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Emergency appendicectomy in Australia: findings from a multicentre, prospective study

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Abstract

Background: Emergency appendicectomy is the most common emergency surgical procedure performed in Australia. Despite this frequency, there is a relative paucity of contemporary, broad-based, local data that examine how emergency appendicectomies are currently performed and what are the outcomes from these operations.
Methods: A multicentre, prospective, observational study was performed. Patients were recruited by local investigators for a period of 2 months with 30-day follow-up. Patients were eligible for study inclusion if they underwent an emergency appendicectomy for suspected acute appendicitis. The primary outcome of the study was the negative appendicectomy rate (NAR), with secondary outcomes including 30-day complication rates, method of operation and conversion rates.
Results: A total of 1189 patients were recruited across 27 centres. The NAR across all centres was 19.0%. 98.2% of appendicectomies were performed with a laparoscopic-first approach. The rate of conversion from laparoscopy to open operation was 2.4%. 9.4% of patients were recorded as having one or more of the following complications: readmission (6.6%), surgical site infection (1.9%), intra-abdominal abscess (2.7%) or further intervention (1.5%). Patients who had an open operation had higher rates of readmission and surgical site infection.
Conclusion: The NAR found in this study is within the traditional measures of acceptance; however, this rate is high when measured against modern international benchmarks.

Introduction

Around 29 000 emergency appendicectomies are performed in Australia each year.[1] It is the most common emergency surgical operation; however, contemporary local data that broadly examine the procedure and their outcomes are scarce. Understanding how emergency appendicectomies are performed and what factors may determine outcomes are of primary importance to patients and service providers.

Research in this area in Australia has predominantly been limited to single-centre retrospective audits of individual institutions.[2–4] Although single-centre audits are important for quality improvement purposes for individual organizations, they can be difficult to apply in a broader sense and inform systemic policy and procedure guidelines.

The large-scale 'snapshot' audit has proven to be a useful tool in international settings to investigate the provision and outcomes of a variety of common surgical procedures, including appendicectomy,[5,6] cholecystectomy[7] and emergency abdominal surgery.[8] The increase of trainee-led research collaboratives has enabled this type of audit to be performed across many institutions, resulting in recruitment of a large number of patients and serves to bolster the deductions and inferences allowed from the data obtained.

The following study is the first large-scale, multicentre, trainee-led collaborative project to be performed in Australia. The aim of the study is to examine the current state of practice of emergency appendicectomy in this country, and establish how the nation compares to modern international benchmarks.

Methods

A multicentre, prospective, observational study was performed between June and October 2016. Data were collected in accordance

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with a protocol that was disseminated to the primary investigators of each institution. Patients were recruited by local investigators for a period of 2 months within the study window, with a 30-day follow-up. The primary outcome of the study was negative appendicectomy rate (NAR), defined as the portion of histologically normal appendices removed in patients suspected of having acute appendicitis. Secondary outcomes included method of operation, conversion rates and 30-day adverse events (recorded as readmission, surgical site infection (SSI), intra-abdominal abscess or complications requiring further intervention (further categorized as unspecified, percutaneous drainage or taken to theatre)).

Patients were eligible to be included in the study if they were suspected of having acute appendicitis and had their appendix removed. Patients who underwent diagnostic laparoscopy for investigative purposes were excluded from the trial. Data were entered by local investigators in a database provided with prefilled variables. Patient details were anonymized prior to central collation and analysis.

Data analysis was performed using SPSS version 24 (SPSS Inc., Chicago, IL, USA). Multivariable logistic regression models were created to explore the factors impacting the negative appendicectomy, readmission, SSI, intra-abdominal abscess and further intervention rates. The models were created in a step-wise fashion with data entering the multivariable model if *P*-value <0.100 on univariable analysis. A *P*-value of <0.050 was regarded as significant.

Ethics approval for the study was provided by the Gold Coast Health and Hospital Service Human Research Ethics Committee, with individual sites subject to local governance approval processes.

