Tracheal Intubation in Out-Of-Hospital Setting is Associated With A High Failure Rate of The First Attempt: A Multicenter Prospective Study

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Abstract

Background

Tracheal intubation in an out-of-hospital setting is a frequent and potentially difficult procedure. The risk of adverse events increases dramatically with the number of attempts. The failure rate of the first intubation attempt ranges from 5 to 32% and the risk factors are unclear. We evaluated the failure rate of the first intubation attempt in an out-of-hospital setting and identified variables potentially associated with such failure.

Methods

This was an observational prospective multicenter study performed over 17 months and involving 10 prehospital emergency medical units. Airway management for patients who needed tracheal intubation followed the national guidelines. Rapid sequence intubation with a sedative and myorelaxant drugs was systematically performed for spontaneously breathing patients. After each tracheal intubation, the operator was required to provide, by completing a data-collection form, information on operator and patient characteristics and the environmental conditions during the intubation. The primary endpoint was failure of the first intubation attempt.

Results

During the study period, 1546 patients were analyzed, of whom 59% had cardiac arrest, and 486 intubations failed on the first attempt (31.4% [95% confidence interval = 30.2–32.6]). A multivariate analysis revealed that the following 7 of 28 factors were associated with an increased risk of a failed first intubation attempt: operator with fewer than 50 prior intubations, small inter-incisor space, limited extension of the head, macroglossia, ear/nose/throat tumor, cardiac arrest, and vomiting. The frequency of adverse events was 13.4% and increased with each additional attempt.

Conclusions

The failure rate of the first attempt was high. Most risk factors could be identified only at the moment of occurrence and were not easily anticipated. Finally, the risk of complications increased with the number of attempts.

Introduction

Tracheal intubation (TI) is a procedure that is frequently performed in an out-of-hospital emergency setting. TI is associated with a risk of adverse events, including severe sequelae such as hypoxemia, vomiting, aspiration, hypotension, and cardiac arrest [1–5]. The risk of adverse events increases dramatically with the number of intubation attempts [3, 4, 6]. Thus, it is important that the first intubation attempt succeeds. In most cases, the environment in an out-of-hospital setting is not appropriate for intubation, and can be austere (outside, restricted space, patient on the floor, or public place) or

dangerous (mountain, sea, or roadside) [7]. Although literature data are abundant, they are extremely heterogenous. Indeed, the available studies differ in terms of operator profiles, TI indications, and design. Based on studies involving management by physician-led teams in out-of-hospital settings and for which data are available, the failure rate of the first intubation attempt ranges from 5% to 32% [8-22] (Table 1). Numerous variables are associated with difficult intubation (DI), such as more than two attempts and bad glottic visualization, but few studies have analyzed risk factors for failure of the first attempt [8, 12, 17, 23-25]. Identification of such factors would decrease the risk of complications.

We evaluated the failure rate of the first intubation attempt in an out-of-hospital setting and identified variables potentially associated with such failure.

Methods

Design

This was an observational prospective multicenter study performed between March 1, 2017 and August 31, 2018 involving 10 mobile emergency medical units in France. The study design complied with the recommendations of the STROBE initiative [26].

The French EMS handles all calls made to a single nationwide emergency telephone number (#15). Physicians responding to the calls evaluate the type of assistance required and dispatch an ambulance manned by an emergency physician, a nurse with training in intensive care (occasionally an anesthetist nurse), and a driver with first-aid experience [27]. The vehicles carry resuscitation equipment and drugs, including sedatives and analgesics [27].

Based on the information available, the publication group of the ethics committee of the university hospital has approved publication of this work (GP-CE 2020-10). Written information was provided to each patient and/or their relatives. All data were anonymized and protected.

Patients and data collection

All patients ≥ 15 years old and intubated in an out-of-hospital setting were included in the analysis. For each intubation, the operators were required to follow the national guidelines. For patients with spontaneous breathing, rapid sequence induction with a sedative drug and a myorelaxant drug (succinylcholine or rocuronium) was performed [28].

After each tracheal intubation, the operator completed a form divided into three parts (Additional file 1). The first part concerned the operator (function and experience with intubation). The second part concerned the patient and included demographic data, main indication for intubation, and any anatomical or circumstantial factor that may be a source of difficulty in intubation. The third part concerned the conditions during intubation: the position of the operator, the position of the patient, and the environment.

Outcome

The primary endpoint was the failure of the first intubation attempt. An attempt was defined as one advancement of the tube in the direction of the glottis during direct laryngoscopy.

The secondary endpoints were the Intubation Difficulty Scale score (IDS) [29], the Cormack–Lehane laryngoscopy view score [30], variables associated with the failed first attempt, and adverse events during or immediately after intubation. A score of > 5 on the IDS indicates a DI [16, 24, 29].

