

Iatrogenic ureteral injury during laparoscopic colectomy: incidence and prevention

A current literature review



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Giovanni Liguori*, Chiara Dobrinja**, Nicola Pavan*, Nicolò de Manzini°, Stefano Bucci*, Silvia Palmisano°, Carlo Trombetta*

University of Trieste, Cattinara Hospital, Trieste, Italy

*Department of Urology

**Division of General Surgery, Department of Medical and Surgical Sciences

***Department of Urology

°Division of General Surgery, Department of Medical and Surgical Sciences

°°Division of General Surgery, Department of Medical and Surgical Sciences

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INTRODUCTION: *Iatrogenic ureteral injury (IUI) is a serious complication that can occur during abdominal or pelvic operations with a reported frequency in literature of approximately 0.3-1.5%. Moreover, the number of iatrogenic ureteric injuries has increased markedly during the past two decades, partly because of the introduction of laparoscopy and the overall increase in surgical procedures.*

MATERIAL AND METHOD: *The present systematic review was set up to compare the incidence of IUI between laparoscopic and open colectomies. The study also assessed the features of the ureteric injuries and their prevention and management. We conducted a search of the literature for prospective and randomized clinical trials presenting a comparison between laparoscopic and open colorectal resections performed for any indication starting from 2003 to 2015.*

RESULTS: *After an initial moderate increase in incidence of IUIs, with growing experience in laparoscopic surgery, ureteral injuries not seem to be more in laparoscopic surgery than conventional surgery. Many surgeons and gynecologists agree that prophylactic ureteral catheterization may reduce the chance of IUIs.*

CONCLUSIONS: *Ureteral injury is especially difficult to detect during laparoscopic operations, and the symptoms of ureteric injury may develop either acutely or more insidiously, depending on the mechanism of injury. These injuries, if recognized late, can result in significant morbidity with loss of renal function. Early recognition and immediate repair of ureteral injuries during the same procedure is highly desirable. A ureteral injury not recognized and treated during the same procedure may require a temporary diverting nephrostomy and secondary surgery with increased morbidity.*

KEY WORDS: Colectomy, Injury, Laparoscopy, Ureter

Introduction

Iatrogenic ureteral injury (IUI) is a serious complication that can occur during abdominal or pelvic operations with a reported frequency in literature of approximately 0.3-1.5%¹⁻⁸.

Moreover, the number of iatrogenic ureteric injuries has increased markedly during the past two decades, partly because of the introduction of laparoscopy and the overall increase in surgical procedures^{9,10}.

There are many reports showing that laparoscopic colorectal surgery is associated with a significantly lower postoperative mortality and morbidity and with a shorter hospital stay than open colorectal resection without jeopardising long-term oncologic results¹¹⁻¹⁴. As the number of cases being performed continues to increase, prospective trials and systematic reviews suggested that the minimally invasive approach is associated with a lower overall complication rate.

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Correspondence to: Chiara Dobrinja, M.D., PhD., Division of General Surgery, Department of Medical and Surgical Sciences, Hospital of Cattinara, Università degli Studi di Trieste, Strada di Fiume 447, 34149 Trieste, Italy (e-mail: chiara.dobrinja@asuis.sanita.fvg.it)

However, there is evidence of criticism regarding this trend of reduced overall post-operative complication rates^{9,10,15}. Above all, there is an impression that the rate of ureteral injuries have become more common in laparoscopic surgery. This problem has been mostly highlighted in the field of the prostate and obstetric-gynaecologic procedures¹⁰, but was also reported in both right and left colic resections⁹.

Although ureteral injury during laparoscopic colectomy is a relatively rare event, it can be devastating for both the surgeon and the patient.

The aim of this paper is to provide a comprehensive review about IUI during laparoscopic colectomy, specifically incidence, prevention, and management in an attempt to determine if an increased risk does indeed exist and to highlight methods and procedures of possible prevention and treatment.

Materials and Methods

We conducted a search of the literature for prospective and randomized clinical trials presenting a comparison between laparoscopic and open colorectal resections performed for any indication starting from 2003 to 2015.

REVIEW CRITERIA

The search was conducted utilizing the most popular computerized databases (PubMed, OVID, Medline) and was then supplemented with a direct analysis of references of every single selected paper.

Information for this review was compiled by searching the PubMed database for articles published in English. Search terms included the words "ureteral injury" and the following terms: "laparoscopic colectomy", "colorectal surgery", "ureteral stent". Full articles were obtained and references were checked for additional source material as appropriate. Primary sources have been quoted where possible. References were chosen on the basis of the best clinical evidence, especially if the results had been supported by other published papers.

In order to reduce bias to reach the conclusions we excluded all references or articles that treated non-specifically the ureteral injuries secondary to colorectal surgeries.

