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ORIGINAL SCIENTIFIC REPORT

Early Laparoscopic Washout may Resolve Persistent Intra-abdominal Infection Post-appendicectomy

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Abstract

Background Intra-abdominal abscess (IAA) complicates 2–3% of patients having an appendicectomy. The usual management is prolonged antibiotics and drainage of the IAA. From 2006, our unit chose to use early re-laparoscopy and washout in patients with persistent sepsis following appendicectomy. The aims of this study were to assess the outcomes of early laparoscopic washout in patients with features of persistent intra-abdominal sepsis and compare those with percutaneous drainage and open drainage of post-appendicectomy IAA.

Methods A retrospective case note review was performed for all patients having a laparoscopic washout, percutaneous drainage or open drainage following appendicectomy between January 2006 and December 2017.

Results During the period, 4901 appendicectomies occurred. Forty-one (0.8%) patients had a laparoscopic washout, 16 (0.3%) had percutaneous drainage, and 6 (0.1%) had an open drainage. The demographics, ASA grade and pathology at initial appendicectomy were similar. The mean time after appendicectomy was significantly shorter for laparoscopic washout (4.1 days vs. 10.1 and 9.0 days, $p = <0.003$). The mean time for resolution of SIRS was significantly shorter (2.0 days vs. 3.3 and 5.2 days, $p < 0.02$). The morbidity and length of stay were similar.

Conclusion Early laparoscopic washout for persistent intra-abdominal sepsis may be an alternative to non-operative management and delayed intervention for IAA and may have better outcomes than either percutaneous drainage or open drainage. A prospective randomised comparison is required to further evaluate the indications and role of early laparoscopic washout post-appendicectomy.

Introduction

Persistent intra-abdominal sepsis and development of intra-abdominal abscess (IAA) is a significant complication following both laparoscopic and open appendicectomy. The overall rates of post-operative IAA formation are low, between 2 and 3% [1–5]. The incidence increases significantly in the context of complicated (gangrenous or perforated) appendicitis, with rates in some studies exceeding 20% [6, 7]. Considering the large number of appendicectomies performed, this complication affects a significant number of people in our communities.

The standard management approach for post-operative IAA following appendicectomy is percutaneous drainage [8, 9]. Some post-operative collections can be managed successfully with antibiotics alone, particularly in the paediatric population [10, 11]. Both these treatment strategies have been shown to be effective, but frequently necessitate a prolonged hospital admission [12–14]. Open surgical drainage is normally reserved for patients with

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overwhelming sepsis or who fail less invasive treatment modalities, and it is associated with significant morbidity [15–17].

Timely, "on-demand" as opposed to planned re-laparotomy and washout is the only surgical option that significantly reduces morbidity and mortality in patients with persisting intra-abdominal sepsis (for any cause) post-initial laparotomy [18–21]. Based on the results at laparotomy, the Acute Surgical Unit (ASU) at Nepean Hospital, Western Sydney, NSW, Australia, chose to manage persistent sepsis post-appendicectomy, including early post-operative collections, with early laparoscopic washout rather than prolonged antibiotics and/or delayed interventions. Although there are reports where laparoscopic washout has been employed successfully in patients with intra-abdominal sepsis following appendicectomy, there is a lack of evidence regarding its efficacy. To date, the available evidence is predominantly from the paediatric population comprising a case report [22] and three small case series, the largest of which included twelve patients [23–25].

The aims of this study were to present our experience with early laparoscopic washout in children and adults with evidence of persistent intra-abdominal sepsis post-appendicectomy and compare these outcomes with percutaneous drainage and open drainage of established IAA post-appendicectomy.

Materials and methods

A retrospective case note review was performed at Nepean Hospital, a tertiary referral centre located in Outer Western Sydney, New South Wales, Australia. Ethics approval was obtained from the Nepean Blue Mountains Local Health District (NBMLHD) Human Research Ethics Committee (Study 14/67) prior to study commencement.

