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Abdominal Trauma in Durban, South Africa: Factors Influencing Outcome

M. N. Mnguni, D. J. J. Muckart, T. E. Madiba

Department of Surgery, University of KwaZulu-Natal and King Edward VIII Hospital, Durban, South Africa

Abdominal injury as a result of both blunt and penetrating trauma has an appreciable mortality rate from hemorrhage and sepsis. In this article, we present our experience with the management of abdominal trauma in Durban and investigate factors that influence outcome. We performed a prospective study of patients with abdominal trauma in one surgical ward at King Edward VIII Hospital in Durban over a period of 7 years, from 1998 through 2004. Demographic details, cause of injury, delay before surgery, clinical presentation, findings at surgery, management and outcome were documented. There were 488 patients with abdominal trauma with a mean age of 29.2 ± 10.7 years. There were 440 penetrating injuries (240 firearm wounds; 200 stab wounds) and 48 blunt injuries. The mean delay before surgery was 11.7 ± 16.4 hours, and 55 patients (11%) presented in shock. Four hundred and forty patients underwent laparotomy, and 48 were managed nonoperatively. The Injury Severity Score was 11.1 ± 6.7, and the New Injury Severity Score was 17.1 ± 11.1. One hundred and thirty-seven patients (28%) were admitted to the intensive care unit (ICU), with a mean ICU stay of 3.6 ± 5.5 days. One hundred and thirty-two patients developed complications (28%), and 52 (11%) died. Shock, acidosis, increased transfusion requirements, number of organs injured, and injury severity were all associated with higher mortality. Delay before surgery had no influence on outcome. Hospital stay was 9.2 ± 10.8 days. The majority of abdominal injuries in our environment are due to firearms. Physiological instability, mechanism of injury, severity of injury, and the number of organs injured influence outcome.

Key words: Abdomen – Trauma – Injury – Blunt – Penetrating

Both blunt and penetrating trauma continue to be major health care problems in South Africa: the former, most often results from motor vehicle collisions, while the latter is predominantly due to interpersonal violence, where the injuries have changed from stab to primarily firearm wounds.[1,2]

Regardless of the mechanism, delayed diagnosis and inappropriate and/or lack of prompt surgical

Reprint requests: Professor T. E. Madiba, Department of Surgery, University of KwaZulu-Natal, Private Bag 7, Congella, 4013, South Africa.

Tel: +27 31 260 4219; Fax: +27 31 260 4389; E-mail: madiba@ukzn.ac.za

management of abdominal injuries are major contributing factors to high morbidity and mortality, and injuries missed at the initial operation or diagnostic procedure can cause disastrous complications.[1–8] Hemorrhage from the liver or pelvis, especially concealed hemorrhage, is a major contributor to mortality after trauma.[4,8] Appropriate and expeditious assessment and investigation of individuals with traumatic injury facilitate definitive management and minimize the risk of complications.[4,9]

There are a number of factors that determine outcome in abdominal trauma, therefore the aim of this study was to present our experience with abdominal trauma in Durban and to establish the factors that influence outcome in our setting.

Patients and Methods

A prospective study of patients with abdominal trauma, from a single surgical ward at King Edward VIII Hospital in Durban, was undertaken over a period of 7 years (1998–2004). Demographic information, mechanism and severity of injury, delay before hospitalization and surgery, clinical presentation, management, and outcome were all documented. Severity of injury was assessed using the Injury Severity Score (ISS)[10] and New Injury Severity Score (NISS).[11] Injuries were graded according to the Organ Injury Scale as described by the American Association for the Surgery of Trauma.[12–14] All patients who died underwent postmortem examination, and the results thereof were obtained.

A policy of selective conservative management was adopted. Patients with peritonitis or shock (systolic blood pressure of 90 mmHg or less) on initial clinical examination underwent laparotomy after resuscitation without further investigation.

