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ORIGINAL ARTICLE

Can centralised care of complex laparoscopic procedures prevent urinary tract injuries?

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Abstract Centralised care of complex laparoscopic procedures offers expertise and multidisciplinary care. The objective was to identify if centralised care makes urinary tract injuries less likely or avoidable. This Retrospective Audit was performed at a Tertiary Referral Centre for Advanced Laparoscopic Surgery in North East England. The incidence of injury to bladder/ureter, time of diagnosis, instrument, location, side and mode of repair were evaluated in 105 consecutive complex laparoscopic procedures. Injuries were identified in three (2.8%) cases. There was one bladder injury which was unavoidable. The bladder dome was opened to allow excision of bladder endometriosis. There were two ureter injuries. The first injury involved the ureter being locked in a vaginal vault stitch. The second injury had stage IV endometriosis with peri-ureteric endometriosis where the anatomy was distorted, with medial displacement and kinking of the ureter secondary to fibrosis at the level of the ureter crossing below the uterine artery, with resultant accidental transection of the ureter close to the uterine artery. The first ureter injury was not a laparoscopic injury but due to vaginal vault closure. Arguably, vault closure in any vaginal hysterectomy could carry the same theoretical risk. The only direct laparoscopic injury was the ureteral transection. Such cases present a challenge due to a higher chance of anatomical distortion and predisposition to urinary tract injury. Noteworthy here is the fact that the ureter injury occurred where there was probable distortion of the anatomy, due to endometriosis, of the ureter at the level of the uterine artery. These cases are tackled by experienced laparoscopic surgeons in tertiary centres, yet injuries still occur. Is it possible then that those injuries represent a minimum unavoidable injury rate, and are they injuries or in fact unavoidable consequences of such inherently dangerous and difficult surgery?

Keywords Complex laparoscopic procedures · Advanced laparoscopic surgery · Complications · Injury · Ureter · Bladder

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Introduction

Gynaecologic laparoscopic surgery (GLS) is becoming more popular. A prime concern with GLS is its safety and the expertise needed to undertake it. There is still the perception that many complications of GLS can or could have been prevented by open surgery. It is unfortunate that the main drive for this perception is historical concerns rather than closer scrutiny and evidence-based analysis.

The urinary tract is vulnerable to injury because of its subtle appearance, its retroperitoneal nature and its long course from the renal pelvis to the bladder. There is a wide variation in reported rates of injury to the urinary tract as a result of GLS [1], mainly due to differences in study design, surgeons' experience, technique and case complexity.

Centralised care of complex laparoscopic procedures offers the advantages of established advanced laparoscopic

skills, advanced multidisciplinary care and an ideal theatre setup. It has been shown that the risk of complications in GLS is inversely proportionate to the experience of the operator [2]. The theatre setup and hospital structure must be capable of adapting to efficient practice of laparoscopic surgery. This keeps risks of complications to a minimum [3] and reduces cost [4]. It is thus reasonable to assume that established operators at minimal access surgery centres already have the experience and the setup to provide safe, specialised advanced laparoscopic surgery.

The aim was to identify the risk of urinary tract injury in complex laparoscopic procedures performed by skilled laparoscopic operators in an advanced laparoscopy centre, and to compare this centre's practice to published parameters for prevention/identification of urinary tract injury [5].

Methods

All the procedures were performed at the James Cook University Hospital (JCUH) in Middlesbrough. This is a large teaching hospital with a well-known (nationally and internationally) referral centre for advanced laparoscopic surgery as well as a regional training centre for minimal access surgery. Until the year 2000, the JCUH was the venue of the 'The WEL Foundation', a multidisciplinary renowned centre for treatment of endometriosis, which was a registered charity whose aim was to provide safe endoscopic surgery for women.

The procedures were identified retrospectively, using the codes of advanced laparoscopic procedures, by searching the operating theatre database. One hundred and five operative procedures were examined. All procedures were performed by experienced laparoscopic surgeons. The notes were examined individually. The individual counts of each procedure are shown in Table 1.