Statistical analysis

We considered all variables that are known to be associated with failure of a first intubation attempt or with DI, as well as those suspected of being associated with a failed first attempt. Variables of interest concerned operator and patient characteristics, indication for TI, environment, and position of the patient and of the operator during intubation (Additional file 1) [8, 12, 17, 23-25].

Normally distributed (verified by Kolmogorov–Smirnov test and Shapiro–Wilk test) quantitative variables are expressed as means and standard deviations and were compared by Student's *t*-test. All other variables are expressed as medians and 25th and 75th percentiles (interquartile range) and were compared by Mann–Whitney non-parametric test. Qualitative variables are expressed as percentages and 95% confidence intervals (CIs) and were compared by chi-squared test, corrected Yates test, or Fisher test, as indicated. To identify variables independently associated with failure of the first intubation attempt, a multivariate analysis adjusted for sex, age, center, and variables with a p-value ≤ 0.2 in univariate analyses, was conducted using a backward step-by-step logistic regression model. The associations are expressed as odds ratios (ORs) with 95% CIs. The goodness of fit of the model was assessed by the Hosmer–Lemeshow test. Data were entered into EpiData 3.0 software, and statistical analysis was performed using SPSS version 26.0 software (IBM, SPSS Inc., Chicago, IL).

Sample size calculation

Sample size was calculated based on data from the literature. The failure rate of the first attempt is around 16% [11], varying between 5 and 32% [8, 9]. With an accuracy of 2%, and a risk a of 5%, the required number of patients was 1290, plus 10% to compensate for loss to follow up. Therefore, at least 1419 patients were required.

Results

Overall, 1819 patients were intubated by the EMS during the study period. Of these, we analyzed 1546 patients (Figure 1). Four hundred and eighty-six intubations (31.4%; 95% CI = 30.2–32.6) failed on the first attempt.

Table 2 lists the main characteristics of the operators. The operators estimated that their experience with intubation was good or very good, moderate, or weak in 62, 25, and 11% of cases, respectively. Of the

operators, 54% had performed at least 50 intubations.

Table 3 lists the main characteristics of the patients. Of the 916 cardiac arrest intubations (59.2%), 857 were realized without rapid sequence induction and 59 patients who had returned to spontaneous circulation before intubation received rapid sequence induction. Among the 163 patients with severe trauma, 55 (33.7%) experienced a cardiac arrest.

Among the 1546 intubation attempts, the rates of Cormack–Lehane scores of 1, 2, 3, and 4 were 52.1%, 26.9%, 15.0%, and 5.8%, respectively. Two cases were missing a Cormack–Lehane score: one was associated with impossible intubation, and the other had an IDS score of 7. In total, 196 intubation attempts (12.7%; 95% CI = 11.1–14.3) had an IDS score of > 5. Of 19 attempts to intubate through a laryngeal mask, 1 failed. In the failed case, ventilation was possible using a laryngeal mask.

The techniques used to improve intubation were external laryngeal pressure in 29% of cases (N = 449), a bougie in 15.3% (N = 236), and a stylet in 10.1% of cases (N = 156). The blade and/or the patient's head position were changed in 4.7% and 3.3% of the cases, respectively. A laryngeal mask was used in 1.2% of the cases (N = 19), nasal intubation in 0.2% (N = 3), and a video laryngoscope in 0.1% (N = 2). These techniques were used alone or in combination.

Two hundred and seven patients (13.4%) had at least one adverse event during or immediately after tracheal intubation. Among non-cardiac arrest patients (N = 629), 93 (14.8%) had at least one adverse event, comprising 45 oxygen desaturation, 35 esophageal intubations, 9 vomiting, 5 cardiac arrest, 1 tooth trauma, and 3 laryngospasms. The frequency of adverse events was 8.9% (33/371) in patients who were intubated on the first attempt and 43% (58/134) in those who required more than one attempt (p = 0.0001). Among the patients who experienced cardiac arrest, the frequency of adverse events was 4.4% (23/520) in those intubated at the first attempt and 35.2% (92/261) in those in whom the first attempt failed (p = 0.0001). Figure 2 shows the complication rates according to the number of intubation attempts.

Univariate analyses of 28 variables identified 24 variables for multivariate analysis (Table 4). Three variables were obvious confounders: operator function, operator experience level, and number of prior intubations. Indeed, 75% of anesthetist nurses (ANs) or postgraduate physicians (PGPs) > 2 years (663/883 intubations) had performed more than 50 intubations, versus 25% for the other operators (156/625 intubations). Similarly, 79.4% of operators with good to very good experience (746/940 intubations) had conducted more than 50 intubations, versus 12.4% for the other operators (69/556 intubations). Therefore, we included the number of prior intubations in the multivariate analysis.

Among patients who experienced cardiac arrest, chest compression was continued during intubation in 439 patients, with a first-attempt failure rate of 41.9%. Chest compression was stopped in 413 patients, with a first-attempt failure rate of 27.4% (p < 0.0001).

