Factors Contributing to Fatal Outcome of Traumatic Brain Injury: A Pilot Case Control Study

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ABSTRACT

Objective: *Patients with traumatic brain injury (TBI) have a high mortality and morbidity. This pilot study was undertaken to identify contributors to outcome in the early management of patients with TBI and to investigate the feasibility of a larger study.*

Methods: *Road trauma patients who died between January 1 and April 30, 2000 were selected from the Alfred Hospital's Intensive Care Traumatic Brain Injury database. These patients were matched with 2 survivors from the data base during the same period for age, injury severity score (ISS) and severity of brain injury using the head abbreviated injury score (head AIS). Patient injury scoring (using the revised trauma score, trauma and injury severity score and Glasgow coma score), arterial blood gas analysis, lactate concentration, inspired oxygen concentration, systolic and mean arterial blood pressures, intracranial pressure, intravenous fluid and blood transfusion volumes, body temperature, haemoglobin, white cell count, INR, APTT, temperature and plasma glucose, urea and creatinine concentrations were recorded for 48 hours from the time of injury. Time periods from the accident to key events (e.g. arrival of ambulance at accident scene, intubation, arrival at the emergency department, insertion of intracranial pressure monitor and primary surgery) were also recorded.*

Results: *Eighteen patients (6 deceased, 12 survivors) were identified. Despite matching, deceased patients had lower initial Glasgow Coma Scores (GCS) (3.6 vs. 7.4, p = 0.01) and lower revised trauma scores (4.41 vs. 5.75; p = 0.044) compared with survivors. There were no significant differences in other parameters. However, deceased patients tended to have longer times to treatment (p = NS) and experienced trauma at night more frequently, and survivors received almost double the volume of fluid resuscitation during the first 12 hours (19.7 ± 19.1 vs. 11.8 ± 2.7 mL/kg/hr, p = 0.513).*

Conclusions: *Both initial GCS and severity of brain injury should be used to match TBI patients for injury severity in future studies. Lower initial GCS in deceased patients was likely due to greater severity of brain injury, although it is also possible that the lower GCS was due to decreased brain perfusion (perhaps reflecting inadequate resuscitation) in these patients. Volume of early fluid resuscitation, time to definitive therapy, and time of presentation to hospital may also be important determinants of patient outcome. A large case control outcome study is required to extend these observations.* (**Critical Care and Resuscitation 2001; 3: 153-157**)

Key words: Traumatic brain injury, outcome, intensive care

Preventable and potentially preventable deaths are common in road trauma patients in Victoria.[1,2,3] From 1992 to 1998 the Consultative Committee on Road Traffic Fatalities in Victoria identified diagnosis and management errors and system inadequacies during all phases of trauma care from the pre-hospital setting to the general hospital wards.

System changes have been recently introduced in

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Victoria to address some of these problems but future improvements in management errors will first require identification of the key problem areas. Traumatic Brain Injury (TBI) is a frequent cause of mortality and morbidity in patients, and therefore preventable problems in this group are important. Possible contributors to poor outcome in TBI patients include hypoxia and hypercapnia, hypoperfusion due to hypovolaemia and hypotension, and hypothermia and coagulopathy.[4,5,6]

Optimal values for blood pressure, oxygenation and haemoglobin content are controversial. During the first 36 hours, optimal management of these variables is considered critical to good outcomes.[7,8] Following this period, secondary problems associated with infection, ventilation and organ failure, perhaps resulting from the systemic inflammatory response, are more important.[9,10,11] This pilot study investigated additional factors contributing to fatal outcome in TBI patients currently treated in Victoria and determined the feasibility of a larger study.

PATIENTS and METHODS

Non-surviving patients with TBI, who were admitted to the Alfred Hospital Intensive Care Unit (ICU) between January 1 and April 30, 2000, were selected from the prospective intensive care traumatic brain injury database.

Inclusion criteria were patients with TBI who were alive on arrival in the emergency department with a head abbreviated injury score (head AIS) > 2 and an injury severity score (ISS) > 15.[12] Each non-surviving patient was matched with two survivors during the same period using the criteria: an equal head AIS, an ISS within ± 5 and age within ± 10 years. Relevant patient data were collected from ambulance and medical records, ICU charts and the intensive care database.

Complete data sets were collected on arrival in the emergency department, and at 4, 12, 24 and 48 hours after admission. These data included injury scoring using the revised trauma score (RTS), trauma and injury severity score (TRISS)[12] and Glasgow coma score (GCS), arterial blood gas analysis, lactate concentration, inspired oxygen concentration (F_IO_2), systolic and mean arterial blood pressure, intracranial pressure, intravenous fluid and blood transfusion volumes, body temperature, haemoglobin, white cell count, INR and APTT coagulation parameters, temperature and plasma glucose, urea and creatinine concentrations. Time periods from the accident to key events (arrival of ambulance at accident scene, intubation, arrival at the emergency department, insertion of intracranial pressure monitor and primary surgery) were also recorded.