Our systematic review allowed us to select a total of 3 prospective studies^{11,12,16} and 6 retrospective studies^{1,5,6,17-19} that compare short-term results for colorectal resections. These studies were then later examined to see if there were reports of iatrogenic ureteral injuries. These articles were analyzed in order to find information regarding prevalence, initial procedure, type and location of the lesion and surgical instruments used.

Results and Discussion

1. INCIDENCE OF IATROGENIC URETERAL INJURIES

The ureters are often exposed to iatrogenic trauma because of their anatomical position. IUI is a serious complication that can occur during abdominal or pelvic operations. These rare injuries have a documented incidence of 0.3% to 1.5%^{1-8,20,21} but, the numbers of iatrogenic ureteric injuries have increased markedly over the last two decades⁹.

1.1 - Incidence of IUIs in laparoscopic colorectal resection. There is or not an increasing numbers of ureteric injuries after the introduction of laparoscopic surgery?

The risk of ureteric injuries seems to be higher in laparoscopic surgery than open surgery and ureteric injury is especially difficult to be detected during laparoscopic operations. Moreover, the symptoms of ureteric injury may be developed either acutely or more insidiously, depending on the mechanism of injury.

In the recent years, various publications originating from urologic centers point out an overall tendency of increased iatrogenic ureteral injuries after the introduction of laparoscopic surgery. In fact, even though the benefits of laparoscopy over open colectomy are well recognized, only few studies thus far adequately assesses whether the risk of ureteral injury significantly differs between the two approaches¹⁰. Similarly, numerous studies^{9,15,20,22,23} have demonstrated increased incidence of iatrogenic ureteral injuries in laparoscopic procedures.

Even if laparoscopy provides the surgeon with magnified vision and a superior view, thereby allowing precise identification and dissection of diseased areas, potential factors contributing to this increased incidence may include decreased tactile sensation and method of dissection. Gynecological surgery has been the traditional cause of more than 50% of iatrogenic ureteric injuries, followed by general surgical procedures^{24,25}. However, in the last 10-15 years, with increase in complex minimally invasive endoscopic procedures being carried out by urologists for pyelo-ureteric disorders, urological procedures now account for most cases of ureteral injuries³. An increase in the incidence and a modification of the etiology of iatrogenic ureteral injuries was already noted in 1994 by Assimos DG et al.⁴, who, examining retrospectively their experience of treatment for this type of lesion, observed that between 1980 and 1984, 8 patients had been treated, whereas in the period of time between 1985 and 1989 the number of patients who reported IUIs was 19. This second period corresponded to the introduction of laparoscopy and ureteroscopy. Authors underlined that the increase of the ureteral lesion rate primarily regarded gynecological procedures and that this had not been observed in general surgery. Similarly, in the experience of Parpala-Sparman et al.⁹ who compre-

hended 72 cases, the 25% of injuries were occurred in the course of general surgery procedures, and 10 % of these were during colorectal resections. The Authors compared the incidence of ureteric injuries before the introduction of laparoscopic surgery in their hospital (1986-1992) with the following two 7 years periods. They collected 72 iatrogenic ureteral injuries, five of which were observed in the first period, 28 in the period between 1993-1999, and 39 between 2000 and 2006: 64 % of these injuries took place during gynecological procedures, 25% during general surgery procedures including 10 colorectal procedures, and 11% during urological procedures. The type of procedure was laparoscopic in 56% of cases, and in 33% of cases open surgery. Unfortunately, the type of approach used in the 10 patients who experienced ureteral injury during colorectal surgery was not reported, but only 2 injuries occurred during laparoscopic general surgery procedures. The lesion was diagnosed during the surgical procedure in 15 patients, while in the other 57 patients it was identified during the post-operative period with an average 6 days delay in identification.

On the contrary, Al-Awadi K. et al.³ who observed 82 ureteral injuries in 75 patients during the last 5 years noted an opposite trend, but only 5% took place during general surgery procedures, being most of them due to gynecological procedures. This low incidence of ureteral injuries was attributed by the authors to the positioning of a "J" stent before each major abdominal-pelvic general surgery procedure.

In another review¹⁰ the authors reported 70 cases of ureteral injuries during laparoscopic surgery among 2491 reported cases in which ureteral laparoscopic complications were discussed. Incidences of injury ranged from <1% to 2%. The ureteral lesion was identified during the procedure in only 8.6% of cases, with transection of the ureter being the most common (20%). Injuries were caused in 24.3% of cases by cauterization.

In a prospective study, Hemandes AK et al.¹² examined the feasibility and safety of laparoscopic resection in high-risk patients with colorectal cancer. A total of 424 patients underwent elective laparoscopic (224) and open (200) resections. Mortality, average length of hospitalization, and complication rate that required a second surgery were lower after laparoscopic surgery.

Interestingly, readmission rate after discharge was more than double after laparoscopic surgery. Unfortunately, neither the type of postoperative complications nor the incidence of ureteral injuries were reported.

