Clinical paper

Prehospital endotracheal intubation in patients with severe traumatic brain injury: Guidelines versus reality?


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The international Brain Trauma Foundation guidelines recommend prehospital endotracheal intubation in all patients with traumatic brain injury (TBI) and a Glasgow Coma Scale (GCS) ≤ 8. Close adherence to these guidelines is associated with improved outcome, but not all severely injured TBI patients receive adequate prehospital airway support. Here we hypothesized that guideline adherence varies when skills are involved that rely on training and expertise, such as endotracheal intubation.

We retrospectively studied the medical records of CT-confirmed TBI patients with a GCS ≤ 8 who were referred to a level 1 trauma centre in Amsterdam (n = 127). Records were analyzed for demographic parameters, prehospital treatment modalities, involvement of an emergency medical service (EMS) and respiratory and metabolic parameters upon arrival at the hospital.

Patients were mostly male, aged 45 ± 21 years with a median injury severity score (ISS) of 26. Of all patients for whom guidelines recommend endotracheal intubation, only 56% were intubated. In 21 out of 106 severe cases an EMS was not called for, suggesting low guideline adherence. Especially those TBI patients treated by paramedics tended to develop higher levels of stress markers like glucose and lactate.

We observed a low degree of adherence to intubation guidelines in a Dutch urban area. Main reasons for low adherence were the unavailability of specialized care, scoop and run strategies and absence of a specialist physician in cases where intubation was recommended. The discrepancy between guidelines and reality warrants changing practice to improve guideline compliance and optimize outcome in TBI patients.

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1. Introduction

The prognosis of patients with severe traumatic brain injury (TBI) and a low Glasgow Coma Scale (GCS) strongly relies on early support of vital functions. In particular, prehospital prevention of hypoxia by adequate respiratory management including endotracheal intubation, normoventilation and prevention of aspiration is strongly associated with improved outcome in these patients. Prehospital airway management of TBI patients is well defined in national and international trauma rules, all based on the guidelines of the Brain Trauma Foundation (BTF). Despite these guidelines, not all severely injured TBI patients are endotracheally intubated prior to arrival at the emergency department of the trauma centre. Although Hesdorffer et al. reported significant improvement of guideline adherence in the last few years, compliance has remained relatively low and ranged from 16 to 33% in other studies. This may have affected patient outcome, since guideline implementation has demonstrated a marked reduction in mortality.

Most studies investigating the implementation of prehospital intubation guidelines in TBI patients are performed in the USA, and the results may not always be applicable for smaller European countries like The Netherlands. The Netherlands comprises several urban areas with short travelling distances of less than 15 min from trauma scenes towards level 1 trauma centres. This geographic situation, together with the specific Dutch prehospital health care system comprises mixed prehospital strategies of ‘scoop and run’ and ‘stay and play’. Furthermore, it is questioned which determinants influence guideline adherence, and how this may affect the health status of the patient upon arrival at the emergency department. Dutch paramedic teams act according to national ambulance guidelines and law enforcements, and may
only intubate patients when application of drugs facilitating intubation like anaesthetics or muscle relaxants is unnecessary, e.g. in case of cardiopulmonary arrest or when airway reflexes are completely absent.\textsuperscript{10} In all trauma patients with severe to moderate TBI, a specialised emergency medical service (EMS) should primarily be requested by the alarm centre. Furthermore, an EMS should be requested by paramedics who are present at the trauma scene in order to assure appropriate respiratory support when necessary. These emergency medical services are staffed by anaesthesiologists or trauma surgeons and act, in contrast to paramedics, according to the BTF guidelines. The discrepancy between Dutch prehospital intubation guidelines for paramedics and the BTF prehospital guideline may typically result in suboptimal treatment of TBI patients. We therefore investigated the degree of guideline adherence of paramedics and emergency physicians as well as other factors that may influence the adherence in severely injured TBI patients who were transported to an urban level 1 trauma centre. Furthermore, we evaluated the association between guideline adherence and the health state of the patient upon arrival at the emergency department. With this study we aimed to provide support for closing the gap between guidelines and reality in prehospital care of patients with severe neurologic injury.