Data were expressed as means, or medians (when non parametric). Measurements within and between groups were analysed using a repeated measures ANOVA. P-values < 0.05 were considered significant. Calculations were done using SPSS WIN9.0.

RESULTS

Matching procedure

Seven deceased patients were identified. One was not included because the medical records had been retained by the Coroner. The remaining 6 patients were matched with 12 survivors using the criteria detailed in table1. Despite excellent matching for head AIS and ISS, the initial GCS in survivors and non-survivors were different (survivors 7.4 ± 3.1, non-survivors 3.5 ± 1.2. p = 0.01). The revised trauma score (RTS) and trauma and injury severity score (TRISS) in both groups also tended to be different, likely owing to the differences in GCS (table 1).

Table 1. Indices of trauma severity (mean ± SD)

	Nonsurvivors	*Survivors*	*p value*
Age	24.7 ± 5.2	28.0 ± 11.1	0.49
ISS	32.0 ± 5.6	32.8 ± 8.2	0.83
head AIS	4.5 ± 0.5	4.3 ± 0.5	0.52
GCS	3.5 ± 1.2	7.4 ± 3.1	0.01
RTS	4.4 ± 0.8	5.7 ± 1.2	0.04
TRISS	0.57 ± 0.2	0.75 ± 0.2	0.14

ISS = injury severity score, head AIS = head abbreviated injury score, GCS = Glasgow coma score, RTS = revised trauma score, TRISS = trauma and injury severity score

Blood gas analysis and PaO_2/FIO_2 values

Arterial PCO_2 was elevated (reflecting inadequate ventilation) in patients from both groups on arrival in the emergency department (table 2), but $PaCO_2$ normalised more quickly in the survivors. Between 12 and 48 hours after admission $PaCO_2$ was lower in the non-survivors, reflecting greater hyperventilation associated with higher intracranial pressures. Both PaO_2 and the PaO_2/F_IO_2 ratio tended to be higher in survivors up until 4 hours after the accident (table 2). Patients in both groups had a mild metabolic acidosis on admission (mean arterial pH 7.28 ± 0.1) which had normalised by 12 hours. There were no differences in blood lactate concentrations.

Table 2 Arterial blood gas and intracranial pressure measurements during the first 48 hours after the accident (mean ± SD)

Times	***ED***	***4 hours***	***12 hours***	***24 hours***	***48 hours***
$PaCO_2$ (mmHg)					
Survivors	45 ± 10	41 ± 9	39 ± 8	40 ± 7	39 ± 6
Nonsurvivors	48 ± 6	44 ± 11	36 ± 4	41 ± 2	35 ± 6
ICP (mmHg)					
Survivors	not applicable	20.7 ± 7.2	17.8 ± 9.6	22.2 ± 6.7	23.8 ± 7.7
Nonsurvivors	not applicable	12 ± 5.6	24 ± 7	29 ± 12	25 ± 4
PaO_2 (mmHg)					
Survivors	354 ± 187	360 ± 173	170 ± 79	202 ± 123	131 ± 37
Nonsurvivors	327 ± 113	287 ± 130	201 ± 88	122 ± 35	129 ± 19
PaO_2/F_IO_2 (mmHg)					
Survivors	369 ± 175	391 ± 166	339 ± 158	473 ± 220	382 ± 166
Nonsurvivors	327 ± 113	318 ± 130	441 ± 127	332 ± 99	348 ± 97

ICP = Intracranial pressure

Arterial blood pressure, temperature and intravenous fluid and transfusion volumes

Systolic blood pressures tended to be higher in non-survivors up to 4 hours after the accident (table 3, p = NS) and vasoactive drugs were not used in these patients during the first 12 hours. The total volume of fluid infused within the first 12 hours was 141 ± 32 mL/kg in non-survivors, and 237 ± 236 mL/kg in survivors (table 4, p = 0.513).

There was no difference in the volume of blood transfused (non-survivors 2.2 ± 2.5 units, survivors 6.3 ± 11.6 units. p = 0.404). There were also no significant differences in initial body temperatures (non-survivors 36.4°C, survivors 35.8°C).

