

Outcomes following prehospital airway management in severe traumatic brain injury

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Background. Prevention of hypoxia and thus secondary brain injury in traumatic brain injury (TBI) is critical. However there is controversy regarding the role of endotracheal intubation in the prehospital management of TBI.

Objective. To describe the outcome of TBI with various airway management methods employed in the prehospital setting in the Cape Town Metropole.

Methods. The study was a cohort descriptive observational analysis of 124 consecutively injured adult patients who were admitted for severe TBI (Glasgow Coma Score ≤ 8) to Groote Schuur and Tygerberg hospitals between 1 January 2009 and 31 August 2011. Patients were categorised by their method of airway management: rapid sequence intubation (RSI), sedation-assisted intubation, failed intubation, basic airway management, and intubated without drugs. Good outcomes were defined by a Glasgow Outcome Score of 4 - 5.

Results. There was a statistically significant association between airway management and outcome ($p=0.013$). Patients who underwent basic airway management had a higher proportion of a good outcome (72.9%) than patients who were intubated in the prehospital setting. A good outcome was observed with 61.8% and 38.4% of patients who experienced sedation-assisted intubation and RSI, respectively. Patients intubated without drugs had the poorest outcome (88%), followed by rapid sequence intubation (61.5%) and by the sedation assisted group (38.2%).

Conclusion. Prehospital intubation did not demonstrate improved outcomes over basic airway management in patients with severe TBI. A large prospective, randomised trial is warranted to yield some insight into how these airway interventions influence outcome in severe TBI.

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Traumatic brain injury (TBI) is the leading cause of death in young adults in the USA.^[1] Death from TBI is particularly high in low-/middle-income countries where resources are limited.^[2] Management of TBI patients is rapidly evolving because of a greater understanding of the physiological derangements resulting in secondary brain injury (SBI). The prehospital phase is arguably the most vital period in determining outcome following TBI. Brief episodes of hypoxia in severe TBI are strongly associated with increased morbidity and mortality.^[3] In their prospective observational study, Stocchetti *et al.*^[4] discovered that 55% of patients with TBI were hypoxic ($\text{SpO}_2 < 90\%$) at the scene of the accident. There are various methods to improve oxygenation and ventilation for the head-injured patient in the field, that range from basic airway management, to use of supraglottic airway devices, to endotracheal intubation and surgical airways. However, there is still uncertainty regarding the most appropriate airway technique in the prehospital management of TBI.

Objective

To describe the outcome of TBI with each airway management technique employed in the Cape Town Metropole.

Methods

This study was a cohort descriptive observational analysis of consecutively injured adult patients who sustained severe TBI in the Cape Town Metropole. The study included 124 adult trauma patients (age ≥ 16 years) admitted to Groote Schuur Hospital (GSH) and Tygerberg Hospital (TBH) from 1 January 2009 to 31 August 2011 for the treatment of severe closed TBI (Glasgow Coma Scale (GCS) ≤ 8) and suspected TBI based on the mechanism of injury or physical

examination. GSH and TBH are both tertiary institutions, with 24-hour neuro-imaging facilities, and are considered neurotrauma centres for state patients in the metropole. Exclusion criteria were: patients transferred to TBH and GSH from another facility, those sustaining penetrating head trauma and those who were declared dead on scene.

Both GSH and TBH have a trauma register at their resuscitation units. Patients were identified by the investigator using the following criteria recorded in the register: working diagnosis of TBI indicated on the register, GCS ≤ 8 , intubated, or patient sent for computed tomography (CT) scan. If one of these criteria was present, the folder was requested from medical records for a more detailed evaluation. The primary selection was broad by design so that patients with suspected TBI were not missed. Patients were finally included if they had a confirmed TBI according to CT scan or had a prehospital GCS ≤ 8 .

