



## Original Article

## Initial emergency laparotomy outcomes following a transdisciplinary perioperative care pathway in Singapore

Marc Weijie Ong,<sup>1</sup>  Serene Si Ning Goh,<sup>1</sup>  Wei Min James Tung,<sup>2</sup> Woan Wui Lim,<sup>1</sup> Hilda Haoling Hu,<sup>3</sup> Choong Yan Lim,<sup>4</sup> Priscilla Ng,<sup>4</sup> Kok Yang Tan,<sup>1</sup> and Tiong Thye Jerry Goo<sup>1</sup>

<sup>1</sup>Department of General Surgery, Khoo Teck Puat Hospital, Singapore City, Singapore, <sup>2</sup>Lee Kong Chian School of Medicine, Nanyang Technological University, Singapore City, Singapore, <sup>3</sup>Department of Anaesthesia, Khoo Teck Puat Hospital, Singapore City, Singapore, and <sup>4</sup>Department of Geriatric Medicine, Khoo Teck Puat Hospital, Singapore City, Singapore

**Aim:** Emergency laparotomy (EL) is a common surgery associated with high morbidity and mortality. An enhanced care pathway incorporates evidence-based care bundles with the aim of providing standardized perioperative care. Prior to 2019, EL management in our institution was not standardized. This study aims to assess whether implementation of a transdisciplinary perioperative Emergency Laparotomy (ELAP) pathway improves clinical and efficiency outcomes of EL.

**Methods:** A prospective single-center audit was undertaken between 1 January and 31 December, 2019 following the implementation of the ELAP pathway. Comparisons were made with retrospective data from the preimplementation period between 1 January and 31 December, 2017. Demographics and clinical and efficiency outcomes were compared for patients (age > 16 years old) requiring EL for acute abdominal conditions.

**Results:** There were 152 and 162 patients from preimplementation and postimplementation periods, respectively. There was a non-significant reduction of 30-day mortality in the intervention group receiving perioperative pathway care compared with the preintervention group (3.1% versus 5.3%, respectively;  $P = 0.40$ ). There was a decrease in postoperative complications in the intervention group, in particular for Clavien–Dindo IV complications (11.2% versus 3.1%,  $p < 0.01$ ). Efficiency outcomes improved postimplementation with increased consultant surgeon and anesthetist presence in operating theater and postoperative geriatric assessment for elderly patients. There was an overall reduction in cost of hospital stay from S\$32,128 to \$27,947 ( $p = 0.24$ ).

**Conclusion:** Implementation of a transdisciplinary perioperative care pathway was associated with significant reduction in postoperative complications, improvement in 30-day mortality and efficiency outcomes at reduced hospital costs for patients following EL in our institution.

**Key words:** Emergency surgery, laparotomy, perioperative care, transdisciplinary

## INTRODUCTION

EMERGENCY LAPAROTOMY (EL) is a commonly performed operation for a myriad of potentially life-threatening abdominal surgical conditions that represent a significant global healthcare burden.<sup>1</sup> In contrast to elective surgery, EL is associated with greater morbidity and mortality.<sup>2</sup> We previously reported a 30-day mortality of 5.3%,<sup>3</sup> a local academic tertiary hospital reported a 14.7% 1-year

mortality,<sup>4</sup> and international figures range from 13% to 19%.<sup>2,5</sup> These varying results could be attributed to substantial variations in processes and lack of coordination across institutes in terms of delivery of care for patients requiring EL.<sup>6,7</sup>

In recent years, health-care systems have implemented benchmarking against national and international standards in their aim to improve quality of care and postoperative outcomes in patients undergoing EL. The National Emergency Laparotomy Audit (NELA) was established in the UK for the aforementioned reasons. The audit highlights 13 key standards in the management of EL that have been shown to achieve improved outcomes for patients. Since the first organizational audit in 2013, NELA has shown a reduction in national 30-day mortality from 11.8% to 9.3%.<sup>8</sup>

**Corresponding:** Marc Weijie Ong, MBBS, FRCS, Department of General Surgery, Khoo Teck Puat Hospital, 90 Yishun Central, Singapore 768828, Singapore. E-mail: ong.marc.wj@ktph.com.sg. Received 14 May, 2021; accepted 7 Oct, 2021

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To date, no other hospitals in Singapore have adopted a perioperative care pathway for EL. A standardized perioperative Emergency Laparotomy (ELAP) pathway with key evidence-based care was established in Khoo Teck Puat Hospital, a regional general hospital, on 1 January, 2019. The ELAP pathway was coordinated by a transdisciplinary team consisting of emergency department physicians, general surgeons, geriatricians, anesthetists, nurses, and allied health professionals. The aim of this study was to evaluate the impact on the care of the patients undergoing EL after implementation of the ELAP pathway.

