Iatrogenic Tracheal Rupture Related to Prehospital Emergency Intubation in Adults: A 15-Year Single Center Experience

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Abbreviations:
ASA: American Society of Anesthesiologists
COPD: chronic obstructive pulmonary disease
CPR: cardiopulmonary resuscitation
CT: computed tomography
EMS: Emergency Medical Services
ICD-10: International Classification of Diseases-Revision 10
ICU: intensive care unit
LOS: length of stay

Abstract

Objective: Iatrogenic tracheal rupture is an unusual and severe complication that can be caused by tracheal intubation. The frequency, management, and outcome of iatrogenic tracheal rupture due to prehospital emergency intubation in adults by emergency response physicians has not yet been sufficiently explored.

Methods: Adult patients with iatrogenic tracheal ruptures due to prehospital emergency intubation admitted to an academic referral center over a 15-year period (2004-2018) with consideration of individual risk factors were analyzed.

Results: Thirteen patients (eight female) with a mean age of 67 years met the inclusion criteria and were analyzed. Of these, eight tracheal ruptures (62%) were caused during the airway management of cardiopulmonary resuscitation (CPR). Stylet use and difficult laryngoscopy requiring multiple attempts were documented in eight cases (62%) and four cases (30%), respectively. Seven patients (54%) underwent surgery, while six patients (46%) were treated conservatively. The overall 30-day mortality was 46%; five patients died due to their underlying emergencies and one patient died of tracheal rupture. Three survivors (23%) recovered with severe neurological sequelae and four (30%) were discharged in good neurological condition. Survivors had significantly smaller mean rupture sizes (2.7cm versus 6.3cm; $P < .001$) and less cutaneous emphysema ($n = 2$ versus $n = 6$; $P = .021$) than nonsurvivors.

Conclusions: Iatrogenic tracheal rupture due to prehospital emergency intubation is a rare complication. Published risk factors are not consistently present and may not be applicable to identify patients at high risk, especially not in rescue situations. Treatment options depend on individual patient condition, whereas outcome largely depends on the underlying disease and rupture extension.

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Introduction

Prehospital emergency intubation may be associated with iatrogenic injuries due to challenging emergency circumstances.[1,2] Although mucosal bleeding and dental lesions are the most common intubation-related iatrogenic injuries, tracheal ruptures of the posterior membrane are also reported occasionally.[1–6] The consequences of tracheal rupture are serious and can be life-threatening, which may aggravate already critical conditions of emergency patients.[5–20] Clinical presentation often includes cutaneous emphysema, bleeding, pneumothorax, and pneumomediastinum, ultimately leading to mediastinitis, sepsis, and organ dysfunction. The gold standard for assessment and diagnosis is endoscopy and computed tomography (CT), whereas rapid treatment with broad-spectrum antibiotic

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Risk Factor
Mechanical Factors
• Multiple vigorous attempts at intubation
• Inexperienced anesthesiologists
• Inappropriate use of stylets
• Overinflation, rapid inflation, rupture of the cuff
• Mal-positioning the tip of the tube
• Tube repositioning without cuff deflation
• Patient moved with bronchial cuff inflated
• Inadequate tube size
• Vigorous coughing
• Abrupt head and neck movement
Anatomic Factors
• Congenital tracheal abnormalities
• Large mediastinal collections, lymph nodes, or neoplasms causing distortion of the trachea
• Weakness of the membranous trachea (woman, elderly, esophageal surgery)
• Woman
• Age >50 years
• Chronic obstructive pulmonary disease; inflammatory lesions of tracheobronchial tree
• Corticosteroid therapy
• Short body height

Table 1. Published Risk Factors for Iatrogenic Tracheal Rupture Related to Tracheal Intubation
Note: Adapted from Marty-Ané, et al[5] and Miñambres, et al.[6]

substances and surgical repair of injuries exceeding two centimeters in length is considered crucial for favorable outcomes.[7,21,22]

Known patient-related risk factors for iatrogenic tracheal ruptures include short body height, female sex, older age, chronic obstructive pulmonary disease (COPD), and steroid use. Operator-related factors may be lack of intubation experience, emergency intubations, inappropriate use of stylets (protruding over the tube tip), use of oversized tubes, and overinflation of the tube cuff (Table 1).[5,6] In the literature, the incidence of iatrogenic tracheal rupture due to tracheal intubation has been estimated to be approximately 0.005%, but the current incidence is unknown.[6] High-quality prospective randomized controlled trials are not available due to the rarity of this event and the high numbers of intubations performed daily. Reports are mainly based on retrospective cohort studies or single case reports. This is especially true for prehospital emergency intubations.[23–26]

