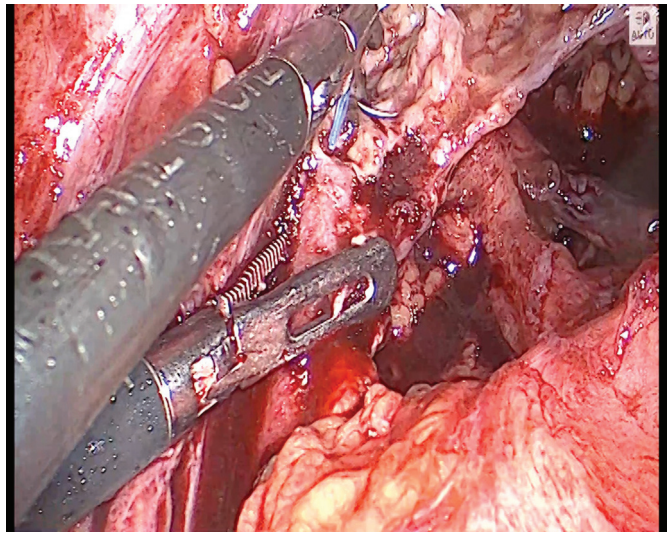

Figure 4. Insertion of guide wire into the proximal cut end of the left ureter laparoscopically.

- All devitalized tissue should be essentially debrided to get healthy vascularized tissue at both the cut ends.
- A tension-free anastomosis with sufficient ureteral mobilization is a must.
- It is critical to preserve the ureteral adventitial sheath (as it has minute vessels interlinked by a web of anastomosing arcades that supply the ureter)[16] and its vasculature for an adequate ureteral blood supply.
- A ureteroureterostomy should be performed over a ureteral stent with a spatulated end from mucosa to mucosa. It should be a water-tight and tension-free anastomosis using an absorbable suture. The choice of repair depends on the availability of distal ureter end length.

The first stitch is placed at the 6 o'clock position with a polyglactin 910 (Vicryl 3-0 or 4-0) approximating mucosa to mucosa and then further stitches are placed in the same way at the 3, 12, and 9 o'clock positions, in a single layer (**Figure 5c, d**). Intraoperatively, postureteric anastomosis, the vascularity of the anastomotic site is assessed using clinical features such as visualization of surrounding capillary refill. Multiple stitches at an anastomotic site should be avoided as it increases the risk of fibrosis and further enhances the risk of stricture formation at the operative site. The intra-peritoneal drain in the pelvic cavity is kept in situ in all cases. The Foley catheter was placed in all patients at the end of the procedure.

