

Original Article

Impact of a dedicated emergency surgical service on appendicitis outcomes

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Aim: The Emergency Surgery and Trauma (ESAT) team is a dedicated consultant-led service to streamline the emergency surgical workload in Singapore. As acute appendicitis is one of the most common acute surgical conditions, we aim to compare outcomes of patients with appendicitis in the ESAT model as compared to the traditional on-call model.

Methods: A retrospective review of patients admitted to Khoo Teck Puat Hospital, Singapore, with acute appendicitis between two periods: May–October 2014 (6 months pre-ESAT) versus January–June 2017 (post-ESAT). Patient demographics, operative details, efficiency, clinical outcomes, and hospital bill savings were evaluated.

Results: There were 192 patients in the pre-ESAT period and 179 patients in the post-ESAT period. Patient demographics and comorbidities were comparable ($P > 0.05$). Time from emergency department referral to surgical review was significantly reduced in the ESAT period: 77.8 ± 46.9 min versus 127 ± 102 in the pre-ESAT period ($P = 0.002$). Time from case booking to operating theatre was significantly shorter in the ESAT period: 72.4 ± 55.2 min compared to 157.3 ± 209.1 ($P < 0.01$). More cases were carried out in the daytime during the ESAT period, 50.2% versus 39.1% ($P = 0.029$). The majority underwent laparoscopic appendectomy 156/179 (87.2%) in the ESAT period, with fewer open appendectomies 3/179 (1.7%) as compared to the pre-ESAT period ($P = 0.062$). There were higher intraoperative consultant supervision rates during the ESAT period, 38/166 (22.9%) as compared to 12/166 (6.7%) in the pre-ESAT period ($P = 0.001$). There were fewer complications (Clavien–Dindo grade II and above) in the ESAT period, 1 (0.6%) as compared to 6 (3.4%) pre-ESAT ($P = 0.07$).

Conclusion: The ESAT service is associated with better efficiency outcomes for patients with acute appendicitis.

Key words: Acute care surgery, appendectomy, appendicitis, emergency surgery

INTRODUCTION

THE TRADITIONAL GENERAL surgeon on call faces competing needs between elective and emergency services, which could delay evaluation and intervention for emergencies. With the implementation of an emergency surgical service in our institution, the emergency workload is streamlined to encourage efficiency and improve clinical outcomes. The application of acute care service in several centers has shown improvement in productivity and outcomes in patients with cholecystitis and appendicitis.^{1–3} Similarly, the Emergency Surgery and Trauma (ESAT)

model in our experience has been shown to provide more early laparoscopic cholecystectomies with improved efficiency and clinical outcomes,⁴ but the outcome in patients with appendicitis has not been studied yet.

To date, only a minority of public hospitals in Singapore have adopted the acute care surgical model. In our institute, the ESAT team is a dedicated consultant-led acute care service established in November 2014. In the period November 2014–January 2017, the ESAT team was spearheaded by a single consultant trained in acute care surgery, which led to improvement in efficiency of workflow, supervision rates, and patients' outcomes as compared to the traditional on-call service.⁵ In January 2017, the ESAT team evolved to a weekly consultant rotation roster instead of a single-consultant-led team while preserving the fundamental principles of the acute care service.⁶ The ESAT team manages all acute surgical referrals during office hours with no elective workload. Referrals after office hours and on weekends will be managed by the on-call team, similar to the traditional

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system. Our study evaluates the impact of this novel service on the improvement of care and outcomes of patients with acute appendicitis. Our hypothesis is that the ESAT model has improved efficiency, which could translate to improved clinical outcomes and cost savings.

METHODS

WE UNDERTOOK A retrospective review of patients with acute appendicitis admitted to Khoo Teck Puat Hospital, a tertiary hospital in Singapore. Two 6-month time periods were studied: May–October 2014 (6 months pre-ESAT) versus January–June 2017 (ESAT period with weekly consultant rotation roster). Inclusion criteria were adult patients with acute appendicitis referred to ESAT. Patients under the age of 16 were excluded as they were sent to pediatric hospitals and patients undergoing elective interval appendectomies were excluded. Patients' electronic medical records, operative reports, and discharge summaries were evaluated. Patient demographics, comorbidities, date of diagnoses and preoperative imaging, type of treatment (antibiotics, surgery, or percutaneous drainage), operative procedure (open, laparoscopic, or conversion), operative findings, histology, and presence of consultant's supervision were recorded. Comorbidities were classified under the Charlson comorbidity index.⁷ Efficiency outcomes, such as time intervals from review in the emergency department (ED) to review by the surgical team, and time from operative case booking to entering the operation theatre, were evaluated. Length of stay, complications categorized based on the Clavien–Dindo classification,⁸ and their interventions were recorded. The total hospital bill was recorded and adjusted to 2014 Singapore dollars, based on the healthcare division of consumer price index.⁹

