

## **Surgical Timeliness in Acute Appendicitis: Evaluating Systemic and Demographic Factors Affecting Time to Theatre**

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### **Abstract**

#### *Aims*

International guidelines advocate for timely appendectomy, within 24 hours of diagnosis of acute uncomplicated appendicitis. The aim of this study was to determine institutional compliance with these guidelines and to establish the impact of demographic and admission factors on time to theatre (TTT) and length of stay (LOS).

#### *Methods*

A retrospective analysis was conducted on 183 patients who underwent appendectomy for acute appendicitis over a 12-month period in 2023. Data collected included age, sex, day of admission, TTT, and LOS.

#### *Results*

183 patients were included in the final analysis, with a mean age of 35.7 years (SD 14.8). Median TTT was 13.0 hours (IQR 16.6), and was within guideline 24 hours for the majority of patients (152, 83.1%). Median LOS was 2.0 days, and was unaffected by TTT.

#### *Discussion*

TTT was within international guidelines for the majority of patients. No significant associations were identified between TTT and patient demographics or admission factors, suggesting that systemic factors underpin access to timely surgical care. The absence of correlation between TTT and LOS further supports the safety of short and clinically managed delays.

### **Introduction**

Acute appendicitis is among the most common cause of emergency abdominal surgery. This common intra-abdominal emergency carries a lifetime incidence of approximately 6.7% in

females and 8.6% in males in Western populations, with peak age of 28 years<sup>1</sup>, making it a common condition in younger patients. Investigation of acute appendicitis includes clinical, biochemical, and radiological evaluation<sup>2,3</sup>, which can lead to delays in diagnosis and treatment of the condition. While data supports the use of non-operative antibiotic therapy for acute appendicitis<sup>4</sup>, timely surgical intervention remains the standard of care<sup>5, 6</sup> and is thought to reduce complications such as perforation, gangrene, and peritonitis<sup>7</sup>. The Jerusalem guidelines, updated in 2020 by the World Society of Emergency Surgery, recommend that patients with uncomplicated appendicitis undergo surgery within 24 hours of diagnosis, minimising the delay wherever possible. These guidelines reflect growing evidence that moderate delays (up to 24 hours) may be safe in selected patients<sup>6, 8, 9</sup> while recognising that prolonged delays can increase morbidity<sup>10</sup>. This study aims to evaluate real-world compliance with the Jerusalem guidelines in a Model 3 Irish hospital by assessing time to theatre (TTT), impact of TTT on length of stay (LOS), and to assess what, if any, basic demographic and admission factors impact TTT and LOS.

## Methods

A retrospective single-centre analysis was performed at Connolly Hospital, Blanchardstown, Ireland. Audit approval was obtained from the institution's Audit Committee. All patients who underwent appendectomy for acute appendicitis between June 2023 to June 2024 were eligible for inclusion. Inclusion criteria included: patients of any sex, over 16 years of age, with clinically or radiologically confirmed acute appendicitis, undergoing emergency appendectomy. Patients undergoing interval elective appendectomy for other, non-emergent indications, were excluded. Histological confirmation of acute appendicitis was not required for inclusion.

Data was extracted from electronic health records and collated electronically. Basic demographic and clinical data were collected, including age at presentation, sex, date and time of presentation, admission, of theatre listing, of when the patient was called for theatre, of knife-to-skin, and of discharge. Patients admitted on Saturday and Sunday were considered weekend admissions, while patients admitted on Monday to Friday considered weekday admissions.

Descriptive statistics were used to summarise baseline demographics, clinical parameters, and outcomes. Continuous variables were reported as medians and interquartile range (IQR) as appropriate. Comparisons of time to treatment (TTT) and length of stay (LOS) across groups were performed using the Mann–Whitney U test. Subgroup analyses examined differences by sex, age category, and day of admission (weekend versus weekday). Multivariable linear regression models were constructed to assess the independent effects of sex, age, and day of

admission on TTT and LOS. A p-value of  $<0.05$  was considered statistically significant. All analyses were conducted using STATA Statistical Software (STATA v17, College Station, Tx: StataCorp LLC).

