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The Unacceptable Morbidity of Negative Laparoscopic Appendicectomy

Matthew G. R. Allaway[1] · Guy D. Eslick[1,2] · Michael R. Cox[1,2]

Abstract

Background One of the most common acute conditions managed by general surgeons is acute appendicitis. Laparoscopic appendicectomy (LA) is the surgical technique used by many surgeons. The aims of this study were to define our unit's negative appendicectomy rate and compare the outcomes associated with removal of a normal appendix with those for acute appendicitis in patients having LA.

Methods A single-centre retrospective case note review of patients undergoing LA for suspected acute appendicitis was performed. Patients were divided into positive and negative appendicectomy groups based on histology results. The positive group was subdivided into uncomplicated and complicated (perforated and/or gangrenous) appendicitis. Outcomes were compared between groups.

Results There were 1413 patients who met inclusion criteria, 904 in the positive group and 509 in the negative group, an overall negative appendicectomy rate of 36.0%. Morbidity rates (6.3% vs. 6.9%; $P = 0.48$) and types of morbidity were the same for negative appendicectomy and uncomplicated appendicitis. There was no significant difference in complication severity (all $P > 0.17$) or length of stay (2.3 vs. 2.6 days; $P = 0.06$) between negative appendicectomy and uncomplicated appendicitis groups. Patients with complicated appendicitis had a significantly higher morbidity rate compared to negative and uncomplicated groups (20.1% vs. 6.3% and 20.1% vs. 6.9%; both $P < 0.001$).

Conclusion The morbidity of negative LA is the same as LA for uncomplicated appendicitis. The morbidity of LA for complicated appendicitis is significantly higher. The selection criteria for LA in our unit needs to be reviewed to address the high negative appendicectomy rate and avoid unnecessary surgery and its associated morbidity.

Introduction

Diagnostic laparoscopy has been advocated to investigate and treat patients presenting with acute right iliac fossa (RIF) pain, particularly to exclude acute appendicitis [1, 2].

When laparoscopy reveals a macroscopically normal appendix without any alternative pathology explaining the patient's pain, there is conflicting evidence as to whether appendicectomy should be performed. Some studies promote the safety of leaving the macroscopically normal appendix in situ [3–5], whereas others have shown that macroscopic findings at laparoscopy are unreliable, supporting the routine removal for histological analysis [6–10].

At our hospital, a standardised approach has been utilised for assessing and managing patients presenting with RIF pain. The acute appendicitis protocol was established in 2006 (Fig. 1) as part of the transition to an Acute

✉ Michael R. Cox
  m.cox@sydney.edu.au

1 Sydney Medical School, The University of Sydney, Nepean
   Hospital, Clinical Sciences Building, P. O. Box 67, Penrith,
   NSW 2751, Australia

2 The Whiteley-Martin Research Centre, Nepean Hospital,
   Penrith, NSW, Australia

Nepean ASU Protocol

Appendicitis

MEDICAL INITIAL ASSESSMENT

Clinical history & assessment

- Abdominal pain; periumbilical shifts to right iliac fossa
- Anorexia, nausea, vomiting, fever, altered bowel function
- Duration of symptoms, menstrual history, sexual history, infectious contacts, recent viral illness
- Examination: temperature, tachycardia, hydration status, peritonism, tenderness McBurney's point, rebound tenderness, guarding, Rovsing's sign. PR exam

Investigations

- Urinalysis, β–HCG, FBC, EUC, BSL
- If Diagnosis unclear: CRP, CXR. If T>38.5: Blood cultures
- Consider US in females if gynaecological cause suspected and consult O&G

Management

Unclear diagnosis, Not unwell,

Admit for observation

NBM

Simple analgesia

SC Heparin and TEDS

IV fluids

Review: discharge if improved, if no improvement consider further imaging or laparoscopy

Suspected Appendicitis
NBM, IV fluids, Heparin/TEDS
IV Abs : Cefazolin, Flagyl (check allergies, broaden Ab cover if unwell or generalised peritonitis)
Consent
Book theatres, inform anaesthetics
Appendicectomy:

