

Approach to the Airway in the Emergency Department (ED) and Intensive Care Unit (ICU) in a Portuguese University Hospital Center: a prospective observational study

Tiago Cabral (✉ tiago_nascimento_cabral@hotmail.com)

Hospital do Divino Espírito Santo de Ponta Delgada EPE <https://orcid.org/0000-0001-5122-9823>

Helena Figueira

Centro Hospitalar do Porto

Ricardo Oliveira

Centro Hospitalar do Porto

Ângela Mota

Centro Hospitalar do Porto

Irene Aragão

Centro Hospitalar do Porto

Carla Margarida Teixeira

Centro Hospitalar do Porto

Research article

Keywords: airway approach; critically ill; operator; inexperience; complications

Posted Date: March 28th, 2019

DOI: <https://doi.org/10.21203/rs.2.517/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Background Airway management is a commonly performed procedure in the Emergency Department (ED) and Intensive Care Unit (ICU), being tracheal intubation the gold standard with relatively high rates of complications in these settings. The purpose of our study was to analyse the airway approach in our institution at ED and ICU identifying the main complications associated and taking notice of possible factors related to them. Methods Prospective observational study conducted between May and September 2014 in the ICU and ED of Santo Antonio Hospital, with the primary aim of identifying the main complications of the airway approach in the critical patient and secondary aim to take notice of possible factors related with complications of the airway approach related to technical skills of the operator, patient's specificities and airway approach techniques. The statistical analysis was done in cooperation with the Medical Informatics and Biostatistics Department of the Faculty of Medicine of the University of Porto. P values <0.05 were considered significant for all hypothesis testing. The analysis was done using the statistical analysis program SPSS® v.21.0 Results A total of 182 patients were included, corresponding to 257 attempted tracheal intubations (ATI). The rate of successful first-pass orotracheal intubation was 67%. Complications related to ATI were reported in 30% of all attempts, being most frequently among residents (81%, $p=0.001$) and those with little experience in airway approach (46%, $p<0.001$). The majority of complications was failed intubation (18%). In the group with complications, relation with an identifiable obvious cause was seen in 87% of cases ($p<0.001$), the major being inexperience in 42% of operators with complications, instead of 1% in the group without complications ($p<0.001$). Conclusions Failed ATI and its complications are largely dependent on operator's expertise. Factors related to patient, lack of appropriate equipment and inappropriate strategy delineation also play a role. Recognition of patients at particular risk of difficult airway management is crucial.

Background

Airway management is a commonly performed procedure in the ED and ICU, being tracheal intubation the gold standard. Several studies identify relatively high rates of complications in these settings, ranging from 20 to 31% in ICUs [1], which can be life-threatening, including severe hypoxia, hemodynamic collapse, cardiac arrest and death [2]. This pool of patients differs from those in elective surgery intubated in the operating room taking into account that they often present with severe respiratory failure, hemodynamic instability, absence of a fasting state and other comorbidities [2]. In general, hypoxemia is common in patients requiring intubation and care should be given to its quick performance to avoid aspiration [3] and further desaturation, given that previous studies reported a significant increase in hypoxemia with the increase in laryngoscopic attempts [3]. In order to minimize the prevalence of severe hypoxemia and severe collapse following intubation and associated complications, specific risk factors for complications related to intubation and difficult intubation in the ICU have been identified [4].

Further circumstances contribute to high incidence of difficult intubation when compared to elective intubation in the operating room [2]. Intubation of critically ill patients is impaired by lack of training and

assistance, unrecognition of patients at risk, failure to plan and to lead an alternative approach, if necessary, and few resources concerning available equipment and the limited space around ICU beds [2]. Differences in outcomes, with higher rate of adverse outcomes and important deficiencies of airway management in ICU and ED, compared with anaesthetic practice, were already emphasized by the 4th National Audit Project of the Royal College of Anaesthetists and Difficult Airway Society (NAP4), leading to a direct response with the recent publication of the guidelines for the management of tracheal intubation in critically ill adults by Difficult Airway Society, Intensive Care Society, Faculty of Intensive Care Medicine and Royal College of Anaesthetists [5]. The particularities and unique challenges of intubation of the critical ill patients were, therefore, recognized. The nature of the urgent procedure, as well as due to patient factors, hinder a complete or proper airway assessment [5], increasing related complications. Moreover, delayed tracheal intubation or multiple attempts at laryngoscopy also potentiate these complications [5].