## METHODS

### Study design

A PROSPECTIVE single-center intervention study was carried out at Khoo Teck Puat Hospital to compare clinical and efficiency outcomes of EL between 1 January and 31 December, 2019. The intervention group was compared with retrospective data from the preimplementation period between 1 January and 31 December, 2017. In the interim year of 2018, work was done to set up the ELAP pathway after multiple rounds of discussions with the various stake-holders. Specific problems faced at the institutional level were also addressed to develop workflows that ensure prompt sepsis management, early conduct of radiological investigations, and efficient theater prioritization to minimize delay.

The integrated ELAP pathway included the following components: early warning score assessed within 30 min of admission, arterial lactate measurement and antibiotics initiated within 1 h of admission for patients with suspected sepsis, general surgical review within 2 h of referral, preoperative risk assessment using Portsmouth Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity (P-POSSUM), the patient receiving

surgery within 6 h of admission with consultant-led perioperative care, admission of high-risk patients to critical care, and postoperative geriatric assessment of patients aged 65 years or older. This pathway was started for all patients presenting with acute abdominal conditions that warrants an EL. A timeline and tracked process for patients placed on the ELAP pathway are shown in Figure 1.

An acute care surgery (ACS) service was established at our hospital in 2014.<sup>9</sup> It is a consultant-led service with dedicated junior staff attached to the team, comprising on average two specialists and six junior staff. With the implementation of an ACS service in our institution, the emergency workload is streamlined to encourage productivity and efficiency and to improve clinical outcomes.<sup>10</sup> There was no additional staffing of the ACS service during the ELAP period compared to the pre-ELAP period.

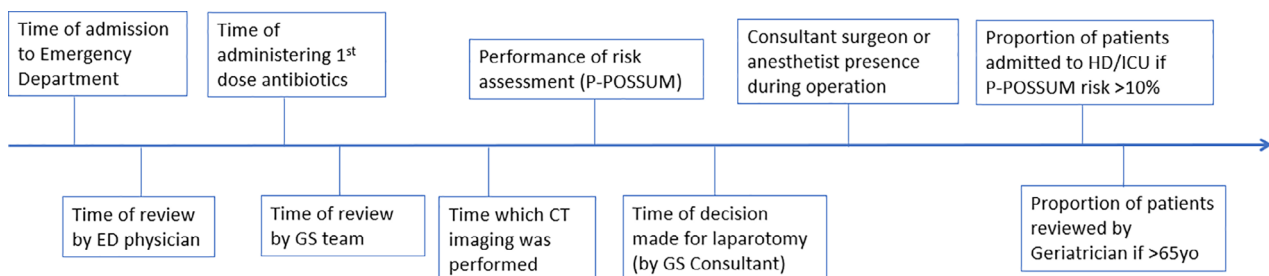
The study was approved by our institutional review board, National Healthcare Group Domain Specific Review Board (2020/00222).

### Trial end-points

The primary aim of this study was to evaluate the effect of a standardized transdisciplinary perioperative protocol on 30-day mortality. Our secondary aim was to compare clinical outcomes such as postoperative complications, hospital length of stay, costs, hospital readmission rates, unplanned critical care requirement or return to operating theater, as well as unplanned postoperative radiological intervention.

### Study cohort

Patients aged above 16 years old who underwent EL for intestinal obstruction, perforated viscus, bowel ischemia, gastrointestinal bleeding, or other suspected acute abdomen were included. Only cases performed as open surgery were included and surgeries carried out using laparoscopy were



**Fig. 1.** Timeline of the Emergency Laparotomy (ELAP) pathway workflow for a patient from time of arrival in the emergency department (ED). CT, computed tomography; GS, general surgical; HD, high dependency; ICU, intensive care unit; P-POSSUM, Portsmouth Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity.

excluded. Laparotomies for trauma, cholecystectomy, appendectomy, or vascular surgery and non-GI surgery were excluded. If a patient had more than one EL carried out during the study period, only data from the first procedure were analyzed.