- Gangrenous, or perforated: 5 days IV Abs
- Free pus: 48hrs IV Abs
- Inflamed/normal: perioperative Abs only

Note: Operative lavage is recommended, but fluid needs to be adequately removed at time of operation

Discharge Criteria:
Tolerating diet, mobilising, course of IV antibiotics complete, afebrile >24hrs

NURSING INITIAL MANAGEMENT

- Complete nursing admission
- Check consent done
- Assess level of pain and document
- Give analgesia as required
- Ensure antibiotics administered if appendicitis suspected/confirmed
- TEDS and Heparin as charted
- Encourage mobilisation post operatively

Nursing Discharge

- Provide D/C paperwork
- Check if F/U appointments are made
- Check if medical certificate is needed
- Check if script or medication required

Fig. 1 ASU appendicitis protocol

Surgical Unit (ASU) model of care [11]. Patients fell into one of two groups: those that had strong clinical evidence or imaging supporting a diagnosis of acute appendicitis and those where there was some clinical doubt. The former proceeded to laparoscopic appendicectomy (LA). The latter had a period of clinical observation and repeated consultant assessment and where there was progression of symptoms and signs, or the pain had not resolved after 24 h, a diagnostic laparoscopy with a view to appendicectomy was performed. In these patients, the macroscopically normal appendix was removed when no other pathology was found [12]. There was an expected higher negative

appendicectomy rate than if routine imaging or a validated scoring system was utilised. It was assumed, as there was no data at the time that the morbidity of a negative LA would be low and associated with shorter length of stay (LOS).

The aims of this study were to define our unit's negative appendicectomy rate, compare the outcomes of LA associated with removal of a normal appendix with those with acute appendicitis and determine predictive factors for acute appendicitis.

Materials and methods

Ethics approval was obtained from the Nepean Blue Mountains Local Health District Human Research Ethics Committee prior to study commencement. A single-centre, retrospective case note review was performed.

Data were collected for patients undergoing LA for suspected acute appendicitis between November 2004 and December 2013. The data had been collected for three time periods as part of a separate study examining the outcomes over time of the ASU model [13]. The periods were pre-ASU (November 2004 to October 2006), early ASU (November 2006 to October 2008) and established ASU (January 2012 to December 2013). The outcomes of LA cases converted to open appendicectomy (OA) were included in the analysis as an LA on an 'intention-to-treat' basis. Patients who had an OA ($n = 324$), an appendicectomy as part of an unrelated operation, or an interval or elective appendicectomy were excluded.

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 for the purpose of this study. Data were collected using electronic medical records (Power Chart, Cerner Australia), paper medical records and the hospital ASU database. Data were de-identified and stored securely according to the human research ethics committee protocol.

Data collected included patient age, gender, symptoms, the presence of fever prior to surgery, pre-operative investigations, operative findings, histology and post-operative course. Unfortunately, abdominal tenderness and signs of peritonitis were not recorded due to inconsistencies of defining and recording these clinical signs. Positive appendicectomy was defined by histological evidence of transmural inflammation of the appendix [14]. Those with histological findings of faecoliths, worms or appendiceal tumours, without concomitant inflammation, were classified as a negative appendicectomy. The positive group was broken down into uncomplicated and complicated (perforated and/or gangrenous) appendicitis based on histological

analysis. Primary outcomes were complications occurring within 30 days of surgery, 30-day mortality and LOS.

Complications were defined as any deviation from the normal post-operative course and were graded according to the Clavien-Dindo Classification of surgical complications [15]. Incisional surgical site infections (SSI) were described according to the Centers for Disease Control and Prevention (CDC) classification [16]. Superficial incisional SSI was therefore defined as infection involving only the skin and subcutaneous tissue. Deep incisional SSI was defined as infection involving deep soft tissue. Intra-abdominal abscess (IAA) was defined as a collection of pus or infected material within the peritoneal cavity.