Unsuccessful first attempt intubation occurs in up to 30% of ICU intubations, again a higher percentage than that seen in the operating room, and around 6% of ICU patients have a predicted difficult airway [5]. Critical illness and the measures taken for its healing can increase airway edema and distortion, increasing the challenge of intubating those patients [5].

It is important to be the most effective possible at first attempt concerning intubation to avoid complications [6] and improve patient outcome who is, by itself, already debilitated. This goal must be achieved, in addition to other measures, using a detailed plan to airway management in the setting of ED and ICU. There are new videolaryngoscopes devices in order to improve airway management, however, its role, particularly in ICU, is still discussed due to lack of scientific evidence in this context [5,7], existing only observational studies and small randomized studies supporting the use of video laryngoscopy for orotracheal intubation in ICU [8].

This prospective observational study aims to analyse how we are dealing with the airway in the ED and ICU in our institution as a way to audit the practice of the airway approach in the referred settings.

Methods

A prospective observational study was conducted between May and September 2014 in the ICU and ED of Santo Antonio Hospital. The study was approved by the Ethics Committee of our institution. It was requested and granted by the Ethics Committee exemption from patients' informed consent because there was no interference in their approach (observational study), no sensitive data was used and an anonymous database has been built ensuring the confidentiality of the data.

An anonymous registry of the airway approach after its performance in critical ill patients was done by the emergencist/intensivist doctor. The paper was identified with a code number separately associated with patient identification, with the purpose of retrospectively completing eventual missing informations.

The main purposes of the study were the follow:

- *primary aim*: identify the main complications of the airway approach in the critical patient;
- *secondary aim*: take notice of possible factors related with complications of the airway approach related to:

- 1) technical skills of the operator
- 2) patient's specificities
- 3) airway approach techniques

All patients submitted to tracheal intubation attempts were included. After building an electronic anonymised database, the surveys were destroyed to preserve patients identity.

In the registry paper, the following information was recorded:

- a) technical skills of the operator who approached the airway: speciality, degree of training, experience in airway approach;
- b) intubated patient's specificities: reason for tracheal intubation, predictive signs of difficult airway;
- c) airway approach technique used for each intubation attempt: materials and drugs, place, date and time of intubation;
- d) outcome: complications likely related to airway approach, identification of reasons for failure and eventual alternative approach.

The statistical analysis was done in cooperation with the Medical Informatics and Biostatistics Department of the Faculty of Medicine of the University of Porto.

In the descriptive analysis of the sample, appropriate summary statistics were applied. Categorical variables were described through absolute (n) and relative (%) frequencies. Continuous variables were described as mean plus standard deviation or median, 5th percentile and 95th percentil, according to their symmetrical or assymetrical distribution, respectively.

Chi-square test of independence was used to analyze categorical variables associations. When more than 20% of contingency table cells regarding the association analysis of two categories were inferior to 5, Fisher exact test (when the two variables had only two categories) or Chi-square exact test (when at least one of the variables had more than two categories) were used.

P values <0.05 were considered significant for all hypothesis testing. The analysis was done using the statistical analysis program SPSS® v.21.0.

Results

During the period of the study 182 patients were included corresponding to a total of 257 attempted tracheal intubations (ATI). The leading cause for tracheal intubation (TI) was primary respiratory failure (26%) and the rate of successful first-pass orotracheal intubation was 67% (**table 1**).