Study Objectives

In two recent studies involving iatrogenic tracheal ruptures of multiple causes of the study center, perioperative complication rates and prognostic factors were explored.[19,20] The rationale for the current study was to determine the incidence, management, and outcome of consecutive patients with iatrogenic tracheal ruptures that were caused by prehospital emergency intubation by emergency response physicians and treated in a tertiary care center. Furthermore, the congruence of published risk factors with characteristics of recent iatrogenic tracheal ruptures was of particular interest.

Material and Methods

Study Patients, Design, and Definitions

A retrospective, observational, single-center case series study was designed to analyze consecutive iatrogenic tracheal rupture patients after prehospital emergency intubation by emergency response physicians. After approval of the Ethics Committee (Ethical Commission of the Medical Faculty of the University of Leipzig [Germany], IRB00001750, AZ: 484/18k), the database of a university hospital was reviewed for iatrogenic tracheal rupture from July 2004 through December 2018. Iatrogenic tracheal rupture was defined as an unintentional full-thickness lesion of the posterior part of the trachea (pars membranacea). Patients with iatrogenic tracheal ruptures related to in-hospital intubation, tracheotomy, surgery, or who were under 18 years of age were excluded (Figure 1). The study is a sub-group analysis of published data[19,20] and is in line with the STROBE guidelines for uniform reporting of observational studies.

General Management

In Germany, the prehospital Emergency Medical Service (EMS) is performed by emergency medical technicians (Rettungssanitäter), paramedics (Rettungsassistent/Notfallsanitäter), and emergency response physicians (Notarzt). Prehospital advanced airway management, including tracheal intubation, is usually performed by emergency response physicians. Emergency response physicians have an auxiliary designation and no full specialty. The curriculum of emergency response physicians lasts two years, whereas the clinical experience of tracheal intubation may vary considerably, which may be particularly relevant for nonanesthetists.[27–30] National guidelines include recommendations of prehospital airway management and prehospital anesthesia.[31,32]

Patients with clinical suspicion of iatrogenic tracheal rupture after prehospital emergency intubation underwent chest CT and flexible bronchoscopy. All patients were admitted to the intensive care unit (ICU) and received broad-spectrum antibiotic administration (carbapenems) for mediastinitis prevention. Depending on individual patients' condition, rupture extension, and diagnostic findings, surgical repair or conservative treatment was performed after an interdisciplinary pragmatic and consensus-based decision process.

Data Collection

Potential study cases were identified using International Classification of Diseases-Revision 10 (ICD-10) coding by independent staff of hospital controlling. Available ICD-10 codes S11.x and S27.x were screened by two physicians (first author and last author) and patients meeting exclusion criteria were removed (Figure 1).

Patient data were obtained from paper-based and/or electronic charts using a set of pre-defined variables by the first author. Patients were analyzed regarding demographic data, including sex, age, body height and weight, American Society of

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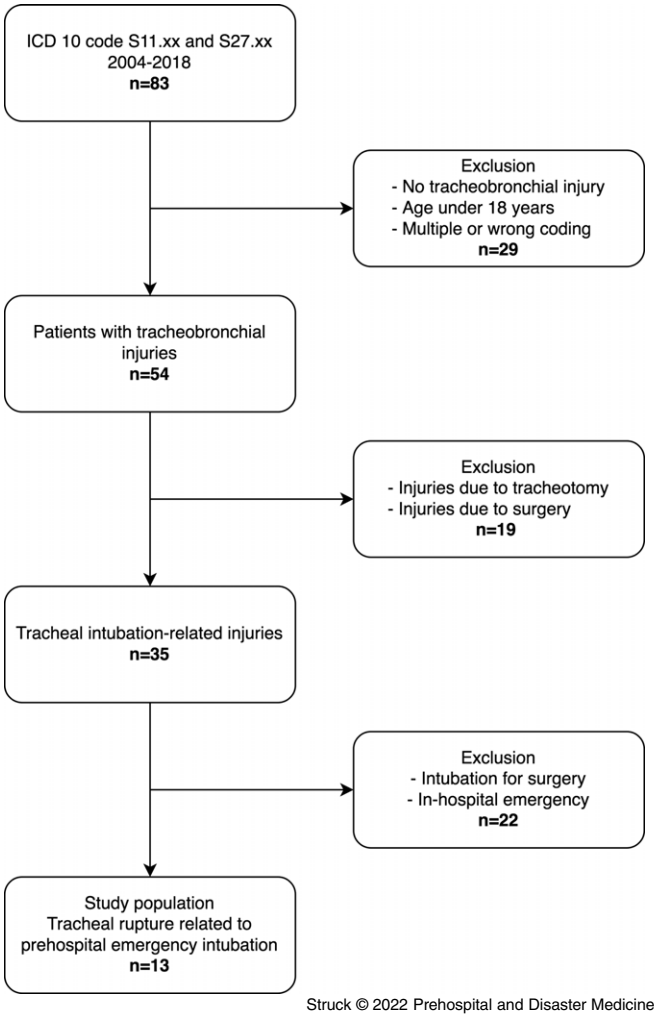