All patients with suspected acute appendicitis were prescribed routine intravenous antibiotic prophylaxis pre-operatively, typically 1 g of cephazolin every 8 h and 500 mg of metronidazole every 12 h. The duration of post-operative intravenous antibiotics varied according to intra-operative findings. A normal appendix or uncomplicated appendicitis without any free fluid or purulent fluid had peri-operative antibiotics only. Those with uncomplicated appendicitis and purulent or free fluid had 2 days of post-operative antibiotics, whilst those with complicated appendicitis had 5 days of antibiotics.

Our statistical analysis included patient demographic and clinical characteristics, which have been reported as mean and standard deviation for numeric-scaled features and percentages for discrete characteristics. Comparison of groups produced odds ratios (OR) including 95% confidence intervals (CI). All P values calculated were two-tailed; the alpha level of significance was set at 0.05. A multivariate logistic regression analysis was performed to determine predictive factors for acute appendicitis.

Results

There were 1413 patients who met inclusion criteria, with 904 total in the positive appendicectomy group and 509 in the negative group, a negative appendicectomy rate of 36.0%. In the positive group, there were 720 (79.6%) with uncomplicated appendicitis and 184 (20.4%) with complicated (perforated and/or gangrenous) appendicitis.

All demographic, clinical, laboratory, operative and outcomes data are summarised in Table 1. The average age increased significantly between negative (23.6 years), uncomplicated appendicitis (28.3) and complicated appendicitis (37.3) groups. There were a higher proportion of females in the negative group but more males in the complicated and uncomplicated appendicitis groups. Migratory pain was significantly more frequent in patients with uncomplicated or complicated appendicitis when compared to the negative group ($P < 0.001$ and $P = 0.03$,

Table 1 Negative and positive appendicectomy (uncomplicated and complicated) group comparison

Variable	Negative appendicectomy $n = 509$	Positive appendicectomy (Uncomplicated) $n = 720$	Positive appendicectomy (complicated) $n = 184$	P values		
				Neg. versus uncomp.	Neg. versus comp.	Uncomp. versus comp.
Mean age, years (SD)	23.6 (12)	28.3 (15)	37.3 (19)	<0.001	<0.001	<0.001
Female gender	354 (69.5)	325 (45.1)	81 (44.0)	<0.001	<0.001	0.81
Symptoms/signs:						
Pain duration < 24H	177 (34.8)	400 (55.6)	61 (33.2)	<0.001	0.73	<0.001
Pain duration > 48H	230 (45.2)	186 (25.8)	80 (43.5)	<0.001	0.64	<0.001
Migratory pain	180 (35.4)	341 (47.4)	81 (44.0)	<0.001	0.03	0.47
Anorexia	234 (46.0)	331 (46.0)	89 (48.4)	1.00	0.64	0.64
Diarrhoea	116 (22.8)	119 (16.5)	51 (27.7)	0.002	0.17	<0.001
Nausea/vomiting	327 (64.2)	482 (66.9)	118 (64.1)	0.27	1.00	0.44
Fever >38 °C	63 (12.4)	138 (19.2)	74 (40.2)	0.001	<0.001	0.001
Investigations:						
WCC >10 × 10⁹/L	194 (38.1)	546 (75.8)	155 (84.2)	<0.001	<0.001	0.02
LA performed by:						
Registrar	420 (82.5)	585 (81.25)	138 (75)	0.65	0.04	0.07
Consultant	89 (17.5)	135 (18.75)	46 (25)	0.37	0.02	0.07
Operation duration, minutes (SD)	56.4 (20.5)	61.3 (36.7)	82.8 (32.9)	0.006	<0.001	<0.001
Converted to open	9 (1.8)	21 (2.9)	36 (19.6)	0.24	<0.001	<0.001
Operative diagnosis of appendicitis	207 (40.7)	684 (95)	183 (99.5)	<0.001	<0.001	0.01
Mean post-operative intravenous antibiotic duration, days (SD)	0.6 (1.0)	1.7 (1.9)	4.4 (1.8)	<0.001	<0.001	<0.001
Morbidity	32 (6.3)	50 (6.9)	37 (20.1)	0.48	<0.001	<0.001
Histopathology:						
Adenoma	4 (0.8)	6 (0.8)	3 (1.6)	1.00	0.17	0.17
Carcinoid	4 (0.8)	10 (1.4)	2 (1.1)	0.63	0.70	1.00
Mean length of stay, days (SD)	2.3 (1.9)	2.6 (2.0)	5.4 (2.4)	0.06	<0.001	<0.001

