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Bladder injury during laparoscopic appendectomy: Detection, management, and learning point for surgical trainees

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ABSTRACT

Background: Laparoscopic appendectomy is one of the most common emergency surgeries. There is a paucity in the literature regarding the incidence and management of iatrogenic bladder injuries. We reviewed a series of iatrogenic bladder injuries during laparoscopic appendectomy to determine incidence, preventable risk factors and management.

Methods: We performed a retrospective review of laparoscopic appendectomy at two large regional teaching hospitals over a five-year period from February 2014 to February 2019. The outcomes measured included intra-operative data, such as type of port used and surgeon experience, incidence of iatrogenic bladder injury, mechanism and time of bladder injury recognition, management and clinical outcome.

Results: A total of 1147 patients underwent laparoscopic appendectomy. Two iatrogenic bladder injuries secondary to port placement were identified (0.17%). Both procedures were performed after-hours by surgical trainees. There was no previous history of abdominal surgery. Neither patient had an indwelling catheter (IDC) during the procedure. There were no other visceral or major vascular injuries. Both bladder injuries were identified in the early post-operative period. One case was managed conservatively, whilst the other required laparoscopic repair of the bladder perforation.

Conclusion: Bladder injury should be suspected in patients with abdominal pain, elevated creatinine and anuria following laparoscopic surgery. Although iatrogenic bladder injury during laparoscopic appendectomy is rare, it has the potential for considerable patient morbidity. Therefore, adequate laparoscopic supervision and specific counselling on port access injuries for surgical trainees, adequate bladder decompression with an IDC, and early detection and management guided by the location of injury are essential.

Introduction

Laparoscopic appendectomy is one of the most common emergency surgeries. It is often the first surgery performed by surgical trainees as it is common, generally safe and has an attainable learning curve of 20–30 cases [1,2]. However, studies have shown that complication rates are significantly higher in laparoscopic appendectomies performed by surgical trainees [3].

The complication rate generally ranges from 6.71 to 12.7% with the most common complications being surgical site or deep wound infection, ileus and intra-abdominal bleeding [4,5]. As with any laparoscopic procedure, there is a rare risk of iatrogenic organ injury, particularly during port insertion. There is minimal data on iatrogenic bladder injuries during laparoscopic appendectomy. We performed a retrospective review of laparoscopic appendicectomies performed over a five-year period to assess the incidence of iatrogenic bladder injury and identify preventable risk factors.

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Materials and methods

We performed a retrospective chart review of laparoscopic appendectomy at two large regional teaching hospitals from February 2014 to February 2019. This study received local ethics approval and informed written consent was provided for the cases discussed. The outcomes measured included intra-operative data, such as type of port used and surgeon experience, incidence of iatrogenic bladder injury, mechanism and time of bladder injury recognition, management and clinical outcome.

All patients were asked to void pre-operatively or an in-out catheter was inserted. Prophylactic antibiotics were routinely given upon induction of general anaesthesia and continued for 24 h post-operatively. The patient was positioned supine and in Trendelenburg to gravitate abdominal contents out of the pelvis. A 10 mm camera port was inserted at the umbilicus with standard Hasson entry and pneumoperitoneum was established to 12 mmHg. Two 5 mm working ports were inserted under direct laparoscopic vision, first in the left lower quadrant, followed by the suprapubic region. Laparoscopic exploration of the abdomen was performed, including inspection of the small bowel from the ligament of Treitz to the ileocaecal valve. The appendix was identified and the mesoappendix was divided with electrocautery. The appendiceal base was ligated with an ENDOLOOP® ligature (Ethicon Inc., Cincinnati, Ohio, USA) and divided distally. The appendix was removed in an ENDOPOUCH RETRIEVER® (Ethicon Inc., Cincinnati, Ohio, USA) specimen bag through the 10 mm port. Drains were not routinely used.

