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Factors influencing emergency intubation in the pre-hospital setting—a multicentre study in the German Helicopter Emergency Medical Service

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Background. Definitive airway control by endotracheal intubation (ETI) is standard of care in pre-hospital airway management. However, there are specific factors that may influence and complicate ETI.

Methods. Prospective, descriptive study at three German Helicopter Emergency Medical Services (HEMS) over a 1-yr period. We examined the success and complication rate for field intubation performed by trauma anaesthetists.

Results. In 342 patients (9.3%) ETI was performed. The overall success rate was 100%; in 87.4% the first attempt was successful, whereas in 11.1% a second and in 1.5% a third ETI attempt was necessary. No patient required a surgical intervention. Limited access to the patient was found upon arrival at the scene in 20.2% of the patients and in 9.6% of the patients at the time of ETI attempt. An orotracheal ETI technique was used in all patients. In the patients in whom only one ETI attempt was necessary for successful intubation, the assessment of ETI conditions was rated 'very good' or 'good' in 94.7%, but in those requiring a second or third ETI attempt this was reduced to 68.6 and 20.0%, respectively. Difficulties encountered during ETI included blood (19.9%), vomit/debris (15.8%) and secretions (13.8%) in the upper airway; anatomical reasons (11.7%), patient position (9.6%) and surrounding conditions (9.1%), making laryngoscopy more difficult.

Conclusions. Despite various factors increasing the difficulties in managing the airway in the field, definitive airway control by ETI seems to be safe practice.

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Introduction

Inadequate airway management is a major contributor to pre-hospital morbidity and mortality. Several studies examining pre-hospital deaths from trauma in the UK have shown that airway obstruction was thought to have contributed to death from major trauma in up to 85% of patients.[1 2] On the other hand, several studies have shown that trauma patients may profit from a definitive airway control by pre-hospital endotracheal intubation (ETI). Winchell and Hoyt[3] demonstrated an overall decrease in mortality from 36 to 26% with pre-hospital intubation of patients with multiple trauma and a decrease from 49 to 23% in patients with isolated severe traumatic brain injury. The need for definitive airway control in the pre-hospital setting has been established, with ETI being the gold standard.[4–6] However, in comparison to in-hospital airway management, pre-hospital airway management is more difficult because of a number of factors, such as limited equipment and monitoring, lack of skilled help, blood, vomit and debris in the upper airway, inadequate lighting, excessive noise and impaired patient access.[4] Therefore, pre-hospital airway management is difficult, even for anaesthetists with extensive experience in airway management.[4] There are a number of studies evaluating ETI in paramedic based emergency medical service (EMS) systems[7–10] but few in physician based EMS systems.[11]

The purpose of this study was to evaluate, within the German Helicopter Emergency Medical Service (HEMS) system, which is a physician based EMS system, the success rate of, and adverse factors influencing, pre-hospital ETI.

Methods

This was a prospective, descriptive study at three German HEMS over a 1-yr period (January 2002 to January 2003). The participating HEMS ('Christoph 22'/Ulm, 'Christoph 23'/Koblenz and 'Christoph 29'/Hamburg) are part of a nationwide network of rescue helicopters. Their medical teams consist of an experienced trauma anaesthetist and a flight paramedic from the Department of Anaesthesiology and Intensive Care Medicine of the corresponding military hospital.

All patients on whom ETI attempts were performed by the trauma anaesthetists during the study period were enrolled in the study. ETI attempts were performed according to the protocols of the respective HEMS. Emergency intubation was performed as a 'rapid sequence induction' (RSI), with preoxygenation and cricoid pressure followed by an induction agent and then suxamethonium. The airway was secured with endotracheal intubation and ventilation started. A non-depolarizing neuromuscular blocking drug was then given, together with appropriate sedation and analgesia. Some patients were intubated without a short acting depolarizing neuromuscular blocking drug. There was no rigid protocol regarding the use or dose of induction agent as this depended on individual patient factors, such as trauma, haemodynamic stability, age and entrapment. Patients with cardiac arrest and comatose patients (Glasgow-Coma-Scale 3) were intubated without any medication. Correct placement of tracheal tube was confirmed by visualization of tube passing the vocal cords, by auscultation and by capnography. Correct placement of the tube was confirmed by chest X-ray at hospital admission.