Patients were identified using the ASU database that prospectively records all patient and operative details. Data were collected by retrospective review of medical records. All consecutive patients of any age who underwent laparoscopic washout for suspected persistent intra-abdominal sepsis post-appendicectomy from January 2006 to December 2017 were included. The indication for early laparoscopic washout was persistence of abdominal sepsis based on clinical grounds. This included the persistence of some or all of the following: systemic inflammatory response syndrome (SIRS), ileus, fevers, not progressing with diet, persistent or worsening abdominal signs, and raised C-reactive protein (CRP) and raised white cell count (WCC). Intra-abdominal sepsis was defined as clinical suspicion of intra-abdominal sepsis post-appendicectomy in association with operative confirmation of intra-abdominal infection with free pus, an infected collection or abscess formation.

For the comparative groups, all patients diagnosed with an IAA that proceeded to either radiological percutaneous drainage or open drainage from January 2006 to December 2017 were included.

All data were collected and entered directly into a computerised spreadsheet (Microsoft Excel, Microsoft Corporation) with coded responses preset for each variable. Data abstractors were blinded to the purpose of this study. Data were collected using electronic medical records (Power Chart, Cerner Australia), and paper medical records. Data were de-identified and stored securely according to the NBMLHD Human Research Ethics Committee protocol.

Data collected included: patient age, gender, American Society of Anesthesiologist (ASA) Score [26], appendicectomy details (including histology), admission and discharge dates and times, symptoms and clinical signs (including heart rate, respiratory rate, temperature and the presence of peritonism), white cell count (WCC), C-reactive protein (CRP), imaging results, laparoscopic washout details, post-operative progress, antibiotic use, hospital length of stay (LOS), need for re-intervention, readmissions and complications occurring within 90 days of the laparoscopic washout, percutaneous drainage or open drainage.

The presence of systemic inflammatory response syndrome (SIRS) was assessed for each patient on the day of the intervention and on post-operative days one, two and three post-intervention. Patients were deemed SIRS-positive if they fulfilled two or more SIRS criteria (Table 1) [27]. Complications were graded according to the Clavien-Dindo Classification of surgical complications [28].

All patients having laparoscopic washout, percutaneous drainage or open drainage were treated with intravenous antibiotics in the peri-operative period. Patients were prescribed ampicillin, gentamicin and metronidazole, or ceftriaxone and metronidazole, based on the hospital protocol at the time, until sensitivity results guided further antibiotic selection. The duration of intravenous and oral antibiotics used post-intervention was recorded.

Table 1 The systemic inflammatory response syndrome (SIRS) [28] was considered present when two or more of the following were present

Temperature >38 °C or <36 °C
Heart rate >90 beats/min
Respiratory rate >20 breaths/min or $PaCO_2$ <32 torr
WCC >12 × 10^9/L, < 4 × 10^9/L or >10% immature band forms

Laparoscopic washout was performed with the patient under a general anaesthetic and positioned supine. All patients received pre-operative intravenous antibiotics. Adults (>18 years) received pharmacological and mechanical venous thromboembolism prophylaxis prior to skin incision. Laparoscopic entry into the peritoneal cavity was obtained via the original laparoscopic port sites. Surgical technique comprised gentle blunt separation of inflammatory adhesions, entry into any abscess cavity, careful disruption of loculations, aspiration of any purulent fluid and generous saline lavage of the entire peritoneal cavity. The procedure was not completely standardised; the volume of lavage and decision to leave surgical drains varied based on the ASU consultant surgeon's preference.

Statistical analysis included patient demographic and clinical characteristics, which have been reported as mean and standard deviation (SD) or median and interquartile range (IQR). Comparison of groups produced odds ratios (OR) including 95% confidence intervals (CI) based on a univariate logistical regression model. All p values calculated were two-tailed; the alpha level of significance was set at 0.05.

Results

During the study period, 4901 patients had an appendicectomy for suspected appendicitis. Forty-one (0.84%) patients met the inclusion criteria for an early laparoscopic washout. The mean patient age was 26.2 years (SD: 14.5) with 25 (61.0%) being male. Fifteen (36.6%) were 16 years of age or under. Twenty-five (61.0%) patients were classified as ASA 1, and the remaining sixteen (39.0%) were ASA 2. Sixteen (0.33%) patients had a percutaneous drainage, and six (0.12%) had an open drainage. The demographics and ASA scores for the percutaneous and open drainage groups were not significantly different from the laparoscopic washout group (Table 2).