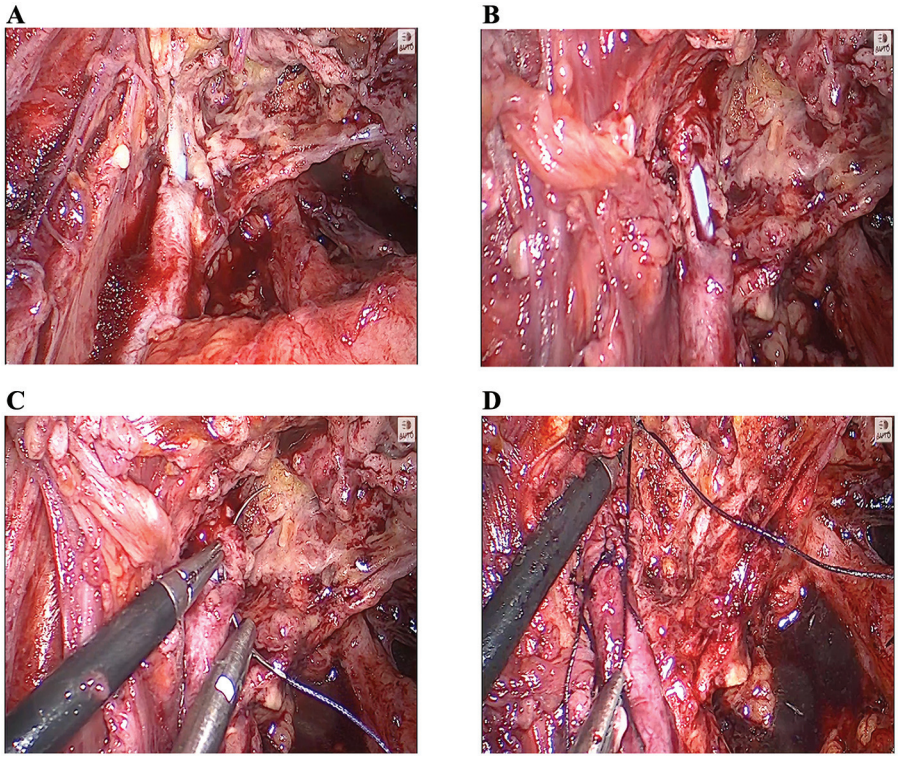

Figure 5. A) Double-J stent in situ with ureteric fistula before excision of devitalized tissue. **B**) Double-J stent in situ with ureteric fistula after excision of devitalized tissue. **C**) Laparoscopy ureteroureterostomy mucosa to mucosa with polyglactin 910 (Vicryl3-0). **D**) Final end view after laparoscopy ureteroureterostomy.

Postoperative

The intraperitoneal drain was removed once output was minimal. The Foley catheter was removed on postoperative day 2. The D-J stent was kept in situ for 6–8 weeks. A CT-IVP was performed in all cases after the removal of the D-J stent. All the patients were followed every 6 months, on an outpatient basis. The patients were asked for their respective symptomatology related to any post-surgery complications. A renal ultrasound was done at each visit to rule out any stricture formation at the anastomotic site post-surgery.

RESULTS

A total of 8 cases were operated during the study duration. All cases of UVF were post-laparoscopic gynecology surgery. Seven cases of UVF were post-total laparoscopy hysterectomy (TLH) and 1 case was reported post-laparoscopy radical hysterectomy (LRH) surgery. Bilaterality was observed in 2 cases, while 6 cases had a unilateral ureteric injury. Interestingly, 1 patient had an injury at 3 sites over both ureters.

The most common presenting symptom was the leaking of clear fluid per vagina followed by flank pain. The median age in the study population was 40 years (range 38–52 years) and the median body mass index was 24 kg/m^2 (range 22–32 kg/m^2). The indications for hysterectomy in the study were adenomyosis (n = 3), fibroid uterus (n = 1), deep infiltrating endometriosis (n = 3), and carcinoma cervix (n = 1). The median post-surgery time to diagnose UVF in the study was 10 days (range 10–21 days). Six cases in our study had immediate management of their UVF. The D-J stent placement was done initially in 2 cases for therapeutic purposes which subsequently failed following which the reconstructive surgery was performed 6 weeks later.

Case number 5 requires special mention (**Table 1**), as this patient presented on postoperative day 7 with complaints of watery discharge per vaginum. A CT-IVP revealed 2 low ureteric fistulas, one on both ureters. The fistula on the right side was 1.5 cm and on the left side approximately 1 cm on

Table 1.
Description of Indication of Primary Surgery with Intraoperative Findings of Individual Cases, and Follow-up Duration Post-Surgery

