Logistical factors associated with adverse outcomes following emergency surgery in an acute care surgical unit

Daniel Benjamin Nel (MBChB)

Submitted to the University of Cape Town
In fulfillment of the requirements for the minor dissertation component (Part III) of the degree MMed in Surgery

Supervisor: Dr Juan H Klopper, MBChB, MMed (Surg)

Table of contents

DECLARATION

I, Daniel Nel, hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

I empower the university to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever.

Signature: Signed by candidate

Date: 5/6/19

Abstract

Purpose

The Acute Care Surgical Unit at Groote Schuur Hospital was established in 2010 and is the first of its kind in Africa. The aim of this study was to describe the outcomes of emergency surgical cases, as well as determine the logistical factors associated with adverse outcomes following surgery within the unit.

Methods

This study was a retrospective audit which reviewed the folders of adult patients who underwent an emergency surgical procedure from July 2016 to July 2017. The primary outcome was a major adverse event (AE) which was defined by a Clavien-Dindo score of 3-5. A number of logistical factors related to patient admission and operation were evaluated for association with outcomes.

Results

A total of 271 patients were included with an mean age of 47 years, with 48% females and 52% males. A major AE was recorded for 13% of patients. The following factors were found to be predictive of a major AE: referral from outside the hospital, urgent booking colour code, reoperation and consultant most senior surgeon present during procedure. Patient admission/surgery performed outside of normal working hours, being booked for surgery on admission, as well as delay to surgery beyond colour code were not associated with a major AE.

Conclusion

Apart from traditional clinical parameters, factors related to perioperative logistics may contribute to the risk of a major AE after emergency surgery and should be considered for inclusion in more comprehensive predictive models for adverse outcomes within an acute care surgery unit.

Acknowledgements & Contributions

Author contributions

Daniel Nel[1] - literature review, data collection & analysis, manuscript preparation & submission
Christo Kloppers[2] - manuscript revision
Shreya Rayamajhi[3] - manuscript revision
Juan Kloppers[4] - data collection, statistical analysis, manuscript revision

[1] MBChB, Division of General Surgery, Groote Schuur Hospital, Cape Town
[2] MBChB, FCS(SA), Head of Acute Care Surgery Unit, Division of General Surgery, Groote Schuur Hospital, Cape Town
[3] MBChB, FCS(SA), Division of General Surgery, Groote Schuur Hospital, Cape Town
[4] MBChB, MMed(Surg), Division of General Surgery, Groote Schuur Hospital, Cape Town

Acknowledgements

The authors wish to thank Dr Richard Spence for his advice on the manuscript preparation.

List of tables, figures & abbreviations

Abbreviations
GSH: Groote Schuur Hospital
ACSU: Acute Care Surgery Unit
ED: Emergency Department
CD: Clavien-Dindo
AE: Adverse Event

Published Manuscript

Accepted 26 December 2018, published online 7 January 2019 - European Journal of Trauma and Emergency Surgery

PubMed ID: 30617401
DOI: 10.1007/s00068-018-01064-3

Introduction

Increasing numbers of surgeons are entering fellowship training positions on completion of their basic surgical training, resulting in an enlarging gap when it comes to providing the primary components of general surgery, especially emergency care.[1-3] The acute care surgery model was recently developed with the aim improving the provision of emergency surgical care. This model has been well described in Europe, Australasia and North America, and has demonstrated its worth with several studies showing improved outcomes for specific emergency surgical procedures.[4-11] Previous studies evaluating traditional clinical parameters in acute care/emergency surgical patients have found the following to be associated with adverse outcomes: shock, tachycardia, tachypnoea, hypothermia, leukopenia/leukocytosis, increasing age, higher ASA class, comorbidity index, preoperative organ dysfunction and type of surgery performed.[12,13] Infrastructure or logistics related factors such as timing of surgery, seniority of surgeon involved, delay to surgery and source of referral, have been shown to affect outcomes in surgical patients.[14,15] These logistical factors are important to consider when planning resource and staff allocation. Unlike elective surgery, there remains a paucity of research regarding the factors predicting adverse outcomes within the acute care surgical population, a distinct subgroup of patients with diverse demographic and surgical pathology.[12] In addition, no study has focused specifically on the impact of perioperative logistical factors on outcomes for acute care surgery patients.

The Acute Care Surgery Unit at Groote Schuur Hospital, the first of its kind in Africa, was established in 2010 and to date, the outcomes of the unit have not been described.[16] The aim of this study was therefore to assess the outcomes of emergency surgical cases, as well as evaluate perioperative logistical factors associated with major adverse events following emergency surgery within the unit.

Methods

This study was a retrospective audit which reviewed the folders of patients who underwent an emergency surgical procedure in the Groote Schuur Hospital (GSH) Acute Care Surgery Unit (ACSU), from July 2016 to July 2017. All patients over the age of 12 who were admitted by the unit and underwent emergency surgery within the study period were included. All types of emergency procedures were included, with the exception of patients who underwent minor procedures such as abscess drainage and

minor debridements (defined as removal of less than 20 square cm of tissue without exposure of ligament, tendon, joint capsule, or deep fascia).

The ACSU is staffed by two senior consultants, two junior consultants and four or five registrars, who rotate on a three monthly basis as part of their surgical training at GSH. The unit initially admits and manages all adult, non-trauma, emergency surgical referrals to the hospital. Referrals may come from the emergency department (ED), another specialist department within the hospital, or a referring hospital within the Cape Town Metro West region. Referrals are discussed directly with the registrar or consultant on call, who reviews the case and decides on a management plan. The ACSU registrar/consultant on call will discuss cases requiring surgery with the anaesthetic registrar/consultant on duty, and together they will make a judgement call on the patient's colour code of urgency: red cases require immediate surgery (e.g. exsanguinating upper GI bleed), orange within two hours (e.g. ruptured appendix with septic shock), yellow within six hours (e.g. acute appendicitis) and green within 24 hours (e.g. amputation for critical limb ischaemia). Surgery is generally performed by the registrar with assistance of an intern doctor, with the consultant present for cases that the registrar is not able to perform independently.

The ACSU is responsible for the initial management of most abdominal and soft tissue emergencies presenting to GSH, with expertise being available from the various general surgical subspecialties when required. In addition to abdominal and soft tissue emergency procedures, the ACSU also performs amputations primarily for diabetic sepsis and wet gangrene, but also for critical limb ischemia deemed not amenable for revascularization by the vascular surgery team. Although the unit manages many patients with acute biliary disease, almost all cholecystectomies are done semi-electively due to the demands placed on the emergency theatres by more urgent emergencies, especially trauma related.

Apart from the usual patient descriptive parameters, a number of perioperative logistical factors potentially affecting surgical outcomes were recorded. Admission factors included the source of referral, timing of admission (weekday working hours, weekday afterhours, or weekend hours) and whether the patient was booked for surgery on presentation (as opposed to being admitted to the ward first for workup and booked thereafter). Operative factors included the urgency colour code of the surgery, whether there was delay to surgery beyond colour code specification, whether a consultant or registrar was the most senior surgeon present, whether the procedure was an index or reoperation, and the timing of surgery (weekday working hours, weekday afterhours, or weekend hours). In terms of outcomes, Clavien-Dindo (CD) score and hospital length of stay was assessed. A major adverse event was defined as a CD score of 3-5 during admission, implying a significant deviation from the normal postoperative course requiring invasive intervention or ICU admission and, at most, defines patient mortality (table 1)[17]. A minor adverse event was defined as any deviation of the clinical course without the need for ICU admission nor surgical, endoscopic or radiological intervention. Adverse event information was collected from the patient's hospital discharge summary, where the CD score was recorded for patients who underwent surgical intervention within the unit. A prolonged hospital stay was defined as total number of days of admission exceeding the 75th percentile of days admitted for the entire cohort.

Table 1: The Clavien–Dindo Adverse Event classification:[17]

Grade	*Definition*
I	Any deviation of the clinical course without the need for pharmacologic treatment or surgical, radiological or endoscopic interventions.
II	Requiring pharmacologic treatment other than such allowed for grade 1 complications
III	Requiring surgical, endoscopic, or radiological intervention
IIIa	Intervention not under general anesthesia
IIIb	Intervention under general anesthesia
IV	Life-threatening complication requiring ICU management
IVa	Single organ dysfunction (including dialysis)
IVb	Multiorgan dysfunction
V	Death of a patient

Data analysis was performed IBM SPSS Statistics©. Categorical variables were analyzed by the Chi-squared test for independence and non-parametric tests. A confidence level of 95% was used to describe odds ratios, with a two-tailed P-value of 0.05 considered statistically significant. Logistic regression analysis was performed to evaluate the association between perioperative factors and outcomes.

