Airway Management Difficulties in a Helicopter Emergency Medical Service (HEMS): A Retrospective Observational Study of 676 Out-of-Hospital Intubations

Urs Pietsch (urs.pietsch@kssg.ch)
Cantonal Hospital St. Gallen
Raphael Müllner
Cantonal Hospital Luzern
Lorenz Theiler
Kantonsspital Aarau
Volker Wenzel
Friedrichshafen Regional Hospital
Lorenz Meuli
University Hospital Zürich
Jürgen Knapp
Inselspital, University of Bern
Stephen J.M. Sollid
Norwegian Air Ambulance Foundation
Roland Albrecht
Swiss Air-Ambulance, Rega (Rettungsflugwacht/Guarde Aérienne)

Research Article

Keywords: HEMS, airway management, difficult intubation, out-of-hospital intubation, difficult airway management

Posted Date: September 1st, 2021

DOI: https://doi.org/10.21203/rs.3.rs-778557/v1

Abstract

Background: Airway management is a key skill in any helicopter emergency medical service (HEMS). Successful intubation is less often than in the hospital, and alternative forms of airway management are needed more often.

Methods: Retrospective observational cohort study in an anaesthesiologist-staffed HEMS in Switzerland. Patients charts from all scene calls (n=9035) that took place between June 2016 and May 2017 (12 months) were analysed. The primary outcome parameter was intubation success rate. Secondary parameters included number of patients intubated by ground-based emergency medical services, alternative devices used, and comparison of patients with and without difficulties in airway management.

Results: A total of 676 patients with invasive ventilatory support were identified. Difficulties in airway management were rare, occurring in 44 (6.5%) patients, and trauma was significantly more common (59.1% vs. 38.6%, p<0.001). In 335 (49.6%) patients, advanced airway management had already been initiated by Ground emergency medical services upon arrival of the HEMS. Paramedics had significantly more exposure to patients needing prehospital anaesthesia than the HEMS physicians; median 12 (IQR 9 to 17.5) versus 3 (IQR 2 to 6), p<0.001.

Conclusion: Despite overall high success rates for endotracheal intubation in the physician-staffed service, each physician gets little real-life experience with advanced airway management in the field, highlighting the importance of a solid basic competence such as anaesthesiology and additional training. Direct laryngoscopy is still a valuable skill and an important Plan B in difficult airway situations in which factors such as fogging, blood, bright radiation on the video laryngoscopes screen, impaired the success of video laryngoscopes intubation.

Background

Where available, helicopter emergency medical services (HEMS) provide fast and effective treatment and transport of severely ill or injured patients, even in areas with difficult access such as alpine regions. Among the critical life-saving skills provided by HEMS, advanced airway management has long been considered a core skill (1). However, prehospital endotracheal intubation (ETI) success rates vary between HEMS services and systems, depending on skills competence and level of experience (2, 3). In the hands of well-trained and experienced personnel, intubation success is comparable to rates in the hospital (4, 5).

Factors that seem to facilitate high success rates are ETI provided by physicians, and trans-oral, rapid-sequence and drug-facilitated ETI (3, 4). On the other hand, success rates are lower in certain patient subgroups, especially patients suffering trauma and cardiac arrest (4). Complication rates are also generally higher and first-pass success (FPS) lower in the prehospital setting, which may have an impact on patient outcome in the long run (4–6).

Typically, exclusive factors for the prehospital setting play a role, such as early management of traumatic facial injuries and environmental factors like weather, light and access to the patient (7). Failed initial intubation attempts usually lead to optimisation of patient positioning, use of intubation assist devices, or use of alternative airway management devices (8). The use of devices such as video laryngoscopes (VL) may further facilitate success rates and reduce complication rates (9). Advanced prehospital airway management therefore still needs close oversight, and HEMS systems should be aware of their success rates and complication rates.

The goal of this study was to critically review cases of advanced airway management encountered by Rega HEMS, identify the success rates and difficulties recorded, and describe the techniques chosen that eventually secured the airway.

Methods

Setting, definitions and ethics

In Switzerland, five organizations provide 24/7 physician-staffed HEMS operations. Two thirds of these are primary missions (pre-hospital retrieval) and one third are secondary missions (inter-hospital transfer). Rega operates 12 helicopter bases, located throughout Switzerland, and helicopter teams can reach any location in the operational area within 15 minutes of flight time, day or night, provided the weather conditions are met.

The HEMS crew typically includes a pilot, an HEMS physician, and a paramedic who serves as technical crew member and hoist operator. The requirements for HEMS physicians are board certification in anaesthesiology. Several HEMS physicians hold an additional certification in intensive and critical care medicine and/or mountain emergency medicine. These physicians are experienced in emergency airway management (according to their local hospital and Rega standardized protocol and training in difficult airway management) and paediatric anaesthesia (paediatric advanced life support providers). The Rega standard of advanced airway management is ETI performed as a rapid sequence induction and intubation without obligation to omit mask ventilation prior to ETI (10). The equipment is standardised throughout the entire organisation (including special paediatric airway equipment).