Figure 1. Study Flow Chart.
Abbreviation: ICD-10, International Classification of Diseases-Revision 10.

Anesthesiologists (ASA; Schaumburg, Illinois USA) physical status, underlying emergency, need for cardiopulmonary resuscitation (CPR), anesthesia medication, stylet use, tube size, number of intubation attempts, interfacility referral, rupture length, cutaneous and mediastinal emphysema, mediastinitis, COPD, steroid medication use, surgical repair, tube thoracostomy, length of stay (LOS) in ICU, ventilator days after surgery, rupture-related mortality, and overall 30-day mortality. Furthermore, data regarding the attending emergency response physicians were screened (specialty and training level).

Statistical Analysis

The data were expressed as numbers and percentages. Depending on the distribution of the variables, the mean and standard deviation (SD) were used for those with a normal distribution and the median and interquartile range (IQR) were used for those with a non-normal (skewed) distribution. The Kolmogorov-Smirnov test of normality was performed for all continuous variables. Comparisons of groups were tested with Student's t-test (normally distributed variables) or the Mann-Whitney U test (non-normally distributed variables) for continuous variables and Fisher's exact test for categorial variables. Significance level was defined as $P < .05$, two tailed. Multivariable tests were not planned due to presumed low sample sizes.

Results

Baseline Characteristics of Patients

Thirteen consecutive patients with iatrogenic tracheal rupture related to prehospital emergency intubation were included, of whom eight were female and five were male, with a mean age of 67.0 (SD = 23.4) years. The mean age of female patients was 68.9 (SD = 24.5) years, of which six were aged above 50 years. The mean body height was 165.4 (SD = 6.9) cm for the whole cohort, and 163.1 (SD = 6.1) cm in females, of which 88% (n = 7) were ≤165cm.

At the scene, eight patients (62%) presented with cardiac arrest and received CPR. Seven patients (53%) were referred from other hospitals after having undergone prehospital emergency intubation. The main underlying emergency that led to prehospital intubation was acute myocardial infarction in five cases (38%; of which four presented with cardiac arrest) and stroke that accounted for two cases (15%). Further detailed characteristics are shown in Table 2.

Intubation Characteristics and Emergency Response Physicians' Characteristics

Of the eight patients who underwent CPR, no anesthetics were administered for tracheal intubation. Anesthetics were administered in the prehospital course after return of spontaneous circulation in four of these patients due to transient neurological recovery, awakening, and movement. In the five patients who were intubated without being in cardiac arrest at the scene, at least three received anesthetics (Case 1: morphine, midazolam, and vecuronium; Case 10: ketamine and rocuronium; and Case 12: fentanyl, etomidate, and succinylcholine). In the remaining two patients, the prehospital emergency protocols were incomplete or missing; however, emergency department charts noted that these patients had undergone prehospital rapid sequence induction for tracheal intubation. All patients were intubated using direct laryngoscopy using Macintosh blades. Stylet use was documented in eight patients (62%), while difficult laryngoscopy and multiple intubation attempts were documented in four patients (31%). Tube size documentation was available in only three patients (Case 4 and Case 9: inner diameter (ID) 7.0mm; Case 12: ID 8.0mm).