Case Number	Laterality	Primary Surgery	Indication for Primary Surgery	Interval between Primary Surgery and Diagnosis (days)	Circumference of Ureteric Injury	Distal Ureteric Length (cm)	Reconstructive Ureteric Surgery	Duration of in situ D-J stent, post-surgery (weeks)	Follow-up (max 36 months)
1	U/L	TLH	Adenomyosis	10	< 50%	4	LUUS	6	35
2	U/L	TLH	Adenomyosis	10	> 50%	5	LUUS	6	32
3	U/L	TLH + BSO	Ovarian Endometriosis	08	> 50%	4	LUUS	6	28
4	U/L	TLH + BSO	Deep infiltrating endometriosis	14	< 50%	4	LUUS	6	26
5	B/L	TLH	Large fibroid uterus	21	Left 100% Right > 50%	Right: 2 – 3	Left LUN Right LUUS	8	23
6	U/L	TLH + BSO	Endometriosis	16	> 50%	6	LUUS	6	20
7	U/L	TLH	Adenomyosis	10	> 50%	5	LUUS	6	14
8	B/L	LRH	Carcinoma cervix (FIGO IB 2)	21	B/L > 50% Left side ureter had 2 sites of injury, one was in lower ureter and another one was at the level of IP ligament	2.5 cm on right side 3 cm on left side	LUUS	8	6

D-J, double-J stent; U/L, unilateral; B/L, bilateral; BSO, bilateral salpingo-oophorectomy; TLH, total laparoscopic hysterectomy; LRH, laparoscopic radical hysterectomy; LUN, laparoscopic uretero-neocystostomy; LUUS, laparoscopic uretero-ureterstomy.

the greatest dimension as per the CT-IVP report. Conservative management was planned for this case with bilateral D-J stent insertions, which were kept in situ for 6 weeks. The follow-up CT-IVP after the removal of the D-J stent still showed a bilateral ureteric fistula, with an even further increase in size. The fistula on the right side was now 2.5 cm and 1.5 cm on the left side. At this point, the decision to proceed with surgery was made, with LUN performed on the left side ureter and LUUS was performed on the right side.

Case number 8 (**Table 1**), required prophylactic intraoperative bilateral D-J stent insertion due to extensive ureterolysis during the surgery, which was kept in situ for 3 weeks. The follow-up CT-IVP after the removal of the D-J stent revealed a bilateral ureteric fistula at 3 sites, 2 cm on the right side and 1.5 at the low pelvis near the bladder, and 1 cm on the left side away from the bladder. The decision for reconstructive surgery was taken with 8 weeks in situ D-J stent post-surgery (**Figure 6**).

The mean operative time was 90 min (range 90–130 min) with an average blood loss of 30 ml (30–50 ml). The intraperitoneal drain was removed if the drain output was < 10 ml per day with a mean duration of 2 days (2–3 days). The D-J stent was kept in situ for a median duration of 8 weeks (6–8 weeks). Three patients had post-D-J stent infection symptomatology, after which treatment was given according to the culture and sensitivity report. One patient had developed post-stent stricture after 6 months of reconstruction surgery at the level of the infundibulopelvic ligament which required ureteroscopy balloon dilatation of the affected part and placement of respective D-J stent for 8 weeks. None of the cases had any associated vesicovaginal fistula in the study population. No postoperative blood transfusion, any serious intraoperative complications, or conversion to laparotomy were required in any of the cases. The median hospital stay was 2 days (range 2–3 days). There were no immediate postoperative complications like infection, paralytic ileus, fever, significant pain, or recurrent fistula. Long-term follow-up also revealed no complaints of leakage, stenosis, obstruction, necrosis, hydronephrosis, fistula, or requirement of revision surgery. All patients had complete disease resolution as per clinical and radiological findings.