Short-term outcomes of laparoscopic surgery versus open surgery for colon cancer were analyzed in another randomized trial performed by the COLOR Study Group¹⁶. In their study the Authors randomized 627 patients in which laparoscopic surgery was performed and 621 patients who underwent open surgery. Post-operative morbidity was reported and the incidence did not differ between the two groups, but also in this study, different complications were not analyzed separately.

In another survey on 84524 patients operated on in France for colon and rectum resection, Panis et al.¹⁷ found that laparoscopic surgery was independently associated with a decreased postoperative 30-day mortality. The study was carried out on 22,359 patients underwent elective laparoscopic resection (26%) and 62,165 open resection (74%), but again, intra-operative ureteral injuries were not analyzed.

Tjandra JJ et al.²⁶, performed a review of 17 randomized trials for a total of 4013 procedures for colon resection in patients with colorectal cancer. Laparoscopic surgery yielded better short-term results. Unfortunately, ureteral injuries were not analyzed.

Even in the case of rectal surgery, although most of the reviews and meta-analysis published in English literature demonstrated that the laparoscopic approach guarantees a shorter post-operative hospitalization, a faster peristalsis recovery and less blood loss, the question of ureteral injury is not specifically reported^{6,27,28}. The incidence of postoperative complications for both laparoscopic and open colon resection for diverticulitis has been described previously in several studies^{11,29-32}.

Russ AJ et al.¹¹ reported a lower rate of abdominal abscess in laparoscopic surgery compared to the open surgery (2.2% vs. 3.5%; $p < 0.01$) in an analysis of 6970 patients (lap 3502; open 3468) who underwent elective surgeries for diverticular disease.

Similarly, in an European multicenter observational study of 332 patients undergoing elective colectomy (lap 163 vs. open 169) for diverticular disease, the authors found a significant decrease in overall morbidity (16% vs. 31%; $p < 0.01$) and intraabdominal abscesses (lap 1.8%; open 8.9%, $p < 0.01$) after laparoscopic compared to open surgery for diverticulitis. Moreover, open procedure was an independent risk factor for morbidity in their patient cohort (OR 2.13, 95% CI 1.29-3.45)³³.

Furthermore, Masoomi H. et al.⁶ reported a total of 124,734 patients who underwent elective surgery for diverticulitis: open, 110,172 (88.3%); laparoscopy, 14,562 (11.7%). The overall intraoperative complication rate was significantly lower in the laparoscopy group (0.63% vs. 1.15%, $p < 0.01$) in terms of a decreased incidence of ileus, anastomotic leakage, intraabdominal abscess, wound infection, and bowel obstruction.

Dwivedi Al. et al. studied 154 patients (lap 66; open 88) undergoing sigmoid colectomy for diverticular disease, showing a decrease in the percentage of ureteral injuries in the laparoscopic group compared to the open group (open 2.2%; lap 1.5%)²⁹. In another study, there was no significant difference observed in ureteral injury between groups (open, 0.17%; lap, 0.12%, $p = 0.15$)⁶. On the contrary, in a recent meta-analysis of 11 non-randomized studies and one randomized trial of 1534 patients on the same topic, the incidence of ureteral injuries was actually double in laparoscopy with respect to open surgery: 2% vs. 1%⁷.

TABLE I

References	Type of study	No of patients	Access	Ureteral injuries (%)
Palaniappa [1]	Retrospective	1060	Laparoscopy	0.66%
		4669	Open	0.15%
Halabi [5]	Retrospective	2,165,848	Laparoscopy	(0.28%)
			Converted	
			Open	
Masoomi [6]	Retrospective	14152	Laparoscopy	0.17%
		11072	Open	0.12%
Cirocchi [7]	Review	570	Laparoscopy	1%
		703	Open	2%
Miller [8]	Review	481,727		0.4%
Russ [11]	Prospective	3502	Laparoscopy	Not reported
		3468	Open	
Hermendas [12]	Prospective	224	Laparoscopy	Not reported
		200	Open	
Veldkamp [16]	Prospective	627	Laparoscopy	Not reported
		621	Open	
Panis [17]	Retrospective	22359	Laparoscopy	Not reported
		62125	Open	0.37%
Andersen [18]	Retrospective	6291	Laparoscopy	0.59%
		12183	Open	0.37%
Zafar [19]	Retrospective	33,092	Laparoscopy	0.53%
		61,434	Open	0.66%
Tjandra [26]	Review	4013	Laparoscopy	Not reported
Paun [27]	Review	36315	Laparoscopy	Not reported
Trastulli [28]	Review	841	Laparoscopy	Not reported
		703	Open	Not reported
Siddiqui [33]	Review	1014	Laparoscopy	Not reported
		369	Open	

Ureteral injury is a devastating complication of colon surgery with an incidence ranging from 0.2% to 1.5%^{1,3,5}. To the best of our knowledge, only few very recent, large scales, studies dealt with the issue whether ureteral injuries has a higher incidence after laparoscopic colectomy or open colectomy. On the other hand, a real incidence of this complication is difficult to determine due to its rarity.