## Results

### *Demographics*

A total of 183 patients were included in the final analysis. The mean age was  $35.7 \pm 14.8$  years and median age was 35.0 years (IQR: 24). Of these, 95 were female (51.9%) and 88 were male (48.1%). Admission of suspected appendicitis were consistent regardless of the day of the week, with 126 (68.8%) patients admitted on weekdays, and 57 (31.1%) patients admitted on weekend.

### *Time to Theatre*

The median TTT was 13.0 hours (IQR 16.6) (Table 1). TTT was within 12 hours for 87 patients (47.5%), 12-24 hours for 65 patients (35.5%), 24-48 hours for 27 patients (14.8%), and over 48 hours for only 4 patients (2.2%). By sex, median TTT was 13.0 hours (IQR 15.8) for females, and 12.4 hours (IQR 16.2) for males, which did not demonstrate a statistically significant difference ( $p = 0.98$ ). In age group 30-39, the median TTT was nearly twice as long in the female cohort ( $p = 0.05$ ). Otherwise no statistically significant difference was seen between sexes for any other age group. Median TTT was 11.6 hours (IQR 13.5) for weekday admissions and 14.1 hours (IQR 14.1) for weekend admissions, which again was not statistically significant ( $p = 0.68$ ).

Linear regression showed no statistically significant association between time to theatre and sex, age group, or day of presentation. Compared to females aged 16–19 presenting on weekdays, males had a slightly longer time to theatre however this was not statistically significant ( $\beta = 1.04$ ,  $p = 0.649$ ). Weekend presentation was also associated with a non-significant delay ( $\beta = 3.55$ ,  $p = 0.152$ ). Age group comparisons showed no statistically significant differences.

### *Length of Stay*

The median LOS was 2.0 days (IQR 3.0) (Table 2). By sex, LOS was 2.0 days (IQR 3.0) for females compared with 2.0 days (IQR 3.0) for males, with no statistically significant differences between groups ( $p = 0.1$ ). Between sexes, there were no significant differences in LOS based on the age group variable. Median LOS was 2.0 days (IQR 3.0) for weekday admissions and 2.0 days (IQR 2.0) for weekend admissions, which was not statistically significant ( $p = 0.68$ ).

Linear regression showed no significant association between length of stay and sex, day of presentation, or most age groups. Compared to the reference group (females aged 16–19 presenting on weekdays), males had a non-significant reduction in LOS ( $\beta=-0.62$ ,  $p=0.382$ ), and weekend presentation was also non-significant ( $\beta=-0.70$ ,  $p=0.368$ ). Only patients aged 50–59 had a significantly longer LOS compared to the 16–19 age group ( $\beta=2.54$ ,  $p=0.047$ ). No other age group differences were statistically significant.

## Discussion

Acute appendicitis represents a common surgical emergency, with the majority of patients undergoing minimally invasive emergency appendectomy<sup>11</sup>. Acute appendicitis has generally low rates of associated morbidity and mortality. Mortality in gangrenous acute appendicitis is higher than non-gangrenous although rates are generally low at approximately 0.06% and 0.01% respectively. Appendiceal perforation rates vary from 16-40%, higher amongst patients at the extremes of age, with mortality rates of approximately 5% seen in such patients<sup>12</sup>. Timely diagnosis and surgical intervention are thought to reduce rates of complication and improve quality of care overall<sup>13, 14</sup>. Appendectomy itself is a generally well-tolerated procedure, with the overall complication rate, including surgical site infection, intra-abdominal sepsis, and ileus, of laparoscopic approaches cited at approximately 8.7%<sup>15</sup>.

