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Selected Topics: Prehospital Care

EARLY-ONSET VENTILATOR-ASSOCIATED PNEUMONIA IN SEVERE TRAUMATIC BRAIN INJURY: IS THERE A RELATIONSHIP WITH PREHOSPITAL AIRWAY MANAGEMENT?

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☐ Abstract—Background: Prehospital airway management in severe traumatic brain injury (TBI) is widely recommended by international guidelines for the management of trauma. Early-onset ventilator-associated pneumonia (EOVAP) is a common occurrence in this population and can worsen mortality and functional outcome. Objectives: In this retrospective observational study, we aimed to evaluate the association between different prehospital airway management variables and the occurrence of EOVAP. Secondarily we evaluated the correlation between EOVAP and mortality and neurological outcome. Methods: The study retrospectively evaluated 223 patients admitted from 2010 to 2017 in our trauma intensive care unit for severe TBI. The population was divided into three groups on the basis of the airway management technique adopted (bag mask ventilation, laryngeal tube, orotracheal intubation). Uni- and multivariate logistic regression analyses were performed using the occurrence of EOVAP as the dependent variable, to investigate potential associations with prehospital airway management. Results: A total of 131 episodes (58.7%) of EOVAP were registered in the study population (223 patients). Laryngeal tube and orotracheal intubation were used in patients with significantly lower Glasgow Coma Scale score on scene and a higher Face Abbreviated Injury Scale; advanced airway management significantly increased the total rescue time. The prehospital airway management technique adopted, prehospital type of sedation or use of muscle relaxants, type of transport, and rescue times were not associated with the occurrence of EOVAP. Conclusions: Prehospital airway management does not have a significant impact on the occurrence of EOVAP in severe TBI patients. Similarly, it does not have a significant impact on mortality or long-term neurological outcome despite increasing duration of mechanical ventilation, intensive care unit, and hospital stay.

☐ Keywords—traumatic brain injury; ventilator-associated pneumonia; risk factors; prehospital emergency care; emergency medical services

INTRODUCTION

Traumatic brain injury (TBI) is a leading cause of mortality and long-term disability in trauma patients. Clinically severe TBI is defined by a Glasgow Coma Scale (GCS) value of 8 or less; in these patients, orotracheal intubation is broadly recommended (1).

The rationale of airway management with orotracheal intubation in TBI patients is related to the protection of the airway from inhalation of oropharyngeal and gastric contents due to the loss of airway protective reflexes. Moreover, controlling oxygenation and ventilation

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reduces the risk of brain hypoxia and secondary cerebral injuries. The most appropriate strategy to manage the airway is still a matter of discussion; recent evidence suggests that prehospital intubation does not modify, or may increase, mortality in trauma patients (2–5). However, TBI management is a particularly complex scenario where convincing and definitive evidence on the issue of airway management is still lacking. The introduction in recent years of supraglottic airway devices in the field of prehospital medicine further complicates this scenario. To overcome the issue of heterogeneity of data reporting in emergency services worldwide, Sollid et al. proposed a consensus-based template to uniform reporting of data from prehospital advanced airway management (6).

Early-onset ventilator-associated pneumonia (EOVAP) is a common occurrence in TBI patients, with an incidence ranging from 24% to 60% (7,8). Recent evidence suggests that this complication can worsen cerebral oxygenation, and its occurrence is an independent risk factor for worse neurologic outcomes (8). The risk factors for EOVAP in TBI patients are not completely established, and the implications of different prehospital airway management techniques on the occurrence of EOVAP in this specific population has not been investigated so far.

The primary objective of this retrospective observational study was to evaluate the difference in the incidence of EOVAP among patients managed with orotracheal intubation, a supraglottic airway device, or noninvasive airway management (spontaneous breathing or bag mask ventilation [BMV]). Only the occurrence of EOVAP was considered in this study; in fact, a plausible correlation between a prehospital macro- or microaspiration and the subsequent pneumonia could be envisioned for EOVAP rather than late-onset VAP.

Secondary objectives were the evaluation of the mortality, the duration of mechanical ventilation, the hospital stay, and the outcome, described as Glasgow Outcome Scale, for the different prehospital airway management strategies.