Patients who were hemodynamically stable but required laparotomy, underwent definitive surgery. Prophylactic antibiotics were given on induction of anesthesia. Damage-control surgery was performed in patients who responded poorly to resuscitation and in those who developed hemodynamic instability during surgery. Indications for damage-control laparotomy were hypovolemia, hypothermia, coagulopathy, and metabolic acidosis.[15] The damage-control procedures entailed perihepatic packing for liver injuries and the use of either staples or abdominal tapes to close the bowel, thus limiting contamination.[15,16] In patients undergoing damage-control laparotomy, abdominal containment was achieved by the use of a Bogota Bag (plastic intravenous fluid container called the 'Bogota Bag', so-called because it was first used in the city of Bogota, Colombia).[17,18]

Patients with blunt injuries and no clinical features of peritonitis underwent repeated clinical assessment. Those with equivocal signs underwent computed tomography (CT) scanning. Recently, this policy has been extended to penetrating trauma, initially for stab wounds and latterly for firearm injuries, especially in those suspected to be tangential.

Data were analyzed using the Statistical Package for the Social Sciences (SPSS, Version 15, SPSS-SA, Cape Town, South Africa). One-way analysis of variance (ANOVA) was used for comparison of means by mechanism of injury and ISSs. Bonferroni *post-hoc* tests were applied for specific 2-way comparisons. Chi- squared tests (or Fisher exact test, where numbers were very small) were used for comparison of pH, hemoglobin (Hb), delay before surgery, hollow visceral injury, blood transfusion, and shock on admission. A P value < 0.05 was taken as significant. Binary logistic regression analysis was performed using a backward stepwise selection method based on likelihood ratios, with entry and removal probabilities set to 0.05 and 0.1, respectively.

Results

A total of 488 patients were treated during this period (Fig. 1), of whom 449 (92%) were male (male to female ratio, 12:1). The age range was from 12 to 70 years (mean, 29.2 $\pm$ 10.7). There were 240 (49.2%) firearm wounds; 200 (41%) stab wounds; and 48 (9.8%) blunt injuries, 18 of which were due to motor vehicle crashes (37.5%). Four hundred and forty patients (90%) presented with compelling signs and underwent laparotomy (176 stab wounds, 229 firearm wounds, 35 blunt injuries) of which 6 were negative (2 stab wounds, 2 firearm wounds, 2 blunt injuries). Disembowelment was evident in 74 (15%) patients. Fifty-five patients (11%) presented with shock, of whom only 2 required damage-control laparotomy. Forty-eight patients were managed nonoperatively (22 stabs wounds, 13 firearm wounds, 13 blunt injuries), none of whom died. Mean delay before surgery was 11.7 $\pm$ 16.4 hours; mean prehospital delay was 8.2 $\pm$ 14.6 hours; and mean in-hospital delay was 3.4 $\pm$ 5.7 hours. One hundred and seventy-nine patients (41%) underwent surgery within 6 hours of injury, and 261 (59%) had a delay of >6 hours; 347 patients (78.9%) underwent surgery within

