



# European Colorectal Congress

3 – 6 December 2023, St.Gallen, Switzerland

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Sun, 3 Dec 2023

MASTERCLASS

PROCTOLOGY DAY

ROBOTIC COURSE

DAVOSCOURSE@ECC

## SCIENTIFIC PROGRAMME

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Seraina Faes, Zurich, CH

#### Diverticular Abscess – Always drainage or who benefits from Surgery?

Johannes Schultz, Oslo, NO

#### Perforated Diverticulitis: Damage Control, Hartmann's Procedure, Primary Anastomosis, Diverting Loop

Reinhold Kafka-Ritsch, Innsbruck, AT

#### When to avoid protective stoma in colorectal surgery

Antonino Spinelli, Milano, IT

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Peter Oppelt, Linz, AT; Andreas Shamiyeh, Linz, AT

#### A gaze in the crystal ball: Where is the role of virtual reality and artificial Intelligence in colorectal surgery

Müller Beat, Basel, CH

### MALIGNANT COLORECTAL DISEASE

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#### and Intraperitoneal Chemotherapy – facts and hopes

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#### Metastatic Colorectal Cancer – surgical approaches and limits

Jürgen Weitz, Dresden, DE

#### Extended lymph node dissection for rectal cancer, is it still under debate?

Miranda Kusters, Amsterdam, NL

#### Organ preservation functional outcome in rectal cancer treatment – in line with patient's needs? (Robot – laparoscopic – open surgery?)

Hans de Wilt, Nijmegen, NL

### ROBOTICS

#### Advances in Robotic Surgery and what we learnt so far

Parvaiz Amjad, Portsmouth, UK

#### Challenging the market: Robotic (assistant) Devices and how to choose wisely (Da Vinci – Hugo Ras – Distalmotion ua)

Khan Jim, London, UK

#### TAMIS - Robotic Transanal Surgery, does it make it easier?

Knol Joep, Genk, BE

#### Live Surgery – Contonal Hospital of St.Gallen

Walter Brunner, St.Gallen, CH;

Salvadore Conde Morales, Sevilla, ES;

Friedrich Herbst, Vienna, AUT;

Amjad Parvaiz, Portsmouth, UK

#### Video Session

#### Lars Pahlmann Lecture

Markus Büchler, Lisboa, PRT

#### Honorary Lecture

Bill Heald, Lisboa, PRT

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## ORIGINAL ARTICLE

# Poor outcomes in patients with sepsis undergoing emergency laparotomy and laparoscopy are attenuated by faster time to care measures

Natthaya Eiamampai<sup>1</sup> | Euan A. Ramsay<sup>1</sup> | Roy L. Soiza<sup>1,2</sup> |  
David A. McDonald<sup>3,4</sup> | Susan J. Moug<sup>5,6</sup> | Phyo K. Myint<sup>1,2</sup>

<sup>1</sup>Ageing Clinical and Experimental Research Team, Institute of Applied Health Sciences, School of Medicine, Medical Sciences and Nutrition, University of Aberdeen, Aberdeen, UK

<sup>2</sup>Aberdeen Royal Infirmary, NHS Grampian, Aberdeen, UK

<sup>3</sup>Centre for Sustainable Delivery, Golden Jubilee University National Hospital, Clydebank, UK

<sup>4</sup>Orthopaedic Research Institute, Bournemouth University, Bournemouth, UK

<sup>5</sup>Department of Surgery, Royal Alexandra Hospital, Paisley, UK

<sup>6</sup>University of Glasgow, Glasgow, UK

## Correspondence

Phyo K. Myint, School of Medicine and Dentistry, University of Aberdeen, Polwarth Building, Foresterhill, Aberdeen AB25 2ZD, UK.  
Email: [phyo.myint@abdn.ac.uk](mailto:phyo.myint@abdn.ac.uk)

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## Abstract

**Aim:** Emergency laparotomy and laparoscopy (EmLap) are amongst the commonest surgical procedures, with high prevalence of sepsis and hence poorer outcomes. However, whether time taken to receive care influences outcomes in patients requiring antibiotics for suspected infection remains largely unexplored. The aim of this work was to determine whether (1) time to care contributes to outcome differences between patients with and without suspected infection and (2) its impact on outcomes only amongst those with suspected infection.