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

LA laparoscopic appendicectomy, *SD* standard deviation, *WCC* white cell count

respectively). Pre-operative fever (>38°) was significantly more frequent in uncomplicated and complicated appendicitis groups when compared to the negative group (Table 1). There was a higher incidence of elevated white cell count (WCC > 10 × 10⁹/L) in both uncomplicated and complicated appendicitis groups compared to the negative group (Table 1). Multivariate regression analysis demonstrated that older age, male gender, pain duration of less than 24 h, migratory pain, fever and leukocytosis were all predictors of acute appendicitis. However, anorexia, diarrhoea and nausea/vomiting were not predictive for acute appendicitis (Table 2).

Operative duration increased significantly between negative, uncomplicated and complicated groups (Table 1). Consultants, assisted by trainees, were more likely to be the primary surgeon in complicated appendicitis, whereas trainees supervised by the consultant were more likely to be the primary surgeon in uncomplicated and normal cases. Conversion to open surgery was required for 66 (4.7%) patients. Conversion occurred more frequently in the complicated group when compared to uncomplicated and negative groups (Table 1). The duration of post-operative intravenous antibiotic use increased significantly between negative, uncomplicated and complicated groups (Table 1). Patients with complicated appendicitis had a significantly longer LOS (5.4 days) when compared to both negative and uncomplicated groups, but there was no difference in LOS between negative and uncomplicated appendicitis groups (Table 1).

Table 2 Multivariate regression analysis: predictive factors for acute appendicitis

Variable	Odds ratio	95% CI	P value
Age	1.04	1.03–1.05	<0.001
Male gender	2.86	2.20–3.72	<0.001
Pain duration <24 h	1.59	1.23–2.07	<0.001
Migratory pain	1.67	1.28–2.17	<0.001
Anorexia	1.02	0.79–1.32	0.89
Diarrhoea	0.79	0.57–1.08	0.14
Nausea/vomiting	0.92	0.70–1.21	0.55
Fever >38 °C	1.96	1.38–2.78	<0.001
WCC >10 × 10^9/L	5.12	3.93–6.66	<0.001

All listed variables were included in multivariate logistic regression analysis

WCC white cell count

The morbidity rate was the same for negative appendicectomy and uncomplicated appendicitis (6.3% vs. 6.9%; $P = 0.48$). Patients with complicated appendicitis had a significantly higher morbidity (20.1%) rate when compared to both negative and uncomplicated groups (both $P < 0.001$) (Table 1). When comparing complication severity using the Clavien-Dindo Classification [15], patients with complicated appendicitis had a significantly higher chance of developing grade I–III complications when compared to both uncomplicated and negative groups (Table 3). The complication severity was similar for negative appendicectomy and uncomplicated appendicitis groups. The incidence of intra-abdominal abscess (IAA) was significantly higher for complicated appendicitis (8.7%) when compared to both negative (1.4%) and uncomplicated (2.5%) groups (both $P < 0.001$), but there was no significant difference in IAA between the negative and the uncomplicated groups ($P = 0.27$). There were no deaths in our study.

Of the 509 negative appendicectomies, 40.5% had histological findings other than acute inflammation (Table 4). The vast majority of these did not require surgical removal for treatment; however, there were four (0.8%) patients in this group who had an appendiceal carcinoid and four (0.8%) with adenoma. None of these cases required further surgery. There were no patients in our study diagnosed with adenocarcinoma.