MATERIALS AND METHODS

After Institutional Review Board Approval (approval number: CE 17167), we conducted a monocentric retrospective study including all the patients admitted to Carlo Alberto Pizzardi Hospital - Bologna Italy for severe TBI and subsequently transferred to the Trauma intensive care unit (ICU) from January 2010 to July 2017.

Setting

Carlo Alberto Pizzardi Hospital is an Italian Trauma Hub receiving trauma patients from the Bologna district, a mixed urban and rural area with a population of 1,009,210 and an overall population density of 272.6 inhabitants/km^2. It is one of the three trauma centers of the Emilia Romagna region, and houses a Helicopter Emergency Medical Service (HEMS) covering an area with a population of approximately 2,000,000 inhabitants, which involves the Modena, Ferrara and Imola districts.

Globally, the Trauma ICU accepts about 250 critical trauma patients per year. The Emergency Medical Services of Bologna district is composed of 44 ambulances equipped with rescuers, 16 ambulances equipped with trained nurses, 10 medical cars equipped with an emergency physician and a nurse, one HEMS, and a second helicopter with Search and Rescue equipment (HEMS/SAR) carrying a physician (an Anesthesia and Intensive Care specialist) and a nurse.

The prehospital management of TBI follows the European Trauma Course guidelines (https://www.erc.edu/courses/european-trauma-course), and emergency personnel are periodically retrained, whereas in-hospital management of severe TBI follows the Brain Trauma Foundation guidelines. All Emergency Medical Services (EMS) Advanced Life Support teams (physician and nurse) are provided with the same equipment, which includes orotracheal tubes and laryngeal tubes as the only supraglottic devices for airway management, cricothyroidotomy sets, drugs for sedation (midazolam, fentanyl, ketamine), and neuromuscular blocking agents (succinylcholine and rocuronium).

Intermediate-level ambulances have one nurse as highest-level health care provider, and are equipped only with supraglottic devices and do not carry sedatives except for morphine, nor neuromuscular blocking agents.

Ventilator-associated pneumonia prevention at our unit consists of semi-recumbent patient positioning, daily sedation discontinuation for neurological evaluation when appropriate, strict hand hygiene, oral care with chlorhexidine and cuff pressure control every 8 h, early enteral feeding, and unit-specific microbiological surveillance.

A Clinical Pulmonary Infection Score (CPIS) > 6 during ICU stay triggers the collection and culture of an endotracheal aspirate. EOVAP was defined as a clinical pulmonary infection score > 6 during the first 7 days of hospital stay after trauma, and then confirmed by microbiological criteria. In the absence of a positive bacteriological sample, EOVAP was diagnosed when the CPIS > 6 could not be explained by pulmonary edema, pulmonary embolism, or atelectasis.

Inclusion and Exclusion Criteria

Inclusion criteria were: age over 18 years old, GCS on scene < 9, Head Abbreviated Injury Scale > 2, and mechanical ventilation ≥ 48 h. Exclusion criteria were: survival < 72 h.

Collected Data

- Patient's data: age and sex.
- Personnel and devices on scene: highest provider level, airway devices available, available drugs, type of transport, rescue time (time from emergency call to Emergency Department [ED] arrival).
- Prehospital clinical data recorded at first observation: type of trauma, indication to airway management, respiratory rate, first recorded peripheral oxygen saturation on scene, first heart rate recorded on scene, first GCS score recorded on scene, revised trauma score, drugs used for induction, type of airway device inserted, procedural sedation, procedural neuromuscular blockade, and number of intubation attempts.
- Hospital data: injury severity score, antibiotic exposure during the first 24 h after trauma, presence of EOVAP (see above for definition), microbiologic data of collected specimens, duration of mechanical ventilation, ICU stay, hospital stay, 30-day mortality, and 6-month Glasgow Outcome Scale score.