## Data collection

Primary data were retrieved from the institute's electronic medical records system (Sunrise Acute Care 5.5) and patients' operative notes. The following patient variables were recorded: patient demographics, preoperative diagnostic evaluation, preoperative risk assessment scores using P-POSSUM, American Society of Anesthesiologists (ASA) physical status grade, surgical procedure, postoperative complications classified according to the Clavien–Dindo system, length of postoperative stay in the intensive care unit, length of hospital stay and 30-day mortality, unplanned admissions to the intensive care unit, and return to theater. For patients aged 65 years or older, postoperative geriatric assessment was recorded.

The Pre-ELAP group included patients who underwent EL between 1 January and 31 December, 2017; the ELAP group included patients who underwent EL between 1 January and 31 December, 2019.

## Data analysis

All analyses were undertaken using SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY). For categorical variables, counts and percentages were reported. Nonparametric data were reported in median and semi-interquartile range. Differences were assessed using the Mann–Whitney *U*-test for continuous data and Fisher's exact test for categorical data. From each of these analyses, results were calculated with 95% confidence intervals. Significance threshold was set at  $p < 0.05$ .

## RESULTS

THERE WERE 152 consecutive patients in the pre-ELAP group compared with 162 consecutive patients in the group following the introduction of the ELAP pathway (ELAP group). Baseline demographics (age, gender, and race) and indications for surgery were comparable between the two groups (Table 1). Of 162 patients in the ELAP group, 53.7% were older than 65 years of age and the majority were male (54.3% versus 45.7%).

There was a difference in the risk profile of patients. A significantly greater proportion of patients with ASA 3–5 was noted in the ELAP group compared to the Pre-ELAP group (58% versus 42.1%,  $p < 0.01$ ). The proportions of

patients with predicted P-POSSUM mortality risk greater than 10% were 32.2% and 43.2% in the Pre-ELAP and ELAP groups, respectively. However, the indications for surgery were comparable between both groups, with the most common indications for EL in both groups being intestinal obstruction followed by gastric perforation.

When comparing perioperative efficiency outcomes, it was found that the presence of a consultant surgeon in the operating theater was similar in both groups. However, it was noted that consultant anesthetist presence during the operation improved significantly (Table 2). Postoperatively, there was a greater than 3-fold increase in elderly patients (>65 years old) receiving formal geriatric assessment after implementation of the protocol (58.6% versus 15%,  $p < 0.01$ ). The time taken from decision to commencement of surgery were comparable between both groups with only an overall average time difference of 8 min, as shown in Table 2.

There was an overall improvement in 30-day mortality rate found in the ELAP group, although it was not statistically significant (3.1% versus 5.3%,  $p = 0.40$ ). However, in the subgroup of patients aged 65 years or more, the reduction in mortality was statistically significant (4.6% versus 8.8%,  $p = 0.03$ ). The 1-year mortality rates were comparable in pre-ELAP and ELAP groups.

In terms of secondary outcome measures, there was a significant reduction in postoperative complications, most notably in the Clavien–Dindo IV group from 11.2% to 3.1% ( $p < 0.01$ ). We also found that unplanned radiological intervention after operation significantly dropped from 12.5% to 1.9% ( $p < 0.01$ ). Other secondary outcome measures, such as length and cost of hospital stay, unplanned critical care requirement, or return to operating theater, and 30-day hospital readmission rates have all shown improvements, albeit not reaching statistical significance, as detailed in Table 3.