Discussion

The results from our large patient cohort demonstrate that the morbidity of negative LA is the same as LA for uncomplicated appendicitis, with no difference in IAA or complication severity. Whilst previous studies have compared complication rates between negative appendicectomy and positive appendicectomy groups [3, 17], few have compared negative appendicectomy with uncomplicated appendicitis [18] and none has graded complications with the Clavien-Dindo Classification [15]. The higher morbidity of LA for complicated appendicitis (20.1%) compared to uncomplicated appendicitis (6.9%) and higher incidence of IAA have been demonstrated in previous studies [19–23].

The higher conversion rate from LA to OA in cases of complicated appendicitis (19.6%) has been previously reported, with conversion rates ranging from 13 to 47% [24–27]. Based on reports of increased risk of IAA associated with LA [28], some authors have argued that complicated appendicitis should be managed with conversion to open surgery on a routine basis [29]. More recent studies, however, indicate that LA for complicated appendicitis is not associated with increased risk of IAA and is less morbid overall [30–32].

A potential confounding factor for the incidence of SSI and IAA is the differences in mean post-operative intravenous antibiotic duration between normal and uncomplicated appendicitis. The shorter duration of antibiotics for a normal appendix is to be expected given that the protocol was only for peri-operative antibiotics in these patients. However, the effect is likely to be minimal, with studies demonstrating that additional doses of post-operative intravenous antibiotics do not change SSI rates after appendicectomy [33–35].

It was expected that the LOS would be shorter in the negative group. However, the LOS was similar for negative appendicectomy and uncomplicated groups. A separate analysis of pre- and post-operative LOS revealed no significant difference between normal and uncomplicated cases. As expected, the LOS was significantly longer in patients with complicated appendicitis. This has been noted previously [19, 22, 23, 36] and is due to the higher conversion rate, the need for prolonged antibiotic administration and higher morbidity.

The fact that there is no difference in morbidity following LA for normal or uncomplicated appendicitis raises serious concerns regarding the negative appendicectomy rate of 36.0% and the use of laparoscopy to manage patients with a lower likelihood of acute appendicitis. Similar negative appendicectomy rates have been published [14, 37, 38]; however, many consider this unacceptably high [39–43]. The use of diagnostic laparoscopy for the management of patients with possible acute appendicitis and then proceeding to laparoscopic appendicectomy is a major contributor to this high negative appendicectomy rate.

Table 3 Complications graded according to Clavien-Dindo classification

Clavien-Dindo group	Negative appendicectomy $n = 509$	Positive appendicectomy (uncomplicated) $n = 720$	Positive appendicectomy (complicated) $n = 184$	P values		
				Neg. versus uncomp.	Neg. versus comp.	Uncomp. versus comp.
I	Haematuria secondary to traumatic IDC (1) Ileus (2) PR bleed managed conservatively (1) Ureteric colic (1) Asymptomatic bacteriuria (1) Viral infection (1)	Angina (1) Ileus (4) Pleural effusion (2) Superficial thrombophlebitis (1) Urinary retention (2) Viral Infection (2)	Ileus (6) SBO managed conservatively (2)	0.17	0.004	0.03
Total	7 (1.4)	12 (1.7)	8 (4.3)			
II	Deep SSI opened at bedside req. antibiotics (1) Intra-abdominal abscess req. antibiotics (3) IVC site infection req. antibiotics (1) IVC thrombus req. anticoagulation (1) Pneumonia req. antibiotics (1) Superficial SSI req. antibiotics (13)	IAA req. antibiotics (12) Clostridium difficile colitis req. antibiotics (1) Pneumonia req. antibiotics (1) Pulmonary embolism without organ failure req. anticoagulation (1) Rapid AF req. pharmacological management (1) Superficial SSI req. antibiotics (11)	IAA req. antibiotics (11) Pneumonia req. antibiotics (3) Rapid AF req. pharmacological management (1) Superficial SSI req. antibiotics (8)	1.00	<0.001	<0.001
Total	20 (3.9)	27 (3.8)	23 (12.5)			
III	IAA req. laparoscopic washout (3) IAA req. percutaneous drainage (1)	IAA req. laparoscopic washout (6) Perforated Diaphragm req. ICC (1) Post-operative haemorrhage req. laparoscopic washout (1) UGI bleed req. gastroscopy (1)	Intra-abdominal abscess req. laparoscopic washout (5) Intra-abdominal abscess req. percutaneous drainage (1)	0.51	0.006	0.02
Total	4 (0.8)	9 (1.3)	6 (3.3)			
IV	Multi-organ failure secondary to renal abscess with staph aureus bacteraemia req. ICU admission (1)	Respiratory arrest req. CPR and ICU admission (1) Respiratory failure req. ICU admission (1)	Nil	0.71	0.54	0.47
Total	1 (0.2)	2 (0.3)	0 (0.0)			
V	Nil	Nil	Nil	N/A	N/A	N/A
Overall	32 (6.3)	50 (6.9)	37 (20.1)	0.48	<0.001	<0.001