Complete blood picture, coagulation and plasma glucose, urea and creatinine values

There were no differences in initial haemoglobin concentrations (non-survivors Hb 129 ± 40 g/L, survivors 120 ± 25 g/L. p = 0.61), white cell count or platelet count between survivors and non-survivors. The mean INR value tended to be higher during the first 4 hours in survivors compared with non-survivors (survivors INR 1.6, non-survivors INR = 1.3. p = 0.323). The plasma glucose levels initially tended to be higher in survivors compared with non-survivors (survivors plasma glucose 10.8 ± 3.3 mmol/L, non-survivors plasma glucose 7.3 ± 1.5 mmol/L. p = 0.102). There were no differences in the plasma urea and creatinine levels at any time during the first 48 hours.

Key event times

Overall times to arrival of ambulance, intubation, arrival in the emergency department, insertion of intracranial pressure monitor and primary surgery were equal in both groups. However, survivors tended to have shorter times to each of several key events (table 5). While the accidents were equally distributed in number between night (1800 to 0600 hours) and day (0600 to 1800 hours), at night 4 of 9 patients died (44%), whereas 2 of 9 patients died during the day (22%, p = NS).

Table 3 Blood pressures on arrival and to 48 hours after the accident (mean ± SD).

Time points	*scene*	*ED*	*4 hours*	*12 hours*	*24 hours*	*48 hours*
Systolic blood pressure	108 ± 25	125 ± 48	136 ± 28	127 ± 18	136 ± 18	131 ± 14
Survivors						
Nonsurvivors	124 ± 20	147 ± 23	129 ± 21	131 ± 18	135 ± 43	140 ± 14
p-value	0.218	0.329	0.606	0.734	0.951	0.424
Mean blood pressure	79 ± 15	102 ± 23	95 ± 20	86 ± 8	89 ± 9	88 ± 8
Survivors						
Nonsurvivors	88 ± 21	98 ± 16	88 ± 11	90 ± 9	87 ± 24	90 ± 9
p-value	0.21	0.73	0.44	0.52	0.84	0.79

ED = Emergency department

Table 4 Intravenous fluid volumes in mL/kg/hr (mean ± SD)

	Scene-ED	*ED - 4 hr*	*4 -12 hr*	*12 - 24 hr*	*24 - 48 hr*
Survivors	12.9 ± 9.2	28.5 ± 41.3	12.9 ± 11.2	4.3 ± 3.3	2.9 ± 1.4
Non-survivors	13.1 ± 10.2	18.6 ± 10.9	6.9 ± 4.3	3.8 ± 4.7	1.3 ± 1.15
p-value	0.976	0.609	0.396	0.83	0.098

ED = emergency department

Table 5 Time interval in minutes from accident to key intervention points (mean±SD).

	Arrival of ambulance	*Intubation*	*Arrival in ED*	*Insertion of ICP monitor*	*Primary surgery*
Survivors	21.2 ± 6.8	51.5 ± 23.4	64.5 ± 25.9	295.0 ± 83.4	373.9 ± 285.4
Non-survivors	28.5 ± 20.2	79.2 ± 49.1	98.7 ± 65.9	350.0 ± 160.9	435.0 ± 233.3
p-value	0.262	0.132	0.129	0.537	0.786

ED = emergency department, ICP = intracranial pressure

However, at night mean times to arrival in the emergency department (85 min) and to primary surgery (652 min) tended to be longer than during the daytime (66 and 325 min, respectively).

DISCUSSION

In patients with traumatic brain injury, hypoxia, hypercapnia and hypotension are associated with poor outcomes.[2,4,13] Biochemical parameters reflecting lactic acidosis are also of prognostic value.[14] This pilot case control study questioned whether these or other factors were associated with poor outcomes in patients with TBI in Victoria.

We found that although deceased patients and controls were well matched for anatomic severity of trauma as represented by the ISS and the head AIS,[15] there were significant differences in patients initial GCS. This suggested that GCS may represent severity of brain injury better after TBI than either of the anatomic scores (i.e. ISS or head AIS). The GCS should therefore be included as a primary matching criteria in addition to the anatomic scores in a larger study. It is also possible that GCS has particular prognostic significance because it reflects both anatomic injury and functional changes due to hypoperfusion.

There were a number of interesting trends identified in this pilot study which may be important.

1. Non-survivors received less fluid resuscitation. This finding is counter to that of Bickel *et al*,[16] who popularised the idea of decreased fluid resuscitation in trauma patients.
2. Survivors tended to have lower temperatures on admission, so initial hypothermia may have a brain protective effect.
3. Longer times to definitive treatment and a nighttime accident tended to be associated with increased risk of a fatal outcome.

This pilot case-control study has confirmed the potential for using an existing prospective traumatic brain injury database to investigate important contributors to poor outcome in patients with traumatic brain injury in Victoria, Australia. Some of these contributors may be preventable. A larger, more definitive study will include initial Glasgow Coma Score as one of the key matching criteria.

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