



Italian Journal of Gynaecology & Obstetrics

June 2024 - Vol. 36 - N. 2 - Quarterly - ISSN 2385 – 0868

Ureteral injuries management in gynaecologic surgery: the role of the conservative approach

Carlo De Cicco Nardone^{1,2}, Fernando Ficarola^{1,3,*}, Laura Feole¹, Cristiana De Luca¹, Francesco Plotti^{1,2}, Roberto Montera^{1,2}, Daniela Luvero^{1,2}, Giovanni Larciprete⁴, Roberto Marci⁵, Roberto Angioli^{1,2}, Corrado Terranova^{1,2}

¹ Department of Gynaecology, Fondazione Policlinico Universitario Campus Bio-Medico, Rome, Italy.

² Research Unit of Gynaecology, Department of Medicine and Surgery, Università Campus Bio-Medico Di Roma, Rome, Italy.

³ Unit of Gynaecology, Department of Surgical and Medical Sciences and Translational Medicine, Sant'Andrea Hospital, Sapienza University of Rome, Rome, Italy.

⁴ Department of Gynecology and Obstetrics, Fatebenefratelli Hospital Isola Tiberina, Gemelli Isola, Rome, Italy.

⁵ Department of Transitional Medicine, University of Ferrara, Ferrara, Italy.

ARTICLE INFO

History

Received: 16 April 2023

Received in revised form: 17 May 2023

Accepted: 24 May 2023

Available online: 03 June 2024

DOI: 10.36129/jog.2023.127

Key words

Ureteral fistula; ureteral laceration; ureteral stenosis; rendezvous; interventional radiology.

*Corresponding author: Fernando Ficarola, M.D. Department of Gynecology, Campus Bio-Medico University Hospital Foundation, via Alvaro del Portillo 200, 00128 Rome, Italy. Email: ficarola.fernando@gmail.com. ORCID: 0000-0002-2474-2442.

ABSTRACT

Objective. Ureter is one of the most important landmarks to be taken into consideration during gynaecological surgery. Today, mini-invasive techniques are available to treat ureteral injuries in a more conservative way. This study aims to propose a progressive operative model to manage ureteral injuries by comparing conservative and open approaches.

Materials and Methods. This retrospective study analysed 27 injuries in 24 patients admitted for ureteral injuries following gynaecological surgery (in 3 cases, ureteral injuries were bilateral). We obtained data from 16 lacerations, 5 stenosis and 6 fistulas. Patients in the study were treated with three different techniques for ureteral injuries: cystoscopy with retrograde ureteral stenting, interventional radiology and ureterocystoneostomy.

Results. In a retrospective analysis for ureteral lacerations, success rates of the various techniques were: 100% ureterocystoneostomy, 67% rendezvous, 58% percutaneous nephrostomy plus ureteral stenting, 33% percutaneous nephrostomy and 33% cystoscopy with ureteral stenting. Considering ureteral stenosis, success rates were: ureterocystoneostomy 100%, percutaneous nephrostomy plus ureteral stent 33%, rendezvous, percutaneous nephrostomy and cystoscopy with ureteral stent 0%. For ureteral fistula, success rates were ureterocystoneostomy 100%, rendezvous 100%, percutaneous nephrostomy plus ureteral stent 100%, cystoscopy with ureteral stent 33%, percutaneous nephrostomy 0%.

Conclusions. According to the obtained results, conservative radiologic procedures represent a valid alternative to open surgery. We propose a progressive operative model: interventional radiology represents an effective approach that could postpone or avoid invasive procedures. Ureterocystoneostomy is the procedure with higher success rates.

INTRODUCTION

Ureter is one of the most important landmarks to be taken into consideration during gynaecological surgery, as it is one of the organs most involved in complications during this type of surgery. Ureteral injury incidence is 0.1-1.5% for benign surgery (myomectomy, hysterectomy, *etc.*) and 5% for oncologic surgery (radical hysterectomy, cytoreduction *etc.*, if we consider surgery for endometriosis, incidence increases to 21% [1-6]. A separate note appears to be important for cancer patients who may present an increase in perioperative morbidity and frailty, scores have been created for this type of patient to prevent and reduce these complications [6-11].

Cystoscopy may help in the identification of ureteral injury and insertion of ureteral stents could help in the diagnosis and its reparation [12, 13]. Regarding treatment, ureteral stenosis is generally treated with the insertion of a ureteral stent or with ureteral reimplantation surgery. If stent insertion is complicated, contemporary laparoscopy may be useful to completely diagnose the type of ureteral injury and to avoid ureteral perforation [3, 14]. A simple suture is generally avoided because it can cause subsequent stenosis, so the ureteral reimplantation must be considered [15]. Recently, other techniques are available to treat ureteral injuries in mini-invasive ways, like interventional radiology. In this category, various procedures may be used, like percutaneous nephrostomy with or without the insertion of a ureteral stent and the endoscopic-radiologic procedure also known as rendezvous. This procedure has higher success rates, until 88% and is a valid alternative to laparoscopic or laparotomy ureteral reimplantation [16]. After the procedure, if patients are asymptomatic and/or creatinine levels are stable, nephrostomy may be removed, and the stent is substituted or removed after 6 months or less [17, 18]. The study aims to propose a progressive operative model to manage ureteral injuries by comparing conservative and open approaches; we also propose a therapeutic algorithm to reduce invasiveness.

MATERIALS AND METHODS

This is a retrospective study conducted in the Department of Gynecology, Campus Bio-Medico University Hospital Foundation Rome on 24 patients admitted for 27 ureteral injuries caused by gynaecological surgical procedures between 15th January

2016 and 6th September 2021. After consultation with our local Ethical Committee, our study was defined as exempt from IRB since the study was observational and not interventional (no randomization was made), due to the type of retrospective study design. This study was conducted following the regulatory standards of Good Clinical Practice and the Declaration of Helsinki (1996). The clinical management of patients included in the study was identical to that routinely proposed in the same period according to our internal protocols. For this reason, all eligible patients were adequately informed of the nature and objectives of the study, and written signed consent was obtained, following the Italian Privacy Law (675/96). A database containing all data from these patients was recorded in a Microsoft Excel sheet. We recorded data regarding primary pathology, type of surgery, laparoscopic or laparotomy technique, ureteral injury, location, clinical manifestations, imaging and laboratory diagnosis, the treatment used and follow-up.