Table 1 - Patients clinical information description (n=182) and success of ATI.

	n	(%)
<u>The patient being intubated:</u>		
- Cause of admission in the Emergency Room		
Medical	147	(81)
Surgical	23	(13)
Trauma	12	(7)
- Reason for endotracheal intubation		
Intoxication	9	(5)
Primary Respiratory Failure	48	(26)
Neurocritical	31	(17)
Cardiopulmonary arrest	31	(17)
Acute Coronary Syndrome/Acute Pulmonar Edema	11	(6)
Sepsis/Shock	18	(10)
Other	34	(19)
Number of attempts		
1	122	(67)
2	50	(27)
3	5	(3)
4	5	(3)
Success rate (successful first attempt)		
Yes	122	(67)
No	60	(33)
Time of intubation		
Day	99	(56)
Night	77	(44)

The majority of the operators had basic training in Internal Medicine (55%), followed by Anesthesiology (39%), being mostly residents (64%). Of all, only 39% reported to have good experience in approaching the airway, contrasting to 5% with none and 27% with little experience. Fifteen percent of the operators with no experience in airway approach and 50% of those with little experience didn't manage to successfully intubate at first attempt, while this number decreased substantially with doctors having good (20%) and excellent (3%) airway expertise ($p < 0.001$). Eighteen percent of anesthesiologists who ATI didn't succeed to intubate at first attempt, whilst that number was 82% for other specialities ($p = 0.013$). When first ATI failed, residents were the operators in 88% of cases, but when this attempt was done by senior doctors, they just missed in 12% ($p = 0.033$) (**table 2**). The intubation success rate after a first miss was 83%. Sixty patients (33%) needed 2 or more attempts (maximum 4). No statistical difference was found in intubation success rate at first ATI during day or night ($p = 0.503$).

Table 2 - Success rate of first ATI according to operator features and daytime.

	Success rate				<i>p</i>
	(Successful first attempt)				
	No		Yes		
	(n=60; 33%)		(n=122; 67%)		
	n	(%)	n	(%)	
<u>Who Approached The Airway:</u>					
- Speciality					0.013***
Internal Medicine	45	(75)	60	(49)	
Anesthesiology	11	(18)	53	(43)	
Infectiology	1	(2)	2	(2)	
Nephrology	2	(3)	4	(3)	
Pulmonology	0	(0)	2	(2)	
Emergency Medicine	1	(2)	1	(1)	
- Degree of training					0.033***
Resident	52	(88)	84	(69)	
Specialist < 5 years	2	(3)	16	(13)	
Specialist > 5 years	2	(3)	3	(2)	
Specialist 10-20 years	2	(3)	17	(14)	
Specialist > 20 years	1	(2)	2	(2)	
- Experience in airway approach					<0.001*
None	9	(15)	3	(2)	
Little	30	(50)	32	(26)	
Mean	7	(12)	18	(15)	
Good	12	(20)	55	(45)	
Excellent	2	(3)	14	(11)	
<u>Time of intubation</u>					0.503*
Day	30	(53)	69	(58)	
Night	27	(47)	50	(42)	

*Chi-Square Test of Independence;
***Chi-Square Exact Test.

Reported causes to explain the failure of TI were seen in 28% of cases, being operator's inexperience the most frequent (13%). Other causes included patient related factors (11%), lack of suitable equipment (2%) and lack of appropriate strategy delineation (2%). In 1% there was an inadequate airway evaluation.

There were 48% of patients with predictive signs of difficult intubation, being obesity the most frequent (25%), followed by neck deformity (21%). 70% of patients with failed first ATI had predictive signs of difficult airway ($p<0.001$).

In what concerns the drugs used to airway approach, the majority used opioid (68%) and hypnotic (76%). However, muscle relaxant was used only in 25% of patients in all attempts of TI.

With regard to material, McCoy blade was used in 12%, videolaryngoscopy in 2% and no use of fibroscopy was registered neither laryngeal mask. In 3% of all attempts, the use of bougie® was necessary. No surgical airway rescue technique was needed.

Complications related to ATI were reported in 30% of all attempts, being most frequently among residents (81%, $p=0.001$) and those with little experience in airway approach (46%, $p<0.001$) (**table 3**).

Table 3 - Complications during ATI according to the number of attempts and operator features.