The Ground-Based Emergency Services (GEMS) crew typically includes two paramedics (board certification) and an emergency physician can be called by paramedic’s already on site or may accompany the ambulance crew from the beginning, depending on the severity of the reported emergency. Experience in intubation skills of GEMS varies, as does the number of prehospital intubations performed.

In HEMS missions conducted by Rega, difficulties in airway management are defined as several reported attempts at intubation, the need for assist devices, secondary placement of a supraglottic airway device, and cricotomy.

The local ethical committee provided approval for this retrospective observational study (Kantonale Ethik Kommission (KEK) Bern, 2017–02094).

Study population

For this retrospective observational cohort study, digital patient charts of all consecutive primary HEMS missions conducted by Rega from June 1, 2016, to May 1, 2017 were screened. All patients with reported use of any type of ventilatory support were included, and those protocols were analysed by hand. Invasive ventilatory support included the use of tracheal intubation, supraglottic devices, and front-of-neck access. Patients with non-invasive ventilatory support (NIV), mask ventilation without attempted invasive ventilatory support, and patients who were transferred between hospitals were excluded from this analysis.

Outcome

The primary outcome was FPS and overall intubation success rate as described by Frerk et al (11). Secondary outcomes included the number of patients intubated by GEMS, the use of ventilatory assist devices, reported solutions addressing initially failed intubation, and alternative devices. Further, the use of neuromuscular blocking agents (NMBA) in intubations performed by Rega, the type of diagnosis (trauma, cardiovascular, neurologic, burns, drowning, intoxication, other), NACA score (National Advisory Committee of Aeronautics), location of intubation (e.g., remote terrain), age, and gender were recorded and the individual total number of intubations performed by each individual was analysed as well.

Statistical analysis

Patients' characteristics were summarised and presented in tables. Continuous variables were summarised by mean ± standard deviation if normally distributed or by median and interquartile range if skewed. Normality was tested using the Shapiro-Wilk test. Categorical variables were summarised with counts and percentages for each level of the variable. Continuous variables were compared using Student's t-test if normally distributed or the Mann-Whitney U test if skewed. Categorical variables were summarised with counts and percentages for each level of the variable and compared using Pearson's chi-squared test.

Exploratory analyses were performed to elaborate the impact of factors that are potentially associated with a difficult airway, using a multivariate logistic regression model. The model included the a priori defined variables *trauma*, *night mission*, *relaxation*, *access to patient*, *CPR*, and *NACA level*. All analyses were conducted with R-Studio, version 3.4.3, on MacOS version 10.15.7. p-values are two-sided with an α-level of 5%.

Results

During the observed time period from June 1, 2016, until May 31, 2017, Rega was deployed for a total of 9,035 missions. The 2,428 secondary missions were excluded and the remaining 6,607 primary missions were potentially eligible for analysis. In 927 missions, some type of airway management was identified.

In 251 of those cases, it was short-term assisted ventilation using only bag-valve mask ventilation. A total of 676 patients received invasive airway management, completing the study cohort (Fig. 1).

The mean age of the patients was 54.6 ± 21.8 years and the majority of patients were male (72.9%). There were no significant differences in these baseline characteristics between patients with difficult airways and patients with non-difficult airways. In a total of 44 patients (6.5% of patients with invasive ventilatory support), difficulties in airway management were reported.

In the 335 patients whose airway was managed by GEMS, intubation failed in 19 (5.5%), in 76 (22.5%) cases the crew used a supraglottic device or bag valve mask (BVM) and was successful in 240 (72%) (Fig. 1). There were no reports available regarding the number of intubation attempts made by GEMS.

There were 341 patients whose airway was managed by Rega HEMS. Intubation failed initially in 25 of these patients and was successful in 316. In addition, Rega physicians solved the airway management difficulties of 20 GEMS patients, using standard intubation in a second attempt. This resulted in a failure rate of 6.9% (25/361) and an HEMS first-attempt success rate of 93%.

The Rega team solved the airway management difficulties using standard intubation (successful intubation on a second attempt) in 24 patients. In six patients 2nd attempt intubation was successful using a special device a bougie, BVM ventilation in 4 patients, intubation via Intubating Laryngeal Mask (ILMA, Teleflex, Westmeath, Ireland) in 3 patients and performing a futile cricotomy in one patient. In 6 patients, the supraglottic airway device was left in place (Fig. 1).

Airway management in paediatric patients (n = 39) was uneventful in 6 cases (age 0–1 years), 18 cases (2–6 years) and 15 cases (7–15 years). A supraglottic airway device was used as a primary device in 55 patients when the GEMS was not staffed by a crew competent in ETI. Twenty-two of these patients were later intubated by Rega personnel, and in 33 patients the supraglottic airway device was left in place until arrival at the hospital.

