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Analysis of time to care and cost of damage control laparotomies in a tertiary centre in South Africa

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Background: Damage control laparotomy (DCL) is a life-saving strategy for the management of hemodynamically unstable abdominal injuries. Although the indications are well established, factors specific to local trauma ecosystems lead to delayed implementation of DCL.
Methods: A retrospective review of prospectively collected data identified all patients who underwent DCL for trauma indications at Tygerberg Hospital between 1 January 2016 and 31 December 2020. Data were analysed using Python [version 3.10]. A hybrid costing model was used to determine the cost of DCL.
Results: One hundred and thirty-one (131) patients were included, of which 96.9% were male and the mean age was 33.4 years. Gunshots were the most common mechanism of injury (77.9%), followed by vehicle collisions (9.9%) and stabs (7.9%). The in-hospital mortality was 41.5%.
The median time from incident to arrival at the trauma centre was 3 hours 7 minutes (187 minutes) and patients waited a median of 6 hours (360 minutes) for surgery once in hospital. The median duration of surgery was 120 minutes and the median time to relook laparotomy was 59 hours. The median ICU and ward stay was 9.7 days and 25.7 days, respectively. Cost was calculated using a hybrid costing model, with the cost of care for survivors estimated at R 464 951 (USD $25 200) and for non-survivors R 307 827 (USD $16 684). Total cost of care for this cohort was R 42 160 625 (USD $2 285 129).
Conclusion: Delay in surgical care for DCL patients is worse for patients treated in our unit compared to those in other units, with associated cost placing significant economic burden on the healthcare sector.
Keywords: damage control surgery, penetrating abdominal trauma, surgical care, treatment costs, healthcare delays

Introduction

Damage control laparotomy (DCL) forms part of an armamentarium of interventions for the management of severely injured patients with abdominal trauma.[1,2] South African trauma centres report the use of DCL in up to 32% of gunshot victims.[3] In a resource-constrained environment, the economic impact of caring for these patients cannot be underestimated.[4]

The cost of trauma care is complex to calculate and published studies have approached this from a single centre perspective as well as on a national scale.[5] Top-down costing models are most commonly reported, while bottom-up costing, which is labour-intensive and provides a hospital-specific cost, can be deployed to extrapolate costs not clearly defined in larger costing models.[6-9]

Access to the operating theatre (OR) is an important cost driver, with delays leading to increased cost of care and rapid access to the OR resulting in significant savings.[10,11] Delay to early emergency care is also associated with an increase in cost, as well as an increase in morbidity and mortality.[12,13]

Access to care is an aspect of a greater healthcare system for which time to care can be used as a surrogate to measure the effectiveness of the system, along with various other parameters.[14]

This study aimed to elucidate the cost of DCL in a specific regional trauma system, using a hybrid costing model and to describe the environment in which these DCL procedures were undertaken, using time as a metric.

Methods

All adult patients (≥ 18 years) who were admitted to the Tygerberg Hospital trauma unit and underwent a DCL during the period 1 January 2016 to 31 December 2020 were included. Patients who underwent DCL at a referring facility or who had a non-trauma indication for damage control were excluded.

Data from pre-hospital emergency services (EMS), triage- and emergency room clerking sheets, operative reports and discharge notes, imaging reports, and laboratory and blood bank data were interrogated to extract relevant data points.

The costs of the intensive care unit (ICU) and ward stay provided by the Tygerberg Hospital finance office considered all inpatient costs attributed to ICU and ward care, including salaries, disposables and sundries, medication, assistive devices, and infrastructure costs. The cost of ward stay included outpatient follow-up and emergency unit care.

Theatre minute cost is based on a recent study by Klopper and Kruger[9] in a neighbouring tertiary hospital with a similar theatre and hospital outlay, and includes staffing, disposable and medication costs.

Imaging investigations were costed using the Compensation for Occupational Injuries and Diseases Act of 1993 as gazetted in March 2020. The cost of blood product usage and laboratory cost was provided by the Western Cape Blood Service and the Western Cape Department of Health and Wellness provincial data centre.

For the hybrid costing model, a bottom-up costing mechanism was used to cost blood bank, laboratory, and imaging costs. Top-down mechanisms were used to calculate the cost of theatre, ward and ICU stay – this included staffing, medication, disposables and sundries.