	There were complications?				<i>p</i>
	No		Yes		
	(n=181; 70%)		(n=76; 30%)		
	n	(%)	n	(%)	
Number of attempts					<0.001*
1	119	(66)	3	(4)	
2	50	(28)	50	(66)	
3	7	(4)	8	(11)	
4	5	(3)	15	(20)	
<u>Who Approached The Airway:</u>					
- Speciality					0.162***
Internal Medicine	92	(51)	50	(66)	
Anesthesiology	80	(44)	21	(28)	
Infectiology	2	(1)	1	(1)	
Nephrology	4	(2)	3	(4)	
Pulmonology	2	(1)	0	(0)	
Emergency Medicine	1	(1)	1	(1)	
- Degree of training					0.001***
Resident	102	(56)	61	(81)	
Specialist < 5 years	24	(13)	2	(3)	
Specialist > 5 years	13	(7)	4	(5)	
Specialist 10-20 years	38	(21)	5	(7)	
Specialist > 20 years	4	(2)	3	(4)	
- Experience in airway approach					<0.001*
None	5	(3)	7	(9)	
Little	34	(19)	35	(46)	
Mean	23	(13)	7	(9)	
Good	80	(45)	19	(25)	

Excellent

37

(21)

8

(11)

*Chi-Square Test of Independence;

***Chi-Square Exact Test.

The majority of complications were failed intubation (18%), followed by esophageal intubation (9%), aspiration of gastric contents (2%) and cardiac arrest (1 case). Complications were more often in patients submitted to 2 ATI (66%), followed by 4 ATI (20%), being only 4% in those who had merely 1 ATI (4%, $p<0.001$). Besides, they were seen mostly in patients with predictive signs of difficult intubation (74%, $p<0.001$). No relation was found between complications and the diagnostic of the intensive care patient or reason to TI, neither with drugs used in the airway approach.

In the group with complications, relation with an identifiable obvious cause was seen in 87% of cases ($p<0.001$). Inexperience was seen in 42% of operators with complications, instead of 1% in the group without complications ($p<0.001$). Lack of appropriate equipment (5%, $p=0.007$), lack of appropriate strategy delineation (8%, $p=0.001$) and factors related to patient (32%, $p<0.001$) were present in the group with complications with higher percentages than those seen in the group without complications (**table 4**).

Table 4 - Operator self-report of reasons for complications during ATI.

	There were complications?				<i>p</i>
	No	Yes	n	(%)	
	(n=181; 70%)		(n=76; 30%)		
	n	(%)	n	(%)	<i>p</i>
<u>Possible reason to fail</u>					
No obvious cause					<0.001*
No	5	(3)	66	(87)	
Yes	176	(97)	10	(13)	
Inexperience					<0.001*
No	179	(99)	44	(58)	
Yes	2	(1)	32	(42)	
Inadequate evaluation of the airway					0.087**
No	181	(100)	74	(97)	
Yes	0	(0)	2	(3)	
Lack of appropriate equipment					0.007**
No	181	(100)	72	(95)	
Yes	0	(0)	4	(5)	
Lack of appropriate strategy delineation					0.001**
No	181	(100)	70	(92)	
Yes	0	(0)	6	(8)	
Related to Patient					<0.001**
No	178	(98)	52	(68)	
Yes	3	(2)	24	(32)	
Other					0.001**
No	181	(100)	70	(92)	
Yes	0	(0)	6	(8)	

*Chi-Square Test of Independence;
**Fisher Exact Test.

Considering all attempts, unsuccessful ATI was more frequent among Internal Medicine doctors (73% vs. 20% of Anesthesiology doctors, $p=0.036$), residents (80% vs. 20% of senior doctors, $p=0.047$) and among those with none or little (13% and 49%, respectively, $p<0.001$) experience in airway approach, as opposed to those with good and excellent experience (18% and 9%, respectively, $p<0.001$). An obvious cause was seen in 96% of attempts in the group who failed ATI ($p<0.001$), as well being inexperienced more frequent (44%) in this group (vs. 7% in successful TI, $p<0.001$). Also there was a statistically significant difference in what concerns factors related to patients as possible causes of failed ATI (40% vs. 4% in the group of successful ATI, $p<0.001$).