Ethical approval for the study was obtained from the university ethics review board (University of Cape Town HREC ref 688/2017).

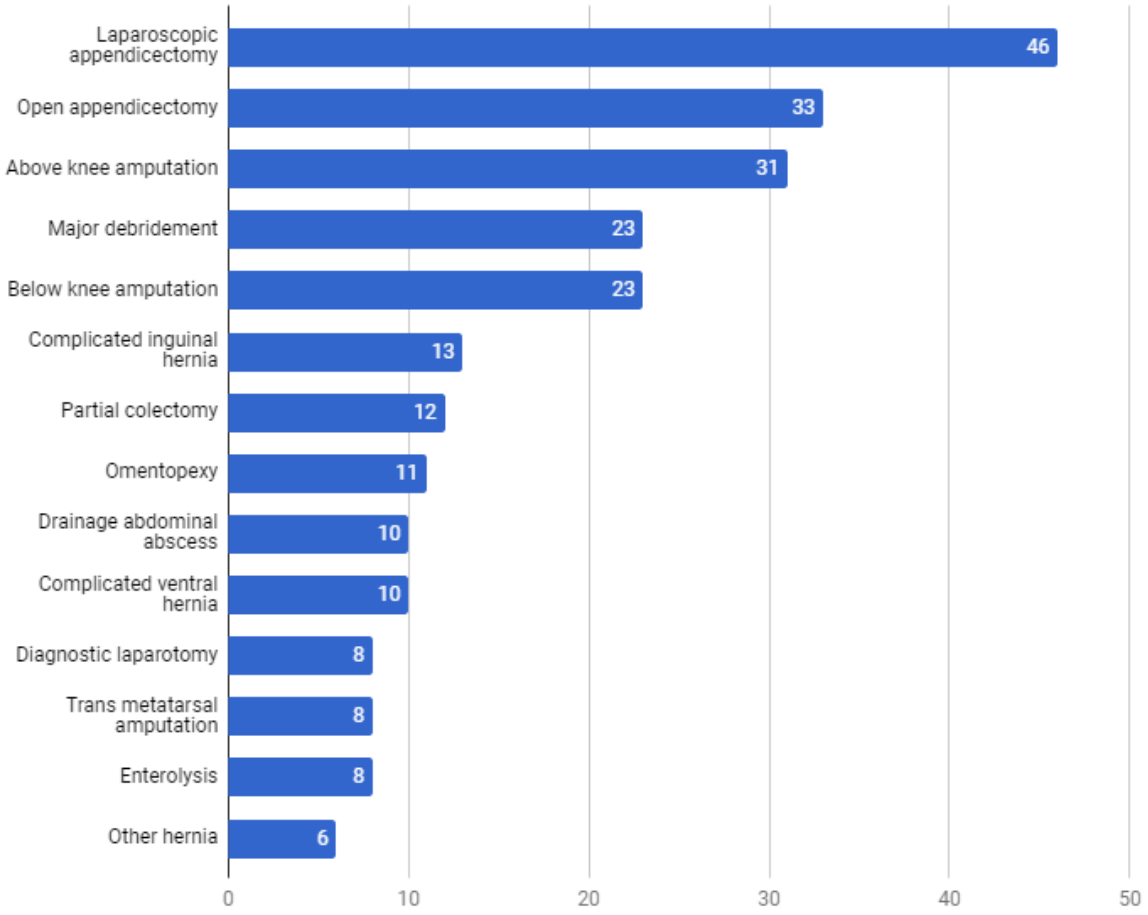
Results

Of 284 eligible patients, 13 were excluded due to incomplete admission or operative records, leaving 271 patients for inclusion the study. The mean age of participants was 47 years (range 13-83), with 48% females and 52% males.

Description of Surgical Procedures

The majority of operations were index procedures (91%) while 9% were follow up operations. The registrar was the most senior surgeon present for 84% of cases, with the consultant called in to assist for 16%. While 32% of patients were booked for surgery on first presentation, 68% were first admitted to the ward while awaiting investigation results or consultant review before being booked for surgery. The distribution of procedures performed is shown in Fig 1:

Fig 1: Distribution of operative procedures performed



In terms of admission timing, 34% of cases were admitted during weekday afterhours and 41% during weekend hours. In terms surgery timing, 37% of patients were operated on during weekday afterhours and 39% during weekend hours.

Low urgency cases comprised 83%, with green cases forming 3% of these and yellow cases 80%. Higher urgency cases comprised 17%, with 16% orange and 1% red cases. In 61% of all procedures, the delay to surgery was longer than that required by the booking colour urgency i.e. more than two hours from booking to surgery starting time for orange cases, more than six hours for yellow cases, and more than 24 hours for green cases.

Outcomes: Adverse events

A major adverse event was recorded for 34 patients (13%). Of the remaining patients, 61% had no adverse event and 26% had a minor adverse event. As is shown in table 2, the following factors were found to be predictive of a major AE: referral from outside the hospital, urgent booking colour code, reoperation and consultant most senior surgeon present during procedure. Patient admission/surgery

performed outside of normal working hours, being booked for surgery on admission, as well as delay to surgery beyond colour code were not associated with a major AE.

Table 2: Factors associated with a major AE post surgery

Perioperative Factor	***% minor/no AE (total n=237)***	***% major AE (total n=34)***	***OR for major AE (95% CI)***	***P-value***
Outside referral	16% (n = 38)	35% (n = 12)	**2.86 (1.30-6.26)**	**0.009**
Booked for surgery on admission	31% (n = 74)	35% (n = 12)	1.20 (0.56-2.55)	0.63
Weekend admission	41% (n = 96)	44% (n = 15)	1.16 (0.56-2.39)	0.68
Weekday afterhours admission	34% (n = 80)	38% (n = 13)	1.21 (0.57-2.55)	0.60
Weekend surgery	41% (n = 97)	29% (n = 10)	0.60 (0.27-1.31)	0.20
Weekday afterhours surgery	38% (n = 89)	29% (n = 10)	0.69 (0.31-1.51)	0.35
Urgent colour code	13% (n = 30)	41% (n = 14)	**4.83 (2.20-10.56)**	**<0.001**
Delay beyond colour code	61% (n = 144)	59% (n = 20)	0.92 (0.44-1.91)	0.82
Consultant most senior surgeon	13% (n = 31)	35% (n = 12)	**3.62 (1.63-8.05)**	**0.002**
Reoperation	7% (n = 16)	26% (n = 9)	**4.97 (1.99-12.42)**	**0.001**

Outcomes: Hospital length of stay

The median hospital length of stay was five days (IQR 3-8), with a prolonged hospital stay (>8 days) recorded for 23% of patients. The following factors were found to be predictive of prolonged stay: urgent booking colour code, reoperation and consultant most senior surgeon present during procedure (table 3). The primary outcome, a major AE following surgery, was also predictive of a prolonged hospital stay. Patients who had a major AE had a significantly longer median hospital stay; ten days compared to six days for those who had a minor or no AE (P<0.001).

Table 3: Factors associated with a prolonged hospital stay

Perioperative Factor	***% stay <8 days (total n=210)***	***% prolonged stay (total n=61)***	***OR for prolonged stay (95% CI)***	***P-value***
Outside referral	17% (n = 35)	25% (n = 15)	1.63 (0.82-3.23)	0.16
Booked for surgery on admission	34% (n = 72)	23% (n = 14)	0.57 (0.29-1.10)	0.97
Weekend admission	40% (n = 83)	46% (n = 28)	1.29 (0.73-2.30)	0.37
Weekday afterhours admission	35% (n = 74)	31% (n = 19)	0.83 (0.45-1.53)	0.55
Weekend surgery	40% (n = 85)	36% (n = 22)	0.83 (0.46-1.49)	0.53
Weekday afterhours surgery	36% (n = 76)	38% (n = 23)	1.06 (0.59-1.92)	0.82
Urgent colour code	13% (n = 28)	26% (n = 16)	**2.31 (1.15-4.63)**	**0.018**
Delay beyond colour code	58% (n = 121)	70% (n = 43)	1.75 (0.95-3.24)	0.07

Consultant most senior surgeon	10% (n = 21)	36% (n = 22)	**5.07 (2.54-10.12)**	**<0.001**
Reoperation	6% (n = 13)	20% (n = 12)	**3.71 (1.59-8.63)**	**0.002**
Major AE	6% (n = 13)	34% (n = 21)	**7.95 (3.68-17.19)**	**<0.001**

Discussion

This study was a retrospective audit which evaluated the outcomes, as well as logistical factors associated with a major adverse event following emergency surgery within the GSH ACSU. Thirteen percent of patients in this study had a major AE after surgery, which is comparable to similar studies assessing outcomes in emergency general surgery, which reported rates of 15.7 and 17.2%.[13,18] The following factors were found to be predictive of a major AE: referral from outside the hospital, urgent booking colour code, reoperation and consultant most senior surgeon present during procedure. The same factors, with the exception of referral from outside the hospital, were also predictive of a prolonged hospital stay.