**Method:** Clinical information was retrospectively obtained from the 2017–2018 Emergency Laparotomy and Laparoscopic Scottish Audit (ELLSA). Time to care referred to six temporal variables describing radiological investigation, anaesthetic triage and surgical management. Outcome measures [mortality, readmission, hospital death, postoperative destination and length of stay (LoS)] were compared using adjusted and unadjusted regression analyses to determine whether the outcome differences could be explained by faster or slower time to care.

**Results:** Amongst 2243 EmLap patients [median age 65 years (interquartile range 51–75 years), 51.1% female], 892 (39.77%) received antibiotics for suspected infection. Although patients with suspected infection had faster time to care (all  $p \leq 0.001$ ) and worse outcomes compared with those who did not, outcome differences were not statistically significant when accounted for time (all  $p > 0.050$ ). Amongst those who received antibiotics, faster time to care was also associated with decreased risk of postoperative intensive care unit (ICU) stay and shorter LoS (all  $p < 0.050$ ).

**Conclusion:** Worse outcomes associated with infection in EmLap patients were attenuated by faster time to care, which additionally reduced the LoS and ICU stay risk amongst those with suspected infection.

## KEYWORDS

emergency laparoscopic surgery, emergency laparotomy, emergency surgery, length of stay, mortality, sepsis, time to care

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## INTRODUCTION

Emergency laparotomy and laparoscopy (EmLap) are amongst the commonest emergency surgeries undertaken within the United Kingdom with over 30 000 operations annually [1, 2]. The majority of these are performed for colorectal indications. The seventh National Emergency Laparotomy Audit (NELA) reported that about 27% of EmLap patients had signs of sepsis upon admission, and up to 16.7% of EmLap 30-day mortality can be attributed to sepsis alone [3].

Existing literature on the relationship between sepsis and poor outcomes in EmLap patients has established that prolonged admission to critical care and death are primarily due to the lack of timely intervention, such as antibiotics administration and source control [4–6]. However, the connection between poor outcomes in patients with sepsis and time taken from admission until specific timepoints in the surgical care pathway, including radiological intervention and anaesthetic triage, remains largely unexplored.

Against this background, a retrospective analysis of prospectively collected data from the Emergency Laparotomy and Laparoscopic Scottish Audit (ELLSA) was carried out. ELLSA was an initiative supported via the Scottish Government Modernising Patient Pathways Programme (MPPP) to explore sustainable methods for improved care delivery [7]. This study aims to determine whether the time taken to receive care (radiological, anaesthetics and surgical) contributes to (1) the differences in outcomes between EmLap patients with or without suspected infection and (2) the impact of time to care on outcomes only amongst EmLap patients with suspected infection.

## METHOD

The study data were derived from the 2017–2018 ELLSA, which compiled records on all consecutive EmLap patients from 17 Scottish hospitals. Patient demographics, clinical details and outcomes were extracted for the analysis. The inclusion and exclusion criteria were as listed in NELA and ELLSA, a summary of which is provided below [7, 8].

### Inclusion criteria:

1. Adults aged over 18 years.
2. Underwent expedited, urgent or emergency abdominal surgery, specifically laparotomy and laparoscopic or laparoscopic-assisted procedures, which could be diagnostic with the intention to treat.
3. Surgery of the gastrointestinal tract involving the stomach, small bowel, large bowel or rectum for conditions such as perforation, ischaemia, abdominal abscess, bleeding or obstruction.

### Exclusion criteria:

1. Children under 18 years of age.
2. Underwent elective surgery or diagnostic laparotomy or laparoscopy without the intention to treat.

### What does this paper add to the literature?

This paper is the first to identify specific timepoints within the emergency laparotomy care pathway where faster time to care attenuates worse outcomes associated with infection in this high-risk population.

3. Surgery of the gastrointestinal tract involving the pathology of the oesophagus, spleen, renal tract, kidneys, liver, gallbladder, biliary tree, pancreas or urinary tract.
4. Surgery where the primary pathology was appendicitis.