Emergency response physicians were anesthetists in six cases (46%), whereas surgeons and internal medicine physicians accounted for two cases each. In another three cases, the specialty was not documented or EMS protocols were missing, as mentioned above. The majority of emergency response physicians were board certified in their original discipline (nine cases, 69%); in two cases, they were trainees, and another two were unknown. In one case, the board certification was confirmed, whereas the specialty was not documented at the EMS protocol.

Diagnostics and Treatments of Tracheal Ruptures

After prehospital emergency intubation, blood inside the tube was the first sign of tracheal rupture in one patient (Case 3) and subcutaneous emphysema as a primary symptom was present in eight patients (62%), of which two received tube thoracostomy by the prehospital emergency physician (Case 10 and Case 12) due to high leakage volumes and massive emphysema. Another two patients (Case 5 and Case 8) received tube thoracostomy at the referring hospital before interfacility transport. Pneumothorax was detected on initial chest CT in eight patients (62%), of which five underwent surgical repair of the rupture and three were treated conservatively. Mediastinal emphysema was visible in nine patients (69%). One

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Case	Age (years)	Gender	ASA	Height (cm)	BMI (kg/m^2)	COPD	Reason for ETI	CPR
1	94	Female	III	157	22	No	AMI	No
2	87	Female	III	161	21	No	AMI	Yes
3	74	Female	III	164	23	Yes	AMI	Yes
4	77	Female	II	165	24	No	DCM	Yes
5	87	Female	III	155	22	No	AMI	Yes
6	26	Male	I	170	22	No	Drowning	Yes
7	68	Female	II	163	26	No	Stroke	No
8	77	Male	II	165	38	No	SAH	No
9	39	Female	II	165	20	No	Intoxication	Yes
10	77	Male	II	170	24	No	RTA	No
11	25	Female	I	174	20	No	Dehydration	Yes
12	55	Male	II	183	25	No	Stroke	No
13	85	Male	III	160	33	Yes	AMI	Yes
Case	**Intubator**	**Stylet**	**Difficult Airway**	**Rupture Length (cm)**	**Cutaneous Emphysema**	**Mediastinitis**	**Surgical Repair**	**Outcome**
1	Ane (S)	Yes	Yes	1	No	No	No	Survived
2	Surg (T)	Unknown	Unknown	6	Yes	No	Yes	Died 12d
3	Ane (S)	Yes	No	7	Yes	No	Yes	Died 3d
4	Ane (S)	Yes	No	4	Yes	No	Yes	Survived
5	Unknown	Yes	Yes	8.5	Yes	Yes	No	Died 9d
6	Ane (S)	Yes	No	5.5	Yes	Yes	Yes	Died 10d
7	Unknown	Unknown	Unknown	2.5	No	No	No	Survived
8	Int (S)	Unknown	Yes	2	No	No	No	Survived
9	Ane (S)	Yes	No	4	Yes	No	Yes	Survived
10	Surg (S)	Unknown	No	3.5	No	No	No	Survived
11	Unknown	Yes	Yes	2	No	No	No	Survived
12	Int (S)	No	No	6	Yes	No	Yes	Died 3d
13	Ane (T)	Yes	No	5	Yes	No	Yes	Died 2d

Table 2. Individual Characteristics of Consecutive Patients with Iatrogenic Tracheal Rupture due to Prehospital Emergency Intubation

Abbreviations: ASA, American Society of Anesthesiologists physical status; BMI, body mass index; COPD, chronic obstructive pulmonary disease; ETI, endotracheal intubation; CPR, cardiopulmonary resuscitation; AMI, acute myocardial infarction; DCM, dilated cardiomyopathy; SAH, subarachnoid hemorrhage; RTA, road traffic accident; Ane (S), anesthetist (specialist); Surg (T), surgeon (trainee); Int (S), internist (specialist).

patient presented with left-sided serial rib fractures due to chest compressions during CPR.

All patients underwent direct endoscopic inspection using fiberoptic bronchoscopy whereas nine patients underwent chest CT before and four thereafter. In these four patients, tracheal rupture remained undetected until percutaneous dilatational tracheostomy (Case 7, Case 8, and Case 10) three days (two cases) and seven days post-intubation or until bronchoscopy after CPR (Case 11) at the day of admission. The ruptures were mainly localized above the carina (10/13 patients); in two cases, they extended into the right main bronchus, and one case presented with punctual perforation at the carina. Except for this punctual perforation, all lesions had longitudinal characteristics. The mean rupture length was 4.4 (SD = 2.2) cm and was measured using CT and bronchoscopy in all patients and additionally measured directly during surgery (if applicable).