The indication for early laparoscopic washout was based on clinical findings consistent with persistent intra-abdominal sepsis. On the day of the laparoscopic washout, moderate–severe abdominal pain was present in thirty-seven (90.2%) patients, with a persistent ileus in six (14.6%). Nine (22.0%) patients had clinical signs of peritonism. Thirty-two patients (78.0%) were SIRS-positive on the day of laparoscopic washout. The mean WCC at diagnosis of intra-abdominal sepsis was 13.3×10^9/L (SD: 4.6), and mean CRP was 221.1 mg/L (n = 20; SD: 83.9). Twenty patients (48.8%) had pre-operative imaging demonstrating intra-abdominal collection prior to laparoscopy. Eighteen had CT scans, and two had an ultrasound. Twelve had a single collection, and eight had multiple collections. The mean diameter of the collections was 5.8 cm (SD = 1.9). Twenty-one patients (51.2%) were taken to theatre based on a strong clinical suspicion of persistent intra-abdominal sepsis without pre-operative imaging. Two (9.5%) of the patients in the clinical diagnosis group did not have subsequent confirmation of intra-abdominal infection at laparoscopy. One of these patients was SIRS-positive pre-operatively, and at the negative laparoscopy was found to have a deep wound collection, which was drained and debrided. The other patient was SIRS-negative pre-operatively but had worsening abdominal pain and nausea. No cause for this patient's symptoms was identified. Neither of these two patients developed post-operative complications. These two patients have been included in the analysis on an intention-to-treat basis.

The mean duration from the primary operation to the laparoscopic washout was 4.1 days (SD = 2.9). The mean time from primary operation to percutaneous drainage (10.1 ± 5.0 days) and open drainage (9.0 ± 7.3 days) was significantly longer ($p < 0.001$ and $p = 0.003$, respectively) (Table 2).

The majority of patients (n = 27, 65.9%) having early laparoscopic washout had a histological diagnosis of gangrenous/perforated appendicitis at the primary operation. Of the remainder, six (14.6%) had suppurative appendicitis, five (12.2%) had simple appendicitis, and three (7.3%) had a normal appendix. Similar rates of complicated, suppurative, inflamed and normal appendices were observed in the percutaneous and open drainage groups (Table 2). Each of the patients with a normal appendix and subsequent laparoscopic washout had a pre-operative CT scan to exclude another or missed pathology as the cause of the persistent sepsis. No other pathology was found either on CT or at laparoscopy.

Thirty-three patients (80.5%) in the early laparoscopic washout group were diagnosed with intra-abdominal sepsis during the same admission as their appendicectomy, whereas eight (19.5%) were discharged and diagnosed on a readmission.

Forty (97.6%) patients in the early laparoscopic washout group had a laparoscopic appendicectomy at the primary operation, and one had an open appendicectomy. The incidence of open appendicectomy was significantly higher in the percutaneous drainage (25%, $p = 0.007$) and open drainage (66.7%, $p < 0.001$) groups (Table 2).

The WCC on the day of the intervention was significantly lower in the early laparoscopic washout group (13.3 ± 4.6) compared to open drainage (19.7 ± 5.3, $p = 0.002$), but not significantly different to the percutaneous drainage group (15.4 ± 7.0, $p = 0.23$) (Table 3). The majority of patients in each of the three groups were SIRS-positive on the day of the procedure (Table 3).