We benchmarked our data with that of the NELA parameters published in their fourth patient report (2016–2017)<sup>8</sup> (Table 4). Clinical outcomes of the ELAP group of patients compared favorably to NELA outcomes. Thirty-day mortality for patients undergoing EL was higher in the NELA group compared to the ELAP group (9.5% versus 3.1%). Length of hospital stay was shorter in the ELAP group (9.5 days versus 15.6 days). Regarding efficiency outcomes, a higher proportion of patients received preoperative risk assessment in the NELA group (75.0% in the NELA group versus 56.2% in the ELAP group). In the NELA group, consultant surgeon and anesthetist presence in theater was also more evident at 78% compared to 42% for the ELAP group. A greater proportion of patients with P-POSSUM mortality risk greater than 10% received critical care after surgery in the NELA group (87% versus 62.9%). However, with regard to elderly patients, a greater proportion of patients received

**Table 1.** Patient demographics of study cohorts who underwent emergency laparotomy (EL) before (Pre-ELAP) and after (ELAP) implementation of a transdisciplinary perioperative EL pathway

	n (%) / mean $\pm$ SD		p-value
	Pre-ELAP	ELAP	
Total cases (N)	152	162	–
Mean age (years)	63 $\pm$ 16	64 $\pm$ 14	0.35
Patients $\geq$ 65 years old	80 (52.6)	87 (53.7)	0.94
Gender			
Male	96 (63.2)	88 (54.3)	0.14
Female	56 (36.8)	74 (45.7)	
Race			
Chinese	113 (74.3)	106 (65.4)	0.11
Malay	24 (15.8)	35 (21.6)	0.24
Indian	10 (6.6)	16 (9.9)	0.39
Others	5 (3.3)	5 (3.1)	1.0
ASA			
1	15 (9.9)	11 (6.8)	0.43
2	73 (48.0)	57 (35.2)	<b>0.03</b>
3	44 (28.9)	77 (47.5)	<b>&lt;0.01</b>
4	20 (13.2)	15 (9.3)	0.36
5	0	2 (1.2)	0.50
3–5	64 (42.1)	94 (58.0)	<b>&lt;0.01</b>
Charlson comorbidity index	3.8 $\pm$ 2.4	3.3 $\pm$ 2.5	<b>0.04</b>
P-POSSUM			
P-POSSUM mortality (%)	11.4 $\pm$ 14.2	14.3 $\pm$ 18.3	0.12
Low (<5%)	74 (48.7)	58 (35.8)	<b>0.03</b>
Medium (5–10%)	29 (19.1)	34 (21.0)	0.78
High (>10%)	49 (32.2)	70 (43.2)	0.06
Indication for surgery			
Intestinal obstruction	67 (44.1)	94 (58.0)	<b>0.02</b>
Gastric perforation	21 (13.8)	21 (13.0)	0.96
Small bowel perforation	21 (13.8)	9 (5.5)	<b>0.02</b>
Large bowel perforation	11 (7.3)	12 (7.4)	0.95
Bowel ischemia	16 (10.5)	17 (10.5)	0.99
Gastrointestinal hemorrhage	4 (2.6)	4 (2.5)	1.0
Intraabdominal infection	12 (7.9)	5 (3.1)	0.10

Abbreviations: –, Not applicable; ASA, American Society of Anesthesiologists; P-POSSUM, Portsmouth Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity; SD, standard deviation. The bold values are the results that are considered significant, taking significance to be a *p*-value of <0.05

postoperative geriatric assessment in the ELAP group (62.7% versus 23%).

The NELA assesses standards of care using a red–amber–green rating scale. Nine of 13 key standards were evaluated in the ELAP cohort (Table 5). Green ratings were achieved in three standards (computed tomography [CT] imaging before surgery, arrival in theatre within timescale appropriate to urgency, and consultant surgeon presence in theater when P-POSSUM risk was 5% or higher). Amber ratings were achieved for another three standards (risk of death

documented preoperatively, admission to critical care when risk is greater than 10% [P-POSSUM], and assessment by specialist in the care of the older person for patients aged 70 and over). Red ratings were achieved for the remaining standards, as shown in Table 5.