A multivariate analysis was conducted for 1346 cases on the totality of the data, 935/1082 (86.4%) cases with one intubation attempt, and 398/486 (84.6%) cases with more than one intubation attempt. The multivariate analysis was adjusted for sex, age, and center. The final model (Hosmer–Lemeshow test, p = 0.4) included 12 variables, 7 of which were significantly associated with the risk of a failed first-attempt intubation: ≤ 50 previous intubations, inter-incisor space < 2 fingerbreadths, cardiac arrest as an indication for intubation, limited extension of the head, macroglossia, vomiting, and ENT tumor (Table 5). Three centers had a lower risk of failure than the other centers.

Discussion

The prevalence of a failed first intubation attempt was 31.4% (95% CI = 30.2–32.6) among patients managed in an out-of-hospital setting. The following variables were independently associated with a failed first intubation attempt, operator with ≤ 50 prior intubations, small inter-incisor space, limited head extension, macroglossia, ENT tumor, cardiac arrest, and vomiting.

A prior meta-analysis indicated a significant difference in the success rate of the first intubation attempt with rapid sequence induction in an out-of-hospital setting between physician and non-physician operators (88% [95% CI = 83–93%] and 78% [95% CI = 65–89%], respectively [1]. The eight studies on physicians in that analysis were heterogeneous: two retrospective [20, 21] and four prospective [13, 14, 18, 19] observational studies, one controlled trial [9], and one study concerning head trauma only [10] (Table 1). In studies of management by physician-led teams in an out-of-hospital setting and involving patients who had and had not experienced cardiac arrest, the failure rate of the first intubation attempt was 12.6–32% [8,12,15-18] (Table 1). Adnet *et al*. published a prospective multicenter observational study in 1998 involving 691 patients, which showed a failure rate of the first intubation attempt of 32% [8]. Two later observational studies involving only anesthesiologists yielded failure rates of 12.6% and 22.4% [12, 18]. However, 70% and 20% and 20% and 54% in the first and second studies, respectively, had trauma and cardiac arrest [12, 18]. In an analysis of 2674 patients, Combes *et al*. reported a failure rate of 26% and another study of 653 intubations a rate of 29.9% [15, 17]. In these two studies, the main operators were emergency physicians, but intubations were also performed by residents or anesthetist nurses under the supervision of the physician. A prospective multicenter study analyzed 1941 intubations managed by paramedics, nurses or physicians, a priori [31]. Paramedics performed 94% of the intubations and the first-attempt failure rate was 31.5%. These observational studies were largely similar to this work. A randomized multicenter trial in an out-of-hospital setting showed a failure rate of 28.8% [16]. Our results are, therefore, similar to those of other studies (Table 1).

Numerous variables are associated with DI, defined as more than two intubation attempts or bad glottic visualization. However, few studies analyzed those associated with first-attempt failure. The seven variables we identified were similar to those for DI [12, 17, 23-25], the exceptions being operator status (resident), maxillofacial trauma, history of ENT tumor, body mass index (BMI), operator position [24], patient on the floor, hyoid-mental length less than three fingerbreadths, airway obstruction [17], blood, secretion or vomit in the upper airway, anatomical factors, patient position, and bright ambient light [12].

Most of these variables—inter-incisor space, macroglossia, limited extension of the head, ENT tumor and maybe vomiting—cannot be foreseen. This hampers prediction of DI.

The risk of first-attempt failure is higher for operators with experience of fewer than 50 intubations [24, 32]. Moreover, the survival rate is higher among patients with cardiac arrest intubated by rescuers with more than 50 prior intubations, and among non-cardiac arrest patients intubated by rescuers with more than 26 prior intubations [33]. A review of the literature concluded that at least 50 intubations with no more than two intubation attempts are necessary to obtain a 90% success rate [34]. Emergency physicians perform a median of 10 intubations per year and 25% perform four or fewer intubations per year [35]. Among 5,245 out-of-hospital rescuers, > 67% had performed two or fewer TIs and > 39% had never performed TI [36]. A retrospective study involving intensive-care paramedics trained in the management of vital distress reported a failure rate of the first intubation attempt of 10.6% [37]. This highlights the importance of the initial training of rescuers, who are likely to be confronted with vital distress. Also, in this study all patients with spontaneous breathing received sedative and myorelaxant drugs. However, paramedics cannot administer curare. This could explain some of the reported risk factors, *e.g.*, clenched jaw, trismus, inability to pass the endotracheal tube through the vocal cords, and an intact gag reflex [25, 36].

Cardiac arrest was a risk factor for failure of the first intubation attempt. Timermann *et al*. showed that intubation difficulty is more frequent in patients with cardiac arrest (17% *vs*. < 10%) but neither Combes *et al*. nor Freund *et al*. found such an association [11, 17, 24]. One possible explanation is continuation of cardiopulmonary resuscitation during intubation in > 50% of patients.