Three (7.3%) patients in the early laparoscopic washout group required conversion to open; two due to dense

Table 2 Pre-operative data for percutaneous drainage, laparoscopic washout and open surgical drainage groups

Variable	Percutaneous drainage (n = 16)	Laparoscopic washout (n = 41)	Open surgical drainage (n = 6)	p values		
				Perc. drain. versus lap. washout	Perc. drain. versus open	Lap. washout versus open
Mean age, years (SD)	34 (17.2)	26.2 (14.5)	23.7 (12.8)	0.09	0.21	0.05
Male gender	7 (43.8)	25 (61.0)	4 (66.7)	0.22	0.24	0.79
ASA score						
1	10 (62.5)	25 (61.0)	2 (33.3)	0.79	0.60	0.70
2	5 (31.25)	16 (39.0)	3 (50.0)	0.59	0.43	0.61
≥ 3	1 (6.25)	0	1 (16.7)	0.49	0.54	0.70
Appendicectomy operative technique/histology result						
Laparoscopic	12 (75)	40 (97.6)	2 (33.3)	0.006	0.08	<0.001
Open	4 (25)	1 (2.4)	4 (66.7)	0.007	0.08	<0.001
Normal	1 (6.25)	3 (7.3)	1 (16.7)	0.89	0.46	0.45
Inflamed	2 (12.5)	5 (12.2)	1 (16.7)	0.98	0.80	0.76
Suppurative	1 (6.25)	6 (14.6)	0	0.39	0.54	0.32
Gangrenous or perforated	12 (75)	27 (65.9)	4 (66.7)	0.51	0.70	0.97
Mean time from appendicectomy to diagnosis of intra-abdo. Infection, days (SD)	10.1 (5.0)	4.1 (2.9)	9 (7.3)	<0.001	0.71	0.003
Diagnostic method						
Ultrasound	1 (6.25)	2 (4.9)	0	0.84	0.54	0.58
Computed tomography	15 (93.75)	18 (43.9)	5 (83.3)	<0.001	0.46	0.07
Clinical	0	21 (51.2)	1 (16.7)	0.004	0.10	0.12

All data are expressed as number of patients, with the percentage of total in brackets unless otherwise specified

ASA American Society of Anesthesiologist, *SD* standard deviation

inflammatory adhesions and one for further management of iatrogenic small bowel injury. Each of these three patients had been discharged and represented with an established IAA more than 8 days post-appendicectomy. Surgical drains were placed in twenty-nine (70.7%) patients. Mean operative duration was 67 min (SD: 31.4). ASU fellows or consultants were the primary operator in twenty-five (61.0%) cases, with the remaining operations being performed by surgical trainees under consultant supervision.

Thirty-seven (90.2%) patients were afebrile within 24 h of early laparoscopic washout (Fig. 1). Only five (12.2%) patients were SIRS-positive 3 days post-laparoscopic washout (Fig. 1). Four of these five patients went on to require re-intervention during their admission (see below). The mean time for resolution of SIRS in the early laparoscopic washout group (2.0 ± 2.5 days) was shorter than for either percutaneous drainage (3.25 ± 3.1 days) and open drainage (5.2 ± 4.1 days) (Table 3).

Six (14.6%) patients in the early laparoscopic washout group required an additional intervention. Although six (37.5%) patients in the percutaneous drainage group required additional interventions, including open and laparoscopic drainage, this was not a significant difference (Table 3). One (16.7%) patient in the open drainage group required an additional intervention with a laparoscopic drainage. None of these re-interventions were included in the early laparoscopic washout, percutaneous drainage or open drainage cohorts.

The incidence of post-operative complications following early laparoscopic washout was 34.1% (Table 3). These included three (7.3%) wound complications and eight (19.5%) recurrent collections or persistent intra-abdominal sepsis. The overall incidence of complications after percutaneous drainage (50%) and open drainage (66.7%) appeared higher, but the difference was not significant. The proportion of Clavien-Dindo type I, II and III complications was similar between the three groups. However, there was a significantly higher incidence of Clavien-Dindo type IV complications in the open group (Table 3). The single Clavien-Dindo type IV complication in the early laparoscopic washout group was an episode of pulmonary aspiration immediately post-operatively that required an ICU admission for 24 h.