Patient survival to hospital discharge was the primary outcome determined from the patient's clinical record. The secondary outcomes – neurological and functional status – were determined at the time of discharge using the Glasgow Outcome Scale (GOS). A GOS of 1 - 3 denoted a 'poor outcome', while 4 - 5 suggested a 'good neurological outcome'. The data were analysed using SPSS version 19. Pearson χ^2 -square and Fisher's exact tests were used to determine associations of airway management with good or poor outcome, with $p=0.05$ being statistically significant. Ethics approval to conduct the study was granted by the University of Cape Town Human Research Ethics Committee (HREC ref. 096/2011).

Results

A total of 124 patients were enrolled from 1 January 2009 to 31 August 2011. Of the 124 patients, 37 (30%) were managed with basic airway

management, 8 (7%) were intubated without drugs, 13 (11%) underwent rapid sequence intubation (RSI), 55 (44%) were managed with sedation-assisted intubation. There were 11 (9%) failed intubations. The major cause of head injury was road traffic accidents (67%), followed by assaults (24%). Males numbered 110 (89%) and females 14 (11%). The mean age of the study population was 32 years (95% confidence interval 30.3 - 34.3) and there was an equal ($n=62$) split of patients obtained from GSH and TBH. There was no significant difference in outcome from the two hospitals ($p=0.583$). Seventy-six (61.3%) patients had isolated head trauma while 48 (38.7%) had concomitant injuries.

The overall mortality for the study population was 38.7%. A total of 74 patients (59.7%) had a good outcome. We showed a statistically significant association between airway management and outcome using Fisher's exact test ($p=0.013$). The group of patients who received basic airway management, had the highest proportion of a good outcome (72.9%), followed by the failed intubation group (63.6%). Patients intubated without drugs had the highest proportion of a poor outcome (88%), followed by the RSI group (62%). In the sedation-assisted intubation group, 62% had a good outcome and 38.4% of the patients where RSI was employed had a good outcome. Of the patients intubated without drugs, 12.5% had a good outcome.

Discussion

Despite the advantages of endotracheal intubation in TBI, multiple studies have demonstrated adverse outcomes from this complex procedure in severe TBI.^[5-7]

Murray *et al.*^[5] demonstrated that patients with severe TBI who were intubated in the prehospital setting had increased mortality when compared with non-intubated patients. Similarly, Bochicchio *et al.*^[6] demonstrated increased morbidity and mortality in prehospital intubated patients. They also documented an increased incidence of pneumonia and ventilator days with the prehospital intubated patients. The latter has also been found in other similar studies.^[8,9] In our study, the RSI group had the longest (14 days) and the sedation-assisted group the shortest (7 days) stay in an intensive care unit (ICU). A study of 31 464 paediatric patients with severe TBI also failed to demonstrate better survival in the patients who were intubated in the out-of-hospital milieu compared with bag-valve mask (BVM) ventilation.^[10] Wang *et al.*^[7] compared the effects of out-of-hospital endotracheal intubation v. emergency department endotracheal intubation on mortality and neurological outcome. They determined an approximately fourfold increase in odds of death in patients who were intubated out of hospital than those who received emergency department, in-hospital endotracheal intubation. Worse neurological outcomes were associated with out-of-hospital endotracheal intubation.

Interestingly, Winchell and Hoyt^[11] found a 21% increase in survival in an analysis of 1 098 TBI patients in the out-of-hospital intubation group. Similarly, Suominen *et al.*^[12] discovered that prehospital intubation resulted in a 34% increase in survival over patients who were intubated in the emergency centre in an evaluation of 59 paediatric TBI patients. However, neither of the studies adjusted for severity of injury or illness and it is unclear whether any pharmacological agents were used to facilitate endotracheal intubation as not all attending paramedics were permitted to carry drugs for this advanced skill. In an analysis of 486 trauma patients intubated in the field without any pharmacological agent, Lockey *et al.*^[13] recorded a single survival. It might be argued that if patients in these aforementioned studies required intubation without drugs in the prehospital setting, they may already have had very low GCSs and therefore a high probability of dying.