Laparoscopic entry and operative techniques were performed using established published techniques [6–9]. All the operations were performed for benign pathology (except for one case with primary peritoneal carcinoma who received four cycles of chemotherapy preoperatively followed by laparoscopic bilateral salpingoophorectomy). One case had laparoscopic-assisted Doderlein vaginal hysterectomy (LADVH) for atypical endometrial hyperplasia and was then found to have FIGO 1B G2 endometrioid adenocarcinoma of the uterus.

Table 1 Distribution of procedures

Procedure (total $n=105$)	Count (%) total=105
Laparoscopic-assisted Doderlein vaginal hysterectomy (LADVH)	53 (50.5%)
Radical/laparoscopic excision of endometriosis (R/LEE)	39 (37.1%)
Total laparoscopic hysterectomy (TLH)	4 (3.8%)
Laparoscopic adhesiolysis/laparoscopic salpingoophorectomy	9 (8.6%)

The vast majority of the procedures was performed by one operator (93.3%), 1.9% for each of three other operators and 0.9% for one operator. The patients were assessed in terms of surgical risk in view of risk factors; previous surgery, known endometriosis (previous confirmation by histology), benign ovarian masses, fibroids, pelvic inflammatory disease, previous irradiation or known urogenital congenital anomalies (one case underwent LADVH and was known to have uterus didelphys with a single right kidney with a history of partial nephrectomy for a right duplex system). The documentation during the clinic consultation was assessed in terms of discussion of planned surgery, alternatives offered, risks of surgery, leaflets provided and GP (general practitioner) letter documentation. The operative notes were then analysed for safety rules for entry as per the Middlesbrough consensus document, meticulous technique, documentation of difficulties and of identification of the ureters at the start, during and at the end of the procedure, method of ureter identification, time of diagnosis of injury, side, type, site of injury, causative instrument, multidisciplinary input, mode and route of repair, follow-up and sequelae. Where necessary, perioperative illuminated ureteric stents were used with cystoscopy with or without indigo carmine dye, which was included in the preoperative discussion and consenting process.

Results

Table 2 shows all the cases needing perioperative ureteric identification. Almost 88% of the procedures had one or more pre-existing risk factors (Table 3), either endometriosis or adhesions from chronic pelvic inflammatory disease (five cases), previous pelvic surgery (examples include caesarean section, CLAM cystoplasty, colposuspension, abdominal hysterectomy, previous midline laparotomy for left borderline mucinous ovarian mass) or from advanced endometriosis, large (>5 cm) adherent ovarian endometriomas, benign ovarian masses or uterine fibroids. In 93% of cases, the ureters were identified visually or by an invasive means. There were eight cases where the ureters were not identified or documented presumably due to the surgeon being relatively reassured that the pathology was away from clearly visible, peristaltic ureters. Interestingly, in those cases, there were two ureteric injuries details of which are described below. Eight cases had no form of bladder integrity

Table 2 This table shows the details of all the 29 cases needing preoperative or intraoperative ureteric stenting, ureteroscopy or retrograde ureterogram

