The effect of systematic factors on the outcome of trauma laparotomy at a major trauma centre in South Africa

C Steenkamp¹, VY Kong¹, DL Clarke^{1,5}, B Sartorius², JL Bruce¹, GL Laing¹, W Bekker¹, V Manchev¹, P Brysiewicz²

¹Pietermaritzburg Metropolitan Trauma Service, Department of Surgery, University of KwaZulu-Natal, Durban, South Africa

²School of Nursing and Public Health, University of KwaZulu-Natal, Durban, South Africa

³Department of Surgery, University of the Witwatersrand, Johannesburg, South Africa

ABSTRACT

INTRODUCTION The aim of this study was to examine and interrogate outcomes in trauma laparotomy in a South African trauma centre to determine whether systematic factors were associated with any discrepancies in outcome.

METHODS This was a retrospective review of a prospectively entered trauma registry undertaken at the Pietermaritzburg Metropolitan Trauma Service, Pietermaritzburg, South Africa. The service has developed a hybrid electronic medical record system (HEMR) where clinical data were captured in real time, which were incorporated into a database.

RESULTS During the period from December 2012 to July 2016, 562 patients underwent emergency laparotomy for trauma and the time and date of surgery was recorded in the HEMR. The mean age of all patients was 29.5 years.

There were 256 operations during the weekend or over a public holiday, with a mortality of 8% ($n = 21$) compared with 306 during the week (mortality of 10%, $n = 31$). This difference was not statistically significant ($P = 0.237$). A total of 327 operations were performed at night (18:00 – 08:00) and 235 operations were performed during the day (08:00–18:00 Hours). This was a significant difference in mortality (10% (33) vs 7 % (16), $P=0.013$). These differences persisted if weekends and public holidays were separated out from normal working days. A total of 188 operations were performed on a week night, with a mortality of 11% ($n = 20$) and 121 operations were performed during a week day, with a mortality of 8% ($n = 10$). There were 139 operations on a weekend or public holiday night, with a mortality of 9% ($n = 13$). A total of 114 operations were performed on a weekend or public holiday day with a mortality of 7% ($n = 8$). A total of 208 procedures were performed with a consultant present. Of these, 32 patients (15%) died. A total of 368 procedures were performed without a consultant present and 8 (2%) died.

CONCLUSIONS This study demonstrated a discrepancy in outcome for trauma laparotomy, depending on whether the operation was performed at night or during the day. The reasons for this are unclear, although the lack of consultant presence at night in comparison to during the day appears to be implicated.

KEYWORDS

Weekend effect – Surgical outcomes – Quality improvement

Accepted 3 April 2017

CORRESPONDENCE TO

Victor Yeewai Kong, E: victoriywkong@yahoo.com

Introduction

Numerous reports from several different institutions have been shown that systematic factors are associated with discrepancies in outcome for emergency surgical procedures.^{1–5} These factors include time of operation and seniority of the staff performing the surgery.^{6–9} Few of these reports have examined how these factors impact on the outcome specifically trauma laparotomy.¹⁰ Trauma laparotomy is an emergency procedure undertaken in less than ideal circumstances by a heterogeneous cohort of staff. The surgical principles behind trauma laparotomy differ from

laparotomy for other surgical emergencies in a number of ways. The priority in trauma is to control bleeding, to control contamination and then to decide on whether to proceed with definitive management or with an abbreviated procedure.

The anaesthetic team also needs to manage a number of competing priorities. These include the need to resuscitate, to decide on a transfusion strategy and to assist the surgeons with critical decision making. Balancing all these competing priorities means that trauma laparotomy is a dynamic procedure with great potential for poor decision making and technical error. In addition, although outcomes for emergency

surgery in the developing world are under researched, it is likely that discrepancies in outcome based on systematic factors will be more pronounced in developing-world compared with developed-world settings.^{11,12}

If systematic factors are associated with discrepancies in outcome for emergency procedures, it is highly likely that they will also impact on the outcome for trauma laparotomy. There is increasing interest in quantifying discrepancies in surgical outcomes and in attempting to understand why these discrepancies occur, with the hope of addressing them. The aim of this study was to examine and interrogate the effect of systematic factors on the outcome of trauma laparotomy in our developing-world setting with the intention of identifying potential discrepancies in outcome.

