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Research Paper

Emergency laparotomy outcomes before and after the introduction of an acute surgical unit

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ABSTRACT

Introduction: Emergency laparotomy is associated with significant morbidity and mortality. This study compared emergency laparotomy outcomes in a traditional service to those after the introduction of an Acute Surgical Unit (ASU).

Methods: A retrospective cohort study was performed by reviewing the medical records of all individuals that had an emergency laparotomy in twelve-month periods before and after the introduction of an ASU. Outcomes included time to surgical review, operation duration, length of stay, complications and mortality. Morbidity and mortality were compared to that predicted by P-Possum scores.

Results: In the pre-ASU group there were 58 participants (26 males, 32 females) with a median age of 60 years (range 15–87) and median P-Possum predicted morbidity and mortality of 68% (18–98%) and 6% (1–66%) respectively. In the post-ASU group there were 109 participants (58 males, 53 females) with a median age of 63 years (range 11–100), and median P-Possum predicted morbidity and mortality of 82% (18–100%) and 12% (1–99%).

Operating time decreased post-ASU (median 1 hr 31 min pre vs 1 hr 15 min post $p = 0.030$) and there was a reduction in the incidence of post-operative fistula formation (5% vs 0% $p = 0.017$). There were no other significant differences in morbidity or mortality.

Conclusions: The post-ASU cohort had shorter operative duration and reduced incidence of complicating fistulas but no other significant difference in outcomes. Further studies may define the impact of an ASU on clinical decision making, service delivery, morbidity and mortality in patients that undergo emergency laparotomy.

1. Introduction

Over the last decade the Acute Surgical Unit (ASU) has replaced the traditional on-call model for the provision of emergency general surgery in many hospitals. On-call models organised emergency surgery to fit in around the elective surgery workload. In contrast, the ASU model separates the provision of emergency and elective surgery with the aim of ensuring timely access to emergency general surgery. Other key features of the ASU model are that it provides a consultant led service with a comprehensive handover system and a dedicated emergency operating theatre [1,2]. Multiple studies have examined the ASU model. While findings have been heterogeneous, proposed potential benefits in particular units have included reduced time from referral to surgical review, time to surgery, after hours operating, length of stay, complications and mortality as well as increased theatre utilisation and greater training opportunities in emergency surgery [2–18].

Emergency laparotomy is a common and costly emergency general surgery procedure. It is performed for multiple indications and is associated with significant peri-procedural morbidity [19]. Overall mortality is approximately 15% but varies substantially depending on the indication, patient specific factors and health-system factors [20]. Recognition of the prevalence and high-risk nature of this procedure has driven the implementation of numerous audits and studies around the world including the National Emergency Laparotomy Audit (NELA) in the United Kingdom. Saunders et al. in their first report of results from the NELA confirmed substantial variation in perioperative and intraoperative systems between hospitals and proposed systemic factors had the potential to influence outcomes [20]. The effect of the introduction of an ASU on outcomes following emergency laparotomy has not

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Table 1
Demographics.

	Pre-ASU n = 58	Post-ASU n = 109
% Female	55%	46%
Median age (range)	60 (15–87)	63 (11–100)

been established. This study aimed to compare outcomes in patients undergoing emergency laparotomy before and after the introduction of an acute surgical unit.

2. Materials and methods

A retrospective cohort study was performed by reviewing the medical records of all individuals that had an emergency laparotomy at Logan Hospital (Queensland, Australia) in twelve-month periods before and after the introduction of an ASU. The two periods (1st February 2012 to 31st January 2013 and 1st February 2014 to 31st January 2015) were separated by a twelve-month period to allow for transition. The ASU model replaced a traditional on-call service. The ASU was led by two consultant general surgeons that were both present during business hours, were free of elective responsibilities and had access to a dedicated emergency operating theatre. This was shared with the orthopaedic and obstetric and gynaecology teams. There was a rotating after-hours and weekend on-call roster in which all the consultants in the department participated (i.e. from both the elective teams and the ASU). In this ASU, patients operated on after-hours generally remained under the care of the operating consultant. The study was approved by the Metro South Human Research Ethics Council (reference number HREC/15/QPAH/65). Predicted rates of morbidity and mortality were estimated using P-Possum scores [21]. Measures of service delivery included time to surgical review, time to theatre, operation duration, the proportion of procedures completed in business hours and length of stay. Other outcomes measured were complications and thirty-day mortality. Statistical analyses were performed on IBM SPSS Statistics. Chi-square tests or Fisher's exact tests (for fewer than five events) were used for categorical variables. The Mann-Whitney U test was used for continuous variables. A *P*-value $< .05$ was considered significant.

