

Accident analysis: factors contributing to a ureteric injury during deep endometriosis surgery

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Objective To analyse factors associated with a ureteric injury.

Design Retrospective accident analysis.

Setting Deep endometriosis surgery in a tertiary referral centre.

Sample Video recording of a surgical accident was analysed by six gynaecologists.

Methods A 26-year-old woman underwent laparoscopy for deep endometriosis that involves the rectosigmoid and left ureter. Post operatively left ureter transection was identified and corrected by laparoscopy. Interventions were recorded and reviewed independently.

Main outcome measures Changes in surgical behaviour that could be measured were identified using the video recording.

Results During the intervention, the periods of uncontrolled bleeding ($P < 0.0001$) and the duration of laser activation ($P = 0.013$) increased progressively. Simultaneous laser activation and bipolar coagulation only occurred at the end of surgery (seven episodes). Fatigue could not be measured.

Conclusion Unconscious acceleration of surgery, possibly as a consequence of fatigue, is suggested as a contributing factor for an error of judgement.

Keywords Deep endometriosis, surgical mistakes, video recording.

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Introduction

Accident prevention in aviation is based upon the analysis of individual accidents and near accidents using the data from the black box. In surgery, however, we do not have, to the best of our knowledge, any analysis of the factors contributing to accidents. The literature even lacks data on the real incidence of accidents; for example, for ureteric injuries there is no data that permits us to distinguish between accidental injuries (i.e. unnecessary and avoidable) and unavoidable injuries (e.g. segmental ureteric resection in cases of transmural endometriosis).

The incidence of complications, that is both the accidents and the unavoidable injuries together, is well documented. Complications vary with the difficulty of the surgery and the experience of the surgeon.¹ For ureteric injuries, the incidence of complications during surgery for endometriosis varies from 0.08 to 1%.^{2–4} The incidence increases to 4.4% in deep endometriosis and to 11.2% for nodules larger than 3 cm.¹

There is only indirect evidence of factors that could contribute to accidents in surgery. Stress and fatigue have been reported to impair judgement during surgery.⁵ Fatigue and stress decrease the quality of clinical work⁶ and mistakes increase after excessive hours of work.⁷

This lack of data on factors contributing to accidents during surgery is not surprising considering the reluctance of most surgeons to report and document mistakes given the medico-legal perspective. However, knowledge of these factors is essential for accident prevention, so we decided to analyse a recent ureteric injury to identify the contributing factors. We also wanted to analyse why the injury had been missed during surgery.

Methods

The surgery

A 26-year-old woman with severe pain (Biberoglu–Behrman scores of dysmenorrhoea 2/3, chronic pain 1/3, dyschezia 1/3

but no deep dyspareunia) underwent laparoscopic surgery for a left-sided endometrioma and deep endometriosis of the rectosigmoid involving the left ureter. Contrast enema had identified a large, deep endometriotic nodule of the rectosigmoid with 40% occlusion over a length of 4 cm. An intravenous pyelogram was normal.

Following a full bowel preparation (6-l Prepacol, Codali SA, Brussels, Belgium), surgical excision was performed as reported, using a CO₂ laser (Sharplan, Tel Aviv, Israel) and three secondary 5-mm ports. First, the sigmoid and rectosigmoid were dissected from the left lateral abdominal wall. The left ureter was identified and the ovary was dissected from the left ovarian fossa. A 5-cm endometrioma was excised, and to improve visualisation the ovary was sutured to the abdominal wall. The same procedure was repeated on the right side with excision of a 4-cm endometrioma. Subsequently, excision of the endometriotic nodule was started laterally with bilateral dissection of both ureters up to the point where they crossed the uterine arteries. Dissection continued up to the pararectal spaces, revealing a nodule of 4 × 3 cm. Finally, the nodule was dissected from the bowel using laparoscopic scissors, leaving a muscularis defect of 3 cm, and subsequently dissected from the uterus and vaginal wall. Following careful control of haemostasis, the muscularis defect of the rectosigmoid was sutured prophylactically with a running polyglactin suture suture (Vicryl® 3/0; Ethicon Inc., Johnson-Johnson, Somerville, NJ, USA). Bowel integrity was confirmed by injection of 250-ml methylene blue solution into the rectum. The total duration of surgery was 181 minutes.