With regard to esophageal intubation as a complication, 54% of operators in this group had little experience in approaching the airway, as opposed to 24% in the group without this complication, where the majority (41%) had good experience ($p=0.039$). Esophageal intubation was also most frequently as the number of ATI increased ($p<0.001$, **table 5**).

Table 5 – Esophageal intubation as a complication according to the number of ATI and patients clinical information

	Esophageal Intubation				<i>p</i>
	No		Yes		
	(n=233; 91%)		(n=24; 9%)		
	n	(%)	n	(%)	
Number of attempts					<i><0.001***</i>
1	122	(52)	0	(0)	
2	82	(35)	18	(75)	
3	12	(5)	3	(13)	
4	17	(7)	3	(13)	
The patient being intubated - Cause of admission in the Emergency Room					0.868***
Medical	183	(79)	20	(83)	
Surgical	33	(14)	3	(13)	
Trauma	17	(7)	1	(4)	
Diagnosis					
Intoxication	9	(4)	2	(8)	
Primary Respiratory Failure	62	(27)	7	(29)	
Neurocritical	47	(20)	6	(25)	
Cardiopulmonary arrest	35	(15)	2	(8)	
Acute Coronary Syndrome/Acute Pulmonar Edema	13	(6)	1	(4)	
Sepsis/Shock	24	(10)	1	(4)	
Other	43	(18)	5	(21)	

* Chi-Square test of independence

Predictive signs of difficult intubation were most common in the group where esophageal intubation occurred (83% vs. 52%, $p=0.003$), particularly obesity (54% vs. 24%, $p=0.002$). In what concerns the reasons for esophageal intubation, inexperience (54% vs. 9%, $p<0.001$), lack of suitable equipment (8% vs. 1%, $p=0.045$) and lack of strategy delineation (13% vs. 1%, $p=0.012$) were present in higher percentages in the group who inadvertently performed esophageal intubation.

Discussion

Failure of tracheal intubation at first attempt occurs in up to 30% of ICU intubations [5]. In our institution, that number was 33%, although it included intubations in ED. Trainee doctors, mostly internal medicine residents without major experience in airway approach, are primarily responsible for intubation of critically ill patients in our hospital, with implications on successful rate of first ATI. Regarding the reported reasons to explain failure of TI, this particular aspect was highlighted in our study, with operator's inexperience accounting for 13%. Patient related factors also played a role, particularly anatomic changes/deformations, as well as obesity. Robust evidence exists that this feature is an important risk factor for interurrences in airway approach of critically ill patients. For example, in NAP4, a patient with a BMI >30 kg/m² was twice as likely as a slim patient to have a complication of airway management [5]. Obesity difficults facemask ventilation, supraglottic airway placement, tracheal intubation and FONA (front of neck airway), also conditioning quick and severe desaturation, mainly in the presence of airway obstruction [5]. Severe hypoxemia is a concern when intubating critically ill patients and several preoxygenation techniques like noninvasive ventilation or high-flow nasal cannula oxygen therapy have been developed with the aim of preventing and limiting its incidence and complications following the intubation procedure [9,10,11].

The presence of predictive signs of difficult intubation is related to an increase in failure of TI. Lack of suitable equipment is another issue as towards the critically ill patient there isn't an optimized and controlled environment as seen in the operating room. The urgency of the procedure in that setting may preclude a standard airway assessment [5] and an appropriate strategy delineation, as was present in our study.

Regardless of the recommendation of using neuromuscular blocking agents, as it reduces intubation complications in the critically ill [5], as well as it improves overall intubating conditions [12], in our study they were used only in 25% of cases, however, no relation was found between drugs used in the airway approach and complications rate. It is crucial for critical care physicians to have skills in advanced airway management as the adoption of algorithmic approaches and rapid-sequence intubation by anesthesiologists and emergency medicine physicians improved the successful rates for the emergency intubations in the critically ill and reduced complications [13].