Table 2
Laparotomy indications.

Indication	Pre-ASU	%	Post-ASU	%
Small bowel obstruction	16	27.59	30	27.52
Perforated viscus	11	18.97	26	23.85
Intraabdominal abscess/collection	10	17.24	8	7.34
Incarcerated/strangulated hernia	5	8.62	8	7.34
Ischaemic bowel	3	5.17	8	7.34
Haemorrhage	2	3.45	8	7.34
Large bowel obstruction	3	5.17	3	2.75
Anastomotic leak	3	5.17	2	1.83
Malignancy	2	3.45	0	0.00
Diverticulitis	1	1.72	1	0.92
Other	2	3.45	15	13.76
Total	58	100.00	109	100.00

Table 3
Perioperative risk profiles.

	Pre-ASU	Post-ASU	P value
	Median (Range)	Median (Range)	
P Possum predicted Morbidity (%)	68 (18–98)	82 (18–100)	0.005
P Possum predicted Mortality (%)	6 (1–66)	12 (1–99)	0.008
ASA grade			
1	7/58 (12%)	8/109 (7%)	0.181
2	23/58 (40%)	38/109 (35%)	
3	19/58 (33%)	40/109 (37%)	
4	9/58 (16%)	22/109 (20%)	
5	0/58 (0.0%)	1/109 (1%)	

Table 4
Service delivery.

	Pre-ASU	Post-ASU	P value
	Median (Range)	Median (Range)	
Referral to surgical review (hr:min)	1:41 (0:05–5:19)	1:12 (0:04–18:11)	0.611
Referral to theatre (hr:min)	12:08 (1:07–292:25)	17: 18 (1:01–288:47)	0.458
Duration (hr:min)	1:31 (0:27–6:32)	1:15 (0:18–4:48)	0.030
Duration after hours operating (hr:min) [a]	0:00 (0:00–6:32)	0:09 (0:00–4:48)	0.916
Length of stay (days)	9 (3–166)	8 (1–64)	0.413
% completed in business hours[b]	52%	46%	0.471

[a] Defined as the length of the operation performed outside the hours of 0800–1700 in minutes.
[b] Defined as the percentage of operations that were completed entirely between the hours of 0800–1700, i.e. for which the duration of after-hours operating = 0 min.

3. Results

Table 1 outlines the demographics of the pre-ASU and post-ASU groups. There were more emergency laparotomies performed in the post-ASU group (58 versus 109). Table 2 compares the operative indications between the two groups. There was no statistically significant difference in ASA class, but the post-ASU group had a significantly higher median P-Possum predicted risk of morbidity and mortality compared to the pre-ASU group (Table 3).

Following the introduction of the ASU there was a statistically significant, sixteen-minute reduction in median operation duration

Table 5
Morbidity.

	Pre-ASU		Post-ASU		P value
	Number	%	Number	%	
Superficial surgical site infection	7/58	12%	11/109	10%	0.695
Deep surgical site infection	5/58	9%	4/109	4%	0.279
Wound dehiscence	2/58	3%	3/109	3%	1.000
Anastomotic leak	1/58	2%	1/109	1%	1.000
Intraabdominal haemorrhage	1/58	2%	2/109	2%	1.000
fistula	3/58	5%	0/109	0%	0.017
Pneumonia	9/58	16%	15/109	14%	0.758
Venous thromboembolism	4/58	7%	3/109	3%	0.238
Urinary tract infection	5/58	9%	9/109	8%	1.000
Readmission to hospital	1/58	2%	3/109	3%	1.000
Intensive Care	27/58	47%	43/109	39%	0.376
Total Parenteral Nutrition (TPN)	24/58	41%	30/109	28%	0.068
Repeat laparotomy	12/58	21%	17/109	16%	0.540

Note: It was decided that although ICU admission, TPN and repeat laparotomy do not necessarily represent a complication (being in some circumstances part of the surgical management plan), they are all unwanted from a patient perspective thus contributing to morbidity.

Table 6
Mortality.

