# Emergency appendicectomy in Australia - findings from a multi-centre, 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 examines how emergency appendicectomies are currently performed and what the outcomes from these operations are.

**Methods:** A multi-centre, prospective, observational study was performed. Patients were recruited by local investigators for a period of two 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, with secondary outcomes including 30 day complication rates, method of operation and conversion rates.

**Results:** 1189 patients were recruited across 27 centres. The negative appendicectomy rate 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: re-admission (6.6%), surgical site infection (SSI) (1.9%), intra-abdominal abscess (2.7%) or further intervention (1.5%). Patients who had an open operation had higher rates of readmission and SSI.

**Conclusions:** The negative appendicectomy rate 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 examines the procedure and its outcomes is scarce. Understanding how emergency appendicectomies are performed and what factors may determine outcomes is of significant 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 organisations, 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 rise 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, multi-centre, 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 multi-centre, prospective, observational study was performed between June and October 2016. Data was collected in accordance with a protocol that was disseminated to the primary investigators of each institution. Patients were recruited by local investigators for a period of two months within the study window, with a 30 day follow-up. The primary outcome of the study was negative appendicectomy rate, 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 categorised 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 was entered by local investigators onto a database provided with prefilled variables. Patient details were anonymised 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, intraabdominal abscess and further intervention rates. The models were created in a step-wise fashion with data entering the multivariable model if $p<0.100$ 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.

**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 represented slightly more than males (50.5% to 49.5%). Other basic demographic data is 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 the most common primary operator. 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 minutes (SD 30.05). Median duration of stay was 45 hours. Operative characteristics are further detailed in table 2.

**Primary outcome**

The negative appendicectomy rate across all centres was 19.0%. The rate of incidental malignancy was 1.1%. Females (24.9%) were more likely to have a negative appendicectomy than males (13%) (Table 3). Raised inflammatory markers were associated with a reduced negative appendicectomy rate ($p<0.001$). The presence of anorexia had no significance on the negative appendicectomy rate. Patients who had an USS alone were twice as likely to have a negative appendicectomy, whilst those patients who only underwent CT were three times less likely to have a negative appendicectomy. A further breakdown of medical imaging and negative appendicectomy rates 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 that had an open incision were more likely to be readmitted (11.8%) or have a 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 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% vs 6.2%, SSI 1.8% vs 1.9%, intra-abdominal abscess 1.8% vs 3.0%, further intervention 0.4% vs 1.6%).

**Pre-operative imaging and negative appendicectomy**

64.7% of patients had some form of pre-operative imaging, with 35.3% proceeding to an operation without radiological investigation. The negative appendicectomy rate for patients who had no imaging was 18.1%. The negative appendicectomy rate 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 negative appendicectomy rate was 6.7%, with a positive CT finding this rate reduced to 4.3%.

**Discussion**

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

The negative appendicectomy rate is an established metric in the treatment of patients with suspected appendicitis[9]. In previous decades, a negative appendicectomy rate between 15 - 25% has been accepted as reasonable[10]. The published literature estimating the negative appendicectomy rate in Australia is predominantly based upon single centre retrospective audits[2-4,11].

The negative appendicectomy rate 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 negative appendicectomy rate 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 negative appendicectomy rate to levels commensurate with those of modern benchmarks could result in a significant reduction in potentially unnecessary operations.

Targeted reduction of negative appendicectomy rates could be considered controversial. A low negative appendicectomy rate 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 socioeconomic 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 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 (that is, those that were taken to theatre). However, some observations and inferences can be made from our data. The relatively low utilisation 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 utilisation 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. This is reflected in their results, which found 99.7% of patients had radiological investigation prior to operation (66.1% USS, 30,6% CT, 3% MRI), with a subsequent negative appendicectomy rate of only 3.3%.

Higher rates of pre-operative utilisation of CT are seen in many US centres, with correspondingly low negative appendicectomy rates[16], although there are studies that suggest the utility of CT in diagnosing appendicitis may be overemphasised[19].

Increased use of CT alone may not make significant improvements to the local negative appendicectomy rate. Australian hospitals have a similar rate of utilisation of CT as those in the Netherlands, yet the negative appendicectomy rate 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 utilisation rates of laparoscopy, with only 1.8% of procedures performed as an open operation for the initial approach. This is in keeping 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 negative appendicectomy rate, 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 surgical site infection seen in converted and open operations.

Some limitations to the study can be identified. The use of the negative appendicectomy rate 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 that had suspected appendicitis cases managed conservatively with or without imaging not included in the study. This meant 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 a large 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.