Ureteral injuries included in our study were lacerations, stenosis, and ureterovaginal fistulas:

- Stenosis is defined a reduction of ureteral lumen, and it may be a consequence of coagulation, trauma, kinking or ligation. In our database, we divided stenosis into complete stenosis (ligation) and partial stenosis (stricture).
- A laceration is a partial opening of the ureteral wall.
- Fistula is pathologic communication between ureter and vagina. We distinguished two types of fistulas: ureterovaginal and ureteral-peritoneal-vaginal fistulas, according to the type of fistular link.

Regarding the clinic, for each patient we recorded data about fever, abdominal pain, vaginal discharges, stranguria and polyuria. For laboratory data, we registered changes in inflammatory factors (VES, PCR, WBC count) or data about renal function (creatinine). We also registered the post-operative day in which clinical manifestations appeared. Treatment approaches were divided into three main procedures: cystoscopy with retrograde stent insertion (CpS), interventional radiology and laparotomy ureteral reimplantation. Another analysis was then conducted dividing radiological procedures in simple percutaneous nephrostomy (PN), percutaneous nephrostomy plus ureteral stent (NpS) with antegrade insertion and combined radiologic-endoscopic procedure, rendezvous (RV).

Cystoscopy and stent positioning

Bladder filling is carried out at low pressure, with cannulation of the ureter with a guide for ureteral stent in its soft portion. Double J stent is placed on the soft guide and location inside the bladder is controlled with cystoscopy.

Rendezvous (RV)

This procedure consists of two phases: the first one is represented by nephrostomy. The second phase is the RV. It can be divided into an anterograde and a retrograde approach. In the anterograde approach, a guidewire is advanced through the nephrostomy catheter reaching the ureter. Then, in the retrograde approach, a guidewire, thanks to a cystoscope, is advanced through the ureteral orifice till the ureter. At this point, a device (Gooseneck) takes the guidewire introduced through the bladder. Subsequently, a double J stent is inserted to maintain the alignment and to help the reparation of ureteral injury.

Laparotomy/laparoscopy ureteral reimplantation/ureterocystoneostomy

The technique allows the creation of a new ureteral orifice on the bladder wall in the portion of the trigone. It crosses one or both ureters depending on whether one or both ureters are replanted.

Regarding follow-up, we registered eventual complications after the failure of the abovementioned procedures or the simple removal of ureteral stents when patients needed no other procedures. We excluded from the study patients that received the positioning of a prophylactic ureteral stent, patients with non-iatrogenic ureteral injuries and patients lost at follow-up.

Data associated with the paper are not publicly available but are available from the corresponding author on reasonable request.

RESULTS

Retrospectively analysing our database for ureteral injuries in patients undergoing gynaecologic surgical procedures between 15th January 2014 and 6th September 2021, we identified 33 ureteral injuries in 30 patients, of which 6 did not meet the inclusion criteria: 4 were lost at follow-up and 2 because of prophylactic ureteral stent. In this paper, we analysed 27 ureteral

Table 1. Characteristics of the patients and their ureteral damage.

	Ureteral lesion (n = 27)
Age, year (mean ± SD)	54.20 ± 9.95
Pathology	
Uterine fibromatosis, n (%)	3 (11.1)
Endometrial cancer, n (%)	3 (11.1)
Cervical cancer, n (%)	8 (29.6)
Ovarian cancer, n (%)	4 (14.8)
Endometrial hyperplasia, n (%)	4 (14.8)
Endometriosis, n (%)	2 (7.4)
Ovarian Cysts, n (%)	1 (3.7)
Leiomyosarcoma, n (%)	2 (7.4)
Type of surgery	
Laparotomic hysterectomy ± bilateral adnexectomy, n (%)	15 (55.6)
Laparoscopy hysterectomy ± bilateral adnexectomy, n (%)	7 (25.9)
Laparotomic radical hysterectomy ± bilateral adnexectomy, n (%)	3 (11.1)
Laparoscopy ovarian cyst removal, n (%)	2 (7.4)
Type of lesion	
Laceration, n (%)	16 (59.3)
Stenosis, n (%)	5 (18.5)
Ligation, n (%)	4 (14.8)
Stricture, n (%)	1 (3.7)
Fistulas, n (%)	6 (22.2)
Ureterovaginal fistulas, n (%)	2 (7.4)
Ureteral-peritoneal-vaginal fistulas, n (%)	4 (14.8)
Clinical manifestation, days (mean ± SD)	13.29 ± 12.72
Clinical manifestation	
Fever, n (%)	9 (33.3)
Abdominal pain, n (%)	15 (55.6)
Vaginal discharges, n (%)	7 (25.9)
Dysuria, anuria, n (%)	3 (11.1)

SD: standard deviation; n: number.

injuries in 24 patients: 3 patients had bilateral ureteral injuries. More specifically, we obtained data from 16 lacerations, 5 stenosis (4 ligations and 1 stricture) and 6 fistulas. Two of these fistulas were ureterovaginal and four of them were ureteral-peritoneal-vaginal. The characteristics of the patients and their ureteral damage are reported in **Table 1**. The procedures leading to ureteral damage were laparotomic in 67% of cases and laparoscopic in 33%. Injuries' diagnosis was intraoperative in 2 cases (7%) and postoperative in 25 cases (93%). Diagnosis was based on clinical suspicion, laboratory exams and imaging. Abdominal pain and abdominal distension were found in 15 patients, fever (T > 38 °C) in 9 patients, vaginal discharges in 7 patients and urinary symptoms in

3 patients. These clinical manifestations appeared in different intervals from surgery, all in a maximal lapse of 45 days. Around 58% of laboratory data were considered to clinically diagnose injuries. TC was the gold standard for the diagnosis of ureteral injuries. Ureteral stents were removed after 6 months in patients that received successful treatment.

Results analysed according to the approach

Three main approaches were used for the management of ureteral injuries: cystoscopy with retrograde ureteral stent (CpS), interventional radiology (RI) and ureterocystoneostomy (UCN). Data showed that 44% of ureteral injuries were solved with a single approach, meanwhile 56% of cases were solved using additional or multiple procedures.

