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ORIGINAL ARTICLE

Optimization of emergency tracheal intubation procedure in pediatric patients

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Rapid sequence induction and intubation, Airway management, Intensive care units, pediatric, Intubation, intratracheal Emergency treatment.

Abstract

Introduction: Tracheal Intubation (TI) is an important procedure in maintaining airway patency or critical control of ventilation. A high number of intubation attempts are associated with an increased risk of adverse events. **Objective:** To assess factors associated with the success of TI procedures performed in the Pediatric Emergency and Intensive Care Service of Hospital de Clínicas de Porto Alegre. **Method:** A contemporary cross-sectional study involving all intubations performed over eight months. Procedure data were obtained through interviews with the physician who performed the tracheal intubation and direct collection from medical records. Among the evaluated data, key factors include the number of attempts, adherence to the protocol, experience, and clinical and demographic characteristics of the sample. **Results:** A total of 130 procedures were evaluated. Rapid sequence intubation was employed whenever indicated. TI were classified as difficult in 18.5% of cases. The mean number of attempts per procedure was 1.7±1.3. Three or more attempts were required in 68.1% of cases with facial or airway anatomical alterations (p<0.001). Airway access was achieved in 100% of patients, despite difficulties. Greater success in the procedure was associated with the experience of the involved professional. **Conclusions:** TI is a safe procedure with a high success rate when performed by appropriately skilled and trained physicians. Adherence to the rapid sequence protocol, combined with a well-defined plan of actions and alternatives in the face of difficulties, ensures greater safety during the procedure in critical situations.

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INTRODUCTION

Tracheal intubation is a procedure performed on critically ill patients, serving as an essential component in the resuscitation process. It is indicated for maintaining airway patency and controlling ventilation[1]. When performed electively, such as in the operating room, it is generally a safe procedure. However, when conducted emergently, it may be associated with a significant risk of morbidity and mortality[2]. Airway management relies on the adequate training of the assisting physician in this skill. For training to be considered effective (with an average success rate of 90%), it is estimated that around 60 intubation maneuvers need to be performed[3]. Advanced airway skills training is a cornerstone in the education of medical residents in pediatric programs, including pediatric emergency and pediatric intensive care medicine. The pediatric airway presents specific challenges that depend on the patient's age, size, and clinical condition. These challenges, coupled with the infrequent opportunities for real-life intubations experienced by residents, make pediatric orotracheal intubation a challenging skill to master[4].

A high number of intubation attempts are associated with an increased risk of adverse events. Efforts to optimize the first intubation attempt in children can help mitigate this risk and improve outcomes. The incidence of complications related to the procedure is proportionally higher with an increased number of attempts[5]. Another way to optimize the success of this procedure is through the use of rapid sequence intubation (RSI). This strategy enhances intubation conditions and first-attempt success rates by improving airway visualization and turning the procedure into one more effective, safer, and reduces the number of attempts[6,7].

In teaching hospitals, newly graduated physicians with limited prior intubation experience may be exposed to performing laryngoscopy under supervision during their initial months of residency. In a study conducted in 4 pediatric and neonatal intensive care units in the city of Porto Alegre in the years 2002 and 2003, an average of 2±1.3 intubation attempts per procedure was observed and in 24% of these procedures, three or more attempts were made. The success rate, stratified by year of residency, was 65% for second-year residents, 81.6% for third-year residents, and 100% for attending physicians. Additionally, it was noted that muscle relaxants were used in only 3% of procedures in pediatric patients, and the primary difficulty in intubation was associated with inadequate muscle relaxation[3].

It is understood that the greater the physician's prior experience and airway management training, whether in live scenarios or simulated training, the higher the success rate of the procedure and the lower the complications for the patient. Additionally, the use of rapid sequence intubation (RSI) enhances the success of the procedure and reduces complication rates. The authors of this study aim to assess the quality and factors associated with the success of emergency tracheal intubation procedures performed in the pediatric emergency and pediatric intensive care units of a renowned university hospital in southern Brazil.

METHODOLOGY

Cross-sectional contemporary study involving all emergency intubations performed in children and adolescents (<18 years old) between March and November 2023 in the Pediatric Emergency and Intensive Medicine Units at Hospital de Clínicas de Porto Alegre.

The procedural data were obtained by a single investigator (MT) through interviews (within 48 hours) with the physician who performed the TI (resident, contracted physician, and/or involved specialist). This information was supplemented by analysis and collection of data from the patient's medical record, including demographic characteristics, reason for intubation, drugs used, adherence to the rapid sequence intubation protocol and a description of any potential complications.