Patients sent from referral hospitals often have complex pathology and more severe disease which necessitates their transfer to a higher level of care. In addition, numerous aspects of the transfer process, including booking/waiting for transport and travel time, may lead to a delay in the institution of definitive management, putting the patient at risk for a major AE and prolonged hospital stay.[15] Whilst previous studies have shown that having a trainee as the most senior surgeon present was predictive of a major AE, this study showed the opposite.[13,14,18] This finding may be explained by the fact that the majority of the registrars rotating through the GSH ACSU have significant prior surgical experience, and thus consultants are only called in for complex or very unstable case. These patients therefore may have more advanced pathologies and physiological derangement placing them at higher risk for a major AE. While the majority of procedures performed were index operations, 9% were reoperations, which are often technically more difficult. In addition, the indication for a reoperation in the acute setting may be failure of initial source control with progressive systemic deterioration of the patient, increasing the risk of a major morbidity and mortality.[13,19]

Although there are fewer staff members present and increased fatigue, neither weekend/weekday afterhours admissions or operations, which accounted for 75% of all cases, were associated with a major AE or prolonged hospital stay. This reassuring finding may be attributable to a number of factors, mostly related to consultant supervision within the unit.[20] First, thorough handover to the on call team during weekday afterhours is ensured by consultant-led afternoon ward rounds. Second, similar rounds are done on weekend mornings which include a consultant and intern from the acute care unit, the on-call registrar, and the post-call registrar. Lastly, consultants are always available for advice and operative expertise, and registrars are encouraged to have a low threshold to contact them for assistance. Delay beyond designated emergency booking colour code was not associated with a major AE, which may be due to the fact that the majority of cases where there was inappropriate delay were low urgency cases with minor sepsis, which can often be safely delayed for more than 6 hours. In addition, should such

green or yellow cases become significantly unwell while awaiting surgery in the ward, a flexible theatre booking system at GSH allows for the colour code to be “upgraded” by the ACSU team to orange or red, which would expedite surgery and thus potentially avert a major AE post surgery.

As seen in previous publications, the occurrence of a major AE was associated with a significantly increased length of hospital stay - in this study more than twice that of cases where there was none, or a minor AE.[18-21] Clearly a major AE has significant implications for the patient as well as the health system. The majority of factors in this study that predict the occurrence of a major AE are non-modifiable, with the exception of referral from outside the hospital, where potentially avoidable delays in the transfer process may present an opportunity for investigation and future research. Despite the fact that little may be done to modify the factors themselves, knowledge of the factors that predict a major AE following surgery within an ACSU allows clinicians within the unit to identify cases where greater vigilance for postoperative deterioration needs to be maintained, which may enable the team to intervene early and thus avert or at least diminish the magnitude of a major AE following surgery. In addition, evaluation of logistical factors that predict adverse outcomes allows for planning of infrastructure, staffing and resource allocation.[14] While this study assessed mainly novel logistical factors, a follow up study is planned with the aim of combining these factors with a more comprehensive list of traditional, clinical factors in a larger cohort, so as to build a more complete predictive model of adverse outcomes following emergency surgery in the GSH ACSU.

A potential weakness of the study is the heterogeneous patient population in terms of demographics, comorbidities as well as type of procedure performed, which may limit the accuracy of the findings for a particular subgroup. However, the decision to include such a diverse population was to increase the generalisability and applicability of the findings to all patients undergoing emergency surgery in a typical ACSU. While a strength of the study is the use of the standardised Clavien-Dindo classification to report adverse events, the evaluation was unfortunately limited to in-hospital outcomes; postdischarge outcomes (e.g. 30 day mortality) were not readily available.

Conclusion

This study evaluated a number of perioperative logistical factors, of which the following were found to be predictive of a major AE following emergency surgery: referral from outside the hospital, urgent booking colour code, reoperation and consultant most senior surgeon present during procedure. Apart from traditional clinical parameters, factors related to perioperative logistics may contribute to the risk of a major AE and should be considered for inclusion in more comprehensive predictive models for adverse outcomes after emergency surgery in an ACSU.

References

1. Stitzenberg KB, Sheldon GF. Progressive specialization within general surgery: adding to the complexity of workforce planning. Journal of the American College of Surgeons. 2005;6:925-32.
2. Cubas RF, Gómez NR, Rodriguez S, Wanis M, Sivanandam A, Garberoglio CA. Outcomes in the management of appendicitis and cholecystitis in the setting of a new acute care surgery service model: impact on timing and cost. Journal of the American College of Surgeons. 2012;5:715-21.
3. Hoyt DB, Kim HD, Barrios C. Acute care surgery: a new training and practice model in the United States. World journal of surgery. 2008;8:1630-5.
4. Lau B, DiFronzo LA. An acute care surgery model improves timeliness of care and reduces hospital stay for patients with acute cholecystitis. The American surgeon. 2011;10:1318-21.
5. Schaetzel S, Dirks R, Davis J. Comparison of outcomes of patients with acute appendicitis between an acute care surgery model and traditional call coverage model in the same community. The American Journal of Surgery. 2016;6:1083-9.
6. Gandy RC, Truskett PG, Wong SW, Smith S, Bennett MH, Parasyn AD. Outcomes of appendicectomy in an acute care surgery model. Med J Aust. 2010;5:281-4.
7. Fu CY, Huang HC, Chen RJ, Tsuo HC, Tung HJ. Implementation of the acute care surgery model provides benefits in the surgical treatment of the acute appendicitis. The American Journal of Surgery. 2014;5:794-9.
8. Von Conrady D, Hamza S, Weber D, Kalani K, Epari K, Wallace M, Fletcher D. The acute surgical unit: improving emergency care. ANZ journal of surgery. 2010;12:933-6.
9. Nagaraja V, Eslick GD, Cox MR. The acute surgical unit model verses the traditional “on call” model: a systematic review and meta-analysis. World journal of surgery. 2014;6:1381-7.
10. Page DE, Dooreemeah D, Thiruchelvam D. Acute surgical unit: the Australasian experience. ANZ journal of surgery. 2014;1-2:25-30.
11. Koea JB, Srinivasa S, Hundal H. Provision of acute general surgery: A systematic review of models of care. Journal of Trauma and Acute Care Surgery. 2014;1:219-25.
12. Sudarshan M, Feldman LS, Louis ES, Al-Habboubi M, Hassan MM, Fata P, Deckelbaum DL, Razek TS, Khwaja KA. Predictors of mortality and morbidity for acute care surgery patients. Journal of surgical research. 2015;2:868-73.
13. Mentula PJ, Leppäniemi AK. Applicability of the Clavien-Dindo classification to emergency surgical procedures: a retrospective cohort study on 444 consecutive patients. Patient safety in surgery. 2014;1:31.
14. Elshove-Bolk J, Ellensen VS, Baatrup G. Logistics and outcome in urgent and emergency colorectal surgery. Colorectal Disease. 2010;12:e255-9.
15. Khan S, Zafar H, Zafar SN, Haroon N. Inter-facility transfer of surgical emergencies in a developing country: effects on management and surgical outcomes. World journal of surgery. 2014;2:281-6.
16. Klopper JH, Rayamajhi S, Venter JJ, De Villiers DJ, Almgla N, Kloppers JC. Provision of acute and elective general surgical care at a tertiary facility in the era of subspecialisation. South African Medical Journal. 2017;11:948-51.
17. Clavien PA, Barkun J, de Oliveira ML, Vauthey JN, Dindo D, Schulick RD, de Santibañes E, Pekolj J, Slankamenac K, Bassi C, Graf R. The Clavien-Dindo classification of surgical complications: five-year

experience. Annals of surgery. 2009;2:187-96.
18. Spence RT, Hampton M, Pluke K, Kahn M, Chinyepi N, Elmusbahi M, van Wyngaard T, Panieri E. Factors associated with adverse events after emergency laparotomy in Cape Town, South Africa: identifying opportunities for quality improvement. Journal of surgical research. 2016;2:363-70.
19. Aloia TA, Cooper A, Shi W, Vauthey JN, Lee JE. Reoperative surgery: a critical risk factor for complications inadequately captured by operative reporting and coding of lysis of adhesions. Journal of the American College of Surgeons. 2014;1:143-50.
20. Shakerian R, Thomson BN, Gorelik A, Hayes IP, Skandarajah AR. Outcomes in emergency general surgery following the introduction of a consultant-led unit. British Journal of Surgery. 2015;13:1726-32.
21. Casadei R, Ricci C, Pezzilli R, Calculli L, D'Ambra M, Taffurelli G, Minni F. Assessment of complications according to the Clavien-Dindo classification after distal pancreatectomy. Journal of the Pancreas. 2011;2:126-30.