2. Materials and methods

2.1. Patient characteristics

Our retrospective study includes data from patients with CT-scan confirmed traumatic brain injury (TBI). All patients were primarily admitted to the Emergency Department of the VU University Medical Center Amsterdam during the period 2003–2007. Data were obtained after approval of the Local Human Subjects Committee of the VU University Medical Center. Study parameters were obtained from the electronic hospital admission register and patient medical records. The initial search of the register found 272 patients of which 231 TBI patients were eligible for further analysis. Patients were excluded when they were younger than 16 years of age or in case of a missing Glasgow Coma Scale (GCS) at the trauma scene. In all patients, arterial blood pressure and peripheral oxygen saturation continuously were documented at a 5-min interval at the accident scene and during the prehospital period. Patients were assigned to three groups according to the level of Glasgow Coma Scale (GCS). The group of severe TBI patients included subjects with a GCS \( \leq 8 \), the moderate TBI group consisted of patients with a GCS >8 and \( \leq 13 \) and the mild TBI group included subjects with a GCS >13.

2.2. Prehospital treatment guidelines

Patients were either treated in accordance with the guidelines of the paramedic ambulance service or emergency medical service (EMS). Dutch paramedics are trained based on the Dutch national ambulance guidelines from the National Ambulance Protocol Foundation (Stichting LAMP).\textsuperscript{10} These guidelines advise to intubate all patients with a GCS of 3 who have no reflexes, while patients with a GCS of 4–8 require the presence of an EMS team that consists of a physician and a specialized nurse to assure proper endotracheal intubation and mechanical ventilation. Thus, guidelines and law enforcement prohibit endotracheal intubation by a paramedic in patients with present airway reflexes. Furthermore, EMS physicians are trained to treat TBI patients in the prehospital phase according to the ‘Guidelines for the prehospital management of traumatic brain injury’ from the Brain Trauma Foundation.\textsuperscript{9} Briefly, these guidelines recommend maintenance of a systolic blood pressure of >90 mmHg and an oxygen saturation of >92%. Furthermore, patients with a GCS \( \leq 8 \) should be intubated at the trauma scene. Of importance, an EMS team was not available for 24 h per day during the study period. Due to the urban level of the Amsterdam service area, the average time between the trauma incident and arrival in a level 1 trauma centre was less than 1 h.

2.3. Data collection and definitions

Patients records were evaluated for the following variables: year and date of trauma, presence of Emergency Medical Service (EMS) at the trauma scene, availability of EMS, reason for traumatic injury, age, sex, reported Glasgow Coma Scale (GCS), injury severity score (ISS), presence of an endotracheal tube at ED arrival, pupil reflexes, incidence of a hypotensive or hypoxic event at the trauma scene or during transportation (Lifepack 12, summary Emergency Medical Service), need for acute surgery, and TBI-related mortality in the post-trauma period. Furthermore, \( P_aO_2, P_aCO_2 \), glucose, pH and lactate levels were recorded upon arrival at the Emergency Department. Probability of survival was determined by the Major Trauma Outcome Score,\textsuperscript{17} the TARN outcome prediction parameter\textsuperscript{18} and the Medical Research Council (MRC) CRASH score.\textsuperscript{19} TBI was defined as brain tissue injury caused by external mechanical force confirmed by CT analysis. A disturbed pupil reflex was defined as an unilateral or bilateral failure of pupil reflexes. A hypotensive or hypoxic event was defined as one or more episodes of hypotension (systolic blood pressure (SBP) < 90 mmHg) or hypoxia (\( O_2 \) saturation < 92%) in the prehospital phase, independent of endotracheal intubation. Mortality was defined as TBI-related death.

2.4. Statistical analysis

GCS and ISS values were rated by two independent researchers. Variables are presented as mean \( \pm \) standard deviation or mean \( \pm \) standard error of the mean where appropriate. Non-parametric variables like the Glasgow Coma Scale (GCS) and injury severity score (ISS) are presented as median and interquartile range. Parametric data were analyzed by ANOVA, whereas Chi-square, Kruskal–Wallis or Mann–Whitney tests were used to compare non-parametric variables. A \( P \)-value of <0.05 was considered statistically significant.