During the interviews with the healthcare professionals, data were collected regarding the number of attempts for TI, potential reasons for difficulty in airway access and the physician previous experience in intubations, whether on mannequins or real patients, within the last six months of practice. Difficulty in obtaining an advanced airway was defined as the need for three or more laryngoscopy attempts to successfully secure the airway. The project received approval from the research ethics committee at Hospital de Clínicas de Porto Alegre (CAAE number 9226823.5.0000.5327), and it was a requirement for parents or legal guardians to sign the informed consent form.

The data were transcribed into a Microsoft Office Excel spreadsheet for Windows and subsequently analyzed using the SPSS software version 16.0. Categorical variables were presented as percentages and compared using the Chi-square test or relative risk. Continuous variables with a normal distribution were expressed as means with their respective standard deviation and compared using the Student's t-test. Continuous variables without a normal distribution were presented as medians with the respective interquartile range (IQR 25%-75%) and compared using the Mann-Whitney or Kruskal-Wallis test. A sample estimate of 130 patients was calculated, which would be sufficient to assess the quality and effectiveness of the IT procedure.

RESULTS

A total of 130 IT procedures were evaluated. The median age was 7.3 months, and the median weight was 6.4 kg, with 56.2% being male. 62.8% of patients had at least one complex chronic disease, and the acute illnesses that led to hospitalization were primarily pulmonary diseases (43.8%) and neurological disorders (18.5%). The

establishment of an advanced airway was necessary due to respiratory failure (59.2%), followed by reintubation (18.5%) and airway protection for elective procedures (7.7%). The population data are presented in Table 1. Rapid sequence intubation was employed in all patients who met the criteria.

Approximately 18.5% of the IT were classified as difficult to obtain. The mean of attempts for each procedure was 1.7±1.3. Tube exchange and reintubation following extubation failure showed the highest difficulty rates (50% and 33.3%, respectively), while no difficulty was observed in patients intubated during cardiac arrest, upper airway obstruction or hemodynamic instability. No procedural dificulty was associated with equipment failure. No difference was observed in the intubation difficulty between patients under one year of age and those one year or older (p=0.69), nor between those with or without complex chronic conditions (p=0.20). Approximately 78% of patients did not have a predicted difficult airway, with a procedure success rate of 86.3%. On the other hand, three or more attempts were required in 68.1% of those with facial or airway anatomical alterations (p<0.00010).

It should be emphasized that in all patients undergoing endotracheal intubation in this sample, their airway was successfully secured, even in those with difficulties and a high number of attempts. Only 1 patient required emergency tracheostomy and 2 patients needed fiberoptic bronchoscopy. Direct laryngoscopy was used in 83% of intubations, with difficulty encountered in 14.8% of cases. Videolaryngoscopy was used in 11.5% of cases, with difficulty in 6.7%, and no significant difference was observed between the methods (p=0.69).

The intubation success rate (two or fewer attempts) was achieved in 58% of procedures performed by second-year pediatric residents and in 82% when performed by third-year residents. Success was achieved in 79.1% of procedures performed by first-year Pediatric Intensive Care Medicine residents and in 71.4% when involving Pediatric Emergency Medicine residents, increasing to 89.3% with second-year Pediatric Intensive Care residents, as shown in Table 2.

Table 1. General data on IT procedures.

Total (n): 130		
Age (months) median (IQR 25-75%)	7,27 [2,68-31,33]	
Weigh (kg) median (IQR 25-75%)	6,4 [4,27-12]	
Gender: n (%)	Female: 57 (43,8)	Male: 73 (56,2)
Complex chronic disease: n (%)	None: 47 (36,2)	One or more: 83 (63,9)
Cause of Admission: n (%)	Pulmonary Disease: 57 (43,6) Neurologic Disease: 24 (18,5) Genetic Disease: 13 (10) Hepatic Disease: 11 (8,5) Oncological Disease: 11 (8,5) Others: 14 (10,8)	
Cause of Intubation: n (%)	Respiratory Insufficiency: 77 (59,2) Reintubation: 24 (18,4) Elective: 10 (7,7) Neurological: 9 (6,9) Cardiorespiratory Arrest: 7 (5,4) Hemodynamic instability: 3 (2,3)	

Table 2. Success related to professional experience.

Professional	**Success n (%)**	**Experience (number of IT in the past six months)**		
		<5	5-10	>10
R2* Pediatrics	17 (58)	18	3	8
R3** Pediatrics	14 (82,4)	6	5	6
R1*** Pediatric ICU	38 (79,2)	9	17	22
R2**** Pediatric ICU	25 (89,3)	0	0	28
Intensivist	19 (73)	13	4	9
R1*** Pediatric Emergency	5 (71,4)	5	2	0
Emergency Specialist	8 (72,7)	7	1	3

Legend: * Students in their second year of general pediatrics formation. ** Students in their third year of general pediatrics formation. *** Students in their first year of subspecialization. **** Students in their second year of subspecialization.