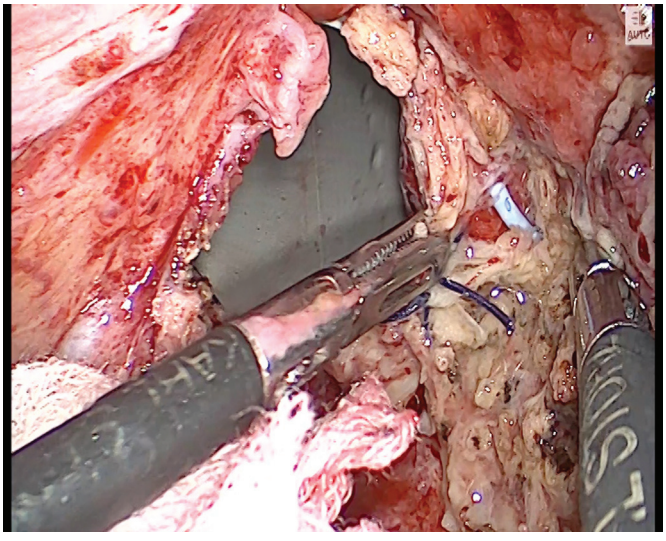

Figure 6. Development of right lower ureteric defect with persistent double-j stent in situ for 21 days (prophylactic placement post primary surgery in case 8).

DISCUSSION

Ureteric injury may frequently lead to catastrophic consequences owing to its delayed exposition.

In this article, we discuss various intraoperative and preventive maneuvers along with varied diagnostic methods as enumerated in the literature for early detection and management. Prophylactic ureteral stents or catheters can be placed before the surgery to assist in the intraoperative identification of ureters. This is often performed in pelvic surgeries that occur close to the ureter, to exemplify gynecologic cases like deep infiltrating endometriosis of parametria, vault endometriosis, and LRH. This is of great significance in cases where the pelvic operative field is already scarred from previous dissection done during the endometriosis surgery with the possibility of ureters being close to the uterus due to healing fibrosis. Nevertheless, the pre-operative ureteric stent placement to prevent its injury is a topic of debate.[17] Ureteric stents can only help in the identification of ureters, but their benefits are limited in cases requiring ureteric tunnel dissection. The proper knowledge of different energy sources[18] along with the identification of their lateral spread is of utmost importance, as the lateral spread of energy, if not identified and managed properly will still be the causative factor for ureteric injury, even after the intraoperative recognition of ureters. Further, ureteric stent placement makes ureteric handling more difficult during dissection, owing to loss of its pliability, and thus, has increased chances of ureteric trauma. The placement of lighted ureteral stents can also be one of the preventive measures but still, there is an associated risk of injury due to lateral spread of thermal energy.

Even the role of prophylactic or therapeutic ureteric stent placement in a case of extensive ureteric dissection with

no intraoperative diagnosed iatrogenic ureteric injury or with a peroperative diagnosed case of iatrogenic ureteric injury respectively, in minimally invasive approach is of questionable advantage in the prevention of ureteric injury, as observed in our study with case numbers 5 and 8 (**Table 1** and **Figure 6**). The intraoperative features might suggest ureteric injury and thus can guide further management plans. If there is capillary refill even delayed, it indicates reversible injury. On the contrary, if it is a complete blanching without refill with loss of vascularity (**Figure 7**) and no capillary refill, this may indicate probable chances of future fistula and this injury should be immediately excised with suturing of healthy ends over a D-J stent for anastomosis. The probable mechanism explained for the injury could be ischemia induced necrosis that gradually increases with time and thus further increases the defect. Also, these cases may have long-term complications on follow-up as stricture or fistula. Ideal management would be to completely excise all devitalized tissue followed by repair of two healthy ends over a D-J stent. Accordingly, since the fibrotic end will not heal and therefore will not seal any minor defect itself as well, the role of a D-J stent cannot be therapeutic. Short-term or long-term use of any ureteral stents are usually associated with minor complications like hematuria, dysuria, frequency, flank, or suprapubic pain to major complications such as vesico-ureteric reflux, migration, encrustation, urinary tract infection, stent fracture, and necrosis.