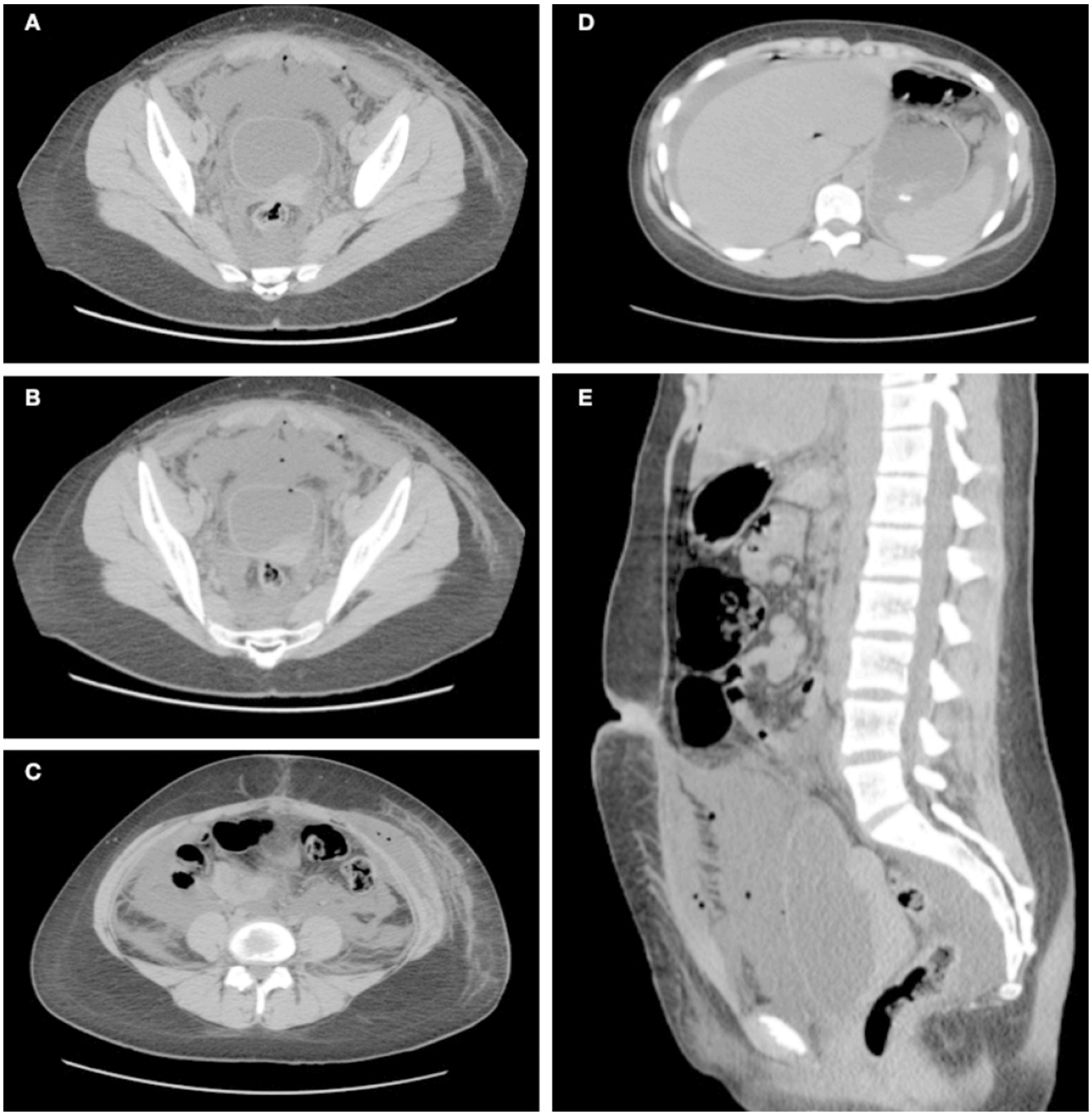

Fig. 1. Non-contrast CT scan of the abdomen of pelvis, performed two days post laparoscopic appendectomy in Case 1. CT images demonstrate a large volume of free fluid within the peritoneal cavity with multiple locules of free air throughout the peritoneal cavity, suggestive of bladder injury and intra-peritoneal urine leak (A–E). A fluid collection is present within the left flank and external oblique (D).