Table 3 Investigation results and outcomes for percutaneous drainage, laparoscopic washout and open surgical drainage groups

Variable	Percutaneous drainage (n = 16)	Laparoscopic washout (n = 41)	Open surgical drainage (n = 6)	p values		
				Perc. drain. versus lap. washout	Perc. drain. versus open	Lap. washout versus open
Investigation results at diagnosis:						
Mean WCC, $\times 10^9$/L(SD)	15.4 (7.0)	13.3 (4.6)	19.7 (5.3)	0.23	0.16	0.002
Mean CRP, mg/L (SD)	175.7 (110.3)	221.1 (83.9)	250.3 (144.2)	0.21	0.35	0.61
Mean collection max. diam., cm (SD)	6.1 (1.8)	5.8 (1.9)	6.3 (3.1)	0.16	1	1
Single collection	12 (75.0)	12 (60.0)	4 (80.0)	0.27	0.82	0.35
Multiple collections	4 (25.0)	8 (40.0)	1 (20.0)	0.41	0.82	0.45
"SIRS-Positive" at diagnosis ($\geq$ 2 SIRS criteria present)	12 (75.0)	32 (78.0)	5 (80.0)	0.81	0.68	0.77
Mean time to achieve "SIRS-Negative" (<2 SIRS criteria present), days (SD)	3.25 (3.1)	2.0 (2.5)	5.2 (4.1)	0.10	0.22	0.02
Re-intervention required						
Percutaneous drainage	2 (12.5)	5 (12.2)	0	0.53	0.91	0.76
Laparoscopic washout	2 (12.5)	1 (2.4)	1 (16.7)	0.32	0.37	0.58
Open surgical drainage	2 (12.5)	0	0	0.49	0.54	NR
Total	6 (37.5)	6 (14.6)	1 (16.7)	0.06	0.36	0.90
Complications (including re-intervention)						
Clavien-Dindo I	0	2 (4.9)	0	0.37	NR	0.58
Clavien-Dindo II	2 (12.5)	3 (7.3)	1 (16.7)	0.54	0.80	0.45
Clavien-Dindo III	6 (37.5)	8 (19.5)	1 (16.7)	0.16	0.36	0.87
Clavien-Dindo IV	0	1 (2.4)	2 (33.3)	0.53	0.02	0.004
Clavien-Dindo V	0	0	0	NR	NR	NR
Total	8 (50.0)	14 (34.1)	4 (66.7)	0.27	0.49	0.13
Readmissions	6 (37.5)	7 (17.1)	1 (16.7)	0.10	0.17	0.98
Mean LOS post-diagnosis, days (SD)	10.1 (6.9)	7.0 (4.8)	8.7 (6.3)	0.07	0.76	0.38
Mean IVAB duration, days (SD)	11.3 (14.3)	5.8 (3.6)	8.3 (4.9)	0.04	0.62	0.17

All data are expressed as number of patients, with the percentage of total in brackets unless otherwise specified

CRP C-reactive protein, *IVAB* intravenous antibiotics, *LOS* length of stay, *NR* no result, *SD* standard deviation, *SIRS* systemic inflammatory response syndrome, *WCC* white cell count

Seven (17.1%) patients in the early laparoscopic washout group required readmission, and only two of these patients required re-intervention. The readmission rates for percutaneous drainage (37.1%) and open drainage (16.7%) were not significantly different (Table 3).

The mean LOS (including readmissions) for early laparoscopic washout was 7.0 (SD = 4.8) days, which was not significantly different to the LOS for percutaneous drainage (10.1 $\pm$ 6.9 days) or open drainage (8.7 $\pm$ 6.3 days) (Table 3).

The mean duration of intravenous antibiotic administration after the intervention was significantly longer for the percutaneous drainage group (11.3 $\pm$ 14.3 days) than the early laparoscopic washout group (5.8 $\pm$ 3.6 days) (Table 3).

A subset analysis of early laparoscopic washout was performed comparing those patients who had confirmation of a collection on imaging with those that proceeded to a laparoscopy on clinical suspicion without imaging. Significant differences between groups were found for mean WCC at diagnosis (imaging group 15.0 vs. no imaging 11.6; p = 0.02) and mean time from the initial appendicectomy to washout (imaging group 6.2 vs. no imaging group 3.0 days; p = 0.003). There was no significant difference in any other result (Table 4).