Ethics Approval Letter

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room E52-24 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 404 7682
Email: nosi.tsama@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

29 August 2017

HREC REF: 483/2017

Dr J Klopper
Department of Surgery
J-Floor
Old Main Building

Dear Dr Klopper

PROJECT TITLE: SURGICAL OUTCOMES OF THE ACUTE CARE SURGICAL UNIT, GROOTE SCHUUR HOSPITAL (MMED CANDIDATE - DR D NEL)

Thank you for submitting study to the Faculty of Health Sciences Human Research Ethics Committee for review.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until the 30th August 2018.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

We acknowledge that the student Dr D Nel will be involved in this study.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval before the research may occur.

Please quote the HREC REF in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Yours sincerely

pp TBurgess

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938

This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical

Hospital Approval Letter

Western Cape Government
Health

GROOTE SCHUUR HOSPITAL
Enquiries: Dr Bernadette Eick
E-mail : Bernadette.Eick@westerncape.gov.za

Dr J. Klopper
Department of Surgery
J-45 – OLD MAIN BUILDING

E-mail: danielnel87@gmail.com / Juan.Klopper@uct.ac.za

Dear Klopper

RESEARCH PROJECT: Surgical Outcomes of the Acute Care Surgical Unit, Groote Schuur Hospital (MMed Candidate Dr D. Nel)

Your recent letter to the hospital refers.

You are granted permission to proceed with your research, which is valid until **30 August 2018**, subject to the approval of Professor E. Muller.

Please note the following:

a) Your research may not interfere with normal patient care.
b) Hospital staff may not be asked to assist with the research.
c) No additional costs to the hospital should be incurred i.e. Lab, consumables or stationary.
d) **No patient folders may be removed from the premises or be inaccessible.**
e) Please provide the research assistant/field worker with a copy of this letter as verification of approval.
f) Confidentiality must be maintained at all times.
g) Should you at any time require photographs of your subjects, please obtain the necessary indemnity forms from our Public Relations Office (E45 OMB or ext. 2187/2188).
h) Should you require additional research time beyond the stipulated expiry date, please apply for an extension.
i) Please discuss the study with the HOD before commencing.
j) Please introduce yourself to the person in charge of an area before commencing.
k) On completion of your research, please forward any recommendations/findings that can be beneficial to use to take further action that may inform redevelopment of future policy / review guidelines.
l) Kindly submit a copy of the publication or report to this office on completion of the research.

I would like to wish you every success with the project.

Yours sincerely

DR BERNADETTE EICK
CHIEF OPERATIONAL OFFICER
Date: 22 September 2017

C.C. Mr L. Naidoo
Dr B. Jacobs
Professor E. Muller

G46 Management Suite, Old Main Building,
Observatory 7925
Tel: +27 21 404 6288 fax: +27 21 404 6125

Private Bag X,
Observatory, 7935
www.capegateway.go.v.za

Instructions for authors -European Journal of Trauma and Emergency Surgery (EJTES)

Manuscript Submission

Submission of a manuscript implies: that the work described has not been published before; that it is not under consideration for publication anywhere else; that its publication has been approved by all co-authors, if any, as well as by the responsible authorities – tacitly or explicitly – at the institute where the work has been carried out. The publisher will not be held legally responsible should there be any claims for compensation.

Permissions

Authors wishing to include figures, tables, or text passages that have already been published elsewhere are required to obtain permission from the copyright owner(s) for both the print and online format and to include evidence that such permission has been granted when submitting their papers. Any material received without such evidence will be assumed to originate from the authors.

Online Submission

Please follow the hyperlink “Submit online” on the right and upload all of your manuscript files following the instructions given on the screen.

Please ensure you provide all relevant editable source files. Failing to submit these source files might cause unnecessary delays in the review and production process.

Title Page

The title page should include:

- The name(s) of the author(s)
- A concise and informative title
- The affiliation(s) and address(es) of the author(s)
- The e-mail address, and telephone number(s) of the corresponding author
- If available, the 16-digit ORCID of the author(s)

Abstract

Please provide a structured abstract of 150 to 250 words which should be divided into the following sections:

- Purpose (stating the main purposes and research question)
- Methods
- Results
- Conclusions

Keywords

Please provide 4 to 6 keywords which can be used for indexing purposes.

Text Formatting

Manuscripts should be submitted in Word.

- Use a normal, plain font (e.g., 10-point Times Roman) for text.
- Use italics for emphasis.
- Use the automatic page numbering function to number the pages.
- Do not use field functions.
- Use tab stops or other commands for indents, not the space bar.
- Use the table function, not spreadsheets, to make tables.
- Use the equation editor or MathType for equations.
- Save your file in docx format (Word 2007 or higher) or doc format (older Word versions).

Manuscripts with mathematical content can also be submitted in LaTeX.

- LaTeX macro package (zip, 183 kB)

Headings

Please use no more than three levels of displayed headings.

Abbreviations

Abbreviations should be defined at first mention and used consistently thereafter.

Footnotes

Footnotes can be used to give additional information, which may include the citation of a reference included in the reference list. They should not consist solely of a reference citation, and they should never include the bibliographic details of a reference. They should also not contain any figures or tables.

Footnotes to the text are numbered consecutively; those to tables should be indicated by superscript lower-case letters (or asterisks for significance values and other statistical data). Footnotes to the title or the authors of the article are not given reference symbols.

Always use footnotes instead of endnotes.

Acknowledgments

Acknowledgments of people, grants, funds, etc. should be placed in a separate section on the title page. The names of funding organizations should be written in full.

References

Citation

Reference citations in the text should be identified by numbers in square brackets. Some examples:

1. Negotiation research spans many disciplines [3].

2. This result was later contradicted by Becker and Seligman [5].

3. This effect has been widely studied [1-3, 7].

Reference list

The list of references should only include works that are cited in the text and that have been published or accepted for publication. Personal communications and unpublished works should only be mentioned in the text. Do not use footnotes or endnotes as a substitute for a reference list.

The entries in the list should be numbered consecutively.

- Journal article
  Smith JJ. The world of science. Am J Sci. 1999;36:234–5.
- Article by DOI
  Slifka MK, Whitton JL. Clinical implications of dysregulated cytokine production. J Mol Med. 2000; https://doi.org/10.1007/s001090000086
- Book
  Blenkinsopp A, Paxton P. Symptoms in the pharmacy: a guide to the management of common illness. 3rd ed. Oxford: Blackwell Science; 1998.
- Book chapter
  Wyllie AH, Kerr JFR, Currie AR. Cell death: the significance of apoptosis. In: Bourne GH, Danielli JF, Jeon KW, editors. International review of cytology. London: Academic; 1980. pp. 251–306.
- Online document
  Doe J. Title of subordinate document. In: The dictionary of substances and their effects. Royal Society of Chemistry. 1999. http://www.rsc.org/dose/title of subordinate document. Accessed 15 Jan 1999.

Always use the standard abbreviation of a journal's name according to the ISSN List of Title Word Abbreviations, see

- ISSN.org LTWA

If you are unsure, please use the full journal title.

For authors using EndNote, Springer provides an output style that supports the formatting of in-text citations and reference list.