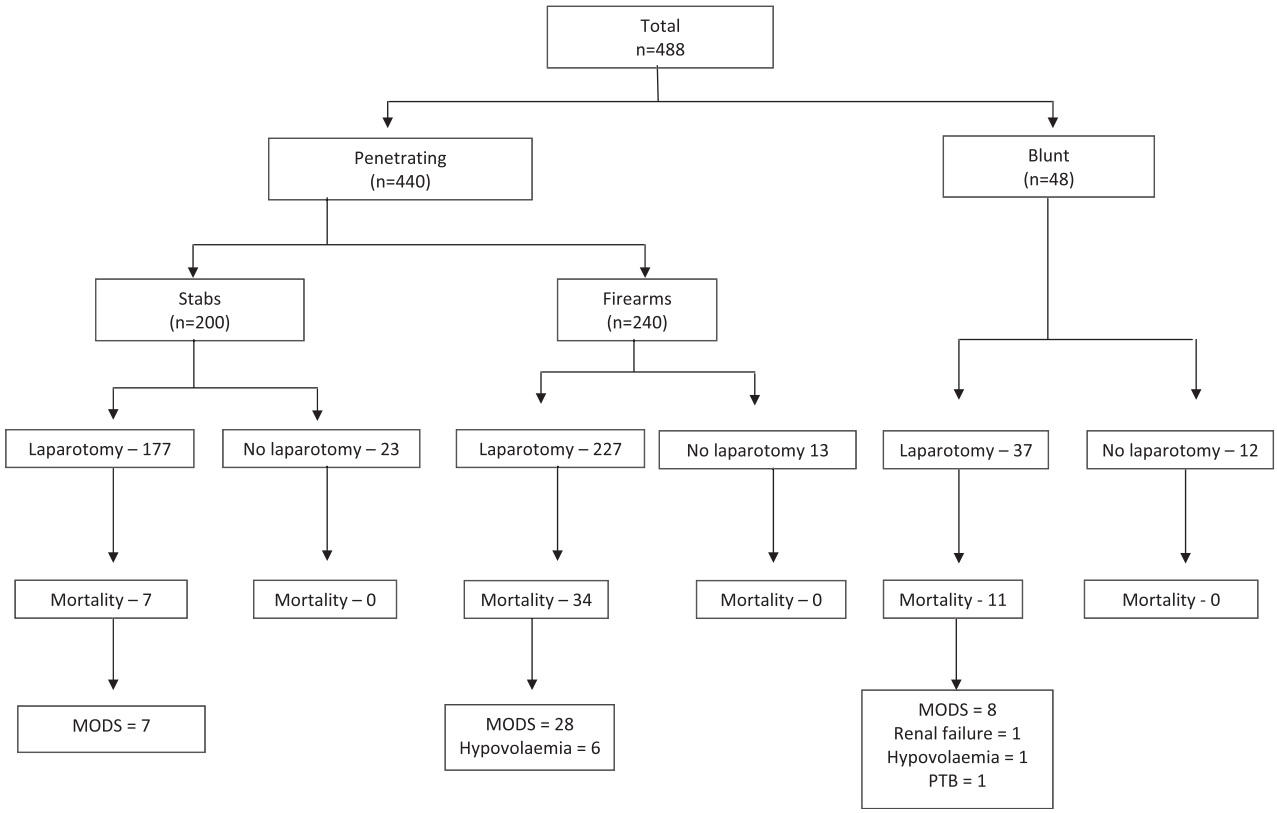

Fig. 1 Flow diagram of patients admitted with abdominal trauma.

12 hours of injury, and 102 (23.2%) had a delay of >12 hours. Patient characteristics and findings are shown in Table 1. The NISS was higher than the ISS regardless of injury mechanism. Firearm injuries had significantly higher scores than the other two injury mechanisms.

Table 2 shows complications following surgery. Of the 488 patients treated, there were 23 complications (6%) directly related to the injury: fistula (15), abscess (5), anastomotic dehiscence (3). Of 315 patients with hollow visceral injury, 24 (8%) had organ-specific morbidity (*e.g.*, abdominal abscess, peritonitis, enteric fistula) compared with 4 of 173 patients (2%) with solid visceral injury [pancreatic fistula (3), peritonitis (1)]. Delay before surgery therefore did not influence morbidity.

Forty-eight patients required re-look laparotomy for a number of reasons: peritonitis (24), removal of packs (11), missed injuries (5), intestinal obstruction (4), failure to improve in which no obvious pathology was found at laparotomy (4), poor visceral containment (1), and planned laparotomy for high-velocity injury to exclude ischemic bowel (1). The findings at re-look laparotomy in the 24 patients with tertiary peritonitis were sero-sanguinous fluid (8), abdominal abscess (4), purulent peritonitis (4), anastomotic dehiscence (2), bile peritonitis (2), gangrenous small bowel (2), missed gastric wall injury (1), and necrotic liver segment (1). There were 5 missed injuries in 5 patients: namely, inferior vena cava injury (2), posterior gastric injury (1), ureteric injury (1), and splenic injury (1); of these patients, 2 (40%) died later from multiple organ dysfunction syndrome (MODS). Seven (3.5%) patients with stab wounds, 6 (12.5%) with blunt injuries, and 35 (15%) with firearm wounds required re-look laparotomies (stab wound versus firearm wound, $P < 0.001$; blunt injury versus firearm wound, $P = 1$; stab wound versus blunt injury, $P = 0.285$).

Logistic regression analysis was performed for the outcome of complications (Table 3). Eleven variables were entered at step 1. After 7 steps, 5 independent variables remained in the model; significant factors were delay >12 hours [odds ratio (OR), 1.77], pH <7.2 (OR, 2.29), transfusion of more than 4 units of blood (OR, 2.11), ICU admission (OR, 2.88), and ISS >10 (OR, 1.70). Not one of the factors achieved an OR of greater than 3, and the majority were closer to or less than 2.