Materials and Methods

Clinical Setting

This was a retrospective review of a prospectively entered trauma registry undertaken at the Pietermaritzburg Metropolitan Trauma Service (PMTS), Pietermaritzburg, South Africa. Kwa Zulu-Natal province (KZN) is located on the east coast of the country and has a population of over 11 million people. Fifty percent of the population lives in rural areas. The PMTS provides definitive surgical care to the city of Pietermaritzburg, the capital of KZN province. It also serves as the referral centre for 19 other rural hospitals within the western portion of the province, with a total catchment population of over 3 million people. The burden of trauma managed by the PMTS is significant and almost 50% of it is secondary to penetrating trauma. During the working day (8am–6pm), there are dedicated trauma specialist surgeons on site and almost all cases are performed under their direct physical supervision. Outside working hours (6pm–8am), an on-call roster of specialist surgeons covers the service but they are not based in the hospital. There are medical officers and registrars present after hours. Over weekends and public holidays, there is a specialist presence in the hospital during the day but at night the specialists cover the hospital from home. Public holidays are considered as part of the weekend. Our service has recently developed a hybrid electronic medical record system (HEMR) which enables the capturing of clinical data in real time. These data are then incorporated into the HEMR. Ethics approval for this study and for maintenance of the registry has been obtained from the Biomedical Research Ethics Committee (BREC) of the University of KwaZulu-Natal (reference: BE 207/09 BCA 221/15).

Methods

The HEMR was reviewed for the period December 2012 to July 2016. All patients older than 13 years of age who underwent an emergency laparotomy for trauma were identified and reviewed.

Statistical methods

Data were processed and analyzed using Stata 13.0 (Stata-Corp, 2013). Continuous variables were summarised using

mean and standard deviation (SD). If there was evidence of skewing or asymmetrical outliers, the median and inter-quartile range (IQR) were presented instead.

Results

During the period December 2012 to July 2016, 562 patients underwent emergency laparotomy for trauma and the time and date of surgery was recorded in the HEMRS. The average age of the patients was 29.5 years. Table 1 compares the cohorts of patients who were operated on during normal working hours and those whose operations were carried out outside of these hours. The demographics, mechanism of injury and physiological status (Table 2) of both cohorts of patients were similar and the case mix was identical between the two cohorts.

There were 256 operations during the weekend or over a public holiday, with a mortality of 8% ($n = 21$) compared with 306 during the week (mortality of 10%, $n = 31$; Figure 1). This difference was not significant ($P = 0.237$). A total of 327 operations were performed between the hours of 6pm and 8am and 235 operations were performed during the working day (8am–6pm). The mortality rates were 10% ($n = 35$) and 7% ($n = 1^{\wedge}$), respectively. This difference was significant ($P = 0.013$). These differences persisted if weekends and public holidays were separated out from normal working days. A total of 188 operations were performed on a week night, with a mortality of 11% ($n = 20$) and 121 operations were performed during a week day, with a mortality of 8% ($n = 10$). There were 139 operations on a weekend or public holiday night, with a mortality of 9% ($n = 15$). A total of 114 operations were performed on a weekend or public holiday day with a mortality of 7% ($n = 8$). A total of 208 procedures were performed with an attending specialist present. Of these, 32 patients (15%) died. A total of 368 procedures were performed without an attending specialist present and 8 (2%) died. A specialist was more likely to be present at operations during the day (51%) than at operations performed at night 23% ($P < 0.001$).

Discussion

Complex cardiovascular operations, transplantation and cancer surgery are routinely performed in large teaching institutions with minimal mortality, although still with formidable morbidity rates.^{1–4} This is not the situation with emergency surgery, which is undertaken in diverse settings by a heterogeneous staff complement and is associated with major discrepancies in outcome, depending on where the surgery is undertaken. There is a great deal of evidence to suggest that outcome of emergency surgical patients is influenced by a number of systems-related factors.^{5–9} These factors include the time of day at which the surgery is performed and the level of qualification of the staff undertaking the surgery. These factors are interlinked and synergistic. One factor that has received a great deal of attention is the so-called ‘weekend effect’.^{8,9} The mere act of being admitted over a weekend carries an increased chance of dying for both elective and emergency surgery. The causes of this

Table 1 Demographics, mechanism of injury, perioperative data and outcome for patients who underwent emergency laparotomy for trauma