- EndNote style (zip, 3 kB)

Tables

- All tables are to be numbered using Arabic numerals.
- Tables should always be cited in text in consecutive numerical order.
- For each table, please supply a table caption (title) explaining the components of the table.
- Identify any previously published material by giving the original source in the form of a reference at the end of the table caption.

- Footnotes to tables should be indicated by superscript lower-case letters (or asterisks for significance values and other statistical data) and included beneath the table body.

Appendix 1: EJTES reviewer comments and author responses

11 October 2018

Dear reviewers

Thank you for taking the time to read through this paper and for your comments and suggestions. Please see below for our response to each query. We hope you will be satisfied with the changes - we welcome your wisdom in making this paper more scientifically valid and clinically applicable to the readers of the EJTES.

Reviewer #1: The manuscript describes a one-year experience looking at operations done on an Acute Care Surgery (ACS) service. The study focused primarily on logistic factors affecting outcome rather than physiologic or laboratory markers. Findings generally parallel those seen in other reports on the ACS experience, with less common findings that outcomes were not improved by presence of senior surgeon, delay in OR, or after-hours operation. Factors that are likely surrogates of injury severity, including transfer from outside hospital, urgent OR category, and need for senior surgeon were associated with more adverse outcomes. The authors note that these factors should be considered in risk stratification, but do not offer suggestions on whether and how these factors might be improved by modification to the ACS service. Though the authors describe their service as a "typical" ACS service, the case volume is highly skewed toward appendectomy (24%), amputation (19%), and soft tissue debridements (22%), and contains no cholecystectomies at all. In this setting, with over 65% of cases of a less complex nature, it is less surprising that senior surgeon involvement is not a critical factor, and also less surprising the delays beyond standards are not a critical factor.

In order to make their findings more widely generalizable and to improve potential for other centers to use the results the authors should:

-Discuss where acute biliary disease is managed, as these cases comprise a significant volume of most ACS services.

Emergent cholecystectomy is considered a “green” emergency case, i.e. can be done after 6 hours but within 24 hours. Due to the constant demands placed on the emergency theatres by general and orthopedic trauma, emergent cholecystectomies get bumped until they eventually pass the first few days when surgery is deemed safe, or settle down clinically and are discharged to free up beds in the ACS ward - to come back for surgery in 6 weeks. Thus, although our ACS service manages many patients with acute biliary disease, almost all cholecystectomies are done semi-electively.

A sentence to briefly clarify this has been added to the methods section:

“Although the unit manages many patients with acute biliary disease, almost all cholecystectomies are done semi-electively due to the demands placed on the emergency theatres by more urgent emergencies, especially trauma related.”

-Define criteria under which case color codes are assigned, are these consistent, who makes the decision?

The decision of urgency is made subjectively - there are no parameters entered into a computer which uses an algorithm to decide colour code. Rather, the decision is a judgement call based on all the clinical and logistical factors involved for the individual case. This is explained in the methods section - the sentence has been changed slightly to clarify the matter:

“The ACSU registrar/consultant on call will discuss cases requiring surgery with the anaesthetic registrar/consultant on duty, and together they will make a judgement call on the patient’s colour code of urgency: red cases require immediate surgery (e.g. exsanguinating upper GI bleed), orange within two hours (e.g. ruptured appendix with septic shock), yellow within six hours (e.g. acute appendicitis) and green within 24 hours (e.g. amputation for critical limb ischaemia).”

-Describe what cases fall under "major" and "minor" debridement headings

Major debridements are defined in the South African Medical Association billing code system as more than 20 square cm including epidermis, dermis and subcutaneous tissue. In our unit, we defined major debridement as more than 20 square cm or exposure of ligament, tendon, joint capsule, or deep fascia.

In the first paragraph of the methods section, minor debridement and abscess drainage has been listed as cases not included in the study. A description of the definition of minor debridement was added as well to clarify:

“All types of emergency procedures were included, with the exception of patients who underwent minor procedures such as abscess drainage and minor debridements (defined as removal of less than 20 square cm of tissue without exposure of ligament, tendon, joint capsule, or deep fascia).”

-What are the indication for amputations? These cases are also not a consistent component of ACS service coverage in other areas, especially as the ACS service does not appear to do re-vascularization. Why are they managed on your ACS service?

The ACS at GSH performs amputations primarily for diabetic sepsis, wet gangrene and occasionally for critical limb ischemia deemed not amenable for revascularization by the vascular surgery team. A sentence has been added to the methods section to clarify this:

“In addition to abdominal and soft tissue emergency procedures, the ACSU at GSH also performs amputations primarily for diabetic sepsis and wet gangrene, but also for critical limb ischemia deemed not amenable for revascularization by the vascular surgery team.”

Due to the poor quality of primary care in our drainage area (especially diabetic care), many patients present for the first time with advanced disease well beyond hope for revascularization. The vascular surgery team would be overwhelmed if they needed to perform amputations for all these patients. They also have a high workload related to trauma - Cape Town is one of the most violent cities in the world and we see an enormous amount of penetrating trauma which, not infrequently, requires vascular surgery expertise. Thus, the ACS unit has agreed to cover emergency amputations for diabetic sepsis, wet gangrene and advanced critical limbs, while the vascular team manages acute limb ischemia, ruptured aneurysms and complex vascular trauma.

-Re-run their analysis excluding amputations, abscess drainages, and minor debridements to see if the same factors are found when looking only at larger abdominal cases and major debridements for necrotizing infection.

We have excluded abscess drainage and minor debridements from the study, redid the full analysis, and updated the results and discussion sections accordingly. Although some percentages changed here and there, the same factors affecting outcome was found.

We decided not to exclude amputations from the analysis because, as is mentioned above, the indication for these are usually septic patients with diabetes or wet gangrene. Such patients are usually systemically unwell and beyond hope of revascularization - hence the need for emergency ablation. Amputation on these patients is therefore a major procedure - indeed it may have greater physiological impact than an appendicectomy for early appendicitis or repair of an incarcerated ventral hernia.

Thus, although we agree that minor debridements and abscess drainage may be “less complex” cases and have removed them from the analysis, we feel we make a compelling argument to include amputations. If including amputations truly swings your decision towards not publishing the article then we are willing to remove them and redo the analysis again.

-After analysis, are there any logistical risk factors that they have addressed, or that could be addressed by changes in ACS service function to improve outcomes.

The second last paragraph in the discussion has been altered to address this question more clearly:

“The majority of factors in this study that predict the occurrence of a major AE are non-modifiable, with the exception of referral from outside the hospital, where potentially avoidable delays in the transfer process may present an opportunity for investigation and future research. Despite the fact that little may be done to modify the factors themselves, knowledge of the factors that predict a major AE

following surgery within an ACSU allows clinicians within the unit to identify cases where greater vigilance for postoperative deterioration needs to be maintained, which may enable the team to intervene early and thus avert or at least diminish the magnitude of a major AE following surgery."

Reviewer #2: This retrospective study is an audit of 323 patients folders (total 336, 13 exculded) who underwent an acute care surgery procedure at Groote Schuur Hospital, Cape Town, South Africa. Adverse events (AE) were marked according to Clavien-Dinto score.

The quote [17] present in the Table 1 legend should also be given in the text (page 5, line 16).

Done.

If the definition of a major adverse event is well given page 5 line 18, the definition of a minor adverse event (that appears later in the text page 8 line 9) should be given as well.

Done.

As well explained in the discussion, the predictive factors of major AE show a good quality of care and are in some way obvious : only patients in bad conditions are referred from other hospitals, and patients in bad conditions are given an urgent colour code, and very fortunately the senior surgeon is present at the operation. It is also (very) obvious that reoperation (CD garde IIIb) is a (very) good predictor of AE graded III to V according to CD. The good new (and very good result) is that 23 patients out of 34 patients (68%) had no or minor AE after a major AE.

In table 2, numbers would be welcome next to percentages.

These have been added to both table 2 and 3.

European Journal of Trauma and Emergency Surgery
https://doi.org/10.1007/s00068-018-01064-3

ORIGINAL ARTICLE

Logistical factors associated with adverse outcomes following emergency surgery in an acute care surgical unit

Daniel Nel[1] · **Christo Kloppers**[2] · **Shreya Rayamajhi**[1] · **Juan H. Klopper**[1]

Received: 30 July 2018 / Accepted: 26 December 2018

Abstract

Purpose The Acute Care Surgical Unit at Groote Schuur Hospital was established in 2010 and is the first of its kind in Africa. The aim of this study was to describe the outcomes of emergency surgical cases, as well as determine the logistical factors associated with adverse outcomes following surgery within the unit.