To explore the effect of suspected infection and time to care on outcomes in emergency surgery, patients were divided into two groups: (1) patients who received antibiotics (had suspected infection) and (2) patients who did not (no suspected infection). ELLSA also contains information on whether these patients had their antibiotics prior to anaesthetic triage and/or surgery. There were no data on patients' sepsis status. However, it was reasonable to infer, based on clinical experience, that those receiving antibiotics were likely to have a suspected infection and lack of antibiotic administration meant no suspected infection, either on arrival or postoperatively. Baseline demographics of these two groups were compared, including age, sex, the American Society of Anesthesiologists (ASA) grade [9], NELA score [3], the Canadian Study of Health and Aging (CSHA) frailty score and whether they were an inpatient with a discharge date or not. The NELA score estimates the predicted 30-day postoperative mortality rate for EmLap while CSHA summarizes the overall fitness or frailty level of an older adult [10]. The operation types indicative of the underlying pathology were also compared with the most recent NELA report. Both upper and lower gastrointestinal tract EmLap patients were included in this study to reflect real world clinical practice of an unselected general surgical population.

'Time to care' referred to six temporal variables within ELLSA describing the time taken to reach different points in the care pathway: (1) time from admission until either computed tomography (CT) scan, (2) anaesthetic triage or (3) surgery; (4) time of CT request until CT scan performed; (5) time of CT scan until anaesthetic triage; and (6) time from CT request until surgery. Fast and slow times to care meant less than and greater than or equal to the median value for each temporal variable, respectively.

The five outcome measures were 30-day mortality, readmission (either no readmission, readmission to the same speciality or readmission to a different speciality), in-hospital death, postoperative destination [surgical ward, high-dependency unit (HDU), intensive care unit (ICU)] and postoperative length of stay (LoS; the amount of time postsurgery until discharge for that episode). With consideration of data interpretation and clinical applicability, total LoS was divided into shorter and longer stay (less than versus greater than or equal to the median value).

Based on the results, a further analysis was performed to evaluate whether the type of operation recorded on ELLSA influenced the likelihood of infection. To account for the possibility that the operation type could affect time to surgery and subsequently the LoS, a comparison of these values for different operation types was made. Operations in which >50% were treated for infection were classed as 'high risk' while the rest were 'low risk'.

A total of three duplicate entries were excluded. Any negative values for time from CT request until CT scan and time from anaesthetic triage until surgery were considered missing for the purpose of analysis. All negative time values for the time of admission until either CT scan, anaesthetic review or surgery were reassigned to the lowest positive value. Finally, all temporal variables were 99% Winsorized to replace extreme outliers with the next smallest data value and to account for the positive skew.

## Statistical analysis

SPSS v.27 was used to perform statistical analyses via either the chi-square test, independent *t*-test or Mann-Whitney *U*-test to compare baseline characteristics between the patient groups.

To compare outcome measures, unadjusted and binomial/multinomial adjusted logistic regression analyses were performed on dichotomous outcome variables (30-day mortality and in-hospital death, shorter or longer LoS) and categorical outcome variables with more than two categories (readmission and postoperative destination). Confounders accounted for in the adjusted analyses were selected based on results of the comparison of baseline demographics and existing literature. For the primary objective, adjusted regression models accounting for age, sex, ASA grade, CSHA score, whether antibiotics were given before anaesthetic triage and time to care was performed to compare outcomes between those with suspected infection and those without. Each time-to-care variable was adjusted individually.

For the second objective, a subgroup analysis was performed only amongst patients who received antibiotics to compare outcome measures between faster and slower than median time to care for each temporal variable. Similar adjusted regression models as the primary objective were used without needing to adjust for time.

For the additional analysis, descriptive analysis and chi-square tests were performed to determine the percentage of patients who received antibiotics for infection and the median time in minutes from admission to surgery in different operation types. A Kruskal-Wallis test was carried out to determine whether a relationship exists between the length of time from admission to surgery and LoS between high- and low-risk operation types.

## RESULTS

After excluding duplicate entries, 2243 EmLap patients were included for statistical analysis, out of which 892 (39.77%) were

administered antibiotics (suspected infection), 1136 (50.65%) were not and 215 (9.59%) were not documented and hence considered missing (Figure 1). The median age was 65 years [interquartile range (IQR) 51–75 years] and 51.1% were women. A total of 1272 (59.05%) patients were ASA 3 or above and 339 (23.66%) had a CSHA score of 4 or more. There were 31 types of operations within ELLSA (Table S3), with the three commonest being small bowel resection (372, 16.6%), right colectomy (283, 12.6%) and Hartmann's procedure (256, 11.4%).