	Operation time				<i>P</i> value
	After hours (<i>N</i> = 328)		Working day (<i>N</i> = 234)		
	<i>n</i>	%	<i>n</i>	%	
Male	298	92	204	87	0.093
Female	30	8	30	13	
Mechanism:					
Penetrating trauma ^a	268	82	180	77	0.101
Blunt trauma ^b	60	18	54	23	
Shock present	22	6	21	9	0.266
Consultant at operation:					
Yes	83	23	125	51	< 0.001
No	271	77	119	49	
Outcome:					
Complication	127	36	83	34	0.64
Intensive care unit admission	111	31	81	33	0.636
Survived	317	90	228	93	0.1
Died	37	10	16	7	

^a Penetrating trauma (*n* = 448), of which 170 (37%) were secondary to a gunshot wound and the remainder were stab wounds.

^b Blunt abdominal trauma (*n* = 114), of which 83 (73%) were secondary to a motor vehicle related incident, 5 (4%) due to falls and 26 (24%) secondary to an assault.

Table 2 Physiological status of patients who underwent emergency laparotomy for trauma

Physiological measure	After hours (N = 328)		Working day (N = 234)		P value
	Median	IQR	Median	IQR	
SpO ₂	96	(94–98)	96	(94–98)	0.488
RR	20	(16–24)	20	(17–22)	0.501
HR	97	(83–114)	95	(82.5–111)	0.547
SBP	121	(110–134)	120	(107–129)	0.036
DBP	73	(63–84)	70	(60–80)	0.023
pH	7.39	(7.31–7.42)	7.39	(7.32–7.42)	0.919
pO ₂	10	(8.1–12.4)	9.9	(7.25–11.95)	0.079
pCO ₂	5.2	(4.5–5.7)	5.2	(4.5–5.7)	0.810
BE	–1.7	(–6.1 to 1.6)	–1.85	(–5.3 to 1.65)	0.763
HCO ₃	23	(19.7–25.7)	22.85	(20–25.95)	0.983
Lac	2	(1.1–3.9)	2	(1.1–4)	0.454

BE, Base excess; DBP, diastolic blood pressure; HR, heart rate; Lac, (lactate); RR, respiratory rate; SBP, systolic blood pressure; SI, shock index

Figure 1 Mortality by time of operation (night vs. day) and weekend (night vs. day), normal day (night vs. day) and public holiday (night vs. day)

weekend effect are unclear and the subject of continuing debate.

We have not been able to demonstrate a weekend effect, although we have identified that patients whose operations for trauma take place at night have a higher mortality rate than those that take place during the day. This holds true regardless of whether it is a night over the weekend or during the working week and is in keeping with data from the United Kingdom, which suggest that after-hours surgery is associated with worse outcomes than surgery performed during the day.^(1–5) One explanation for this discrepancy may be a difference in case mix between day and night emergencies, although this does not appear to be the case in our setting, as both the day and the night cohorts comprised trauma patients with a similar breakdown in terms of demographics, mechanism and physiology (Table 1). During the day, even over weekends, there is a strong presence of specialist surgeons and anaesthetists in the hospital. Weekend ward rounds at our institution are specialist led and the specialist surgeon and anaesthetist are on site until late afternoon. Similarly, specialist radiological staff are present in the hospital on weekend mornings. This means that it is easier to obtain advanced imaging during the day. The situation at night is different, as specialist staff are not present in the hospital. It would appear that being operated on at night is associated with an increased risk of dying compared with being operated on during daylight hours. The difference in staffing may well account for this discrepancy in outcome. This is supported by the literature.^{5,6,7}

Aldridge et al performed a cross-sectional study to assess the efficacy of the newly introduced seven-day hospital

services in England.¹⁵ They looked at the effect of specialist staffing levels in 115 NHS trusts across the UK and interviewed over 1500 specialists about the amount of time they allocated to caring for emergency patients on a Wednesday and on a Sunday. The authors estimated that the weekend effect increased mortality rates for patients admitted over the weekend by 10%. They also showed that patients received 50% less specialist care over a weekend as compared with a weekday.

The exact mechanism by which the presence of specialist staff results in improved emergency outcomes is not well understood. There are two interlinked aspects of emergency surgery, namely technical skill and appropriate decision making.^{2–4} Delayed recognition of the need for surgery and inappropriate investigation and therapeutic strategies translate into poor outcomes. The presence of senior staff in the hospital may ameliorate both of these factors. The finding that the presence of a specialist is associated with a significantly higher mortality almost certainly reflects the fact that on-call specialists are called out for the more challenging technical cases.