Surgical repair was performed in seven patients (67%), all of whom underwent right-side thoracotomy and one-lung ventilation. The rupture was sutured and covered with reinforcement of pericardium, thymus, and/or muscle tissues. During surgery, all patients received tube thoracostomy (four bilateral and three only right-sided), of which four had undergone preoperative tube thoracostomies, as mentioned earlier. One patient received surgical tracheotomy after surgery.

Six patients underwent nonoperative treatment either due to minor lesions and noncritical conditions (Case 1, Case 7, Case 8, Case 10, and Case 11) or due to best supportive care in a highly critical patient (Case 5). None of these patients received tube thoracostomy, however, three of them presented with small pneumothorax. Four patients received tracheotomy (percutaneous dilation tracheotomy and surgical tracheotomy, two each).

Mean rupture lengths were 5.4 (SD = 1.1) cm in patients with surgical repair and 3.3 (SD = 2.7) cm in patients with conservative treatments (P = .092). Mediastinitis developed in two patients (15%), of which one patient was treated conservatively (Case 5) and one underwent surgery (Case 6).

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Outcomes

The overall mean LOS in the ICU was 13 (SD = 12.7) days, whereas the mean mechanical ventilation time was 11.6 (SD = 2.7) days (Table 3). The overall 30-day mortality was 46% (six cases), whereas five patients died due to their underlying emergencies and one patient died of tracheal rupture (Case 6). Nonsurviving patients died at two, three (two patients), nine, ten, and twelve days after prehospital emergency intubation, and no individual died immediately after the initial incident. Three survivors (23%) recovered with severe neurological sequelae and four (30%) were discharged in good neurological condition. Of the eight patients requiring CPR at the scene, three (38%) survived (two with severe neurological deficits), and four out of five patients (80%) without CPR at the scene survived (three with good neurological condition). Patients who needed surgical repair had a survival rate of 29% compared with patients who needed conservative approaches with a survival rate of 80% (P = .103). Survivors had significantly smaller rupture sizes (2.7 [SD = 1.1] cm versus 6.3 [SD = 1.3] cm; P <.001), less cutaneous emphysema (n = 2 [29%] versus n = 6 [100%]; P = .021), and a nonsignificant trend of longer LOS ICU (19.9 [SD = 14.6] days versus 6.5 [SD = 4.3] days; P = .054) compared with nonsurvivors.

Discussion

Key Results and Definitions

The results of this study are in line with other studies suggesting that the outcome of iatrogenic tracheal rupture related to tracheal intubation largely depends on underlying emergency conditions and rupture extension.[5–21,33]

In the literature, the definition "rupture" is not consistent, and some studies prefer the term "laceration" or "perforation" for iatrogenic injuries.[25] The term "rupture" is often used in association with blunt forces, as it may occur in rapidly increasing intrathoracic pressures and blunt velocity impact (eg, due to massive coughing, falls from height, road traffic accidents, or CPR-related chest compressions). On the other hand, "rupture" may be understood and defined as a full-thickness lesion of tracheal tissue that may be the result of both blunt and penetrating forces. However, "laceration" describes an unspecific lesion that may not exceed full thickness, and "perforation" is usually caused by a penetrating force that excludes lesions caused by cuff hyperinflation. Although the iatrogenic injuries of this study were presumably caused by the forced insertion of the tracheal tube into the trachea, as almost all injuries had longitudinal lesion characteristics, it cannot be excluded that some lesions might have been partly associated with rapid or high-volume cuff inflations.[5,6,34] Thus, it was decided to use the term "rupture" for all injuries described in this study, as it may be applied in both mechanisms.

Risk Factors

Only moderate (female sex, body height, and stylet use) or weak agreement (difficult intubation, inexperienced operator, COPD, and steroid medication) was found with published risk factors (Tables 1-3).[5,6] Since some potential risk factors remained incomplete or unknown in this retrospective analysis (eg, tube sizes), these results should be interpreted with caution. Future and prospective studies from other centers are necessary to confirm the present data, especially regarding the absence of known risk factors for prehospital iatrogenic tracheal ruptures.

