International Journal of Surgery Open 10 (2018) 47–54

Contents lists available at ScienceDirect

International Journal of Surgery Open

journal homepage: www.elsevier.com/locate/ijso

Research Paper

Risk factors for intra-abdominal abscess post laparoscopic appendicectomy for gangrenous or perforated appendicitis: A retrospective cohort study

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ARTICLE INFO

Article history:
Received 10 December 2017
Received in revised form
15 December 2017
Accepted 21 December 2017
Available online 3 February 2018

Keywords:
Risk factor
Abscess
Appendicectomy
Appendicitis

ABSTRACT

Introduction: Acute appendicitis is one of the most common causes of abdominal pain. Post-operative Intra-abdominal Abscess (PIA) frequently complicates appendicectomy and increases morbidity and cost (1). Its incidence is increased in perforated or gangrenous appendicitis (2). Risk factors for the development of PIA within this high-risk group have not been established in adults. This study aimed to identify risk factors associated with PIA following laparoscopic appendicectomy for gangrenous or perforated appendicitis in adults. Secondary aims were to describe the timing and anatomical location of PIA occurrence.

Methods: A retrospective cohort study was performed. The data of all adults that underwent laparoscopic appendicectomy for gangrenous or perforated appendicitis at Logan Hospital (Queensland, Australia) from July 2010 to June 2014 were reviewed using a database from a previous study (3). The Primary outcome was the association between the development of PIA and; age, gender, American Society of Anaesthesiologists class, Disease Severity Score (4), blood tests on admission (white cell count (WCC), C-reactive protein, total bilirubin) and histopathology of the appendix.

Results: Of 143 patients, 13 developed PIA (9.1%). There was a weakly positive association between elevated preoperative WCC and the risk of PIA (Spearman's correlation coefficient 0.174, $P = 0.038$). No other factors were significantly associated with increased risk of PIA. The median post-operative day of diagnosis was day nine (mean 7.9, range 2–17).

Conclusions: In this cohort, there was a weakly positive association between preoperative WCC and PIA. Prospective trials investigating other potential risk factors are required.

1. Introduction

1.1. Background

Acute appendicitis is one of the most common causes of acute abdominal pain. The annual incidence is approximately 90 per 100,000 population and the lifetime risk is 8% [1,2]. Obstruction of the appendiceal lumen by faecalith, faecal stasis, lymphoid hyperplasia or caecal neoplasia and numerous infectious agents have been proposed as precipitating factors [3]. It was previously thought that the natural history of appendicitis consisted of inflammation followed by necrosis then perforation, but it is now recognised that not all cases progress through this spectrum [1]. Gangrenous or perforated appendicitis occurs in approximately 25% of cases. It is more likely at the extremes of age, occurring in approximately 40% of patients under 10 years and 50% of those over 50 years [2]. Appendicectomy has been the preferred treatment of appendicitis for decades. For gangrenous or perforated appendicitis, laparoscopic appendicectomy has replaced open appendicectomy in many centres due to decreased blood loss, reduced postoperative pain and hospital stay, fewer overall complications, and an earlier return to usual activities [1,4].

Post-operative Intra-Abdominal Abscess (PIA) complicates 3%–25% of appendicectomies [5,6]. The risk is highest following perforated or gangrenous appendicitis [4,7–11]. Clinical features include fever, pain, ileus, leucocytosis and an intra-abdominal collection on ultrasound or computed tomography [12]. Management of PIA includes antibiotics, with or without

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https://doi.org/10.1016/j.ijso.2017.12.003

percutaneous or operative drainage [12]. Fike et al. (2011) compared a cohort of 63 patients with appendicitis from previous prospective trials to a matched group of 61 patients that did not develop PIA. They found that in addition to inflicting considerable morbidity, PIA doubled the total length of stay (11.6 vs 5.1 days, $P < 0.001$) and total hospital charges ($P < 0.001$). To date, risk factors predicting PIA within the high-risk group of patients with gangrenous or perforated appendicitis have not been established in adults.

1.2. Aim

The primary objective of this study was to identify risk factors associated with PIA following laparoscopic appendicectomy for gangrenous or perforated appendicitis in adults. Secondary aims were to describe the timing and anatomical location of PIA occurrence.

2. Materials and methods

2.1. Study design

A retrospective cohort study was performed and is reported in accordance with the STROCSS criteria [13].

2.2. Participants, setting and data sources

All adults were included that underwent laparoscopic appendicectomy at Logan Hospital and had an intraoperative diagnosis of gangrenous or perforated appendicitis over a four-year period from July 2010 to June 2014. Logan Hospital is a 330-bed, outer metropolitan teaching hospital in Queensland, Australia. The data was sourced from a database collated by the author by reviewing the medical records and outpatient notes of eligible patients during a previous study examining the relationship between intravenous antibiotic duration and the incidence of PIA [14]. The operation reports and discharge summaries of patients that developed PIA were examined to enable subgroup observations.

2.3. Exclusion criteria

Children (less than 18 years of age) were excluded. Patients undergoing open appendicectomy, laparoscopic converted to open appendicectomy or laparotomy were excluded.