Methods This study was a retrospective audit which reviewed the folders of adult patients who underwent an emergency surgical procedure from July 2016 to July 2017. The primary outcome was a major adverse event (AE) which was defined by a Clavien–Dindo score of 3–5. A number of logistical factors related to patient admission and operation were evaluated for association with outcomes.

Results A total of 271 patients were included with a mean age of 47 years, with 48% females and 52% males. A major AE was recorded for 13% of patients. The following factors were found to be predictive of a major AE: referral from outside the hospital, urgent booking colour code, reoperation, and consultant most senior surgeon present during procedure. Patient admission/surgery performed outside of normal working hours, being booked for surgery on admission, as well as delay to surgery beyond colour code were not associated with a major AE.

Conclusion Apart from the traditional clinical parameters, factors related to perioperative logistics may contribute to the risk of a major AE after emergency surgery and should be considered for inclusion in more comprehensive predictive models for adverse outcomes within an acute care surgery unit.

Keywords Emergency surgery · Acute care surgery · Complications · Mortality · Prognostication

Introduction

Increasing numbers of surgeons are entering fellowship training positions on completion of their basic surgical training, resulting in an enlarging gap when it comes to providing the primary components of general surgery, especially emergency care [1–3]. The acute care surgery model was recently developed with the aim improving the provision of emergency surgical care. This model has been well described in Europe, Australasia, and North America, and has demonstrated its worth with several studies showing improved outcomes for specific emergency surgical procedures [4–11].

The previous studies evaluating the traditional clinical parameters in acute care/emergency surgical patients have found the following to be associated with adverse outcomes: shock, tachycardia, tachypnoea, hypothermia, leukopenia/leukocytosis, increasing age, higher ASA class, comorbidity index, preoperative organ dysfunction, and type of surgery performed [12, 13]. Infrastructure or logistic-related factors, such as timing of surgery, seniority of surgeon involved, delay to surgery, and source of referral, have been shown to affect outcomes in surgical patients [14, 15]. These logistical factors are important to consider when planning resource and staff allocation. Unlike elective surgery, there remains a paucity of research regarding the factors predicting adverse outcomes within the acute care surgical population, and a distinct subgroup of patients with diverse demographic and surgical pathology [12]. In addition, no study has focused specifically on the impact of perioperative logistical factors on outcomes for acute care surgery patients.

✉ Daniel Nel
danielnel87@gmail.com

[1] Division of General Surgery, Groote Schuur Hospital, Cape Town, South Africa

[2] Head of Acute Care Surgery Unit, Division of General Surgery, Groote Schuur Hospital, Cape Town, South Africa

Published online: 07 January 2019

The Acute Care Surgery Unit at Groote Schuur Hospital, the first of its kind in Africa, was established in 2010, and to date, the outcomes of the unit have not been described [16]. The aim of this study was, therefore, to assess the outcomes of emergency surgical cases, as well as evaluate perioperative logistical factors associated with major adverse events following emergency surgery within the unit.

Methods

This study was a retrospective audit which reviewed the folders of patients who underwent an emergency surgical procedure in the Groote Schuur Hospital (GSH) Acute Care Surgery Unit (ACSU), from July 2016 to July 2017. All patients over the age of 12 who were admitted by the unit and underwent emergency surgery within the study period were included. All types of emergency procedures were included, with the exception of patients who underwent minor procedures such as abscess drainage and minor debridements (defined as removal of less than 20 square cm of tissue without exposure of ligament, tendon, joint capsule, or deep fascia).

The ACSU is staffed by two senior consultants, two junior consultants and four or five registrars, who rotate on a 3-monthly basis as part of their surgical training at GSH. The unit initially admits and manages all adult, non-trauma, emergency surgical referrals to the hospital. Referrals may come from the emergency department (ED), another specialist department within the hospital, or a referring hospital within the Cape Town Metro West region. Referrals are discussed directly with the registrar or consultant on call, who reviews the case and decides on a management plan. The ACSU registrar/consultant on call will discuss cases requiring surgery with the anaesthetic registrar/consultant on duty, and together, they will make a judgement call on the patient's colour code of urgency: red cases require immediate surgery (e.g., exsanguinating upper GI bleed), orange within 2 h (e.g., ruptured appendix with septic shock), yellow within 6 h (e.g., acute appendicitis), and green within 24 h (e.g., amputation for critical limb ischaemia). Surgery is generally performed by the registrar with assistance of an intern doctor, with the consultant present for cases that the registrar is not able to perform independently.

The ACSU is responsible for the initial management of most abdominal and soft-tissue emergencies presenting to GSH, with expertise being available from the various general surgical subspecialties when required. In addition to abdominal and soft-tissue emergency procedures, the ACSU also performs amputations primarily for diabetic sepsis and wet gangrene, but also for critical limb ischemia deemed not amenable for revascularization by the vascular surgery team. Although the unit manages many patients with acute biliary disease, almost all cholecystectomies are done semi-electively due to the demands placed on the emergency theatres by more urgent emergencies, especially trauma related.

Apart from the usual patient descriptive parameters, a number of perioperative logistical factors potentially affecting surgical outcomes were recorded. Admission factors included the source of referral, timing of admission (weekday working hours, weekday afterhours, or weekend hours), and whether the patient was booked for surgery on presentation (as opposed to being admitted to the ward first for workup and booked thereafter). Operative factors included the urgency colour code of the surgery, whether there was delay to surgery beyond colour-code specification, whether a consultant or registrar was the most senior surgeon present, whether the procedure was an index or reoperation, and the timing of surgery (weekday working hours, weekday afterhours, or weekend hours). In terms of outcomes, Clavien–Dindo (CD) score and hospital length of stay were assessed. A major adverse event was defined as a CD score of 3–5 during admission, implying a significant deviation from the normal postoperative course requiring invasive intervention or ICU admission and, at most, defines patient mortality (Table 1) [17]. A minor adverse event was defined as any deviation of the clinical course without the need for ICU admission nor surgical, endoscopic, or radiological

Table 1 Clavien–Dindo adverse event classification: [17]

Grade	Definition
I	Any deviation of the clinical course without the need for pharmacologic treatment or surgical, radiological, or endoscopic interventions
II	Requiring pharmacologic treatment other than such allowed for grade 1 complications
III	Requiring surgical, endoscopic, or radiological intervention
IIIa	Intervention not under general anesthesia
IIIb	Intervention under general anesthesia
IV	Life-threatening complication requiring ICU management
IVa	Single-organ dysfunction (including dialysis)
IVb	Multiorgan dysfunction
V	Death of a patient

intervention. Adverse event information was collected from the patient's hospital discharge summary, where the CD score was recorded for patients who underwent surgical intervention within the unit. A prolonged hospital stay was defined as total number of days of admission exceeding the 75th percentile of days admitted for the entire cohort.

Data analysis was performed IBM SPSS Statistics©. Categorical variables were analyzed by the Chi-squared test for independence and non-parametric tests. A confidence level of 95% was used to describe odds ratios, with a two-tailed *P* value of 0.05 considered statistically significant. Logistic regression analysis was performed to evaluate the association between perioperative factors and outcomes.

Ethical approval for the study was obtained from the university ethics review board (University of Cape Town HREC ref 688/2017).

Results

Of 284 eligible patients, 13 were excluded due to incomplete admission or operative records, leaving 271 patients for inclusion the study. The mean age of participants was 47 years (range 13–83), with 48% females and 52% males.

Description of surgical procedures

The majority of operations were index procedures (91%), while 9% were follow-up operations. The registrar was the most senior surgeon present for 84% of cases, with the consultant called in to assist for 16%. While 32% of patients were booked for surgery on the first presentation, 68% were first admitted to the ward while awaiting investigation results or consultant review before being booked for surgery. The distribution of procedures performed is shown in Fig. 1.

In terms of admission timing, 34% of cases were admitted during weekday afterhours and 41% during weekend hours. In terms surgery timing, 37% of patients were operated on during weekday afterhours and 39% during weekend hours.