The most common condition requiring any form of airway management was trauma (39.9%), followed by cardiovascular emergencies (33.9%) and neurological emergencies (16.6%). The median NACA score was 5 (IQR 5 to 6) and was not significantly different among the groups, $p = 0.94$. The use of catecholamines was associated with fewer difficulties in airway management in both the univariate and the multivariate analysis ($p = 0.048$). Trauma was associated with more difficulties in airway management than cardiovascular disease, but only in the multivariate analysis ($p = 0.021$). There was no significant difference in all other baseline characteristics in both the univariate and the multivariate analyses (Tables 1 and 2, Fig. 3). The use of neuromuscular blocking agents to facilitate tracheal intubation was reported in only 390 (66%) patients and was not available for 286 patients. Succinylcholine was used in 176 patients (45.1%), rocuronium in 107 patients (27.4%), and no neuromuscular blocking agents (NMBA) in 107 patients (27.4%). The absence of NMBA was found significantly more often ($p < 0.001$) in patients undergoing CPR than in the remaining patients.

Table 1
Baseline Characteristics

Variable	Successful First Attempt Intubation N = 632	Difficult Airway N = 44	Total N = 676	p value
Age, years mean (SD)	54.9 (21.8)	51.4 (20.8)	54.6 (21.8)	0.305
Male sex	460 (72.8%)	33 (75.0%)	493 (72.9%)	0.749
Diagnosis				0.056
Trauma	244 (38.6%)	26 (59.1%)	270 (39.9%)	
Cardiovascular	219 (34.7%)	10 (22.7%)	229 (33.9%)	
Neurological	106 (16.8%)	6 (13.6%)	112 (16.6%)	
Other	63 (10.0%)	2 (4.5%)	65 (9.6%)	
CPR	175 (27.7%)	10 (22.7%)	185 (27.4%)	0.475
NACA				0.935
Median	5	5	5	
IQR	5 to 6	5 to 6	5 to 6	
Use of NMBA	412 (65.2%)	31 (70.5%)	443 (65.5%)	0.477
Type of NMBA				0.659
Missing	275	11	286	
None	100 (28.0%)	7 (21.2%)	107 (27.4%)	
Succinylcholine	159 (44.5%)	17 (51.5%)	176 (45.1%)	
Rocuronium	98 (27.5%)	9 (27.3%)	107 (27.4%)	
Use of catecholamines	254 (40.2%)	11 (25.0%)	265 (39.2%)	0.046
Night-time Mission	81 (12.8%)	8 (18.2%)	89 (13.2%)	0.309
Remote Location	105 (16.6%)	4 (9.1%)	109 (16.1%)	0.190

Data was complete if not otherwise stated. CPR=cardiopulmonary resuscitation. IQR: Interquartile Range. NMBA=neuromuscular blocking agents

Table 2
Multivariable Regression

Variable	Odds Ratio	95% C.I.	p value
Age, years	1.00	0.99–1.02	0.991
Male sex	1.04	0.51–2.24	0.926
Cardiovascular diagnosis	0.34	0.13–0.84	0.021
Neurological diagnosis	0.59	0.21–1.48	0.286
Other diagnosis	0.27	0.04–0.97	0.086
Remote location	0.49	0.14–1.26	0.183
Night-time mission	1.48	0.60–3.30	0.362
Use of NMBA	1.26	0.52–3.32	0.627
Use of catecholamines	0.45	0.19–0.97	0.048
CPR	0.82	0.29–2.32	0.704
NACA	1.82	0.99–3.39	0.057

Footnote: Complete case analysis of 676 patients. Pseudo-R^2 (Cragg-Uhler) = 0.06. Intercept OR = 0.00 (0.00 - 0.18) p= 0.005.

In the observed time period, a total of 137 different Rega physicians treated the patients who needed advanced airway support. Paramedics (n = 48) were significantly more involved than physicians in pre-hospital airway manoeuvres: median 12 (IQR 9 to 17.5) versus 3 (IQR 2 to 6), $p < 0.001$ (Fig. 2).

Discussion

In this cross-sectional study of advanced airway management cases encountered by Rega HEMS over a one-year period we found a high FPS rate of ETI. Most airway problems could be solved on a second attempt, and only 1.6% of patients in the entire cohort of attempted ETIs were unsuccessfully treated or managed with another strategy to maintain ventilation and oxygenation.

Difficult airway management in HEMS

With an incidence of 6%, difficulties in airway management occurred less often than in comparable studies. As reported in a meta-analysis by Lossius et al. (3), the overall out-of-hospital intubation success rate seems to be around 90%, regardless of the number of intubation attempts. In a large prospective study on advanced airway management in HEMS staffed by physicians of different specialties, a first-attempt failure rate of 14.5% was recorded, whereas the overall failure rate was 1.2% (5). Although the advanced airway management skills play a core role, the overall impact of HEMS staffed by physicians is difficult to demonstrate due to a lack of solid evidence (12), and probably has to be seen in a broader perspective than the isolated effect of airway management outcome (13).

Patients' categories

The patients most in need of advanced airway management were trauma patients (39.9%) and patients with cardiovascular emergencies (33.8%). Injuries due to trauma seem to be a dominating reason for providing advanced airway management in many HEMS services in Europe. Some studies have demonstrated lower fractions of trauma patients, such as the study by Gellerfors et al., with data from HEMS services in the Nordic countries. In that study, trauma patients only accounted for 19% of patients receiving ETI, but with a consequently higher proportion of cardiovascular emergencies (53%) (4).