Two of the 27 injuries were diagnosed intraoperatively and managed at first instance with ureterocystoneostomy (UCN) with a success rate of 100%. Five of the 27 injuries were treated with CpS as first approach, with only one case solved at first glance (success rate 20%) with subsequent failure of the other 4 injuries (Figure 1a). In one of the 4 injuries in which CpS failed, a RV was attempted, with a success rate of 100%. In the other 3 cases, treatment was NpS as second approach; one case was solved uneventfully, in the other 3 cases, RV approach was tempted, but unfortunately failed with a subsequent need for ureteral reimplantation (fourth approach) that was resolute in all the cases.

Interventional radiology (NpS, PN and RV) was used in the first instance in 20 of the 27 injuries with a resolution of 9/20 ureteral injuries (global success rate of 45%) (Figure 1b). In 11/20 injuries NpS was used in the first instance with the resolution of 7 injuries (success rate of 64%); in the other 4 cases attempt failed and a second approach was used. In 6/20 injuries PN was used in the first instance: in all cases, the approach failed, and a second procedure was used. In 3/20 injuries RV was used in the first instance, with the resolution of 2 cases (success rate of 67%), and failure in 1 case (failure rate of 33%) and a second approach was attempted. Interventional radiology was not resolute as the first approach in 11 of the 20 ureteral injuries and in these 11 injuries a second procedure was used. Four of the 11 cases were treated with UCN with resolution in all cases (success 100%). 2/11 ureteral injuries were treated with NpS as second approach with the resolution of 1 injury (success of 50%). RV was used in 1/11 injury as the second approach with success (success rate 100%). The second radiological procedure brought to resolution in 6/11 injuries (global success if 67%). 5/11 were treated with CpS as second approach which was not decisive in any case. 5/11 injuries were not resolved with a second procedure and continued with a third approach. 3/5 underwent laparotomy ureteral reimplantation with a 100% success rate. 1/5 of injuries resolved with CpS as third approach and 1/5 of injuries

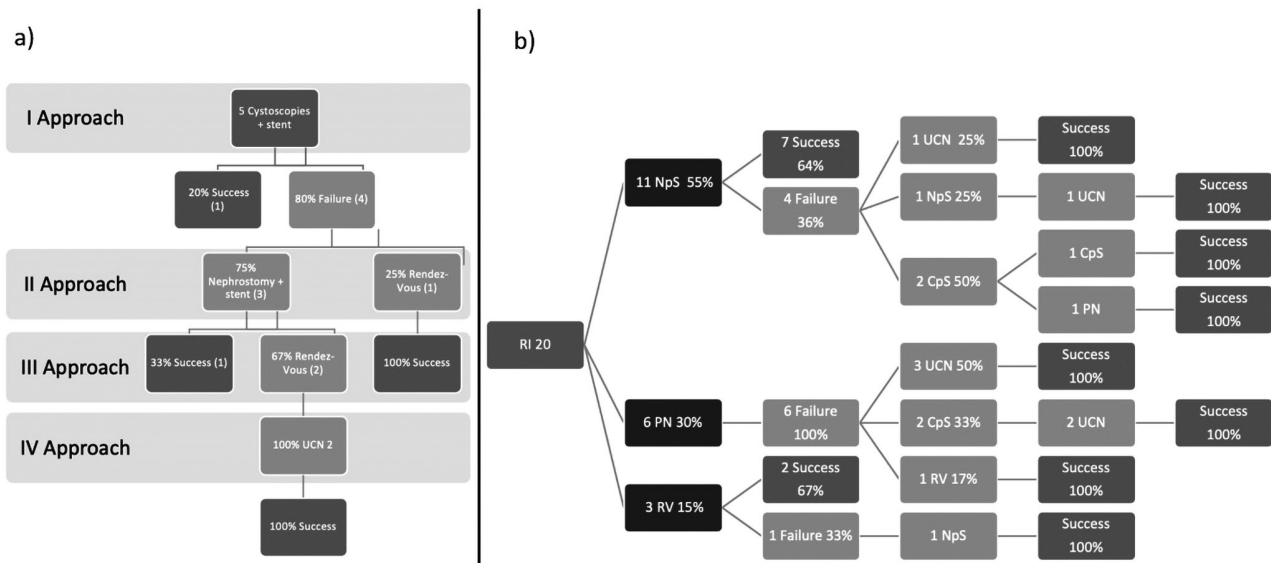


Figure 1. (a) Patient treated in first instance with retrograde positioning of ureteral stent; (b) Patient treated in first instance with interventional radiology. UCN: ureterocystoneostomy; CpS: cystoscopy + stent; NpS: percutaneous nephrostomy + stent; RV: Rendezvous; NP: simple percutaneous nephrostomy; IR: interventional radiology.

resolved with PN as third approach. 7/20 injuries treated in the first instance with IR in the end underwent UCN with subsequent resolution (success rate 100%). All these last approaches solved the problem (Figure 1b). The combined radiologic-endoscopic approach of RV had a success rate of 67% at the first attempt with only one injury that required stent apposition with nephrostomy, with resolution at the second intervention.

Sub-analysis showed global success rates of the different methods used. These data were obtained from the success and failure rates of each approach used. In this way, we found a success rate of 25% for CpS, 100% for ureteral reimplantation and 58% for all interventional radiology procedures. The success rate for each radiological procedure was 14% for simple PN, 57% for RV and 56% for NpS.

Results analysed for injury

A further analysis was done on the result for injury classification (stenosis, lacerations and fistulas) concerning the different techniques used for the treatment.