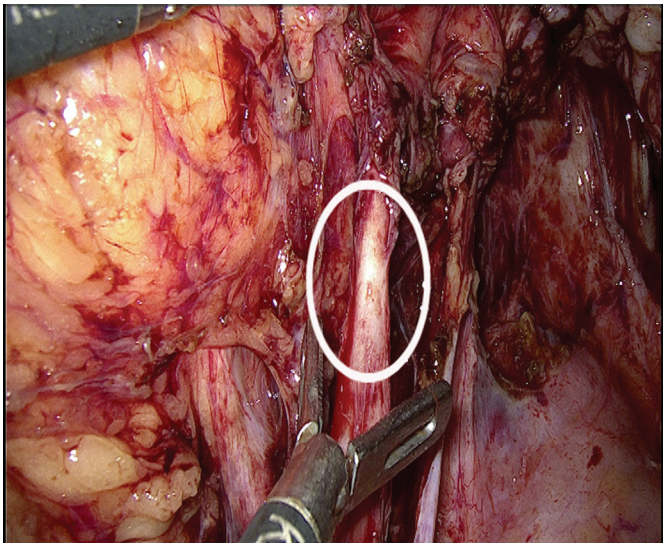

Figure 7. Left side lower ureter with murk color, absent capillary vessel suggestive of devitalized tissue (highlighted in circle).

Another practical and handy method for an intraoperative identification of ureteric injury involves direct visual inspection of the ureters patency using intravenous dyes such as phenazopyridine or sodium fluorescein to evaluate for any dye leakage along the course of the ureter.[19] Its use in a thermal energy-induced injury is limited as there is no immediate leakage of urine owing to its delayed development of ureteric fistula. It usually manifests approximately after 7 days.

The role of intraoperative indocyanine green dye for ureteric injury diagnosis by assessing vascularity along the ureter course and assessing vascularity over the ureter-ureter anastomosis site still requires strong recommendation with a good supporting study.[20]

Intraoperative cystoscopy may help to assess ureteral patency by demonstrating urinary jet from the ureteric orifice due to its peristaltic activity. As noted in the literature, the spontaneous, forward, normal peristaltic movement has also been observed in the ureteral segments isolated in vitro or even after inversing a ureteral segment in situ. Consequently, it could be concluded that the nervous system has only a modulatory role in ureteral peristalsis.[21] So, the definitive role of intraoperative cystoscopy with visualization of the ureteric jet for the diagnosis of thermal energy-induced ureteric injury is limited. A meta-analysis study by Teeluckdharry, et. al.,[22] showed that it does not have any significant detection rate on postoperative ureteric injury. Also, the routine cystoscopy performed at the time of hysterectomy for any benign indication does not lower the rate of delayed lower genitourinary tract injury, on the contrary, it increases the risk of urinary tract infection and further increases the operative time.

Intraoperatively, if there is a suspicion of ureteric injury, then a very low threshold should be maintained for the visual inspection. The surgical exploration of the retroperitoneum and direct visualization of the ureter is the most accurate method to identify the ureteral injury. The inspection of the ureter should involve the entire course of the pelvis after complete mobilization of the ureter from its peritoneal attachment, and visualization of the complete wall of it circumferentially for any evidence of discoloration, contusion, hemorrhage, or disruption.

In the literature there is no consensus on the timing of surgery as some suggest delayed management after 6 weeks,[11] and others show no difference in outcome between immediate and delayed.[12] In our study, the timing for reparative surgery was usually immediate post-diagnosis. In cases with immediate management after diagnosis (cases 1, 2, 3, 4, 6, 7) available distal ureter end

was approximately 4–5 cm and in cases with delayed management (cases 5 and 8) available ureter distal end was 2.5–3 cm. Also, intraoperative ureter injury size was more compared to pre-operative imaging findings due to devitalized tissue. This leads to delayed intervention decreasing the chance for UUS due to short distal end length and might increase the chance of failure.