The microbiological criterion used for EOVAP confirmation was a positive culture of an endotracheal aspirate specimen with a bacterial growth threshold of 1×10^6 colony-forming units/mL (9). All extra-hospital data were retrieved from the prospectively compiled database of the Bologna EMS/HEMS (FileMaker Pro; FileMaker Inc., Santa Clara, California). The intrahospital data were collected from the Italian ICU outcomes database (Prosafe GiViTi - Istituto di Ricerche Farmacologiche "Mario Negri"- Villa Camozzi (BG) Italy), also prospectively compiled, data missing from the Prosafe database were collected from the hospital electronic records and from the Italian trauma registry (10). After appropriate training, three physicians blinded to the study hypothesis were involved in data collection. Interrater reliability of pivotal data elements was judged high because most of the elements extracted (e.g., microbiologic culture results, ICU stay, mortality) did not require any interpretation, and these data were all registered prior to the beginning of this study.

Statistical Analysis

The study population was divided into three groups on the basis of the airway management adopted in the prehospital setting (no airway management/BMV, laryngeal tube, orotracheal intubation). Statistical analyses were performed using Stata/SE 14.1 for Windows (StataCorp LLC, College Station, Texas); continuous variables were expressed as mean ± standard deviation or medians and interquartile range; categorical data were expressed as numbers (percentages). For the continuous variables, a one-way analysis of variance test was used, and the Kruskal-Wallis test when appropriate. For the categorical variables, the chi-squared test was used. Univariate logistic regression analyses were performed using the occurrence of EOVAP as dependent variable and the candidate risk factors object of study as independent variables. All the variables presenting an association to the occurrence of EOVAP with a $p < 0.3$ were included in a multivariate model built with a stepwise removal of the less significant variable. The final model was chosen on the basis of the lowest Akaike's Information Criteria and Bayesian Information Criteria values. All p values refer to two-tailed tests of significance; $p < 0.05$ was considered significant.

RESULTS

During the observation period, a total of 282 patients met the inclusion criteria for this study. Within this pool of patients, within the first 72 h of hospitalization, 52 patients died, and 7 were transferred to other hospitals and therefore excluded. The remaining 223 patients were considered for the analysis and divided into groups according to the prehospital management of the airways.

Table 1 synthesizes the study population characteristics on the basis of the airway management technique adopted. The patients not having the airway managed invasively in the prehospital setting had a significantly higher median GCS, lower Face Abbreviated Injury Scale, and they were more frequently managed by less-trained personnel and transported on ground ambulances. Prehospital airway management significantly increased the total time of rescue. Our data show a minimal difference between the rescue time when a laryngeal tube was used, compared with orotracheal intubation. This difference is probably due to the common use of a supraglottic device as a rescue airway in case of failed orotracheal intubation; in fact, in only 18% of cases this was the first device used.

During the study period, the relative distribution of the airway management did not significantly differ (Figure 1). The most commonly used drugs for sedation were midazolam plus fentanyl or midazolam plus ketamine; in 16% of cases airway management was attempted without sedation (Figure 2). Procedural neuromuscular blockade was used in 36% of cases. All patients, once admitted to the ED, received orotracheal intubation by the hospital trauma team if the airway had not been previously secured in this way. No patient required early or emergency tracheostomy in the ED.