A rand dollar exchange rate of USD 1 = R 18.45 was used – the average for the year 2023.

Data were analysed using Python (version 3.10) with appropriate external packages.[15] The mean with standard deviation or the median with interquartile range are presented for numerical variables. Where appropriate, the median with interquartile range is presented for ordinal variables. Nonparametric tests were used as indicated when the assumptions for the use of parametric analysis were not met. A 5% level of significance was used throughout. The association between categorical variables was expressed as odds ratios with 95% confidence intervals.

Results

In the research period, 2216 trauma laparotomies were undertaken, of theses 163 patients underwent DCL, with 131 cases with complete records for analysis (mean age 33.4 years) undergoing DCL for abdominal trauma, representing 5.9% of all trauma laparotomies performed. Mechanisms of injury and sex distributions are presented in Table I.

The most common mechanism of injury was penetrating injury, and males required the majority of DCLs. The median ISS for both groups was 25 (IQR16 for survivors and IQR 18 for patients who died). The in-hospital mortality rate was 41.5%. Mortality distribution, categorised in hours after DCL completion, is shown in Table II. The majority of deaths occurred within 24 hours of DCL being performed.

Table I: Distribution by sex and mechanism of injury (*n* = 131)

Sex	Blunt	Penetrating	Totals
Female	3 (2.2%)	1 (0.8%)	**4 (3.1%)**
Male	16 (12.3%)	111 (84.7%)	**127 (96.9%)**
Totals	19 (14.5%)	112 (85.5%)	

Table II: Distribution of deaths (hours after DCL completed)

Time interval following surgery	Frequency (Relative frequency)
Total deaths	54
Death within 6 hours	7 (13%)
Death between 6 and 24 hours	8 (14.8%)
Death between 24 and 48 hours	8 (14.8%)
Death between 48 and 96 hours	10 (18.5%)
Death between 96 and 168 hours	10 (18.5%)
Death after 168 hours	11 (20.4%)

Time measurements

Figure 1 represents a timeline of care. The median time from injury to arrival was 187 minutes (3:07 hours) (IQR 02:00). The median time from arrival at facility to start of surgery was 360 minutes (6:00 hours) (IQR 06:15). The median duration of surgery (time from start skin incision to temporary abdominal closure) was 120 minutes (2:00 hours) (IQR 95:00min). None of the above-mentioned durations were significantly associated with an increase in mortality.

Sixty-nine of the 131 DCL procedures took place between 08:00 and 16:00. There was no statistically significant difference in the mortality rate when comparing surgeries performed within working hours and those performed after hours.

In survivors, the median time to the first relook laparotomy was 59 hours (IQR 40 hours). The median ICU length of stay was 9.7 days (IQR 4 days) and the median length of ward stay was 25.7 days (IQR: 31 days).

Of survivors, 52% had a stoma, which in only 25% of cases had been reversed, as documented in health records up to the date of submission. Post-discharge follow-up notes indicated that 44% of survivors had incisional hernias requiring re-intervention.