Table 1 Demographic and preoperative information (total = 1189)

Age (years)	
0–17	237 (20.0)
18–35	558 (47.0)
36–65	322 (27.2)
>65	69 (5.8)
—	3
Gender	
Male	687 (49.5)
Female	600 (50.5)
ASA grade	
1–2	1105 (94.0)
3–4	70 (6.0)
—	14
BMI	
<30	642 (79.1)
>30	170 (20.9)
—	377
Aboriginal or Torres Strait Islander	
Yes	21 (1.8)
No	1119 (98.2)
—	49
Duration of symptoms (h)	
<48	918 (78.8)
>48	231 (22.2)
—	23
Preoperative imaging	
None	416 (35.3)
USS only	373 (31.7)
CT only	349 (29.6)
CT and USS	40 (3.4)
—	11

Percentages in parentheses; — denotes missing values. ASA, American Society of Anesthesiologists; BMI, body mass index; CT, computed tomography; USS, ultrasound scan.

Results

Demographics and clinical factors

A total of 1189 patients were recruited across 27 centres, with an average of 48 patients per centre. Centres were recruited from the five mainland states and one territory. The average age of the patients was 31.4 years (range: 1–99 years), with females representing slightly more than males (50.5–49.5%). Other basic demographic data are described in Table 1.

Operative characteristics

98.2% of appendicectomies were performed with a laparoscopic-first approach. The rate of conversion from laparoscopy to open operation was 2.4%. 37.9% of cases had a consultant at the operating table, with vocational trainees as the most common primary operator. About 17.4% of cases were identified intra-operatively as complicated (determined by the presence of perforation, empyema or abscess or faeculent peritonitis). The mean duration of operation was 61 min (SD: 30.05). Median duration of stay was 45 h. Operative characteristics are further detailed in Table 2.

Table 2 Operative characteristics

Timing of surgery (hours)	
08:00–18:00	758 (70.9)
18:01–07:59	311 (29.1)
—	120
Approach	
Laparoscopic	1137 (95.8)
Laparoscopic converted to open	39 (2.4)
Open	21 (1.8)
—	2
Primary operator level	
Prevocational	348 (29.3)
SET trainee	485 (40.9)
Fellow	12 (1.0)
Consultant	342 (28.8)
—	2
Consultant supervision	
Scrubbed	422 (37.9)
In theatre	98 (8.8)
Available	593 (53.3)
—	76
Macroscopic identification	
Simple	701 (59.6)
Gangrenous	88 (7.5)
Complicated	205 (17.4)
Normal	183 (15.5)
—	12

Percentages in parentheses; — denotes missing values. SET, surgical education and training.

Primary outcome

The NAR across all centres was 19.0%. The rate of incidental malignancy was 1.1%. Females (24.9%) were more likely to have a

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negative appendicectomy than males (13%) (Table 3). Increased inflammatory markers were associated with a reduced NAR ($P < 0.001$). The presence of anorexia had no significance on the NAR. Patients who had an ultrasound scan (USS) alone were twice as likely to have a negative appendicectomy, whilst those patients who only underwent computed tomography (CT) were three times less likely to have a negative appendicectomy. A further breakdown of medical imaging and NARs is detailed in Table 4.

Adverse events

9.4% of patients were recorded to have one of the following complications within 30 days; readmission (6.6%), SSI (1.9%), intra-abdominal abscess (2.7%) or further intervention (1.5%). Patients who had an open incision were more likely to be readmitted (11.8%) or have an SSI (13.7%) than those who had a laparoscopic-only procedure (6.5%, 1.3%). The same association was noted in those identified as Aboriginal or Torres Strait Islander, with higher rates of readmission (19.0%) and SSI (9.1%). Patients who had a malignancy were more likely to be readmitted (23.1%) and have a further intervention (15.4%, $P < 0.001$). Patients who had complicated or gangrenous appendicitis were more likely to have an intra-abdominal abscess as a complication (7.4% and 8.0%, respectively, $P < 0.001$). Further information is provided in Table S1.

Patients who had a negative appendicectomy had minor differences in reported complications that were not statistically significant when compared to those with appendicitis (readmission: 7.1% versus 6.2%; SSI: 1.8% versus 1.9%; intra-abdominal abscess: 1.8% versus 3.0%; further intervention: 0.4% versus 1.6%).