BMI was not a risk factor for failure, contrary to prior reports [24, 38, 39]. In a study similar to ours, BMI was associated with DI (OR = 1.0 [95% CI = 1.0–1.1]) [24]. In this study, the dependent variable was DI (frequency, 7%), defined as an IDS > 5 [24]. In a retrospective analysis involving paramedics, a BMI ≥ 40 $kg.m^{-2}$ was significantly associated with DI (OR = 3.68 [95% CI = 1.3–10.6] [38]. However, the body weight of 39% of the patients was not available and the multivariate analysis was adjusted for only age, sex, pathology, and BMI [38]. In the emergency department (ED), obese patients (N = 342) had a failure rate of the first intubation attempt of 40.7% vs. 29.1% for leaner patients (N = 5370) (adjusted OR = 0.62 [95% CI = 0.49–0.79]) [39]. Obesity remains a controversial risk factor for DI; therefore, caution is required when intubating obese patients in emergency settings.

The overall rate of adverse events was > 13%, and significantly increased with the number of intubation attempts. This result is consistent with prior studies in out-of-hospital settings or in the emergency department [4,6, 8]. Indeed, Adnet *et al*. reported an incidence of mechanical complications of 12.2% and general complications of 12.3% in an out-of-hospital setting; complications were associated with a significantly higher number of intubation attempts [8]. In an emergency department, the incidence of adverse events was 14.2%, increasing to 47.2%, 63.6%, and 70.6% after two, three, and four or more intubation attempts, respectively [4]. This is consistent with a previous report of adverse event rates for two attempts or fewer and three attempts or more of 9% and 35%, respectively [6].

Overall, the failure rate of the first intubation attempt was high. Some of the associated factors can be improved (operator training and experience), but most cannot. A randomized control trial performed in an emergency department showed that systematic use of a bougie during the first intubation attempt improved the success rate [40]. However, a secondary analysis of a study conducted in an out-of-hospital setting involving paramedics found no significant difference according to bougie use [41].

Limitations

Several limitations of this study should be discussed. This study was subject to self-reporting bias, possibly leading to underestimates of intubation difficulties. Real-time independent monitoring of the airway is complex in an out-of-hospital setting; although we requested and expected real-time data entry by operators, this did not always occur. Three centers had a significantly lower failure rate than the other centers. This was associated with the operator, who was more frequently a physician with > 2 years of experience (Additional file 2). We took this into account by adjusting for center in the multivariate analysis.

This study was conducted in 10 prehospital departments, all of which performed the procedures according to the national guidelines. So, the results are applicable to similar emergency prehospital units. However, it was performed in a prehospital emergency medical system, and the findings cannot be generalized to other non-medical prehospital systems. Nevertheless, knowledge of the risk factors associated with difficult airway management in an out-of-hospital emergency setting can help non-physician operators to improve their practice and anticipate DI.

Additionally, the follow-up of adverse events was limited to out-of-hospital management; it is possible that some adverse events, such as aspiration-mediated pulmonary complications, endotracheal tube dislodgement, or pneumothorax, were not captured. Moreover, the rate of adverse events may have been underestimated in patients with a successful first intubation attempt. We believe the large multicenter sample accurately represents the airway management practices in an out-of-hospital setting.

Conclusion

In this multicenter study, the first intubation attempt failed in more than 30% of patients. Seven variables were associated with an increased risk of failure, and most of them were not foreseeable. The rate of complications during or immediately after intubation increased dramatically with the number of attempts. We plan to explore means of minimizing the rate of a failed first intubation attempt by, for example, improving operator training and the use of several items of equipment during intubation (for example, a bougie).

Abbreviations

TI: Tracheal intubation; EMS: Emergency Medical System; STROBE: Strengthening the Reporting of Observational studies in Epidemiology; IDS: Intubation Difficulty Scale score; DI: Difficult Intubation; ENT: Ears - Nose - Throat; PGP: Postgraduate Physician; AN: Anesthetist Nurse; ANS: Anesthetist Nurse Student BMI: Body Mass Index. RSI: Rapid Sequence Induction

Declarations

Ethics approval and consent to participate

The locally appointed ethics committee (Publication group of the ethics committee of the university hospital of Bordeaux) has approved publication of this work (GP-CE 2020-10). Written information was provided to each patient and/or their relatives. All data were anonymized and protected. Need for written consent was waived, as the study collected anonymized data. The study design complied with the recommendations of the STROBE initiative.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

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Authors contributions

MG, CGJ, and BS conceived the study, designed the trial. MG, MW, RB and BS supervised the conduct of the trial and data collection. MG, PC and CGJ undertook recruitment of participating centers. RB, PGR, MR, GD, GB, ED, JB, JPL, SG, KM undertook recruitment of patients and managed the data, including quality control. MG, PC and CGJ analyzed the data. MG drafted the manuscript, and all authors contributed substantially to its revision. MG takes responsibility for the paper as a whole.