	Risk factors	Operation	Injury
Case 1	Endometriosis IV, ovarian mass	RLEE, large endometriomas, adherent rectum, bilateral stents	No
Case 2	Endometriosis IV, previous left nephrectomy, left ureterectomy, LSO, segmental sigmoid resection	LADVH, RSO, adhesiolysis, right stent	No
Case 3	Endometriosis I	Treatment of endometriosis, left stent	No
Case 4	Caesarean section	LADVH, LSO, right stent	No
Case 5	Fibroid	LADVH (no dye from left ureter, paste-like material dislodged by ureter guide, bilateral retrograde ureterogram, ureters normal on USS, IVP, CT scan)	No
Case 6, 18, 22	Endometriosis II–IV	LEE, left/bilateral stents	No
Case 7	Endometriosis IV, fibroid, previous surgery	RLEE, left stent, left ureterolysis, enterolysis, LSO, Mirena insertion	No
Case 8	Endometriosis I/II, previous surgery	LAVDH, bilateral stents, LEE	No
Case 9	Endometriosis II	Ablation of endometriosis, left stent, hysteroscopy, Fenton's	No
Case 10, 11	Endometriosis IV	RLEE, bilateral stents, left ovarian cystectomy (case 10), dye test	No
Case 12	Endometriosis, previous surgery	Extensive adhesiolysis, trachelectomy, ureteroscopy	No
Case 13	Endometriosis	Adhesiolysis, LEE, Dye test, Hysteroscopy	No
Case 14	Endometriosis, pelvic inflammatory disease	LAVDH, LSO, excision of bladder endometriosis, check cystoscopy+left retrograde rigid ureteroscopy	Yes (bladder)
Case 15	Endometriosis	LEE, adhesiolysis, bilateral ureterolysis, bilateral stents	No
Case 16	Endometriosis III	LEE, hysteroscopy, bilateral stents	No
Case 17	Endometriosis IV, rectovaginal endometriosis, ovarian mass	RLEE, LADVH, BSO, bilateral stents, ureterolysis	No
Case 19	Endometriosis, previous surgery	LADVH, RSO, right stent	No
Case 20	Previous radical hysterectomy for 1B1 cervical cancer and lymphadenectomy	Adhesiolysis, left oophorectomy, bilateral stents	No
Case 21	Endometriosis II	LEE, dye test, bilateral stents	No
Case 23	Endometriosis IV	RLEE, bilateral stents	No
Case 24	Endometriosis IV	RLEE, LADVH, BSO, bilateral stents	No
Case 25	Endometriosis, fibroid	Ablation of endometriosis, LSO, hysteroscopy, left stent	No
Case 26	Endometriosis IV	RLEE, LADVH, BSO, bilateral stents	No
Case 27	Endometriosis IV	RLEE, excision/ablation of endometriomas, bilateral stents	No
Case 28	Endometriosis	TLH, RSO, excision of endometriosis, repair of right ureter (JJ stent)	Yes (ureter)
Case 29	Fibroid, left ovarian fibroma 9 cm	LADVH, LSO, left JJ stent, retrograde ureterogram	Yes (ureter)

LSO left salpingoophorectomy, *RSO* right salpingoophorectomy, *BSO* bilateral salpingoophorectomy, *USS* ultrasound scan, *LADVH* laparoscopic-assisted Doderlein vaginal hysterectomy, *TLH* total laparoscopic hysterectomy, *LEE* laparoscopic excision of endometriosis, *RLEE* radical laparoscopic excision of endometriosis

check most likely due to uneventful surgery and a reassured surgeon. There were no injuries in this group. Details of the procedures with bladder injury and ureteric injuries are as follows:

Bladder injury

This case was undergoing LADVH and LSO with excision of bladder endometriosis. This patient was known to have

Table 3 Adherence to recommendations to prevent/diagnose urinary tract injury

	Number/105	%
Risk factors (RFs)		
No RF	13	12.4
1 RF	50	47.6
2 RFs	36	34.3
3 RFs	6	5.7
Clinic documentation adequate (and leaflets)?	105	100
Difficulties documented?	105	100
Meticulous technique?	105	100
Ureter identification: visual/otherwise		
Yes	97	92.4
No (includes not documented)	8 (2 ureteric injuries)	7.6
Cystoscopy+ureteric stents/ureterogram/ureteroscopy		
Yes	29	27.6
No	76	72.4
Cystoscopy+indigo carmine		
Yes	60	57.1
No	45	42.9
Cystoscopy alone	8	7.6
Bladder not checked by any means	8	7.6
Injury (total):	3	2.8
Bladder	1 (bladder endometriosis)	0.9
Ureter	2 (vault stitch/50% transection)	1.9