Trauma was also the condition most commonly encountered in patients with difficulties in airway management, and significantly more so than in patients with non-difficult airway management (59.1% vs. 38.6%, respectively, $p < 0.001$). In contrast to a study by Sunde et al., cardiac arrest patients showed no higher first-attempt failure rates than non-cardiac arrest patients in our data (5). An explanation for this remains speculative but may have to do with differences in the timing of ETI during cardiopulmonary resuscitation (CPR) or the general organisation of CPR between services.

Unlike many other airway studies, we included paediatric airway management in our analysis, with no difficulties reported in the nine intubations performed in the age group ≤ 2 years. This is interesting since this age group is known to be particularly vulnerable to adverse events (13, 23). There are no studies evaluating the outcome of paediatric patients treated by GEMS vs. HEMS, but as the above-mentioned studies imply, the mere possibility of encountering paediatric patients who require advanced airway management mandates emergency physicians on scene who are thoroughly trained.

Environmental factors & patient location

Environmental factors may also play a role. This may be especially true for patients treated outdoors, where hazardous weather conditions (rain, overly bright sunlight), difficult terrain, and noise may be encountered at an accident site. Importantly, this should not lead to a delay of tracheal intubation if the indication is correct (14). Remote environments like alpine terrain had no influence on the occurrence of a difficult airway in our data. This is in contrast to the latest data from Knapp et al., who found that being located outdoors had a significantly negative effect on the FPS, e.g. due to direct sun radiation on the VL screen or suboptimal patient positioning on the FPS intubation with a VL (15). This finding could be explained by the previously described experience that successful intubation with VL is less likely in bright sunlight due to poor visibility on the screen (16). Theiler et al. previously described this phenomenon and the advantage of the Macintosh laryngoscope over VL in a manikin study (16). Fogging is an additional factor which seemed to impact FPS in the recent paper by Knapp et. al. (15). These factors, which impaired the success of VL, demonstrate that although VL is increasingly becoming the gold standard, direct laryngoscopy is still a valuable skill and an important Plan B in difficult situations.

Solutions for airway management difficulties

According to our findings, Rega personnel was able to solve airway management difficulties in 20 of the 23 patients in whom GEMS encountered a problem (87%). In cases of failed intubation, supraglottic airway devices were the primary solution when intubation was not possible, highlighting the importance of these tools as back-up devices (17, 18). Likewise, BVM ventilation was possible in almost all cases, and this remains a valuable option for adequately trained personnel to provide ventilation, if securing the airway by advanced means is not possible. Six of the cases with first-pass failure were resolved with an airway introduction catheter ("bougie"). It is unknown whether the primary use of this device would have further improved the FPS rate, but other studies have reported an increase in success rates from 85.7–98.2% after the introduction of a bougie for use in all out-of-hospital intubation (19, 20). The use of VL was documented in only 26 cases, 24 of which were managed with a C-MAC STORZ® device, and the other two with an AIRTRAQ. Still, as a consequence of the findings in this study, Rega HEMS has introduced the regular use of VL as the primary intubation aid to increase FPS rates (15, 21).

Airway management failed in one patient in our data material, a morbidly obese patient with extensive facial injuries. A failed ETI, followed by failed ventilation with a supraglottic airway device and failed BVM ventilation led to an attempted emergency front of the neck access (eFONA) with the failed use of a Quicktrach cannula (VBM, Sulz a. N., Germany). As a consequence of this experience, Rega has changed its technique for eFONA to a surgical approach according to the Difficult Airway Society (DAS) guidelines (11).

Education

As our data illustrates, advanced airway procedures are performed on only a small fraction of patients encountered by HEMS. With one in ten patients receiving advanced airway management and 137 physicians in the service, it is not surprising that each physician encounters a median of only three difficult intubation cases per year. Other studies from similar HEMS systems have demonstrated similarly low numbers for airway management and other advanced skills (23). To perform complex and time-critical (difficult) airway interventions, the necessary procedural and manual skills have to be trained and perfectly mastered in in-hospital settings (OR, intensive care unit, emergency department, etc.) as well as out-of-hospital under emergency conditions (in GEMS and non-alpine HEMS) before a physician can be signed off for HEMS rescue missions (24–26).

Limitations

When discussing difficulty rates in airway management, there is a selection bias, as is always the case with retrospective studies. Documentation of airway management was performed by the responsible physician. However, airway management may not have been accurately described with regard to the devices used, difficulties encountered or number of intubation attempts performed. For our study, questionable protocols were all evaluated by hand, and individual physicians were contacted for clarification if necessary. Relationship between level of training and successful airway has not been explored.

Conclusions

Despite overall high success rates for endotracheal intubation in the physician-staffed service, each physician gets little real-life experience with advanced airway management in the field, highlighting the importance of a solid basic competence like anaesthesiology and additional training. Direct laryngoscopy is still a valuable skill and an important Plan B in difficult airway situations in which factors like fogging, blood, bright radiation on the VL screen, impaired the success of VL intubation.