## DISCUSSION

HIGH MORTALITY RATES have been described after EL, hence guidelines were developed with the aim to

**Table 2.** Comparison of perioperative efficiency outcomes between patients who underwent emergency laparotomy (EL) before (Pre-ELAP) or after (ELAP) implementation of a transdisciplinary perioperative EL pathway

	<i>n</i> (%) / mean ± SD		Odds ratio (95% CI)	<i>p</i> -value
	Pre-ELAP	ELAP		
<b>Preoperative</b>				
Time from decision for surgery to start of surgery (min)	94 ± 43	102 ± 60	–	<b>0.03</b>
P1 operations (to be performed within 1 h) (min)	79 ± 27	66 ± 42	–	0.24
P2 operations (to be performed within 4 h) (min)	96 ± 46	105 ± 62	–	0.06
<b>Intra-operative</b>				
Consultant surgeon presence in operating theater	140 (92.1)	150 (92.6)	0.93 (0.41–2.15)	0.87
Consultant anesthetist presence in operating theater	47 (30.9)	73 (45.1)	0.55 (0.34–0.87)	<b>0.01</b>
<b>Postoperative</b>				
Geriatric assessment for patients ≥65 years old	12 (15.0)	51 (58.6)	0.19 (0.09–0.37)	<b>&lt;0.01</b>
P-POSSUM > 10% patients admitted to critical care (HD/ICU)	36/49 (73.5)	44/70 (62.9)	1.64 (0.74–3.64)	0.31

Abbreviations: –, Not applicable; CI, confidence interval; HD, high dependency; ICU, intensive care unit; P-POSSUM, Portsmouth Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity; SD, standard deviation. The bold values are the results that are considered significant, taking significance to be a *p*-value of <0.05

**Table 3.** Comparison of clinical outcomes between patients who underwent emergency laparotomy (EL) before (Pre-ELAP) or after (ELAP) implementation of a transdisciplinary perioperative EL pathway

	<i>n</i> (%) / mean ± SD		Odds ratio (95% CI)	<i>p</i> -value
	Pre-ELAP	ELAP		
30-day mortality	8 (5.3)	5 (3.1)	0.57 (0.18–1.79)	0.40
1-year mortality	14 (9.2)	19 (11.7)	1.31 (0.63–2.71)	0.59
<b>Postoperative complications</b>				
Clavien–Dindo I	13 (8.6)	10 (6.2)	0.70 (0.30–1.66)	0.46
Clavien–Dindo II	44 (28.9)	42 (25.9)	0.86 (0.52–1.41)	0.64
Clavien–Dindo III	7 (4.6)	10 (6.2)	1.36 (0.51–3.68)	0.72
Clavien–Dindo IV	17 (11.2)	5 (3.1)	0.25 (0.09–0.70)	<b>&lt;0.01</b>
Clavien–Dindo V	5 (3.3)	5 (3.1)	0.94 (0.27–3.30)	1.00
<b>Hospital length of stay (days)</b>				
Overall length of stay, mean	15.6 ± 17.4	14.2 ± 15.4	–	0.45
Overall length of stay, median	10.0	9.5	–	–
Critical care days, mean	6.6 ± 7.1	5.3 ± 7.3	–	0.28
Critical care days, median	4.0	3.0	–	–
Unplanned critical care admission	4 (2.6)	1 (0.6)	0.23 (0.03–2.08)	0.20
Unplanned return to operating theater	8 (5.3)	2 (1.2)	0.23 (0.05–1.08)	0.054
Unplanned radiological abdominal drainage/intervention post-op	19 (12.5)	3 (1.9)	0.13 (0.04–0.46)	<b>&lt;0.01</b>
30-Day readmission	10 (6.6)	10 (6.2)	0.93 (0.38–2.31)	0.88
Hospital cost (\$)	32,128 ± 34,185	27,947 ± 28,515	–	0.24

Abbreviations: –, Not applicable; CI, confidence interval; CT, computed tomography; P-POSSUM, Portsmouth Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity. The bold values are the results that are considered significant, taking significance to be a *p*-value of <0.05

**Table 4.** Comparison of study outcomes against National Emergency Laparotomy Audit (NELA) results

	n (%) / median	
	ELAP	NELA 4th report (2016–17), %
<b>Patient demographics</b>		
Median age (years)	67	67
Patients ≥70 years old	67 (41.4)	44.5
P-POSSUM >10%	70 (43.2)	38.5
<b>Clinical outcomes</b>		
Hospital length of stay (days)	9.5	15.6
Unplanned critical care	1 (0.6)	3.4
Unplanned return to theater	2 (1.2)	6.0
30-Day mortality	5 (3.1)	9.5
1-Year mortality	19 (11.7)	23.0
<b>Efficiency outcomes</b>		
Preoperative risk assessment	91 (56.2)	75.0
Preoperative CT imaging	150 (92.6)	87.0
Arrival in theatre within timescale appropriate to urgency	141 (87.0)	82.0
Consultant surgeon and anesthetist presence in theatre	68 (42.0)	78.0
P-POSSUM >10% patients admitted to critical care	44/70 (62.9)	87.0
Postoperative geriatric assessment (≥70 years old)	42 (62.7)	23.0