Table 1. The Descriptive Statistics of the Study Population

	No Airway Device/BMV (n = 43)	Laryngeal Tube (n = 33)	Orotracheal Tube (n = 147)	*p* Value
Total rescue time (min)	40 (30–55)	59 (47.50–72.50)	60 (50–70)	<0.001*
First GCS recorded on scene	7 (5–8)	5 (4–6)	5 (3–7)	<0.001*
First heart rate recorded on scene (beats/min)	90 (70–105)	92 (80–105)	100 (85–120)	0.016*
First SpO_2 recorded on scene (%)	96.5 (90–98.5)	90 (80–96)	93 (85–98)	0.035*
RTS	8.02 ± 1.60	8.09 ± 1.68	7.99 ± 1.69	0.947
Age (years)	48.42 ± 21.92	49.27 ± 19.40	45.09 ± 18.89	0.403
Sex (male)	31 (72.1%)	25 (75.8%)	102 (69.4%)	0.752
Trauma category				
Blunt trauma	43 (100%)	33 (100%)	147 (100%)	1.000
Drugs available on scene, n (%)				<0.001*
Analgosedation and curarization	39 (90.7%)	33 (100%)	147 (100%)	
None	4 (9.3%)	0 (0%)	0 (0%)	
Airway devices available on scene, n (%)				
Supraglottic devices and tracheal tubes	39 (90.7%)	33 (100%)	147 (100%)	<0.001*
Supraglottic devices only	4 (9.3%)	0 (0%)	0 (0%)	
Highest provider level on scene, n (%)				<0.001*
Nurse	4 (100%)	0 (0%)	0 (0%)	
Physician - Nonanesthetist	21 (19.1%)	24 (21.8%)	65 (59.1%)	
Physician - Anesthesia Resident	4 (21.1%)	7 (36.8%)	8 (42.1%)	
Physician - Anesthesia and Intensive Care specialist	14 (15.6%)	2 (2.2%)	74 (82.2%)	
Number of intubation attempts, n (%)				<0.001*
0	41 (95.3%)	6 (18.2%)	0 (0%)	
1	0 (0%)	8 (24.2%)	114 (77.6%)	
2	1 (2.3%)	14 (42.4%)	28 (19%)	
≥ 3	1 (2.3%)	5 (15.2%)	5 (3.4%)	
Type of transport n (%)				<0.001*
Ground ambulance	34 (22.8%)	30 (20.1%)	85 (57%)	
Helicopter ambulance	9 (12.2%)	3 (4.1%)	62 (83.8%)	
Procedural analgosedation, n (%)	15 (34.9%)	32 (97%)	139 (94.6%)	<0.001*
Procedural neuromuscular blockade, n (%)	0 (0%)	1 (3%)	80 (54.4%)	<0.001*
Antibiotic exposure during the first 24 hours, n (%)	19 (44.2%)	10 (30.3%)	54 (36.7%)	0.453
EOVAP, n (%)	28 (65.1%)	22 (66.7%)	81 (55.1%)	0.304
Microbiologic criterion, n (%)	23 (53.5%)	15 (45.5%)	64 (43.5%)	0.515
Hospital stay (days)	34.40 ± 43.76	35.52 ± 33.92	49.20 ± 77.45	0.321
ICU stay (days)	13.49 ± 9.93	13.67 ± 9.16	15.16 ± 10.12	0.527
Ventilation length (days)	10.30 ± 9.07	10.55 ± 8.45	11.61 ± 8.16	0.596
30-day mortality, n (%)	9 (20.9%)	7 (21.2%)	32 (21.8%)	0.992
1-year mortality, n (%)	17 (39.5%)	7 (21.2%)	38 (25.9%)	0.139
GOS 6 months				0.653
1 - Death	9 (20.9%)	8 (24.2%)	34 (23.1%)	
2 - Persistent vegetative state	3 (7.0%)	4 (12.1%)	16 (10.9%)	
3 - Severe disability	8(18.6%)	8 (24.2%)	37 (25.2%)	
4 - Moderate disability	14 (32.6%)	5 (15.1%)	25 (17.0%)	
5 - Low disability	9 (20.9%)	8 (24.2%)	35 (23.8%)	
ISS	30.47 ± 11.08	32.97 ± 13.12	35.07 ± 13.43	0.115
H-AIS	5 (4–5)	5 (4–5)	5 (4–5)	0.909
F-AIS	0 (0–1.25)	0 (0–2)	1 (0–2)	0.003*
T-AIS	2 (0–3.25)	2 (0–3)	3 (0–4)	0.217
A-AIS	0 (0–0)	0 (0–0)	0 (0–1)	0.636
SC-AIS	0 (0–2)	0 (0–2)	0 (0–3)	0.534
E-AIS	0 (0–0)	0 (0–0)	0 (0–0)	0.120

BMV = bag mask ventilation; GCS = Glasgow Coma Scale; RTS = Revised Trauma Score; EOVAP = early-onset ventilator-associated pneumonia; ICU = intensive care unit; GOS = Glasgow Outcome Scale; ISS = Injury Severity Score; H-AIS = Head Abbreviated Injury Scale; F-AIS = Face Abbreviated Injury Scale, T-AIS = Thoracic Abbreviated Injury Scale, AAIS = Abdominal Abbreviated Injury Scale, SC-AIS = Skeletal Abbreviated Injury Scale, E-AIS = External Abbreviated Injury Scale.
* $p < 0.05$.