Postoperative management was standard. The first day after surgery antibiotics were started because of pyrexia (38.4°C), mild abdominal pain and a raised C-reactive protein (49 mg/l). On the second day, the woman had more pain and the C-reactive protein had increased to 235 mg/l. This prompted us to perform a repeat laparoscopy to exclude a late bowel perforation, an intra-abdominal bleed and a bladder or ureteric trauma. The laparoscopy was normal and only about 50 ml of fluid was found in the pelvis. As the pelvis looked slightly injected, infection was suspected, and a drain was left *in situ* and antibiotics were continued. On the next day, the woman was clinically much better. On the fifth day, the amount of fluid from the drain suddenly increased. A creatinine concentration of 57.6 mg/dl identified this as urine, and a computed tomography scan demonstrated that the leakage was arising from the left ureter. To determine the degree of damage sustained to the ureter, a third laparoscopy was performed which demonstrated complete transection of the left ureter at the level of the uterine artery. A laparoscopic anastomosis was performed by inserting five interrupted monocryl 5*0 stitches over a ureteric stent. The subsequent postoperative recovery of the patient was uneventful.

Analysis of contributing factors

This surgery had been performed by P.K. and two fellows in gynaecological endoscopy (R.S. and C.D.C.) as the third intervention after 8 hours of surgery for two other, very difficult, deep endometriosis excisions. All interventions were registered (Nebula; eSaturnus Ltd, Leuven, Belgium) from beginning to end with exact indication of time (hour, minute, second) imprinted in the video.

To identify contributing factors, all the videos were reviewed independently by each of the authors. Specifically, each author attempted to identify when the initial surgical mistake was made, to try to understand why this went unnoticed not only during the first laparoscopy but also during the second laparoscopy. The videos were reviewed for changes in surgical behaviour. Increases in the speed at which the surgery was performed were measured indirectly by measuring the duration of CO₂ laser activation, the number of bleeding episodes that (on review) were judged not to be controlled immediately were documented, and episodes of simultaneous activation of CO₂ laser and bipolar coagulation were also recorded. For each event, including the ureteric injury, the exact time from the beginning of surgery was noted from the time imprinted on the video. Specific signs of fatigue could not be identified or measured, although the impression prevailed that at the end of surgery the speed of movement of instruments was increased with a decreased precision (e.g. during suturing) and the camera image was less stable.

Statistics

Statistical analysis used the SAS system, using a Spearman correlation

Results

The ureteric injury occurred after 84 minutes during the excision of the nodule from the vagina and left sidewall. This large nodule extended laterally below the level of the uterine artery. When bleeding occurred from a branch of the uterine artery, coagulation included coagulation of the left ureter. Later, the coagulated area was cut with the laser, and this mistake was not recognised during the course of the surgery. Dissection of the ureter distal of the uterine artery had not been considered necessary because it had already been identified and dissected up to the point where it crossed the uterine artery and because it was considered not to be at risk of damage. The coagulation of the ureter had masked the subsequent transection, which was even on review difficult to identify.

The duration of CO₂ laser activation increased over time, suggesting that each surgeon operated more quickly with time (Spearman, $P = 0.013$). At the beginning of surgery, coagulation was performed immediately, keeping the operating field dry. However, towards the end of surgery, the coagulation of smaller vessels was less particular, that is the delay between bleeding event and coagulation increased (Spearman, $P < 0.0001$).

