



ORIGINAL ARTICLE

Frequency of tracheal intubation associated adverse events and contributing factors in the Pediatric Intensive Care Unit (PICU).

Murk Shaikh¹, Arshalooz Jamila Rahman², Samina Akhtar³, Tarab zehra⁴, Suhana Shaikh⁵, Tayyaba Anwar⁶

Article Citation: Shaikh M, Rahman AJ, Akhtar S, Zehra T, Shaikh S, Anwar T. Frequency of tracheal intubation associated adverse events and contributing factors in the Pediatric Intensive Care Unit (PICU). Professional Med J 2024; 31(04):563-568.
<https://doi.org/10.29309/TPMJ/2024.31.04.7968>

ABSTRACT... Objective: To determine the frequency of adverse events associated with immediate tracheal intubation in children (1-18 years) from Pediatric Intensive Care Unit of Tertiary Care Hospital of Karachi, Pakistan. **Study Design:** Observational study. **Setting:** PICU of the Aga Khan University Hospital Karachi. **Period:** September 2020 to August 2021. **Methods:** A total of 183 intubations occurred during the study period. Data was extracted using the pre-designed peri-intubation proforma, data recorded on the checklist by the observer (Staff) who was fully trained by the Physician, later on compared by the researcher using the video recorded laryngoscopy used during the intubation procedure. **Results:** There were 183 intubations occurred during study period. Maximum intubations were in age group of 1-5 years (27.3%) and among total intubations, there were 11 (6%) intubation related complications occurred. 6 (3.3%) cases have hypoxia, 3 (1.6%) bradycardia and 2 (1.1%) others (hypotension and esophageal intubation). Majority of the complications were observed during morning hours with statistically significant association. 63.60% TI related cases survived whereas 36.40% of them expired, 54.5% stayed in PICU for 0-10 days. **Conclusion:** Tracheal intubation related adverse events were 6% and majority of them lead to hypoxia. Physiological and mechanical complications with the procedure do occur in spite of our best efforts. Recognizing the complications associated with tracheal intubation can help physicians better care for patients requiring intubation.

Key words: Endotracheal Intubation, Pediatrics, Adverse Events.

INTRODUCTION

Endotracheal intubation (TI) represents the most commonly used procedures in the Pediatric Intensive Care Unit (PICU). However, it carries significant potential for serious complications, including severe hypoxemia and life-threatening events. It is estimated that approximately 15% of tracheal intubation procedures result in adverse TI-associated events (TIAEs), and roughly 13% lead to hypoxemia, defined as a drop in oxygen saturation below 80% during Tracheal Intubation (TI). Notably, critically ill pediatric patients face a significantly higher risk of encountering adverse events during TI when compared to the relatively uneventful TIs observed in healthy patients undergoing elective surgery under anesthesia. The ramifications of these adverse TIAEs resonate

throughout pediatric critical care, often resulting in increased morbidity and mortality. Consequently, they serve as pivotal benchmarks for quality improvement (QI) initiatives and indicators of patient safety.

The relationship between airway events during PICU care and clinical outcomes has been explored in previous studies. For example, infants experiencing extubation failure following cardiac surgery have shown significantly prolonged stays in the ICU. Similarly, children who experience unplanned extubations in their PICU course have displayed extended lengths in stay, both within the PICU itself and also in broader hospital setting. However, a lingering question remains: do factors occurring during the intubation procedure

1. MBBS, FCPS Trained (Paediatrics), Department of Pediatrics & Child Health, Aga Khan University Hospital, Karachi.
2. MBBS, FCPS (Pediatrics), Assistant Professor & Sec Head Pediatrics & Child Health, Aga Khan University Hospital, Karachi.
3. Ph.D Student, Research Instructor, Aga Khan University Hospital, Karachi.
4. MBBS, FCPS trained (Pediatrics), Consultant Pediatrics & Child Health, Aga Khan University Hospital.
5. MBBS Student, Liaquat National Medical College Karachi, Pakistan.
6. MBBS, FCPS Trained (Pediatrics), Pediatrics & Child Health, Aga Khan University Hospital, Karachi.