The 5 stenotic injuries were treated as follows (Figure 2a): in two of the 5, ligations CpS was used, in two of the 5, ligation PN was used, and in one of the 5, strictures NpS was used. CpS as first approach had a negative outcome in bilateral ureteral ligation and required other 3 interventions (NpS, RV and UCN) before definitive resolution. Globally, PN as first approach showed a failure rate of 100%: injuries were treated with laparotomic ureteral reimplantation, and half of them first received cystoscopy with a negative outcome. In this type of ureteral damage, conservative techniques did not conduce

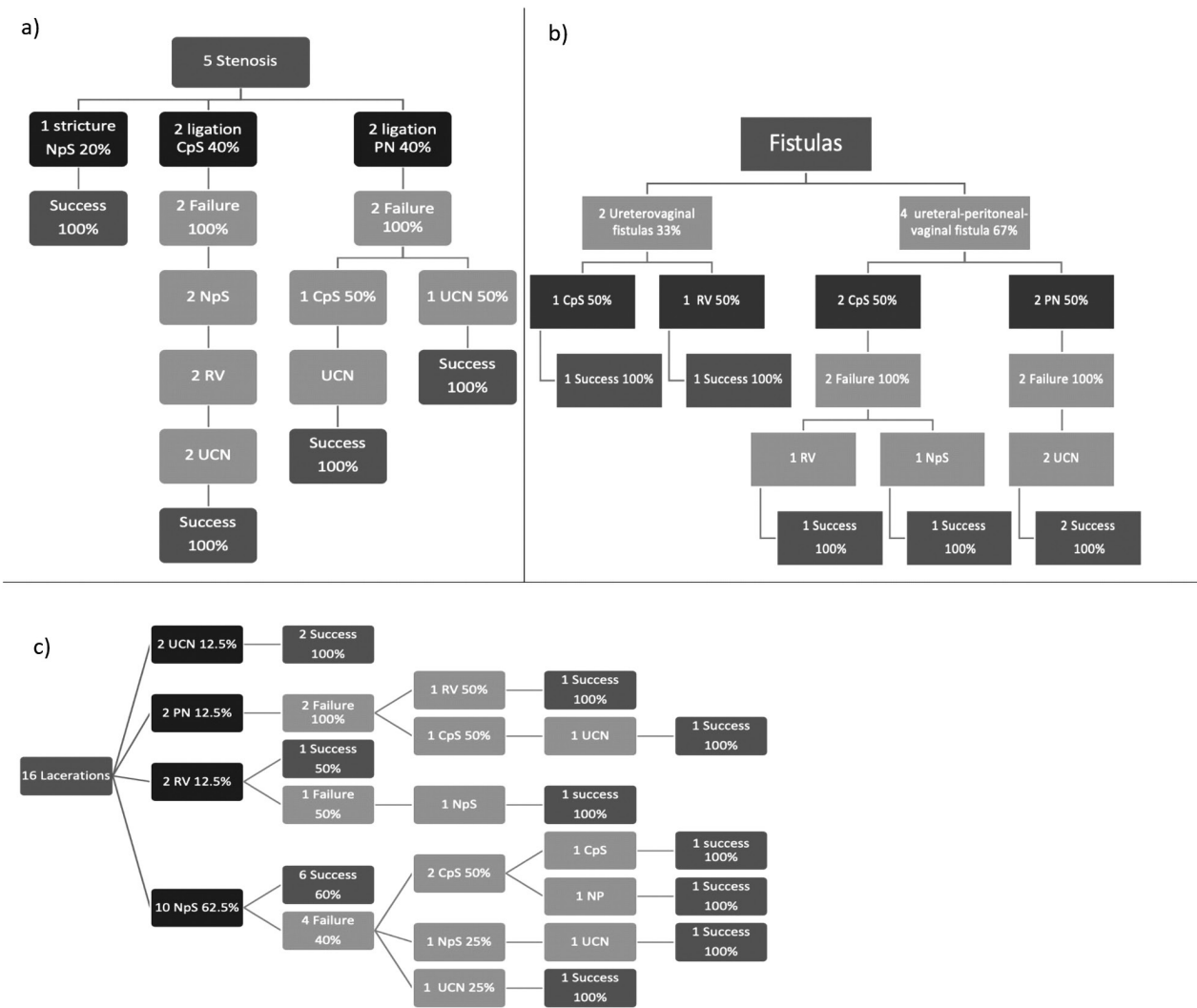


Figure 2. (a) Stenosis treatment; (b) Fistula treatment; (c) Laceration treatment.

UCN: ureterocystoneostomy; CpS: cystoscopy + stent; NpS: percutaneous nephrostomy + stent; RV: Rendezvous; NP: simple percutaneous nephrostomy; IR: interventional radiology.

to resolution and, in 80% of cases, patients received laparotomy: CpS, RV and PN never solved ureteral damage, while NpS positioning had a success rate of 33% (Figure 3).

The 16 lacerations were treated (Figure 2c) with UCN in 2 of the 16 ureteral injuries, RV in 2 of the 16 injuries, PN in 2 of the 16 injuries and NpS in the other 10 cases. The combined anterograde and retrograde approach had direct success in 50% of cases; in the other 50% of cases, NpS was necessary. PN in the first instance had negative results in all cases and injuries required RV in half cases and ureteral reimplantation in other cases. In the end, NpS positioning had a 60% success rate in the first instance. The Conservative procedure mainly used in lacerations was RV with a 67% success rate, followed by NpS (58% success rate). PN and CpS had good results with a rate of 33%. Ureteral reimplantation was effective in 5 lacerations with a success rate of 100% (Figure 3).

The 6 fistulas comprised 2 ureterovaginal fistulas and 4 ureteral-peritoneal-vaginal fistulas (Figure 2b). Ureterovaginal fistulas are solved, 1 with RV and 1 with CpS for a 100% success rate, respectively. The 4 ureteral-peritoneal-vaginal fistulas had a negative outcome in all the procedures first attempted: 2/4 CpS failed and also 2/4 PN. After radiologic failure, in 2 cases laparotomic ureteral reimplantation was used with a 100% success rate. In the other 2 cases with the previous failure of CpS, one was solved using RV and the other one with NpS (Figure 2b). For this type of injury, UCN was effective in 2 of the 6 ureteral injuries. In the other 4 cases, IR conservative approaches had good outcomes: RV was used in two cases with a 100% success rate, and also for NpS 1/6 and CpS had a 33% resolution rate

when applied in three cases. PN failed in both of the cases in which it was used (Figure 3).

Subsequently, a global rate for IR was calculated. We reported a success rate for lacerations (67%) and fistulas (60%). IR procedures for stenosis showed a lower success rate (25%).

DISCUSSION

Ureteral injuries are associated with high morbidity rates because the ureter is near to vascular structures and pelvic organs. Around 75% of ureteral injuries are iatrogenic: in particular, the third tract of the ureter has a higher risk because it is the most accessible during gynaecological surgery [19]. Incidence varies according to surgery complexity: 0.03-2% for abdominal hysterectomy, 0.02-0.5% for vaginal hysterectomy, 0.2-5% for LAVH, 1.7-3% for urogynaecological procedures [20].