Abbreviations: CT, computed tomography; ELAP, emergency laparotomy transdisciplinary perioperative care pathway; P-POSSUM, Portsmouth Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity.

improve postoperative outcomes.<sup>2,11,12</sup> In this comparative study, we found that 30-day mortality rates have further improved from our previous study in 2017 (from 5.3% to 3.1%). These results compare favorably with other countries including the UK NELA annual reports (11.8% in the first year to 9.3% in the sixth year) and a prospective multihospital audit in Australia that reported a 5.4% 30-day mortality rate<sup>13</sup>.

There are several reasons that could attribute to the low mortality rates noted in this study. First, as Singapore is a small country, patients usually experience little delay in reaching the hospital from the time of presentation of symptoms. Upon arrival at the emergency department, resuscitation is commenced expeditiously and decision-making for surgery augmented with prompt performance of diagnostic imaging, including CT scans. In a previous paper analyzing

**Table 5.** Benchmarking Emergency Laparotomy (ELAP) transdisciplinary perioperative care pathway results against National Emergency Laparotomy Audit key standards

	ELAP n (%)	RAG rating <sup>a</sup>
CT scan reported before surgery	150 (92.6)	Green
Risk of death documented preoperatively	91 (56.2)	Amber
Arrival in theatre within timescale appropriate to urgency	141 (87.0)	Green
Preoperative input by consultant surgeon and anesthetist where risk of death is ≥5% (P-POSSUM)	–	–
Preoperative input by consultant surgeon where risk of death is ≥5% (P-POSSUM)	–	–
Preoperative input by consultant anesthetist where risk of death is ≥5% (P-POSSUM)	–	–
Preoperative input by consultant intensivist where risk of death is >10% (P-POSSUM)	–	–
Consultant surgeon and anesthetist both present in theater when risk ≥5% (P-POSSUM)	46/104 (44.2)	Red
Consultant surgeon present in theater when risk ≥5% (P-POSSUM)	97/104 (93.3)	Green
Consultant anesthetist present in theater when risk ≥5% (P-POSSUM)	48/104 (46.2)	Red
Admission to critical care when risk ≥5% (P-POSSUM)	56/104 (53.8)	Red
Admission to critical care when risk >10% (P-POSSUM)	44/70 (62.9)	Amber
Assessment by specialist in the care of the older person for patients aged ≥70 years	42 (62.7)	Amber

Abbreviations: –, Not applicable; CT, computed tomography; P-POSSUM, Portsmouth Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity; RAG, red–amber–green.

<sup>a</sup>Amber, standard met for 55–84% of patients; Green, standard met for ≥85% of patients; red, standard met for <55% of patients.

time delays to surgery for patients undergoing emergency surgery within the same institution, it was found that delays to obtaining CT imaging is associated with higher complication rates in patients.<sup>14</sup> Hence, patients identified as

potentially having an acute abdomen are immediately placed on the ELAP pathway, which helps facilitate processes such as early review by the surgical team and quicker performance of imaging, which ultimately translates to reduced surgical delays. In both Pre-ELAP and ELAP cohorts, surgery was routinely carried out within 2 h, which is within the timeframe of the patient receiving surgery within 6 h of admission as per NELA recommendations.

Another reason is the direct involvement of senior surgeons and anesthetists in patient care. Early consultant review and input allows for experienced clinical decision-making, which translates to appropriate prioritization of care. The key role of senior clinician involvement has been reported in the care of acute medical patients in a study undertaken by Bell *et al.*<sup>15</sup> Our study also found that, following the protocol implementation, there has been an increase in consultant involvement, especially during operations. The presence of senior surgeons to carry out the surgery is believed to ensure the lowest chance of surgical complications occurring. The involvement of specialist anesthetists present during the operation would also optimize goal-directed intraoperative resuscitation and mandate postoperative intensive or intermediary levels of care appropriately. These factors combined would have explained the significant reduction of postoperative complications (Clavien–Dindo IV) and postoperative radiological interventions in the ELAP group.