Table 1 Organ injuries in 488 patients with abdominal trauma

	Total (n = 488)	Stab wound (n = 200)	Firearm wound (n = 240)	Penetrating wound (n = 440)	Blunt injury (n = 48)
Age	29.2 ± 10.7	30 ± 11	28.6 ± 10.6	29.3 ± 10.8	28.8 ± 10.3
Male to female ratio	12:1	11:1	17:1	13:1	5:1
Total delay (hours)	11.7 ± 16.4	14 ± 19.8	8.3 ± 8.4	10.8 ± 14.8	22 ± 27
HVI	493	152	315	467	26
SVI	196	47	124	171	25
EAI	189	81	92	173	16
Most common HVI	Colon (161)	Colon (54)	Colon (102)	Colon (156)	Small bowel (13)
Most common SVI	Liver (107)	Liver (27)	Liver (71)	Liver (98)	Spleen (10)
Most common EAI	Diaphragm (68)	Diaphragm (40)	Diaphragm (27)	Diaphragm (67)	Orthopedic (8)
ISS[a]	11.1 ± 6.6	10 ± 5.3	12.2 ± 7.2	11.2 ± 6.5	10.8 ± 8.2
NISS[b]	17.1 ± 11.1	13.5 ± 8.2	20.9 ± 12.1	17.5 ± 11.1	13 ± 9.9
No. requiring ICU[c]	137 (28%)	25 (13%)	95 (40%)	120 (27%)	17 (35%)
Hospital stay (days)	9.2 ± 10.8	6.5 ± 4.8	11.6 ± 13.7	9.2 ± 10.9	9.2 ± 9.8
Complications[d]	134 (28%)	40 (20%)	76 (32%)	116 (26%)	18 (38%)

HVI, hollow visceral injury; SVI, solid visceral injury; EAI, extra-abdominal injury.

[a]ISS: stab wound versus firearm wound, $P = 0.030$; firearm wound versus blunt injury, $P = 1.0$; blunt injury versus stab wound, $P = 1.0$. One-way ANOVA.

[b]NISS: stab wound versus firearm wound, $P < 0.0001$; firearm wound versus blunt injury, $P < 0.0001$; blunt injury versus stab wound, $P = 0.635$. One-way ANOVA.

[c]ICU: firearm wound and blunt injury versus stab wound, $P < 0.001$.

[d]Morbidity: firearm wound versus stab wound, $P = 0.018$; firearm wound versus blunt injury, $P = 1$; stab wound versus blunt injury, $P = 0.082$.

Three hundred and fifteen patients sustained intra-abdominal injury only with 30 deaths (9%), 101 had a combination of intra- and extra-abdominal trauma with 21 deaths (21%), 7 had extra-abdominal injury alone with one death (14%), and 65 patients had no injury detected with no deaths. The combination of intra-abdominal and extra-abdominal injuries had a significantly higher mortality rate compared with intra-abdominal injury alone ($P < 0.01$).

Fifty-two (11%) patients died: 34 (14%) following firearm injuries, 11 (20%) following blunt trauma, and 7 after stab wounds (3.5%). MODS accounted for 42 (82%) deaths, acute hypovolemia for 7 (13.7%), and acute renal failure and pulmonary tuberculosis for 1 death each. No further missed injuries were found at postmortem examination. None of the 6 patients with a negative laparotomy died or developed complications. The ISS for survivors and nonsurvivors was 10.4 ± 6.0 and 17.2 ± 8.9, respectively ($P < 0.0001$), and the NISS for survivors and nonsurvivors was 15.8 ± 10.5 and

Table 2 Complications in 488 patients with abdominal trauma

		Complications		
Parameter	Total	n	%	*P*
Overall	488	132	27	
Stab wounds[a]	200	40	20	
Firearm wounds[a]	240	76	32	
Blunt injuries[a]	48	18	37.5	
Delay ≤6 hours	179	56	31	0.351
Delay >6 hours	261	76	29	
Delay ≤12 hours	338	96	28	0.168
Delay >12 hours	102	36	35	

[a]Firearm wound versus stab wound, $P = 0.018$; firearm wound versus blunt injury, $P = 1$; stab wound versus blunt injury, $P = 0.082$.