Results

A total of 1 147 patients underwent laparoscopic appendectomy. Two iatrogenic bladder injuries secondary to port placement were identified (0.17%). Both procedures were performed after-hours by surgical trainees who were post-graduate year 5, 6. There was no previous history of abdominal surgery. Both patients' bladders were emptied voluntarily or via an in-out catheter pre-operatively, however, neither patient had an indwelling catheter (IDC) during the procedure. There were no other visceral or major vascular injuries.

Case 1

A 13-year-old female underwent laparoscopic appendectomy. She voluntarily voided prior to the surgery. The appendix was macroscopically normal, however, blood stained fluid was noted in the Pouch of Douglas and thought to be suggestive of retrograde menstruation. On review of the operative notes, there had been some difficulty in inserting the suprapubic port, with multiple passes and counter tension required. On post-operative day one, she had generalised abdominal pain and was oliguric. Despite intravenous fluid resuscitation, she was tachycardic and developed diffuse peritonism. Her white cell count (WCC) was 19.7 $\times$ 10^9/L and serum creatinine was 434 μmol/L (4.91 mg/dL). A non-contrast CT scan showed a large volume of intraperitoneal free fluid and free gas locules extending to the paracolic gutters (Fig. 1). She underwent a diagnostic laparoscopy which demonstrated a large amount of free fluid in the abdomen and pelvis. The appendiceal stump was intact, excluding a leak causing peritonitis. The fluid was collected for microscopy and culture. The bladder was filled with 2 mL of Patent Blue V Dye diluted in 300 mL of 0.9% NaCl. The dye was noted to be tracking toward the left iliac fossa. A urology consult was obtained and an on table cystogram was performed showing a small amount of contrast extravasation (Fig. 2). A decision for conservative management was made given the small bladder injury and an 18Fr IDC was inserted. She developed a fever on post-operative day two and the fluid culture subsequently grew Candida glabrata, for which she was commenced on Caspofungin. A repeat cystogram was performed seven days later, which showed no ongoing urine leak so the IDC was removed (Fig. 3).

Case 2

A 20-year-old female underwent a laparoscopic appendectomy for acute appendicitis. She had an in-out catheter prior to the surgery. On review of the operative notes, there had been difficulty inserting the suprapubic port, requiring multiple passes and use of laparoscopic forceps to grip the peritoneum and aid trocar insertion. She was noted to be oliguric on post-operative day 1 with a urine output of 10–20 mL/h, however, a bladder scan revealed a residual of only 30 mL. An 16Fr IDC was inserted. Her serum creatinine was 185μmol/L (2.09 mg/dL) and a CT intravenous pyelogram (CT IVP) revealed contrast extravasation suggestive of an intraperitoneal bladder injury (Fig. 4). She was commenced on IV amoxicillin/clavulanate. Cystoscopy revealed two bladder wall perforations at the right anterior wall and right posterolateral wall, approximately 1 cm each (Fig. 5). Bilateral retrograde pyelograms showed no ureteric injury. Methylene blue was instilled into the bladder and laparoscopy showed methylene blue extravasation through the bladder perforations. The defects were closed in two layers with 3-0 V-Loc (braided polyglactin) (Fig. 6). An 10Fr Jackson-Pratt drain was left *in situ* for four days. She was discharged five days post-appendectomy. A repeat cystogram 10 days after bladder repair showed no evidence of ongoing urine leak (Fig. 7) so the IDC was removed.

