PERIODICUM BIOLOGORUM
VOL. 127, No 1–2, 89–92, 2025
DOI: 10.18054/pb.v127i1-2.35798

UDC 57:61
CODEN PDBIAD
ISSN 0031-5362

Review article

Early airway management in patients with severe traumatic brain injury

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Keywords: airway management; traumatic brain injury; intubation

Abbreviations

AIS score – abbreviated injury severity score
CI – confidence interval
C-spine – cervical spine
ETI – endotracheal intubation
GCS – Glasgow Coma Scale
ICP – intracranial pressure
OR – odds ratio
RSI – rapid sequence intubation
TBI – traumatic brain injury

Received March 28, 2025
Revised June 12, 2025
Accepted July 15, 2025

Abstract

Background and purpose*: Traumatic brain injury (TBI) is the main cause of death and disability in injured patients. Airway management in these patients is challenging because unsuccessful endotracheal intubation (ETI) can lead to hypoxemia, hypercapnia, and consecutive secondary brain damage. The aim of this review is to answer the questions about appropriate airway management in patients with severe TBI.*

Materials and methods: *We searched the PubMed database using keywords of our paper: „airway management", „traumatic brain injury" and „intubation". During the period from January 2010 to January 2025, 213 articles were published, relevant for this review.*

Discussion: *The difficulty of obtaining an airway in patients with TBI is a consequence of presence of airway reflexes and muscular tone, the necessity to maintain cervical spine stabilization, and presence of blood and secretions in the upper airway. Influence of ETI on intracranial pressure and cerebral blood flow can also determine outcome. An alternative way for airway management is the use of supraglottic airway devices. Rapid sequence intubation (RSI) as a form of ETI for patients with severe TBI is an appropriate choice with the use of sedatives, hypnotics, opioid analgesics, and muscle relaxants to prevent an increase in intracranial pressure. ETI in patients with cervical spine injury should be done using manual in-line stabilization and video laryngoscope.*

Conclusions: *Airway management in patients with severe TBI is essential because it can influence mortality. TBI patients with airway compromise must be identified, and airway must be secured early to ensure ventilation and oxygenation.*

INTRODUCTION

Traumatic brain injury (TBI) is a leading cause of death and disability of injured patients. The incidence of TBI is higher in developing countries as well as mortality rate of TBI *(1).* Purpose of the airway management is to maintain oxygenation and ventilation and to prevent secondary brain injury *(2).*

The aim of this review is to answer the questions of prehospital airway management in patients with severe TBI, if endotracheal intubation (ETI) is indicated, whether it should be done in prehospital or in-hospital setting and how ETI should be performed in in-hospital settings.

MATERIALS AND METHODS

We searched the PubMed database using keywords of our paper: „airway management", „traumatic brain injury" and „intubation". The

literature search was done in February 2025. During the period from January 2010 to January 2025, 213 articles were published, relevant for this review.

Traumatic brain injury and secondary brain injury

Primary brain injury is a consequence of external force, when energy of external force is transferred to brain tissue. Secondary brain injury develops during minutes and hours after primary injury and it is a result of hypoxia, hypotension, hypo/hypercapnia, hypo/hyperglycemia, hypo/hyperthermia and seizure *(3)*. The way of prevention of secondary brain injury is optimization of oxygenation and ventilation, blood pressure management, as well as blood sugar, body temperature, intracranial pressure and electrolyte level regulation *(4)*.

Airway management in severe TBI

The ETI upon the first medical contact of a severe TBI patient is a reasonable approach. Severe TBI is associated with loss of airway reflexes and increased risk of inhalation of gastric and pharyngeal contents. ETI failure can lead to respiratory arrest, secondary brain injury and aspiration which finally result in development of early-onset ventilator-associated pneumonia. Early airway management should have a protective role. However, meta-analysis of Fevang et al. *(5)* have questioned this practice. According to this study, prehospital ETI significantly increases the mortality in trauma patients with a Glasgow Coma Scale (GCS) score ≤ 8. Effective prehospital care should provide key interventions when indicated and proceed to the most appropriate hospital with minimum delay *(6)*.