Preoperative imaging and negative appendicectomy

64.7% of patients had some form of preoperative imaging, with 35.3% proceeding to an operation without radiological investigation. The NAR for patients who had no imaging was 18.1%. The NAR for patients who had an USS alone was 35.7%. This increased to around 50% in patients who had an inconclusive USS and no further imaging (Table 4). In patients who had a CT alone the NAR was 6.7%, and this rate reduced to 4.3% with a positive CT finding.

Discussion

This study is the first large-scale, multicentre project to be performed by a trainee-led collaborative in Australia. A total of 1189 patients were recruited in the study period, making this the largest prospective study to look at appendicectomy outcomes in this country.

The NAR is an established metric in the treatment of patients with suspected appendicitis.[9] In previous decades, a NAR between

Table 3 Logistic regression models of normal appendix on histopathology

	Univariable		Multivariable	
	P	OR (CI)	*P*	OR (CI)
Gender				
Male		1.00		1.00
Female	<0.001	2.22 (1.64–3.01)	0.005	1.68 (1.17–2.42)
Age (years)				
<50		1.00		1.00
>50	<0.001	0.21 (0.10–0.41)	0.15	0.55 (0.25–1.24)
ASA grade				
1–2		1.00		
3–4	0.19	0.62 (0.30–1.27)		
Anorexia				
No		1.00		
Yes	0.16	1.36 (0.89–2.07)		
Aboriginal or Torres Strait Islander				
No		1.00		
Yes	0.27	0.44 (0.10–1.90)		
Primary operator				
Consultant		1.00		
Fellow	0.43	0.43 (0.06–3.41)		
SET trainee	0.19	1.27 (0.90–1.82)		
Prevocational	0.86	1.04 (0.00–1.53)		
Duration (h)				
<72		1.00		1.00
>72	<0.001	1.86 (1.32–2.62)	0.003	1.82 (1.23–2.70)
Inflammatory markers				
Normal		1.00		1.00
Raised	<0.001	0.17 (0.12–0.23)	<0.001	0.20 (0.14–0.29)
Imaging				
None		1.00		1.00
USS only	<0.001	2.13 (1.53–2.92)	0.08	1.41 (0.955–2.08)
CT only	<0.001	0.32 (0.20–0.52)	<0.001	0.34 (0.21–0.72)
Both	0.99	0.99 (0.42–2.33)	0.17	0.52 (0.21–1.32)

ASA, American Society of Anesthesiologists; CI, confidence interval; CT, computed tomography; OR, odds ratio; SET, surgical education and training; USS, ultrasound scan.

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Table 4 Imaging and the negative appendicectomy rate

Modality	*n* (%)	NAR
No imaging	416	18.1
USS only		
Consistent	192 (51.9)	12.0*
Normal	23 (6.2)	52.2*
Not found	155 (41.9)	54.5*
CT only		
Consistent	327 (93.9)	4.3*
Normal	6 (1.7)	53.3*
Equivocal	15 (4.3)	16.7*
Both	40	17.9

Percentages within parentheses are within imaging modality. *$P < 0.001$ on univariable regression analysis. CT, computed tomography; NAR, negative appendicectomy rate; USS, ultrasound scan.

15% and 25% has been accepted as reasonable.[10] The published literature estimating the NAR in Australia is predominantly based upon single-centre retrospective audits.[2–4,11]

The NAR found in this study is 19.0%. This is within the traditional measures of acceptance and consistent with measurements in the United Kingdom (20.6%).[5] The NAR is noted to be lower in a number of other international settings. In recent years, large-scale studies in the Netherlands (3.3%),[6] Switzerland (6.4%),[12] Korea (4.1%),[13] Canada (6.8%),[14] Sweden (7.9%)[15] and United States (2.5%)[16] have shown significantly decreased rates of removing an appendix with normal histology. A comparison of this study with the results of international trainee-led collaborative studies of similar methodology is seen in Table 5.

There are almost 29 000 appendicectomies performed in Australia each year.[1] A reduction in the NAR to levels commensurate with those of modern benchmarks could result in a significant reduction in potentially unnecessary operations.