Discussion

Our study is a stark reminder that iatrogenic bladder injury, usually due to port insertion, is a serious and preventable complication of laparoscopic appendectomy. The incidence of iatrogenic bladder injury was 0.17% in our study, which is slightly lower than previously reported rates of 0.36–0.45% [6,7]. Although this incidence is low, bladder injury results in high morbidity, either requiring catheterisation for a prolonged period or re-operation.

An important factor in iatrogenic bladder injury is operator experience. The risk of iatrogenic injury is higher in emergency cases, which are often performed by general surgery trainees after hours [8]. Both of our reported injuries occurred after hours whilst a trainee was performing the surgery without the attending surgeon on-site. Levy et al. [6] reported six iatrogenic bladder injuries in a series of 1 671 laparoscopic appendicectomies. Similarly all of the injuries occurred during an emergency or expedited surgery and four out of six cases were performed by a trainee. Nason et al. [7] similarly reported four iatrogenic bladder injuries in a two-year series of 894 laparoscopic appendicectomies. They highlighted that an increasing amount of surgical trainees are involved in performing laparoscopic appendectomy. This has been shown to increase operative times and complications, regardless of year in postgraduate training [9].

A number of other factors may contribute to the risk of iatrogenic bladder injury. Incomplete voiding may occur due to pain or bladder irritation from appendicitis, or pre-existing bladder outlet obstruction or detrusor failure. Some studies have suggested a routine pre-operative bladder scan to assess post-void residuals and the need for catheterisation [10], however, the availability of a bladder scanner may limit its

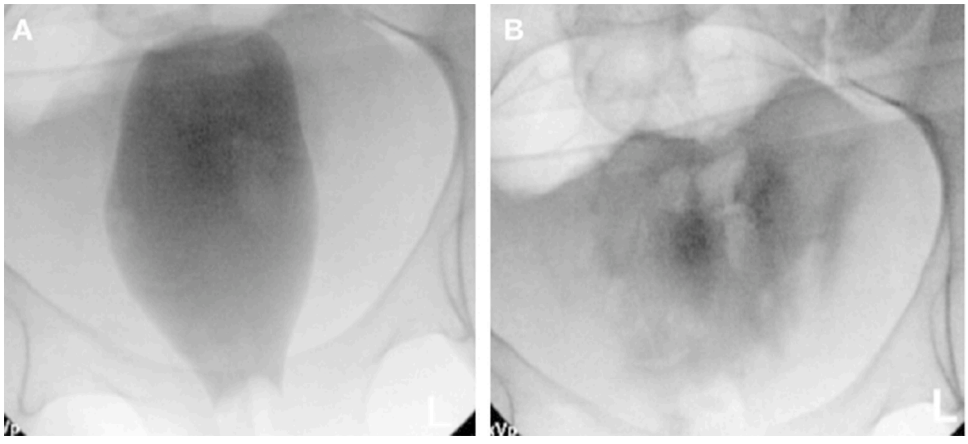

Fig. 2. On table cystogram was performed during re-look laparoscopy in Case 1. Post void image showed residual pelvic opacities concerning for peritoneal spillage (B).