EOVAP appeared in 131 patients (58.7%); in 102 cases the endotrnacheal aspirate specimen culture was positive, and in 31 of the 102 episodes (30.4%), the culture revealed a multimicrobial infection. The microbiological data of the episodes of pneumonia are displayed in Table 2, a cut-off of 10^6 colony-forming units was used to consider the sample positive for infection. Univariate logistic regression analysis showed a significant association between age, sex, and EOVAP development. Multivariate logistic regression analysis considering all the variables

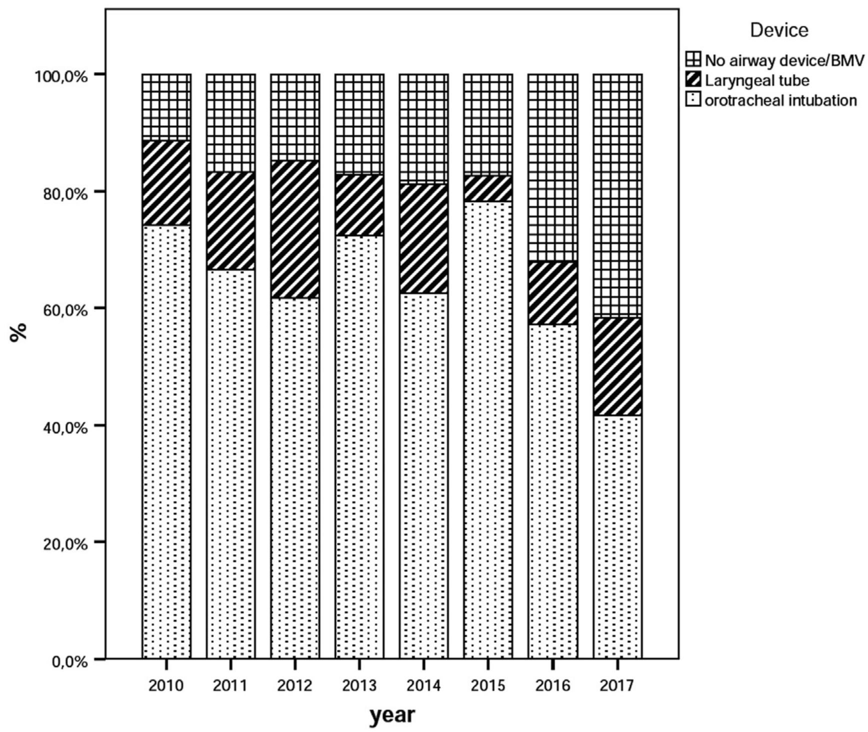

Figure 1. Airway management devices distribution during the study period.

associated with EOVAP with a p value < 0.3 confirmed only age and sex as risk factors for EOVAP development (Table 3). Table 4 displays the differences in length of mechanical ventilation, ICU, and hospital stay, and outcomes between patients who developed EOVAP and those who did not, regardless of prehospital airway management.

DISCUSSION

Evaluating the impact of prehospital management in trauma is a very complicated task, considering the complexity of traumatized patients and the heterogeneity of Emergency Medical Services worldwide. The