Table 3 Logistic regression analysis for the outcome of complications[a]

	P	OR	CI for OR	
Delay (<12 hours = baseline)	0.102			
Delay >12 hours	0.033	1.766	1.048	2.977
Delay not calculated	0.997	0.000	0.000	-
pH (>7.2 = baseline)	0.011			
pH, not done	0.038	0.519	0.279	0.964
pH ≤7.2	0.057	2.287	0.976	5.359
Blood (none = baseline)	0.100			
Blood <4 units	0.963	0.987	0.576	1.691
Blood >4 units	0.062	2.105	0.964	4.598
ICU	0.000	2.879	1.653	5.015
ISS >10	0.029	1.699	1.055	2.736
Constant	0.000	0.195		

CI, confidence interval.

[a]Eleven variables were entered on step one. After 7 steps, 5 variables remained in the model. Significant factors were delay > 12 hours (OR 1.77), PH < 7.2 (OR 2.29), receiving > 4 units of blood (OR 2.11), ICU (OR 2.88), and ISS positive (OR 1.70). Variables that remained after seven steps are delay, pH, blood transfusion, ICU and ISS.

Table 4 Factors affecting mortality in 488 patients with abdominal trauma

Parameter	n	Mortality (%)	*P* value
Overall	488	52 (10.7%)	N/A
Injury mechanisms			
Stab wounds	200	7 (3.5%)	[a,b]
Firearm wounds	240	34 (14%)	
Blunt injuries	48	11 (23%)	
Penetrating injuries	440	41 (9%)	
Hemoglobin[c]			
≤7	14	5 (36%)	$P = 0.020$
>7	365	37 (10%)	
Blood transfusion			
≤6 units	174	25 (14%)	$P = 0.0001$
>6 units	34	16 (47%)	
No transfusion	288	11 (3.8)	
Shock			
Shock	55	23 (44%)	$P < 0.0001$
No shock	433	29 (6%)	
pH			
≤7.2	30	13 (43%)	$P < 0.0001$
>7.2	316	27 (8.5%)	
Delay			
≤6 hours	179	32 (17.9%)	$P = 0.001$
>6 hours	251	20 (8%)	
≤12 hours	338	41 (12%)	$P = 0.432$
>12 hours	102	11 (11%)	
Hollow visceral injury			
Yes	315	41 (13%)	$P = 0.017$
No	173	11 (6%)	

[a]Stab wound versus firearm wound, $P = 0.001$; stab wound versus blunt injury, $P < 0.0001$; blunt injury versus firearm wound, $P = 0.204$; penetrating injury versus blunt injury, $P = 0.011$.

[b]One-way ANOVA.

[c]Fisher's exact test.

[d]Chi-squared test.

27.9 ± 13.4, respectively ($P < 0.0001$). Blunt trauma and firearm wounds, shock, metabolic acidosis, massive blood transfusion, and the presence of a hollow visceral injury were all significantly associated with death (Table 4). Mortality increased with the number of organs injured (Fig. 2). Five or more injured viscera conferred a significantly higher mortality compared with all others ($P < 0.001$). Delay before surgery and complication rate had no influence on mortality.

Logistic regression analysis was performed for the outcome of death (Table 5). Thirteen variables were entered at step 1. After 6 steps, 7 independent variables remained in the model. Significant factors were blunt injury (OR, 11.61), shock (OR, 7.03), pH <7.2 (OR, 4.83), ICU admission (OR, 4.56), complications (OR, 7.79), ISS >10 (OR, 3.04), age 41 to 50 (OR, 8.11) and age >50 (OR, 18.72), and 4 organs involved compared with none (OR, 11.49).

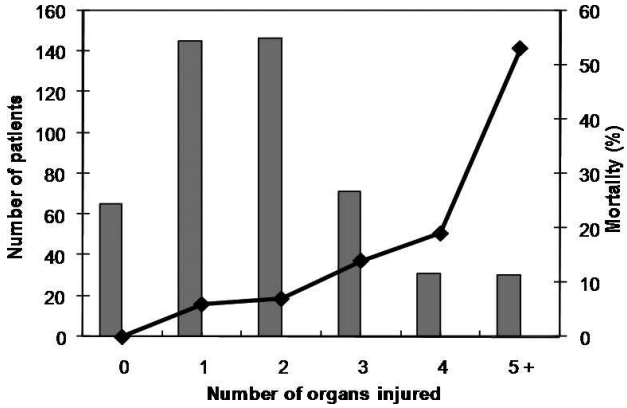

Fig. 2 Number of organ injuries per patient and mortality versus number of organs injured.

