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Temporal Considerations in the Operative Management of Acute Appendicitis: A Review of Current Practices in a Tertiary Center in Australia

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Arjun Fadia [1], Shaveen Kanakaratne [2], Meet Patel [3], Van Hoang [4], Seoyeon Kim [5], Isuri Seneviratne [5], Christopher McDonald [2]

1. Department of General Surgery, Northern Adelaide Local Health Network, Adelaide, AUS 2. Department of Colorectal Surgery, Northern Adelaide Local Health Network, Adelaide, AUS 3. Department of Medicine, The University of Sydney, Sydney, AUS 4. Department of Biostatistics, Northern Adelaide Local Health Network, Adelaide, AUS 5. Department of Medicine, Northern Adelaide Local Health Network, Adelaide University, Adelaide, AUS

Corresponding author: Arjun Fadia, arjunfadia99@gmail.com

Abstract

Background and aim

Timely appendectomy is a cornerstone of the management of acute appendicitis, as delays may adversely affect patient outcomes and increase costs. This study aimed to assess the impact of operating room delays among patients with acute appendicitis.

Methods

A retrospective review was conducted of patients who underwent appendectomy for suspected acute appendicitis between February and April 2025 at a tertiary hospital in Adelaide, Australia. Statistical analysis was completed to compare operative timing, findings, and length of stay (LOS).

Results

A total of 76 consecutive appendectomies from the study period were included. The median age was 37 years. Seventy percent of operations were completed in hours (08:00-17:00). A total of 59.2% of patients were delayed beyond their triage category due to hospital factors (triaged as within 4, 12, or 24 h). A total of 16 (21.1%) patients had perforated appendicitis, and there was no statistically significant difference in the proportion of perforated cases between delayed (20%) and non-delayed cases (22.6%). Non-perforated cases had a median time from operation to discharge of 21 h (IQR: 15-24) with total median LOS of three days (IQR: 2-4) (p=0.002), while perforated cases had an extended stay, with a median of 74 h (IQR: 39-91) (p<0.001) and total LOS of five days (IQR: 3.8-5.3) (p=0.002). The median LOS for delay cases was four days (IQR: 3-5), whereas the median LOS for non-delay cases was only two days (IQR: 2-3) (p<0.001). Hence, delaying cases resulted in a median longer total LOS of two days.

Conclusion

This study highlights the acuity, caseload, and challenges associated with adhering to guidelines in a tertiary hospital in Adelaide. Delays in transfer to the operating room were associated with increased LOS, which may increase healthcare costs. Potential strategies to decrease LOS can include increasing availability of elective lists for emergent cases, which would prevent delays and improve healthcare utilization. Further studies should also complete a cost-benefit analysis of increasing operating theatre availability and reducing time to surgery. A larger sample size is required to evaluate the impact of delayed operations on perforation, complication, and readmission rates and LOS.

Categories: General Surgery, Public Health, Epidemiology/Public Health
Keywords: acute appendicitis, appendicitis, australia, delay, operative timing of appendicitis, perforated appendicitis, tertiary center, theater delay

Introduction

Acute appendicitis is a common general surgical emergency worldwide. The widely accepted standard is early surgical intervention [1-3]. Delayed care affects hospital length of stay (LOS), complication rates, and overall resource utilization [4-6]. Delay to the operating theatre can be influenced by both patient and hospital factors. Patient-related factors can include the radiological, biochemical, or clinical severity of the appendicitis, comorbidities, or age, whereas hospital-related factors include the timing of the procedure, availability of staff, and availability of theatre space [7]. Although hospital-related factors should not prevent timely access to surgery, the realities of modern healthcare mean stable patients are often delayed to accommodate more urgent cases. Delays in operative management >24 h within admission for acute uncomplicated appendicitis have been associated with increased morbidity and increased length of stay in

hospital [8]. Therefore, the 2020 World Society of Emergency Surgery (WSES) guidelines recommend completing appendectomies for acute uncomplicated appendicitis within 24 h of admission and minimizing delays wherever possible [8]. Therefore, understanding the impact of these delays on clinical sequelae is important for rationalizing current triaging protocols.

This project assessed the local practices at a tertiary hospital in Adelaide, Australia, from a quality improvement perspective. This study aimed to identify whether delays to timely surgical intervention were associated with adverse patient outcomes. It was hypothesized that delays to the operating theatre would be associated with increased rates of perforated appendicitis and longer length of stay in hospital.

This article was presented as a poster at the 2026 Royal Australasian College of Surgeons (RACS) Annual Scientific Conference on May 1, 2026.