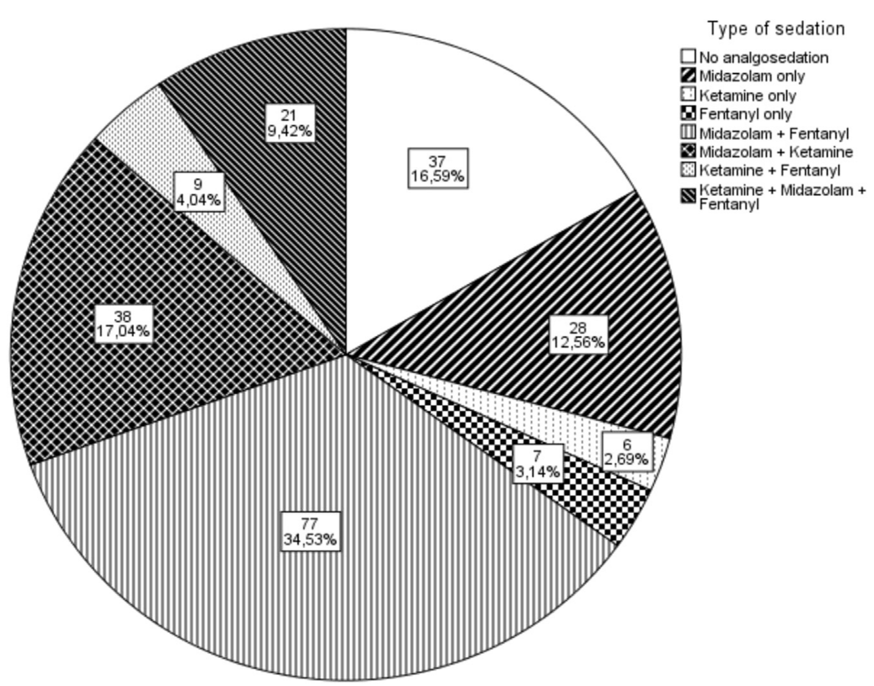

Figure 2. Sedative regimens used for rapid sequence induction.

Table 2. Microbiological Data

Microorganism	Positive Cultures n (%)
Staphylococcus aureus MSSA	43 (29.7%)
Staphylococcus aureus MRSA	2 (1.4%)
Streptococcus pneumoniae	7 (4.8%)
Haemophilus influenzae	27 (18.6%)
Pseudomonas aeruginosa	13 (9%)
Escherichia coli	15 (10.3%)
Klebsiella species (*Oxytoca/pneumoniae*)	12 (8.3%)
Other Gram negative	25 (17.2%)
Enterococcus spp	1 (0.7%)
Total	145

MSSA = methicillin-sensitive *Staphylococcus aureus*; MRSA = methicillin-resistant *Staphylococcus aureus*.

management of a traumatized patient involves different means and times of transport to the ED and different personnel in the prehospital and hospital environment, varying in training and competence. Finally, the prehospital setting involves more environmental variables than the intrahospital one. For these reasons, drawing definite conclusions from the literature is particularly difficult.

The rationale for invasive airway management in the comatose traumatized patient is very strong, and to this date, guidelines suggest this intervention. However, in the past two decades, several studies have started questioning this widely spread practice, showing its association with a higher mortality when compared with airway management in the ED (5). More recent literature suggests that prehospital airway management conducted by skilled personnel and with procedural sedation may have a beneficial role in reducing mortality and improving neurological long-term outcome in severe TBI (11–13). Also, a slight difference in results seems to appear between European and North American EMS systems, which may be related to the different staffing and training of EMS personnel in these two macro areas (5).

In this context, supraglottic devices represent an alternative way to manage the airways for less-trained personnel, or in case of orotracheal intubation failure; although their safety in contrast to no airway management and orotracheal intubation still has to be demonstrated. Supraglottic devices, by definition, lack an endotracheal cuff, which is considered to be the gold standard for the protection of the respiratory tract from aspiration. It must be underlined that new supraglottic devices, and notably, the laryngeal tube, used on the patients in this