	Pre-ASU		Post-ASU		P value
	Number	%	Number	%	
Mortality	6/58	10%	15/109	14%	0.526

(Table 4). There was no difference in other measures of service delivery. The incidence of post-operative fistula (colocutaneous or enterocutaneous) also demonstrated a significant reduction post ASU (5% vs. 0%, $P = .017$). This was the only statistically significant difference in morbidity between the groups (Table 5). There was no significant difference in mortality between the groups (Table 6).

4. Discussion

To the authors knowledge there is no published data from prospective controlled trials comparing emergency laparotomy outcomes between traditional on-call and ASU models. A systematic review and meta-analysis by Nagaraja et al. (2014) found eighteen mostly retrospective observational studies evaluating the ASU model and concluded it was associated with reduced complication rates and length of stay in patients undergoing laparoscopic cholecystectomy and appendicectomy. A more recent systematic review (without meta-analysis) by Chana et al. (2016) identified twenty-seven retrospective studies including 744,238 patients across the United States, Australia, the United Kingdom, New Zealand, Norway and Canada [2]. They found mixed results between the included studies but concluded that overall the ASU model when compared to the traditional model seemed to improve morbidity, mortality, time to surgical review, time to theatre and that costs in same cases were reduced. The same authors subsequently published a multinational observational study that included 69,490 patients, admitted to 23 centres across Australia, England and the USA from 2007 to 2012 and compared outcomes following emergency general surgery between different models of care [22]. They reported that freeing consultants of elective responsibilities decreased risk of long length of stay in patients that underwent an operation (OR 0.80, $P < .01$). Outcomes for patients undergoing emergency laparotomy were not reported in these studies.

Stupart et al. (2012) performed a cohort study with historical control (n = 1950) that included 304 emergency laparotomies. They found the time from booking to surgery was reduced from 3.1 (2.2–4.1) to 2.4 (1.8–2.9) hours ($P = .016$) and length of stay was reduced from 13 [11–15] to 10 [9–12] days ($P = .0086$). Shakerian et al. (2015) performed a retrospective cohort study in Melbourne, Australia including 4468 admissions resulting in 1804 operations of which 226 patients had a laparotomy [16]. They reported significant reductions in time in the emergency department (8.0–6.0 h, $P < .001$), length of stay (3.0–2.0 days, $P < .001$), complications (6.2%–3.3%, $P < .01$) and mortality (16.9%–8%, $P = .039$). They reported no statistically significant difference in complication rates post laparotomy but a significant reduction in mortality following laparotomy in the post-ASU group (23% vs. 12%, $P < .001$).

Retrospective cohort studies similar to the present study have examined the impact of an ASU on participants with acute cholecystitis, acute appendicitis and small bowel obstruction. Lehane (2010) and Pepingco (2012) in separate studies with 202 and 271 participants respectively found reduced time to surgery, length of stay and complications in participants with acute cholecystitis [8,11]. Poh (2013), Suen (2014) and Lancashire (2014) in separate studies with 539, 675 and 548 participants respectively found decreased after hours operating with the ASU model for patients with acute appendicitis [13,15,18] without demonstrating a difference in complications. Musiienko et al. (2016) examined the impact of the introduction of an ASU model for patients with small bowel obstruction and found that although complications and length of stay did not decrease there was a significant reduction in time to surgical intervention and mortality from 5.8% to 2.0% ($P = .03$) [17].

Our study did not replicate these findings in patients undergoing emergency laparotomy. One possible explanation is that the ASU model may offer greater benefit for higher-volume and lower-acuity procedures such as laparoscopic cholecystectomy or appendicectomy. Another is that the ASU models studied have been heterogeneous and that particular elements of the ASU model, often dictated by local resources, may have greater influence on outcomes than others. The number of emergency laparotomies and the P-Possum predicted perioperative risk both increased in the post-ASU group. The results need to be interpreted in light of this increase in workload and complexity, as the benefits of the ASU model may have been underrepresented. For example, the increase in workload may have hidden the benefits of an ASU model on the percentage of procedures completed within business hours. Utilisation of the P-Possum score enabled better comparison between heterogenous groups. The 10% mortality rate pre-ASU was 167%% of that predicted (6%), while the 14% mortality rate post-ASU was 117% of that predicted (12%) meaning a relative reduction occurred in actual mortality compared to that predicted by P-Possum scores. This illustrates the potential for the impact of the ASU model on outcomes to have been underestimated in this study.