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Tables

Table 1: Studies of management by out-of-hospital physician-led teams for which data on the first intubation attempt were available.

1st Author/year/ Ref	Study	Population	Operator	N	Failure rate of 1st attempt (%)
Adnet 1998 (8)	Observational prospective Aim: DI rate	RSI and non-RSI	Emergency physicians, residents, anesthetist nurses	N = 691 Cardiac arrest: 48%	32
Smith 2002 (9)	RCT Rocuronium *vs.* vecuronium	RSI only	Emergency physicians	N = 100	29
Grmec 2004 (10)	Observational prospective TI modalities confirmations	RSI only Trauma	Emergency physicians	N = 81	10
Timermann 2006 (11)	Observational prospective Aim: DI rate	RSI and non-RSI	Emergency physicians	N = 982 OTI Cardiac arrest: 50% Trauma: 26%	16.2
Helm 2006 BJA (12)	Observational prospective Aim: success rate and complications of TI	RSI and non-RSI	Anesthetist physicians	N = 342 Cardiac arrest: 20% Trauma = 70%	12.6
Nakstad 2011 (13)	Observational prospective Aim: Desaturation rate	RSI only	Emergency physicians	N = 122 Trauma: 65%	11
Harris 2011 (14)	Observational prospective Aim: number of attempts to success TI	RSI only	Emergency physicians Training < 6 months *vs.* > 6 M	N = 402	12.5
Combes 2011 (15)	Observational prospective	RSI and non-RSI	Emergency physicians, residents,	N = 2674	26

	Management of 160 DI		Anesthetist nurses		
Jabre 2011 (16)	Controlled randomized trial. Reusable *vs.* single-use laryngoscope blade Aim: success of first attempt	RSI and non-RSI	Emergency physicians, residents, anesthesia nurses	N = 817 Cardiac arrest: 51%	28.8
Freund 2012 (16) (17)	Observational prospective Aim: DI rate	RSI and non-RSI	Emergency physicians residents, anesthesia nurses	N = 653 Cardiac arrest: 56%	29.9
Rognas 2013 (18)	Observational prospective Aim: DI rate: > 1 attempt Complication rate	RSI and non-RSI	Anesthetist physicians	N = 683 Cardiac arrest: 54% Complications: 14%	22.4
Helm 2013 (19)	Observational prospective Aim: desaturation rate	RSI only	Emergency physicians	N = 150	8
Soti 2015 (20)	Observational retrospective Aim: Attempt number	RSI only	Emergency physicians	N = 433	5
Peters 2015 (21)	Observational retrospective Aim: success of first attempt	RSI only	Physicians Nurses Paramedics	N = 1399 Physicians: 52% Nurses: 7% Paramedics: 41%	Phys:15.5 Nurs: 41.7 Param: 53.6
Sunde 2015 (21)	Observational Prospective, multicenter,	RSI only	Physicians	N = 2144 Cardiac Arrest: 42%	CA:20.0% RSI: 11.0%

	international Aim: Assessment of airway management.		RSI: 58%

RSI: rapid sequence induction; DI: difficult intubation; TI: tracheal intubation; OTI: orotracheal intubation.

Table 2: Characteristics of the first operator for each intubation

Function	Missing	Total	PGP years > 2	PGP years ≤ 2	Resident	AN	ANS
N (%)	3	1543	836 (54)	325 (21)	286 (18.5)	71 (4.6)	25 (1.6)
Previous intubations, N(%)	35	1511					
< 10		47 (3.1)	9 (1.1)	5 (1.6)	32 (11.4)	0	1 (4.0)
10–20		162 (10.7)	29 (3.6)	78 (24.4)	55 (19.6)	0	0
20–50		481 (31.9)	182 (22.3)	190 (59.4)	107 (38.2)	0	1 (4.0)
> 50		821 (54.3)	595 (73.0)	47 (14.7)	86 (30.7)	70 (100)	23 (92.0)

PGP: postgraduate physician; resident: resident in training for anesthesia or emergency medicine; AN: anesthetist nurse; ANS: anesthetist nurse student.

Table 3: Patients' characteristics.

