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The Complication Profile and Contributing Factors in Adverse Events of Endotracheal Intubation in a Paediatric Intensive Care Unit of Karachi, Pakistan

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Declaration
Authors' Contribution
SI was the lead investigator who designed this study and collected data.
SS helped in analyzing the results and writing the final manuscript.
SA and **RT** assisted in data analysis and converting it into tabulations and graphic forms.
SM helped in collecting data and interpreting information and results.
HK assisted in manuscript writing, particularly adding references in Vancouver style.

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ABSTRACT

Background: Endotracheal intubation (ETI) is an essential and potentially life-saving procedure in pediatric intensive care units (PICUs). Despite its importance, the technique is associated with notable risks, particularly in children, who are more vulnerable to complications because of their distinct anatomical and physiological characteristics. Data from these studies indicate that adverse events are frequent, with approximately one in five intubations complicated by some form of tracheal intubation–associated event. Current study was designed to assess the frequency and nature of ETI-related complications in children admitted to the PICU. **Methods:** A cross-sectional study was conducted in the Pediatric Intensive Care Unit of the Indus Hospital Karachi, from September 2024 to February 2025. The data collected encompassed a wide range of variables, including patient demographics like age, weight and gender, the primary diagnosis at hospital admission, details of intubation like number of attempts, type, size of tube and time of intubation either in morning or night hours, monitoring and checklist according to RSI. Additionally, unfavorable effects at pre-intubation, during intubation and post-extubation were checked. Cardiac arrest, bradycardia, hypoxia, esophageal intubation with or without observed aspiration, direct airway injury, dental and perioral trauma, bronchial intubation was systematically recorded as well as the outcomes of the patients in terms of LOS, duration of MV and patient's survival were also noted. Data was collected and analyzed by using Statistical Package for Social Science (SPSS) version 23. **Results:** The mean age of the study participants was 5.7 ± 4.8 years while the mean weight was 18.2 ± 14.6kg. The main indication for intubation was of respiratory cause (67%) while the non-respiratory causes (31.8%) were cardiac (3.4%), post-operative (3.4%), shock (8%) and neurological (19.3%). About 74.7% study participants were intubated in first attempt. Looking over the adverse events, none of the study participant had dental trauma or vocal cord palsy. About 5 (5.7%) patients faced perioral laceration, 10 (11.4%) patients had bronchospasm, 2 (2.3%) had esophageal intubation, 4 (4.5%) had cardiac arrest, 1 (1.1%) had aspiration into lungs, 8 (9.1%) had hypotension, 13 (14.8%) had bradycardia. Other adverse events included desaturation hypoxia in 21 (23.9%), unexplained extubation in 5 (5.7%), tube blockage in 11 (12.5%), endobronchial intubation in 1 (1.1), stridor in 2 (2.3%) and hoarseness of voice in 3 (3.4%) patients but the study found good patient's outcome after intubation. **Conclusion:** It can be concluded that the main indication for intubation was of respiratory cause (67%) and 74.7% study participants were intubated in first attempt. Adverse tracheal intubation–associated events are frequently observed during intubation of critically ill children admitted in PICU. Desaturation hypoxia was the most frequent adverse event (23.9%) followed by bradycardia (14.8%), tube blockage (12.5%), bronchospasm (11.4%) and hypotension (9.1%).

INTRODUCTION

Endotracheal intubation (ETI) is an essential and potentially life-saving procedure in pediatric intensive care units (PICUs), commonly performed for critically ill children with conditions such as respiratory failure, cardiac arrest, neurologic or oncologic disease, hemodynamic instability, and in the post-operative setting. Despite its importance, the technique is associated

with notable risks, particularly in children, who are more vulnerable to complications because of their distinct anatomical and physiological characteristics (1-3).

Large multicenter registries, including the National Emergency Airway Registry for Children (NEAR4KIDS), have provided valuable insights into the safety profile of airway management in PICUs. Data from these studies indicate that adverse events are frequent, with approximately one in five intubations complicated by some form of tracheal intubation–associated event (TIAE). Severe TIAEs occur in about 3% to 6.5% of cases. (4-6). Children in critical condition are especially prone to such complications due to their limited physiological reserves and the likelihood of hemodynamic or respiratory instability. Furthermore, severe TIAEs are strongly associated with poorer clinical outcomes (4, 7).