DISCUSSION

Tracheal intubation (TI) is an essential skill for pediatricians working in emergency and pediatric intensive care settings, involving the care of critically ill patients[8]. The success in the intubation procedure is related to: I) Technical preparation before the procedure, including a review of necessary materials and the use of a rapid sequence intubation protocol; II) Patient assessment with early identification of anatomical changes that may pose difficulties; III) Adequate training of the team in advanced airway management; and IV) Having a rapid and effective action plan in place to address difficulties.

A high number of intubation attempts are associated with an increased risk of adverse events, both major (bradycardia, cardiac arrest, hypoxemia, and pneumothorax) and minor (mucosal trauma, dental trauma). Efforts to optimize and achieve success on the first intubation attempt in children can reduce this risk and improve outcomes. Complications related to the procedure are associated with a higher number of attempts, with a relative risk (RR) of 3.3 [95% CI 2.1-5.0] for two or fewer attempts and 4.6 [95% CI 2.2-9.5] for three or more attempts[5].

The optimization of the procedure begins with the preparation of materials, reviewing, and testing them. In cases where difficulty in intubation is anticipated, an alternative plan should already be defined at this stage[1]. The use of rapid sequence intubation (RSI) involves the administration of rapidly acting drugs, including a hypnotic agent, a paralytic agent and a neuromuscular blocking agent. This strategy is well-recognized for improving overall intubation conditions and the success rate on the first attempt[6]. RSI facilitates airway visualization by inducing muscle relaxation, controlling agitation, and reducing involuntary reflexes such as those associated with laryngoscopy. The practical goal is to achieve excellent intubation conditions approximately 60 seconds after the administration of the neuromuscular blocking agent, with complete relaxation of the jaw, opening and immobilization of the vocal cords, absence of coughing, resistance, or diaphragmatic movement in response to intubation. This makes the procedure more effective and safer, often requiring fewer attempts[7].

The prediction of a challenging airway can be made through a pre-analysis of the patient's anatomy. Challenges may arise due to restricted mandibular opening, a very short and/or thick neck, cranial and airway deformities, macroglossia, restricted cervical mobility and cervical masses[9]. The LEMON mnemonic, a well-researched strategy for predicting difficult intubation, consists of the following components: look externally (L): External assessment; evaluate 3–3-2 (E): assessment of the mouth opening distance, mandibular space, and glottic view; mallampati score (M), obstruction and/or obesity (O) and neck mobility (N). This mnemonic provides a systematic approach for assessing potential challenges in intubation by considering various anatomical and clinical factors[10]. Y. Hagiwara et al. evaluated this score and found high sensitivity and negative predictive value in its use for predicting a difficult airway[11].

An alternative plan needs to be defined early on, ready to be implemented as soon as any difficulty in the procedure is identified. There is limited evidence in pediatrics defining the most suitable technique in these situations. The specific anatomy of children includes an anteriorized position of the larynx, a small cricothyroid membrane and abundant adipose tissue in the cervical region. These factors contribute to the technical challenge of locating the correct anatomical structures, making most emergency surgical access techniques potentially dangerous[12]. In children under 8 years of age, surgical tracheostomy is the procedure of choice, while in older children, needle cricothyroidotomy is recommended. The flexible bronchoscope continues to be a useful tool in managing difficult airways, serving as a valuable option in patients with limited mouth opening. It also offers advantages over other techniques in ensuring more reliable stability of the cervical spine[13].

The training of physicians performing the procedure is an essential part of its success, with complications being potentially avoidable or at least modifiable when the team possesses adequate skills and training[14]. Simulation has been recognized as an effective methodology for training technical skills and teamwork. Overly et al. assessed that the success rate of intubations by resident physicians performed on mannequins was 56%, and the success rate of these same residents in real emergency department patients was 50%. This supports educational strategies aimed at improving skills for the procedure as well as acquiring teamwork skills.This technique is effective in teaching airway skills to pediatric residents, as well as fundamental teamwork principles for the effective management of acute airway situations[15]. It was noticed that as residents underwent training, fewer attempts were needed to secure the airway. In more experienced professionals, failure was mainly noted in cases where a difficult airway had been identified before the procedure. The first attempt was often made by an experienced professional with an established safety plan in place.

Among the limitations of this study, it is important to note that it was conducted at a single center, and data collection occurred during a specific period, which may be subject to seasonal variations or temporal events that could influence the results. Despite these potential limitations, it is clear that prior training plays a crucial role in the success of the procedure, along with adherence to protocols and the establishment of action plans for difficulties. Investing in continuous training for the professionals involved not only raises performance standards but also proves to be an essential element in creating a safe environment for patients.

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AUTHORS' CONTRIBUTIONS

All authors contributed to the study conception and design. MT organized the data collection; MT, PML and JPP analyzed the data; MT drafted the manuscript; JPP contributed to drafting the manuscript. All authors read and approved the final manuscript.

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