Developing a simplified clinical prediction score for mortality in patients with cerebral gunshot wounds: The Maritzburg Score

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ABSTRACT

INTRODUCTION Cerebral gunshot wounds are highly lethal and literature on the clinical scores for mortality prediction is limited.

MATERIALS AND METHODS A retrospective study was undertaken over a 5-year period at the Pietermaritzburg Metropolitan Trauma Service in South Africa. A simplified clinical prediction score was developed based on clinical and/or physiological variables readily available in the resuscitation room.

RESULTS A total of 102 patients were included; 92% (94/102) were male and the mean age was 29 years; 22% (22/102) died during the admission. The presence of visible brain matter (odds ratio 12.4, $P = 0.003$) and motor score less than 5 (odds ratio 89.6, $P < 0.001$) allows the prediction success of 92% (sensitivity 73% and specificity 98%). The area under the receiver operating characteristic curve was 94% (95% confidence interval 88–100%, $P < 0.001$).

CONCLUSIONS The presence of visible brain matter, together with a motor score of less than 5, allows accurate identification of non-survivors of cerebral gunshot wounds. Further study is required to validate this score.

KEYWORDS

Cerebral – Gunshot wound – Mortality

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Introduction

Cerebral gunshot wounds are the most lethal form of traumatic brain injury and are associated with a high mortality.¹ The management of patients with such injury is resource intensive and places a substantial burden on the already overstretched trauma services in South Africa. This often raises difficult questions regarding the appropriate allocation of precious resources.^{2,3} An effective clinical triage tool that allows early and reliable identification of non-survivors assists clinicians in directing resources appropriately and avoids potentially futile care. Stoffel et al., from Baragwanath Hospital in Johannesburg, proposed a scoring system which uses three clinical parameters (admission blood pressure, brain matter spillage and summed Glasgow Coma Scale) and has been validated.¹ Glasgow Coma Scale (GCS) comprises three separate components: eye opening, verbal and motor response. Recent literature suggested that the motor component of GCS performs as well as the summed

GCS in predicting mortality of patients with traumatic brain injury.⁴ Furthermore, eye opening and verbal response may be difficult to assess accurately in the resuscitation room, where patients are often intoxicated and may have other confounding factors, such as facial swelling. In light of this, we designed our current study to propose a more simplified clinical score that would allow early prediction of mortality in patients with isolated cerebral gunshot wounds.

Materials and Methods

Clinical setting

A retrospective study was undertaken at the Pietermaritzburg Metropolitan Trauma Service (PMTS), Pietermaritzburg, South Africa. Our electronic regional trauma registry was reviewed over a 5-year period from January 2010 to December 2014. Ethics approval for this study and for maintenance of the registry was formally endorsed by the Biomedical Research Ethics Committee of the University of

KwaZulu Natal (reference: BE 207/09). The PMTS provides definitive trauma care to the city of Pietermaritzburg (often referred to as ‘Maritzburg’), the capital of KwaZulu Natal province. It also serves as the trauma referral centre for 19 other rural hospitals within the province, with a total catchment population of over three million. Although the PMTS is located in the capital city of the province, the sole provincial neurosurgery centre is based at Inkosi Albert Luthuli Central Hospital in Durban, so all cases who require neurosurgical intervention are transferred out from PMTS. Approximately 3000 trauma cases are admitted to the PMTS per annum, with over 50% being penetrating traumas. This is a direct reflection of the high incidence of firearm-related interpersonal violence and criminal activities experienced throughout the entire province.

The study

All patients with a single, isolated cerebral gunshot wound were included. Those with concurrent gunshot wounds to other body regions were excluded. Basic demographic data were reviewed. Further data reviewed included the mode of injury (assault, suicide or accident), type of firearms, vital signs (physiological parameters on arrival), physical examination findings, GCS and the final clinical outcome. The GCS was further divided into its component scores of eye opening, vocal response and motor response for each patient.

Statistical analysis

The IBM SPSS version 23 statistical program was used to analyse the data. Crude associations between independent variables and the outcome of death or survival were

assessed using Pearson’s chi square test or Fisher’s exact tests, as appropriate, in the case of categorical variables. Continuous variables were tested using t-tests or Mann-Whitney nonparametric tests, as appropriate. Receiver operating characteristic analysis was used to determine the optimum cut-off points for each variable to predict mortality. Multiple logistic regressions were used to determine predictors independently and significantly associated with mortality and to determine a simple clinical model to predict mortality with a high level of accuracy. A backward stepwise model was used with entry and exit probabilities set at 0.05 and 0.1, respectively.

Results

Patient cohort

During the 5-year study period, a total of 102 patients with isolated cerebral gunshot wounds were included; 92% (94/102) were male and the mean age was 29 years; 94% (94/102) of injuries were related to interpersonal violence (assaults) and the remaining 6% (6/102) were attempted suicides. The mean and standard deviation (SD) values of physiological parameters on arrival were heart rate 85 beats/minute (SD 24 beats/minute), systolic blood pressure 124 mmHg (SD 22 mmHg), temperature 36°C.¹ The mean GCS on arrival was 12 (SD 5) and 33% (31/102) of all patients had visible brain matter oozing from the wound. All 102 patients underwent computed tomography (CT). Of the 102 patients, 22% (22/102) died during admission. The remaining 80 patients (78%) survived until discharge to rehabilitation. The mean GCS on discharge of all 80 survivors was 14 (SD 2).