Correspondence Address:

Dr. Murk Shaikh
Department of Pediatrics & Child Health,
Aga Khan University Hospital, Karachi.
murkshaikh01@gmail.com

Article received on: 31/10/2023
Accepted for publication: 27/01/2024

itself have an impact on critical clinical outcomes in pediatric intensive care, including Pediatric ICU stay duration, mechanical ventilation (MV) duration plus patient mortality?¹

A study conducted in the UK reported that all endotracheal tube-associated events occurred in 22.7% of cases (n=1051). In a similar study at Great Ormond Street Hospital in London, the most commonly encountered tracheal intubation-associated events included endo-bronchial intubation (6.2%), hypotension (5.4%), and bradycardia (4.2%).²

An analogous study carried out in India found that complications occurred in 31% of intubations (n=42), with hypoxia and cardiovascular collapse each accounting for 16.7%, and cardiac arrest occurring in 9.6% during intubation.³

Previous research endeavors have delved into the connection between airway-related events and clinical outcomes in pediatric intensive care settings. For instance, infants experiencing extubation failure following cardiac surgery have demonstrated significantly prolonged stays in the ICU.⁴ Similarly, children who experience unplanned extubations during their Pediatric ICU course displayed extended lengths in stay, both within the PICU and throughout the hospital.⁵ However, a pivotal question that remains unanswered pertains to the influence of factors occurring during the intubation procedure itself on these critical clinical outcomes, such as the period of PICU stay, length of mechanical ventilation (MV), and also patient mortality.⁶

METHODS

This study employed a cross-sectional research design, conducted within the Pediatric Intensive Care Unit (PICU) at The Aga Khan University Hospital in Karachi. The research duration spanned for one year, beginning after obtaining approvals from the Ethics Review Committee (ERC) (2020-3433-10807) (5-7-20), and acceptance of synopsis from the College of Physicians and Surgeons Pakistan (CPSP). For comprehensive coverage in outcomes, the sample size calculation was based on the prevalence of

adverse events, including desaturation (29%), cardiac arrest (6.2%), and bradycardia (3.1%), as previously reported by Margaret M. Parker et al. Consequently, the final sample size was established at 183 children. Employing consecutive non-probability sampling, this research project included children aged between 1 month and 18 years who underwent primary tracheal intubation in the PICU. Exclusions were applied to cases involving tracheal re-intubation, secondary intubations, and those with pre-existing tracheostomy tubes. The data collection process relied on a meticulously designed Peri-intubation proforma, filled out by a trained observer (staff member) under the supervision of a physician. To ensure data accuracy and reliability, the recorded information was cross-referenced with video recordings of the intubation procedure. Airway classifications were based on the Malam Patti classification system, wherein grades 1-3 were considered as non-difficult airways, and grades 4 to 5 were considered as difficult airways.

The data collected encompassed a wide range of variables, including patient demographics (age, weight, sex), the primary diagnosis at hospital admission, and frequency of intubation attempts. Additionally, unfavorable effects such as cardiac arrest, bradycardia, hypoxia, esophageal intubation with late recognition, observed aspiration, hypotension, hypertension, direct airway injury, bronchial intubation, and arrhythmias were systematically recorded. Effect modifiers, including age, gender, primary disease, airway difficulty assessed according to the Malam Patti classification, operator designation (resident, fellow, or attending), and the number of intubation attempts, were documented. To account for the timing of intubation (day hours: 0900 to 1700 or after 1700hrs), a controlled stratification approach was employed, followed by post-stratification chi-square tests to assess significance, with threshold set at a p-value of less than 0.05. Subsequently, data analysis was carried using SPSS version 20, computing descriptive statistics for both quantitative (e.g., age, weight) and qualitative variables (e.g., gender, sex), including mean, standard deviation, frequency, and proportion.

RESULTS

In the course of the study, a total of 183 tracheal intubations were carried out. Amongst them number of intubations occurred in the age group of 1-5 years, accounting for 27.3% of cases, closely followed by those aged above 5 to 10 years (26.2%) and less than 1 year (25.7%). Among the intubated individuals, the majority were male, constituting 60.7%, with the remaining 39.3% being female. This data was collected during the study period from August 2020 to 2021, and complete records were available for all patients, with no missing data. Concerning the mode of admission, the majority of intubations were from the Emergency Room (ER), comprising 62.3% of cases, followed by those shifted from the clinic (1.6%). Additionally, 36.1% of intubations involved patients who initially fell ill in the ward and were subsequently transferred to the PICU for further care. The majority of intubations, 93.4%, took place in the PICU, while the remaining intubations were equally distributed among the ward, operating theater, and ER, each accounting for 2.2% of cases. Intubations during the morning hours (0900 to 1700) totaled 49.2%, while those in the evening hours (1700 to 08:59) accounted for 50.8%. First attempt success was achieved in 95.6% of cases, with second attempts in 3.3%, and three or more attempts in 1.1%.