Materials And Methods

Study design

A retrospective review was conducted of all consecutive adult patients who underwent appendectomy for suspected acute appendicitis in a three-month period between February 2025 and April 2025 at a single tertiary hospital in Adelaide, Australia. The hospital database was used to identify patients booked for a laparoscopic +/- open appendectomy consecutively in the time period described. Patients who did not ultimately undergo an appendectomy due to the finding of alternative pathology intra-operatively or if the operation was elective (i.e., appendectomy for mucocele) were excluded. Through retrospective interrogation of the electronic medical record, demographics such as age and sex were collected. Other data, such as operative timing, operation booking urgency category (within 4, 12, or 24 h), intra-operative findings, and LOS were also collected.

Evaluating and defining variables

At this center, adults were defined as patients aged ⩾16 years. The urgency code under which an operation was booked was recorded as per the South Australian Health Policy for emergency surgery and institution policy [9]. There were three possible booking codes as follows: within 4, 12, or 24 h [9]. If a patient did not undergo operative intervention within their respective urgency code, they were defined as having faced a delay in receiving operative intervention. Operative timing was categorized into three periods depending on when the operations were performed in the morning (08:00-12:00), afternoon (12:00-17:00), or evening and overnight (17:00-08:00).

Intra-operative findings were identified by reviewing the operation note. Intra-operative findings were split into categories based on the American Association for the Surgery of Trauma (AAST) grading system [10]. The AAST grading system defines intra-operative findings on a scale of grade 1 to grade 5, with grade 1 being an acutely inflamed but intact appendix and grade 5 being a perforated appendix with generalized peritonitis [10]. For comparison, we focused on intra-operative findings of perforated appendicitis (AAST grade ⩾3) vs. non-perforated appendicitis (AAST grade ⩽2), as this directly changed management (i.e., longer IV antibiotic duration). Total LOS was defined as hospital triage to discharge, and post-operative length of stay was defined as theatre to discharge.

Statistical analysis

Continuous baseline variables that were normally distributed were presented as mean with standard deviation (SD), while non-normally distributed continuous variables were reported as median and interquartile range (IQR). Categorical variables were presented as frequencies with percentages. Categorical variables were compared using Fisher's exact test. Continuous variables were compared between two independent groups using the Mann-Whitney U test and were presented as median (interquartile range). Between-group effect estimates for continuous outcomes are reported as Hodges-Lehmann estimated location shifts with 95% confidence intervals (CI), alongside corresponding p-values.

Results

Demographics, timing of operation, and duration of symptoms

A total of 76 consecutive patients who underwent laparoscopic appendectomy for suspected acute appendicitis were identified, and all were included in the study. There were no cases of open appendectomy during the period when data were collected. Baseline characteristics are listed in Table *1*. The median age was 37 years (IQR: 25-53), and 41 (53.9%) patients were male.

Categories	Value
Total cases (n)	76
Median age, years (IQR)	37 (25-53)
Sex (M/F)	41/35
Perforated cases (n)	16
Proportion perforated (%)	21.1
Delayed cases, n (%)	45 (59.2)
Perforation in delayed cases, n (%)	9 (20)
Perforation in non-delayed cases, n (%)	7 (22.6)
Mean time: triage to ED review, hours (SD)	4.0 (2.9)
Mean time: booking to theatre, hours (SD)	25.0 (22.5)
Median total LOS in hospital, days (IQR) - all	3 (2-4)
Median total LOS in hospital, days (IQR) - non-perforated (AAST grade ≤2)	3 (2-4)
Median total LOS in hospital, days (IQR) - perforated (AAST grade ≥3)	5 (3.8-5.3)
Median post-operative LOS in hospital, hours (IQR) - non-perforated (AAST grade ≤2)	21 (15-24)
Median post-operative LOS in hospital, hours (IQR) - perforated (AAST grade ≥3)	74 (39-91)
AAST grade 1, n (%)	56 (73.7)
AAST grade 2, n (%)	4 (5.3)
AAST grade 3, n (%)	10 (13.2)
AAST grade 4, n (%)	6 (7.9)

TABLE 1: Characterizing patient demographics, impact of delay vs. non-delay groups and perforation.

AAST: American Association for the Surgery of Trauma; LOS: length of stay

The most common booking urgency code for theatre was “within 24 h” (72.4%), followed by the code “within 12 h” (22.4%). The final and least common code was “within 4 h” (5.3%). Of the operations, 20 (26.3%) were performed between 08:00 and 12:00 h, 33 (43.4%) between 12:00 and 17:00 h, and 23 (30.3%) after 17:00-08:00 h. This indicates that 53 (70%) operations were completed within normal business hours (08:00-17:00). A total of 45 patients (59.2%) faced a delay in timely operative management. These patients faced delays due to hospital and system issues, such as inadequate theatre time to complete operations booked onto the emergency list and operations being delayed due to other competing cases, such as an emergent cesarean section.