Palaniappa NC et al.¹ who found a significantly increased incidence of IUI after laparoscopy has showed an increased risk of IUI in laparoscopic colectomy. The author studied 5,729 patients (4669 open and 1060 laparoscopy) treated for benign as well as malignant colorectal diseases from 2005 to 2012. During this period, 14 ureteral injuries occurred (0.244%) of which 7 in females and 7 in patients who had already undergone previous abdominal surgeries. Access was laparoscopic in 7 cases, with two conversions. Injuries occurred in 2 of 4 patients who received prophylactic insertion of a ureteral stent and in 5 of the 10 patients who did not receive a stent. Lesion incidence was relatively low (0.244%), but significantly higher in laparoscopic colectomies (7/4669 cases, 0.15%; P=0.007). Female sex and intraoperative blood loss were associated to a higher risk of injury. Another important fact that arises from these results are the important long term consequences of ureter-

al injuries, such as compromise of renal function and necessity of a nephrectomy in 2 out of the 14 cases.

Consistent with these findings, very recently a nationwide study has shown an IUI rate of 0.44% after colorectal cancer resection in Denmark. In multivariate analysis adjusted for age, gender, ASA score, BMI, tumor stage, preoperative chemo-radiation, calendar year, and specialty of the surgeon, the laparoscopic approach in colorectal cancer surgery was associated with a 1.6-fold increase of IUI as compared with open surgery. In rectal cancer surgery, the risk of ureteral injury was even higher, with a 2.7-fold (95 % CI 1.3-5.7) increase, when a laparoscopic technique was adopted¹⁸.

In contrast, in a recent nationwide study examining the trends of iatrogenic ureteral injuries occurring in colon and rectal surgical procedures over a 10-year period⁵, the laparoscopic colectomies were associated with lower ureteric injuries compared to open colectomies and the use of laparoscopy resulted a protective variable for ureteral injuries. In fact, the authors identified 6027 ureteral injuries (0.28%) from estimated 2,165,848 colorectal surgical procedures performed over the study period in the United States. The rate of ureteral injuries was higher in the second half of the decade (2006-2010) compared with the first half (2001-2005; 3.1/1000 vs 2.5/1000; p < 0.001). Ureteral injuries were indepen-

dently associated with higher mortality (OR, 1.45; $p < 0.05$), morbidity (OR, 1.66; $p < 0.001$), longer length of stay (mean difference, 3.65 days; $p < 0.001$), and higher hospital charges by \$31,497 ($p < 0.001$). Risk factors for ureteral injuries included rectal cancer (OR, 1.85), adhesions (OR, 1.83), metastatic cancer (OR, 1.76), weight loss/malnutrition (OR, 1.08), and teaching hospitals (OR, 1.05). Protective factors included the use of laparoscopy (OR, 0.91), transverse colectomy (OR, 0.90), and right colectomy (OR, 0.43).

Similar results have been described more recently by Zafar¹⁹ who, in another US surgical database study from 2005 to 2010, also found that laparoscopic colectomy is associated with a lower incidence of intraoperative ureteral injury when compared with open procedures.

Of a total of 94 526 colectomies, 33 092 (35%) were completed laparoscopically. Ureteral injury occurred in a total of 585 patients (0.6%). The incidence in the open group was higher than that in the laparoscopic group (0.66% versus 0.53%, $P=0.016$) and matched analysis showed the likelihood of ureteral injury after laparoscopic colectomy to be 30% less than after open colectomy (odds ratio, 0.70; 95% confidence interval, 0.51-0.96). Patients with ureteral injury were independently more likely to have septic complications and have longer lengths of hospital stay than those without ureteral injury.

To answer the original question, if it is true or not that the incidence of ureteral injury is increased with the introduction of laparoscopy, we can affirm that after an initial moderate increase in incidence of IUIs, with growing experience in laparoscopic surgery, ureteral injuries not seem to be more in laparoscopic surgery than conventional surgery.

In our review of the literature we analyzed 3 prospective studies^{11,12,16} carried out on a total of 8,642 patients, 6 retrospective studies^{1,5,6,17-19} on 2,394,285 patients, and 6 reviews on 526,255 patients^{7,8,26-28,33}. Amongst all the literature reviewed, only 7 studies^{1,5,6,7,8,18,19} reported the incidence of ureteral injuries, with a total of 8673 out of 2,791,528 (0.31%) (Table I).