Complications are listed individually, followed by the number of patients with each complication in brackets. Totals are expressed as number of patients, with the percentage of total in brackets

AF atrial fibrillation, *CPR* cardiopulmonary resuscitation, *IAA* intra-abdominal abscess, *ICC* intercostal catheter, *ICU* intensive care unit, *IDC* indwelling catheter, *IVC* intravenous cannula, *PR* per rectal, *SBO* small bowel obstruction, *UGI* upper gastrointestinal, *SSI* surgical site infection

Based on our 2012–2013 data and an estimated catchment population of 348,096 [44], the incidence of appendicectomy (laparoscopic and open) was 132.58 per 100,000 persons per year. This rate is lower than the national average of 177 per 100,000 but is still among the highest in the Organization for Economic Co-operation and Development [45].

During the development of the ASU in 2006, the evidence available for selection of cases was carefully considered. The Alvarado scoring system has a sensitivity

Table 4 Alternative histological findings for negative appendicectomy group

Histological finding	Negative appendicectomy $n = 509$
Enterobius vermicularis	34 (6.7)
Faecolith	48 (9.4)
Carcinoid	4 (0.8)
Adenoma	4 (0.8)
Lymphoid hyperplasia	116 (22.8)
Total	206 (40.5)

All data are expressed as number of patients with the percentage of total in brackets

ranging from 66 to 93.5% and specificity of 81% [46, 47]. The concern was that whilst a scoring system may reduce the rate of negative appendicectomy, it might have a higher missed appendicitis rate and an increase in incidence of complicated appendicitis. Ultrasound (US) was reliable in children [48], but the majority of our cases (>90%) were adults. There was a lack of local ultrasonographer expertise in assessing the appendix, and studies have demonstrated that reduced operator experience in adults leads to poor results [49–52]. CT scanning had a high sensitivity (98.5%) and specificity (98%) for the diagnosis of acute appendicitis, and during the last decade, this has become common practice in many centres [53, 54]. Although there was a large increase in the use of CT during the 1990s and early 2000s, there was no reduction in the negative appendicectomy rate when assessed in population-based studies [55, 56]. Other disadvantages of routine CT scanning in the mid-2000s included the potential for unreasonable delays in surgery [52, 57] and the risks of radiation exposure [58, 59].

Therefore, the ASU chose to use diagnostic laparoscopy to manage patients with possible acute appendicitis and if no other pathology was found to remove the appendix. This was based on the high accuracy of diagnostic laparoscopy, the ability to diagnose alternative pathology and the ability to remove the appendix when required [2, 60, 61]. In 2006, there was an assumption that the morbidity of LA for a normal appendix would be lower than LA for uncomplicated appendicitis. Clearly, the use of diagnostic laparoscopy for the assessment of possible appendicitis is not appropriate, as it is associated with the same morbidity as LA for uncomplicated appendicitis. There are two options to reduce the morbidity associated with negative appendicectomy at LA. Firstly, continue to use diagnostic laparoscopy but not remove the normal appendix. Secondly, to improve the selection process and lower the negative appendicectomy rate.