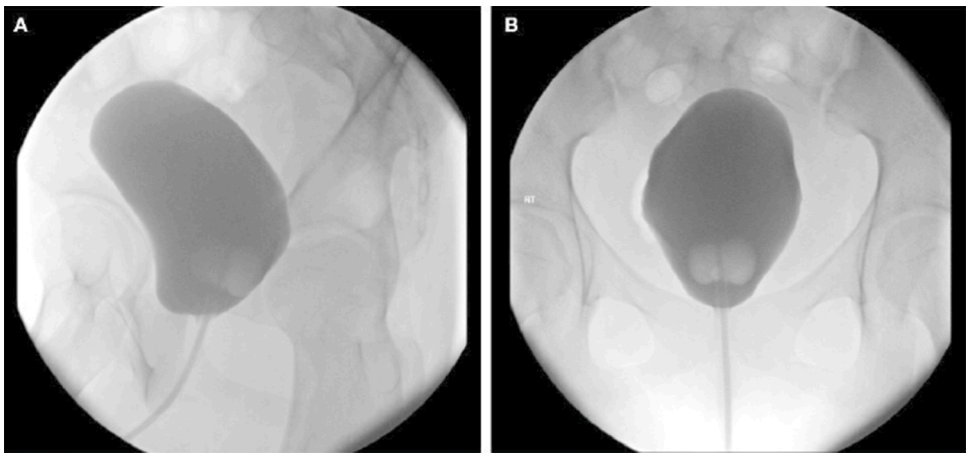

Fig. 3. Cystogram performed 7 days post IDC insertion in Case 1. Images show normal opacification of the urinary bladder with no evidence of any leak.