Abbreviations

BVM: Bag valve mask

CPR: Cardiopulmonary Resuscitation

GEMS: Ground-Based Emergency Services

ETI: Endotracheal Intubation

FPS: First-pass success

Rega: acronym combining «Rettungsflugwacht» and «Garde aérienne» (translating to "air rescue" in both German and French, respectively)

HEMS: Helicopter Emergency Medical Service

NACA: National Advisory Committee for Aeronautics

NMBA: neuromuscular blocking agents

NIV: Non-invasive ventilatory support

No: Number

VL: videolaryngoscope

Declarations

Ethics

Ethical approval for this study (Ethical Committee N° Project ID 2017-02094) was provided by the Ethical Committee Bern cantonal ethics committee (KEK Bern, Murtenstrasse, 3010 Bern) Switzerland on Nov 27th, 2017.

Acknowledgements relating to this article

We would like to thank Jeannie Wurz, Medical Editor, Bern, Switzerland, for editorial assistance.

Financial support and sponsorship

None

Conflict of interest

None

Presentation

None declared

Consent for publication

Not applicable

Availability of data and material

Please contact author for data requests.

Authors' contributions

UP, JK and RM performed the study; UP wrote the manuscript; LM performed the statistical analyses; SS, LT, RA and VW made substantial contributions to conception and design of the study and critically revised the article for important intellectual content. All authors read and approved the final manuscript.

References

1. Lossius HM, Søreide E, Hotvedt R, Hapnes SA, Eielsen OV, Førde OH, et al. Prehospital advanced life support provided by specially trained physicians: is there a benefit in terms of life years gained? Acta Anaesthesiol Scand. 2002;46(7):771-8.
2. Peters J, van Wageningen B, Hendriks I, Eijk R, Edwards M, Hoogerwerf N, et al. First-pass intubation success rate during rapid sequence induction of prehospital anaesthesia by physicians versus paramedics. Eur J Emerg Med. 2015;22(6):391-4.
3. Lossius HM, Røislien J, Lockey DJ. Patient safety in pre-hospital emergency tracheal intubation: a comprehensive meta-analysis of the intubation success rates of EMS providers. Critical Care.

2012;16(1):R24.

4. Gellerfors M, Fevang E, Bäckman A, Krüger A, Mikkelsen S, Nurmi J, et al. Pre-hospital advanced airway management by anaesthetist and nurse anaesthetist critical care teams: a prospective observational study of 2028 pre-hospital tracheal intubations. British journal of anaesthesia. 2018;120(5):1103-9.
5. Sunde GA, Heltne JK, Lockey D, Burns B, Sandberg M, Fredriksen K, et al. Airway management by physician-staffed Helicopter Emergency Medical Services - a prospective, multicentre, observational study of 2,327 patients. Scand J Trauma Resusc Emerg Med. 2015;23:57.
6. Bernhard M, Becker TK, Gries A, Knapp J, Wenzel V. The First Shot Is Often the Best Shot: First-Pass Intubation Success in Emergency Airway Management. Anesth Analg. 2015;121(5):1389-93.
7. Cobas MA, De la Pena MA, Manning R, Candiotti K, Varon AJ. Prehospital intubations and mortality: a level 1 trauma center perspective. Anesth Analg. 2009;109(2):489-93.
8. Breckwoldt J, Klemstein S, Brunne B, Schnitzer L, Mochmann H-C, Arntz H-R. Difficult prehospital endotracheal intubation – predisposing factors in a physician based EMS. Resuscitation. 2011;82(12):1519-24.
9. Cavus E, Callies A, Doerges V, Heller G, Merz S, Rösch P, et al. The C-MAC videolaryngoscope for prehospital emergency intubation: a prospective, multicentre, observational study. Emerg Med J. 2011;28(8):650-3.
10. Neuhaus D, Schmitz A, Gerber A, Weiss M. Controlled rapid sequence induction and intubation - an analysis of 1001 children. Paediatr Anaesth. 2013;23(8):734-40.
11. Frerk C, Mitchell VS, McNarry AF, Mendonca C, Bhagrath R, Patel A, et al. Difficult Airway Society 2015 guidelines for management of unanticipated difficult intubation in adults. British journal of anaesthesia. 2015;115(6):827-48.
12. Risgaard B, Draegert C, Baekgaard JS, Steinmetz J, Rasmussen LS. Impact of Physician-staffed Helicopters on Pre-hospital Patient Outcomes: A systematic review. Acta Anaesthesiol Scand. 2020.
13. Sollid SJM, Rehn M. The role of the anaesthesiologist in air ambulance medicine. Current Opinion in Anesthesiology. 2017;30(4):513-7.
14. Lockey DJ, Crewdson K. Pre-hospital anaesthesia: no longer the 'poor relative' of high quality in-hospital emergency airway management. Br J Anaesth. 2018;120(5):898-901.
15. Knapp J, Eberle B, Bernhard M, Theiler L, Pietsch U, Albrecht R. Analysis of tracheal intubation in out-of-hospital helicopter emergency medicine recorded by video laryngoscopy. Scand J Trauma Resusc Emerg Med. 2021;29(1):49.
16. Nabecker S, Greif R, Kotarlic M, Kleine-Brueggeney M, Riggenbach C, Theiler L. [Outdoor performance of different videolaryngoscopes on a glacier: a manikin study]. Emergencias. 2016;28(4):216-22.
17. Leventis C, Chalkias A, Sampanis MA, Foulidou X, Xanthos T. Emergency airway management by paramedics: comparison between standard endotracheal intubation, laryngeal mask airway, and I-gel. Eur J Emerg Med. 2014;21(5):371-3.

