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Physician-based on-scene airway management in severely injured patients and in-hospital consequences: is the misplaced intubation an underestimated danger in trauma management?

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ABSTRACT

Background Endotracheal intubation (ETI) is the gold standard for the out-of-hospital emergency airway management in severely injured patients. Due to time-critical circumstances, poor patient presentation and hostile environments, it may be prone for mechanical complications and failure.

Methods In a retrospective study (January 2011 to December 2013), all patients who underwent out-of-hospital ETI before admittance to a level 1 trauma center were analyzed consecutively. Patients with supraglottic airways, being under cardiopulmonary resuscitation and interfacility transports were excluded. The main study endpoint was the incidence of unrecognized tube malposition; secondary endpoints were Glasgow Outcome Scale (GOS) and in-hospital mortality adjusted to on-scene Glasgow Coma Scale (GCS), Injury Severity Score (ISS), Abbreviated Injury Scale head (AIS head), and on-scene time.

Results Out of 1176 patients, 151 underwent out-of-hospital ETI. At hospital admission, tube malpositions were recognized in nine patients (5.9%). Accidental and unrecognized esophageal intubation was detected in five patients (3.3%) and bronchial intubation in four patients (2.7%). Although ISS (p=0.053), AIS head (p=0.469), on-scene GCS (p=0.151), on-scene time (p=0.530), GOS (p=0.748) and in-hospital mortality (p=0.431) were similar compared with correctly positioned ETI tubes, three esophageal intubation patients died due to hypoxemic complications.

Discussion In our study sample, out-of-hospital emergency ETI in severely injured patients was associated with a considerable tube misplacement rate. For safety, increased compliance to consequently use available technologies (eg, capnography, video laryngoscopy) for emergency ETI should be warranted.

Level of evidence Level of Evidence IIA.

BACKGROUND

Out-of-hospital emergency endotracheal intubation (ETI) is the gold standard in severely injured patients who require advanced airway management.[1–3] It represents an important skill in emergency medical service (EMS) and is recognized as a quality indicator.[4] Due to potential risk of severe complications which includes multiple intubation attempts, inadvertent esophageal or bronchial intubation, transient hypoxia, airway edema and bleeding, and tracheal aspiration, out-of-hospital ETI is discussed controversially.[5 6] The aim of our study was to determine the prevalence and outcomes of patients who experienced tube malpositioning after emergency out-of-hospital ETI due to severe injuries.

METHODS

After approval by the ethical committee of the Medical Faculty of the University Hospital Leipzig (No 137-15-20042015), we analyzed all electronic and paper-based medical charts of patients who were admitted to our university emergency department (ED) with trauma team activation between January 1, 2011 and December 31, 2013.

Investigated variables

Patient characteristics included age, gender, injury patterns, Abbreviated Injury Scale head, Injury Severity Score (ISS), Glasgow Coma Scale (GCS) on scene, and on-scene time (OST, time from EMS arrival until hospital admission). Patients <16 years, with supraglottic airways, being under cardiopulmonary resuscitation and interfacility transports were excluded. The main study endpoint was the incidence of unrecognized tube malposition (esophageal and endobronchial intubation); secondary endpoints were Glasgow Outcome Scale (GOS) and in-hospital mortality adjusted to injury severity, head injury and OST.

Setting

In Germany, out-of-hospital emergency treatment of patients with major trauma is provided by EMS physicians. In the current 'Guideline on the Treatment of the Severely Injured' the intubation is indicated in polytraumatized patients with apnea or snap breathing and recommended in patients with hypoxia (SpO_2 <90%), a traumatic brain injury (GCS <9), a trauma-associated hemodynamic instability (RR systolic <90 mm Hg) or after severe thorax trauma with respiratory insufficiency. However, some EMS physicians perform out-of-hospital intubation in case of severe pain after major trauma.[7] In the receiving ED, the trauma team consists of traumatologists, visceral surgeons, neurosurgeons, anesthetists and radiologists due to national recommendations.[7] Primary and secondary surveys are performed according to advanced trauma life

Table 1 Demographic data

	All patients (n=151)	Successful ETI (n=142)	Tube malposition (n=9)	P value
Age (years)*	43±23, 40 (16–91)	42±23, 36 (16–91)	43±17, 43 (19–74)	0.448
Male gender, n (%)	105 (69)	93 (65)	7 (78)	0.321
GCS*	8±5, 7 (3–15)	8±4, 7 (3–15)	10±5, 12 (3–15)	0.151
AIS head*	4±1, 4 (1–5)	3±1, 3 (1–5)	4±1, 3 (2–5)	0.469
ISS*	31±17, 25 (4–75)	30±17, 25 (4–75)	40±18, 38 (16–66)	0.053
OST* (min)	56±24, 51 (36–85)	56±25, 51 (36–145)	55±35, 36 (32–114)	0.530

*Mean±SD, median (min-max).
AIS, Abbreviated Injury Scale; ETI, endotracheal intubation; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; OST, on-scene time.