Treatment Options

Conservative or nonsurgical management may be considered in stable patients with sufficient spontaneous breathing and small ruptures, providing low risks for developing mediastinitis.[10,15,17,18,21] In patients suitable for conservative treatment, early tracheal tube removal and spontaneous breathing may provide less shearing stress to the tracheal tissue. Frequent bronchoscopic inspections should be performed to monitor the healing process. Lesions may also be treated with local fibrin glue application or stent placement.[33,35] Apart from one patient who was too unstable for surgery, all conservatively treated patients in the study cohort survived, indicating that these patients were less prone to fatal outcomes.

Surgical repair is recommended in patients with deterioration of gas exchange due to massive leakage volumes and the presence or high risk of mediastinitis.[6–9,12–15,17] Surgical techniques include anterior approaches in ruptures localized in cervical parts and upper thoracic parts of the trachea, or right thoracotomy under one-lung ventilation in deeper injuries reaching the carina, right main bronchus, or proximal left bronchus. In the study, the right thoracotomy approach was performed in all patients requiring surgical repair.

Prognostic Factors

Prognostic variables for mortality in iatrogenic tracheal rupture are similarly nonspecific as are the risk factors. The results confirm at least some prognostic variables of previous analyses of the study team, in which the current data were already included.[20] Thus, a previously identified predictor for mortality, rupture extension, reveals this association for this sub-group of prehospital emergency intubations even with relatively low sample sizes. Subcutaneous emphysema, as one primary clinical sign of iatrogenic tracheal rupture, was also significantly associated with mortality, which may be a surrogate parameter of a larger extension of the rupture. Given the small number of cases, a receiver operating characteristic analysis was not performed to define potential cutoffs in length. The ICU LOS tended to be longer for survivors, which reflects the effect of deaths that occurred earlier within twelve days in nonsurvivors, but did not occur immediately in this given cohort.

In previous studies, mediastinitis was identified as an independent prognostic parameter.[6,12,17,20] Although two cases of mediastinitis were present in the study cohort (in two nonsurvivors), sample sizes were too low to reach statistical significance.

For outcome relevance, it must be pointed out again that the low sample size of the study may account for the absence of significance in patients with pre-rupture morbidity (according to ASA classification).

Management Recommendations

To avoid iatrogenic tracheal ruptures in prehospital emergency intubations, safety measures are summarized in Table 4. Although all patients in this study were intubated using direct laryngoscopy and Macintosh blades, tracheal injuries may also be possible using video laryngoscopy, which is becoming increasingly popular in emergency intubation.[36–40] When using hyper-angulated blades in video laryngoscopy, the use of introducing guides are common. This may be a potential risk factor for mechanical complications including tracheal ruptures.

Tracheal rupture should be considered after emergency intubation when patients develop cutaneous emphysema, airway leakage, deterioration of oxygenation, and lack of breathing sounds during mechanical ventilation. Subsequent pneumothorax should be

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	Total (n = 13)	Survivors (n = 7)	Nonsurvivors (n = 6)	P
Age, years	67.0 (SD = 23.4)	65.3 (SD = 24.3)	69.0 (SD = 24.4)	.789
Female	8 (62)	5 (71)	3 (50)	.592
Height, cm	165.4 (SD = 6.9)	165.7 (SD = 5.6)	165.0 (SD = 8.8)	.863
Weight, kg	65.5 (SD = 10.2)	64.3 (SD = 7.9)	66.7 (SD = 13.1)	.693
BMI, kg/m^2	24.6 (SD = 5.3)	24.9 (SD = 6.2)	24.3 (SD = 4.5)	.867
ASA >II	5 (38)	1 (14)	4 (67)	.103
COPD	2 (15)	0 (0)	2 (33)	.192
Steroid Medication	2 (15)	0 (0)	2 (33)	.192
CPR	8 (62)	3 (43)	5 (83)	.266
Multiple Attempts	4 (31)	3 (43)	1 (17)	.559
Stylet Use	8 (62)	6 (86)	2 (33)	.102
Rupture Length, cm	4.4 (SD = 2.2)	2.7 (SD = 1.1)	6.5 (SD = 1.3)	***<.001***
Emphysema	8 (62)	2 (29)	6 (100)	***.021***
Mediastinitis	2 (15)	0 (0)	2 (33)	.192
Surgical Repair	7 (54)	2 (29)	5 (83)	.103
Ventilator Days	11.6 (SD = 12.7)	14.6 (SD = 16.1)	6.5 (SD = 4.3)	.389
ICU LOS, Days	13.7 (SD = 12.7)	19.9 (SD = 14.6)	6.5 (SD = 4.3)	.054