Although ureteral repair is historically an open technique, we believe that the recent technological advancements in the field of minimally invasive surgery lead to the possibility of evaluating, as first option, a more conservative management: laparoscopic reimplantation or IR techniques. The advent of interventional radiology with the RV technique in addition to the classic techniques can allow the restoration of ureteral integrity, especially in the case of lacerations or ureteral transections [21].

The recent evidence in literature supports the use of a minimally invasive approach by IR (e.g., RV or NpS) as a first step in the case of ureteral injuries, as it presents a low risk of perioperative complications, shorter hospital stays and good success rate [22, 23]. In this paper, we analysed 27 ureteral injuries from 24 patients (three patients had bilateral injuries). The diagnosis was made during surgery in 2 cases (7%) and postoperative in 25 cases (93%). These data concerning post-operative diagnoses is in line with the literature, as the injuries are often not immediately visible. A large number of post-operative diagnoses it is also relatable to the type of surgery that is performed in our hospital, which is a referral centre for complex benign surgery, deep endometriosis and oncological surgery. The 2 injuries that were diagnosed during surgery were treated with UCN.

Laparotomic UCN is the gold standard treatment first described by Boari and modified over the years. This surgical procedure has a high success rate, which in the last decades has been revisited with a minimally invasive laparoscopic and robotic approach with

Ureteral injuries - global success rates according to techniques

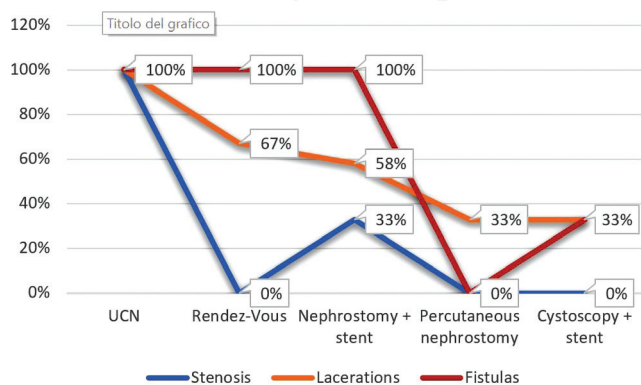


Figure 3. Ureteral injuries - global success rates according to techniques. UCN: ureterocystoneostomy.

similar success rates [24, 25]. Currently, the psoas hitch is a useful technique for injuries involving the lower third of the ureter. The success rate, regardless of the method, is very high among different studies. The minimally invasive approach for laparoscopic ureteral reimplantation is associated with a success rate of 95.8% (including psoas hitch, psoas hitch plus Boari flap, and extravesical ureteral reimplantation) [26]. In cases of failure, the persistence of ureteral obstruction, presenting as a long-term complication, is caused by ureteral ischemia, tension on the anastomosis, or kinking and often requires surgical management. Ureteral kinking may occur if the ureter is replaced in the lateral bladder wall, which is more mobile. A ureteral fistula may be related to ischemia, tension, and a lack of water-tight anastomosis. In case of failure of the bladder flap procedure, the UCN with psoas hitch is indicated.

In the other cases, treatment was CpS positioning or IR.

CpS had a global rate of success of 25%, but when used in the first instance in 5 ureteral injuries it had good results in 1 of 5 cases (20%). Failures are all due to endoprosthesis positioning: surgeon experience, distal location of injury and damage entity are the factors that mainly influenced the results of this procedure. Other causes of CpS failure in ureteral injuries are related to several factors, such as the impossibility of assessing the size of the lacerations, the impossibility of overcoming the strictures, and the possible risk of enlargement of small injuries. Complete stenosis and ureters-peritoneal-vaginal fistulas made difficult stent positioning. There are no good quality randomized or prospective studies in the literature that indicate the role of CpS and its outcome in the various types of injuries. The role of CpS in pelvic surgery has a recognized role only in minor ureteral injuries, ureteral decompressions and its use in the prevention of ureteral injury in patients where ureteral recognition is difficult [27, 28]. IR was used as the first approach in 20 injuries. The global success rate was 58% for all the approaches. Despite few data are disposable about the comparison between open surgery and minimally invasive techniques, these data are similar to those obtained in other studies: Ku *et al.* obtained a success rate of 64% for the conservative approach [29].

PN was used in the first instance in 6 cases and only once as subsequent approaches. 6 failures in the first instance out of a total of 7 PN procedures were due to complications during the procedure (stenosis and leakage), clinical complications (renal failure, hy-

dronephrosis) or in most of the cases to impossible stent positioning in cases of total stenosis and ureteral-peritoneal-vaginal procedures. So, failure derived from PN was expected because the stent was not positioned, and did not offer support to the ureteral wall, making healing difficult in case of large lacerations or fistulas. Literature agrees that in the case of ureteral damage stent positioning is better than simple PN [30, 31]. This technique was used because of contraindications to other techniques: these aspects can explain its apparent failure in a group of radiological successful procedures.

NpS would seem to be useful for small lacerations and incomplete stenoses. The advantage over PN is the presence of the stent, which increases the repair capacity of the ureteral tissue. Ureteral stenting promotes the healing process because it allows the realignment of the two stumps, excluding the damaged site from the passage of urine into the bladder, and maintains an adequate lumen, which prevents scar stenosis by reaction of the fibroblasts [32]. The possible success linked also in non-tightened stenosis (stricture) is probably linked to the passage of the guide and therefore of the stent, safeguarding renal function.

RV turns out to be an innovative technique introduced in the last two decades with a combined percutaneous antegrade and cystoscopic retrograde approach. From our results, this approach is effective in the resolution of lacerations and fistulas with a good success rate. There are several studies in literature reporting numerous successes. Yates *et al.* report the resolution of 8 strictures with a rendezvous success rate of 100%. Similar data are also reported by Macrì *et al.* with a success rate ranging between 78-88% on strictures [21, 22]. Regarding lacerations, we found in this paper a high success rate, in line with the literature. Liu *et al.*, using the RV technique, resolved 8 ureteral transections with a mean ureteral injury length of 19 mm (range 15-30 mm) with a success rate of 100% [33].