Table 1 Comparison of demographics and clinical parameters of non-survivors and survivors of cerebral gunshot wounds					
Demographic:	Non-survivors (N = 22)		Survivors (N = 80)		P value
	Mean	SD	Mean	SD	
Age	30	10	29	8	0.7943
Male	22	100%	72	90%	0.196
Female	0	0%	8	10%	
Clinical parameters:					
Respiratory rate (minute)	17	6	18	4	0.3915
Heart rate (minute)	76	30	87	21	0.0336
Systolic blood pressure (mmHg)	124	29	124	19	0.608
Temperature (°C)	36	1	37	1	0.0012
Visible brain matter	17	77%	14	18%	< 0.001
No visible brain matter	5	23%	66	83%	
Admission Glasgow Coma Scale	4	3	14	2	< 0.001
Eye-opening component (median, IQR)	1	(1–2)	4	(4–4)	< 0.001
Vocal response component (median, IQR)	1	(1–1)	5	(4–5)	< 0.001
Motor response component (median, IQR)	2	(1–5)	6	6–6	< 0.001

Table 2 Comparison between non-survivors versus survivors in terms of the need for neurosurgical intervention

	Non-survivors (N = 22)		Survivors (N = 80)		P value
	(n)	(%)	(n)	(%)	
Neurosurgical intervention	6	27	25	31	0.799
No neurosurgical intervention	16	73	55	69	0.799

Non-survivors compared with survivors

Direct comparison was made between the 22 non-survivors and the 80 survivors. Table 1 summarises this comparison in terms of demographics and clinical parameters.

Neurosurgical interventions

Some 30% (31/102) of all patients required neurosurgical interventions; 28 (90%) of these 31 patients underwent debridement and/or elevation of depressed skull fracture and 3 required formal craniotomy for haematoma evacuation. There was no significant difference in outcome between non-survivors and survivors in terms of the need for neurosurgical interventions (27% vs. 31%, $P = 0.799$). This is summarised in Table 2.

Clinical prediction model

To derive a clinically relevant model of practical value, the following parameters were entered into a backward stepwise model: clinical and/or physiological variables on admission (temperature, heart rate, systolic blood pressure, motor score and the presence of visible brain matter) were considered in succession. Using backward selection, after four steps, the following two factors remained as the best predictors in the model: visible brain matter (odds ratio, OR, 12.4, $P = 0.003$) and motor score less than 5 (OR 89.6, $P < 0.001$). The prediction success for this model was 92% (sensitivity 73%, specificity 98%). The area under the receiver operating characteristic curve (AUROC) was 94% (95% confidence interval, CI, 88–100%, $P < 0.001$). The ROC curve for the combined model is shown in Figure 1. The model coefficients were highly statistically significant against the constant-only model (chi square 61.4, $P < 0.001$; Nagelkerke's R squared 0.699 indicated a high level of variance explained by the model).

Discussion

Cerebral gunshot wounds are associated with significant mortality.^{1,5–8} Historically, the management of these injuries in the civilian setting has relied heavily on the published experience from the Vietnam war.⁹ Over the past three decades, major improvements in pre-hospital care and changes in resuscitation strategies, together with almost universal availability of advanced imaging, coupled with parallel development in neurosurgical techniques have resulted in marked improvements in patient outcomes.^{5,6,10} However,

over 90% of victims still die before reaching hospital and a further 50% die in the resuscitation room.^{5–10}

Given the dismal prognosis for many patients, clinicians are often faced with difficult decisions as to the subgroup which may benefit from intensive management.¹¹ Numerous studies have proposed a multitude of risk factors for predicting poor prognosis.^{5–14} These include an admission GCS less than 5, unilateral or bilateral large or unreactive pupils, subarachnoid haemorrhage, intra-cerebral haematoma, ventricular injury on CT, missile traversing the central part of the brain, diffuse fragmentation, hypoxia, prolonged extraction times, self-harm, high velocity injury, deranged coagulation and advanced age.^{5–14} Many of these are not immediately known or available to the clinicians in the resuscitation room.¹

A study by Aldrich et al.¹⁵ found that initial GCS on admission is the strongest predictor of mortality. The majority of neurosurgeons regard the patient subgroup with a low initial GCS scores as being ultimately unsalvageable and tend to limit aggressive treatment.^{1,15} On the other hand, good outcomes for patients with a low initial GCS have been also reported.^{1,15} The only two South African studies to date were both from Johannesburg.^{1,16} The original score proposed by Stoffel et al.¹ was based on his series of 214 patients using three clinical parameters. Admission systolic blood pressure was divided into three further categories (< 100 mmHg, 100–199 mmHg and ≥ 200 mmHg). The presence of visible brain matter was dichotomised (present or absent) and the summed GCS was arbitrarily defined as either ≤ 6 or > 6 . Each variable was assigned a different value and combined score of 5 based on this algorithm is associated with 80% mortality. The complex algorithm places limitation on the usefulness of such score and thus a more simplified clinical score is preferable.

In our experience, accurate assessment of each component of the GCS in the setting of cerebral gunshot wounds is often challenging, especially with concurrent facial swelling and often intoxicated patients. The use of motor score alone has been shown to be as accurate as the summed GCS in traumatic brain injury.⁴ In our present model, we propose the 'Maritzburg score'; by using only two simple clinical variables: the presence of visible brain matter and a motor score less than 5 allows accurate identification of non-survivors.

Selective conservatism has been the underlying philosophy behind trauma care in South Africa for over half a

century.³ Correct and early identification of those with a dismal prognosis is important. On the other hand, those who survive to reach our institutions must not be denied treatment based on anecdotal evidence and any single clinical factor. By applying a simple two-parameter clinical scoring system to these injuries, it is possible to objectively identify those patients who are unsalvageable. This may allow for the more rational allocation of scarce resources in a resource constrained environment.

Conclusions

By using two simple clinical variables, namely the presence of visible brain matter and a motor score of less than 5, our clinical prediction score allows accurate identification of non-survivors of cerebral gunshot wounds. Further study is required to validate this score.

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