Targeted reduction of NARs could be considered controversial. A low NAR was previously thought to incur a high rate of perforations; however, numerous studies have suggested that perforation is principally determined in the pre-hospital period – dependent largely on socio-economic status, access to care and timeliness to evaluation.[17] There was no significant difference between negative appendicectomy and perforation rates in the centres in this study. Negative appendicectomy has been evaluated to have a significant economic cost to the healthcare system. A recent study estimated that an additional ~$800 (USD) was spent per admission on patients with a negative appendicectomy when compared to patients with non-perforated appendicitis.[18]

It is difficult to draw inferences from this study on the utility of imaging in reducing negative operations, as only a particular subset of patients have been represented (i.e. those who were taken to theatre). However, some observations and inferences can be made from our data. The relatively low utilization of medical imaging by the centres recruited for this study may in part explain the increased rate of negative appendicectomies.

Approximately 65% of patients in this study had imaging prior to being taken to the operating room. This low rate of utilization of imaging can be contrasted against the findings in the Netherlands,[6] where national guidelines dictate that all patients should have radiological investigation (predominantly ultrasound) prior to operation.

Table 5 International comparison of emergency appendicectomy

Country	*n*	NAR (%)	LR (%)	CR (%)	CT (%)
The Netherlands	1378	3.3	79.5	3.4	30.6
Australia	1189	19.0	98.2	2.4	33.0
United Kingdom	3326	20.6	66.3	6.9	12.9

CR, conversion rate; CT, computed tomography; LR, laparoscopic rate; NAR, negative appendicectomy rate.

This is reflected in their results, which found that 99.7% of patients had radiological investigation prior to operation (66.1% USS, 30.6% CT and 3% magnetic resonance imaging), with a subsequent NAR of only 3.3%.

Higher rates of preoperative utilization of CT are seen in many US centres, with correspondingly low NARs,[16] although there are studies that suggest the utility of CT in diagnosing appendicitis may be overemphasized.[19]

Increased use of CT alone may not make significant improvements to the local NAR. Australian hospitals have a similar rate of utilization of CT as those in the Netherlands, yet the NAR is significantly higher (Table 5). Only 4.5% of patients in the Netherlands study were taken to theatre with imaging that was inconclusive for appendicitis (4.2%) or without imaging (0.3%). In contrast, 50.2% of patients in this study were taken to theatre with imaging that was inconclusive (14.9%) or without imaging (35.3%). This could reflect greater accuracy of imaging (particularly USS) in the Netherlands, or greater use of medical imaging to exclude patients from operative intervention.

The centres in this study had high utilization rates of laparoscopy, with only 1.8% of procedures performed as an open operation for the initial approach. This is in accordance with international guidelines on the use of laparoscopy as the primary modality in operative treatment of suspected appendicitis.[20] High rates of laparoscopy have been thought to contribute to a higher NAR, with the minimal morbidity of the operation conferring a lower threshold for pursuing operative intervention.[21] A negative laparoscopy is subject to the same potential complications as procedures performed in patients positive for appendicitis. In this study, patients who had a normal appendix on histology had complication rates that were statistically insignificant from those who had histologically confirmed appendicitis.

The conversion rate across all centres was 2.4%, with higher rates of conversion in patients where a consultant was involved. This is likely a representation of more complicated pathology in those cases requiring senior input. Over two-thirds of patients that required conversion had complicated appendicitis as assessed by the operating surgeon. A higher rate of complicated pathology would also account for the higher rate of SSI seen in converted and open operations.

Some limitations to the study can be identified. The use of the NAR as a quality indicator is questionable – primarily that it does not indicate resolution of clinical symptoms. It is possible that patients with a finding of a negative appendicectomy had improvement in their symptoms following their procedure. A further limitation is that only patients who had an appendicectomy were captured, with patients who had suspected appendicitis cases managed conservatively with or without imaging not included in the

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study. This indicates that the accuracy of USS and CT could not be assessed. A large-scale study looking at all patients admitted to a surgical unit with right iliac fossa pain could yield further insights into these limitations, this is currently being planned for the United Kingdom in 2017.

One of the aims of this study was to test the merits of trainee-led collaborative research in Australia. The authors firmly believe that the collaborative research model has an important role to play in research performed by trainees. It is hoped that this study encourages institutions and trainees in Australia and New Zealand to embrace this model and embark on similar projects in the future.

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Table S1. Complication rate in significant variables on logistic regression.

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