Variable	Entire cohort (N = 1546)
Age, median (IQR), y	64 (50–75)
Range	15–99
Missing N = 12	
Sex, N (%)	
Men	984 (64.2)
Women	548 (35.8)
Missing N = 14	
Size, median (IQR), cm	170.0 (165–175)
Range	140–197
Missing N = 172	
Weight, median (IQR), kg	75 (65–85)
Range	37–250
Missing N = 55	
Body mass index, median (IQR), $kg \cdot m^{-2}$	25.0 (22.8–28.3)
Range	13.8–70.3
Missing N = 175	
Main indications of intubation, N (%)	
Missing N = 1	
Cardio-respiratory arrest	916 (59.3)
Acute respiratory failure	132 (8.5)
Acute cardiovascular failure	22 (1.5)
Acute neurological failure	294 (19.0)
Voluntary intoxication	68 (4.4)
Medical etiology without precision	5 (0.3)
Severe trauma	108 (7.0)
Rapid sequence induction, N (%)	
Missing N = 5	
Yes	684 (44.4)
No	857 (55.6)

Sedative drug, N (%)	
Missing N = 4	
Etomidate	597 (87.3)
Ketamine	48 (7.0)
Propofol	4 (0.6)
Nesdonal	31 (4.5)
Myorelaxant drugs, N (%)	
Missing N = 11	
Succinylcholine	660 (96.5)
Rocuronium	13 (1.9)

IQR, interquartile range

Table 4: Factors associated with failure of the first intubation attempt, as identified by univariate analyses.

Variable	Missing N	1 attempt N = 1060 (%)	>1 attempt N = 486 (%)	OR [95% CI]	p-value
Centers	0				0.0001
1		295 (63.9)	167 (36.1)	1	
2		196 (66.4)	99 (33.6)	0.9 [0.7–1.2]	
3		125 (68.7)	57 (31.3)	0.8 [0.8–1.2]	
4		42 (72.4)	16 (27.6)	0.7 [0.4–1.2]	
5		114 (77.4)	33 (22.4)	0.5 [0.3–0.8]	
6		176 (82.2)	38 (17.8)	0.4 [0.3–0.6]	
7		6 (67)	3 (33)	0.9 [0.2–3.6]	
8		20 (57)	15 (43)	1.3 [0.7–2.7]	
9		33 (66)	17 (34)	0.9 [0.5–1.7]	
10		53 (56.4)	41 (43.6)	1.4 [0.9–2.1]	
Function	3				0.007
Senior MD, AN		646 (61.1)	261 (53.8)	1	
Junior MD, Resident, ANS		412 (38.9)	224 (46.2)	1.3 (1.1 - 1.7)	
Experience level	29				0.0001
Simulation, weak, moderate		326 (31.3)	233 (48.8)	2.1 [1.7 - 2.6]	
Good or very good		714 (68.7)	244 (51.2)	1	
Number of prior intubations ≤ 50	36	433 (41.6)	257 (54.7)	1.7 [1.4 - 2.1]	0.0001
Operator position during intubation	36				0.3
Upright		292 (28.2)	122 (25.7)	1	
On knees		470 (45.4)	222 (46.7)	1.1 [0.9 - 1.4]	
Lying on the floor		146 (14.1)	82 (17.3)	1.3 [0.9 - 1.9]	
Lateral left decubitus		90 (8.7)	39 (8.2)	1.0 [0.7 - 1.6]	
Other		37 (3.6)	10 (2.1)	0.6 [0.3 - 1.3]	
Gender, M	14	654 (62.3)	330 (68.5)	1.3 [1.0 - 1.6]	0.02
Age, years, mean (SD)	12	61.9 (18.8)	59.8	0.99 [0.99-1.0]	0.04

			(17.8)		
Weight, kg, mean (SD)	55	75.1 (17.4)	79.8 (20.2)	1.01[1.00–1.08]	0.0001
Body mass index, $kg \cdot m^{-2}$,mean (DS)	175	25.7 (5.5)	27.2 (6.5)	1.04[1.02–1.06]	0.0001
Macroglossia	18	130 (12.4)	131 (27.2)	2.6 [2.0 - 3.5]	0.0001
Facial malformation	16	4 (0.4)	8 (1.7)	4.4 [1.3 - 14.7	0.02
Goiter	18	9 (0.9)	10 (2.1)	2.4 [1.0 - 6.1]	0.05
ENT tumor	17	6 (0.6)	12 (2.5)	4.4 [1.7 - 11.9]	0.003
Inter-incisor space	73				0.0001
<2 fingerbreadths		148 (14.6)	137 (29.7)	2.5 [1.9 - 3.2]	