In our cohort of 183 patients undergoing acute appendectomy in a Model 3 hospital in Dublin, Ireland, the median TTT was 13 hours, with the majority of patients (152 patients, 83.1%) operated on within the 24 hours. However, the 31 patients (16.9%) operated outside this guideline are not insignificant and warrant further evaluation. The value of early appendectomy is supported by several large observational and prospective studies. Bickell et al. demonstrated that the risk of perforation increases significantly when surgery is delayed beyond 24 hours<sup>13</sup>, a finding corroborated by Papandria et al., who also noted increased morbidity and prolonged recovery in delayed cases<sup>14</sup>. However, recent research has challenged this paradigm, with studies suggesting that in selected cases, short in-hospital delays of up to 24 hours may not significantly affect outcomes if patients are appropriately triaged and receive appropriate management<sup>8, 16</sup>. No demographic or temporal variables (age, sex, or day of admission) were found to significantly influence TTT in this cohort. This reinforces the notion that TTT is largely governed by hospital-level factors such as delays in radiology, ward-bed availability, emergency theatre availability, and staffing rather than patient characteristics. The absence of a "weekend effect"<sup>17</sup> is particularly notable and likely reflects sufficient surgical, anaesthetic, theatre, and other staffing across the week.

The absence of significant variation in LOS, even among those waiting >24 hours, supports the contention that clinical deterioration during the wait period was uncommon. It is notable that all patients were admitted and treated according to local guidelines and unit protocol during this wait period. This finding aligns with the safety of brief delays observed in observational studies and may reflect the influence of early imaging and targeted antibiotic use in stabilising early or uncomplicated cases of acute appendicitis<sup>8</sup>.

From a clinical perspective, these findings offer some reassurance that timely appendectomy remains a feasible standard in an acute setting. Additionally, our results support the notion that where intervention within 24-hours is not possible, limited surgical delays in stable patients, are acceptable. In the context of a modern acute hospital where demand is often greater than emergency theatre capacity our findings show that appropriately managed delays are not deleterious to patient outcomes. Lastly, stratifying patients based on risk could reduce unnecessary overnight operations, lessen anaesthetic and perioperative complications in borderline cases, and contribute to more sustainable staffing models.

This study has inherent limitations. Its retrospective nature introduces potential selection biases that cannot be fully accounted for. The limited sample size restricts the statistical power to detect subtle differences in outcomes. Certain potentially relevant data including co-morbidities, duration of symptoms, rates of perforation, complication rates, and histological results were not accounted for, which prevents a more nuanced understanding of whether delays impacted morbidity. Additionally, specific time points, including time of imaging, were not systematically recorded and may have impacted outcomes. It is worth noting that TTT is not a binary variable, in this study TTT was calculated as time from admission to time to theatre which includes time taken to obtain imaging. Lastly, all patients were managed within a single institution, which enhances consistency, however this restricts the generalisability of these findings to different institutions.

Despite these limitations, this study offers insight into real-world surgical logistics within an Irish context, an area with limited published data. The findings may therefore inform national audits or quality improvement projects focused on emergency general surgery performance metrics. Future studies should incorporate clinical outcome data and patient reported outcomes. They should also seek to stratify patients based on imaging findings, perforation risk, and co-morbidities. The role of standardised triage tools (e.g., Alvarado score<sup>18</sup> or AIR score<sup>19</sup>) in prioritising theatre access should be evaluated. Additionally, given the growing interest in robotic surgery, future work should explore whether robotic appendectomy impacts TTT or LOS in cases of uncomplicated appendicitis. Finally, further work to determine methods to enhance recovery time and shorten LOS without negatively affecting outcomes may serve to free up inpatient resources and improve timeliness and quality of care overall.

In this retrospective analysis of 183 patients undergoing acute appendectomy for suspected acute appendicitis the majority of patients underwent surgery within the recommended 24-hour window, demonstrating generally good alignment with international best practice. No significant associations were identified between TTT and patient demographics or day of admission, suggesting that systemic factors underpin access to timely surgical care. The absence of correlation between TTT and LOS further supports the safety of short, and clinically managed delays. Future work should aim to integrate outcome metrics and patient complexity variables to better understand the clinical ramifications of TTT and to optimise resource utilisation in emergency general surgery.