endometriosis and pelvic inflammatory disease from previous laparoscopies. The patient was counselled appropriately in the clinic. The endometriotic nodule was noted to involve the bladder wall. An intentional cystotomy was performed to allow complete excision of this bladder nodule. It was repaired laparoscopically with the urological surgeon in attendance. The urological surgeon then performed check cystoscopy to verify the integrity of the repair with a left retrograde rigid ureteroscopy which revealed no abnormalities. This patient has suffered no long-term morbidity.

Ureteric injury: case 1

This case was undergoing TLH, RSO and LEE. This patient was nulliparous with narrow vaginal access and known to have stage IV endometriosis. Preoperative counselling was adequate. In the operative notes, the surgeon wrote; 'there was thick nodular endometriosis around the right ureter pulling it medially'. The injury of the right ureter was noted immediately and was caused by the bipolar diathermy and scissors leading to 50% transection. It was erroneously believed to be a blood vessel as the injury of the right ureter was close to the site of the right uterine artery. The urology team were asked to attend who inserted a JJ-shaped ureteric stent and laparoscopic repair of the right ureter followed. A 10-mm portion of the coagulated ureter ends (till healthy ureter) was excised and tension-free reanastomosis of healthy ureter ends followed using full thickness 3/0 polyglactin sutures. An intravenous urogram 10 days later showed no abnormalities. The stent was removed at 8 weeks and intravenous pyelograms (IVP) at 6 and 12 months were normal. To date, this patient has suffered no long-term morbidity.

Ureteric injury: case 2

This case was undergoing LADVH and LSO. This patient was known to have a fibroid uterus and a 9-cm left ovarian fibroma. Preoperative counselling was adequate. The ureters were identified visually transperitoneally at the start of the operation. At the end of the operation, the ureter integrity was checked by cystoscopy and indigo carmine. It was then noted that there was no dye coming from the left ureteric orifice. The urology team were called who then performed a retrograde ureterogram. The left ureter was blocked possibly due to a uterine pedicle or vaginal vault stitch that had perforated the ureter and locked it. A JJ-shaped stent was placed and the stitch released. Eight weeks later, a retrograde ureterogram revealed no problems and the left ureteric stent was removed. Table 4 shows a summary of the cases of ureteric injury.

Discussion

There is now accumulating evidence for the comparable safety of GLS. A recent publication by the National Institute for Health and Clinical Excellence (NICE) institute on laparoscopic hysterectomy [10] has said that there is now adequate evidence to support the safety, efficacy of laparoscopic techniques for hysterectomy. It has been shown in a meta-analysis that GLS is not inherently dangerous for patients presenting with benign gynaecological pathologies and that the complication risk should no longer be advanced as an argument against laparoscopic surgery [11].

The total rate of injury to the urinary tract in this study was 2.8%. If considered separately, the risk of bladder injury was 0.9% and that of ureter injury was 1.9%. These rates are somewhat higher than published figures (Table 5). We, however, have to take into consideration the complexity of the cases being studied, most of whom have been referred to this tertiary centre following unsuccessful treatment elsewhere and their pre-existing risk factors. They are therefore more 'challenging' cases. Ou et al.