Table 3. Baseline Characteristics of Patients Comparing Survivors and Nonsurvivors
Note: Data are means (standard deviation) and counts (%). P-values below .05 are printed in italic bold type font.
Abbreviations: BMI, body mass index; ASA, American Society of Anesthesiologists classification; COPD, chronic obstructive pulmonary disease; CPR, cardiopulmonary resuscitation; ICU, intensive care unit; LOS, length of stay.

1. Consideration of known patient-related and operator-related risk factors for intubation-related iatrogenic rupture (Table 1).
2. Improvement of positioning of the patient in order to achieve the best possible intubation conditions.
3. Providing appropriate depth of anesthesia and use of muscle relaxants in patients not requiring CPR.
4. Thorough and rational use of stylets or introducing bougies.
5. Use of cuff-pressure monitoring devices and avoidance of rapid or over-inflation of the tube cuff.
6. Use of appropriate tube sizes and avoidance of oversized tubes, particularly in patients with short height.
7. Never to advance tubes or stylets against resistances during the intubation process and avoidance of rapid and forced advancements.
8. To pay particular attention while intubating patients receiving simultaneous chest compression during CPR.
9. Avoidance of advancement and pull forces to the tube during EMS transport.
10. Early consideration of alternative airway techniques (laryngeal masks, laryngeal tubes, or bag-mask ventilation until hospital admission) in difficult airway management and multiple intubation attempts.

Table 4. Practical Aspects of the Prevention of Iatrogenic Tracheal Rupture
Abbreviations: CPR, cardiopulmonary resuscitation; EMS, Emergency Medical Services.

anticipated and treated using needle decompression or tube thoracostomy, which is particularly important in patients with chest trauma and after CPR.[41] Blind tracheal tube advancement over the rupture site into one mainstem bronchus may be performed to control airway leakage until initial diagnostics.

All patients in which iatrogenic tracheal rupture is suspected should receive the earliest possible diagnosis and treatment in a center providing interdisciplinary expertise and appropriate infrastructure.

Limitations

The results of retrospective single-center studies may not be representative for other cohorts with different settings and infrastructures. Long observational periods and low sample sizes further impair the generalizability of the results. Due to differences in underlying emergency conditions and training levels of emergency response physicians, the outcomes of patients are not comparable. More than one-half of the patients underwent CPR at the scene. A reliable conclusion regarding the incidence of this complication cannot be drawn from this study because data on all prehospital emergency intubations of the responsible EMS catchment area and referring EMS regions could not be provided. Furthermore, the number of prehospital iatrogenic tracheal ruptures might be higher due to missing cases (ie, nonsurvivors after CPR who did not undergo forensic autopsy). Surprisingly, not a single case died without initial return of spontaneous circulation at the scene or at the emergency department. Of course, this is due to selection bias for the given study, as tracheal ruptures here are defined to be explored by clinical imaging. However, forensic data of the authors investigating various iatrogenic injuries due to primary unsuccessful

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CPR in more than 600 autopsy cases yielded not a single case with tracheal rupture, meaning that this entity is a very rare diagnosis post-mortem.[42]

Due to the retrospective nature of the study, some important information could not be obtained. Tube sizes, a known risk factor for iatrogenic injuries, were documented in only three of 13 cases. These important data should generally be documented in the EMS protocols.[43] The specialty and training level of emergency response physicians were incompletely documented or not available in five of 13 cases, which neglects legal requirements of personal details for proper documentation. However, new data and, to the authors knowledge, the highest number of reported cases of iatrogenic tracheal ruptures related to prehospital emergency intubation are presented.

Conclusions

Iatrogenic tracheal rupture due to prehospital emergency intubation is rare. The specialty and training level of emergency response physicians as well as the heterogeneity of patient characteristics of this study suggest that the absence of known risk factors may not avoid this complication. Emergency Medical Service providers should be aware that prehospital emergency intubation always carries the risk for severe iatrogenic complications, including tracheal rupture.

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