2.4. Variables and outcome measures

The primary outcome of this study was the association between the development of PIA and the following independent variables; age, gender, American Society of Anaesthesiologists (ASA) class, preoperative blood tests including white cell count (WCC), C-reactive protein (CRP) and total bilirubin, Disease Severity Score (DSS) as described by Garst et al. (2013) and the histopathology of the appendix (normal, inflamed, gangrenous/necrotic or perforated) [15,16].

The diagnosis of necrotic or perforated appendicitis was defined by the surgeon at laparoscopy as documented. Histopathology was recorded as per the pathologist's report. Cases of PIA were identified either as inpatients, on representation to the emergency department or on outpatient follow-up review within 60 days. PIA was defined as an intra-abdominal abscess as reported by a radiologist on computed tomography or ultrasound scan or reported by the operating surgeon on relook laparoscopy/laparotomy.

2.5. Data analysis

Categorical variables were presented as frequencies and continuous variables as descriptive statistics. Statistical tests were applied for association between the dependent variable (PIA) and the independent variables listed previously. Pearson's correlation or Spearman's Rho was used for continuous variables. Chi-square test was used for dichotomous variables. Where an association was found, the Mann-Whitney *U* test was applied to assess the difference in the independent variables between those that did develop PIA and those that did not. Logistic regression was used to assess the predictive value of the independent variables. Analysis was performed using IBM SPSS statistics version 23. A *P* value < 0.05 was considered statistically significant. Power was calculated using the calculator available from the Australia and New Zealand Melanoma Trials Group (ANZMTG) [17] with α set at 0.05. With a sample size of 143 the study was >90% powered to detect a correlation of 0.3 using Spearman's correlation coefficient and effect size 0.3 for the Chi-Square and Mann-Whitney *U* tests.

2.6. Ethics

Human Research Ethics Committee (HREC) approval for this study was granted by the Metro South HREC, Queensland, Australia (reference number HREC/16/QPAH/861). The study is registered at ResearchRegistry.com (UIN researchregistry3398).

3. Results

3.1. Participants and descriptive data

Of 1310 patients who underwent laparoscopic appendicectomy during the study period, 143 (10.9%) were adults who had necrotic or perforated appendicitis on laparoscopy and formed the cohort for this study (Appendix A). PIA occurred in 13 of these patients (9.1%). The cohort included 66 (46.2%) females and 77 (53.8%) males aged 18–86 with a median age of 37 years. The incidence of the independent variables is outlined in Figs. 1–3 and Table 1.

3.2. Primary outcome: the association between the independent variables and PIA

Pearson's correlation coefficient demonstrated no statistically significant linear relationship between the continuous independent variables and PIA. The Chi-squared test for association similarly demonstrated no statistically significant association for dichotomous variables. Nonparametric testing (Spearman's Rho) revealed a very weakly positive association between increasing preoperative WCC and the development of PIA (correlation coefficient 0.174, $P = 0.038$). No other variable showed a statistically significant correlation (Table 2). PIA occurred in patients with WCC between 11.5-20.8 $\times 10^9$/L (reference range = 3.5-11 $\times 10^9$/L). The Mann-Whitney *U* test demonstrated a significant difference between the mean WCC in those that did not develop PIA and those that did (15.08 $\times 10^9$/L, SD 4.2 $\times 10^9$/L versus 16.82 $\times 10^9$/L, SD 2.9 $\times 10^9$/L respectively, $P = .038$). Fig. 4 depicts histograms of the distribution of the frequencies of preoperative WCC in those that did not develop PIA and those that did. Logistic regression demonstrated no statistically significant predictive relationship between the independent variables and PIA (Table 3).

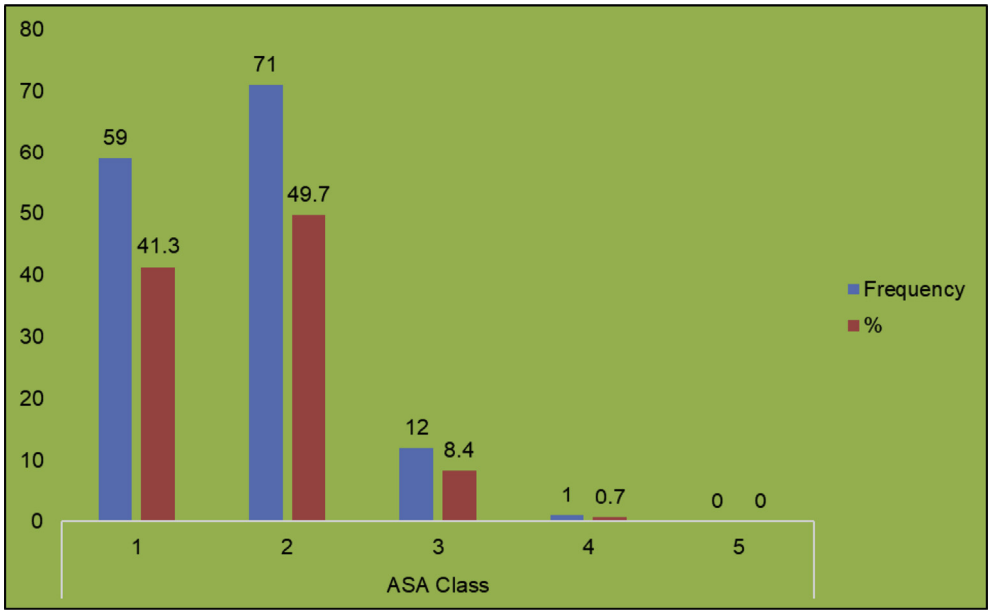


Fig. 1. American Society of Anaesthesiologist (ASA) class.