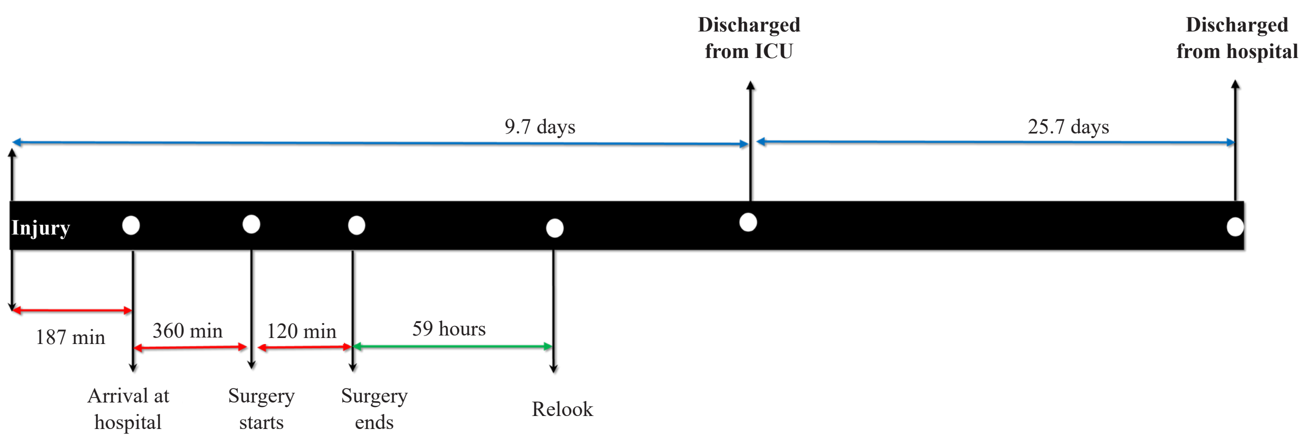

Figure 1: Timeline of mean time durations for survivors of DCL procedures

Table III: Cost per costing element for survivors and non-survivors and total cost

Costing element	Survivor		Non-Survivors		Total cost	
	Rand value	USD value	Rand value	USD value	Rand value	USD value
ICU stay	R 126 604	USD 6 862	R 49 052	USD 2 659	R 12 347 010	USD 669 215
Ward stay	R 44 644	USD 2 419	R 953	USD 52	R 3 532 754	USD 191 477
DCL theatre cost	R 32 434	USD 1 757	R 3 654	USD 1 824	R 4 281 120	USD 232 039
Further procedure costs	R 113 520	USD 6 152	R 60 578	USD 3 283	R 10 702 800	USD 580 098
Radiology cost	R 40 468	USD 2 193	R 35 510	USD 1 925	R 4 837 735	USD 262 208
Laboratory cost	R 10 330	USD 559	R 3 798	USD 206	R 718 621	USD 38 950
Blood product cost	R 96 951	USD 5 254	R 124 282	USD 6 736	R 5 737 585	USD 310 980
Total	**R 464 951**	**USD 25 200**	**R 307 827**	**USD 16 684**	**R 42 160 625**	**USD 2 285 129**

Cost analysis

A total of 1262 ICU days were recorded for the cohort. The median length of ICU stay was 9.7 days (IQR: 8 days) whilst the median ward stay was 25.7 days (IQR: 31days).

The total theatre time for DCL was 17 838 minutes (297 hours). Additional theatre time for relook procedures and other surgeries was 62 433 minutes (1040 hours).

A total of 1972 imaging investigations were performed, costing USD 262 207.85 (R 4 837 735). Blood product cost and laboratory cost amounted to USD 310 980 (R 5 737 585) and USD 38 949 (R 718 621), respectively.

The average cost per patient, based on overall outcome and total costs is shown in Table III.

The biggest contributor to cost for the cohort was derived from ICU care, followed by operative interventions following DCL. The average cost for survivors was R 464 951 (USD 25 200) and for non-survivors R 307 827 (USD 16 684).

Discussion

The mortality rate recorded in this study is higher than the mortality rates reflected in both international literature and other local studies.[2,3,16,17] Although not statistically significant, the clinical impact of time to care is an important factor in the outcome of these patients, as the higher than average mortality rate is thought to be related to timely access to care.

Time-based data presented in this study forms only one part of evaluating the trauma system but is an easily understood metric.[14] In studies from the same setting, time from scene to hospital was identified as a contributor to mortality. Pre-hospital time reported in this study was 187 minutes, which is longer than that reported by Möller et al. (45 minutes) and Kruger et al. (131 minutes) at two other high-volume trauma centres in the region.[16,18] The excessive delay to presentation identified in this study is a knock-on effect of an ambulance shortage in the Tygerberg Hospital drainage area, as reported in 2023.[19] Patients who require ambulance transfer from clinics where no definitive surgical care is offered, or from the location where the injury occurred, experience long delays waiting for transfer to our facility.