Table 3. Logistic Regression Analysis

Variable	Univariate Logistic Regression		Multivariate Logistic Regression	
	Or (95% CI)	*p* Value	Or (95% CI)	*p* Value
Age	0.98 (0.97–1.00)	0.008	0.98 (0.97–0.99)	0.020*
Sex (m)	1.89 (1.05–3.39)	0.033	1.79 (0.98–3.28)	0.005*
Type of transport (helicopter ambulance)	0.96 (0.55–1.69)	0.892		
GCS	1.06 (0.92–1.24)	0.424		
RTS	1.01 (0.86–1.18)	0.946		
ISS	1.01 (0.99–1.03)	0.510		
T-AIS ≥ 3	0.78 (0.46–1.33)	0.358		
F-AIS ≥ 3	1.35 (0.67–2.72)	0.402		
Airway management				
Laryngeal tube	1.59 (0.72–3.51)	0.251	1.57 (0.70–3.50)	0.274
Orotracheal tube	1.38 (0.68–2.81)	0.378		
Number of intubation attempts				
1	1.34 (0.36–5.05)	0.663		
2	1.09 (0.31–3.75)	0.897		
≥ 3	1.41 (0.369–5.36)	0.618		
Total rescue time	1.00 (0.98–1.01)	0.647		
Highest provider level on scene				
Physician - Nonanesthetist	1.39 (0.19–10.2)	0.746		
Physician - Anesthesia Resident	1.71 (0.20–15.02)	0.626		
Physician - Anesthesia and Intensive Care specialist	1.43 (0.19–10.63)	0.725		
Procedural analgosedation	0.91 (0.44–1.85)	0.788		
Procedural neuromuscular blockade	0.82 (0.47–1.44)	0.494		
Antibiotic exposure during the first 24 hours	1.15 (0.66–1.99)	0.621		

Male sex is associated with a higher incidence of early-onset ventilator-associated pneumonia (EOVAP). Increasing age is not associated with EOVAP.
OR = odds ratio; CI = confidence interval; GCS = Glasgow Coma Scale; RTS = Revised Trauma Score; ISS = Injury Severity Score; T-AIS = Thoracic Abbreviated Injury Scale; F-AIS = Face Abbreviated Injury Scale.
* $p < 0.05$.

Table 4. EOVAP and Outcomes

	EOVAP (n = 131)	No EOVAP (n = 92)	*p* Value
Ventilation length (days)	11 (8–16)	7.5 (3–12.5)	<0.001*
ICU stay (days)	14 (10–21)	9 (5–18.5)	0.001*
Hospital stay (days)	25 (13–69)	17.5 (7.5–36.5)	0.002*
GOS			0.068
1 - Death	22 (16.8%)	28 (30.8%)	
2 - Persistent vegetative state	16 (12.2%)	8 (8.8%)	
3 - Severe disability	37 (28.2%)	16 (17.6%)	
4 - Moderate disability	28 (21.4%)	16 (17.6%)	
5 - Low disability	28 (21.4%)	24 (26.1%)	

EOVAP = early-onset ventilator-associated pneumonia; ICU = intensive care unit; GOS = Glasgow Outcome Scale.
* $p < 0.05$.

study, seem to provide some sort of protection of the airways. However, these properties have been established only in experimental anesthesia models, and never in the prehospital environment (14,15). Also, a recent study evaluated the performance of supraglottic devices compared with BMV and endotracheal intubation during cardiopulmonary resuscitation, establishing a net superiority of the endotracheal tube in terms of protection from aspiration. The same study, however, also showed some benefit provided by the laryngeal tube over other supraglottic devices and BMV (16).

Early-Onset Pneumonia

The primary objective of this study was to evaluate the impact of different prehospital airway management on EOVAP development in patients with TBI. Incidence of EOVAP in our population was 58.7%, and etiology distribution was in line with literature data for severe TBI (7,8). The statistical analysis did not demonstrate any significant association between the type of prehospital airway management, analgesia, sedation, use of muscle relaxants, or prehospital rescue times and EOVAP; only the age and sex of patients reached significance in the multivariate analysis. Previous studies found that younger age, injury severity score, gastric content aspiration, therapeutic hypothermia, and positive culture of an endotracheal aspirate at hospital admission are significant risk factors for EOVAP (7,8). This study only partially confirmed these data with regard to a younger age being a protective factor (also some associated interventions in previous studies, such as hypothermia, or early tracheal aspirates upon admission, were not in use at our center during the study period).

This finding seems to favor the hypothesis that in comatose TBI patients, micro- or macroinhalation of oropharyngeal contents occurs prior to, or despite, the efforts of the EMS team to manage the airway. This probably limits the possibility to prevent the pathophysiologic events inducing EOVAP in these patients. This hypothesis seems to be confirmed by a recent open-label interventional study from Mohr et al., which failed to demonstrate a significant effect of the administration of oral chlorhexidine prior to orotracheal intubation in trauma patients, in reducing the CPIS, tracheal colonization, clinical pneumonia incidence, and mortality (17).