The suture material used in our study for LUUS was polyglactin 910 (Vicryl 3-0 or 4-0). Many studies in literature[12] support the use of 5-0 or still above numerology polyglactin 910 (Vicryl) for suturing. Early intervention (3 weeks) was done in cases (1, 2, 3, 4, 6, 7) in our study which precludes the use of polyglactin 910 (Vicryl 5-0 or 6-0) sutures owing to tissue inflammation in these cases which will not be able to hold these fine suture material. We have successfully used polyglactin 910 (Vicryl 3-0 or 4-0) in these types of cases with considerable results as well. Some studies were skeptical regarding the increased chances of fibrosis and stricture following the use of polyglactin 910 (Vicryl 3-0 or 4-0), but the same has not been observed in our study. However, further larger comparative studies are required to validate this fact.

The shortest distal end of the ureter for anastomosis was 2–3 cm in our study. This is well supported by Lee et al,[23] which recommends that even if a distal 2-cm end is present for LUUS, we can expect good results without any increased risk of stricture in the future.

The literature recommends that ureteric reimplantation can be achieved through a refluxing or nonrefluxing methodology and nonrefluxing reimplantation is usually favored.[24] Executing a laparoscopic nonrefluxing ureteric reimplantation is challenging due to an arduous surgical step and difficult ergonomics. This factor is usually vanquished with LUUS, which retains the natural VUR mechanism. Also, the LUUS group had shorter operative time and lesser intraoperative blood loss than the LUN group.[25]

Postoperative, the D-J stent was kept in the repaired ureter for a median of 6 weeks duration (range 6–8 weeks). The prolonged stent placement also increases the risk of UTI. According to a study, 2 to 8 weeks are required for adequate healing and prevention of stricture post-repair.[26] A study by Visser et al,[27] suggests a ≤ 3 weeks' time post-surgery as longer renal transplant increases the risk of UTI. Currently, there are no published studies that provide a concrete recommendation regarding the timing of stent removal. Only complaints of UTI in three cases, which were managed by antibiotics have occurred in our study.

Prophylactic Precautionary Steps in TLH

The gynecology pathologies such as superficial peritoneal endometriosis, large cervical fibroid, or parametrial DIE may have the probability of deviated ureteric anatomy, so a retroperitoneal dissection and, if needed, an ureter dissection in the tunnel as in radical hysterectomy to keep the ureter under vision during the surgery is warranted.[16]

We note the following important landmarks during laparoscopic pelvic surgeries where thermal energy should be applied cautiously as the ureter may lie nearby and may lead to an increased risk of ureteric injury due to lateral energy spread. While operating near to uterosacral ligament, the ureter is approximately 3 cm away (**Figure 8**), and the distance may further decrease due to it pulling up in endometriosis cases, so one must be vigilant. The gauze is preferably used for hemostasis instead of a bipolar energy source if required at these sites (**Figure 9**). The cervicovaginal junction, especially at 2 o'clock and 10 o'clock positions (**Figure 10**) (vaginal artery location) should be properly coagulated before cutting, as it may get retracted leading to undue overapplication of energy to achieve hemostasis. This may lead to energy delivery to the ureter with its lateral spread and probably increase the chances of ureteric injury. The surgery should be performed cautiously while dissecting the cardinal ligament to avoid taking the posterior pelvic peritoneum (**Figure 11**). The management of any thermal energy-induced