A summary of the baseline characteristics in Table 1 revealed that all six time-to-care variables were significantly shorter in patients who received antibiotics ( $p \leq 0.001$ ). These patients were also younger (mean age 60.0 vs. 62.7 years,  $p < 0.001$ ) and had a higher median NELA predictive mortality (4.4 vs. 3.0,  $p = 0.008$ ) and ASA grade (60.5% vs. 54.3% ASA  $\geq 3$ ,  $p < 0.001$ ).

## Primary outcomes

Patients with suspected infection had poorer outcomes than their counterparts who did not. Thirty-day mortality (OR=1.75, 95% CI 1.28–2.40,  $p < 0.010$ ), in-hospital death (OR=1.72, 95% CI 1.27–2.33,  $p < 0.010$ ), postoperative ICU stay (OR=2.10, 95% CI 1.60–2.77,  $p < 0.001$ ) and longer LoS (OR=1.27, 95% CI 1.05–1.52,  $p = 0.012$ ), were significantly more prevalent in the group with suspected infection for the unadjusted analysis (Table 2). Note that the median LoS was 10 days.

Odds of 30-day mortality, in-hospital death, postoperative stay in ICU and longer LoS remained significantly higher in those who received antibiotics when adjusted for sex and age (Table 3, Model A). However, only postoperative ICU stay risk remained statistically significant when adjusted for sex, age, ASA grade and CSHA score (Table 3, Models B and C). No other trends were observed.

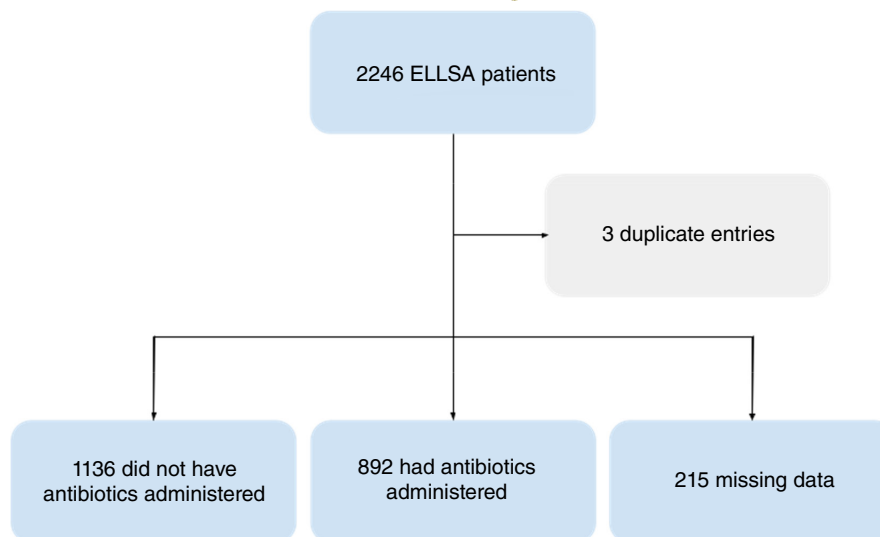
## Secondary outcomes

Table S1 depicts the results of unadjusted regression analysis models comparing faster and slower time to care when only patients who received antibiotics for suspected infection were analysed. The increased likelihood of postoperative ICU stay remained statistically significant at three timepoints: time from CT request until CT scan ( $p = 0.024$ ), time from CT scan until anaesthetic triage ( $p < 0.001$ ) and time from CT request until surgery ( $p < 0.001$ ). Slower time to care in the remaining timepoints contributed to significantly increased chances of having a longer total LoS: time from admission until CT scan ( $p = 0.011$ ), time from admission until anaesthetic triage ( $p < 0.001$ ) and time from admission until surgery ( $p < 0.001$ ). Note that the median LoS was now 11 days.