Regarding the duration of patient stays following intubation, the majority (50.8%) stayed for 1-10 days, followed by 30.6% staying for more than 10 to 20 days, and 18.6% staying in the PICU for more than 20 days as shown in Table-I.

Analysis of the specialty of healthcare providers involved in the intubation procedures revealed that a significant portion, 78.1%, were performed by the PICU team, while 21.9% were conducted by the anesthesia team. In terms of patient outcomes, 76.0% of patients survived and were discharged home, while 24.0% unfortunately did not survive.

A subset of intubations, approximately 6%, experienced complications related to the procedure. These complications included hypoxia in 3.3% of cases, bradycardia in 1.6%, and other

issues such as hypotension and esophageal intubation in 1.1% as shown in Pie Figure-1.

Variable Names	Frequency (%)
Mode of Admission	
ER	114 (62.3%)
Outdoor	03 (1.6%)
Ward	66 (36.1%)
Duration of stay (days)	
1-10	93 (50.8%)
>10 to 20	56 (30.6%)
>20	34 (18.6%)
Location of intubation	
Ward	4 (2.2%)
ER	4 (2.2%)
ICU	171 (93.4%)
OR	4 (2.2%)
Number of attempts	
1	175 (95.6%)
2	6 (3.3%)
3	2 (1.1%)
Time of intubation	
9am to 5pm	90 (49.2%)
5pm to 9am	93 (50.8%)

Table-I. Demographic characteristics of TI Encounter

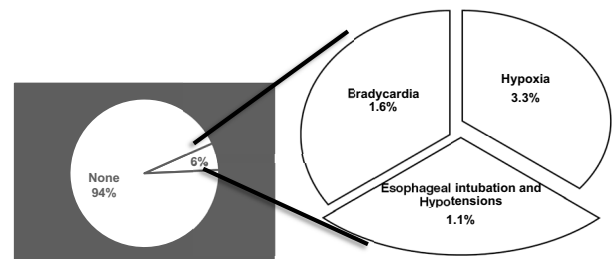


Figure-1. % of tracheal intubation associated adverse event

Further analysis revealed that 39% of endotracheal intubations were performed by critical care faculty, 35% by pediatric intensive care fellows, and 26% by pediatric intensive care residents. Comparing clinical demographics, it was found that complications occurred more frequently in cases where intubation was attempted for the second or third time (4%) compared to those successfully intubated on the first attempt. Residents exhibited a higher proportion of complications (12.8%) compared to faculty (4.2%) and fellows (3.1%). Complications were also more common during morning hours (10%) compared to evening hours (2.2%) and in cases where intubation

was performed by the anesthesia team (10%) compared to the PICU team (4.9%).

Furthermore, the data indicated that complications were more frequently observed in patients intubated in the ward and ER (25%) compared to those intubated in the well-controlled environment of the PICU (5.3%) as shown in Table-II.

Independent Variable	Complication Yes	No	Chi (P-Value)
No of attempts			28.65 (0.00)
1 st	7 (4.0)	168 (96.0)	
2 nd	3 (5.0)	3 (5.0)	
3 rd	1 (5.0)	1 (5.0)	
Expertise			
Resident	6 (12.8)	41 (87.2)	5.187 (0.075)
Fellow	2 (3.1)	63 (96.9)	
Faculty	3 (4.2)	68 (95.8)	
Time of intubation			
Morning	9 (10.0)	81 (90)	4.98 (0.026)
Evening	2 (2.2)	91 (97.8)	
Specialty of Dr who performed intubation			
Anesthesia	4 (10.0)	36 (90.0)	1.442 (0.230)
ICU	7 (4.9)	136 (95.1)	
Location of intubation			
Ward	1 (25.0)	3 (75.0)	5.53 (0.137)
ER	1 (25.0)	3 (75.0)	
ICU	9 (5.3)	62 (94.7)	

Table-II. Association between independent variables and TIs related complication

In evaluating the association between complications and patient outcomes, it was found that 63.60% of surviving patients experienced complications, while 36.40% of deceased patients had complications. This data suggests that the occurrence of complications did not significantly influence patient survival.

DISCUSSION

Determining the precise incidence of complications arising from endotracheal intubation in mechanically ventilated patients remains a challenging task, and published reports exhibit substantial variability in this regard. In our investigation focusing on Tracheal Intubation-associated complications and the contributing factors, we observed that hypoxia emerged as the most prevalent complication,

accounting for 3.3% of the total adverse events. A parallel study by Margaret M. Parker et al. reported desaturation (hypoxia) in 29%, cardiac arrest in 6.2%, and bradycardia in 3.1%. Our study identified bradycardia as the second most common complication, occurring in 1.6% of cases, while other issues like hypotension and esophageal intubation constituted 1.1%.