3. Results

3.1. Patient characteristics

The study included 231 TBI patients aged 16 years and older. Patients were typically male (71%) and the average age was 45 \( \pm \) 21 years. Major causes of TBI were fall from a height (32%), bicycle accident (15%), car accident (10%) and motorcycle/moped accidents (8%). From these 231 patients, 127 presented with severe brain injury (GCS \( \leq 8 \)), 40 with moderate brain injury (GCS = 9–13) and 64 with mild brain injury (GCS = 14–15). Demographic variables of the total population are presented in Table 1.

3.2. Adherence to prehospital intubation guidelines

In compliance with prehospital intubation guidelines, it was expected that all patients in the severe category would be intubated in the prehospital phase. Fig. 1 demonstrates the number of endotracheal intubations in the severe category who were primarily referred to the VU University Medical Center and with complete medical dossiers with respect to EMS support (\( n = 106 \)). Of these patients, 52 were treated by an ambulance team whereas the EMS supported prehospital care in 54 patients. Fig. 1 depicts the number of patients who were endotracheally intubated prior to arrival.
Table 1
Characteristics of all patients with traumatic brain injury (TBI) divided according to GCS values (n = 231). Values are presented as mean ± SD or median with interquartile range. The number of valid cases is presented in brackets. GCS: Glasgow Coma Scale; ISS: injury severity score; EMS: emergency medical service; ICU: intensive care unit.

<table>
<thead>
<tr>
<th>TBI</th>
<th>Severe</th>
<th>Moderate</th>
<th>Mild</th>
</tr>
</thead>
<tbody>
<tr>
<td>Included number of patients</td>
<td>127</td>
<td>40</td>
<td>64</td>
</tr>
<tr>
<td>Age (years)</td>
<td>45 ± 21</td>
<td>49 ± 20</td>
<td>51 ± 20</td>
</tr>
<tr>
<td>Males/females</td>
<td>93/34</td>
<td>30/10</td>
<td>42/22</td>
</tr>
<tr>
<td>Median GCS</td>
<td>3 (3–5)</td>
<td>12 (10–13)</td>
<td>15 (14–15)</td>
</tr>
<tr>
<td>Involvement EMS</td>
<td>54 (n = 112)</td>
<td>3 (n = 29)</td>
<td>3 (n = 55)</td>
</tr>
<tr>
<td>Intubated patients</td>
<td>71 (n = 127)</td>
<td>0 (n = 40)</td>
<td>0 (n = 64)</td>
</tr>
<tr>
<td>Secondary referral</td>
<td>6 (n = 127)</td>
<td>5 (n = 40)</td>
<td>14 (n = 64)</td>
</tr>
<tr>
<td>Need for acute surgery</td>
<td>95 (n = 127)</td>
<td>24 (n = 40)</td>
<td>29 (n = 64)</td>
</tr>
<tr>
<td>ICU admission</td>
<td>109 (n = 127)</td>
<td>16 (n = 40)</td>
<td>13 (n = 64)</td>
</tr>
</tbody>
</table>

*P < 0.01 versus GCS ≤ 8.

Table 2
Representation of the number of endotracheally intubated or non-intubated traumatic brain injury (TBI) patients with a GCS ≤ 8 when an emergency medical service (EMS) was available or unavailable. Values in brackets represent the number of patients treated by the EMS.

<table>
<thead>
<tr>
<th></th>
<th>EMS unavailable</th>
<th>EMS available</th>
</tr>
</thead>
<tbody>
<tr>
<td>No endotracheal intubation</td>
<td>25</td>
<td>21 (6)</td>
</tr>
<tr>
<td>Endotracheal intubation</td>
<td>5</td>
<td>54 (48)</td>
</tr>
</tbody>
</table>

Fig. 1. This figure depicts the number of patients with severe traumatic brain injury (TBI) who were endotracheally intubated in the prehospital phase prior to arrival at the emergency department. Our data shows that 44% of patients with a Glasgow Coma Score (GCS) ≤ 8 did not receive an endotracheal tube in the prehospital phase.