Sedation-assisted intubation is the administration of a sedative/induction agent such as midazolam prior to intubation. In theory, sedation-assisted intubation could lead to or worsen outcomes owing to SBI as a result of blood pressure changes, as noted by Sams and Kelly^[14]

where 22% of patients had a change in blood pressure of >20 mmHg. There is also the fear of increasing the intracranial pressure during laryngoscopy should the patient not be fully relaxed during intubation, thus further reducing cerebral perfusion. With high failure rates associated with this procedure (37.5%), as noted by Wang *et al.*,^[15] there is an increased risk of aspiration as the patient might have a depressed cough reflex following administration of the pharmacological agent(s). On the other hand, sedation-assisted intubation avoids a paralysed, apnoeic patient should the practitioner fail to secure the airway.

RSI is thought to be the airway management technique of choice in the patient with severe TBI as it attenuates the intracranial pressure response during laryngoscopy. It has also been used by some emergency medical services (EMS) to increase the success rate of endotracheal intubation.^[16,17] Patients in this study receiving RSI, despite its advantages, had poorer outcomes than other airway methods. There is conflicting evidence regarding prehospital RSI in the literature. Davis *et al.*^[18] evaluated 209 TBI patients receiving RSI and matched them to 627 non-intubated controls, comparing prehospital RSI with the alternative of no intubation. The RSI group had a 33% mortality rate v. 24.2% in the no intubation group with a decreased prevalence of good outcome of 45.5% v. 57.9%, respectively. These findings contradict those by Bernard *et al.*,^[19] who, in a randomised controlled trial, found that prehospital RSI increases the chances of a favourable outcome at 6 months compared with hospital intubation. Sloane *et al.*^[8] compared patients who underwent prehospital RSI with those who underwent emergency department RSI, finding no difference, somewhat counter intuitively in mortality, or length of ICU or hospital stay.

Davis *et al.*^[20] demonstrated that hyperventilation is a common phenomenon following prehospital RSI. This, in its turn, results in cerebral vasoconstriction with reduction in cerebral perfusion. A correlation was noted between hyperventilation and increased mortality. A ventilator is not always available in the Cape Town EMS setting. Advanced life support (ALS) practitioners often have to rely on the BVM reservoir device to ventilate intubated patients. They have no control over the minute volume, and hyperventilation is therefore a very likely scenario. The ventilator is a mandatory adjunct during prehospital RSI as per Health Professions Council of South Africa (HPCSA) regulations. However, Christopher^[21] found that South African EMS providers were non-compliant with the HPCSA protocols for various reasons. It is not clear whether ALS practitioners take hyperventilation into account when setting a ventilator for the severe TBI patient. Likewise, patients with associated thoracic injuries might require lower pressures or volumes to minimise the risk of increased intrathoracic pressure, which would impede venous drainage from the cerebral vasculature, resulting in decreased cerebral blood flow and a rise in intracranial pressure.

Our study has certain limitations. There was a relatively small sample size. The role of other factors such as response time, patient co-morbidity and time to hospital could not be fully explored in this descriptive study.

Conclusion

Our study is unique in that it looks at all the various airway techniques utilised in the prehospital emergency setting for the management of severe TBI in South Africa. While it demonstrates an association between prehospital airway management and outcome, there are still unanswered questions regarding the value of endotracheal intubation v. basic airway management for patients maintaining $SpO_2 < 90\%$. Based on the rationale that early aggressive airway management reverses the deleterious effects of hypoxia, it would be reasonable to expect that RSI would have a positive impact on TBI. However, our study and others found adverse outcomes following RSI in patients with severe TBI contrary to the assumption that aggressive airway management is associated with better outcomes. A large prospective, randomised

trial is warranted to yield insight into the best airway management of a TBI patient and how various techniques influence outcome. However, ethics approval is a challenge in conducting such a trial as many consider endotracheal intubation to be a standard of care in severe TBI.

Author contributions. SS was responsible for writing the manuscript while HBH and HG were responsible for the study design and critical revision of the manuscript. CU was responsible for the statistical input.

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