Table 2 Patients' characteristics of esophageal misplacements

Patient	Age	Gender	ISS	AIS head	GCS on scene	Trauma mechanism	Outcome
1	42	Male	66	3	3	Motor vehicle crash	Survived
2	43	Male	16	4	3	Fall from height	Deceased
3	74	Male	38	3	15	Motor vehicle crash	Deceased
4	57	Female	57	3	11	Fall from height	Deceased
5	48	Male	43	5	12	Fall from height	Survived

AIS, Abbreviated Injury Scale; GCS, Glasgow Coma Scale; ISS, Injury Severity Score.

support standard. All major trauma patients undergo multislice CT after focused assessment of sonography for trauma.

Statistics

Descriptive statistics was performed using numbers (percentage) and mean values (±SD). Computations used SPSS V.20 (SPSS) for Windows using X^2 test or Fisher's test for categorical variables. Normal distribution was tested using Student's t-test or Mann-Whitney test. Differences between the two groups were compared by using X^2 test for categorical variables and the t-test for continuous variables. The significance level was set up at $p<0.05$. Multivariate analysis was not performed due to low sample sizes.

RESULTS

During the 3-year study period, 1176 patients were admitted to our center and presented to our trauma team. One hundred and fifty-one patients (12.8%) underwent emergency out-of-hospital ETI by EMS physicians. Demographic data and patient's characteristics are displayed in table 1. Context of injuries were motor vehicle crash in 85.1%, falls from height in 10.4%, and 4.5% other trauma mechanisms. After hospital admission, 139 patients (92.1%) were classified as successfully intubated and in nine patients (5.9%) tube malpositions were recognized. Five patients (3.3%) had esophageal malpositions and four patients (2.7%) had mainstem malpositions (three right side, one left side). Esophageal malpositions were associated with three fatal outcomes (60.0%) and two patients had a GOS score of 3 and 4, respectively (table 2). Four esophageal malpositions were detected during primary survey after connecting to capnography and in one patient after a whole-body CT scan (table 3).

DISCUSSION

In this study, we investigated the prevalence and outcomes of tube malpositions of major trauma patients admitted to a level I trauma center after out-of-hospital ETI by EMS physicians. The incidence of misplaced ETI was 5.9% whereas esophageal misplacements are more likely to cause irreversible neurological sequelae and are often fatal due to inadvertent iatrogenic hypoxemia in contrast to mainstem bronchial misplacements. In the current literature, the reported incidence of unrecognized esophageal misplacements in out-of-hospital ETI is ranging from <1% up to 16.7% (table 4).

We did not select patients due to ISS, which can only be calculated after completion of diagnostic and thus may not be applied appropriately for acute patient triage. The study population reflected real-life presentations to the trauma team.

EMS physicians usually do not work in EMS only but attend several days per month. Thus, the performance of emergency ETI may vary considerably. EMS physicians perform ETI only once every 0.5–1.5 months depending on the type of EMS program (ground vs. helicopter EMS).[6 8] The needed number of ETIs prior to the active participation in EMS is still an area of debate: studies found between 75 and 150 performed ETI as a prerequisite to reach a high first-pass success.[8–10] Furthermore, video laryngoscopy showed improved intubation success rates in trauma patients.[11] Therefore, the recently revised German guideline on treatment of patients with severe and multiple injuries particularly recommends video laryngoscopy use and frequent training in emergency anesthesia, ETI, and alternative ways of securing an airway (including bag valve mask, supraglottic airway devices, and emergency cricothyrotomy).[11]

Detailed neurological outcomes of patients with delayed or unrecognized malpositioned tubes are not available.[2 7 12] In our study, patients who suffered from unrecognized tube misplacement had more unfavorable GOS in comparison to patients with successful airway management.

Esophageal intubation can be survived when spontaneous breathing is warranted. Due to the use of paralytics and anesthetic drugs, this may be impaired or impossible. Furthermore, the risk of tracheobronchial aspiration may be increased when the tube is removed from the esophagus. Therefore, direct laryngoscopy and ETI should be performed before esophageal placed tube removal. In four cases, the fatal esophageal misplacement was detected immediately after admission, but in one case due to spontaneous breathing despite tube obstruction the misplacement was found after a whole-body CT scan.