Each participating HEMS has a Difficult Airway Algorithm which the staff are trained to perform. We used the standard German pre-hospital data reporting record,[12] as a basis for data analysis. A specific ETI study questionnaire was completed by the trauma anaesthetist immediately after completing each mission and included on the patients' pre-hospital data reporting record. Details noted for each patient included initial diagnosis, intubation route, the patient's location at the scene and at the time of ETI attempt, the anaesthetic technique used, the number of ETI attempts, the laryngoscopic view[13] and the cause of any difficulties.

Data were collected on all patients, but the forms were anonymized. An investigator—the attending trauma anaesthetist at each HEMS—collected and checked all forms. For non-Gaussian distribution (gender and age of the patients, out-of-hospital diagnosis, number of attempts), we used nonparametric Mann–Whitney *U*-test. A probability value of <0.5 was considered significant. All values in the tables and figures are expressed as mean (SD) unless otherwise indicated.

Results

During the 12-month study period, 3669 patients were treated by the participating HEMS. Pre-hospital ETI was performed in a total of 342 patients (9.3%). A significant difference in the frequency of ETI was found between individual HEMS. At HEMS 'Christoph 29'/Hamburg (3.8%) intubation rate was significantly lower than at the two other HEMS (15.0% at HEMS 'Christoph 22'/Ulm and 10.0% at HEMS 'Christoph 23'/Koblenz; $*P<0.05$) (Table 1). The lower intubation rate at HEMS 'Christoph 29'/Hamburg is probably because of the area covered by this rescue helicopter (only the city area of Hamburg) being comparable with that of a ground ambulance system in a big city.

The overall success rate of ETI attempts was 100%. In 87.4% of the patients, the first attempt was successful, whereas 11.1% of the patients needed a second and 1.5% a third ETI attempt (Table 2). There was only one case in which an alternative airway device was used at some time. No patient within the study group required a surgical intervention for the airway. In all patients (100%) orotracheal ETI technique was performed. The indication for ETI and the method used are shown in Table 2. The induction agents used were etomidate (33%), thiopental (31%), fentanyl (21%), midazolam (19%) and ketamine (10%)—often in combination. In patients in whom only one ETI attempt was necessary, the view at laryngoscopy was grade I and II in 84.8% (Table 3). In patients in whom a second or third attempt was necessary, this was reduced to 57.9 and 40.0%, respectively ($*P<0.05$). Limited access to the patient, mainly because of entrapment, was found in 20.2% of the patients and this was present in 9.6% at the time of ETI attempt. A number of measures were performed to assist ETI (Table 4). Difficulties encountered during ETI included blood (19.9%), vomit and debris (15.8%), and hypersalivation (13.8%), anatomical reasons (11.7%), the patient's

Table 1 Comparison of patients at the participating HEMS. $*P<0.05$

	HEMS			
	Ulm	**Koblenz**	**Hamburg**	**Total**
Number of missions	1187	1130	1352	3669
Number of ETI	178 (15.0%)	113 (10.0%)	51 (3.8%)*	342 (9.3%)
Male	112 (62.9%)	73 (64.6%)	32 (62.7%)	217 (63.5%)
Female	66 (37.1%)	40 (35.4%)	19 (37.3%)	125 (36.5%)
Age (yr)	43.5 (25.3)	44.0 (22.4)	59.9 (23.5)*	45.6 (24.5)
Trauma	140 (78.7%)	80 (70.1%)	15 (29.4%)*	235 (68.7%)
Non-trauma	38 (21.3%)	33 (29.9%)	36 (70.6%)*	107 (31.3%)

Table 2 Number of ETI attempts for successful intubation, the application of alternative airway devices and performance of a surgical airway within the study population. *$P<0.05$