At the time of our study there were not yet in our institution a wide use of videolaryngoscopy dedicated to ED and ICU and its use was limited to 2% of cases. Videolaryngoscopy in critically ill patient is still requiring further high-quality research. A systematic review and meta-analysis provided evidence that videolaryngoscopy for orotracheal intubation in ICU helps to reduce difficult orotracheal intubation, esophageal intubation, Cormack 3/4 grade and increases first-attempt success, although without reducing other complications such as severe hypoxemia, severe cardiovascular collapse or airway injury [14]. Although in elective surgery procedures, the use of glidescope® for endotracheal tube placement also resulted in reduction in the incidence and severity of postoperative sore throat compared to Macintosh laryngoscope [15]. In a randomized clinical trial among ICU patients requiring intubation,

videolaryngoscopy compared with direct laryngoscopy did not improve first-pass orotracheal intubation rates and was associated with higher rates of severe life-threatening complications [3]. In another randomized controlled trial comparing direct versus videolaryngoscopy using the C-MAC® for TI in the ED, there was no difference between videolaryngoscopy or direct laryngoscopy using the C-MAC® device in first-pass success and duration of intubation attempt [16]. However, the 2018 guidelines for the management of tracheal intubation in critically ill adults recommend early use of a videolaryngoscope, with a screen visible to all, and second generation supraglottic airways for airway rescue [5]. The role of laryngeal mask airway in critical care medicine has been addressed long time ago, particularly its use in the difficult airway and its role as an aid to intubation [17].

No use of fibroscopy was registered in our study seen that awake intubation is often inappropriate in the critically ill [5]. No surgical airway rescue technique was necessary, although 3% of patients had 4 ATI.

Complications related to ATI were reported in 30% of cases, the most frequently being failed intubation (18%). Also esophageal intubation, aspiration of gastric contents and cardiac arrest occurred. A multicenter cohort study reported an ICU intubation-related cardiac arrest of 1 in 40 procedures with high immediate and 28-day mortality, identifying five independent risk factors for cardiac arrest (overweight or obesity, age more than 75 years old, low SBP [systolic blood pressure] prior to intubation, hypoxemia prior to intubation and absence of preoxygenation before intubation procedure) [4]. In our study, only one case of cardiac arrest was reported, corresponding to less than 1%. Complications increased with the increase in TI attempts, as well as in patients with predictive signs of difficult intubation. This is a well known relationship. When they occur it is extremely important to identify the cause(s) of those complications and what should have been done differently. In our study, that cause was reported in 87% of cases. Again, inexperience accounted mostly as it attained 42% of operators who had complications, instead of 1% in those without, having a statistical significance. Lack of appropriate equipment, inappropriate strategy delineation and factors related to patient were also higher in the group with complications.

Recently published guidelines for the management of tracheal intubation in critically ill adults highlighted the importance of human factors rather than only valuing technical skills or introducing new devices. Communication between team elements, sharing a mental model and planning is of crucial importance. Task fixation and delays in tracheal intubation should be avoided limiting the number of attempts, as well as encouraging the transitioning to the next algorithm step as early as possible once failure has occurred [5]. In fact, it was already recognized in a prospective, multiple-center study that the implementation of an intubation management protocol can reduce immediate severe life-threatening complications related to intubation of ICU patients [18].

As far as we know there are very few studies analysing so many variables and relationships concerning the operator's expertise performing intubation in critically ill patients. One of them, a prospective cohort study, reported an overall risk of complications of 39% [19], higher than in our study. Nevertheless, our study has several limitations. First, it is a single center prospective observational study, with a small sample. Second, in our institution, first airway approach in the ED and ICU is largely done by residents,

which may not represent the reality in other centers and, thus, affecting the correlations found. Third, at the time of the study, the 2018 guidelines for the management of tracheal intubation in critically ill adults haven't been published, so our study does not reflect the impact of applying these guidelines.