18. Kendall MC. Laryngeal mask airway as a rescue device for failed endotracheal intubation. Eur J Emerg Med. 2019;26(1):73.
19. Angerman S, Kirves H, Nurmi J. A before-and-after observational study of a protocol for use of the C-MAC videolaryngoscope with a Frova introducer in pre-hospital rapid sequence intubation. Anaesthesia. 2018;73(3):348-55.
20. Hossfeld B, Thierbach S, Allgoewer A, Gaessler H, Helm M. First pass success of tracheal intubation using the C-MAC PM videolaryngoscope as first-line device in prehospital cardiac arrest compared with other emergencies: An observational study. Eur J Anaesthesiol. 2021;38(8):806-12.
21. Sulser S, Ubmann D, Schlaepfer M, Brueesch M, Goliasch G, Seifert B, et al. C-MAC videolaryngoscope compared with direct laryngoscopy for rapid sequence intubation in an emergency department: A randomised clinical trial. Eur J Anaesthesiol. 2016;33(12):943-8.
22. Hossfeld B, Frey K, Doerges V, Lampl L, Helm M. Improvement in glottic visualisation by using the C-MAC PM video laryngoscope as a first-line device for out-of-hospital emergency tracheal intubation: An observational study. Eur J Anaesthesiol. 2015;32(6):425-31.
23. Sollid SJ, Bredmose PP, Nakstad AR, Sandberg M. A prospective survey of critical care procedures performed by physicians in helicopter emergency medical service: is clinical exposure enough to stay proficient? Scand J Trauma Resusc Emerg Med. 2015;23:45.
24. Pietsch U, Strapazzon, G., Ambühl, D. et al. Challenges of helicopter mountain rescue missions by human external cargo: need for physicians onsite and comprehensive training. . Scand J Trauma Resusc Emerg Med. 27, 17 (2019).
25. Pietsch U, Knapp, J., Kreuzer, O. et al. Advanced airway management in hoist and longline operations in mountain HEMS – considerations in austere environments: a narrative review This review is endorsed by the International Commission for Mountain Emerg. Scand J Trauma Resusc Emerg Med 26, 23 (2018) https://doiorg/101186/s13049-018-0490-5.
26. Pietsch U, Knapp J, Mann M, Meuli L, Lischke V, Tissi M, et al. Incidence and challenges of helicopter emergency medical service (HEMS) rescue missions with helicopter hoist operations: analysis of 11,228 daytime and nighttime missions in Switzerland. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine. 2021;29(1):92.