Data were analyzed using spss version 21 (IBM SPSS Statistics for Windows, IBM Corp, Armonk, NY). Parametric data are described with mean and standard deviation; non-parametric data are presented as median and interquartile range. Categorical data are presented as frequency and percentage. Univariate analysis was undertaken to assess for significant differences in outcomes among the two time periods. Categorical variables were analyzed using the χ^2 -test, whereas continuous variables were analyzed using the Mann–Whitney *U*-test. A *P*-value of <0.05 was considered statistically significant.

RESULTS

THERE WERE 192 patients in the pre-ESAT period and 179 patients in the ESAT period. The mean age was 39.1 ± 15.9 years, and the majority were Chinese men (63.9%) (Table 1). Both groups had comparable Charlson

comorbidity indices ($P = 0.45$). Patients in the ESAT period presented with longer duration of symptoms prior to hospital visit (2.0 ± 1.8 days versus 1.8 ± 1.6 days; $P = 0.08$). A total of 345 out of 371 (93.0%) patients had preoperative computed tomography imaging (Table 1).

The time from ED referral to surgical review was significantly reduced in the ESAT period: 77.8 ± 46.9 versus 127 ± 102 min in the pre-ESAT period ($P = 0.002$). Time from case booking to operating theater was also shorter in the ESAT period: 72.4 ± 55.2 min compared to 157.3 ± 209.1 min ($P < 0.01$). More cases were undertaken in the daytime (07:30–16:00 h) during the ESAT period $n = 90$ (50.2%) compared to the pre-ESAT period $n = 75$ (39.1%) ($P = 0.029$) (Table 2).

The majority of patients underwent laparoscopic appendectomy, 162 patients (84.4%) pre-ESAT and 156 (87.2%) patients in the ESAT period ($P = 0.43$). Seven in each group required conversion of laparoscopic surgery to open ($P = 0.24$). There were 10 open appendectomies in the pre-ESAT period and 3 in the ESAT period ($P = 0.062$). There were 9 (4.7%) patients in the pre-ESAT period who had

Table 1. Demographics, comorbidities, duration of symptoms, and preoperative imaging in patients with acute appendicitis treated before and after introduction of an Emergency Surgery and Trauma (ESAT) team

Variable	Pre-ESAT (<i>n</i> = 192)	ESAT (<i>n</i> = 179)	<i>P</i> -value
Age (years)	36.2 ± 14.5	42.0 ± 16.3	0.59
Male sex	123 (64.1)	114 (63.7)	0.94
Race			
Chinese	93 (48.6)	102 (56.9)	0.14
Malay	21 (11.2)	23 (12.9)	
Indian	29 (14.5)	24 (13.4)	
Eurasian and others	49 (25.7)	30 (16.7)	
Charlson comorbidity index			
0	183 (95.5)	166 (92.7)	0.45
1	6 (3.0)	10 (5.6)	
2	2 (1.0)	1 (0.6)	
3	0 (0.0)	1 (0.6)	
4	0 (0.0)	1 (0.6)	
5	1 (0.5)	0 (0.0)	
Duration of symptoms (days)	1.8 ± 1.6	2.0 ± 1.8	0.08
Preoperative imaging			
CT	177 (92.2)	168 (93.9)	0.53
None	15 (7.8)	11 (6.1)	

Data are shown as mean ± standard deviation or *n* (%).

Table 2. Efficiency outcomes of cases of acute appendicitis treated before and after introduction of an Emergency Surgery and Trauma (ESAT) team

Variable	Pre-ESAT (<i>n</i> = 192)	ESAT (<i>n</i> = 179)	<i>P</i> -value
Time from ED referral to GS review (min)	127 ± 102	77.8 ± 46.9	<i>0.002</i>
Time from case booking to OT (min)	157.3 ± 209.1	72.4 ± 55.2	<i>0.010</i>
Cases undertaken in daytime/night-time (%)			
Day (07:30–16:00 h)	75 (39.1)	90 (50.2)	<i>0.029</i>
After hours (16:00–07:30 h)	117 (60.9)	89 (49.8)	
Readmission rates	4.3 (2.2)	3.6 (2.0)	<i>0.760</i>
Mean LOS (overall) (days)	2.9 ± 2.9	2.5 ± 1.9	<i>0.270</i>
Mean LOS (operation done) (days)	2.7 ± 2.9	2.4 ± 1.8	<i>0.240</i>
Mean hospital bill (overall) (\$SG)	5,663 ± 2,003	5,623 ± 3,158	<i>0.880</i>
Mean hospital bill (operation done) (\$SG)	5,697 ± 1,953	5,731 ± 3,072	<i>0.900</i>

Data are shown as mean ± standard deviation or *n* (%).
P value < 0.05 is statistically significant is indicated in italics.
 ED, emergency department; GS, general surgery; OT, operating theater.