1.2 - Ureteral injuries associated with single incision laparoscopy

For several years, single incision laparoscopy (SIL) procedures are more and more used and specifically for left side colectomy. Considering the decrease space for triangulation and the increase collision between instruments, complication rate could compare unfavorably to standard laparoscopic approaches. However, there are several reports stressing the benefit of SIL over conventional multiport laparoscopy, in colorectal surgery in term of less blood loss, smaller incisions, and quicker left colectomy.

Khayat A et al.³⁴ compares SIL to conventional multiport laparoscopy for colorectal resection.

From July 2009 to April 2013, 764 patients who under-

went 799 colorectal resections by SIL or conventional multiport laparoscopy were analyzed. Eighty-four colorectal resections were performed using SIL: 43 ileocolic resections, 15 right-sided colectomies, 14 left-sided colectomies, 5 rectal resections, 4 subtotal colectomies, and 3 total proctocolectomies. Intra-operative complications occurred in three procedures (4%): a cecal injury during a right colectomy, a rectal injury during a restorative coloproctectomy, and a small bowel injury during an ileo-colonic resection. These intra-operative complications required a conversion into an open approach in one case, but were managed without needed conversion in the two other patients. Outcomes of SIL, when compared to those of 715 conventional multiport laparoscopy, using a propensity score adjusted analysis, showed no difference in terms of intra-operative complication ($p = 0.315$).

Another comparative study performed by Marks JH et al.³⁵ demonstrated that SIL shows equivalent or better outcomes to standard laparoscopic surgery with equivalent morbidity rates. Particularly, intraoperative complications occurred in 1.0 % of SIL cases and 2.0 % of conventional multiport laparoscopy ($p = 0.56$). SIL complications included temporarily lost needle whereas conventional multiport laparoscopy included enterotomy and presacral bleeding.

2. PREVENTION OF IATROGENIC URETERAL INJURIES

The best management of a ureteral injury is prevention.

2.1 - Predictive risk factors of ureteral injury in colorectal surgery

In literature are described some predictive risk factors of ureteral injury in colorectal surgery that should be taken in consideration.

W.J. Halabi et al.⁵ analyzed the trends of iatrogenic ureteral injuries in the United States over a decade, as well as their outcomes and risk factors. The Authors concluded affirming that the incidence of iatrogenic ureteral injuries appears to be rising and their incidence can be predicted by several factors. The "Predictive variables" were Rectal cancer, Adhesions, Metastatic cancer, Weight loss, Teaching hospital. The Authors individuated also the "Protective variables" to avoid the iatrogenic ureteral injuries as Use of Laparoscopy, Transverse colectomy, and Right hemi colectomy. The LASSO algorithm for logistic regression was used to identify predictive variables for iatrogenic ureteral injuries. An estimated 2,165,848 colorectal surgical procedures were performed in the United States over the study period, and 6027 ureteral injuries were identified (0.28%). The rate of ureteral injuries was higher in the second half of the decade (2006-2010) compared with the first half (2001-2005; 3.1/1000 vs 2.5/1000; $p < 0.001$). Ureteral injuries were independently associated with higher mortality

(OR, 1.45; $p < 0.05$), morbidity (OR, 1.66; $p < 0.001$), longer length of stay (mean difference, 3.65 days; $p < 0.001$), and higher hospital charges by \$31,497 ($p < 0.001$). Risk factors for ureteral injuries included rectal cancer (OR, 1.85), adhesions (OR, 1.83), metastatic cancer (OR, 1.76), weight loss/malnutrition (OR, 1.08), and teaching hospitals (OR, 1.05). Protective factors included the use of laparoscopy (OR, 0.91), transverse colectomy (OR, 0.90), and right colectomy (OR, 0.43).

Another interesting work presented at the annual meeting of the American society of colon and rectal surgeons, April 27-May 1, 2013 Phoenix, USA about the predictive factors of ureteral injuries in colorectal surgery was presented by Miller P. et al.⁸. The goal of his study was to determine the national incidence of ureteral injury during colorectal surgery and analyze the predictive risk factors. A retrospective analysis of the Nationwide Inpatient Sample from years 2008-2009 was performed and a total of 481,727 patients underwent colorectal resection during this period were analyzed.

The overall the rate of ureteral injury was 0.4%. Laparoscopic colorectal resection was independently associated with a decreased risk of ureteral injury (OR 0.61, $p < 0.01$). On the contrary, the metastatic cancer (OR 3.03, $P < 0.01$), proctectomy (OR 2.43, $p < 0.01$), sigmoidectomy (OR 1.80, $p < 0.01$), left colectomy (OR 1.42, $p < 0.01$), and female sex (OR 1.12, $p < 0.01$) were independent risk factors for ureter injury.

2.2 - Awareness of the anatomy

Most important is an awareness of the anatomy from different perspectives, depending on the performed technique and type of approach.