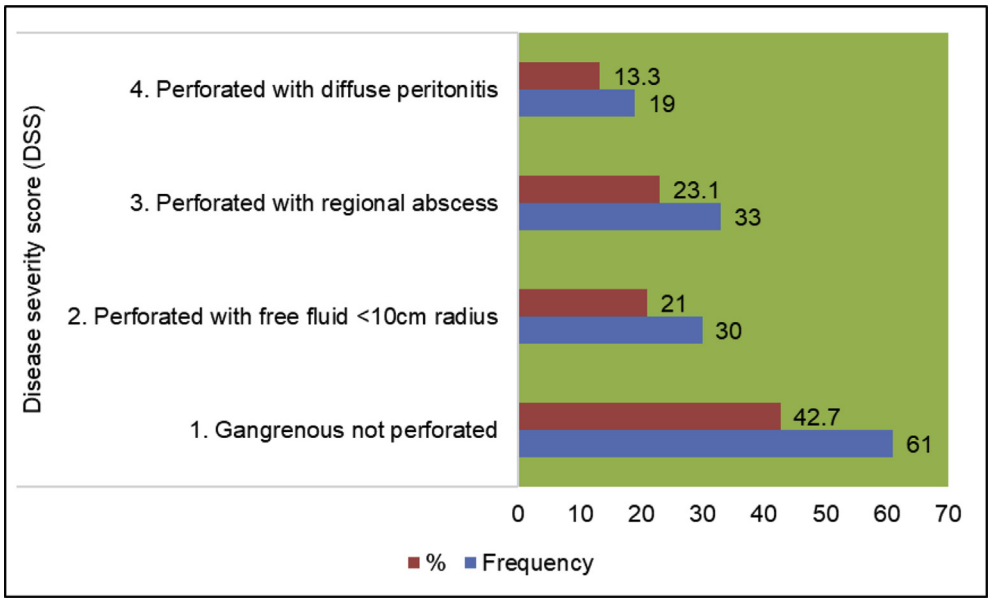


Fig. 2. Disease severity score (DSS).

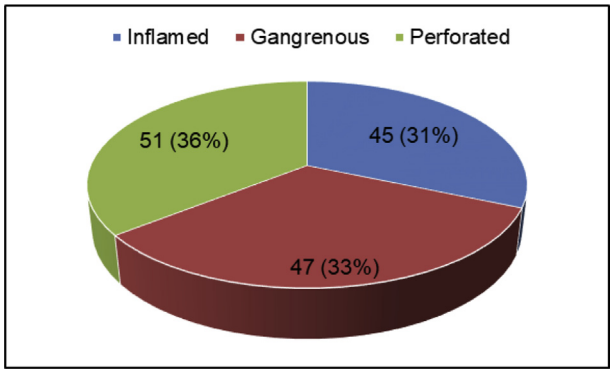


Fig. 3. Histopathology. Note: Histologically normal appendixes = 0 (0%).

3.3. Secondary outcomes: timing of post-operative intra-abdominal abscess (PIA)

The median day of diagnosis was post-operative day nine (mean 7.9, range 2–17). The frequency of location of PIA is demonstrated in Fig. 5.

3.4. Subgroup observations

PIA occurred in eight males and five females with a median age of 41 (mean 39.5, range 20–62). Comorbidities included asthma, renal calculi, HT, obesity and Graves' disease with only asthma occurring in more than one patient (two). Five patients had no significant medical or surgical history. Past surgical histories

Table 1
Preoperative blood tests.

Descriptive statistics (units, normal range)	WCC (x10^9/L, 3.5–11)	CRP (mg/L, <5.0)	Bilirubin (Umol/L, <20)
Valid	143	103	133
Missing	0	40	10
Median (range)	14.9 (4.3–34.9)	82.0 (2–474)	21.0 (7–60)
Standard Deviation	4.1	115.4	11.1

WCC = White Cell Count, CRP = C-Reactive Protein.

Table 2
Spearman's Rho test for association.

	Age	ASA	DSS	Gender	WCC	CRP	Bili	Histopathology
Correlation coefficient	0.000	0.095	0.093	−0.049	0.174	−0.024	0.023	0.041
P-value	0.997	0.257	0.271	0.563	0.038	.812	0.796	0.630

ASA = American Society of Anaesthesiologists class, DSS = Disease Severity Score, WCC = White Cell Count, CRP = C-Reactive Protein, Bili = total bilirubin.