Adjusting for sex, age, ASA grade, CSHA score and whether antibiotics were administered before admission to anaesthetics (Table S2) revealed that time from CT request until anaesthetic triage ( $p = 0.030$ ) and time from CT scan until surgery ( $p = 0.036$ )



**FIGURE 1** Flow chart summarizing the total number of patients included in this study.



**TABLE 1** Baseline demographics of patients who did and did not receive antibiotics for infection.

	Patients (n, % of total)	Did not receive antibiotics (n = 1136 <sup>a</sup> )	Received antibiotics (n = 892 <sup>a</sup> )	p-value
Average age (years)	2028 (90.4%)	62.73	60.02	<0.001
Sex (n, %)	2028 (90.4%)			0.105
Female		599 (52.7%)	438 (49.1%)	
ASA grade (n, %)	1948 (86.8%)			<0.001
1		95 (8.4%)	84 (9.9%)	
2		384 (33.8%)	253 (29.7%)	
3		436 (38.4%)	315 (37.0%)	
4		165 (14.5%)	170 (20.0%)	
5		16 (1.4%)	30 (3.5%)	
Median NELA score (0%–100%, IQR)		3.0 (0.9–8.6)	4.4 (1.2–11.8)	0.008
CHSA score (1–7) (N, %)	1301 (58.0%)			0.230
Nonfrail (1–3)		544 (77.3%)	447 (74.9%)	
Pre frail (4–5)		121 (17.2%)	119 (19.9%)	
Frail (6–7)		39 (5.5%)	31 (5.2%)	
Median time variables (min, IQR)	1965 (87.6%)			
Admission until CT scan		896.0 (281.5–2372.0)	559.5 (210.0–1766.3)	0.001
Admission until review by anaesthetics		2593.0 (1063.5–6454.5)	1554.0 (528.5–4547.5)	<0.001
Admission until surgery		2632.0 (1127.8–6243.5)	1577.5 (573.3–4475.5)	<0.001
CT request until CT scan		88.0 (38.0–198.0)	63.5 (30.0–141.8)	<0.001
CT scan until reiview by anaesthetics		1217.0 (296.5–2849.0)	417.0 (199.5–1589.5)	<0.001
CT request until surgery		1240.0 (335.3–2816.0)	454.5 (243.0–1623.5)	<0.001
Inpatient status (N, %)	2028 (90.4%)			0.482
Not an inpatient		1133 (99.7%)	888 (99.6%)	
An inpatient		3 (0.3%)	4 (0.4%)	

Abbreviations: ASA, American Society of Anesthesiologists; CHSA, Canadian Study of Health and Aging; IQR, interquartile range; NELA, National Emergency Laparotomy Audit.

<sup>a</sup>Not all patients from either group have documented information for each characteristic, the total number of patients analysed for each variable and percentage of the total of 2243 patients are recorded in the 'Patients' column.

**TABLE 2** Unadjusted binary and multinomial regression models comparing outcome measures between patients who did and did not receive antibiotics for infection.

Variables	OR (95% CI)	p-value
30-day mortality	1.75 (1.28–2.40)	<0.001
Readmission destination (ref: no readmission)		
Same speciality	1.19 (0.85–1.68)	0.31
Different speciality	1.43 (0.85–2.41)	0.18
Hospital death	1.72 (1.27–2.33)	<0.001
Postoperative destination (ref: ward)		
High-dependency unit	1.15 (0.89–1.48)	0.26
Intensive care unit	2.10 (1.60–2.77)	<0.001
Length of stay $\geq$ median (10 days)	1.27 (1.05–1.52)	0.012

contributed to higher risk of postoperative ICU admission. On the other hand, longer postoperative LoS could be attributed to longer time from admission until anaesthetic triage ( $p < 0.001$ ) and time from admission until surgery ( $p < 0.001$ ). No other outcome measures consistently revealed a statistically significant difference when adjusted for all the confounders.

### Impact on LoS by type of operation

There were eight operation types (Table S3) in which more than 50% of patients received treatment for infection and were, as defined in this study, considered high risk ( $p < 0.010$ ). These were: colorectal resection (61.0%), debridement (75.0%), drainage of abscess/collecion (80.0%), Hartmann's procedure (63.6%), peptic ulcer suture or repair of perforation (68.1%), repair of intestinal perforation (61.1%), repair or revision of anastomosis (59.1%) and washout only (56.5%). Table S4 listed the median time from admission to surgery and the median LoS for all operation types (10 days for the cohort and 11 days for those with suspected infection only). Comparison of these values in high- and low-risk operations (Table S5) revealed that high-risk operations had a significantly shorter time from admission to surgery (1459.0 min vs. 2569 min,  $p < 0.001$ ) and longer postoperative LoS (11.0 days vs. 10.0 days,  $p < 0.001$ ).