The median duration of symptoms prior to presentation was 22 h (IQR: 14-44) for delayed cases and 22 h (IQR: 19-37) for non-delayed cases. The mean duration of symptoms prior to presentation was slightly greater in delayed cases (36.1 h) compared to non-delayed cases (33.5 h). However, no statistically significant difference in duration of symptoms prior to presentation was noted between delayed and non-delayed cases (p=0.488). The mean time from triage to an emergency department physician review was 4 h, and the median was 3 h. The mean time from a patient being booked on the system to having an operation was 25.0 h, and the median was 19 h (IQR: 12.8-25.3).

Operative findings and delay to theatre

The most common intra-operative finding was grade 1 (American Association for the Surgery of Trauma {AAST}), with 56 cases (73.7%) having simple acute appendicitis without evidence of gangrene. This was followed by grade 3 appendicitis with 10 cases (13.2%) showing perforated appendicitis without surrounding frank pus. Next was grade 4, as there were six cases (7.9%) that had findings of perforated appendicitis with gross contamination. Finally, there were four grade 2 cases (5.3%) that showed gangrenous appendicitis without perforation.

There were 16 cases (21.1%) of perforated appendicitis (AAST grade ⩾3). Of the 45 patients (59.2%) who experienced delay to operative management, nine (20.0%) had perforated appendicitis and 36 (80.0%) had non-perforated appendicitis. Among the 31 patients (40.8%) who did not experience delay, seven (22.6%) had perforated appendicitis, and 24 (77.4%) had non-perforated appendicitis. There was no statistically significant association between delay to theatre and perforated appendicitis (p=0.783). The unadjusted odds ratio was 0.86 (95% CI: 0.2812-2.6130, p=0.786).

Length of stay (LOS) and delay to theatre

Mean time from triage to ED review was 4 h, while registrar booking occurred at a mean of 10.7 h. However, the mean time to theatre was 24.9 h, largely due to resource-driven delays, including theatre overrun and higher-priority emergencies. The median total LOS (days) for patients with non-perforated appendicitis (AAST grade ⩽2) was three days (IQR: 2-4). On the other hand, the median total LOS for patients with perforated appendicitis (AAST grade ⩾3) was five days (IQR: 3.8-5.3). The estimated location shift was one day (Hodges-Lehmann estimate, 95% CI: 1-2; Mann-Whitney U test p=0.003). Similarly, there was also a statistically significant difference between the perforated and non-perforated appendicitis groups in terms of post-operative LOS (hours) in hospital. The non-perforated group had a median time of 21 h from operation to discharge (IQR: 15-24), whereas the perforated group had a median time of 74 h (IQR: 39-91). The estimated location shift was 46 h (Hodges-Lehmann estimate, 95% CI: 25-60; Mann-Whitney U test p<0.001).

The post-operative time to discharge was comparable between patients who experienced delay and patients who underwent timely operative intervention. The delayed group had a median post-operative stay in hospital of 22 h (IQR: 14-44), compared with the non-delayed group, which had a post-operative stay in hospital of 22 h (IQR: 19-39). There was no statistically significant difference between these groups (p=0.343). As expected, the delayed group had a longer total stay in hospital (four days, IQR: 3-4) compared to the non-delayed group (two days, IQR: 2-3). The estimated location shift was one day (Hodges-Lehmann estimate, 95% CI: 1-2; Mann-Whitney U test, p<0.001).

Discussion

The presented study assessed the impact of delayed access to operative management for 76 patients with acute appendicitis. The findings showed that there was no significant difference in the rates of perforated appendicitis between the delayed and non-delayed groups. The odds ratio was also not significant, as it was unable to reject the null hypothesis. Although a previous meta-analysis by van Dijk et al. demonstrated that delaying an appendectomy for up to 24 h after admission does not increase the risk of complicated appendicitis, post-operative surgical site infection, or morbidity, the present study had a mean time to operation theatre of 25 h after booking the case [11]. Therefore, it is important to identify trends and factors that lead to perforated appendicitis, as patients face longer LOS and complications [12-14]. This study aligns with these global trends, as it showed an association between perforated appendicitis and longer median LOS than non-perforated appendicitis (AAST grade ⩽2) (p=0.003). However, these findings were not adjusted for confounders such as symptom duration, clinical severity, and biochemical markers.