Figures

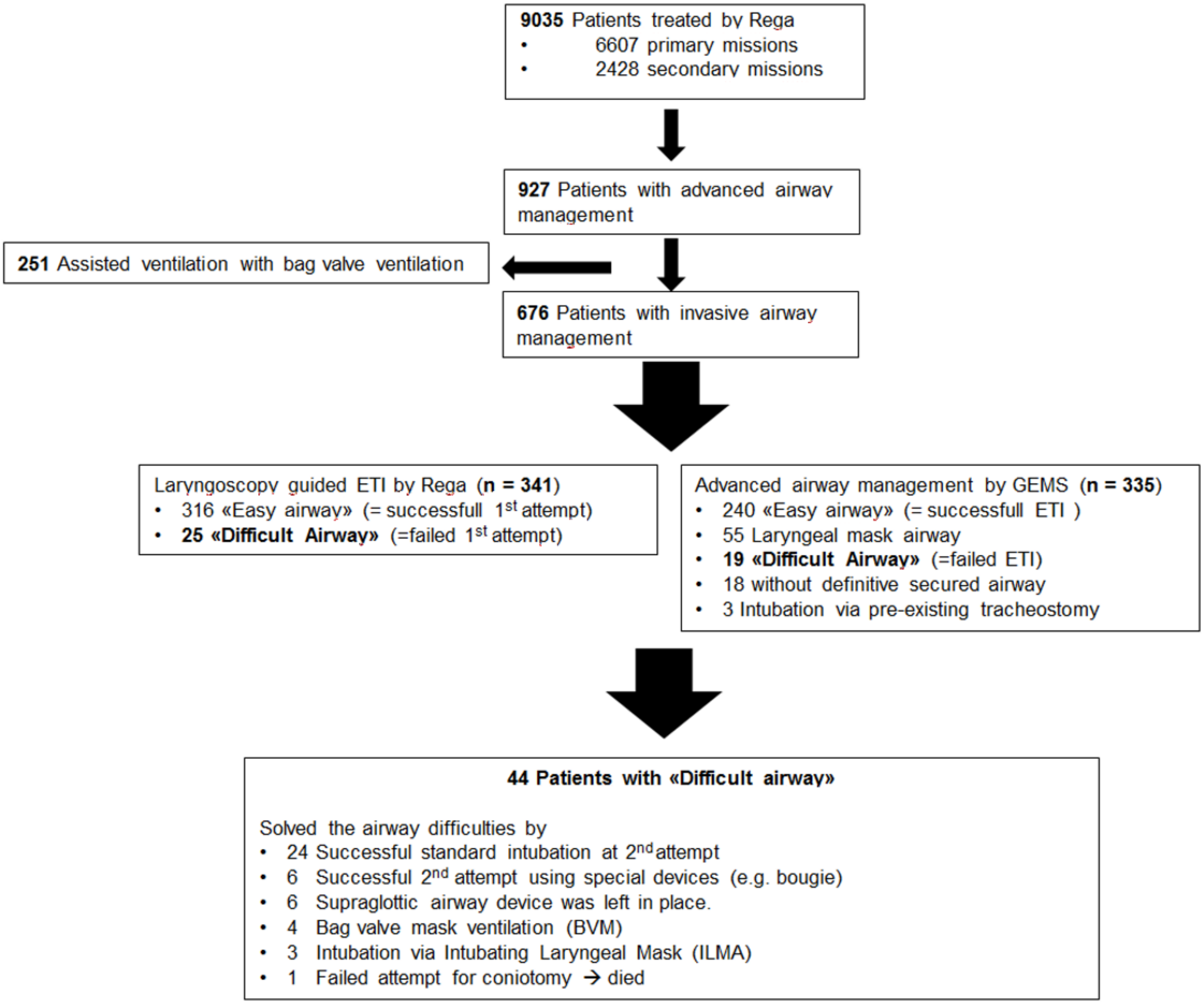

Figure 1

Patient flow chart

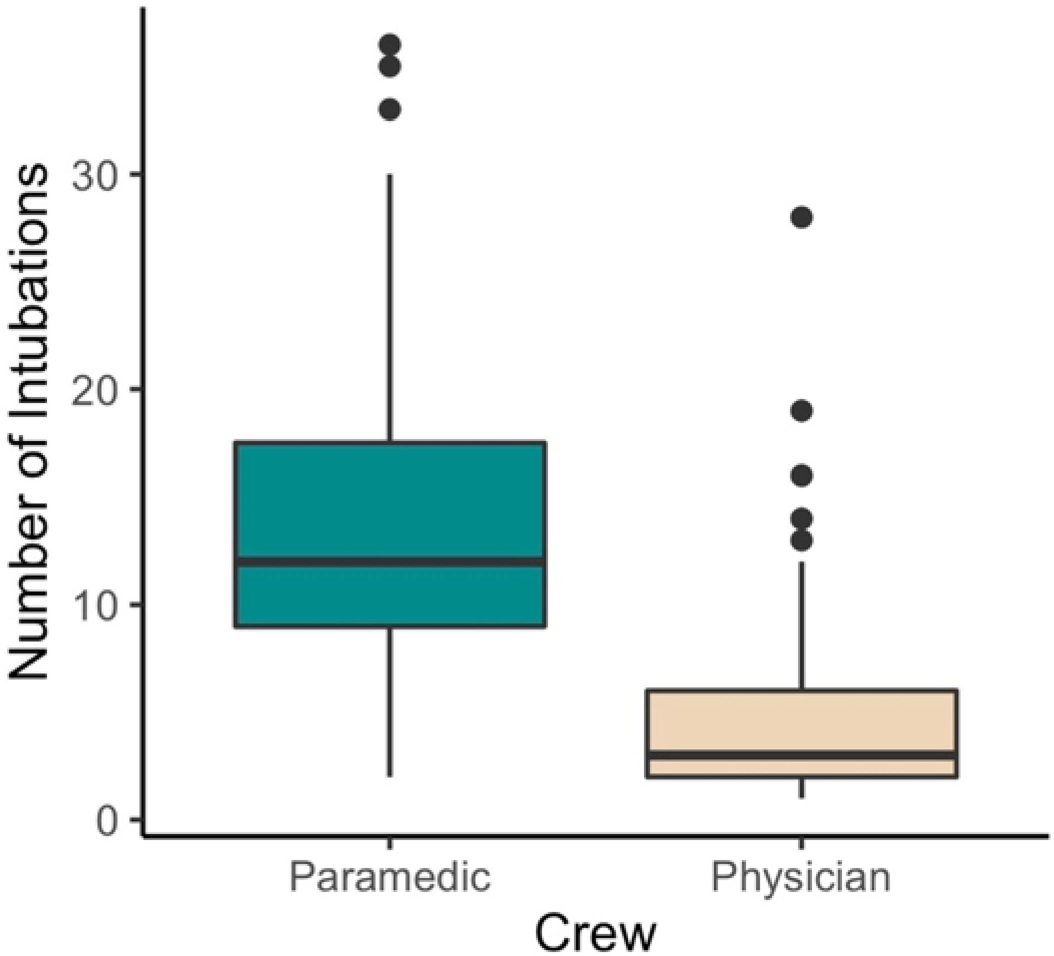

Figure 2

137 Rega physicians and 48 Rega paramedics treated the patients who needed advanced airway support. Paramedics had significantly more frequency than the involved physicians in pre-hospital airway manoeuvres, median 12 (IQR 9 to 17.5) versus 3 (IQR 2 to 6)/, p<0.001.

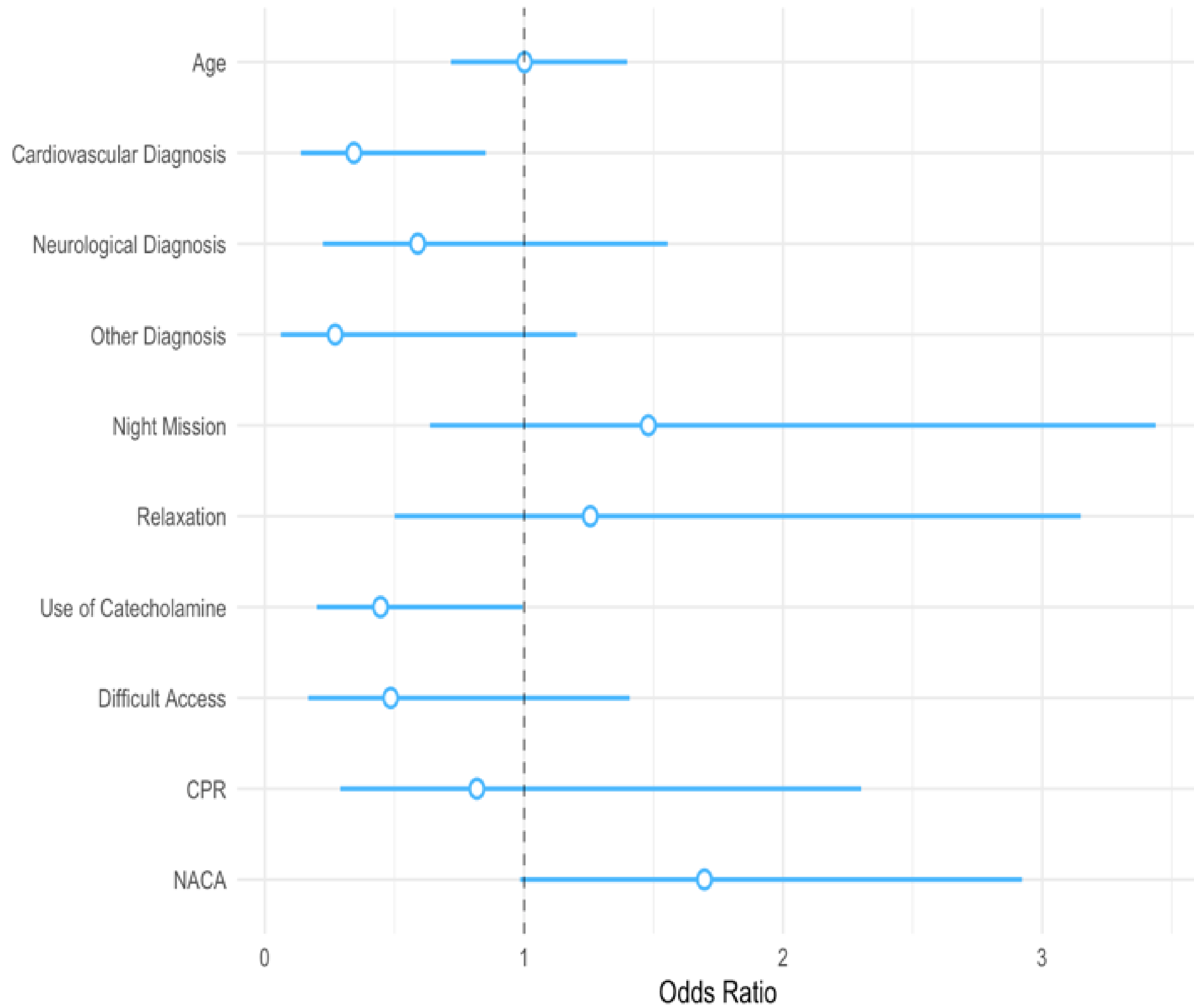

Figure 3

Illustration of the multivariate logistic regression model summarized in Table 2. Regression coefficients are exponentiated and scaled. The horizontal lines around the dots indicate the 95% confidence interval of the odds ratio. The OR indicates the attributable risk of having the condition (e.g. having a trauma was significantly associated with non-successful first attempt intubation compared to non-trauma patients). Difficult access = remote location / alpine terrain