Conclusion

As seen in our study, failed ATI and its complications are largely dependent on operator's expertise which should be improved once TI in our ED and ICU is performed mostly at first by trainee doctors. Factors related to patient, lack of appropriate equipment and inappropriate strategy delineation also play a role. Recognition of patients at particular risk of difficult airway management is crucial and is recommended even in the most urgent situations [5], being a central element in planning the approach of the difficult airway in these settings. Currently videolaryngoscopy is widely available in our institution in ED and ICU, being its use of great value.

List Of Abbreviations

ATI (Attempted tracheal intubation); ED (Emergency Department); ICU (Intensive Care Unit); NAP4 (4th National Audit Project of the Royal College of Anaesthetists and Difficult Airway Society); SBP (Systolic Blood Pressure); TI (Tracheal Intubation).

Declarations

- **Ethics approval and consent to participate:** The study was approved by the Ethics Committee of Porto University Hospital Centre. It was requested and granted by the Ethics Committee exemption from patients's informed consent because there was no interference in their approach (observational study), no sensitive data was used and an anonymous database has been built ensuring the confidentiality of the data.
- **Consent for publication:** Not applicable.
- **Availability of data and material:** Authors can confirm that all relevant data are included in the article and/or its supplementary information files. Additional datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.
- **Competing interests:** The authors declare that they have no competing interests.
- **Funding:** Not applicable.
- **Authors' contributions:** HF and CMT contributed to study concept and design. CMT, TC, HF, RO, AM and IA contributed to study execution and in acquisition of the data. TC and CMT contributed to statistical data analysis, interpretation, article preparation and drafting. CMT and IA contributed in article critique and review. All authors approved the article submitted.

· **Acknowledgements:** We want to give a special thanks to Dr. Orquídea Ribeiro from Faculty of Medicine of University of Porto for its contribution in investigation methodology and biostatistics in this work.

References

- [1] Huang HB, Peng JM, Xu B, Liu GY, Du B. Video Laryngoscopy for Endotracheal Intubation of Critically Ill Adults, A Systemic Review and Meta-Analysis. *CHEST*. 2017; 152(3):510-517. doi: <http://dx.doi.org/10.1016/j.chest.2017.06.012>
- [2] Cabrini L, Landoni G, Baiardo Radaelli M et al. Tracheal intubation in critically ill patients: a comprehensive systematic review of randomized trials. *Critical Care*. 2018; 22:6. doi:10.1186/s13054-017-1927-3.
- [3] Lascarrou JB, Boisrame-Helms J, Bailly A et al. Video Laryngoscopy vs Direct Laryngoscopy on Successful First-Pass Orotracheal Intubation Among ICU Patients: A Randomized Clinical Trial. *JAMA*. 2017; 317(5): 483–493. doi:10.1001/jama.2016.20603;
- [4] De Jong A, Rolle A, Molinari N, Paugam-Burtz Catherine, Constantin J-M, Lefrant J-Y, Asehnoune K, Jung B et al. Cardiac Arrest and Mortality Related to Intubation Procedure in Critically Ill Adult Patients: A Multicenter Cohort Study. *Critical Care Medicine*. 2018; 46(4):532-539. doi: 10.1097/CCM.0000000000002925.
- [5] Higgs A, McGrath BA, Goddard C, Rangasami J, Suntharalingam G, Gale R, Cook TM. Guidelines for the management of tracheal intubation in critically ill adults. *British Journal of Anaesthesia*. 2018; 120(2): 323-352. doi: 10.1016/j.bja.2017.10.021;
- [6] Natt BS, Malo J, Hypes CD, Sakles JC, Mosier JM. Strategies to improve first attempt success at intubation in critically ill patients. *Br J Anaesth*. 2016; 117 Suppl 1:i60-i68. doi: 10.1093/bja/aew061.
- [7] De Jong A, Clavieras N, Conseil M, Coisel Y, Moury PH, Pouzeratte Y et al. Implementation of a combo videolaryngoscope for intubation in critically ill patients: a before–after comparative study. *Intensive Care Medicine*. 2013; 39:2144–2152. doi 10.1007/s00134-013-3099-1;
- [8] Lascarrou JB, Boisrame-Helms J, Bailly A, Le Thuaut A, Kamel T, Mercier E et al. Video laryngoscopy vs direct laryngoscopy on successful first-pass oro-tracheal intubation among ICU patients, a randomized clinical trial. *JAMA*. 2017; 317(5):483-493. doi: 10.1001/jama.2016.20603.
- [9] Jaber S, Monnin M, Girard M, Conseil M, Cisse M, Carr J, Mahul M, Delay JM, Belafia F, Chanques G, Molinari N, De Jong A. Apnoeic oxygenation via high-flow nasal cannula oxygen combined with non-invasive ventilation preoxygenation for intubation in hypoxaemic patients in the intensive care unit: the single-centre, blinded, randomised controlled OPTINIV trial. *Intensive Care Med*. 2016; 42(12):1877-1887. doi: 10.1007/s00134-016-4588-9.