Table 3. Treatment strategies in cases of acute appendicitis before and after introduction of an Emergency Surgery and Trauma (ESAT) team

Variable	Pre-ESAT (<i>n</i> = 192), <i>n</i> (%)	ESAT (<i>n</i> = 179), <i>n</i> (%)	<i>P</i> -value
Antibiotics only	9 (4.7)	7 (3.9)	0.590
Percutaneous drainage	4 (2.1)	6 (3.4)	
Surgery			
Laparoscopic	162 (84.4)	156 (87.2)	0.430
Laparoscopic converted to open	7 (3.6)	7 (3.9)	0.240
Open	10 (5.2)	3 (1.7)	0.062

antibiotics as compared to 7 (3.9%) in the ESAT period (*P* = 0.71). There were 4 (2.1%) in the pre-ESAT period and 6 (3.4%) in the ESAT period who had percutaneous drainage for appendiceal abscesses (*P* = 0.45) (Table 3). The duration of surgery was comparable in both groups, with a mean of 80.2 (80.2 ± 37.5) min in the pre-ESAT period and 81.0 (81.0 ± 37.3) min in the ESAT period (*P* = 0.87). There were significantly higher rates of consultant supervision during surgery in the ESAT period (*P* = 0.001). Negative appendectomy was similar in both groups (*P* = 0.26) (Table 4).

The frequency of postoperative surgical complications was similar in both groups, 14 (7.8%) in the pre-ESAT period and 10 (6.0%) in the ESAT period (*P* = 0.512). However, there were more complications (Clavien–Dindo grade

Table 4. Surgery, histology, and presence of consultant in the operating theater (OT) for cases of acute appendicitis treated before and after introduction of an Emergency Surgery and Trauma (ESAT) team

Variable	Pre-ESAT (<i>n</i> = 179)	ESAT (<i>n</i> = 166)	<i>P</i> -value
Duration of surgery (min)	80.2 ± 37.5	81.0 ± 37.3	0.870
Intraoperative findings			
Non-perforated	154 (86.0)	133 (80.1)	0.170
Perforated	38 (21.2)	46 (27.7)	
Negative appendectomy	2 (1.1)	1 (0.6)	<i>0.260</i>
Presence of consultant in OT	12 (6.7)	38 (22.9)	<i>0.001</i>

Data are shown as mean ± standard deviation or *n* (%).
P value < 0.05 is statistically significant is indicated in italics.

II and above) in the pre-ESAT period, 6 (3.4%) as compared to 1 (0.6%) in the ESAT period (*P* = 0.07) (Table 5). There were no Clavien–Dindo grade IV complications. There were 2 relook laparotomies in the pre-ESAT period for intra-abdominal collection and iatrogenic bladder perforation as compared to none in the ESAT period. There were similar rates of intra-abdominal collections, 7 (3.9%) versus 4 (2.4%) in the pre-ESAT and ESAT period, respectively (*P* = 0.63).

Overall length of stay was similar for both periods, 2.9 ± 2.9 days in pre-ESAT period as compared to

Table 5. Complications among cases of acute appendicitis treated before and after introduction of an Emergency Surgery and Trauma (ESAT) team

Variable	Pre-ESAT (n = 179), n (%)	ESAT (n = 166), n (%)	P-value
Total complications	14 (7.8)	10 (6.0)	0.512
Clavien–Dindo classification			
I	8 (4.5)	9 (5.4)	0.125
II	1 (0.6)	0 (0.0)	
III	5 (2.8)	1 (0.6)	
II + III	6 (3.4)	1 (0.6)	0.070*
Specific			
Intra-abdominal collections	7 (3.9)	4 (2.4)	0.630
Antibiotics – 2		Antibiotics – 3	
Percutaneous drainage – 3		Percutaneous drainage – 1	
Relook laparotomy – 2			
Open limited right hemicolectomy with drainage of abscess			
Primary closure of iatrogenic bladder wall injury			
Postoperative ileus	2 (1.1)	2 (1.2)	0.940
Intestinal obstruction (adhesions)	1 (0.6)	0 (0)	NA
Partial intestinal obstruction, managed conservatively			
Wound infection	3 (1.7)	2 (1.2)	0.710
General			
UTI	0 (0)	1 (0.6)	NA
Cardiac	1 (0.6)	1 (0.6)	0.960
Fast atrial fibrillation, required blood transfusion		Type II myocardial infarction	

NA, not applicable; UTI, urinary tract infection.