Information on the seniority of the operating surgeon was specified in 303 procedures. One hundred and seventy-nine laparotomies were performed by a senior registrar, 80 by a junior registrar, and 44 by a consultant. There were 5 missed injuries; 2 in laparotomies performed by a consultant, 2 in those by a senior registrar, and 1 where the seniority of the surgeon was unspecified. Anastomotic dehiscence occurred in 2 procedures performed by senior registrars and 1 by a consultant. The mean hospital stay was 9.2 ± 10.8 days. The length of hospital stay for the various categories is shown in Table 6.

Discussion

The 9.8% of cases with blunt trauma is in keeping with the 10% reported in the literature,[5] whereas the 37.5% resulting from motor vehicle crashes was lower than the reported 45% to 50%.[8] Unlike other series, small bowel was the most frequently injured organ following blunt trauma. Although still high, the proportion of firearm injuries (49%) was lower than the 64% reported in the literature.[8]

The maximum delay in this series was related to the prehospital component, and there are a number of reasons to account for this. There are an inadequate number of emergency service vehicles; the initial receiving hospital may not possess the required surgical expertise, necessitating further transportation to definitive care; and peripheral clinics and district hospitals are staffed predominantly by junior doctors who may not appreciate the

Table 5 Logistic regression analysis for the outcome of death

	P	OR	95% CI for OR	
Cause (stab wound = baseline)	0.008			
Cause, firearm wound	0.174	2.360	0.685	8.129
Cause, blunt injury	0.002	11.612	2.387	56.495
Shock	0.000	7.028	2.531	19.516
pH (>7.2 = baseline)	0.007			
pH, not done	0.014	4.291	1.349	13.644
pH ≤7.2	0.013	4.827	1.391	16.755
ICU	0.004	4.564	1.617	12.882
Complications	0.000	7.794	2.983	20.367
ISS >10	0.017	3.044	1.225	7.564
Age (<20 = baseline)	0.003			
Age 21–30	0.269	2.053	0.573	7.357
Age 31–40	0.542	1.522	0.395	5.863
Age 41–50	0.022	8.113	1.346	48.896
Age >50	0.000	18.715	3.624	96.647
Organs involved (0 = baseline)	0.055			
1 Organ involved	0.752	0.758	0.137	4.212
2 Organs	0.549	1.676	0.309	9.088
3 Organs	0.174	3.692	0.562	24.251
4 Organs	0.020	11.491	1.463	90.218
5 Organs	0.154	4.701	0.559	39.544
Constant	0.000	0.000		

Thirteen variables were entered on step one. After 6 steps, 7 variables remained in the model. Significant factors were blunt cause (OR 11.61), shock (OR 7.03), PH either not done (OR 4.29) or <7.2 (OR 4.83), ICU (OR 4.56), Complications (OR 7.79), ISS positive (OR 3.04), Age 41–50 (OR 8.11) and >50 (OR 18.72), and 4 organs involved compared with 0 (OR 11.49).

severity of injury and the need for surgical intervention. In contrast to other continents, where the average delay from injury to hospital admission is approximately 30 minutes,[19] patients in South Africa suffer a prolonged delay before medical care is reached. Unfortunately, this is the norm rather than the exception, and the golden hour is an unattainable time frame in our environment. We believe that the shorter delay for firearm injuries is related to the devastating nature of firearm injuries and the patient's instability, which compels attendant staff to act promptly and hasten patient transfer.

Table 6 Hospital stay in patients with abdominal trauma

Parameter	Hospital stay (days)	*P*
Overall	9.2 ± 10.8	N/A
Stab wound	6.5 ± 4.6	[a]
Firearm wound	11.6 ± 13.7	
Blunt injury	9.2 ± 9.8	
Delay <6 hours	6.2 ± 13.5	0.603
Delay >6 hours	9.8 ± 8.8	
Delay <12 hours	9.8 ± 11.8	0.055
Delay >12 hours	10.4 ± 8.5	
Complications	15.9 ± 16.4	<0.0001
No complications	6.8 ± 6.2	
Re-look laparotomy	22.2 ± 22.4	<0.0001
No re-look laparotomy	7.9 ± 7.7	

[a]Firearm wound versus stab wound, $P < 0.0001$; firearm wound versus blunt injury, $P = 0.455$; stab wound versus blunt injury, $P = 0.359$.