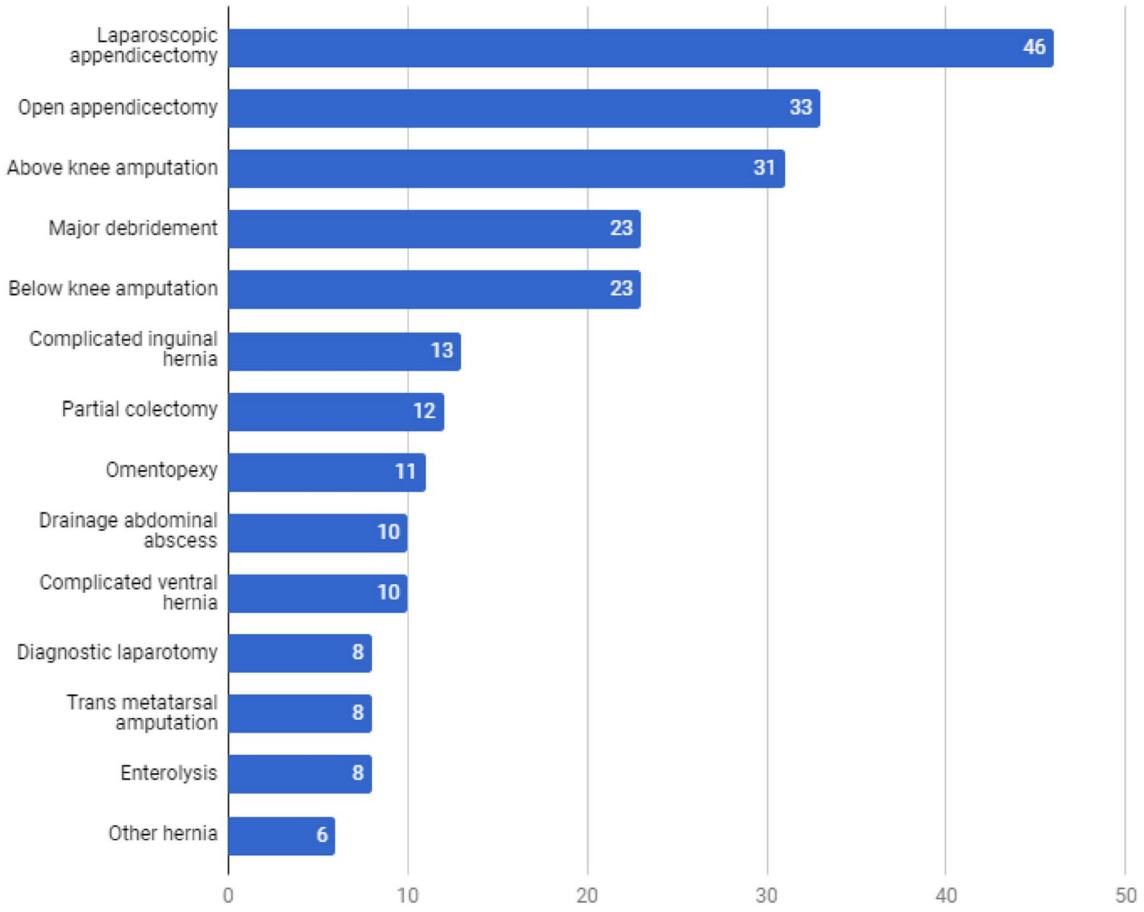


Fig. 1 Distribution of operative procedures performed

Low urgency cases comprised 83%, with green cases forming 3% of these and yellow cases 80%. Higher urgency cases comprised 17%, with 16% orange and 1% red cases. In 61% of all procedures, the delay to surgery was longer than that required by the booking colour urgency, i.e., more than 2 h from booking to surgery starting time for orange cases, more than 6 h for yellow cases, and more than 24 h for green cases.

Outcomes: adverse events

A major adverse event was recorded for 34 patients (13%). Of the remaining patients, 61% had no adverse event and 26% had a minor adverse event. As is shown in Table 2, the following factors were found to be predictive of a major AE: referral from outside the hospital, urgent booking colour code, and reoperation and consultant most senior surgeon present during procedure. Patient admission/surgery performed outside of normal working hours, being booked for surgery on admission, as well as delay to surgery beyond colour code were not associated with a major AE.

Outcomes: hospital length of stay

The median hospital length of stay was 5 days (IQR 3–8), with a prolonged hospital stay (> 8 days) recorded for 23% of patients. The following factors were found to be predictive of prolonged stay: urgent booking colour code, reoperation, and consultant most senior surgeon present during procedure (Table 3). The primary outcome, a major AE following surgery, was also predictive of a prolonged hospital stay. Patients who had a major AE had a significantly longer median hospital stay; 10 days compared to 6 days for those who had a minor or no AE ($P < 0.001$).

Discussion

This study was a retrospective audit which evaluated the outcomes, as well as logistical factors associated with a major adverse event following emergency surgery within the GSH ACSU. Thirteen percent of patients in this study had a major AE after surgery, which is comparable to similar studies assessing outcomes in emergency general surgery, which

Table 2 Factors associated with a major AE post-surgery

Perioperative factor	% Minor/no AE (total $n=237$)	% Major AE (total $n=34$)	OR for major AE (95% CI)	P value
Outside referral	16% ($n=38$)	35% ($n=12$)	**2.86 (1.30–6.26)**	**0.009**
Booked for surgery on admission	31% ($n=74$)	35% ($n=12$)	1.20 (0.56–2.55)	0.63
Weekend admission	41% ($n=96$)	44% ($n=15$)	1.16 (0.56–2.39)	0.68
Weekday afterhours admission	34% ($n=80$)	38% ($n=13$)	1.21 (0.57–2.55)	0.60
Weekend surgery	41% ($n=97$)	29% ($n=10$)	0.60 (0.27–1.31)	0.20
Weekday afterhours surgery	38% ($n=89$)	29% ($n=10$)	0.69 (0.31–1.51)	0.35
Urgent colour code	13% ($n=30$)	41% ($n=14$)	**4.83 (2.20–10.56)**	**< 0.001**
Delay beyond colour code	61% ($n=144$)	59% ($n=20$)	0.92 (0.44–1.91)	0.82
Consultant most senior surgeon	13% ($n=31$)	35% ($n=12$)	**3.62 (1.63–8.05)**	**0.002**
Reoperation	7% ($n=16$)	26% ($n=9$)	**4.97 (1.99–12.42)**	**0.001**

Table 3 Factors associated with a prolonged hospital stay

Perioperative factor	% Stay < 8 days (total $n=210$)	% Prolonged stay (total $n=61$)	OR for prolonged stay (95% CI)	P value
Outside referral	17% ($n=35$)	25% ($n=15$)	1.63 (0.82–3.23)	0.16
Booked for surgery on admission	34% ($n=72$)	23% ($n=14$)	0.57 (0.29–1.10)	0.97
Weekend admission	40% ($n=83$)	46% ($n=28$)	1.29 (0.73–2.30)	0.37
Weekday afterhours admission	35% ($n=74$)	31% ($n=19$)	0.83 (0.45–1.53)	0.55
Weekend surgery	40% ($n=85$)	36% ($n=22$)	0.83 (0.46–1.49)	0.53
Weekday afterhours surgery	36% ($n=76$)	38% ($n=23$)	1.06 (0.59–1.92)	0.82
Urgent colour code	13% ($n=28$)	26% ($n=16$)	**2.31 (1.15–4.63)**	**0.18**
Delay beyond colour code	58% ($n=121$)	70% ($n=43$)	1.75 (0.95–3.24)	0.07
Consultant most senior surgeon	10% ($n=21$)	36% ($n=22$)	**5.07 (2.54–10.12)**	**< 0.001**
Reoperation	6% ($n=13$)	20% ($n=12$)	**3.71 (1.59–8.63)**	**0.002**
Major AE	6% ($n=13$)	34% ($n=21$)	**7.95 (3.68–17.19)**	**< 0.001**

reported rates of 15.7 and 17.2% [13, 18]. The following factors were found to be predictive of a major AE: referral from outside the hospital, urgent booking colour code, reoperation, and consultant most senior surgeon present during procedure. The same factors, with the exception of referral from outside the hospital, were also predictive of a prolonged hospital stay.

Patients sent from referral hospitals often have complex pathology and more severe disease which necessitates their transfer to a higher level of care. In addition, numerous aspects of the transfer process, including booking/waiting for transport and travel time, may lead to a delay in the institution of definitive management, putting the patient at risk for a major AE and prolonged hospital stay [15]. Whilst the previous studies have shown that having a trainee as the most senior surgeon present was predictive of a major AE, this study showed the opposite [13, 14, 18]. This finding may be explained by the fact that the majority of the registrars rotating through the GSH ACSU have significant prior surgical experience, and thus, consultants are only called in for complex or very unstable case. These patients, therefore, may have more advanced pathologies and physiological derangement placing them at higher risk for a major AE. While the majority of procedures performed were index operations, 9% were reoperations, which are often technically more difficult. In addition, the indication for a reoperation in the acute setting may be failure of the initial source control with progressive systemic deterioration of the patient, increasing the risk of a major morbidity and mortality [13, 19].