Limited head extension	40	174 (16.8)	137 (29.1)	2.0 [1.6 - 2.6]	0.0001
Immobilization of the head during intubation	40	122 (11.8)	75 (16.0)	1.4 [1.0 - 1.9]	0.03
Mandibular subluxation	72	107 (10.6)	86 (18.6)	1.9 [1.4 - 2.6]	0.0001
Thyromental length	98				0.0001
<3 fingerbreadths		189 (18.9)	131 (29.2)	1.8 [1.4 - 2.3]	
Neck size	43				0.0001
Large		165 (16.0)	141 (29.9)	2.2 [1.7 - 2.9]	
Foreign body in upper airway	18	52 (5.0)	28 (5.8)	1.2 [0.7 - 1.9]	0.5
Missing anterior teeth	19	238 (22.8)	108 (22.5)	0.9 [0.7 - 1.3]	0.9
Upper airway bleeding/fluid	18	90 (8.6)	66 (13.7)	1.7 [1.2 - 1.3]	0.002
Facial trauma	16	63 (6.0)	44 (9.1)	1.6 [1.0 - 2.3]	0.03
Vomiting	16	181 (17.3)	119 (24.7)	1.6 [1.2 - 2.0]	0.001
Cardiorespiratory arrest	1	605 (57.1)	311 (64.1)	1.3 [1.1 - 1.7]	0.009
Trauma	522	97 (13.6)	66 (21.1)	1.7 [1.2 - 2.3]	0.003
Patient on the floor	23	649 (62.3)	316 (65.6)	1.2 [0.9 - 1.4]	0.2
Place where intubation was done	50				0.01
Outside		136 (13.2)	93 (20.0)	1.6 [1.2 - 2.3]	
At home		517 (50.2)	218 (46.8)	1.0 [0.8 - 1.3]	
Others		105 (10.2)	41 (8.8)	0.9 [0.6 - 1.4]	
Ambulance		272 (26.4)	114 (24.5)	1	
Restricted space	33	374 (36.1)	188 (39.4)	1.1 [0.9 - 1.4]	0.2

OR: odds ratios; 95% CI: 95% confidence intervals.

Table 5: Multivariate analysis

Variable	Odds Ratio	95% Confidence Interval
Center		
1	1	
2	0.9	0.6–1.2
3	0.9	0.6–1.5
4	0.3	0.2–0.8
5	0.6	0.3–0.9
6	0.3	0.2–0.5
7	0.7	0.1–3.9
8	1.1	0.5–2.6
9	0.7	0.3–1.5
10	1.2	0.7–2.1
Number of prior intubations ≤ 50	1.8	1.4–2.4
Sex, M	1.3	0.99–1.71
Age, years	0.99	0.98–1.0
Macroglossia	2.3	1.6–3.2
ENT tumor	4.4	1.4–13.4
Inter-incisor space (< 2 fingerbreadths)	2.3	1.7–3.2
Thyromental length (< 3 fingerbreadths)	1.2	0.9–1.7
Limitation of head extension	1.6	1.1–2.1
Vomiting	1.7	1.3–2.3
Cardio-respiratory arrest	1.8	1.3–2.6
Patient on the floor	1.3	0.9–1.8

Multivariate analysis adjusted for gender, age, centers, and variables with a p-value ≤ 0.2 in univariate analyses, conducted using a backward step-by-step logistic regression model.