	HEMS			
	Ulm	**Koblenz**	**Hamburg**	**Total**
Number of ETI attempts				
One	164 (92.1%)	88 (77.9%)*	47 (92.2%)	299 (87.4%)
Two	13 (7.3%)	22 (19.5%)*	3 (5.9%)	38 (11.1%)
Three	1 (0.6%)	3 (2.6%)*	1 (1.9%)	5 (1.5%)
Route for ETI				
Orotracheal	178 (100%)	113 (100%)	51 (100%)	342 (100%)
Nasotracheal	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Alternative airway device (laryngeal mask)	1 (0.6%)	0 (0%)	0 (0%)	1 (0%)
Surgical airway (cricothyrotomy)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Indication for ETI (multiple choice)				
Pattern of injury	104 (58.4%)	52 (46.0%)	24 (47.1%)	167 (48.8%)
Low GCS	51 (28.7%)	38 (33.6%)	15 (29.4%)	99 (28.9%)
Respiratory insufficiency	49 (27.5%)	25 (22.1%)	11 (21.6%)	89 (26.0%)
Cardiac arrest	28 (15.7%)	25 (22.1%)	10 (19.6%)	77 (22.5%)
Method of ETI				
RSI	129 (72.5%)	75 (66.4%)	13 (25.5%)*	217 (63.5%)
Without relaxants	15 (8.4%)	7 (6.2%)	11 (21.6%)*	33 (9.7%)
Without any medication	34 (19.1%)	31 (27.4%)	27 (52.9%)*	92 (26.8%)

Table 3 Laryngoscopic view according to Cormack and Lehane[13] within the study population, depending on the number of ETI attempts necessary for successful intubation. *$P<0.05$

	Number of ETI attempts		
	First attempt	**Second attempt**	**Third attempt**
Laryngoscopic view			
Cormack I and II	290 (84.8%)*	22 (57.9%)*	2 (40.0%)*
Cormack III and IV	52 (15.2%)*	16 (42.1%)*	3 (60.0%)*

Table 4 Measures for ETI manoeuvres within the study population (multiple choice). OELM, optimal external laryngeal pressure; OSP, optimal sniff position

	(1) ETI attempt n_{tot}=299	**(2) or (3) ETI attempt n_{tot}=43**
Gum elastic bougie	280 (93.6%)	43 (100%)
OELM	243 (81.3%)	36 (83.7%)
OSP	79 (26.4%)	17 (39.5%)
Change length of blade	0 (0.0%)	10 (23.3%)
Suction	60 (20.1%)	18 (41.8%)
Bag-valve-mask ventilation	0 (0.0%)	11 (25.6%)

Table 5 Difficulties in context with ETI manoeuvre within the study population

	n	**%**
Blood	68	19.9
Vomit/debris	54	15.8
Hypersalivation	47	13.8
Anatomy	40	11.7
Trauma related anatomical changes	15	4.4
Patient position	32	9.4
Bright ambient light	31	9.1
Technical problems	10	2.9

location (9.6%) and surrounding conditions, for example, bright light making laryngoscopy more difficult (9.1%) (Table 5).

Discussion

Inadequate pre-hospital management of the compromised airway is a major contributor to pre-hospital morbidity and mortality. Hussain and Redmond[1] concluded, in their study examining pre-hospital deaths from trauma in the UK, that up to 85% of patients who die with survivable injuries before reaching hospital may do so because of airway obstruction. In another study, Nicholl and colleagues[2] have shown that airway obstruction was thought to have contributed to death from major trauma in 28% of patients treated by ambulance crews. Karch and colleagues[14] noted in their study of field intubation in trauma patients that, in nearly a quarter of the patients, intubation failure was most likely from gagging or combative patients. Definitive airway control by pre-hospital ETI is, therefore, not only essential, but also difficult to perform.[4]

Previous studies evaluating pre-hospital ETI have been mainly performed in US-American EMS systems by paramedic providers.[7–10] The success rates reported in these studies vary between 41.2[10] and 97.9%.[7] Furthermore studies have shown that the smaller the number, the better trained and the greater the experience of the personnel involved, the higher the intubation success rate.[15–17] There are only a few previous studies evaluating pre-hospital ETI by physician providers. Two French studies, a multi-centre study of physician staffed mobile ICUs of the Service d'Aide Medical Urgente in Paris[11] and a prospective in-field evaluation of ETI by EMSs physicians,[18] reported success rates of 99.1 and 97.4%, respectively. A study of pre-hospital RSI by HEMS doctors from London[19] reported an overall success rate of 98.3%. These results are similar to those in our study, where we found a 100% intubation success rate. The present study was performed at three different HEMS throughout Germany with some differences with respect to mission area (rural *vs* urban), mission tactics and patient population (trauma *vs* non-trauma cases), but in each the medical team consisted of a trauma anaesthetist and a flight paramedic, both members of the anaesthesiology department of the corresponding hospital. An important factor in our study may be that the number of anaesthetists and paramedics participating was small and they are all trained in trauma and work regularly as a team. The overall success rate of ETI at first attempt was 87.4%, which is at the upper end of the range reported in previous studies (57.9–98.9%).[11 16 19 20] Only 1.5% of the patients required a third attempt for successful intubation, and this again compares favourably with the reported values of 1.1–11%.[11 19]