**Collaborators**

Contributors to the Queensland Surgical Trainee (QUEST) Collaboration for this study included (in alphabetical order) Tahmina Anwari, Leigh Archer, Michael Auld, Dominic Bagguley, Jubin Bhatt, Christopher Bierton, Sarah Bormann, Kimberley Bradshaw, Rosie Callahan, Gian Capati, Daniel Cattanach, Debbie Chai, Matthew Cozier, Fermina Daza, Olivia Della Martina, Marilla Dickfos, Catriona Duncan, Laura Edward, Kristen Elstner, Luke Franceschini, Emma Fuller, Roderick Gavey, Hariette Goldman, Hobia Gole, Elizabeth Harrison, Matthew Honore, Ian Hughes, Yang Hwang, Matthew Jacob, Anshini Jain, Stephanie Jones, Anita Kothapalli, Michael Kwok, Bruce Lavarack, Lisa Lee, David Liu, James Lonie, Nicholas Low, David Mackrill, Guy Maddern, Julia McFarlane, Dinusha Metcalfe, Xavier Moar, Brendon Morden, Hajir Nabi, Eu Nice Neo, Daniel Ng Ying Kin, Eavan O'Brien, Peter O'Donohue, Sarah Paget, Keith Potent, Harald Puhalla, Roshan Ramachandran, Muhammad Rosley, Michael Schachtel, Amy Schmidt, Kendall Sharpe, Arjun Shivunanda, Douglas Stupart, Shayan Ta'I, Mary Theophilus, Phill Toonsen, Cristian Udovicich, Bianca Van Der Nest, Anna Walch, Daniel Walker, Enoch Wong, Zee Hame Wong, Omar Zubair


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## Tables



**Table 1**. Demographic and pre-operative information (total = 1189)

| | |
|---|---|
| Age | |
| 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 | |
| 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 | |
| < 48 hours | 918 (78.8) |
| > 48 hours | 231 (22.2) |
| - | 23 |
| Pre-operative 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. -, missing values; ASA, American Society of Anaesthesiologists; BMI – Body Mass Index; CT, Computer Tomography scan; USS, Ultrasound scan

**Table 2.** Operative characteristics

| | |
|---|---|
| Timing of surgery | |
| 0800 – 1800 | 758 (70.9) |
| 1800 – 0800 | 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; -, missing values; SET, Surgical Education and Training.

**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** | | | | |
| <50 | | 1.00 | | 1.00 |
| >50 | <0.001 | 0.21 (0.10 -0.41) | 0.15 | 0.55 (0.25 -1.24) |
| **ASA** | | | | |
| 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** | | | | |
| > 72 hours | | 1.00 | | 1.00 |
| > 72 hours | <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) |

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



**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 |

*p <0.001 on univariable regression analysis. Percentages within parentheses are within imaging modality.

**Table 5.** International comparison of emergency appendicectomy

| Country | n | NAR % | LR % | CR % | CT % |
|---|---|---|---|---|---|
| Netherlands | 1378 | 3.3 | 79.5 | 3.4 | 30.6 |
| Australia | 1189 | 19.0 | 98.2 | 2.4 | 33.0 |
| UK | 3326 | 20.6 | 66.3 | 6.9 | 12.9 |

NAR, Negative appendicectomy rate; LR, Laparoscopic rate; CR, conversion rate. CT – Computed tomography

## Supplementary

**Table S1** – Complication rate in significant variables on logistic regression

| | **Readmission** | **SSI** | **Abscess** | **Intervention** |
|---|---|---|---|---|
| **Total = n (%)** | 78 (6.6) | 22 (1.9) | 32 (2.7) | 18 (1.5) |
| **Severity** | | | | |
| Simple | 35 (5.0) | | 9 (1.3) | |
| Gangrenous | 5 (5.7) | | **7 (7.9)**** | |
| Complicated | **18 (8.8)*** | | **15 (7.2)**** | |
| Normal | **19 (10.4)**** | | 1 (0.5) | |
| **Method** | | | | |
| Laparoscopic | 72 (6.3) | 15 (1.3) | | |
| Open/Conversion | 6 (11.8) | **7 (13.5)**** | | |
| **ATSI** | | | | |
| No | 74 (6.5) | 20 (1.7) | | |
| Yes | **4 (19)**** | **2 (9.5)*** | | |
| **Histology** | | | | |
| Appendicitis | 60 (6.2) | | | 15 (1.6) |
| Normal | 16 (7.0) | | | 1 (0.4) |
| Malignancy | **3 (21.4)*** | | | **2 (14.3)**** |
| **Primary operator** | | | | |
| Consultant | | | 14 (4.0) | |
| Fellow | | | 1 (8.3) | |
| SET Trainee | | | 14 (2.8) | |
| Prevocational | | | **3 (0.9)*** | |

*p-value <0.10 on univariable analysis; ** p-value <0.05 on multivariable analysis.