Table 4 Details of the two cases with ureteric injury

	Ureteric injury cases	
	Case 1	Case 2
Surgeon	Senior	Senior
Procedure	LADVH, LSO	TLH, RSO, RLEE stage IV
Risk factors	Fibroid, 9-cm ovarian fibroma	Stage IV endometriosis
Diagnosis	Intraoperative; suspected at check cystoscopy	Intraoperative: transected, ?? blood vessel
Side	Left	Right
Type	Perforation thru and thru/locking	50% transaction
Site	Distal ureter close to left vaginal vault	Close to right uterine artery, thick nodular endometriosis
Instrument	Vaginal vault stitch	Bipolar diathermy, scissors
Urology input	Yes (intraoperative)	Yes (intraoperative)
Mode of repair	Retrograde ureterogram, left JJ stent, vaginal vault stitch release	Right JJ ureteric stent, full thickness repair of ureter, excision, tension-free reanastomosis
Route of repair	Vaginal	Laparoscopic
Follow-up	8 weeks	10 days, 8 weeks, 6 months, 12 months
Investigations/ sequelae	Cystoscopy, stent removal, left retrograde ureterogram/none	IVU, stent removal, renogram/none

[12] questioned the existence of a learning curve as they could not find a reduction in operating time in 839 LAVHs undertaken by four surgeons. The explanation for that was that as the surgeon accrues experience, more difficult cases are undertaken. The results of an American survey suggested that complication rates increase with more complex laparoscopic procedures [13]. Furthermore, a noteworthy fact is that the ureter injured in Dorderlein's hysterectomy was associated with distortion of the pelvic anatomy and probable kinking and displacement of the ureter at the uterine vessel complex. Therefore, based on the above arguments, those cases were more challenging and more prone to injury, despite being operated upon by expert laparoscopic surgeons.

It could be argued that the bladder hole was unavoidable if complete excision of the bladder endometriotic nodule was to be achieved. The alternatives were to avoid surgery or to avoid removing the nodule or to try and remove it without causing a bladder hole. Certainly, avoidance of surgery or leaving the nodule behind would not have treated the patient's cyclical hematuria. A similar challenge would have been encountered if this procedure was done by open surgery, with the surgeon losing the added benefit of magnification and clear views of organs and anatomical landmarks with laparoscopy compared to the crude, gross views offered by laparotomy. Relevant disadvantages of laparoscopy in this case are the loss of depth perception and tactile sensation. Nevertheless, the bladder hole was detected immediately and repaired laparoscopically with no added long-term morbidity. A further benefit of this surgery being done in this tertiary centre is the ability to repair this complication laparoscopically.

Both ureters were injured in their distal segment, one on the right side and one on the left side. One case of ureteric injury had stage IV endometriosis. It is known that 38% of ureter injuries occur during treatment of endometriosis [14]. There was clear documentation of the presence of thick nodular endometriosis around the right ureter causing anatomical distortion and pulling the ureter medially. Studies have indicated that remaining strictly within the boundaries of the lateral edge of the uterus medially and a sectioned uterine artery laterally would make injury of the ureter theoretically impossible as it is located outside the uterine artery [5]. In this instance, however, the ureter was

Table 5 Urinary tract complications with laparoscopic surgery reported in different studies

Study	Bladder injury %	Ureter injury %	Overall %
Baggish et al. 1992 [1]	–	–	4.8
Liu and Reich 1994[2]	–	0.19	1.4
Garry and Phillips 1995[3]	1.1	0.3	1.4
Saidi et al. 1996a[4]	0.84	–	–
Saidi et al. 1996b[5]	–	2.9	–
Harris et al. 1996[6]	–	–	1.6
O'Shea et al. 1996[7]	–	–	2.4
Harkki-Siren 1997[8]	–	1.29	–
Hulka et al. 1997[9]	1	0.3	1.3
Meikle et al. 1997[10]	1.0–1.8 (vv fistula 0.2)	0.3–0.4	1.3–2.2
Garry 1998[11]	–	2	–
Tamussino et al. 1998[12]	–	4.3	–
Harkki-Siren 1998[13]	0.22	1.39	1.61
Makinen et al. 2001[14]	–	1.1	–
Johnston et al. 2003[15]	0.16	0.16	0.32
Garry et al. 2004[16]	2.1	0.9	3.0 (LH in AH arm)
	0.9	0.3	1.2 (LH in VH arm)
Jha et al. 2004[17]	–	1.39–6.0	–
McMaster-Fay and Jones 2006[18]	–	0.39	–
Leonard et al. 2007[19]	–	0.3	–
NICE 2007[20]	0.4 (vv fistula 0.2)	1.3	1.7
Range	0.16–2.1	0.16–6.0	0.32–8.1
This study	0.9	1.9	2.8