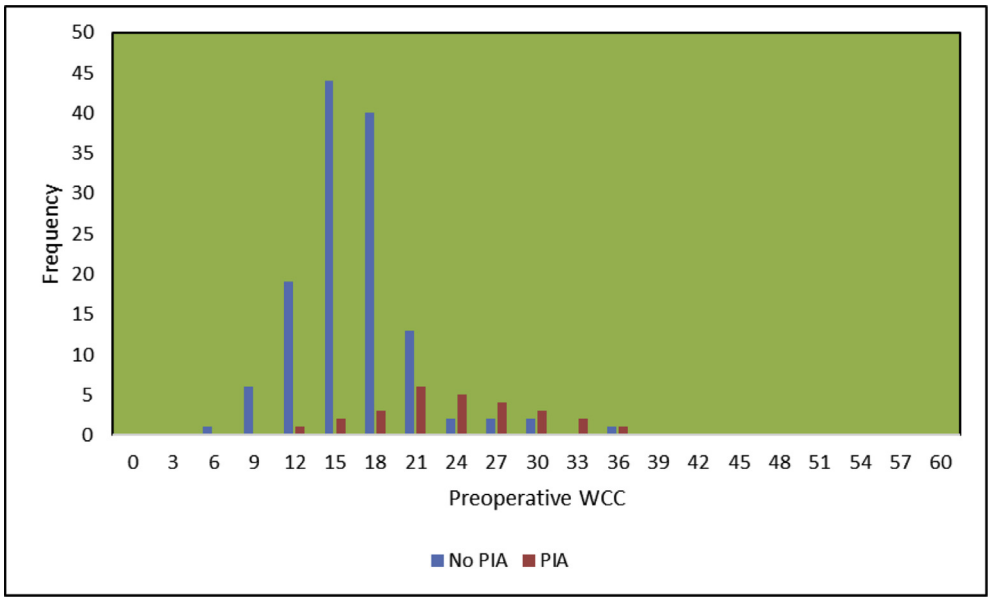


Fig. 4. Frequency distribution histograms comparing preoperative White Cell Count (WCC) in patients that did not develop Post-operative Intra-abdominal Abscess (PIA) to those that did.

Table 3
Logistic regression.

	Odds Ratio	*P* value
Gender	1.022	0.977
Age	0.971	0.258
WCC	1.113	0.185
CRP	0.997	0.424
Bilirubin	1.031	0.346
ASA	2.161	0.179
DSS	1.301	0.418
Histopathology	1.918	0.222

included tonsillectomy, a lower uterine caesarean section, a tubal ligation and an umbilical hernia repair with only tonsillectomy occurring in more than one patient (two). One patient was pregnant, in their first trimester.

There were 10 different consultant surgeons present in the 13 operations subsequently complicated by PIA and no surgeon was involved in more than two. A consultant surgeon was the primary operator in 11 of the 13 laparoscopic appendicectomies complicated by PIA. In the other two it was not clear whether the consultant was the primary operator or supervising the registrar. No patient had attended a surgical outpatient appointment prior to their emergency department presentation when the diagnosis of PIA was made. Management is outlined in Fig. 6. Thirty-day mortality was 0%.

4. Discussion

The literature evaluating risk factors for PIA is heterogenous and largely retrospective. PIA is not uniformly defined, and most of the studies have evaluated risk factors in children. The degree to which findings can be generalised to an adult population is unclear. In children, risk factors may include diarrhoea at presentation, leucocytosis, bowel obstruction at presentation, aspects relating to surgical technique, diffuse peritonitis, dominant abscess on laparoscopy and intraoperative faecalith [5,6,18].

4.1. Incidence of PIA

The 10.9% rate of gangrenous or perforated appendicitis and the 9% incidence of PIA in those with gangrenous or perforated appendicitis was similar to other published cohorts [6,12,15,19].

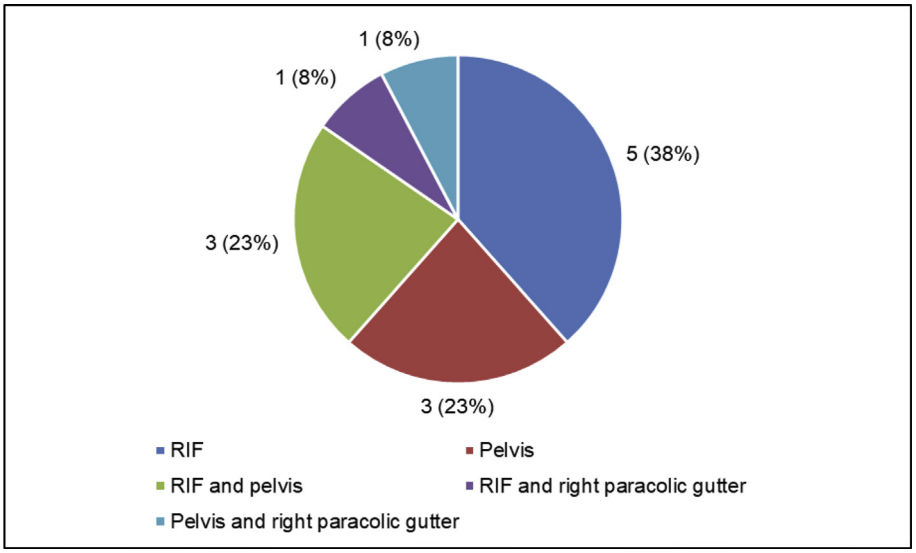


Fig. 5. Location of Post-operative Intra-abdominal Abscess (PIA). RIF = right iliac fossa.