Regarding lacerations, the global success rate of IR procedures was 67%. The conservative procedure with a higher success rate was RV, with a 67% success rate, followed by NpS (58% success rate). PN and CpS had good success rates (both 33%). UCN had success in 5 injuries (100% success rate). So, there is a high success rate considering all radiological procedures together, but these rates reduce when we consider each single specific technique: NpS and RV demonstrated to be otherwise valid techniques and good alternatives to surgery in the

first instance. Despite the higher success rate of laparotomy reimplantation, IR is a valid alternative to surgery. Open surgery is associated with higher infective rate, haemorrhage, mortality and morbidity. Failures obtained with these two techniques are due to complications raised after the procedures themselves: stenosis, fistulas and leakage. A probable cause was the excessive tissue damage due to the injury entity, the number of attempts trying to solve it and difficult diagnostic interpretation. In the case of laceration, a combined radiological-endoscopic procedure is a valid alternative to the gold standard as the first step. If NpS is used as the first approach without success, it is better to use RV because the success rate is higher. CpS and PN should be avoided. We found in our study a similar success rate, considering each radiological procedure: success rates were 58% for NpS positioning and 67% for RV similar to Ku *et al.* [29].

Regarding iatrogenic stenosis, CpS had a 0% success rate, IR 14% with only a case of NpS that was solved in the first instance. This injury was the unique partial stenosis while the others were complete stenosis: all solved thanks to UCN. In this case, it was possible to observe a reduced success rate for IR, especially in cases of serrated stenosis. It is fundamental to analyse the grade of stenosis: in case of stricture, nephrostomy with stent positioning may be considered, but in case of ligation it is necessary to undergo open surgery. CpS should be avoided in stenosis. There are studies in literature about this topic, but they mainly concern stenosis following renal transplantation and they propose still open techniques, even if minimally invasive [34]. Despite the classic open/minimally invasive approach, some studies show good results of the endoscopic approach with laser endopyelotomy and balloon dilation especially on non-ischemic stenosis, not from malignant pathology and less than 2 cm in length [35]. These two techniques have a variable success rate based on the site of the injury, the residual vascularity, and the length of the stenosis which are 52-83% with laser endopyelotomy and from 33-100% with balloon dilation (in the case of stenosis greater than 2 cm long 0-17%) [35, 36]. In our study in the case of stenosis, it was possible to observe a reduced success rate for IR, disagreeing with success rates reported by the abovementioned studies, especially in serrated stenosis. In case of stricture, NpS positioning may be considered, but in the case of ligation is necessary UCN [37]. Therefore, either from the literature or in our study, in the case of ureteral stenosis, it is possi-

ble to try a minimally invasive approach with interventional radiology, but the definitive and standard treatment is the classic technique.

Regarding fistulas, CpS had a global success rate of 33% while IR reached 60%: PN failed in both cases it was used while RV and NpS had a 100% success rate. In 2 of the 6 fistulas, injuries were treated with ureteral reimplantation. Considering two types of fistulas, we observed that both radiological and urological conservative approaches were effective for ureterovaginal fistulas. For ureteral-peritoneal-vaginal fistulas, other approaches (50% surgical and 50% conservatives) were necessary before the final resolution. We can conclude that conservative approaches are more effective in case of ureterovaginal fistula. On the other side, a conservative approach should be avoided in ureteral-peritoneal-vaginal fistulas because of a more difficult stent positioning: in this case, ureteral reimplantation should be preferred. In literature, there are no randomized studies about the minimally invasive approach in the management of iatrogenic ureteral fistulas. In case of ureteral fistula, the vesicovaginal fistula must always be investigated as the two conditions can be associated [38]. In the study conducted by Angioli *et al.* on the management of vesicovaginal fistulas, even if associated with ureteral ones, an attempt at conservative management for 4-6 weeks is foreseen [39]. We believe that the CpS approach is justified in the first instance. In our study, CpS had a global success rate of 33%, higher than that of simple waiting with an intravesical foley (15-20%), but above all with a mini-invasive approach RV and NpS had a 100% success rate. Considering two types of fistulas, we observed that for ureterovaginal fistulas both radiological and urological conservative approaches were effective. On the other side, a conservative approach should be avoided in ureteral-peritoneal-vaginal fistulas because of a more difficult stent positioning: in this case, UCN should be preferred.

Limitations

The limitations of this study are the small number of ureteral injuries and the fact that it is a retrospective study based on the experience of a single centre.

CONCLUSIONS

According to the obtained results, conservative IR procedures are valid alternatives to open surgery.

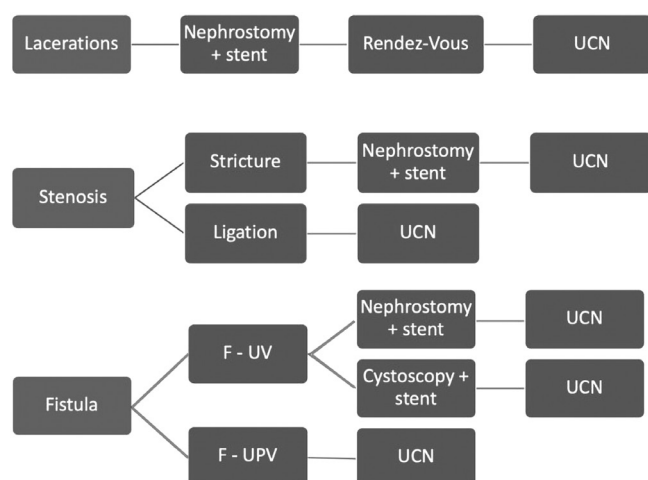


Figure 4. Flow chart for the treatment of ureteral injuries.

UCN: ureterocystoneostomy; CpS: cystoscopy + stent; NpS: percutaneous nephrostomy + stent; RV: Rendezvous; NP: simple percutaneous nephrostomy.

UCN is otherwise the procedure with higher success rates, despite it presents various limits of applications, especially in older patients with other pathologies. Interventional radiology represents an effective approach that could postpone or avoid the use of invasive procedures. Other studies are needed to have more data and validate various conservative treatment strategies.

We propose the following flow chart for the treatment of ureteral injuries (**Figure 4**).