As far as colorectal surgery is concerned, the risk for ureteral injuries is well known, so much so that its prevention is regulated by well-coded technique principles both in open and laparoscopic surgery. Laparoscopic colectomies in particular require a medial-lateral dissection both for the right colon³⁶ and for the left³⁷, with hemostasis of the major blood vessels with vascular staples or clips. For dissection on the avascular plane between colon and Gerota's fascia, coagulation is done with the ultrasonic shear alternated to gentle traction. During this dissection one must take great care to avoid injuries of Gerota's fascia and diving into the retroperitoneal soft tissue, because this exposes the patient to ureteral injuries as well as other retroperitoneal structures (like the kidney and duodenum and large vessels). When Gerota's fascia is either involuntarily or necessarily violated, great caution needs to be taken when coagulating with an Ultrasonic scalpel which can cause necrosis at the dissection plane compared to the monopolar electrocautery. Regardless, following a correct technique ureteral injuries are rare.

Many authors^{1,3,21,38} underline the importance of early recognition of the lesion, if possible already in the intra-

operative phase. This is because at this point the surgeon has different approaches available with different invasive degrees: surgical inspection, intravenous injection of a contrast agent, cystoscopy. Unfortunately, most iatrogenic ureteral injuries are identified postoperatively³⁹. These patients usually present with flank pain, fever, abdominal pain and distention, ileus, decreased urine output, or increased drainage from the drain site. In the post-op period, a conspicuous amount of clear liquid with an elevated creatinine level from the drainage tube must make one take into consideration the possibility of a ureteral injury. In the absence of a drainage tube, small intra-peritoneal collections can accumulate and give signs of a peritoneal reaction. In case of a major leakage, an abdominal compartmental syndrome can occur³.

2.3 - Surgeons experience and learning curve

To prevention of iatrogenic ureteral injuries, another important variables are the surgeons experience and learning curve. Lack of experience is the major cause of ureteric injuries.

In order to reduce the risk of injury, adequate preoperative preparation is recommended and meticulous surgical technique based on proper understanding of the anatomy of the urogenital system should be practiced by the surgeon⁴⁰.

Lesions can be prevented by the experience of the surgeon and the systematic intraoperative recognition/protection of the structures⁴¹. To increment the risk for lesions to urinary tract we must add some anatomic anomalies as ureteral duplication (81/125), retrocaval ureter, "horseshoe" kidney, and pelvic kidney (1/400).

In rectal surgery, the lesions of ureter can occur in three key moments: during detachment of Toldt's fascia, at the moment of incision of the pelvic peritoneum anteriorly to the iliac vessels, and during dissection of the lateral ligaments of the rectum. A lesion at the level of the ureter may occur by section, ligature, devascularization or transmitted thermal damage.

Experience is dependent on training, repetitions (learning curve) and on case load (of the surgeon and of the hospital). The learning curve demonstrates the progress in mastering a new surgical technique and is completed when the monitored parameters reach a steady state. In most studies these monitored parameters are operating time, intra- and postoperative complications, conversion rate for a laparoscopic approach, days to discharge, overall morbidity and mortality. The cut off to when a steady state is reached is dependent on many factors and varies greatly with each surgeon. For example, for laparoscopic colorectal resections the learning curve reached a steady state after 30 operations⁴².

2.4 - Preventive strategies to reduce the risk of ureteral injury

2.4.1. How to avoid the ureteric injuries? When do we need prophylactic ureteral catheterization?

Many surgeons and gynecologists agree that prophylactic ureteral catheterization may reduce the chance of a ureter injury. The use of prophylactic "J" stent insertion prior to expected difficult abdomino-pelvic surgery (large masses, fistulizing inflammatory bowel disease, or diverticular disease, previous pelvic surgery) makes the identification of the ureter easier and makes it less predisposed to injury. When the ureter is injured the stent also makes it easier to detect the injury at the time of surgery⁴³.

Preoperative ureteral stenting is still controversial because of potential complications³¹, however, more recent studies have drawn different and conflicting conclusions that praised to the use of ureteral stents.

Nam Y et al. analyzed 162 patients underwent ureteric catheterization and laparoscopic segmental left or right colectomy. The mean time for placement of ureteric catheters was 11.4 min for the right hemicolectomy and 11.3 min for the left hemicolectomy group. The mean preparation times for right hemicolectomy and left hemicolectomy (group 1 vs. group 2) were 54.7 vs. 39.1 min ($p=0.00001$) and 61.4 vs. 47.6 min ($p=0.006$), respectively. There were no significant differences in the laparoscopic operative time in either the right or left hemicolectomy groups (134.2 vs. 145.5 min and 198.4 vs. 170.1 min, respectively). There was no morbidity directly related to the ureteric catheters and in fact the incidence of postoperative urinary tract infection was lower in group 1 (1.5%) than in group 2 (5.3%) ($p<0.05$)⁴⁴. Chahin F et al. evaluated the potential implications of lighted ureteral stenting in laparoscopic colectomy⁴⁵. 66 patients underwent laparoscopic colectomy with lighted ureteral stents inserted preoperatively. Stents were removed in the immediate postoperative period.