Time from arrival at the trauma emergency centre to surgery for DCL at our facility is longer (360 minutes) than the 325 minutes reported by Kruger et al. at a similar facility in Cape Town[16] and is a symptom of the congested emergency theatre lists, the overwhelming burden of disease, and resource constraints within the trauma care system. The average waiting time for emergency surgery at Tygerberg Hospital is more than 22 hours.[16,20] Thirty-eight per cent of theatre cases booked at Tygerberg Hospital are booked for life-threatening emergencies, whilst emergency theatre utilisation is estimated at only 45%.[20] Difficulty in accessing theatre is further underlined with planned relook surgery only taking place on average after 59 hours, instead of the recommended 24–48 hours.[1,21]

There was no difference in outcome between office hours and after-hours surgery, a surrogate for the presence of a consultant at the start of the procedure. This is indicative of the exposure and training received in a country where trauma is an epidemic, translating into skilled juniors who can start a DCL procedure whilst senior help is en route instead of having to defer the initiation of surgery.[22,23]

Given the delays to care as described a survivor bias can be expected, and it is likely that patients who suffered exsanguinating injuries demised on scene, or in the emergency department. A review of trauma deaths in the Tygerberg Hospital drainage showed that 94% of all deaths happened on the scene of an incident within one hour.[24] The delays to theatre reported are a reminder that expedited theatre access remains a challenge for the South African trauma system.

With regards to costing models, this study makes use of a hybrid model, including bottom-up costing elements where feasible and available (theatre time, blood usage, laboratory cost) and top-down costing (ICU cost, ward cost, radiology cost) for other costs. This is a pragmatic approach to delivering results in settings where neither model would exclusively work based on available information and is an acceptable merger of the two techniques.[25] This approach has been used with success in other costing studies in Africa and Europe.[26,27] By using a hybrid costing model, the accuracy of the costing model is improved compared to using a top down model only.[27] A bottoms up costing model requires complex costing systems to be in place, or a dedicated team to track cost, neither of which is available in our setting.[27] This is the first costing study in South Africa to exclusively review DCLs.

The contributing cost elements in this study are similar to a study conducted by Allard et al. nearly 20 years ago on "serious abdominal gunshot wounds" in Cape Town.[26] The study population differs, but both evaluated patients with severe abdominal injuries from trauma. The cost has significantly increased in the 20 years from USD 1 467 to USD 25 269 since 2005 (a 1 600% increase in cost), in the same period health expenditure per capita has increased from

USD 404.4 to USD 583.3 (a 44% increase in expenditure) in South Africa.[27]

The largest drivers of cost are ICU stay and theatre time, concurring with an earlier study in the same setting.[28] This is reflective of the reliance on skilled personnel in both these areas and the cost of salaries for staff in these areas, as reflected in other costing studies and overall personnel cost of 69% of the hospital budget.[9]

A costing audit of elective procedures at Tygerberg Hospital by the author, utilising the same costing framework, estimated the cost of laparoscopic cholecystectomy to be R 26 084 (USD 1 413) and elective hernia repair to be R 22 784.75 (USD 1 234). This places the resource utilisation of trauma care into perspective and underscores the value of preventative programmes from an economic perspective.[29]

The current study does not consider the loss of income to the patient, the cost of post-discharge rehabilitation, and future surgeries to manage complications.

The true cost of trauma care in the South African public sector remains unknown with a paucity of dedicated costing studies investigating the various cost contributors and the knock-on effects of delays and limited resources. No studies comparing the cost of trauma care in the private and public sectors have been published, furthering our lack of understanding. Given the proposed National Health Insurance (NHI) model, understanding the cost of trauma care should be a priority for policymakers and researchers.

A detailed bottom-up costing model, although resource intensive, is of the utmost importance in determining the true cost of trauma care in South Africa and should be undertaken as soon as possible to understand the financial impact of the trauma pandemic in South Africa. This model should be repeatable between institutions to ensure a true reflection of the financial burden of trauma. Additionally, projects that aim to improve time to care and access to theatre will contribute to address the mortality and morbidity associated with DCL in this population group.

Limitations

The retrospective nature of the study, lack of facility-based costing models, and small study population are acknowledged as study limitations.

Conclusion

Damage control laparotomy, although lifesaving, adds a significant cost to the healthcare system. The impact of delay in care on both cost and patient outcomes is significant and warrants further research to direct interventions.

Conflict of interest

The authors have no conflicts of interest to declare.

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Ethical approval

Ethical approval was obtained from the Stellenbosch University Human Research Ethics Committee (Ref: S21/10/199).

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