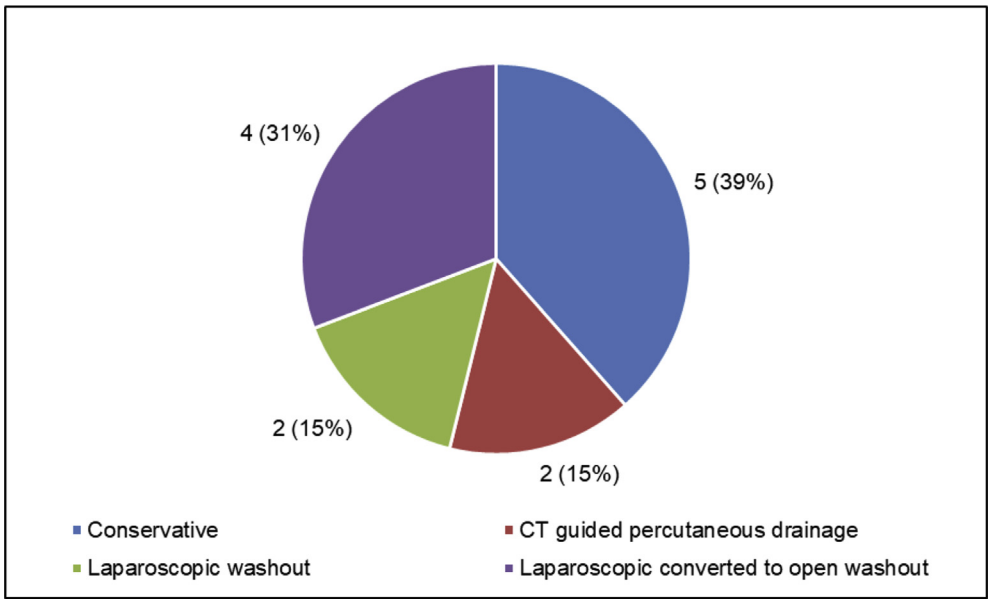


Fig. 6. Management of post-operative intra-abdominal abscess (PIA).

4.2. Age, gender and PIA

Males have a slightly higher reported incidence of acute appendicitis than females and the risk of gangrenous or perforated appendicitis is highest at the extremes of age [2]. Asarias et al. reported a 30% increase in the risk of a postoperative abscess for every decade of life in those with gangrenous or perforated appendicitis [4]. Neither increasing age or gender were associated with a higher risk of PIA in this cohort.

4.3. American Society of Anaesthesiologists (ASA) class and PIA

In a large, prospective National Surgical Quality Improvement Program (NSQIP) study of 4163 patients, ASA class III or greater was associated with increased 30 day post-operative morbidity following appendicectomy (Odds ratio 2.532, *P* .0001) [20]. The cohorts mean age was 50 years and 96% were males, therefore findings may not be applicable to younger and/or female patients. ASA was not associated with increased risk of PIA in the present study.

4.4. Preoperative blood tests and PIA

WCC and CRP are useful adjuncts in the diagnosis of appendicitis, particularly when combined for their negative predictive value [21,22]. However, in isolation they are not diagnostic and do not predict post-operative complications. The same NSQIP trial reported elevated WCC (odds ratio 1.026, *P* .0006) and bilirubin (odds ratio 1.185, *P* .0190) were associated with increased post-operative morbidity. Emil et al. (2014) reported a lower preoperative WCC in children that did not develop PIA to those that did (17.3 ± 5.3 versus 19.9 ± 6.8) [5]. The findings were similar in this study. Hyperbilirubinaemia has previously been demonstrated to be associated with perforated appendicitis. This is thought to be secondary to the

impact of the *Escherichia* coli endotoxin on biliary function [23]. Hyperbilirubinaemia has not been shown to be associated with PIA.

4.5. Disease Severity Score (DSS), histopathology and PIA

Necrotic or perforated appendicitis increases the risk of PIA compared to simple appendicitis. Garst et al. demonstrated a stepwise increase in morbidity with increasing DSS [15]. The present study did not replicate this finding for PIA. There were no specimens reported as normal on histopathologic examination which is in keeping with the laparoscopic diagnosis of gangrenous or perforated appendicitis. Those reported as inflamed without signs of gangrene or perforation on histopathology could represent an overestimation by the operating surgeon, a sampling error during histopathologic sections or a lack of emphasis on differentiating the severity of inflammation during reporting. These factors could not be controlled for in a retrospective setting.

4.6. Timing and location of PIA

Most PIA occurred in the RIF and/or pelvis in this study, replicating findings of previous studies [4]. Emil et al. (2014) reported a similar median day of diagnosis of 8 days (range 5–14) in children [5].

4.7. Other potential risk factors for PIA

4.7.1. Antimicrobial therapy

A Cochrane review in 2005 that included 45 randomised control trials and a total of 9576 patients found that broad spectrum antibiotics decreased infective complications (including PIA) when given before, during and/or after appendicectomy for acute appendicitis on pooled meta-analysis [24]. Particular antibiotic regimes, prolonged duration and the tailoring of therapy to microbial sensitivities have not been found to be superior in preventing PIA [6,25,26]. The present study did not assess the impact of antibiotic therapy on the risk of PIA.

4.7.2. Non-operative management and infective complications

The conservative management of simple appendicitis with antibiotics may be a safe alternative to surgery in selected patients [27,28]. No large-scale prospective controlled trials have been performed that assess conservative management in patients with gangrenous or perforated appendicitis and the risk of PIA.