## DISCUSSION

To the best of our knowledge, this is the first paper to identify specific timepoints in the surgical care pathway where reduction in time to care can alleviate worse outcomes associated with infection in emergency surgery and to demonstrate this within a consecutive unselected emergency surgical patient population undergoing EmLap. Shorter time to care was also found to be beneficially associated with shorter postoperative LoS and decreased risk of postoperative ICU stay in those with suspected infection.

In the first analysis, outcomes between patients with and without suspected infection were initially compared, before accounting

for time to care in the adjusted regression analysis. In the unadjusted analysis, while baseline characteristics suggested that patients with suspected infection had faster care, outcomes (30-day mortality, in-hospital death, postoperative LoS and postoperative ICU stay) were significantly worse in this patient group (Table 2). These findings could be supported by the results of the additional analysis, which revealed that high-risk operations where more than 50% of patients had suspected infection, had a significantly longer LoS despite having a faster time to surgery (Table S5). However, after accounting for time to care in the adjusted model (Table 3), the initially worse outcomes amongst those with suspected infection no longer differed significantly from those without infection. This indicated that faster time to care contributed to the improvement in most outcomes in those with suspected infection.

The second regression analysis firstly compared outcomes amongst patients who received antibiotics for infection with time to care as the independent variable, before adjusting for confounders (Tables S1 and S2). The only trend observed across both the adjusted and unadjusted regression models was that slower time from admission to anaesthetic triage and admission until surgery contributed to a longer postoperative LoS. On the other hand, slower time from CT request until anaesthetic triage and CT scan until surgery were associated with a higher risk of postoperative ICU stay.

Multiple studies have listed common and well-established factors that influence mortality after emergency surgery, namely age, ASA grade and comorbidities [11–13]. This could potentially explain why, most of the time, there was a statistically significant impact on outcomes only in Models A and B but not in later models where all these factors were accounted for (Tables 3 and S2).

A 2019 prospective nationwide cohort study on patients with perforated peptic ulcer extracted from NELA (which contains similar patient population and pathologies to ELLSA) showed that there is a 3% increase in 90-day mortality for every hour EmLap was delayed, and up to a 6% increase in physiologically shocked patients [14]. Another Canadian single tertiary cohort study involving 2820 urgent and emergency surgical patients who experienced delayed surgical intervention reported an association between delayed operating theatre access and mortality, longer LoS and increased financial burden [15]. It is important to note, however, that the study included all noncardiac emergency surgery. An older retrospective study from the United States published in 2014 similarly demonstrated that the odds of 24-h mortality and 30-day mortality in laparotomy patients would increase by 1.50- and 1.41-fold, respectively for every 10-min delay in reaching the operating theatre [16]. A recent systematic review (2021) compiling 16 papers across Europe identified delays in various timepoints in the emergency laparotomy pathway and explored how this impacted the mortality rate. Thirteen out of 16 studies found that delays to surgery lead to an increased mortality rate, although it was inconclusive exactly which part of the surgical pathway contributed the most [17]. The results of our study comparably reflected worse outcomes in association with delayed time to care. Additionally, it appears that reduced time to care across specific points in the care pathway had the benefit of decreasing

**TABLE 3** Adjusted binary and multinomial regression models comparing poor outcomes between patients who received and did not receive antibiotics for infection.