For ureteral lacerations, the first approach that should be used is NpS or RV and only subsequently UCN.

In case of ureteral stenosis, NpS should be used for strictures first and then UCN. In case of ligation stenosis, the intended approach is directly UCN.

In case of fistula, we distinguish the ureterovaginal fistulas and the ureteral-peritoneal-vaginal. In case of ureterovaginal fistulas, CpS or NpS should be used as the first approach, and in case of failure, UCN is the best approach.

For ureteral-peritoneal-vaginal fistulas, the best approach is to perform a UCN.

COMPLIANCE WITH ETHICAL STANDARDS

Authors contribution

C.D.C.N., F.F., L.F., C.D.L., F.P., R.M., D.L., G.L., R.M., R.A., C.T.: Conceptualization, investigation, methodology, resources, software, visualization. C.D.C.N., F.F., L.F.: Data curation. C.D.C.N., F.F.: Formal analysis. C.D.C.N., F.F., C.T.: Project admin-

istration, supervision, validation, writing – original draft, writing – review & editing.

Funding

None.

Study registration

N/A.

Disclosure of interests

The authors declare that they have no conflict of interests.

Ethical approval

Considering the retrospective nature of the study (observational and not interventional, no randomization was made) not approval by our IRB was requested. Approval was granted by the University “Campus Bio-Medico” of Rome. This study was conducted following the regulatory standards of Good Clinical Practice and the Declaration of Helsinki (1946).

Informed consent

The enrolled patients gave their informed consent to the study.

Data sharing

Data are available under reasonable request to the corresponding author.

REFERENCES

- Schonman R, De Cicco C, Corona R, Soriano D, Koninckx PR. Accident analysis: factors contributing to a ureteric injury during deep endometriosis surgery. *BJOG*. 2008;115(13):1611-5. doi: 10.1111/j.1471-0528.2008.01941.x
- Plotti F, Ficarola F, Messina G, Terranova C, Montera R, Guzzo F, et al. Tailoring parametrectomy for early cervical cancer (Stage IA-IIA FIGO): a review on surgical, oncologic outcome and sexual function. *Minerva Obstet Gynecol*. 2021;73(2):149-59. doi: 10.23736/S2724-606X.20.04683-3.

3. Lim MC, Lee BY, Lee DO, Joung JY, Kang S, Seo SS, et al. Lower urinary tract injuries diagnosed after hysterectomy: seven-year experience at a cancer hospital. *J Obstet Gynaecol Res.* 2010;36(2):318-25. doi: 10.1111/j.1447-0756.2009.01153.x.
4. Bogani G, Di Donato V, Scambia G, Raspagliesi F, Chiantera V, Sozzi G, et al. Radical Hysterectomy for Early Stage Cervical Cancer. *Int J Environ Res Public Health.* 2022;19(18):11641. doi: 10.3390/ijerph191811641.
5. Bogani G, Donato VD, Scambia G, Landoni F, Ghezzi F, Muzii L, et al. Practice patterns and 90-day treatment-related morbidity in early-stage cervical cancer. *Gynecol Oncol.* 2022;166(3):561-6. doi: 10.1016/j.ygyno.2022.07.022.
6. Montera R, Ficarola F, Plotti F, Terranova C, De Cicco Nardone C, Guzzo F, et al. The use of sealing hemostat patch (HEMOPATCH®) in laparotomic myomectomy: a prospective case-control study. *Arch Gynecol Obstet.* 2023;307(5):1521-8. doi: 10.1007/s00404-023-06957-2.
7. D'Oria O, Golia D'Auge T, Baiocco E, Vincenzoni C, Mancini E, Bruno V, et al. The role of preoperative frailty assessment in patients affected by gynecological cancer: a narrative review. *Ital J Gynaecol Obstet.* 2022;34(2):76-83 doi: 10.36129/jog.2022.34.
8. Di Donato V, Di Pinto A, Giannini A, Caruso G, D'Oria O, Tomao F, et al. Modified fragility index and surgical complexity score are able to predict postoperative morbidity and mortality after cytoreductive surgery for advanced ovarian cancer. *Gynecol Oncol.* 2021;161(1):4-10. doi: 10.1016/j.ygyno.2020.08.022.
9. Giannini A, Di Donato V, Schiavi MC, May J, Panici PB, Congiu MA. Predictors of postoperative overall and severe complications after surgical treatment for endometrial cancer: The role of the fragility index. *Int J Gynaecol Obstet.* 2020;148(2):174-80. doi: 10.1002/ijgo.13020.
10. Di Donato V, Caruso G, Bogani G, Giannini A, D'Oria O, Perniola G, et al. Preoperative frailty assessment in patients undergoing gynecologic oncology surgery: A systematic review. *Gynecol Oncol.* 2021;161(1):11-9. doi: 10.1016/j.ygyno.2020.12.030.
11. Di Donato V, D'Oria O, Giannini A, Bogani G, Fischetti M, Santangelo G, et al. Age-Adjusted Charlson Comorbidity Index Predicts Survival in Endometrial Cancer Patients. *Gynecol Obstet Invest.* 2022;87(3-4):191-9. doi: 10.1159/000525405.
12. Gilmour DT, Dwyer PL, Carey MP. Lower urinary tract injury during gynecologic surgery and its detection by intraoperative cystoscopy. *Obstet Gynecol.* 1999;94(5 Pt 2):883-889. doi: 10.1016/s0029-7844(99)00456-1.
13. Rigatti P, Pompa P. La patologia dell'uretere ginecologico [Pathology of the gynecologic ureter]. *Arch Ital Urol Androl.* 2002;74(1):21-2.
14. Burks FN, Santucci RA. Management of iatrogenic ureteral injury. *Ther Adv Urol.* 2014;6(3):115-24. doi: 10.1177/1756287214526767.
15. De Cicco C, Ret Dávalos ML, Van Cleynenbreugel B, Verguts J, Koninckx PR. Iatrogenic ureteral lesions and repair: a review for gynecologists. *J Minim Invasive Gynecol.* 2007;14(4):428-35. doi: 10.1016/j.jmig.2007.01.003.
16. Pastore AL, Palleschi G, Silvestri L, Leto A, Autieri D, Ripoli A, et al. Endoscopic rendezvous procedure for ureteral iatrogenic detachment: report of a case series with long-term outcomes. *J Endourol.* 2015;29(4):415-20. doi: 10.1089/end.2014.0474.
17. Trombatore C, Giordano G, Magnano San Lio V. Interventional radiology in iatrogenic ureteral leaks: case series and literature review. *Radiol Med.* 2017;122(9):696-704. doi: 10.1007/s11547-017-0774-2.
18. De Cicco C, Schonman R, Craessaerts M, Van Cleynenbreugel B, Ussia A, Koninckx PR. Laparoscopic management of ureteral lesions in gynecology. *Fertil Steril.* 2009;92(4):1424-7. doi: 10.1016/j.fertnstert.2008.08.021.
19. Esparaz AM, Pearl JA, Herts BR, LeBlanc J, Kapoor B. Iatrogenic urinary tract injuries: etiology, diagnosis, and management. *Semin Intervent Radiol.* 2015;32(2):195-208. doi: 10.1055/s-0035-1549378.
20. De Cicco C, Ussia A, Koninckx PR. Laparoscopic ureteral repair in gynaecological surgery. *Curr Opin Obstet Gynecol.* 2011;23(4):296-300. doi: 10.1097/GCO.0b013e328348a29a.
21. Yates DR, Mehta SS, Spencer PA, Parys BT. Combined antegrade and retrograde endoscopic retroperitoneal bypass of ureteric strictures: a modification of the 'rendezvous' procedure. *BJU Int.* 2010;105(7):992-7. doi: 10.1111/j.1464-410X.2009.08807.x.
22. Macrì A, Magno C, Certo A, Basile A, Scuderi G, Crescenti F, et al. Combined antegrade and retrograde ureteral stenting: the rendezvous technique. *Clin Radiol.* 2005;60(2):257-60. doi: 10.1016/j.crad.2004.06.008.