Brain Trauma Foundation Guidelines from 2016 *(3)*, defined severe TBI as a TBI in patients with GCS score equal or less than 8. Prehospital management of severe TBI consists of basic maneuvers for airway maintenance such as forehead tilt- chin lift and jaw trust maneuver. If there is possibility for oropharyngeal tube use, it is recommended, as well as bag-mask ventilation. Nasopharyngeal tube is not recommended in patients with suspected fracture of the skull basis. Supraglottic devices (laryngeal mask) can be used if there are trained personnel. It is also indicated definitive airway management with endotracheal intubation (ETI) if personnel are equipped and trained. But the use of anesthetics and sedatives in prehospital settings is not clear.

Guidelines from 2023 *(1)* about prehospital airway management of patients with severe TBI aren't significantly different except early application of continuous mask oxygen. Oxygen is applied even there is no signs of hypoxemia, but it is obligatory if peripheral oxygen saturation (SpO2) is less than 90% or if cyanosis occurs. It is necessary to monitor continuously SpO2. Use of additional devices for airway management is also recommended. If personnel are equipped for ETI management, it should be done. However, it is necessary also to monitor end-tidal CO2 and to maintain CO2 values from 35 to 45 mmHg. Medications used for ETI are not regarded.

Prehospital endotracheal intubation

However, question about relation of prehospital ETI and outcome in patients with severe TBI is still not answered. Study of Bernard et al. from 2010 *(7)* open the possibility of early prehospital ETI and favorable effect on outcome in patients with TBI. The aim of the study was to determine whether paramedic ETI in patients with severe TBI improves neurological outcome at 6 months, compared with in-hospital ETI. There were no differences in: ICU length of stay, length of hospitalization, or in survival to hospital discharge. In adults with severe TBI, prehospital RSI by paramedics increases the rate of favorable neurologic outcome at 6 months, compared with in-hospital ETI. The authors didn't emphasize the relationship with prehospital ETI and incidence of cardiac arrest. 12 years later, meta-analysis of Anderson et al. *(8)* didn't prove benefits of prehospital ETI. Knapp et al. *(9)* in their retrospective cohort study confirmed that normocapnia on admission, but not prehospital ETI, is strongly associated with reduced probability of mortality.

European practice of airway management in patients with severe TBI is not uniform. Multicenter, prospective cohort study of Gravesteijn et al. *(10,11,12)* is done from 2014 to 2017 and included 3878 patients from 18 European countries and Israel. The probability of ETI increased with younger age, lower pre-hospital or emergency department GCS, higher abbreviated injury severity (AIS) scores (head and neck, thorax and chest, face or abdomen AIS score), and one or both unreactive pupils. The presence of anesthetist was independently associated with more pre-hospital intubation (OR 2.9, 95%CI 1.3-6.6), in contrast to the presence of ambulance personnel who are allowed to intubate (OR 0.5, 95%CI 0.3-0.8). In the same study, prehospital ETI was associated with better functional outcome in patients with higher thorax and abdominal AIS scores (P=0.009 and P=0.02, respectively). In-hospital ETI was associated with better functional outcome in patients with lower Glasgow Coma Scale scores (GCS≤10) (P=0.01).

Prehospital ETI in TBI has been proposed as a potential life-saving intervention for patients with severe TBI to mitigate hypercapnia and hypoxemia. Shafique et al. *(13)* conducted a systematic review and meta-analysis to assess the effects of prehospital ETI versus in-hospital ETI on morbidity and mortality in patients with severe TBI. 24 studies, comprising 56 543 patients are included. There wasn't significant difference in mortality between prehospital and in-hospital ETI (OR 0.89, 95% CI 0.65–1.23, p = 0.48), although substantial heterogeneity was noted. Morbidity analysis also showed no significant dif-

ference (OR 0.83, 95% CI 0.43–1.63, p = 0.59). Careful interpretation of data due to heterogeneity is necessary. Initial assessment did not reveal any apparent disparity in mortality rates between individuals who received prehospital ETI and in-hospital ETI. Subsequent analyses and randomized control trials demonstrated that patients who underwent prehospital ETI had a reduced risk of death and morbidity.