A second subset analysis for early laparoscopic washout was performed comparing paediatric patients (16 years or younger) with adults (>16 years). Although paediatric patients appeared more likely to undergo pre-operative imaging, this was not significant (OR 2.04; 95% CI

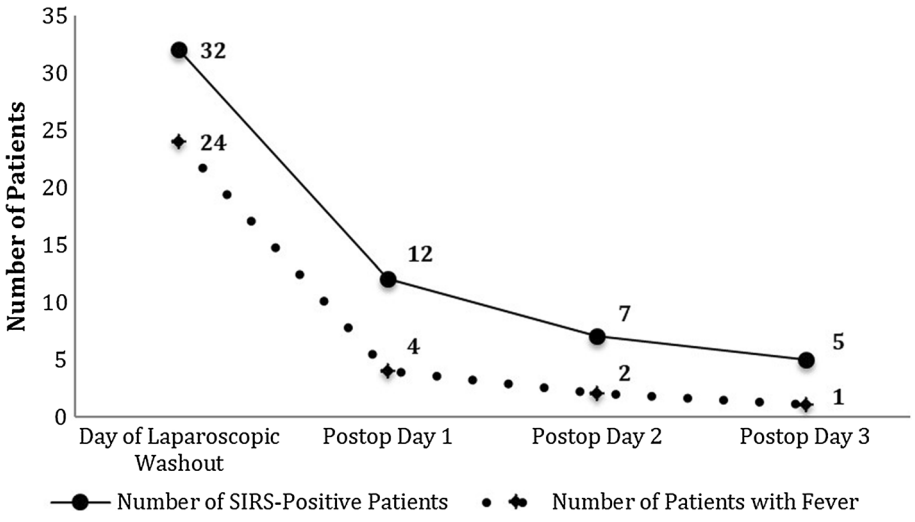

Fig. 1 The incidence of SIRS and persistent fever (>37.5 degrees) following early laparoscopic washout

Table 4 Subset analysis of laparoscopic washout comparing: (A) pre-operative imaging group with the clinical assessment group, (B) paediatric patients (<17) with adult patients

Variable	A: Pre-operative imaging versus clinical assessment			B: Paediatric patients versus adult patients		
	Imaging group $n = 20$	Clinical group $n = 21$	p value	Paediatric patients $n = 15$	Adult patients $n = 26$	p value
Number of patients with pre-operative imaging (%)	20 (100)	0 (0)	NR	9 (60.0)	11 (42.3)	0.28
WCC at diagnosis, $\times 10^9$/L	15.0 (5.5)	11.6 (2.8)	0.02	12.8 (4.5)	13.5 (4.7)	0.67
Time from appendicectomy to washout, days	6.2 (4.5)	3 (0.9)	0.003	4.4 (2.9)	4.7 (3.9)	0.83
Number of patients SIRS-positive at diagnosis (%)	15 (75.0)	17 (81.0)	0.70	11 (73.3)	21 (80.8)	0.61
Time to SIRS-negative, post-washout, days	2.5 (3.5)	1.4 (0.9)	0.18	1.4 (1.1)	2.3 (3.1)	0.30
Number of patients requiring re-intervention (%)	4 (20.0)	2 (9.5)	0.32	2 (13.3)	4 (15.4)	0.86
Number of complications (%)	7 (35.0)	7 (33.3)	0.90	4 (26.7)	10 (38.5)	0.44
LOS post-diagnosis, days	6.8 (5.9)	6.3 (3.6)	0.73	6.2 (3.9)	6.7 (5.3)	0.75
IVAB duration post-washout, days	5.8 (3.6)	5.8 (3.7)	1.00	5.9 (3.6)	5.8 (3.6)	0.91

All values are expressed as a mean with standard deviation in brackets unless otherwise specified

IVAB intravenous antibiotics, *LOS* length of stay, *NR* no result, *SIRS* systemic inflammatory response syndrome, *WCC* white cell count

0.56–7.45; $p = 0.28$). There were no significant differences found between these groups (Table 4).