pulled medially, away from its normal position. Indeed, it was mistaken for a blood vessel and was injured close to the uterine artery. The injury, as documented, was 50% transection using bipolar diathermy and scissors. The injury was identified immediately and repaired laparoscopically with the urology team. The immediate identification of the injury, multidisciplinary input and laparoscopic repair all help reduce the impact of the injury on morbidity, recovery time, kidney and ureter function.

Using a retrospective critical analysis of this complication, it is possible that preoperative ureter stent in this particular case might have prevented the ureter injury. The policy in this unit regarding usage of ureteric stents is that of selective use. This depends on the ability to visualise, dissect the ureter, the proximity of the disease to the ureter or if there is significant pelvic sidewall disease at the time of the procedure. Therefore, it is usually a retrospective decision during the laparoscopy. In this case, a problem in ureteric identification was not anticipated and therefore this complication was not expected. The ureter was completely surrounded by disease and its location was distorted as it was pulled medially at the level of the uterine artery. The authors feel that in this particular case, had the ureter been identified, safe removal of disease would have involved leaving residual disease due to the extensive nature of this disease at this critical area. This selective policy of stent usage is based on the surgeon's expertise, judgement at the time and it is a process that is undergoing continuous modification and review depending on complication rates.

From the authors' point of view, this complication shows that the judgement made at the time was incorrect and that preoperative stent usage in that particular instance might have averted the injury. The learning point for the authors is to have a lower threshold for stent usage in the future.

The other ureteric injury was completely unexpected as the procedure was straightforward. It is possible that the ureteric anatomy was distorted by the fibroid uterus and the ovarian fibroma. The left ureter injury was suspected when indigo carmine dye failed to show at the left ureteric orifice at the time of cystocopy. The left ureter was locked by a uterine pedicle or vaginal vault stitch. Arguably, this complication is not a direct laparoscopic injury and, theoretically speaking, could occur in any vaginal hysterectomy. Complications of laparoscopic surgery have been classified as either approach or technique related [15]; this complication does not fit in either category. Had it not been for the check cystoscopy and indigo carmine at the end, this complication would have been missed with disastrous consequences.

The major limitation of this study is that it is retrospective in nature with underestimation of the potential risk (reporting bias) due to subclinical injury or inadvertent omission if the identification mechanism fails. Furthermore, the sample size was relatively small. Extrapolation of the findings in this study would be difficult for other units as the caseload in this study represents complicated cases referred to skilled laparoscopic surgeons for tertiary care.

Conclusion

Injuries to the urinary tract, albeit some cases have anatomical distortion with increased likelihood of urinary tract injury, still occur despite skilled laparoscopic surgeons undertaking those advanced laparoscopic procedures in a well-established theatre setting. It has already been said that surgery adjacent to the ureter will continue to result in occasional iatrogenic injury [16]. Is it then fair to say that those injuries represent a minimum unavoidable injury rate, and are they injuries or in fact unavoidable consequences of such inherently dangerous surgery? The important issue primarily should be the early recognition and management of urinary tract injuries, yet undoubtedly avoidance, if at all possible, remains the most attractive option.

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Contribution to authorship Hassan Morsi designed the study, collected and analysed the data and prepared the draft paper. Graham Phillips reviewed the paper and provided corrections until the final draft was achieved.

Ethics approval This was a retrospective audit conducted, within the Trust's Clinical Audit program, with Trust approval through the Audit Lead and the Clinical Audit department and registered (audit design and results) on the Trust's Clinical Audit Database. In view of this not being within the confines of research, independent research ethics committee approval was not sought.

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