Despite obvious clinical signs of peritonitis on admission in the majority of patients, substantial hindrances to the timing of laparotomy also occurred within our hospital. High patient volumes and competition for theater space amongst the surgical disciplines are the most common reasons. An increased rate of complications and prolonged hospitalization are inevitable sequelae. Although the former was not mathematically significant on univariate analysis, it emerged as an independent risk factor on logistic regression.

The high prevalence of penetrating injury as a result of firearm wounds reflects the ongoing problem of interpersonal violence and homicide in South Africa.[20] Considering that the data are obtained from only 1 of 3 surgical wards at King Edward VIII Hospital, and each surgical ward manages a similar number of patients, an estimated total of almost 1500 patients with abdominal trauma has been managed at this institution during this time period.

A policy of selective nonoperative management for both blunt and penetrating trauma has been practiced by our department for many years,[21–24] even for abdominal gunshot wounds.[24–28] This has become the international standard in centers

handling a high trauma load.[21,28–34] Given the average delay between injury and hospitalization in our patients and the large number of those sustaining penetrating trauma, the absence of clinical signs is a reliable means of excluding intra-abdominal injury. Of greater concern is the possibility of missed injuries intra-operatively, where the mortality rate increases. In this series, the missed injury rate was 1%, with a mortality rate of 33%, which falls within the 17% to 44% reported in the literature.[6,7] Other series have reported missed injuries to occur in 2% of abdominal trauma[7] and in 9% to 65% of all injuries.[3,7,9] The negative laparotomy rate of only 1.2% with zero mortality in this series is encouraging compared with the reported negative laparotomy rate of 13% to 57%[35–37] and the mortality rate of 6.3%.[24]

Independent risk factors for morbidity, identified using logistic regression analysis, were the severity of injury, delay in undergoing surgery, a metabolic acidosis, the need for transfused blood, and admission to the ICU. It is worth noting that mathematical significance and clinical relevance do not always coincide. Physiological instability as evidenced by hypovolemic shock, acidosis, blood transfusion needs, and low Hb levels were associated with mortality. All significant factors in relation to risk of mortality had much higher odds ratios on logistic regression analysis. Blunt trauma affects multiple anatomic compartments, and the mortality in those sustaining both intra-abdominal and extra-abdominal injury was double compared with isolated abdominal trauma. Projectiles from firearms and other sources have a higher degree of energy and produce fragmentation and cavitation resulting in multiple injuries and greater morbidity.[8,16] It is therefore not surprising that there were more re-look laparotomies among patients with firearm injuries.

The odds ratios for the ISS and the number of injured organs were paradoxical, with the ISS showing a weak association, and the number of organ injuries showing a strong association with death. The reason lies in the methodology, whereby only the most severely injured organ in any one compartment may be scored using the ISS. This is problematic in isolated abdominal trauma with multiple injuries. Although the NISS has addressed this issue by allowing more than 1 injury to be scored in a single anatomic compartment, the maximum remains 3. Logic and experience would suggest that severely injured patients with significant blood loss or peritoneal contamination who fail to reach definitive care timeously would undoubtedly develop an acidosis, require blood transfusion, and ultimately, admission to the ICU.

Each surgical unit at King Edward VIII Hospital is staffed by a team comprising a surgical consultant, a senior registrar, a junior registrar, and an intern. One would expect the complications and mortality rate to be significantly higher when the surgery was performed by a junior trainee as compared with a consultant. The fact that patients operated on by consultants had the highest mortality rate followed by senior registrars is not surprising, since consultants are likely to be called in for unstable patients with severe injuries or those with complex management problems. A surprising observation from this study is that a delay in definitive management failed to influence outcome. This can be explained by the fact that patients who survive the long journey to the hospital are likely to survive, as those with fatal injuries would have succumbed to their injuries prior to their arrival at the hospital.

In conclusion, this study has shown that the mechanism of injury, its severity, and marked physiological derangement are the most influential predictors of outcome. It is incumbent on clinicians and trauma surgeons to be familiar with these factors. Although delay before surgery did not influence outcome, the challenge still exists for developing countries to minimize delay between injury and surgery.

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