The UK has had a multifaceted response to the problem of discrepancies in outcome for emergency surgery. There is now increased emphasis on both specialist-led emergency services at night and on delaying emergency cases till daylight. The NHS is attempting to introduce a so-called seven-day working week, with the objective of eliminating fluctuations in the levels of staffing and resources that are associated with the traditional working week.¹⁵ In addition, the increasing centralisation of trauma services in the UK seems to have eliminated the discrepancy in outcome associated

with time of admission.¹⁴ In North American trauma services, the presence of an attending surgeon in the hospital throughout the entire 24-hour cycle is emphasised. The data on whether the weekend or after hours effect is seen in North America are conflicting.^{15,16}

Conclusion

We have identified a discrepancy in outcome for trauma laparotomy depending on whether the operation was performed at night or during the day. The reasons for this are not clear, although the lack of senior presence at night in comparison with during the day appears to be implicated. The presence of specialist staff impacts on both surgical decision making and technical skills. Further research is needed to better understand this phenomenon.

References

1. Pearse RM, Harrison DA, James P *et al.* Identification and characterisation of the high-risk surgical population in the United Kingdom. *Crit Care* 2006; **10**(3): R81.
2. Cullinane M, Gray AJ, Hargraves CM *et al.* 2003 Report of the National Confidential Enquiry into Perioperative Deaths. London: NCEPOD; 2003.
3. Association of Surgeons of Great Britain and Ireland. *Emergency General Surgery. The future: a consensus statement.* London: Association of Surgeons of Great Britain and Ireland; 2007.
4. Semmens JB, Aitken RJ, Sanfilippo FM *et al.* The Western Australian Audit of Surgical Mortality: advancing surgical accountability. *Med J Aust* 2005; **183** (10): 504–508.
5. Cook TM, Day CJE. Hospital mortality after urgent and emergency laparotomy in patients aged 65yr and over. Risk and prediction of risk using multiple regression analysis. *Br J Anaesth* 1998; **80**: 776–781.
6. Tan BH, Mytton J, Al-Khyatt W *et al.* A Comparison of mortality following emergency laparotomy between populations from New York State and England. *Ann Surg* 2016 Aug 19.
7. Vohra RS, Evison F, Bejaj I *et al.* The effect of ethnicity on in-hospital mortality following emergency abdominal surgery: a national cohort study using Hospital Episode Statistics. *Public Health* 2015; **129**(11): 1,496–1,502.
8. Mohammed MA, Sidhu KS, Rudge G *et al.* Weekend admission to hospital has a higher risk of death in the elective setting than in the emergency setting: a retrospective database study of national health service hospitals in England. *BMC Health Serv Res* 2012; **12**: 87.
9. Meacock R, Anselmi L, Kristensen SR *et al.* Higher mortality rates amongst emergency patients admitted to hospital at weekends reflect a lower probability of admission. *J Health Serv Res Policy* 2016 May 6. pii: 1355819616649630.
10. Clarke JR, Trooskin SZ, Doshi PJ *et al.* Time to laparotomy for intra-abdominal bleeding from trauma does affect survival for delays up to 90 minutes. *J Trauma* 2002; **52**: 420–425.
11. GlobalSurg Collaborative. Mortality of emergency abdominal surgery in high-, middle- and low-income countries. *Br J Surg* 2016; **103**(8): 971–988.
12. Spence RT, Panieri E, Rayne SL. A multicentre evaluation of emergency abdominal surgery in South Africa: Results from the GlobalSurg-1 South Africa study. *S Afr Med J* 2016; **106**(2): 163–168.
13. Aldridge C, Bion J, Boyal A *et al.*, HiSLAC Collaborative. Weekend specialist intensity and admission mortality in acute hospital trusts in England: a cross-sectional study. *Lancet* 2016; **388**(10040): 178–186.
14. Metcalfe D, Perry DC, Bouamra O *et al.* Is there a 'weekend effect' in major trauma? *Emerg Med J* 2016; **33**(12): 836–842.
15. Carmody IC, Romero J, Velmahos GC. Day for night: should we staff a trauma center like a nightclub? *Am Surg* 2002; **68**(12): 1,048–1,051.
16. Egol KA, Tolisano AM, Spratt KF *et al.* Mortality rates following trauma: the difference is night and day. *J Emerg Trauma Shock* 2011; **4**: 178–183.