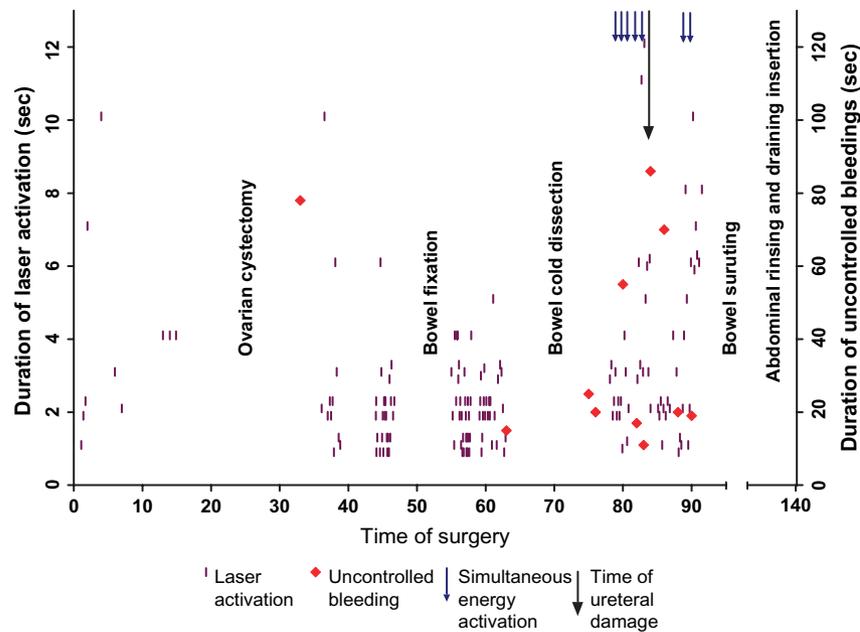


Figure 1. Duration of laser activation, episodes of bleeding that were not immediately controlled, and episodes of laser activation and bipolar coagulation occurring simultaneously during the surgery. The moment of ureteric injury is indicated.

Finally, all seven episodes of simultaneous bipolar coagulation by the assistant, while the surgeon continued to activate the CO₂ laser, occurred towards the end of surgery (Figure 1).

Careful review of the video of the second laparoscopy failed to identify the ureteric injury, which was not searched for actively in the presence of less than 50 ml of peritoneal fluid. The sudden increase in fluid draining from the abdomen on the fifth day was consistent with, and was confirmed as, a late ureteric leak.

Discussion

Accident prevention during surgery remains poor. To prevent accidents from occurring, it is helpful to categorise injuries as 'unavoidable', 'understandable' or a 'preventable' accident. A ureteric injury can be necessary (e.g. a partial resection because of transmural endometriosis) or understandable (when surgery is very difficult) or it may be an accident that should never have happened. Notwithstanding the presence of a large nodule, known to be associated with a higher incidence of ureteric injuries, this injury was felt to be due to an error of judgement, and so preventable. Although dissection of the distal part of the ureter would have been technically easy, this was not considered because the ureter was erroneously assumed to be much higher and at a safe distance.

After a surgical error has been identified, it is important to analyse all the factors that may have contributed to the mistake. During this surgery, we identified the following: increases in the speed at which the surgery was performed (as evidenced by significantly longer periods of laser activa-

tion), less strict control of bleeding as surgery progressed and increased events of simultaneous use of bipolar coagulation and laser activation with time. Although we do not have objective data to explain why the attitudes of the surgeons changed, we suggest a combination of three contributing factors. After 'the difficult' part of the surgery has been completed, the surgeon relaxes, leading to an increase in speed. In addition, at the end of the day, there is a greater pressure to finish the surgery. Fatigue is likely to be the biggest contributing factor, after three complex endometriotic cases and 11 hours of surgery. Unfortunately, this is difficult to measure objectively.

Fatigue is known to influence human judgement and to increase mistakes. Longer working shifts have been shown to cause trainees to make more serious errors during medical and intensive care treatment,⁶ whereas shorter working shifts have been suggested to reduce mortality rates.⁸ For surgical interventions, the effect of fatigue has not been documented unequivocally but already in 1969 the issue of 'The Tired Surgeon' was being discussed in medical literature and it was suggested that fatigue impaired judgement.⁵ Laparoscopic surgery is physically demanding as shown by a higher muscular load and muscular fatigue in comparison with laparotomy, especially for less-experienced surgeons.⁹ Fatigue causes tremor in both arms.¹⁰ The position of the surgeon contributes to increased fatigue because of the upright position with fewer upper body movements and less anteroposterior weight shifting.¹¹ During laparoscopy, the stress of high concentration during difficult surgery will also contribute to fatigue.¹²

Only after reviewing the videos did we understand why the transection had been missed during both the first and second

interventions. Coagulation of an area including the ureter had sealed both free ends of the divided ureter, making the transection difficult to identify, both during the initial surgery and during the repeat laparoscopy. This supports a policy of routinely checking the patency of both ureters via cystoscopy after all major surgery. Errors of judgement are unlikely ever to be eliminated completely, and even if accidental damage to the ureter occurs in as few as 1% of cases, picking up and dealing with these cases is essential if serious morbidity is to be prevented.