In-hospital endotracheal intubation

If in-hospital ETI is preferred, how should it be done? According to available studies, protocols for rapid sequence intubation (RSI) should be applied. RSI is endotracheal intubation with fast achievement of neuromuscular relaxation and decreased risk of aspiration. RSI imply use of sedatives, hypnotics, opioids and neuromuscular relaxants. As hypoxemia and hypotension worsen outcomes in TBI, an appropriate drug selection for RSI limits the hemodynamic consequences and adverse responses due to laryngoscopy/intubation. The aim is to prevent increase of intracranial pressure (ICP) and cerebral blood flow. According to different studies, there are different protocols for RSI in severe TBI.

To minimize secondary brain injury, patient's comorbidities, volume status, and associated injury should be considered while selecting induction agents. Upper airway stimulation during laryngoscopy and intubation increases ICP due to an increase in sympathetic adrenergic stimulation, resulting in hypertension. Appropriate choice of induction anesthetics is of utmost importance.

Drugs used intravenously for RSI in TBI patients mostly depends on hemodynamic state of the patient. Propofol (1-2 mg/kg) is preferred in patients without hemodynamic compromise, as well as sodium-thiopentone (3-5 mg/kg) *(14,15).* Ketamine (1 mg/kg) is useful in patients with hemorrhagic shock. Etomidate (0.3 mg/kg) doesn't cause hemodynamic disturbances. In terms of neuromuscular blockers, there is no recommendations for succinylcholine neither rocuronium. Succinylcholine (1-1.5 mg/kg) causes transient and slight elevation in ICP, but it has negligible clinical significance. Advantage of its use is short duration of action. Rocuronium (1 mg/kg) doesn't change intracranial hemodynamic, but its prolonged action made it inconvenient for early neurological assessment. The use of intravenous lidocaine (1-1.5 mg/kg) and fentanyl (1-3 mcg/kg) with induction agents can be considered to blunt laryngoscopy response *(3).*

Airway management in traumatic brain injury patients with cervical spine injury

Cervical spine (C-spine) injury is common in patients with severe TBI (5-6 %) *(2,3).* TBI patients are approximately 4-fold more likely to have additional C-spine injuries than those without head injury *(2,3).* Airway management in these patients is performed with manual in-line stabilization and RSI. Manual in-line stabilization is a maneuver during airway management when the assistant maintains the patient's head in a neutral position while fixing it against the force exerted during ETI. However, manual in-line stabilization can reduce mouth opening and lead to poor laryngoscopic view. For better visualization, video laryngoscopes can be used. Video laryngoscopy decrease C-spine movement during laryngoscopy, but the duration of ETI can be prolonged. Awake fiberoptic bronchoscope-guided intubation can be procedure of choice when the operator is skilled.

CONCLUSIONS

Airway management in patients with severe TBI needs preparation and coordinated team approach. ETI in prehospital settings is performed if there are experienced rescuers. In-hospital RSI should be done with careful choice of medications according to hemodynamic state of the patients. ETI in patients with cervical spine injury should be done using manual in-line stabilization and video laryngoscopes to prevent spinal cord injury. TBI patients with airway compromise must be identified, and airway must be secured early to ensure ventilation and oxygenation.

Acknowledgements*: Author contributions: T.N. made a conception of research, T.I. wrote the original draft, A.G.B. provided study materials, S.B. revised the original draft. All the authors reviewed the final manuscript.*

Data availability: The authors confirm that the data supporting the findings of this study are available within the article.

Ethical Declarations: not applicable.

Funding: The authors declare that no funds, grants, or other support were received during the preparations of this manuscript.

Competing interests: The authors declare no competing interests.

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