Discussion

Intra-abdominal abscess (IAA) formation is a serious complication following appendicectomy. The published incidence at Nepean Hospital prior to 2006 is 2.8% [4, 5], which is comparable to that reported in the literature [1–3]. Whilst this complication can occur following negative appendicectomy, the risk of intra-abdominal abscess formation increases four- to fivefold in patients with complicated (gangrenous and perforated) appendicitis [6, 7]. There were initial reports that laparoscopic appendicectomy was associated with increased risk of intra-abdominal abscess formation when compared to open appendicectomy [7, 29, 30]. However, recent meta-analyses have demonstrated no difference in the incidence of intra-abdominal abscesses comparing laparoscopic with open appendicectomy [2, 31, 32].

Following appendicectomy, most surgeons wait until there is an established collection or abscess prior to performing any intervention [8, 9, 12, 15, 17]. The approach reported was an earlier intervention to reduce the risk of subsequent abscess formation. On-demand re-look laparotomy for persistent intra-abdominal infection for causes other than appendicitis has been demonstrated to be effective management compared to non-operative management or routine planned re-laparotomy [18–21]. It was based on these trials that the Nepean ASU decided to use early re-laparoscopy and washout to manage persistent intra-abdominal sepsis post-appendicectomy. The "on-demand" approach is consistent with the current recommendations for the treatment of intra-abdominal sepsis [33]. The decision for early re-laparoscopy was based on clinical assessment of persistent intra-abdominal infection. Imaging was used to confirm a collection in almost half of the cases. Whilst the rate of negative laparoscopy was low in our series, the role of routine pre-operative imaging should be considered, particularly in patients who do not fulfil SIRS criteria, in an effort to reduce the incidence of unnecessary operations. Currently, there are minimal data on the outcomes of early interventions in persistent intra-abdominal infection post-appendicectomy.

Similarly, there are limited data for the outcomes of laparoscopic treatment of intra-abdominal collections post-appendicectomy [22–25]. These are a case report [22] and three small retrospective case series [23–25]. The largest series (12 patients) described their experience with laparoscopic drainage of CT-proven post-appendicectomy IAA in paediatric patients (mean age of 8.5 years) an average of 10 days post-appendicectomy [24]. Two (16.7%) patients required a repeat laparoscopic washout. These results are similar with another series reporting on five patients (3 paediatric and 2 adults) that had laparoscopic drainage of an established intra-abdominal abscess (IAA) a mean of 11 days post-appendicectomy with a mean LOS of 7 days [25]. The most recent case series had seven paediatric patients, all undergoing early laparoscopic suction of the collection without washout 3 to 5 days post-appendicectomy with a post-operative LOS of 2–3 days [23]. None of these studies comprehensively reported post-operative morbidity. The present study examining early laparoscopic washout is much larger and involves adults and children.

The treatment strategies for established IAA post-appendicectomy include non-operative management with intravenous antibiotics, percutaneous drainage or open surgical drainage. The non-operative approach has been shown to be effective in the paediatric population, with treatment failure necessitating intervention in 8–31% of patients [10, 11, 14, 16, 34]. In the adult population, there are no specific data for the non-operative treatment cohort. The mean LOS for patients treated non-operatively is between 8 and 11 days [10, 11, 35], with larger abscesses being associated with longer LOS [35] and a higher chance of treatment failure and subsequent need for intervention [13].

Percutaneous drainage is used for patients who fail non-operative treatment or who have collections larger than 3 cm in diameter [9]. Whilst the procedure is generally well tolerated, it is occasionally associated with serious morbidity [36]. In our study, percutaneous drainage had a morbidity rate of 50%, which was similar to early laparoscopic washout. The reported mean LOS for patients undergoing percutaneous drainage for post-appendicectomy abscess ranges from 6 to 15 days [35, 37], which is similar to our results (10.1 days). The LOS for percutaneous drainage was not significantly shorter than for early laparoscopic washout (7.0 days). The readmission rate for percutaneous drainage has not been previously reported, although in our study it was higher, than for early laparoscopic washout, this difference was not significant.