- [10] Mosier JM, Hypes CD, Sakles JC. Understanding preoxygenation and apneic oxygenation during intubation in the critically ill. *Intensive Care Med.* 2017; 43(2):226-228. doi: 10.1007/s00134-016-4426-0.
- [11] Vourc'h M, Asfar P, Volteau C, Bachoumas K, Clavieras N, Egreteau PY, Asehnoune K, Mercat A, Reignier J, Jaber S, Prat G, Roquilly A, Brule N, Villers D, Bretonniere C, Guitton C. High-flow nasal cannula oxygen during endotracheal intubation in hypoxemic patients: a randomized controlled clinical trial. *Intensive Care Med.* 2015; 41(9):1538-48. doi: 10.1007/s00134-015-3796-z.
- [12] Mencke et al. Intubating conditions and side effects of propofol, remifentanyl and sevoflurane compared with propofol, remifentanyl and rocuronium: a randomised, prospective, clinical trial. *BMC Anesthesiology.* 2014; 14:39. doi.org/10.1186/1471-2253-14-39.
- [13] Reynolds SF, Heggner J. Airway management of the critically ill patient: rapid-sequence intubation. *Chest.* 2005; 127(4):1397-412. doi: 10.1378/chest.127.4.1397.
- [14] De Jong A, Molinari N, Conseil M, Coisel Y, Pouzeratte Y, Belafia F, Jung B, Chanques G, Jaber S. Video laryngoscopy versus direct laryngoscopy for orotracheal intubation in the intensive care unit: a systematic review and meta-analysis. *Intensive Care Med.* 2014; 40(5):629-39. doi: 10.1007/s00134-014-3236-5.
- [15] Aqil M, Khan MU, Mansoor S, Mansoor S, Khokhar RS, Narejo AS. Incidence and severity of postoperative sore throat: a randomized comparison of Glidescope with Macintosh laryngoscope. *BMC Anesthesiology.* 2017; 17:127. doi 10.1186/s12871-017-0421-4.
- [16] Driver BE, Prekker ME, Moore JC, Schick AL, Reardon RF, Miner JR. Direct versus video laryngoscopy using the c-mac for tracheal intubation in the emergency department, a randomized controlled trial. *Acad Emerg Med.* 2016; 23(4):433-9. doi: 10.1111/acem.12933.
- [17] Brimacombe J, Berry A, Verghese C. The laryngeal mask airway in critical care medicine. *Intensive Care Med.* 1995; 21:361-364. doi: <https://doi.org/10.1007/BF01705417>.
- [18] Jaber S, Jung B, Corne P, Sebbane M, Muller L, Chanques G, Verzilli D, Jonquet O, Eledjam JJ, Lefrant JY. An intervention to decrease complications related to endotracheal intubation in the intensive care unit: a prospective, multiple-center study. *Intensive Care Med.* 2010; 36(2):248-55. doi: 10.1007/s00134-009-1717-8.
- [19] Griesdale DEG, Bosma TL, Kurth T, Isac G, Chittock DR. Complications of endotracheal intubation in the critically ill. *Intensive Care Med.* 2008; 34:1835–1842. doi 10.1007/s00134-008-1205-6.