Of the elderly patients in this study, aged 65 years and above, 62.7% received postoperative geriatric assessment. In the pre-ELAP era, elderly patients had a 6-fold higher 30-day mortality compared to young patients (8.8% versus 1.4%).<sup>3</sup> Elderly patients are more likely to have age-related physiological impairment and exhibit frailty, sarcopenia, and functional and cognitive impairment.<sup>16</sup> As a large proportion of EL patients are elderly, postoperative geriatric assessment and care should receive more attention, in a manner analogous to orthogeriatric care in patients with hip fractures.<sup>17</sup> In the first 4 years that NELA data were collected, improvements in 30- and 90-day mortality were most apparent in the oldest cohort of NELA patients.<sup>18</sup> On the same note, introduction of the ELAP pathway was associated with reduction in 30-day mortality in the elderly. There is emerging evidence advocating comprehensive geriatric assessment in older populations undergoing surgery to improve outcomes.<sup>19</sup> In our experience, the improvement in comprehensive geriatric assessment rates for this specific group of patients due to its inclusion as a care bundle process have optimized postoperative recovery by early identification and management of geriatric-related problems.

Similar studies have shown that implementing perioperative protocols for patients undergoing emergency surgery

have yielded excellent results. In Copenhagen, Denmark, such protocol implementation resulted in a reduction of 30-day and 180-day mortalities.<sup>20</sup> In the UK, the multicenter Emergency Laparotomy Pathway–Quality Improvement Care (ELPQuIC) trial revealed that implementation of evidence-based care bundles led to significant reductions in P-POSSUM risk-adjusted 30-day mortality across several National Health Service hospitals across the country.<sup>21</sup> A further UK-based prospective study, which included 28 National Health Service hospitals, showed a collaborative approach incorporating such care bundles improved mortality rates and reduced hospital length of stay.<sup>22</sup>

The NELA aims to improve care of the EL patient through collection of high-quality comparative data. The key elements of our pathway are based on the NELA recommendations. Overall, 30-day mortality of EL at our institution (3.1%) compares favorably with 9.5% in the fourth NELA patient report.<sup>8</sup> Benchmarking against NELA is an excellent opportunity to evaluate performance and identify areas for improvement. The discrepancies shown between the results of this study and NELA could be attributed to variations in organizational barriers between Singapore and the UK. Wide variations in structure and process characteristics also exist between hospitals and it is pivotal to identify measures that have significant associations with risk-adjusted mortality after general surgical emergencies. Nevertheless, it serves as a strong framework to identify areas of deficiencies within the pathway and establish new systems for optimizing results in a continual fashion.

This study has limitations that must be considered. Data collected are from a single institution providing treatment to a heterogeneous group of patients with small sample size. The surgical pathology is variable and heterogeneous with certain pathologies known to be associated with higher morbidity, hence creating difficulties in accurate comparisons. The care bundle pathway represents a pragmatic approach with multiple interventions, but it is impossible to infer causality or identify which elements are most important. Randomization would be an ideal way to analyze these components but is not pragmatic or feasible due to the nature of emergency surgery.

## CONCLUSION

**T**HIS STUDY HAS used quality improvement practices to implement an evidence-based care pathway that has led to a reduction in postoperative complications and clinical efficiency outcomes after EL, while maintaining low rates of mortality. Based on the findings in this present study, the authors recommend optimization of care through a standardized perioperative pathway in patients requiring EL.

## DISCLOSURE

**A**PPROVAL OF THE research protocol: The protocol for this research project has been approved by our institutional review board, National Healthcare Group Domain Specific Review Board. and it conforms to the provisions of the Declaration of Helsinki (approval no. 2020/00222).

**Informed consent:** Informed consent was exempted in view of minimal potential risks to research subjects and that all attempts to preserve anonymity of the data by deidentification of the patients' data had been taken.

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

**Animal studies:** N/A.

**Conflict of interest:** None.

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