One (1.5%) patient suffered a left ureteral laceration during sigmoid colectomy. This was managed successfully with stent reinsertion. Sixty-five (98.4%) patients had gross hematuria lasting 2.93 days (1 to 6 days). The cost of bilateral stent placement was \$1,504.32. A statistically significant difference occurred in the duration of hematuria (days) between patients who had unilateral (2.5 +/- 0.82) and bilateral stent placement (3.37 +/- 1.05), ($P < 0.001$). Four patients suffered from anuria, 2 required renal support-needing hemodialysis for 3 to 6 days, 3 (75%) had bilateral stents, and 1 (25%) had a unilateral stent. In conclusion, the Authors recommended the placement of lighted ureteral stents as a valuable adjunct to laparoscopic colectomy to safeguard ureteral integrity affirming that transient hematuria is common but requires no intervention and reflux anuria occurs infrequently and is reversible.

Also another study reported by Pokala N. et al.⁴⁶ stressed the importance of simultaneous ureteric catheter insertion during abdominal procedures.

Although known risk factors for iatrogenic urinary tract injury include previous pelvic operations, infection, and inflammatory bowel disease, the majority of ureteral injuries occur in patients without obvious risk factors^{47,48}. Few studies have examined the current status of ureteral stent use or the indications for stenting, particularly in laparoscopic colorectal surgery⁴⁹.

Prophylactic ureteric catheter placement has the advantage of facilitating intraoperative ureter identification and assisting in immediate injury recognition and repair. However, its use has been controversial because of fear of ureteric damage during catheter insertion and postoperative urinary complications such as obstructive oliguria and urinary tract infection. Although the exact indications for prophylactic catheter placement are not clearly defined, it is generally used for reoperative cases, large tumors, previous radiation therapy, diverticulitis, fistulas, Crohn's disease and obesity.

Speicher PJ et al.⁴⁹, to determine predictors of ureteral stent use among laparoscopic colorectal surgery, created a forward-stepwise multivariable logistic regression model making an a priori decision to include the following potential preoperative variables, which they judged to be potential predictors: procedure type, diagnosis, preoperative radiation and/or chemotherapy, age >60, sex, smoking, body mass index >30, alcohol abuse, diabetes, chronic obstructive pulmonary disease, coronary artery disease, bleeding disorder, ascites, functional status, recent steroid use, recent weight loss, American Society of Anesthesiologists classification, year of operation, preoperative transfusion, and preoperative creatinine level.

S. Tsujinaka et al., in 2008⁵⁰ evaluated the use of ureteric catheter placement in laparoscopic colorectal surgery and to assess the morbidity related to this procedure. Between 1994 and 2001, 313 elective laparoscopic colorectal surgeries were performed. Patients with and without ureteric catheters were retrospectively analyzed. They concluded that ureteric catheter placement was successful in most cases and was not associated with intraoperative injuries.

Also Beraldo S. et Al.⁵¹ affirm that the prophylactic use of a ureteral stent in laparoscopic colorectal surgery leads to minor complications and may be cost-effective.

The Authors analyzed 89 patients undergoing elective laparoscopic resection of their colon or rectum from June 2009 to June 2011 and one or two prophylactic ureteral stents were placed in all patients.

2.5 - Diagnosis of Iatrogenic ureteric injury

Iatrogenic ureteric injury carries significant morbidity and mortality, which can be further compounded by delayed diagnosis due to its non-specific clinical presentation.

Approximately two-thirds of iatrogenic ureteric injury are not recognized intra-operatively, with a widely ranging time until diagnosis (median times quoted from 6 to 65 days). Selzman and Spirnak²⁰ found that ureteric injuries during urological surgery are more likely to be detected intra-operatively than those occurring during non-urological surgery.

Investigation of IUI should depend on the extent of clinical suspicion, the type of operation undertaken and nature of the suspected injury. Early diagnosis improves outcomes, with delay in diagnosis considered the most important contributory factor in morbidity.

Briggs JH et al. reviewed ureteric anatomy, types of Iatrogenic ureteric injury, and imaging strategies available for diagnosis and proposed an imaging protocol for prompt diagnosis and follow-up based on clinical features and imaging (ultrasound, CT and urography)⁵².

Briggs JH et al. affirmed that Ultrasound should be undertaken in patients in whom clinical suspicion is low or as first investigation for patients with contrast medium allergy, poor renal function, or in pregnancy. If the triad of hydronephrosis, absent ureteric jets, and peritoneal fluid are not demonstrated, IUI can be considered unlikely and expectant management may be appropriate. On the contrary, if there is moderate or high clinical suspicion, CTurography should be performed due to higher spatial resolution and high sensitivity. If there is contrast medium allergy or any other reason precluding CT urography, then MR urography should be performed with intravenous gadolinium and diuretic. If these are negative with persistent clinical concern, or where therapeutic intervention is being considered, retrograde pyelography could be undertaken in selected cases if such expertise is available.