Table 3 Use of medication, blood gas analysis and evidence of anoxia

No	Anesthesia medication	Blood gas analysis	Evidence of misplacement
1	Midazolam, fentanyl	pH 7.18, pCO_2 50.3, pO_2 205.4, BE −9	Capnography in trauma room
2	Etomidat, propofol	pH 7.17, pCO_2 55.1, pO_2 80.2, BE −7	Whole-body CT scan
3	Propofol, midazolam, fentanyl, succinylcholin	pH 7.28, pCO_2 68, pO_2 443, BE 2.5	Capnography in trauma room
4	Piritramid	pH 7.1, pCO_2 47.1, pO_2 64.9, BE −10	Capnography in trauma room
5	Hypnomidate propofol, morphin	pH 7.16, pCO_2 52.4, pO_2 255, BE −9	Capnography in trauma room

Table 4 Case series of delayed detected or undetected inadvertent esophageal misplacement of tracheal tubes in out-of-hospital emergency medical service since 2000

Reference	Origin	Population	Study design	Patients	Esophageal (%)	EMS provider	Helicopter EMS	Outcome
Katz and Falk[13]	USA	Trauma	Pro	108	18 (16.7)	Paramedic	No	Unknown
Jones *et al*[14]	USA	Mixed	Pro	208	12 (5.8)	Physician	No	Unknown
Jemmett *et al* [15]	USA	Mixed	Pro	136	10 (9)	Paramedic	Yes	Unknown
Thierbach *et al* [7]	Germany	Mixed	Pro	598	0	Physician	No	NA
Wang *et al*[16]	USA	Mixed	Pro, mc	783	102 (13.8)	Mixed	Mixed	Unknown
Albrecht *et al* [17]	Switzerland	Mixed	Retro	762	1 (0.13)	Physician	Mixed	Survived
Helm *et al* [18]	Germany	Mixed	Pro	342	0	Physician	Yes	NA
Gunning *et al* [19]	Australia	Mixed	Pro	89	0	Physician	Yes	NA
Geisser *et al* [20]	Germany	Mixed	Retro	488	0	Physician	No	NA
Cobas *et al* [21]	USA	Trauma	Pro	203	25 (12)	Paramedic	No	17 died
Timmermann *et al* [6]	Germany	Mixed	Pro	149	10 (6.7)	Physician	Mixed	8 died, 2 survived
Wirtz *et al* [22]	USA	Mixed	Pro	132	11 (9)	Physician	Mixed	Died
Sollid *et al* [23]	Norway	Trauma	Retro	240	1 (0.4)	Physician	Yes	Died <24 hours
Nakstad *et al* [24]	Norway	Mixed	Pro	122	0	Physician	Yes	NA
Lockey *et al* [10]	UK	Trauma	Pro	472	7 (1.5)	Mixed	No	Unknown
Kamiutsuri *et al* [25]	Japan	Mixed	Retro	742	4 (0.5)	Physician	No	Unknown
Rognas *et al* [26]	Denmark	Mixed	Pro	734	31 (4.2)	Physician	No	Survived
Schöeneberg *et al* [27]	Germany	Trauma	Retro	166	14 (8.4)	Physician	Mixed	Unknown
Özkurtul *et al* 2019	Germany	Trauma	Retro	151	5 (3.2)	Physician	Mixed	3 died, 2 survived

EMS, emergency medical service; NA, not assayed.

Limitations of this study include the retrospective design which may have caused a study bias. The study was conducted at a single trauma center, and local structures can limit the interpretation of the results. Furthermore, the sample size is too small for multivariate logistic regression analysis. We did not include patients undergoing alternative airway devices (eg, laryngeal masks, laryngeal tubes or Combitubes) which may impair the interpretation of our results. Although all patients with tube malpositions underwent direct laryngoscopy using Macintosh blades, we did not investigate the rate of video laryngoscopy in our whole study collective and patients in the successful intubation group may have had more frequent use of video laryngoscopy. We did not particularly analyze the training levels of EMS physicians regarding ETI performance, which may have varied considerably. However, we present real-world data with all strengths and weaknesses.

CONCLUSION

We found a considerable incidence of unrecognized misplacements of endotracheal tube emergency ETI of severely injured patients in a physician-based out-of-hospital EMS setting. Further studies should be warranted to develop strategies for an improved ETI performance of EMS providers by consequent application of available technologies.

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Contributors OÖ conceived the study and designed the protocol. OÖ, SS and JF collected the data. OÖ, MFS and MB analyzed the data. CJ and HW supervised the conduct of the study and data collection. OÖ, MFS and MB drafted the article, and all authors contributed substantially to its revision. OÖ take responsibility for the article as a whole. All authors read and approved the final article.

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Patient consent for publication Not required.

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