Whilst percutaneous drainage is less invasive than surgical drainage, its use is typically restricted to the radiologically accessible, unilocular abscess [38, 39]. Open surgical drainage is used in patients requiring urgent management of overwhelming sepsis, or who fail less invasive treatment modalities [17]. Open surgical drainage is associated with high morbidity and mortality, and a mean LOS of greater than 2 weeks [15–17]. In our study, the incidence of Clavien-Dindo type IV complications was significantly higher in the open drainage group. Although open drainage had a similar overall incidence of morbidity, the small numbers (6 cases) make it highly likely that the failure to reach significance was a type II statistical error.

The major difference in our study from previous reports was that the majority of the patients had the intervention early prior to the establishment of an IAA. The intention of this approach was to treat persistent intra-abdominal infection early to decrease the morbidity associated with IAA formation and reduce overall LOS. These findings have been reported in re-laparotomy and washout for other causes of persistent intra-abdominal infection [18–20, 40]. One of the difficulties is that the natural history of the disease found at early laparoscopy for a clinical picture of persistent intra-abdominal infection is unknown. The proportion of cases that will progress to IAA formation or shall resolve with non-operative treatment is simply not known. The outcomes of early laparoscopic washout are comparable to those for percutaneous drainage in this study. Open drainage outcomes were also similar to early laparoscopic washout. It is likely that the low case numbers for open drainage resulted in a failure to demonstrate better outcomes for early laparoscopic washout.

A morbidity rate of 37% for early laparoscopic washout appears high, but is not significantly higher than percutaneous drainage. Furthermore, the group of patients having early laparoscopic washout have persistent sepsis following an operative intervention, making them a particularly high-risk subgroup. The incidence of morbidity for appendicectomy for complicated (perforated/gangrenous) acute appendicitis is 17.6–26% [41–43]. Therefore, a morbidity of 37%, mostly minor wound infections, is to be expected.

In our early laparoscopic washout cohort, there were no statistically significant differences between the paediatric and adult patient groups. The trend towards more imaging being performed prior to surgery in the paediatric group may reflect the increased diagnostic complexity normally associated with paediatric patients. The similar results for the paediatric and adult patients support any future evaluation of early laparoscopic washout being performed in both children and adults.

The intervention of early laparoscopic washout was associated with resolution of SIRS within 24 h in 62.5% of patients, with only 12.2% having persistent SIRS at 72 h. Four (80%) of these patients with persistent SIRS progressed to develop an IAA requiring further intervention. The marked clinical improvement that was noted in the initial cases encouraged the continued use of this intervention. The mean time for resolution of SIRS was significantly shorter following early laparoscopic washout compared to open drainage, indicating a much more rapid improvement and resolution of sepsis. Further research is required to assess whether persistent SIRS is a reliable and accurate indicator of failure of resolution of intra-abdominal sepsis following appendicectomy and if it may be used for selection of patients for early intervention post-appendicectomy.

Our results demonstrate that early laparoscopy and washout in patients with suspected persistent intra-abdominal sepsis post-appendicectomy may be an appropriate management strategy. However, it may not be any better than non-operative management with prolonged antibiotics and delayed intervention for an established IAA with either percutaneous drainage or open drainage. Clearly, to test this hypothesis requires a randomised controlled trial (RCT). Such an RCT would need to be a multi-centre trial in order to accrue adequate numbers. Although about half of our patients did not have pre-operative imaging, an RCT would require imaging for all patients in order to define the presence of a collection and allow for stratification of patients for analysis of data. Such a RCT would define the natural history of the progression of early intra-abdominal infection post-appendicectomy towards resolution or abscess formation. The data collected may be used to determine the risk factors for subsequent abscess development and better improve patient selection for early intervention if that were to be proved beneficial.

Compliance with ethical standards

Conflict of interest Dr. Allaway, Dr. Clement, Professor Eslick and Professor Cox have no conflicts of interest or financial ties to disclose.

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