3.3. Medical status according to the prehospital treatment level

Patient data were further examined for complicating events (Table 3; n = 106). There was no difference in the occurrence of a disturbed pupillary reflex, a hypoxic event and mortality between paramedic and EMS-treated patients. However, the present study was not powered to reveal these differences. There was a significant lower occurrence of hypotension in TBI patients treated by paramedics only (P = 0.01 versus EMS treated patients) but the observed difference may have been due to the requirement for administration of drugs to allow intubation. TBI-related mortality rates in the study population were similar in ambulance and EMS treated TBI patients. Interestingly, observed survival rates were slightly higher as compared to the survival probability as predicted by MTOS, TARN and the 14-day mortality rate calculated by CRASH, in particular in EMS-treated patients. Fig. 2 represents a more detailed analysis of intubated versus not-intubated TBI patients with a GCS ≤ 8 treated by paramedics or the EMS. Intubated patients treated by EMS trended to have higher P O2 and lower P CO2 values, and lower glucose (P = 0.12) and lactate (P = 0.07) levels. Low patient numbers however prohibited retrieval of statistically significant differences.

We finally analyzed differences in clinical values of patients with a GCS = 3 and complete EMS data records (n = 74). In this group, endotracheal intubation is obligatory under all circumstances. However, paramedic-treated patients were less frequently intubated (P < 0.001) and had higher glucose and lactate levels (both P < 0.05; Table 4).

4. Discussion

4.1. Prehospital intubation guidelines in severely injured TBI patients

Accurate intubation guideline application during prehospital management of severely injured TBI patients is associated with reduced morbidity and mortality.15,16,20 In this context, endotracheal intubation of patients with a Glasgow Coma Scale (GCS) ≤ 8 was recommended by the European Resuscitation Council (ERC)15 as a part of the guidelines released in 2005. However, the current study shows that such an approach is not always followed in clinical practice.
is recommended by the Brain Trauma Foundation in all cases.\textsuperscript{9} Recent literature however reveals controversy regarding optimal prehospital airway management.\textsuperscript{21} First, endotracheal intubation may lead to a transition of ‘scoop and run’ into ‘stay and play’, with a consequent prolongation of the prehospital treatment phase. Secondly, there is evidence that early endotracheal intubation may increase mortality if subsequent ventilation is inadequate.\textsuperscript{7,22} In particular, hyperventilation following intubation results in hypocapnia with serious consequences for brain function.\textsuperscript{14} Positive pressure ventilation may reduce cardiac output, especially in hypovolemic patients, and any reduction of venous return from the brain to the heart during ventilation may critically increase intracranial pressure. In addition, hypocapnia decreases cerebral blood flow resulting in cerebral ischemia and deteriorated patient outcome.\textsuperscript{23–25} Thus, endotracheal intubation must be followed by normoventilation which requires knowledge and expertise in mechanical ventilation. The Dutch ambulance guidelines for TBI therefore only recommend endotracheal intubation by paramedics in patients with a GCS = 3. For all other patients with an indication for endotracheal intubation in the prehospital phase (GCS 4–8) it is recommended to summon an emergency physician team which is trained according to the BTF recommendations. This study however shows that the EMS team was not called for in some patients where endotracheal intubation was necessary, thereby providing suboptimal care to patients at risk for severe complications of their neurologic injury. International guidelines for prehospital treatment of patients with severe traumatic brain injury (TBI) recommend immediate endotracheal intubation, thereby reducing the incidence of hypoxia and improving patient outcome. In particular, patients with GCS values below 9 should be intubated in all cases. Here we show low adherence to intubation guidelines in severely injured TBI patients located in an urban area of The Netherlands. Although low compliance was sometimes caused by the unavailability of specialized care, an emergency medical service (EMS) team was not always called for in cases where intubation would have been indicated, thereby possibly leading to suboptimal prehospital care. Moreover, EMS support was associated with more physiological pO\textsubscript{2}, pCO\textsubscript{2}, glucose and lactate values, thereby suggesting that improvement of hemodynamic and respiratory function in TBI patients is better assured when paramedics are supported by an EMS physician. The study was underpowered to show a clear relation between suboptimal prehospital treatment and outcome, but the observed survival rates were comparable with predicted outcome scores. The discrepancy between guidelines and reality warrants re-evaluation of prehospital management of severely injured TBI patients who require endotracheal intubation.