The postoperative management followed the standard procedures as performed in our hospital for the last 5 years. Whenever a late bowel perforation is suspected (either from the clinical picture alone or in combination with an increasing C-reactive protein level), a repeat laparoscopy is immediately performed. Preoperative examinations such as computed tomography scan, contrast enema or intravenous pyelogram are not performed because we consider that they would not add to the diagnosis given by the laparoscopy. However, if symptoms are so minimal that a repeat laparoscopy is hardly indicated, additional investigations are performed for reassurance. This case demonstrates clearly that a coagulated ureter, which will lead to a ureter leak after 4 days or more, will not be recognised at laparoscopy if it is not suspected. We have, therefore, changed our standard procedure to be much more radical by adding ureteral evaluation before repeat laparoscopy. Ureteral anastomosis over a stent is now standard.¹³

In conclusion, a detailed review of all complications such as ureteric injuries should be performed to identify those injuries that should be considered accidental, to identify contributing factors and to understand why some injuries are missed during surgery. If such a review was performed systematically, the resulting data would permit us to organise prevention objectively. Video recording and reviewing enables us to perform these accident analyses. From this analysis the following conclusions can be made. A systematic cystoscopy after surgery to prevent any injuries being missed is recommended. Awareness of surgical fatigue is important and trainees and nurses should be encouraged to comment when they think that the surgeon seems tired.

Disclosure of interests

The authors R.S., C.D.C., R.C. and D.S. declare that neither they, nor any member of their families, have a financial interest, arrangement or affiliation with any commercial organisations. P.R.K. declares that two of his sons have a financial interest through their ownership of the company – eSaturnus, Belgium.

Contribution to authorship

R.S. reviewed the video recording and analysed it for surgical mistakes and changes in surgical behaviour. He analysed the

results and statistics and wrote the manuscript. C.D.C., R.C. and D.S. reviewed the video recording for surgical mistakes and reviewed the manuscript, making important remarks. P.R.K. reviewed the video recording and analysed it for surgical mistakes and changes in surgical behaviour. He helped in analysis of the results and statistics and reviewed and corrected the manuscript.

Details of ethics approval

This study involves analysis of video recordings. Permission to record the laparoscopies and for their following analysis was given by the patient involved.

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Editor's Commentary

The paper by Schonman *et al.* (115:1611–1615) in this month's *BJOG* is unique in that it is the first ever paper published by *BJOG* critically examining why a serious gynaecological surgical complication occurred. The authors, who work in one of the leading endometriosis centres, describe how following difficult surgery, a surgeon coagulated and subsequently transected a ureter. The injury was eventually diagnosed and repaired 5 days later.

The team have analysed why this complication occurred. In some cultures, for example aviation, after an adverse event there are well organised and accepted investigation procedures. In medicine, such investigational procedures are more limited, or do not exist at all. We do not know the true incidence of surgical complications, as most published series almost certainly under-report them (possibly because of surgeons' concerns about the medico-legal implications).

Analysing their work later, the authors consider the complication occurred for a number of reasons: they had not dissected the ureter enough, there had been bleeding that was difficult to control, the speed of surgery was noticed to have increased, and probably most significantly of all, they had prior to this case been operating for 8 hours on two women with equally challenging endometriosis (they were probably tired, although measuring surgical fatigue objectively was not possible).

The aim of all accident analyses is to learn from them to reduce the chance of similar accidents happening again. This paper is a brave attempt to undertake such an analysis. The effect of human factors on a doctor's performance is becoming increasingly recognised. A new group called 'The Clinical Human Factors Group' was formed in 2007 and aims to share good practice (www.chfg.org). It is an independent not-for-profit organisation, made up of specialists from both within and without the clinical professions, and their goal is to increase awareness within clinical practice of human factors, and how this knowledge can be used for the reduction of clinical error. As well as reducing adverse events by specific procedures, cultural changes are also needed. As the authors of this paper point out, it can be something as uncomplicated as asking theatre nurses to comment when they believe the surgeon is tired and maybe not performing effectively (see also Berguer *et al.*, *Surg Endosc* 2001;15:1204–7). ■

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