4.7.3. The timing of appendicectomy and PIA

Several retrospective studies have reported increased risk of gangrenous or perforated appendicitis with a prolonged delay to surgery [29–31]. Fair et al. (2015) performed a retrospective cohort study using the American College of Surgeons NSQIP database to compare outcomes in 69,926 patients undergoing appendicectomy for acute appendicitis within 24 h, 24–48 h or > 48 h. They reported delays of >48 h increased the risk of post-operative complications (odds ratio 1.66, 95% confidence interval 1.34 to 2.07) but no adverse effects with delays up to 48 h. The impact on the severity of the appendicitis and PIA rate was not reported. In contrast, Saar et al. (2016) performed a prospective study that evaluated the association between time from symptom onset to surgery and post-operative complications in 266 patients, 83% of whom had laparoscopic appendicectomy [32]. The authors reported a stepwise increase in complications with increasing delay from the onset of symptoms to surgery by 12-h intervals. The impact of delays to surgery on clinical outcomes remains unclear.

4.7.4. Standardised operative technique and PIA

Emil et al. (2014) performed a retrospective cohort study investigating risk factors for PIA in 284 children with perforated appendicitis over a 5-year period. 231 cases were performed laparoscopically, there were 10 conversions and 44 were performed open. 42 developed PIA (14.8%). Leucocytosis, bowel obstruction at presentation, operative findings of diffuse peritonitis with a dominant abscess and one specific surgeon were associated with PIA. The authors proposed that aspects of operative technique likely contributed to PIA risk.

Aspects of perioperative management that may influence the risk of PIA include the use of perioperative antibiotics, the choice of if, when and how to operate and particular elements of operative technique. There have been advocates for the concept of a standardised technique for laparoscopic appendicectomy, but there is no consensus as to what this entails [12,33]. The development of PIA in this cohort could not be explained by the level of surgical training of the operating surgeon or the presence of any one surgeon.

4.7.5. Open versus laparoscopic appendicectomy and PIA

It has been proposed that a laparoscopic approach to appendicectomy may increase the risk of PIA compared to open [7,10,34]. Sauerland et al. (2010) in their Cochrane review evaluated 67 studies comparing laparoscopic versus open surgery for suspected appendicitis. They reported an increase risk of PIA with a laparoscopic approach (OR 1.87; CI 1.19 to 2.93). A limitation of meta-analyses evaluating laparoscopic surgery is the impact of studies from the early days of laparoscopic surgery that may underestimate benefits and overestimate complications. More recently, Asarias et al. (2011) performed a retrospective cohort study that included 2464 adults (18 years and older) that underwent appendicectomy across two centres in Hawaii from 1996 to 2007. 1924 were performed laparoscopically (78%) and 540 open (22%). There was no significant difference in the incidence of PIA between the groups overall (2.2% versus 1.9% respectively, $P = .74$) or in those with complicated appendicitis (5.9% vs 4.1%; $P = .44$).

4.7.6. Intra-operative irrigation and PIA

There are advocates for both copious [33] and sparing [12] use of lavage. Those in favour of liberal irrigation followed by suction subscribe to the adage “dilution is the solution to pollution”. Those opposed cite concerns about wider distribution of contaminants and interference with the action of mesothelial cells and phagocytes [35,36]. St Peter e al. (2012) performed a prospective randomised trial that compared the use of at least 500 mL irrigation with normal saline versus suction alone in 220 children with perforated appendicitis. They reported no difference in the rate or location of PIA. Routine irrigation was not recommended. The present study did not assess the impact of lavage or of other specific intra-operative techniques and their impact on PIA.

4.7.7. Resection of the appendix, stump closure and PIA

Laparoscopic options for dividing the appendix and closing the appendiceal base include the use of endo-staplers, endo-ligatures/loops, clips and bipolar diathermy. No prospective trial has evaluated all methods and compared their respective risk of PIA. Gomes et al. (2012) in their review highlighted several advantages and disadvantages comparing the use of an endo-loop to a linear stapler [37]. The authors reported that clinical outcomes were similar between those closed with an endo-ligature versus a linear stapler but that costs were substantially higher with the use of a stapling device.

4.7.8. Surgical drains and PIA

The routine use of a surgical drain postoperatively has not been proven to improve outcomes and the exact impact on risk of PIA in gangrenous or perforated appendicitis remains unclear. Studies by Allemann et al., 2011 and Narci et al., 2007 reported that the use of drains at operation increased abscess formation and therefore were not recommended [38,39].

4.7.9. Future research directions

The utility of genetic factors, comorbidities and other biomarkers such as procalcitonin for predicting PIA and the impact of specific antimicrobials, perioperative management and intraoperative techniques on mitigating risk warrant further study. Once patients at highest risk of PIA are known, trials can evaluate optimal peri-operative management and follow-up. Care can then be individualised to achieve optimal patient outcomes and efficient allocation of perioperative and outpatient resources.

4.8. Limitations

This study was a retrospective, non-blinded, single-centre study with a single observer.

5. Conclusions

Those with gangrenous or perforated appendicitis are at risk of PIA. Although there is an association between elevated preoperative WCC and PIA, it cannot be used to predict PIA in this high-risk group. None of the other variables that were examined demonstrated an association with PIA in this cohort. Other patient and operative factors require investigation to improve prediction and early intervention for this morbid complication.