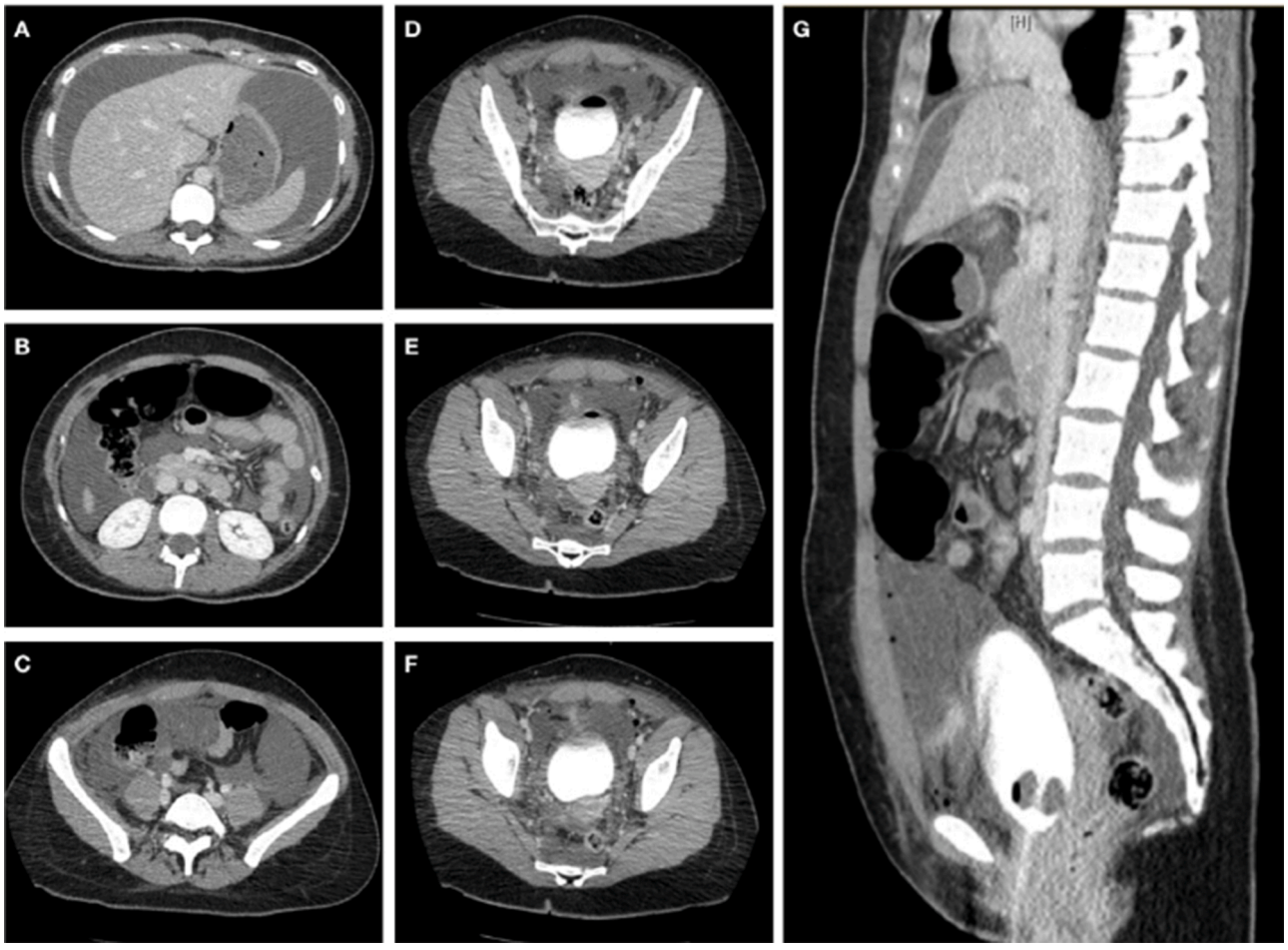

Fig. 4. CT IVP performed with a clamped IDC on post-operative day one in case 2. Images show free fluid throughout the abdomen (A–C, G) and contrast extravasation from the bladder suggestive of bladder perforation (D–G).

use. Furthermore, this may not be suffice to guarantee an empty bladder, as it may partially refill between voluntary voiding or the insertion of an in-out catheter and insertion of suprapubic port, as was possible in both of our reported cases. The risk of bladder injury may also be higher in paediatric populations where a full bladder can occupy a larger proportion of the abdominal cavity. These risks can be mitigated by IDC insertion and free drainage of urine throughout the surgery.