Performing a diagnostic laparoscopy and leaving the normal appendix has a reported morbidity of 2% [62]. The main concern with this approach is the possible inaccuracy of laparoscopic assessment. Studies have demonstrated the difficulty of diagnosing a 'normal appendix' intra-operatively, with up to 29% of laparoscopically 'normal' appendixes being shown to have histological evidence of inflammation [7, 8, 38, 63]. There is no good prospective study with long-term follow-up on the outcomes of performing a diagnostic laparoscopy for suspected appendicitis and leaving the macroscopically normal appendix in situ. Hence, removal of the macroscopically normal appendix is advocated by many authors to exclude appendicitis [8, 9, 37, 63, 64]. As our protocol was to remove the normal appendix if there was no other pathology found, we have no data available to address this question.

Until better data are available, the preferred option is a selection process with a lower negative appendicectomy rate. This requires an understanding of predictive factors for acute appendicitis. Our study demonstrated that older age, male gender, pain duration of less than 24 h, migratory pain, fever and elevated WCC were all predictive for acute appendicitis. Some studies report diarrhoea, nausea, vomiting and anorexia as symptoms that aid in diagnosis [65, 66]. Our study and others have not demonstrated these to be independent predictors [67–69]. An elevated C-reactive protein (CRP) is an independent predictor [69–71] and when used in conjunction with an elevated WCC further improves prediction [71–74]. A normal CRP and WCC have been noted to have a higher negative predictive value [71, 72, 74]. Unfortunately, as CRP was not performed in the majority of patients in our study, the role of CRP in prediction could not be assessed.

The appendicitis inflammatory response (AIR) score is a scoring system that uses seven clinical and laboratory data to stratify patients with suspected acute appendicitis into three risk groups [69]. The score includes fever and leukocytosis that were noted to be independent predictive factors in the present study. One limitation of our study is that we could not assess the presence of RIF tenderness and/or signs of peritonitis as used by others [65, 67–69] due to the inconsistent reporting of these clinical findings. For future prospective studies, a graded scale will be used as reported in the AIR scoring system where 'rebound tenderness or guarding' is graded as either light, moderate or strong [69]. Another limitation was the absence of data for assessment of CRP levels. The AIR has been validated in several studies and provides better prediction compared to other scoring systems [42, 73, 75, 76]. The high-risk group (12.6 to 14% of patients) has a high positive predictive value of 97 to 98%, with a low negative appendicectomy rate (3.4 to 5%). The low-risk group (45 to 50.2% of

patients) has an acceptably high negative predictive value of 94 to 96%. The intermediate group (43.5 to 47% of patients) has an incidence of acute appendicitis of 44.1 to 50% [42, 69, 75, 77]. Some authors have proposed that the intermediate group have a CT scan to improve selection for surgery and reduce the negative appendicectomy rate [42, 75]. A randomised controlled trial comparing CT and ongoing observation with repeat AIR scoring found no difference between the two groups and suggested repeated assessment was appropriate to avoid the cost and other problems associated with CT scans [77]. Furthermore, in the CT group, a significantly higher proportion of patients were diagnosed with acute appendicitis suggesting that some patients in the repeated observation group had mild appendicitis which resolved with non-operative management [77].

Given the results of our study, there needs to be a change in the selection criteria for LA. We propose a prospective use of the AIR score as a validation study outside of Scandinavia. Patients with an intermediate score shall be managed with repeated observation and assessment. In addition, data on age, gender, pain duration and migratory pain shall be collected to assess if these proven independent factors can be used to improve the prediction of appendicitis.

Compliance with ethical standards

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