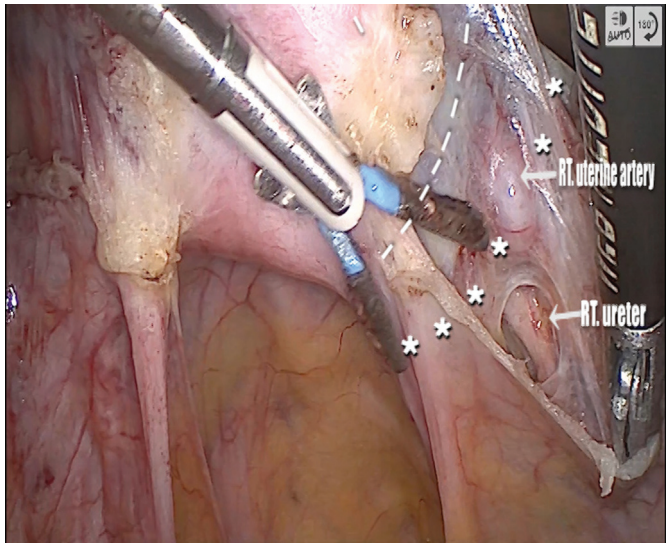

Figure 8. Incision line (highlighted by dashed line) for posterior peritoneal dissection towards uterosacral ligament in total laparoscopic hysterectomy to avoid lateral thermal energy spread. Starred line indicates an incision with a high probability for ureteric injury due to lateral thermal energy spread.

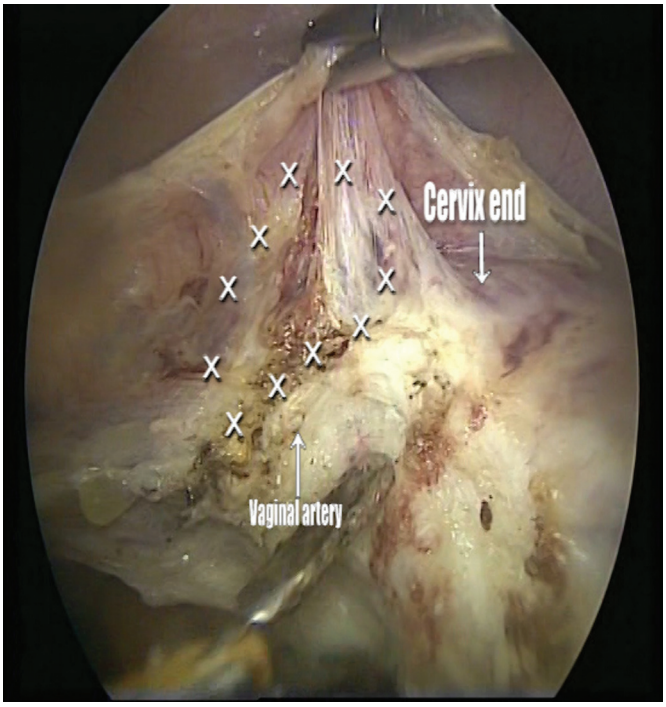

Figure 9. Area around the vesico-uterine ligament, to be avoided with the use of thermal energy, as it may lead to ureteric injury (area between the starred circumference).

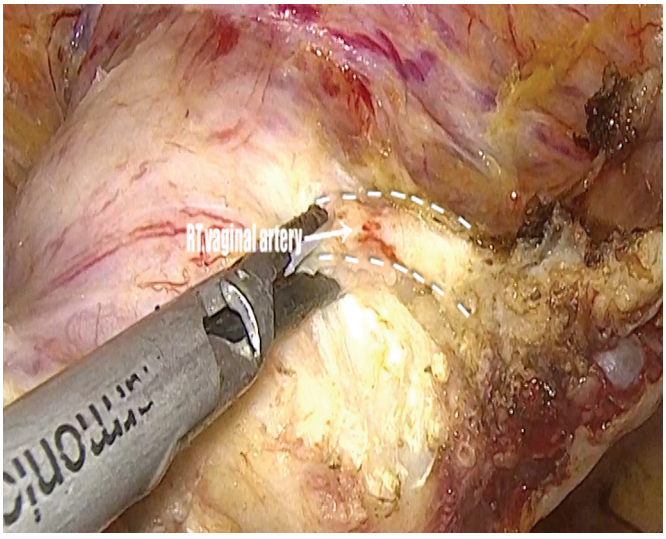

Figure 10. Right-sided partial cut end of vaginal artery at 2 o'clock position in total laparoscopic hysterectomy.

injury should be done immediately by an implant surgery or UUS, after excising any devitalized tissue rather than only placement of the ureteric stent. If there is viability but with a delayed capillary refill and cyanosed appearance (**Figure 12**),