Secondary Outcomes

The secondary outcomes (mortality, duration of mechanical ventilation, length of hospital stay, and Glasgow Outcome Scale) did not show any statistically significant difference among the three groups. However, in critical trauma patients, many factors could modify strong outcome variables, such as hospital stay and mortality, so it is difficult to demonstrate significant effects of prehospital maneuvers in small populations. The development of EOVAP significantly increased the length of mechanical ventilation, ICU, and hospital stay.

The rationale for early invasive airway management is mainly related to improving oxygenation and ventilation, reducing secondary brain injury. This has been documented in other studies, showing improved neurological outcomes with better early airway management (5,11,13). These results were not confirmed in this study. However, it must be noted that the three groups had a statistically significant difference in the first recorded GCS and peripheral O_2 saturation in the field, showing better values in both the BMV and laryngeal tube groups. These results indicate a probable selection bias toward worse patients being managed with a tracheal tube rather than the other two approaches.

Finally, our data show a significantly lower rescue time for patients whose airways were not managed invasively, but it must be noted that in all three groups, overall rescue time is within 60 minutes from the activation of the EMS system. This is a marker of the good performance of the EMS system and of a geographically favorable environment (high population density and smaller distances), and may make it more difficult to show significant effects on outcomes of prehospital management changes.

Provider Experience

A recent meta-analysis from Bossers et al. demonstrated that the provider's experience in orotracheal intubation has a significant effect on mortality in TBI (12). In fact, prehospital intubation performed by insufficiently skilled personnel was associated with increased odds ratio for mortality; whereas attempts from more skilled providers did not increase the odds ratio for mortality. In our sample, the analysis did not show any difference regarding the training of the health care provider involved in the rescue on the incidence of EOVAP. The EMS system in question is staffed to a large percentage (almost 50%) by Anesthesia and Intensive Care specialists or last-year residents; therefore, most of the personnel involved in these rescues can provide a high level of expertise in airway management.

Limitations

The main limitation of this study consists of its retrospective nature, despite the databases being prospectively compiled, the heterogeneity in the patient sample, and the irregular distribution of the three types of airway management. Furthermore, the sample originated from a single center and patients were all treated in a single ICU. All patients who died within the first 72 h of hospitalization were excluded from the study, which may have introduced bias in the sampling. Also, the sample size may have been underpowered to detect differences in outcomes, which were smaller than expected.

To be able to draw definite conclusions and possibly influence clinical practice, more high-quality evidence is needed in this field of research. At the moment, it is the authors' opinion that it would not be possible to design an interventional study in this particular field. We consider orotracheal intubation to be the gold-standard technique for airway protection and ventilation control, so, when possible, it cannot be withheld from patients.

CONCLUSIONS

EOVAP is a very frequent complication in severely brain-injured trauma patients, with a significant impact on their hospital stay and prognosis (8). The risk factors for this clinical entity are still poorly understood, and previously proposed preventive strategies failed to demonstrate a significant reduction in terms of incidence. Despite the rationale of an association between nonoptimally prehospital protected airways and the occurrence of EOVAP in TBI patients, this study did not demonstrate an association between the prehospital airway management technique adopted or other prehospital factors and the occurrence of EOVAP. Considering the significant incidence and impact of EOVAP in TBI patients, further studies are required to highlight EOVAP risk factors and their possible management strategies.

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ARTICLE SUMMARY

1. Why is this topic important?

Early-onset ventilator-associated pneumonia occurrence is a frequent event in severe traumatic brain injury patients; moreover, recent evidence suggests that it could worsen functional outcome.

2. What does this study attempt to show?

This study evaluated how prehospital airway management could influence the occurrence of early-onset ventilator-associated pneumonia in severe traumatic brain injury patients.

3. What are the key findings?

Prehospital airway management with orotracheal intubation, use of supraglottic devices or bag mask ventilation, as well as sedation and neuromuscular blockade for rapid sequence induction do not seem to be significantly associated with early-onset pneumonia occurrence.

4. How is patient care impacted?

Despite its strong rationale, and being still recommended by international guidelines, invasive airway management does not have an impact on the occurrence of early-onset ventilator-associated pneumonia.