3. MANAGEMENT OF IATROGENIC URETERAL INJURIES

The data from international literature indicates a trend in which injuries that are diagnosed postoperatively are most often repaired using laparotomy. When injuries are diagnosed intraoperatively, the likelihood of a laparoscopic repair is increased, but if the team is not sufficiently experienced, an immediate open conversion would be required⁵³. The preferred technique of ureteral injury repair is dependent on the level of the injury, the loss of ureteric segment³ and on the time of injury diagnosis. The majority of the ureteral injuries can be repaired endoscopically with a combination of internal ureteral stenting and percutaneous nephrostomy tube drainage²⁰. The rest are amenable to a variety of surgical techniques. Operative repair of ureteral injuries requires scrupulous procedures. Minimizing ureteral trauma and preservation of adequate blood supply are mandatory. The ureter should be touched gently to avoid ischemia and mobilized with a generous periureteral tissue to preserve collateral circulations. The level and the

length of ureteral injury dictates the type of surgical repair feasible for a successful outcome. In fact, injuries to the lower ureter can generally be repaired with direct ureteral reimplantation in the bladder alone or with combination of a psoas hitch procedure. Injuries to the midureter may necessitate the addition of a Boari bladder flap or direct ureteroureterostomy if the injured ureteral segment is short. Injuries to the upper ureter may require a transureteroureterostomy. Mobilizing the kidney will allow an additional 5-8 cm in length. Finally, complete ureteral injury will necessitate an ileal loop ureteral interposition or autotransplantation.

Conclusions

The heterogeneity in presentation of short-term results after colorectal surgery and the lack of specific information on the incidence of ureteral injuries represented the main limitations of this review.

Given the lack of studies in the literature analyzing this short-term surgical outcome, it is not possible to assess the role of the surgical approach, laparoscopic or open, in the incidence of iatrogenic ureteral injuries.

Nevertheless in international literature the overall incidence of ureteral injuries is very low (less than 1%), but possible complications are severe, especially if they are not identified early during surgery. Intraoperative recognition and immediate repair of ureteral injuries result in fewer complications and reduced renal function loss.

Riassunto

INTRODUZIONE: La lesione ureterale iatrogena (IUI) rappresenta una grave complicanza che può verificarsi durante chirurgia addominale ed in particolare pelvica con una frequenza riportata in letteratura di circa 0,3-1,5%.

La frequenza delle lesioni ureterali iatrogene è notevolmente aumentata nel corso degli ultimi due decenni, in parte legata inizialmente all'introduzione della laparoscopia e in parte dovuta al maggior numero delle procedure chirurgiche in generale.

MATERIALI E METODI: Abbiamo effettuato una revisione sistematica per confrontare l'incidenza delle IUIs tra colectomie laparoscopiche e convenzionali. Lo studio è stato mirato anche alla valutazione delle caratteristiche/tipo delle lesioni ureterali e alla loro prevenzione e gestione. Abbiamo effettuato una revisione della letteratura per studi clinici prospettici e randomizzati che mettevano a confronto resezioni coloretali laparoscopiche e convenzionali eseguite per qualsiasi indicazione a partire dal 2003 al 2015.

La ricerca è stata realizzata utilizzando le banche dati informatizzate più popolari (PubMed, Ovidio, Medline). La nostra revisione sistematica ci ha permesso di selezionare un totale di 3 studi prospettici e 6 studi retro-

spettivi che confrontano i risultati a breve termine per resezioni coloretali.

RISULTATI: Dopo un moderato aumento iniziale dell'incidenza delle IUIs, con la crescente esperienza in chirurgia laparoscopica, le lesioni ureterali non sembrano essere più frequenti in chirurgia laparoscopica rispetto alla chirurgia tradizionale. Molti chirurghi e ginecologi concordano sul fatto che la profilassi ureterale mediante cateterizzazione/stent possa ridurre il rischio di una lesione dell'uretere.

CONCLUSIONI: Le lesioni ureterali sono particolarmente difficili da rilevare soprattutto durante gli interventi eseguiti per via laparoscopica, la sintomatologia delle stesse varia a seconda del meccanismo di lesione e alle volte, il rilevamento clinico può non essere tempestivo. Queste lesioni, se riconosciute in ritardo, possono portare anche ad una perdita della funzionalità renale. Il riconoscimento precoce e la riparazione immediata delle lesioni ureterali nel corso dello stesso intervento chirurgico è altamente auspicabile. Una lesione ureterale non riconosciuta e quindi non trattata intraoperatorialmente può richiedere una nefrostomia temporanea o un reintervento con conseguente aumento della morbilità.

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