Table 6. Cost savings among cases of acute appendicitis treated before and after introduction of an Emergency Surgery and Trauma (ESAT) team

Cost factors in \$SG	Pre-ESAT (n = 192)	ESAT (n = 179)	P-value
Mean hospital bill per case	5,663 ± 2,003	5,623 ± 3,158	0.88
Adjusted hospital bill per case†	5,663	5,508	
Average savings per case	NA	155	
Total average annual savings	NA	55,490	

NA, not applicable.

†Adjusted to 2014 dollars based on the healthcare division of the consumer price index (www.singstat.gov.sg).

2.5 ± 1.9 in the ESAT period ($P = 0.27$) (Table 5). The average hospital bill was lower (\$5,623 ± 3,158) in the ESAT period as compared to pre-ESAT period

(\$5,663 ± 2,003) with no significant statistical difference ($P = 0.88$) (Table 6).

DISCUSSION

ACUTE APPENDICITIS IS a common surgical condition that requires timely management as the risk of rupture increases with time to surgery.¹⁰ The introduction of the acute care models has promised increased efficiency in the management of acute appendicitis in other regions but little is known about its impact in Asia.¹ This is the first paper in Asia comparing the efficiency, clinical outcomes, and cost savings in the management of acute appendicitis before and after the implementation of the ESAT model.

During the study period, patients experienced an average of 49.2 min (38.7%) reduction in time interval between review in the ED and surgical consultation. The duration between operative case booked after surgical consult to surgery also significantly reduced by 85 min. More surgeries were carried out in the daytime during the ESAT period as compared to the pre-ESAT period. With a greater proportion of daytime surgeries, the presumption is that there could be

fewer mistakes as staff are more alert and vigilant. Recent evidence has shown that night-time surgery is associated with increased risk of intraoperative complication.^{11,12}

The improvement in these efficiency outcomes can be attributed to the streamlined work processes and improved communication between disciplines. Most studies on acute care surgeries also reported similar benefits.^{13–16} Our study had a low negative appendectomy rates of 1–2% as compared to similar studies. This could be explained by the use of preoperative computed tomography imaging for more than 90% of the patients.¹⁷

Although there was reduction in waiting times to operative intervention, there was no reduction in perforated cases in the ESAT period. This could be related to the longer duration of symptoms that patients had prior to hospital visit in the ESAT period, and possible higher perforation rates to begin with. Only one study reported a statistically significant reduction in perforation rate.¹³ More surgeries were done using laparoscopic approaches than open, and conversion rates were comparable to the pre-ESAT period. Laparoscopic appendectomies have been the gold standard of care as there are fewer postoperative wound infections and faster postoperative recovery for patients. A similar study by Madore *et al*². revealed that patients treated at hospitals with traditional models of care were more likely to undergo open appendectomies than laparoscopic as compared to hospitals with acute care services.

Based on the Clavien–Dindo classification of complications, there were five more grade II and III complications in the pre-ESAT than the ESAT period, such as those requiring blood products, percutaneous drainage of intra-abdominal collections, and laparotomies. Although this difference did not reach statistical significance, likely due to low complication rates in our study, it is still essential to review the nature of these complications as they could have been avoided with better surgical techniques or adequate supervision by consultants. The reoperations were undertaken for iatrogenic bladder injury and large intra-abdominal collections encountered during the pre-ESAT period. These technical complications were not observed during the ESAT period. This could be due to significantly greater presence of consultants during the surgeries in the ESAT period, with greater emphasis on safety and increased ability to tackle challenging situations. Almost all previous studies that assessed complication rates found statistically significant decreases in complication rate with the acute care surgery model as well.^{13–16}

Interestingly, there was no additional rise in overall costs between the two time periods, despite improved productivity. Although not reaching statistical significance, the estimated savings per annum was \$SG55,490 after the implementation of ESAT in 2017 as compared to the pre-

ESAT period in 2014. Limitations of our study include its retrospective nature and its small sample size from a single institute.

CONCLUSION

THE ESAT SERVICE is associated with better efficiency outcomes for patients with acute appendicitis and fewer complications of Clavien–Dindo grade II and above.

DISCLOSURE

Approval of the research protocol: N/A.

Informed consent: N/A.

Registry and the registration no. of the study/trial: N/A.

Animal studies: N/A.

Conflict of interest: None.

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