Our data underscore the fact that even experienced laryngoscopists may frequently encounter severe complications related to tracheal intubation. Our findings emphasize the importance of considering the location of tracheal intubation, which carries a notably high risk. Therefore, our results serve as a cautionary note for healthcare professionals involved in this procedure. One potential intervention to mitigate desaturation during tracheal intubation is the administration of continuous flow of oxygen throughout the period of apnea when intubation is being done.

Similar studies in the adult population have investigated methods of continuous oxygenation flow, often referred to as "apneic oxygenation," across different clinical set ups. For instance, Wimalasena et al. introduced the use of apneic oxygenation as part of protocol for out of the hospital settings tracheal intubations, involving the delivery of 15 L/min of oxygen flow via nasal cannula during the intubation procedure. In this approach, they achieved a significant reduction in desaturation rates, from 23%-17%. Similarly, in a single-center study conducted in adult ICU in France showed a significant decrease in drop of saturations from 14% to 2% by employing high-flow nasal cannula at a rate of 60 L/min throughout the apneic phase of tracheal intubation.

Considering the relationship between the frequency of tracheal intubation attempts and complications, another potential intervention to reduce adverse events could be minimizing the No: of attempts. While various other studies conducted in emergency departments and operating rooms have shown the use of video laryngoscopes to be associated with the improved visualization and first attempt success, there is

also conflicting evidence indicating that video laryngoscopy may enhance glottis visualization without necessarily improving intubation success, potentially prolonging intubation times and increasing procedure-related complications.

Furthermore the research efforts should focus on determining in the optimal implementation of video laryngoscopy in the clinical care of critically ill children across diverse Pediatric Intensive Care Units (PICUs). It is essential to acknowledge several limitations in our study. The dataset relies on self-reported Quality Improvement (QI) data, which may introduce reporting bias. However, we have taken rigorous measures to reduce this bias, including adherence monitoring, precise operational definitions, and authentication procedures.

In spite of these limitations, our study boasts several strengths. Firstly, we shed light on risk factors associated with tracheal intubation-related complications, filling a gap in the existing body of knowledge. Previous studies have provided limited insights into this area. Secondly, our use of structured PICU records, coupled with a meticulous peer-review process overseen by the department director, ensured the absence of missing data, bolstering the reliability of our findings

CONCLUSION

Oxygen desaturations and tracheal intubation related adverse events (TIAEs) are common in the pediatric intensive care unit (PICU). The choice of the intubating provider and correcting intubation conditions are crucial for reducing TIAEs and ensuring patient safety. Furthermore research should focus on development and validation of pediatric intubation scores and defining standardized protocols for endotracheal intubation in critically ill patients.

Primarily using video laryngoscope is related with a lower incidence of adverse TIAEs, highlighting its potential benefits in improving intubation outcomes. Factors such as the use of anticholinergics, analgesia, and proper depth of anesthesia can help minimize complications

during tracheal intubation. Standard monitoring, including capnography, pulse oximetry, and ECG, should be routine practice, and having a difficult airway algorithm readily available can aid in early detection and management of complications.

While quality improvement interventions to reduce desaturation and TIAEs are valuable, their direct impact on ICU outcomes remains uncertain. Tracheal intubation-related adverse events, predominantly hypoxia, occur in a significant proportion of cases despite best efforts. Recognizing these complications is essential for improving the care of intubated patients.

Clear and consistent guidelines for mechanical ventilation in children, derived from pediatric-specific research, are lacking, and much of the current knowledge is extrapolated from adult studies. Increasing the frequency of intubation attempts is associated with desaturation and adverse events in critically ill children. Therefore, being careful in selection of the initial intubating provider and optimizing intubation condition is crucial to increase first attempt success and enhance patient safety.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

SOURCE OF FUNDING

There are no sponsors for the research being carried out, it's a self-sponsored research.






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AUTHORSHIP AND CONTRIBUTION DECLARATION

No.	Author(s) Full Name	Contribution to the paper	Author(s) Signature
1	Murk Shaikh	Synopsis & manuscript writing, data collection, Statistical analysis.	
2	Arshalooz Jamila Rahman	Review and proof reading of manuscript.	
3	Samina Akhtar	Synopsis & manuscript writing, Statistical analysis.	
4	Tarab zehra	References writing.	
5	Suhana Shaikh	Proof reading of manuscript.	
6	Tayyaba Anwar	Reference writing.	