As would be expected, the reported grade of laryngoscopy view was poorer in those patients with more attempts at ETI: I/II in 84.8% of patients with in whom the first ETI was successful and III/IV in 60.0% of patients in whom three attempts were necessary. A previous study[19] reported that emergency physicians recorded a greater number of patients as having grade III or IV than anaesthetists did (18% *vs* 5%).

There was only one patient in whom an alternative airway was used during the study. In this patient, after a failed ETI, a laryngeal mask was inserted and, after optimization of the patient's head position and optimal external laryngeal manipulation (OELM), a second ETI attempt was successful. This followed the local HEMS ('Christoph 22'/Ulm) difficult airway algorithm of a maximum of three intubation attempts, then insertion of a laryngeal mask. The laryngeal mask has been used successfully to secure the airway by UK paramedics.[21]

There was no need for a surgical intervention to secure an airway in the present study. A previous study at one of the participating HEMS ('Christoph 22'/Ulm) showed that this was only required once in 3000–3500 missions.[21] Previous studies have reported an incidence of tracheotomy of 0.6–2.2%[18 19] and 3.3–19%[23–26] for cricothyroidotomy.

The main reasons mentioned by paramedics for unsuccessful field intubation in previous US studies[14] have been patient gagging and patient combativeness or trismus in up to 38% of the cases, factors that were not observed within the present study. This may reflect differences in staffing and treatment philosophy where sedation and neuromuscular blocking drugs were used in the present study. The choice of sedation protocol for airway control in critically ill patients remains a source of controversy. In the present study, the majority of the patients underwent RSI with appropriate doses of i.v. induction agents and succinylcholine (63.5%) and a relatively small number (9.7%) with sedation only. In the French pre-hospital medical system only 8.8% of pre-hospital intubated patients were sedated using RSI,[11] most frequently with etomidate and midazolam.

One of the aims of this study was to identify, prospectively, specific factors that influenced pre-hospital ETI—the most common difficulties that were related to blood, vomit/debris and secretions (49.5%) and anatomical factors, either pre-existing or a result of trauma—in 16.1%. These are similar rates to those described in other studies.[20] A suction was used during ETI manoeuvre in 20.1% of the patients in whom the first ETI attempt was successful but in 41.8% of the patients in whom a second or third ETI attempt was necessary. These results underline the necessity and importance of a highly sufficient suction unit ready before ETI attempt and using large diameter suction catheters.

It is important that an optimal/best attempt at conventional laryngoscopy be made as early as possible. The definition of an optimal/best attempt at conventional laryngoscopy comprises a reasonably experienced endoscopist, no significant muscle tone, an optimal sniff position, the use of OELM in patients with laryngoscopic view grade either II, III or IV and the change of length of blade or type of blade.[27] Therefore, the overall high success rate—especially of the first ETI attempts—in this study, might be a result of meeting these criteria in a high percentage of the study population. We used a gum elastic bougie (93.6%) and OELM to overcome visualization and anatomical problems. OELM, which can improve the laryngoscopic view by at least a whole grade,[27] was performed in 81.3% of the patients in whom the first ETI attempt was successful and in 83.7% in whom a second or third ETI attempt was necessary. The definition of an optimal/best attempt at conventional laryngoscopy furthermore comprises that the patient should always be in an optimal sniff position. However, in the pre-hospital environment this is often not possible and we found limited accessibility to the patient in 9.6%, mainly caused by entrapment. Despite these circumstances, optimal sniff position was performed in this study population in 26.4% of the patients at the first ETI attempt and in 39.5% of the patients requiring a second or third ETI attempt.

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