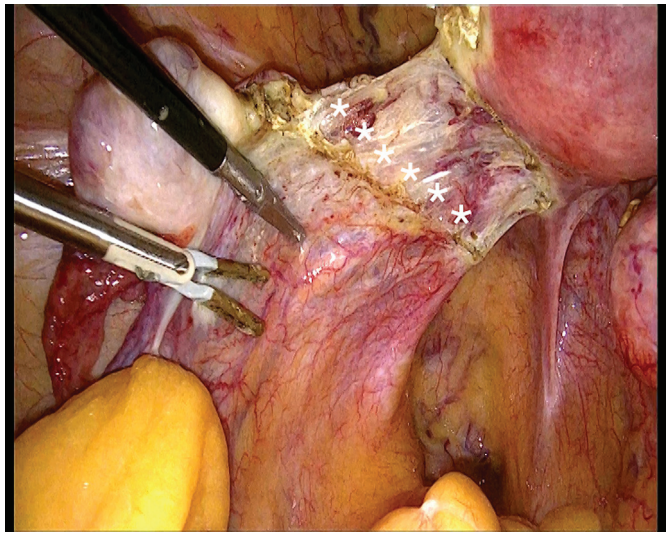

Figure 11. Cut end of the posterior peritoneum to be avoided to prevent ureteric injury due to lateral thermal energy spread (highlighted by starred line).

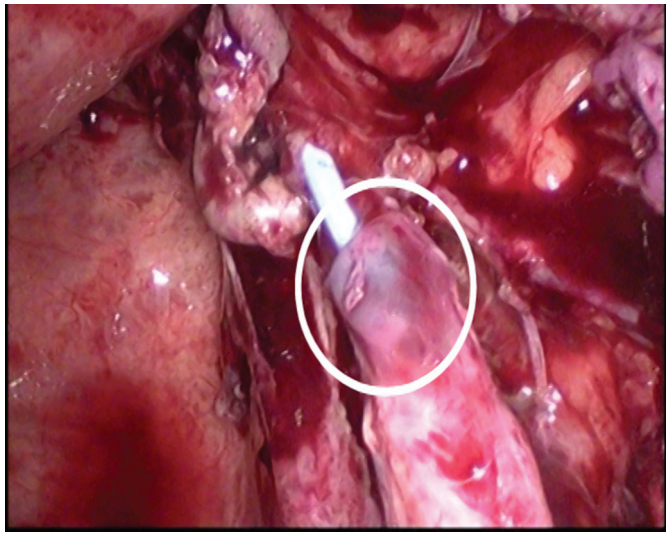

Figure 12. Double-j stent in situ with cyanosed proximal ureteric end (highlighted in circle), which needs to be excised.

the D-J stent should be kept. This is not completely therapeutic and in a scenario of strong suspicion for ureteric injury, CT-IVP is suggested. The mode of approach could be by any modality, open or laparoscopy, but minimally invasive surgery is surpassing open with a better vision and depth assessment, and accurate tissue dissection. Furthermore, technically challenging surgeries like LUUS can be made possible with the benefits of minimally invasive surgery such as less blood loss and

shorter hospital stay. There were no immediate or long-term complications such as stenosis, the requirement of redo surgery, or operative failure post-LUUS in our study. The two cases with bilateral ureteric fistula were successfully repaired. The cons of our study are its small sample size and the retrospective nature.

CONCLUSION

The management of thermal energy-induced ureteric injury is noteworthy as compared to other types of ureteric injury. Our aim should be immediate surgical management rather than conservative D-J stent placement following its definitive diagnosis to avoid long-term sequelae. Iatrogenic lower ureteral injury occurring during pelvic surgery can be managed successfully by LUUS. The LUUS is a satisfactory surgical option in terms of the operative and subsequent outcomes, but must be managed precisely by an expert. Lastly, detailed pelvic anatomical knowledge, especially regarding the course of the ureter should be the learning objective for all pelvic surgeons.

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