There remains a paucity in the literature regarding the incidence and optimal management of iatrogenic bladder injuries. Our study is limited as we have identified only two bladder injuries in a series of 1147 patients so are unable to make broad recommendations on management pathways. However, successful outcomes have been demonstrated in our study and the previously discussed publications, with a variety of tailored management options, ranging from catheterisation to laparotomy. Our first case was managed conservatively given it was a small leak and the decision to proceed to laparoscopy over laparotomy in the

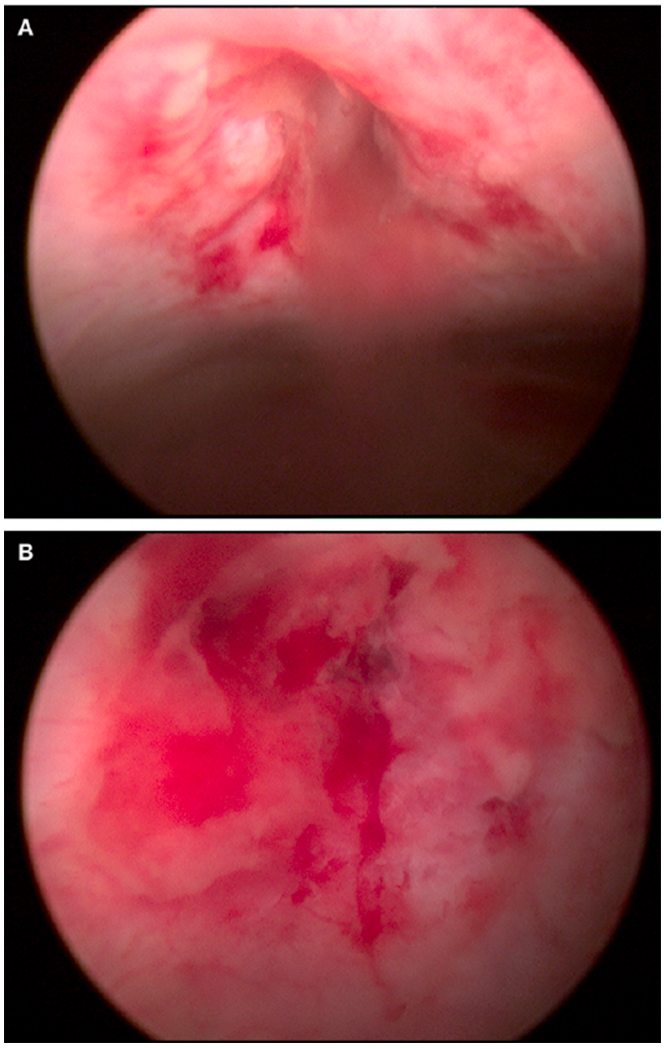

Fig. 5. Intra-operative photos taken during cystoscopy in Case 2, demonstrating a 1 cm right anterior wall perforation (A), and a 1 cm postero-lateral wall perforation (B).