Consent

An exemption to obtain consent was approved by the Metro South Human Research Ethics Council (reference number HREC/16/QPAH/861) on the basis that this retrospective observational study involved review of historical records only and posed negligible risk. All data is completely de-identified.

Ethical approval

Human Research Ethics Committee (HREC) approval for this study was granted by the Metro South HREC, Queensland, Australia (reference number HREC/16/QPAH/861).

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. It was conducted by the author during completion of the Edinburgh Surgical Sciences Qualification (MSc) via the University of Edinburgh.

Author contribution

Dr Stephen Guy is the lead author and is responsible for the design, literature review, human research ethic committee application, data collection, analysis and manuscript preparation for this study.

Dr Peter Wysocki is the senior author for this study and provided consultant expertise throughout the design, literature review, human research ethic committee application, data collection, analysis and manuscript preparation for this study.

Conflicts of interest

The authors have no conflict of interest to declare.

Guarantor

Dr Stephen Guy

Research registration number

researchregistry3398.

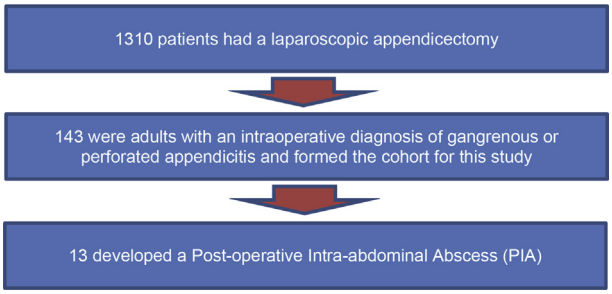
Acknowledgements

Dr Tania Billing assisted with the conceptual design of this study.

Mica Wilhite assisted with statistical analysis for this study.

Appendix

Population flow diagram.



Appendix B. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.ijso.2017.12.003.

References

[1] Bhangu A, Soreide K, Di Saverio S, Assarsson JH, Drake FT. Acute appendicitis: modern understanding of pathogenesis, diagnosis, and management. Lancet 2015;386(10000):1278–87.
[2] Buckius MT, McGrath B, Monk J, Grim R, Bell T, Ahuja V. Changing epidemiology of acute appendicitis in the United States: study period 1993–2008. J Surg Res 2012;175(2):185–90.
[3] Lamps LW. Infectious causes of appendicitis. Infect Dis Clin 2010;24(4):995–1018.
[4] Asarias JR, Schlussel AT, Cafasso DE, Carlson TL, Kasprenski MC, Washington EN, et al. Incidence of postoperative intraabdominal abscesses in open versus laparoscopic appendectomies. Surg Endosc 2011;25(8):2678–83.
[5] Emil S, Elkady S, Shbat L, Youssef F, Baird R, Laberge J-M, et al. Determinants of postoperative abscess occurrence and percutaneous drainage in children with perforated appendicitis. Pediatr Surg Int 2014;30(12):1265–71.
[6] Fike FB, Mortellaro VE, Juang D, Sharp SW, Ostlie DJ, St Peter SD. The impact of postoperative abscess formation in perforated appendicitis. J Surg Res 2011;170(1):24–6.
[7] Kouwenhoven EA, Repelaer van Driel OJ, van Erp WF. Fear for the intra-abdominal abscess after laparoscopic appendectomy: not realistic. Surg Endosc 2005;19(7):923–6.
[8] Reid RI, Dobbs BR, Frizelle FA. Risk factors for post-appendicectomy intra-abdominal abscess. Aust N Z J Surg 1999;69(5):373–4.
[9] Schmit PJ, Hiyama DT, Swisher SG, Bennion RS, Thompson Jr JE. Analysis of risk factors of post appendectomy intra-abdominal abscess. J Am Coll Surg 1994;179(6):721–6.
[10] Tang E, Ortega AE, Anthone GJ, Beart Jr RW. Intraabdominal abscesses following laparoscopic and open appendectomies. Surg Endosc 1996;10(3):327–8.