Model		30-day mortality	Readmission destination (ref: No readmission)		Hospital death	Postoperative destination (ref: Ward)		Postoperative length of stay $\geq$ median (10 days)
			Same specialty	Different specialty		HDU	ICU	
Model A	<i>p</i> -value	<0.001	0.475	0.184	<0.001	0.068	<0.001	0.001
	OR	2.04	1.13	1.43	2.00	1.27	2.40	1.40
	95% CI	[1.47–2.83]	[0.80–1.60]	[0.84–2.41]	[1.46–2.75]	[0.98–1.63]	[1.80–3.18]	[1.16–1.70]
Model B	<i>p</i> -value	0.008	0.435	0.305	0.013	0.092	<0.001	0.020
	OR	1.62	1.15	1.32	1.56	1.26	2.16	1.27
	95% CI	[1.14–2.32]	[0.81–1.64]	[0.78–2.25]	[1.10–2.20]	[0.96–1.64]	[1.58–2.95]	[1.04–1.56]
Model C	<i>p</i> -value	0.150	0.989	0.306	0.157	0.020	<0.001	0.076
	OR	1.39	1.00	1.39	1.39	1.48	2.69	1.26
	95% CI	[0.89–2.19]	[0.63–1.60]	[0.74–2.62]	[0.88–2.19]	[1.06–2.05]	[1.80–4.04]	[0.98–1.62]
Model D	<i>p</i> -value	0.207	0.454	0.552	0.529	0.335	0.811	0.614
	OR	1.97	1.53	1.59	1.44	0.69	0.886	0.84
	95% CI	[0.69–5.63]	[0.51–4.61]	[0.34–7.38]	[0.46–4.53]	[0.32–1.47]	[0.33–2.39]	[0.43–1.65]
Model E1	<i>p</i> -Value	0.106	0.489	0.821	0.351	0.900	0.707	0.725
	Odds ratio	2.45	1.58	1.28	1.76	0.94	1.25	1.15
	95% CI	[0.83–7.26]	[0.43–31.7]	[0.15–10.62]	[0.54–5.72]	[0.36–2.44]	[0.39–4.05]	[0.54–2.44]
Model E2	<i>p</i> -value	0.171	0.505	0.374	0.485	0.358	0.760	0.768
	OR	2.10	1.46	2.01	1.51	0.701	0.856	0.90
	95% CI	[0.73–6.06]	[0.48–4.43]	[0.43–9.34]	[0.48–4.78]	[0.33–1.49]	[0.32–2.32]	[0.46–1.77]
Model E3	<i>p</i> -value	0.188	0.480	0.379	0.490	0.381	0.801	0.762
	OR	2.04	1.49	1.99	1.50	0.71	0.88	0.901
	95% CI	[0.71–5.87]	[0.49–4.54]	[0.43–9.22]	[0.47–4.76]	[0.33–1.52]	[0.32–2.39]	[0.46–1.77]
Model E4	<i>p</i> -value	0.112	0.389	0.735	0.442	0.786	0.574	0.724
	OR	2.45	1.78	1.44	1.61	0.88	1.40	1.15
	95% CI	[0.81–7.39]	[0.48–6.66]	[0.17–12.07]	[0.48–5.38]	[0.34–2.28]	[0.43–4.55]	[0.53–2.51]
Model E5	<i>p</i> -value	0.158	0.516	0.932	0.549	0.358	0.760	0.647
	OR	2.19	1.54	1.10	1.44	0.70	0.86	1.19
	95% CI	[0.74–6.52]	[0.42–5.67]	[0.13–9.13]	[0.44–4.71]	[0.33–1.49]	[0.32–2.32]	[0.56–2.54]
Model E6	<i>p</i> -value	0.128	0.476	0.970	0.433	0.381	0.801	0.765
	OR	2.33	1.61	0.96	1.60	0.71	0.88	1.12
	95% CI	[0.79–6.89]	[0.44–5.91]	[0.11–8.08]	[0.49–5.21]	[0.33–1.52]	[0.32–2.39]	[0.453–2.39]

Abbreviations: HDU, high-dependency unit; ICU, intensive care unit.

Note: Binary and multinomial logistic regression models were used. Model A was adjusted for age and sex, Model B was adjusted for age, sex and American Society of Anesthesiologists grade. Model C was adjusted for age, sex, ASA grade and Canadian Study of Health and Aging score. Model D was adjusted as in Model C and for sepsis anaesthetics (whether antibiotics was administered before care by anaesthetists). Model E1 was adjusted as in Model D and for time from admission until CT scan. Model E2 was adjusted as in Model D and for time from admission until care by anaesthetists. Model E3 was adjusted as in Model D and for time from admission until surgery. Model E4 was adjusted as in Model D and for time from CT request until CT scan. Model E5 was adjusted as in Model D and for time from CT scan until care by anaesthetists. Model E6 was adjusted as in Model D and for time from CT request until surgery.

postoperative LoS and risk of postoperative ICU stay in patients with suspected infection.