second case was also due to the presumed small size of the potential injury. Given the low incidence of bladder injuries, we recommend a systematic review with meta-analysis to pool cohorts of patients so that guidelines for optimal management can be developed. Pleasingly, both complications were recognised early. This highlights the importance of monitoring observations, fluid balance and post-operative blood tests, particularly in the first 24 h following laparoscopic appendectomy. Four out of six cases reported by Levy et al. [6] and two out of four cases reported by Nason et al. [7] represented to hospital 2–4 days following laparoscopic appendectomy. This highlights the importance of monitoring observations, fluid balance and post-operative blood tests, particularly in the first 24 h following laparoscopic appendectomy. There is evidence for conservative management with an IDC and selective laparoscopic repair of large iatrogenic intra-peritoneal bladder injuries, such as during endourological procedures.

Conclusion

Although iatrogenic bladder injury during laparoscopic appendectomy is rare, it has the potential for considerable patient morbidity. Therefore, adequate laparoscopic supervision and specific counselling on port access injuries for surgical trainees, adequate bladder decompression with an IDC, and early detection and management guided by

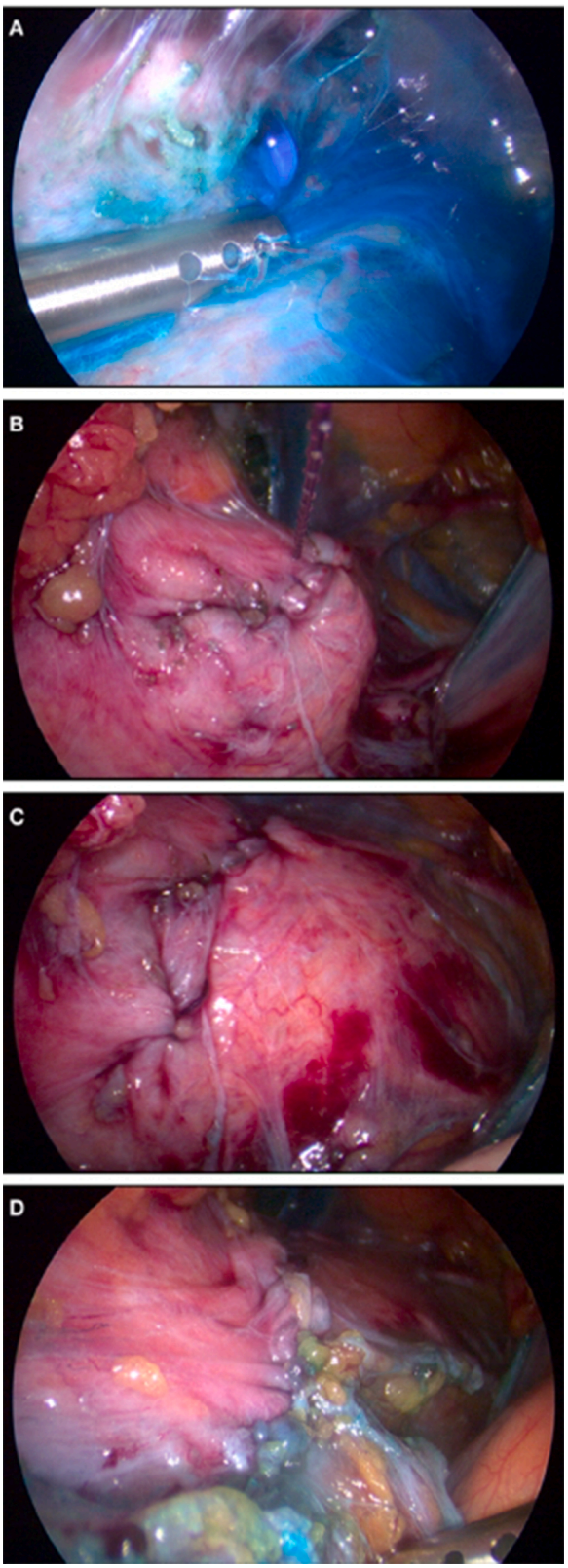

Fig. 6. Intra-operative photos taken during re-look laparoscopy and laparoscopic bladder repair in Case 2. Images demonstrate extra-peritoneal bladder perforation with extravasation of methyelene blue (A), V-Loc suture repair of larger bladder defect (B), leak test with no contrast extravasation (C), V-Loc suture repair of peritoneal defect.

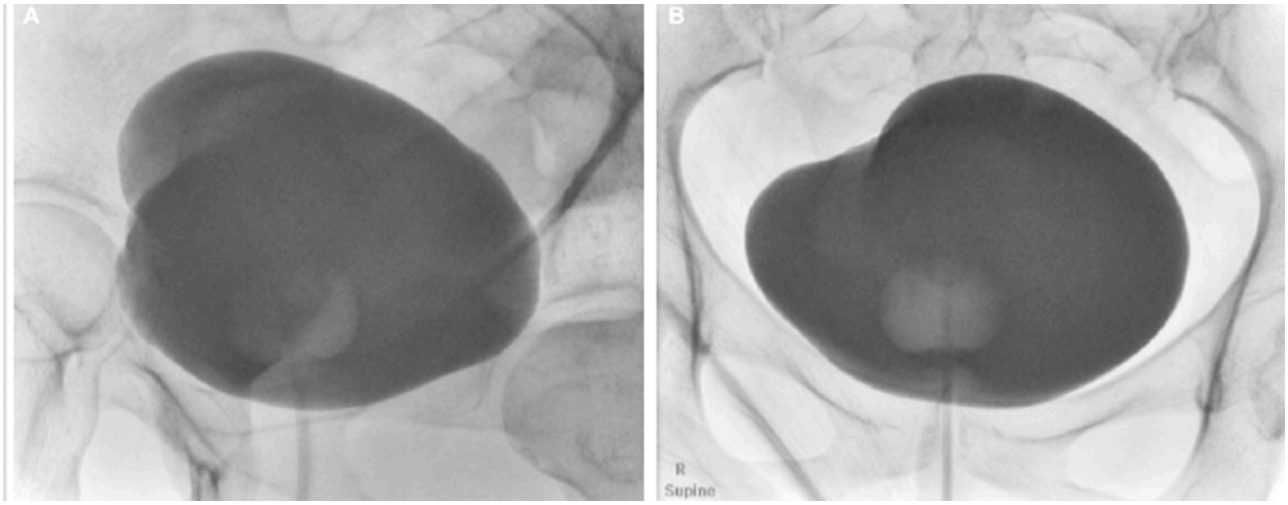

Fig. 7. Cystogram performed on post-operstive day 10 with IDC *in situ* in Case 2. Images show normal opacification of the urinary bladder with no evidence of any leak.

the location of injury are essential.

Data availability statement

Data is available upon request.

Funding statement

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Patient consent statement

Informed written consent was provided by each participant.

CRediT authorship contribution statement

Joseph Xavier: Conceptualization, Project administration, Data curation, Investigation, Writing – original draft, Writing – review & editing. **Cecile T Pham:** Formal analysis, Writing – original draft, Writing – review & editing. **Hock Cheah:** Conceptualization, Supervision. **Kenneth Wong:** Conceptualization, Supervision. **Shannon Di Lernia:** Conceptualization, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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