[11] Romano A, Parikh P, Byers P, Namias N. Simple acute appendicitis versus non-perforated gangrenous appendicitis: is there a difference in the rate of post-operative infectious complications? Surg Infect 2014;15(5):517–20.
[12] Gupta R, Sample C, Bamehriz F, Birch DW. Infectious complications following laparoscopic appendectomy. Can J Surg 2006;49(6):397–400.
[13] How to calculate sample size for the Mann-Whitney-U test based on the sample size for the Student test? IBM; 2010 [FAQ]. Reference #: 1478271. Modified date:20 January 2010, https://www-304.ibm.com/support/docview.wss?uid=swg21478271.
[14] Guy S, Billing T, Wysocki P. Prolonged intravenous antibiotics and the rate of post-operative intra-abdominal collection following necrotic or perforated appendicitis. In: Royal Australasian College of surgeons annual scientific congress; 02 05 2016; Brisbane; 2016.
[15] Garst GC, Moore EE, Banerjee MN, Leopold DK, Burlew CC, Bensard DD, et al. Acute appendicitis: a disease severity score for the acute care surgeon. J Trauma Acute Care Surg 2013;74(1):32–6.
[16] ASA physical status classification system. American Society of Anaesthesiologists; 2014. Available from: https://www.asahq.org/resources/clinical-information/asa-physical-status-classification-system.
[17] Power calculator. The Australia and New Zealand Melanoma Trials Group (ANZMTG); 2017. Available from: https://www.anzmtg.org/stats/PowerCalculator.
[18] Henry MC, Walker A, Silverman BL, Gollin G, Islam S, Sylvester K, et al. Risk factors for the development of abdominal abscess following operation for perforated appendicitis in children: a multicenter case-control study. Arch Surg 2007;142(3):236–41. discussion 41.
[19] Boenigk H, Meyer F, Koch A, Gastinger I. Surgical determinants, perioperative course and outcome of a representative patient cohort with acute appendicitis undergoing appendectomy over 3 decades. Pol Przegl Chir 2012;84(10):509–20.
[20] Margenthaler JA, Longo WE, Virgo KS, Johnson FE, Oprian CA, Henderson WG, et al. Risk factors for adverse outcomes after the surgical treatment of appendicitis in adults. Ann Surg 2003;238(1):59–66.
[21] Andersson R. Meta-analysis of the clinical and laboratory diagnosis of appendicitis. Br J Surg 2004;91(1):28–37.
[22] Sengupta A, Bax G, Paterson-Brown S. White cell count and C-reactive protein measurement in patients with possible appendicitis. Ann R Coll Surg Engl 2009;91(2):113–5.
[23] Sand M, Bechara FG, Holland-Letz T, Sand D, Mehnert G, Mann B. Diagnostic value of hyperbilirubinemia as a predictive factor for appendiceal perforation in acute appendicitis. Am J Surg 2009;198(2):193–8.
[24] Andersen BR, Kallehave FL, Andersen HK. Antibiotics versus placebo for prevention of postoperative infection after appendicectomy. Cochrane Database Syst Rev 2005;3.
[25] Fishman SJ, Pelosi L, Klavon SL, O'Rourke EJ. Perforated appendicitis: prospective outcome analysis for 150 children. J Pediatr Surg 2000;35(6):923–6.
[26] Van Wijck K, De Jong J, Van Heurn L, Van der Zee D. Prolonged antibiotic treatment does not prevent intra-abdominal abscesses in perforated appendicitis. World J Surg 2010;34(12):3049–53.
[27] Rollins KE, Varadhan KK, Neal KR, Lobo DN. Antibiotics versus appendicectomy for the treatment of uncomplicated acute appendicitis: an updated meta-analysis of randomised controlled trials. World J Surg 2016;40(10):2305–18.
[28] Sallinen V, Akl E, You J, Agarwal A, Shoucair S, Vandvik P, et al. Meta-analysis of antibiotics versus appendicectomy for non-perforated acute appendicitis. Br J Surg 2016;103(6):656–67.
[29] Giraudo G, Baracchi F, Pellegrino L, Dal Corso HM, Borghi F. Prompt or delayed appendectomy? Influence of timing of surgery for acute appendicitis. Surg Today 2013;43(4):392–6.
[30] Ditillo MF, Dziura JD, Rabinovici R. Is it safe to delay appendectomy in adults with acute appendicitis? Ann Surg 2006;244(5):656–60.
[31] Papandria D, Goldstein SD, Rhee D, Salazar JH, Arlikar J, Gorgy A, et al. Risk of perforation increases with delay in recognition and surgery for acute appendicitis. J Surg Res 2013;184(2):723–9.
[32] Saar S, Talving P, Laos J, Podramagi T, Sokirjanski M, Lustenberger T, et al. Delay between onset of symptoms and surgery in acute appendicitis increases perioperative morbidity: a prospective study. World J Surg. 40(6):1308–1314.
[33] Katkhouda N, Friedlander MH, Grant SW, Achanta KK, Essani R, Paik P, et al. Intraabdominal abscess rate after laparoscopic appendectomy. Am J Surg 2000;180(6):456–9. discussion 60–61.
[34] Krisher SL, Browne A, Dibbins A, Tkacz N, Curci M. Intra-abdominal abscess after laparoscopic appendectomy for perforated appendicitis. Arch Surg 2001;136(4):438–41.
[35] Abbasoglu O, Sayek I, Hascelik G. The effect of peritoneal lavage on peritoneal cellular defense mechanisms. Acta Chir Belg 1993;94(6):321–4.
[36] St Peter SD, Holcomb 3rd GW. Should peritoneal lavage be used with suction during laparoscopic appendectomy for perforated appendicitis? Adv Surg 2013;47:111–8.
[37] Gomes CA, Nunes TA, Soares Jr C, Gomes CC. The appendiceal stump closure during laparoscopy: historical, surgical, and future perspectives. Surg Laparosc Endosc Percutaneous Tech 2012;22(1):1–4.
[38] Allemann P, Probst H, Demartines N, Schafer M. Prevention of infectious complications after laparoscopic appendectomy for complicated acute appendicitis–the role of routine abdominal drainage. Langenbeck's Arch Surg 2011;396(1):63–8.
[39] Narci A, Karaman I, Karaman A, Erdogan D, Cavusoglu YH, Aslan MK, et al. Is peritoneal drainage necessary in childhood perforated appendicitis?–a comparative study. J Pediatr Surg 2007;42(11):1864–8.