Figures

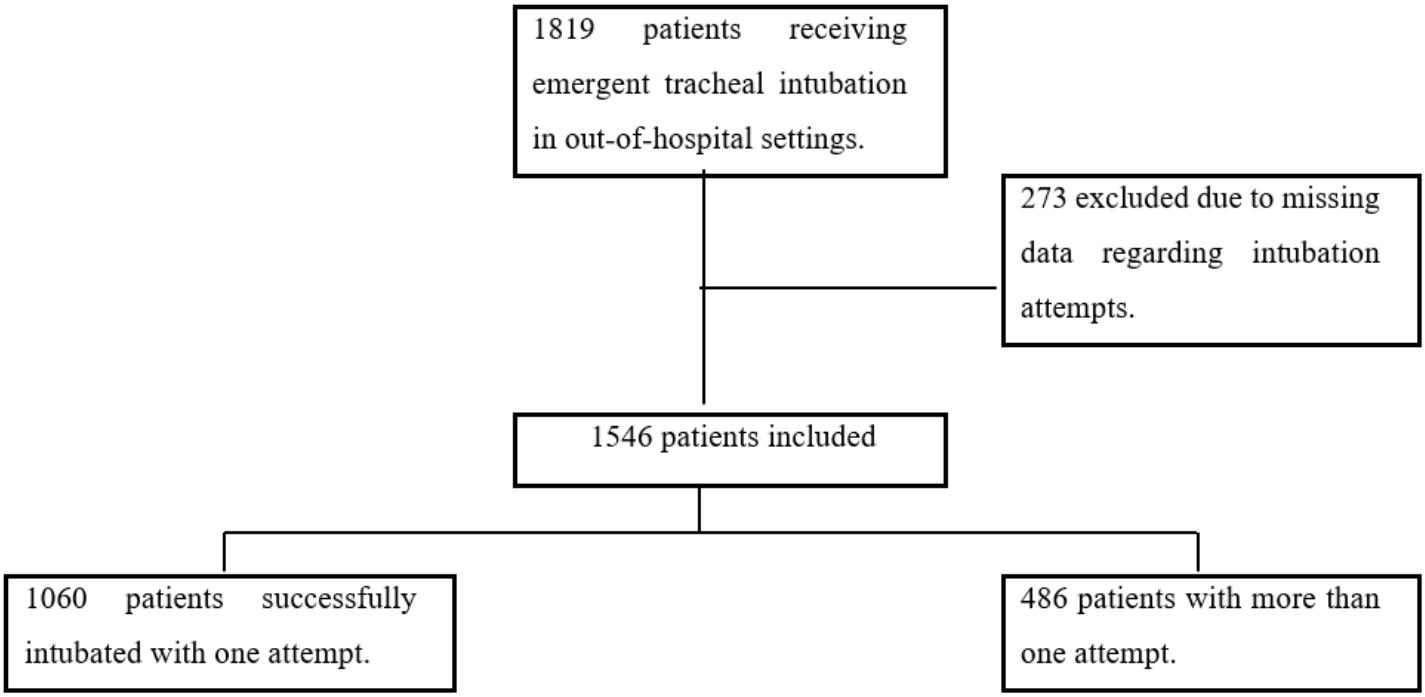

Figure 1

Flow chart

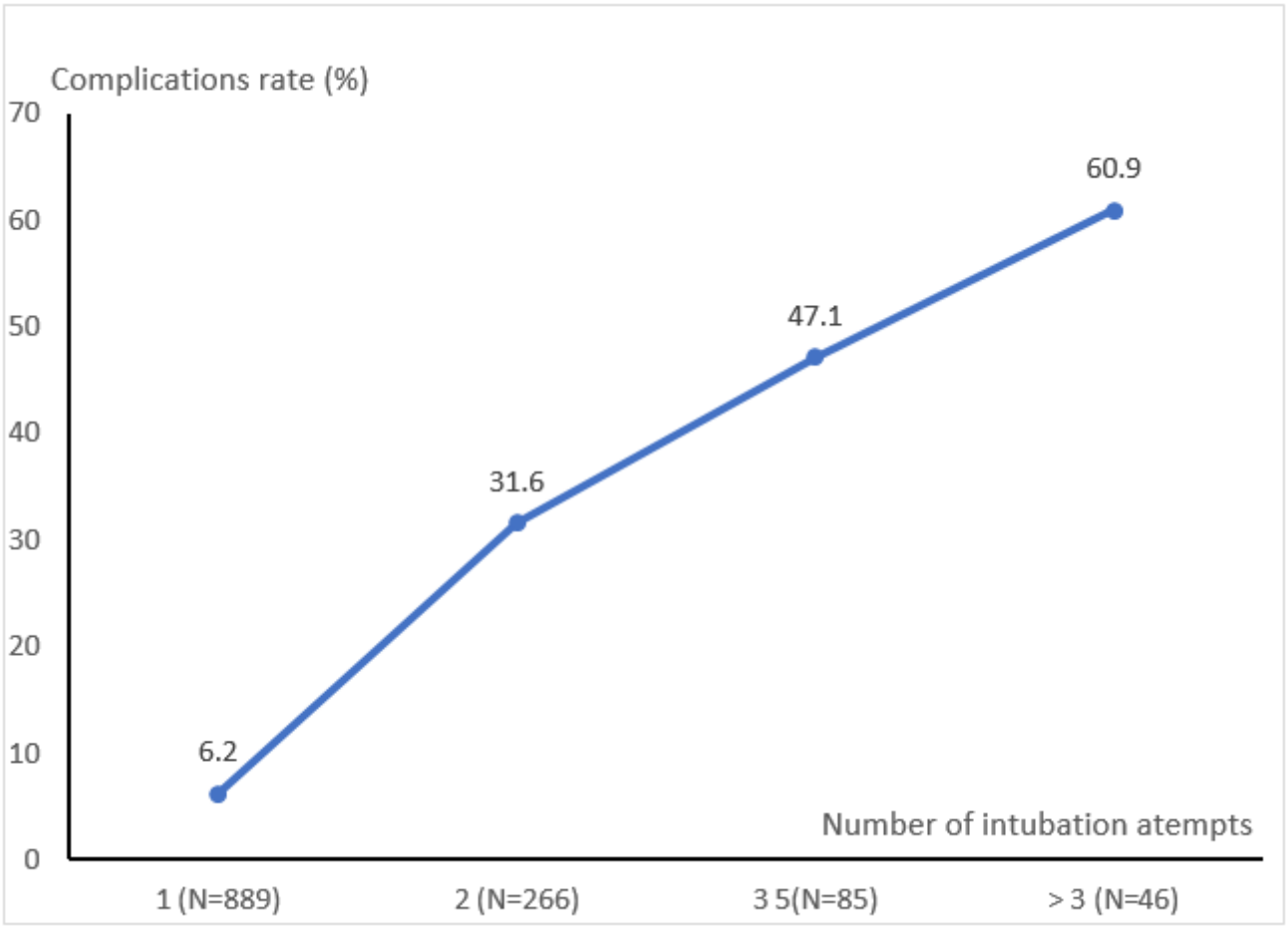

Figure 2

Complication rates according to number of intubation attempts.

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