*Table 1 – Time to Theatre*

| Variable                    | All n=183         | Male n=88            | Female n=95         | p    |
|-----------------------------|-------------------|----------------------|---------------------|------|
| <b>TTT median (IQR) [n]</b> | 13.0 (16.6) [183] | 12.4 (16.2) [88]     | 13.0 (15.8) [95]    | 0.98 |
| within 12 hours             | 87 (47.5%)        | 43 (48.9%)           | 44 (46.0%)          |      |
| 12-24 hours                 | 65 (35.5%)        | 30 (34.1%)           | 35 (36.8%)          |      |
| 24-48 hours                 | 27 (14.8%)        | 13 (14.8%)           | 14 (14.7%)          |      |
| over 48 hours               | 4 (2.2%)          | 2 (2.3%)             | 2 (2.1%)            |      |
| <b>Age Range</b>            |                   |                      |                     |      |
| 16-19                       | 8.42 (18.1) [32]  | 8.57 (16.32) [17]    | 4.87 (17.93) [15]   | 0.88 |
| 20-29                       | 13.37 (15.7) [42] | 8.73 (15.35) [20]    | 14.53 (19.63) [22]  | 0.88 |
| 30-39                       | 14.23 (15.4) [39] | 16.84 (10.96) [20]   | 8.65 (16.10) [19]   | 0.05 |
| 40-49                       | 13.05 (17.1) [33] | 12.73 (20.95) [13]   | 13.59 (16.19) [20]  | 0.66 |
| 50-59                       | 8.13 (11.0) [25]  | 7.38 (11.70) [14]    | 9.38 (8.93) [11]    | 0.89 |
| 60+                         | 15.77 (11.3) [12] | 12.65 (5.17) [4]     | 17.96 (15.05) [8]   | 0.57 |
| <b>Day of week</b>          |                   | <b>Weekday n=126</b> | <b>Weekend n=57</b> |      |
|                             |                   | 11.6 (13.5)          | 14.1 (14.1)         | 0.32 |

*Table 1: Median time to theatre from admission in hours with standard deviations for males and females per age groups. Time to theatre for all patients per day of admission, weekends vs weekday. P values of differences by independent T test. TTT= time to theatre from admission, IQR=interquartile range, n=sample size.*

*Table 2 –Length of Stay*

| Variable                           | All n=183     | Male n=88            | Female n=95         | p    |
|------------------------------------|---------------|----------------------|---------------------|------|
| <b>LOS (days) median (IQR) [n]</b> | 2 (3) [183]   | 2 (3) [88]           | 2 (3) [95]          | 0.10 |
| <b>Age range</b>                   |               |                      |                     |      |
| 16-19                              |               |                      |                     |      |
| 20-29                              | 2 (2) [32]    | 1 (2) [17]           | 2 (1) [15]          | 0.32 |
| 30-39                              | 2 (3.75) [42] | 2 (5) [20]           | 2 (3) [22]          | 0.97 |
| 40-49                              | 2 (2) [39]    | 2 (0.5) [20]         | 2 (2) [19]          | 0.98 |
| 50-59                              | 3 (5) [33]    | 2 (2) [13]           | 4.5 (6) [20]        | 0.20 |
| 60+                                | 3 (4) [25]    | 3 (3) [14]           | 4 (5.5) [11]        | 0.39 |
|                                    | 3 (4.75) [12] | 3 (3.5) [4]          | 3 (4.75) [8]        | 0.66 |
| <b>Day of week</b>                 |               | <b>Weekday n=126</b> | <b>Weekend n=57</b> |      |
|                                    |               | 2 (3)                | 2 (2)               | 0.68 |

*Table 2: Median length of stay in days with interquartile range for male and female patients per age group. Length of stay in days for all patients base on day of admission, weekend vs weekday. P values of differences by Mann Whitney U testing. IQR=interquartile range, n=sample size, LOS=length of stay.*

#### **Declarations of Conflicts of Interest:**

None declared.

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