One major limitation of our study was the lack of information on the timing of antibiotics administration and whether patients were indeed diagnosed with sepsis. Sepsis has been defined in the National Institute for Health and Care Excellence guidelines as a clinical syndrome caused by the body's response to infection, which can be

organ- or life-threatening [18]. Therefore, this study was conducted based on the rationale that patients who received antibiotics must have had suspected infection. Furthermore, while all the patients included in the study had EmLap, the fact that different sources of admission could impact the urgency of the surgery was not accounted for, and the possibility of delayed intervention as a deliberate treatment strategy could not be ruled out. Since this is a retrospective



study, statistical analyses were subjected to inaccuracies in data collection, and 10%–20% of patients had missing information. In terms of analysis, although modelling times and LoS as factor variables would allow easier interpretation and clinical applicability, it could cause underestimation of results. Lastly, due to the nonparametric distribution of data, all negative time variables were replaced with the smallest positive value and 99% Winsorized to reduce the effect of positive skew, which could potentially lead to inaccuracies.

The strength of this study is the large sample size and the consecutive nature of all admissions to the 17 Scottish surgical units within ELLSA, providing real-world results. Furthermore, the operation types within this database are almost identical to that of NELA [3], which increases the generalizability and reliability of results. The study accounted for well-established confounders associated with the outcome of interest such as age, ASA grade and comorbidities [12–14]. Although, arguably, longer LoS in high-risk operations could be attributed to lengthier admission time in less urgent cases, results of the additional findings supported the rationale that this was unlikely to be the case, as high-risk operation types still had longer LoS despite faster time to surgery.

Our findings reflect the recommended urgency of emergency surgery associated with sepsis for minimization of complications outlined in the Royal College of Surgeons England's 'Emergency surgery: standards for unscheduled care' [19] and 'The high-risk general surgical patient' [6]. While the guidelines are developed based on evidence from randomized controlled trials, our study has demonstrated this in real clinical settings as we have a consecutive unselected EmLap patient population. Additionally, our study explored various timepoints in the EmLap care pathway through the six time-to-care variables and their impact on outcomes in patients with and without suspected infection.

## CONCLUSION

To conclude, this study found that shorter time to care alleviated worse outcomes in EmLap patients with suspected infection. There was also an additional benefit of decreased risk of ICU stay and shorter postoperative LoS with faster time to care at specific points in the care pathway. These results suggest that faster emergency surgical pathways at targeted timepoints should be considered not only for patients with sepsis but also those with a high index of suspicion for infection. To minimize the limitations, data collection on the exact timing of antibiotics administration and diagnosis of sepsis within ELLSA is highly encouraged. Further audits are recommended to explore effective ways to reduce the time taken to receive care in this patient group.

## AUTHOR CONTRIBUTIONS

**Natthaya Eiamampai:** Conceptualization; methodology; formal analysis; writing – original draft; visualization. **Euan A. Ramsay:** Validation; supervision; writing – review and editing. **Roy L. Soiza:** Conceptualization; writing – review and editing; methodology;

supervision. **David A. McDonald:** Supervision; writing – review and editing; data curation. **Susan J. Moug:** Data curation; supervision; writing – review and editing. **Phyo K. Myint:** Conceptualization; methodology; funding acquisition; writing – review and editing; supervision.

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## CONFLICT OF INTEREST STATEMENT

The authors declared no potential conflicts of interest with respect to research, authorship, and/or publication of this article.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from ELLSA. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from the author(s) with the permission of ELLSA.

## ETHICAL APPROVAL

There are no human subjects with identifiable records in this article and informed consent is not applicable. As the present study used routinely collected audit data for ELLSA, formal ethical approval was not required.

## ORCID

Natthaya Eiamampai <https://orcid.org/0000-0002-3102-8810>

Euan A. Ramsay <https://orcid.org/0000-0002-6531-9499>

Roy L. Soiza <https://orcid.org/0000-0002-1397-4272>

David A. McDonald <https://orcid.org/0000-0002-9805-7720>

Susan J. Moug <https://orcid.org/0000-0001-9969-9760>

Phyo K. Myint <https://orcid.org/0000-0003-3852-6158>

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### SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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