23. Raimondo D, Alboni C, Orsini B, Aru AC, Farulla A, Maletta M, et al. Comparison of perioperative outcomes between standard laparoscopic and robot-assisted approach in patients with rectosigmoid endometriosis. *Acta Obstet Gynecol Scand.* 2021;100(9):1740-6. doi: 10.1111/aogs.14170.
24. Passoni N, Peters CA. Robotic Ureteral Reimplantation. *J Endourol.* 2020;34(S1):S31-4. doi: 10.1089/end.2019.0619.
25. Rassweiler JJ, Gözen AS, Erdogru T, Sugiono M, Teber D. Ureteral reimplantation for management of ureteral strictures: a retrospective comparison of laparoscopic and open techniques. *Eur Urol.* 2007;51(2):512-23. doi: 10.1016/j.eururo.2006.08.004.
26. Gözen AS, Cresswell J, Canda AE, Ganta S, Rassweiler J, Teber D. Laparoscopic ureteral reimplantation: prospective evaluation of medium-term results and current developments. *World J Urol.* 2010;28(2):221-26. doi: 10.1007/s00345-009-0443-8.
27. Linder BJ, Occhino JA. Cystoscopic ureteral stent placement: techniques and tips. *Int Urogynecol J.* 2019;30(1):163-5. doi: 10.1007/s00192-018-3762-8.
28. A Al-Kandari AM, Al-Shaiji TF, Shaaban H, Ibrahim HM, Elshebiny YH, Shokeir AA. Effects of proximal and distal ends of double-J ureteral stent position on postprocedural symptoms and quality of life: a randomized clinical trial. *J Endourol.* 2007;21(7):698-702. doi: 10.1089/end.2007.9949.
29. Ku JH, Kim ME, Jeon YS, Lee NK, Park YH. Minimally invasive management of ureteral injuries recognized late after obstetric and gynaecologic surgery. *Injury.* 2003;34(7):480-3. doi: 10.1016/s0020-1383(02)00412-6.
30. Hesselman S, Högberg U, Jonsson M. Effect of remote cesarean delivery on complications during hysterectomy: a cohort study. *Am J Obstet Gynecol.* 2017;217(5):564.e1-564.e8. doi: 10.1016/j.ajog.2017.07.021.
31. Vorobev V, Beloborodov V, Golub I, Frolov A, Kelchevskaya E, Tsoktoev D, et al. Urinary System Iatrogenic Injuries: Problem Review. *Urol Int.* 2021;105(5-6):460-9. doi: 10.1159/000512882.
32. Lang EK. Antegrade ureteral stenting for dehiscence, strictures, and fistulae. *AJR Am J Roentgenol.* 1984;143(4):795-801. doi: 10.2214/ajr.143.4.795.
33. Liu C, Zhang X, Xue D, Liu Y, Wang P. Endoscopic realignment in the management of complete transected ureter. *Int Urol Nephrol.* 2014;46(2):335-40. doi: 10.1007/s11255-013-0535-7.
34. Engel O, Rink M, Fisch M. Management of iatrogenic ureteral injury and techniques for ureteral reconstruction. *Curr Opin Urol.* 2015;25(4):331-5. doi: 10.1097/MOU.0000000000000175.
35. Lucas JW, Ghiraldi E, Ellis J, Friedlander JI. Endoscopic Management of Ureteral Strictures: an Update. *Curr Urol Rep.* 2018;19(4):24. doi: 10.1007/s11934-018-0773-4.
36. Richter F, Irwin RJ, Watson RA, Lang EK. Endourologic management of benign ureteral strictures with and without compromised vascular supply. *Urology.* 2000;55(5):652-7. doi: 10.1016/s0090-4295(00)00484-2.
37. Bilotta A, Wiegand LR, Heinsimer KR. Ureteral reconstruction for complex strictures: a review of the current literature. *Int Urol Nephrol.* 2021;53(11):2211-9. doi: 10.1007/s11255-021-02985-6.
38. Goodwin WE, Scardino PT. Vesicovaginal and ureterovaginal fistulas: a summary of 25 years of experience. *J Urol.* 1980;123(3):370-4. doi: 10.1016/s0022-5347(17)55941-8.
39. Angioli R, Penalver M, Muzii L, Mendez L, Mirhashemi R, Bellati F, et al. Guidelines of how to manage vesicovaginal fistula. *Crit Rev Oncol Hematol.* 2003;48(3):295-304. doi: 10.1016/s1040-8428(03)00123-9.