4.2. Reasons for low adherence to intubation guidelines in the prehospital phase

The two major reasons for low adherence to international intubation guidelines for severely injured TBI patients in our population were unavailability of an EMS on the one hand and solitary patient treatment by paramedics without calling for EMS support on the other hand. In the period 2003–2007, governmental regulations restricted EMS availability to daytime. In the remaining hours, patient treatment is provided by ambulance paramedics. About one third of our patients with severe TBI were treated in the period where an EMS was unavailable, which may have lead to suboptimal treatment of these TBI trauma patients. Our findings support the recent broadening of the flight hours of EMS teams in The Netherlands towards 24-h availability. However, in 20% of the cases, ambulance paramedics independently treated severely injured TBI patients while an EMS team was available but not called for.

Moreover, only half of the patients with severe TBI were endotracheally intubated, and the lowest adherence to intubation guidelines was found in patients treated by ambulance paramedics. In case of a primary request for EMS support by the alarm centre, the EMS team would arrive within 20 min at the trauma scene. However, we found several cases showing that an EMS was not requested by the alarm centre but only requested for by paramedics at the trauma scene, thereby delaying specialized patient care with respect to endotracheal intubation and mechanical ventilation. Furthermore, in some patients an EMS was not alarmed at all, thereby prohibiting appropriate respiratory support in severely injured patients. Thus, guideline adherence might improve when EMS team are more frequently alarmed on a primary base by the alarm centre. Since our population lives in an urban area, short travel distances are guaranteed, irrespective of the presence of an EMS. Indeed, almost all TBI patients included in our study were transported to a trauma centre within 1 h after the incident. In some cases, the call for EMS support may lead to increased transportation time and unwanted transition of ‘scoop and run’ into ‘stay and play’ when the trauma scene was located near a level 1 trauma centre but far from the area where the EMS helicopter was stationed. Variability in international prehospital healthcare systems does not allow comparison of our findings with international literature, and our
specific geographic situation including an urban area with short travelling distances to a level 1 trauma centre is unique. Several reports however suggest that there should be an exclusive role for an EMS to secure rapid sequence induction followed by intubation and adequate mechanical ventilation.26–28

4.3. Possible consequences of low adherence to intubation guidelines in TBI patients

Although we observed that guideline adherence was relatively low in severe TBI patients with an indication for endotracheal intubation, observed survival rates were comparable to predicted outcome values using MTOS, TARN or CRASH irrespective of treatment by ambulance or EMS-treated.17–19 However, there were differences observed between ambulance and EMS treated patients regarding respiratory and metabolic parameters. Patients treated by an EMS team showed higher $P_{aO_2}$ levels and lower glucose and lactate levels upon arrival at the emergency department. Stress hyperglycaemia is common in critically ill patients and is considered part of a systemic response triggered by an increase in cortisol, glucagon, catecholamines and cytokines.29–32 Hyperglycaemia may additionally aggravate pathophysiological pathways, thereby compromising the already impaired cerebral microcirculation and promoting the development of cerebral ischemic areas. Higher levels of glucose additionally have a prognostic value related to poorer outcome.33 Furthermore, serum lactate levels were higher in paramedic treated patients, which might be due to increased anaerobic glycolysis during ischemia irrespective of the intracerebral pressure.34,35 Thus, elevated levels of glucose and lactate in patients treated by paramedics may be an indication for relatively more compromised brain function.36 Differences in respiratory and metabolic parameters could not be explained by differences in the injury severity, since median ISS levels were even higher in EMS treated patients. Finally, the incidence of hypotensive events in the prehospital phase was more abundant in EMS treated patients, which might be due to medication used for endotracheal intubation. Our results suggest that current prehospital management strategies of TBI patients are related to patient outcome comparable with international figures. However, our results indicate higher physiological stress parameters in paramedic treated patients, suggesting that prehospital care by an EMS might be more appropriate in severe TBI patients.

In summary, our results show a discrepancy between guidelines and reality in prehospital treatment strategies of severe TBI patients. Although our data are underpowered to relate low adherence to prehospital guidelines with patient outcome, we showed trends towards respiratory and metabolic deterioration in patients who were treated without consideration of prehospital intubation guidelines. With this study we raise the question that the discrepancy between guidelines and practice in the Netherlands may affect the treatment of TBI victims. Our results warrant a re-evaluation of the ambiguity in prehospital intubation guidelines in our country and advocate optimization of EMS participation in the care for severely injured TBI patients in the prehospital phase.

Conflict of interest statement

None to declare.

References