The reason for the increase in the number of emergency laparotomies in this study was not obvious. Emergency department presentations to Logan Hospital increased from 72,129 in 2012/13 to 75,932 in 2014/15 representing only a 5.3% increase [23]. It is not thought likely that the introduction of the ASU influenced clinical decision making regarding the decision to perform an emergency laparotomy. However, this possibility cannot be excluded based on this study, as evaluation of the influence of the ASU on clinical decision making was not within its scope. There was a statistically significant increase in median P-Possum predicted morbidity (68 vs. 82%, $P = .005$) and mortality (6 vs. 12%, $P = .008$) in the post ASU group. This may represent year to year variation between the chosen cohorts rather than a genuine impact of the ASU. Again, the possibility the ASU model impacted on the decision to perform an emergency laparotomy in higher risk patients, though thought unlikely, cannot be excluded based on this study. Musiienko et al. (2016) reported that the introduction of an ASU was associated with increased likelihood of surgical intervention for small bowel obstruction (20.9 versus 32.0%, $P = .003$) [17]. The hypothesis that the introduction of an ASU model leads to increased rates of operative intervention may warrant investigation.

The retrospective, observational nature of this study has inherent limitations shared by most of the literature evaluating the ASU model. These include the risk of bias, lack of control of confounding factors and dependence on the accuracy of documentation. As an example, the measure "time to theatre" was confounded by the fact the database captured patients initially admitted with a plan for conservative management, that subsequently deteriorated and required emergency surgery. Where clinical controversies were identified with the benefit of hind sight, data integrity was maintained. For example, "malignancy" would not usually be considered an indication for emergency laparotomy in clinical practise but when documented was still recorded as such during data collection.

The generalisability of this study and others that evaluate different ASU models may be limited due to heterogeneity between models, resources and settings. For example, in larger units, the participation of elective consultants in the on-call roster may not be required. Another example was the inclusion of elective patients of visiting surgeons with complications that required emergency laparotomy. These were on some occasions managed by the ASU rather than the consultant who performed the index procedure. To minimise selection bias, all patients who underwent emergency laparotomy were included in the analysis regardless of indication, giving a more representative sample of the work demands placed on this ASU team. The need to share access to the emergency theatre with the orthopaedic and obstetrics and gynaecology teams may also have blunted the benefits of the ASU in this setting. The implementation of an ASU model requires access to significant resources. A “one-size fits all” approach to implantation between health services will not be cost effective, particularly in regional/rural settings [24]. This poses a challenge when incorporating reported findings in the literature into clinical practise.

The 16-min decrease in operation duration and the reduced incidence of fistula formation demonstrated in this study is likely of limited clinical and long-term significance. In the pre-ASU group, there were two enterocutaneous fistulas and one colocutaneous fistula all occurring in elderly patients requiring complex abdominal procedures for gastrointestinal malignancies. No fistulas occurred post the introduction of the ASU. The small number of events makes it impossible to draw strong conclusions about the implications of this difference. In addition to system factors, technical performance and patient characteristics have the potential to strongly influence this outcome. Further research is required to determine whether the introduction of an ASU is associated with improved surgical performance and how this may translate to changes in patient outcomes.

5. Conclusions

In this study, the post-ASU cohort had a decrease in emergency laparotomy duration and reduced incidence of complicating fistulas, but demonstrated no other significant differences. Further prospective studies may better define the impact of the ASU model on clinical decision making, service delivery, morbidity and mortality in patients that undergo emergency laparotomy. They may also determine which elements of the model convey the most benefit and how these may be implemented in different clinical settings.

Consent

An exemption to obtain consent was approved by the Metro South Human Research Ethics Council (reference number HREC/15/QPAH/65) on the basis that this retrospective observational study involved review of historical records only and posed negligible risk. All data is completely de-identified.

Ethical Approval

The study was approved by the Metro South Human Research Ethics Council (reference number HREC/15/QPAH/65).

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Author contribution

Dr Stephen Guy is the lead author and is responsible for the design, literature review, human research ethic committee application, data collection, analysis and manuscript preparation for this study.

Dr Carl Lisec is the senior author for this study and provided consultant expertise throughout the design, literature review, human research ethic committee application, data collection, analysis and manuscript preparation for this study.

Conflicts of interest

The authors have no conflicts of interest to disclose.

Guarantor

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