The association between delayed operative management and increased total hospital length of stay also has important implications for healthcare resource utilization. Patients who experienced delay remained in hospital for a median of two additional days compared with those undergoing surgery within their allocated urgency category. Although the association between increased LOS and delayed appendectomy was not controlled for appropriate confounders, a 59.2% (n=45) delay rate highlights opportunities for improvement and optimization. Although direct healthcare costs were not assessed in this study or adjusted for potential confounders, prolonged hospitalization is likely to increase resource utilization through additional bed occupancy, nursing care, medical review, and other inpatient services. These findings suggest that improving access to emergency operating theatre capacity may have benefits beyond reducing operative delay, potentially improving patient flow and overall hospital efficiency. However, increasing theatre availability also carries substantial staffing and infrastructure costs. A formal cost-benefit or cost-effectiveness analysis is therefore warranted to determine whether the additional expenditure associated with increased emergency theatre capacity is offset by reductions in hospital length of stay and associated resource utilization.

Our findings showed similar rates of perforation between patients who experienced delay and patients who underwent timely operative intervention. However, the comparison between these groups was found to be statistically insignificant (p=0.783), likely due to the small sample size and heterogeneity in the duration of symptoms prior to patient presentation. Our 21.1% (n=16) perforation rate is within international ranges (18-28%) [15-17]. Time from presentation to operative intervention is an important consideration for perforated or complicated appendicitis. Modern literature suggests that a modest delay in appendectomy up to 24 h does not increase the risk of perforation in other uncomplicated cases of acute appendicitis [11,18-20]. However, a delay in medical intervention for acute appendicitis results in a 5% increased chance of perforated appendicitis every 12 h. Studies by Etbiga et al. and Aiken et al. found no increase in perforation with surgical delays under 24 h but confirmed prolonged LOS and costs in delayed cohorts [1,21]. Additionally, signals suggest that higher modified Alvarado scores are associated with worse histological and

intra-operative findings [22].

In our center, we hypothesize that the significant delay rate was largely due to factors such as systemic pressures and challenging caseload rather than failure to clinically identify the pathology. Systemic challenges include insufficient resources to have numerous concurrent operations (especially after hours) and competing emergent cases such as emergent cesarean sections. Similarly, Yin and Wu highlighted that delays due to systemic inefficiencies, not clinical prioritization, are a key contributor to poorer outcomes [23]. Our findings support recent literature suggesting system-level factors, rather than clinical triage alone, can significantly affect appendicitis progression and patient morbidity [24,25].

Limitations

An important limitation to highlight in this study is the inclusion of patients with a delayed presentation. Patients who have a delayed presentation may present with a worse clinical status on arrival, e.g., septic due to potential pre-hospital perforated appendicitis, and are more likely to receive expedited emergent operative intervention at the expense of other less emergent cases. These patients will not be captured in the category of patients that have experienced delay to theatre despite potentially enduring the pathology for up to several days prior to presentation. This will affect the accuracy of rates of perforation between patients who experienced delay and patients who underwent timely operative intervention, as these patients have technically met the definition of undergoing an operation within their allocated booking time, which was, however, derived from a patient safety perspective rather than efficient system-wide resource utilization. Future prospective studies should account for this.

Other limitations of this study include the small sample size (76), where the statistical power was too limited to perform a regression analysis for confounders. Additionally, the single-center nature is prone to bias. There was a relatively short period during which these data were collected, which can introduce further environmental bias into the study. However, this study was hypothesis-generating for this center, and subsequent studies will be completed with a longer duration and further long-term follow-up to improve statistical power and identify independent predictors. Other factors that can affect the accuracy of these data are that perforation status was solely based on the operation documentation, which can have some inter-observer variability [26].

Conclusions

This single-center retrospective review of operative management of acute appendicitis in Adelaide, South Australia, demonstrated some key findings. Although overall in-hospital delays were not statistically associated with increased perforation rates, patients who experienced delay to theatre had a longer LOS. The other finding that this study highlights is the large proportion of patients who breach their allocated booking urgency code. This is likely largely attributable to system-level pressures, including emergency theatre access and resource availability. However, these findings should be further investigated with larger, prospective studies over a longer duration and across multiple centers to better characterize the relationship between delay to theatre and its impact on patients. Future studies can also evaluate whether the timing of the operation, e.g., in-hours vs. after-hours, has any impact on outcomes such as complication and readmission rates.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Arjun Fadia, Shaveen Kanakaratne, Meet Patel, Christopher McDonald

Acquisition, analysis, or interpretation of data: Arjun Fadia, Shaveen Kanakaratne, Van Hoang, Isuri Seneviratne, Seoyeon Kim

Drafting of the manuscript: Arjun Fadia, Shaveen Kanakaratne, Isuri Seneviratne, Seoyeon Kim

Critical review of the manuscript for important intellectual content: Arjun Fadia, Shaveen Kanakaratne, Meet Patel, Christopher McDonald, Van Hoang

Supervision: Arjun Fadia, Shaveen Kanakaratne, Christopher McDonald

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Central Adelaide Local Health Network Human Research Ethics Committee issued approval #23356. **Animal subjects:** All authors have confirmed that this study did not involve animal

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