Although there are fewer staff members present and increased fatigue, neither weekend/weekday afterhours admissions or operations, which accounted for 75% of all cases, were associated with a major AE or prolonged hospital stay. This reassuring finding may be attributable to a number of factors, mostly related to consultant supervision within the unit [20]. First, thorough handover to the on-call team during weekday afterhours is ensured by consultant-led afternoon ward rounds. Second, similar rounds are done on weekend mornings which include a consultant and intern from the acute care unit, the on-call registrar, and the post-call registrar. Finally, consultants are always available for advice and operative expertise, and registrars are encouraged to have a low threshold to contact them for assistance. Delay beyond designated emergency booking colour code was not associated with a major AE, which may be due to the fact that the majority of cases where there was inappropriate delay were low urgency cases with minor sepsis, which can often be safely delayed for more than 6 h. In addition, should such green or yellow cases become significantly unwell while awaiting surgery in the ward, a flexible theatre-booking system at GSH allows for the colour code to be "upgraded" by the ACSU team to orange or red, which would expedite surgery and thus potentially avert a major AE post-surgery.

As seen in the previous publications, the occurrence of a major AE was associated with a significantly increased length of hospital stay—in this study, more than twice that of cases where there was none or a minor AE [18–21]. Clearly, a major AE has significant implications for the patient as well as the health system. The majority of factors in this study that predict the occurrence of a major AE are non-modifiable, with the exception of referral from outside the hospital, where potentially avoidable delays in the transfer process may present an opportunity for investigation and future research. Despite the fact that little may be done to modify the factors themselves, knowledge of the factors that predict a major AE following surgery within an ACSU allows clinicians within the unit to identify cases where greater vigilance for postoperative deterioration needs to be maintained, which may enable the team to intervene early and thus avert or at least diminish the magnitude of a major AE following surgery. In addition, evaluation of logistical factors that predict adverse outcomes allows for planning of infrastructure, staffing, and resource allocation [14]. While this study assessed mainly novel logistical factors, a follow-up study is planned with the aim of combining these factors with a more comprehensive list of traditional, clinical factors in a larger cohort, so as to build a more complete predictive model of adverse outcomes following emergency surgery in the GSH ACSU.

A potential weakness of the study is the heterogeneous patient population in terms of demographics, comorbidities, as well as type of procedure performed, which may limit the accuracy of the findings for a particular subgroup. However, the decision to include such a diverse population was to increase the generalisability and applicability of the findings to all patients undergoing emergency surgery in a typical ACSU. While a strength of the study is the use of the standardised Clavien–Dindo classification to report adverse events, the evaluation was unfortunately limited to in-hospital outcomes; postdischarge outcomes (e.g., 30-day mortality) were not readily available.

Conclusion

This study evaluated a number of perioperative logistical factors, of which the following were found to be predictive of a major AE following emergency surgery: referral from outside the hospital, urgent booking colour code, reoperation, and consultant most senior surgeon present during procedure. Apart from the traditional clinical parameters, factors related to perioperative logistics may contribute to the risk of a major AE and should be considered for inclusion

in more comprehensive predictive models for adverse outcomes after emergency surgery in an ACSU.

Acknowledgements The authors wish to thank Dr Richard Spence for his advice on the manuscript preparation.

Compliance with ethical standards

Conflict of interest Daniel Nel, Christo Kloppers, Shreya Rayamajhi, and Juan Klopper declare that they have no conflicts of interest to disclose.

References

1. Stitzenberg KB, Sheldon GF. Progressive specialization within general surgery: adding to the complexity of workforce planning. J Am Coll Surg. 2005;6:925–32.
2. Cubas RF, Gómez NR, Rodriguez S, Wanis M, Sivanandam A, Garberoglio CA. Outcomes in the management of appendicitis and cholecystitis in the setting of a new acute care surgery service model: impact on timing and cost. J Am Coll Surg. 2012;5:715–21.
3. Hoyt DB, Kim HD, Barrios C. Acute care surgery: a new training and practice model in the United States. World J Surg. 2008;8:1630–5.
4. Lau B, DiFronzo LA. An acute care surgery model improves timeliness of care and reduces hospital stay for patients with acute cholecystitis. Am Surg. 2011;10:1318–21.
5. Schaetzel S, Dirks R, Davis J. Comparison of outcomes of patients with acute appendicitis between an acute care surgery model and traditional call coverage model in the same community. Am J Surg. 2016;6:1083–9.
6. Gandy RC, Truskett PG, Wong SW, Smith S, Bennett MH, Parasyn AD. Outcomes of appendicectomy in an acute care surgery model. Med J Aust. 2010;5:281–4.
7. Fu CY, Huang HC, Chen RJ, Tsuo HC, Tung HJ. Implementation of the acute care surgery model provides benefits in the surgical treatment of the acute appendicitis. Am J Surg. 2014;5:794–9.
8. Von Conrady D, Hamza S, Weber D, Kalani K, Epari K, Wallace M, Fletcher D. The acute surgical unit: improving emergency care. ANZ J Surg. 2010;12:933–6.
9. Nagaraja V, Eslick GD, Cox MR. The acute surgical unit model verses the traditional "on call" model: a systematic review and meta-analysis. World J Surg. 2014;6:1381–7.
10. Page DE, Dooreemeah D, Thiruchelvam D. Acute surgical unit: the Australasian experience. ANZ J Surg. 2014;1–2:25–30.
11. Koea JB, Srinivasa S, Hundal H. Provision of acute general surgery: a systematic review of models of care. J Trauma Acute Care Surg. 2014;1:219–25.
12. Sudarshan M, Feldman LS, Louis ES, Al-Habboubi M, Hassan MM, Fata P, Deckelbaum DL, Razek TS, Khwaja KA. Predictors of mortality and morbidity for acute care surgery patients. J Surg Res. 2015;2:868–73.
13. Mentula PJ, Leppäniemi AK. Applicability of the Clavien–Dindo classification to emergency surgical procedures: a retrospective cohort study on 444 consecutive patients. Patient Saf Surg. 2014;1:31.
14. Elshove-Bolk J, Ellensen VS, Baatrup G. Logistics and outcome in urgent and emergency colorectal surgery. Colorectal Dis. 2010;12:e255-9.
15. Khan S, Zafar H, Zafar SN, Haroon N. Inter-facility transfer of surgical emergencies in a developing country: effects on management and surgical outcomes. World J Surg. 2014;2:281–6.
16. Klopper JH, Rayamajhi S, Venter JJ, De Villiers DJ, Almgla N, Kloppers JC. Provision of acute and elective general surgical care at a tertiary facility in the era of subspecialisation. S Afr Med J. 2017;11:948–51.
17. Clavien PA, Barkun J, de Oliveira ML, Vauthey JN, Dindo D, Schulick RD, de Santibañes E, Pekolj J, Slankamenac K, Bassi C, Graf R. The Clavien–Dindo classification of surgical complications: five-year experience. Ann Surg. 2009;2:187–96.
18. Spence RT, Hampton M, Pluke K, Kahn M, Chinyepi N, Elmusbahi M, van Wyngaard T, Panieri E. Factors associated with adverse events after emergency laparotomy in Cape Town, South Africa: identifying opportunities for quality improvement. J Surg Res. 2016;2:363–70.
19. Aloia TA, Cooper A, Shi W, Vauthey JN, Lee JE. Reoperative surgery: a critical risk factor for complications inadequately captured by operative reporting and coding of lysis of adhesions. J Am Coll Surg. 2014;1:143–50.
20. Shakerian R, Thomson BN, Gorelik A, Hayes IP, Skandarajah AR. Outcomes in emergency general surgery following the introduction of a consultant-led unit. Br J Surg. 2015;13:1726–32.
21. Casadei R, Ricci C, Pezzilli R, Calculli L, D'Ambra M, Taffurelli G, Minni F. Assessment of complications according to the Clavien–Dindo classification after distal pancreatectomy. J Pancreas. 2011;2:126–30.