Children in critical condition are especially prone to such complications due to their limited physiological reserves and the likelihood of hemodynamic or respiratory instability. Furthermore, severe TIAEs are strongly associated with poorer clinical outcomes (8, 9). These complications may arise during three phases: immediately at the time of intubation, while the tube remains in place, or after extubation (10). Studies have shown that hypotension and bradycardia are the most common complications at the time of intubation, tube obstruction is a frequent problem during the intubation period, and sore throat is the most commonly reported complaint after extubation, occurring in about 22% of patients (2). Research from Ethiopia further reported that hypoxemia (oxygen saturation <80%) developed in 13–15% of intubations (11), while other studies estimated overall complication rates at around 6%, with hypoxia, bradycardia, hypotension, and esophageal intubation being among the most frequent adverse outcomes (1).

Successful and safe ETI in children requires careful attention to multiple contributing factors. These include the child's underlying condition, the skill and experience of the clinician, selection of appropriate equipment (such as tube size and cuff type), number and timing of intubation attempts, duration of the procedure, use of apneic oxygenation, adherence to rapid sequence intubation (RSI) protocols, structured monitoring checklists, and awareness of laryngeal motor responses (3, 11). . Mastery of these elements emphasizes the need for well-trained providers, careful clinical judgment, and close observation to minimize complications. Recognizing risk factors, understanding the spectrum of potential complications, and implementing preventive strategies are all critical in improving the safety and outcomes of ETI in pediatric patients. Accordingly, this study was designed to assess the frequency and nature of ETI-related complications in children admitted to the PICU.

MATERIAL AND METHODS

A cross-sectional study was conducted in the Pediatric Intensive Care Unit of the Indus Hospital Karachi, from September 2024 to February 2025. Sample size was calculated by using OpenEpi software keeping confidence interval of 95% and 5% margin of error. The calculated sample size was 87. Non-probability consecutive sampling technique was used. The inclusion criteria for the study was i) age between 1month to 16 years ii) requiring endotracheal intubation (ETI) and Mechanical ventilation iii) reason of intubation could be respiratory or non-respiratory while those were excluded who were i) having age <1month > 16years ii) previous intubations, surgeries or traumas in the cervical region or oropharynx iii) Children with tracheostomies iv) whose parents/guardian failed to give consent.

The study was conducted after taking formal approval from the institutional review board of concerned hospital. An informed consent from parents/guardians was taken prior to enrolling them in the study. Detailed history and physical examination was carried out. The data collection process relied on a meticulously designed peri-intubation proforma. The data collected encompassed a wide range of variables, including patient demographics like age, weight and gender, the primary diagnosis at hospital admission, details of intubation like number of attempts, type, size of tube and time of intubation either in morning or night hours, monitoring and checklist according to RSI. Additionally, unfavorable effects at pre-intubation, during intubation and post-extubation were checked. Cardiac arrest, bradycardia, hypoxia, esophageal intubation with or without observed aspiration, direct airway injury, dental and perioral trauma, bronchial intubation was systematically recorded as well as the outcomes of the patients in terms of LOS, duration of MV and patient's survival were also noted.

Data was collected and analyzed by using Statistical Package for Social Science (SPSS) version 23. Demographic data like gender, indication for intubation, type of intubation, RSI followed, complications and patient outcome was presented as frequency and percentage. Mean with standard deviation was calculated for quantitative variables like age, size of endotracheal tube and length of stay in ICU.

RESULTS

The mean age of the study participants was 5.7 ± 4.8 years while the mean weight was 18.2 ± 14.6kg. Majority of study participants were male (62.5%) as compared to their counterpart (36.4%). The main indication for intubation was of respiratory cause (67%) while the non-respiratory causes (31.8%) were cardiac (3.4%), post-operative (3.4%), shock (8%) and neurological (19.3%). Elective intubation was the common type (54.5%) than emergency intubation. The mean size of endotracheal tube was 4.6 ± 1.1mm. About 74.7% study participants were intubated in first attempt followed by second attempt in 17.2% participants and even third attempt in 8% participants. All the patients were sedated but muscle relaxant was used in only 39.8% study participants. The mean length of stay in PICU was 11.9 ± 13.0 days as mentioned in Table 1.

Looking over the adverse events, none of the study participant had dental trauma or vocal cord palsy. About 5 (5.7%) patients faced perioral laceration, 10 (11.4%) patients had bronchospasm, 2 (2.3%) had esophageal intubation, 4 (4.5%) had cardiac arrest, 1 (1.1%) had aspiration into lungs, 8 (9.1%) had hypotension, 13 (14.8%) had bradycardia. Other adverse events included desaturation hypoxia in 21 (23.9%), unexplained

extubation in 5 (5.7%), tube blockage in 11 (12.5%), endobronchial intubation in 1 (1.1), stridor in 2 (2.3%) and hoarseness of voice in 3 (3.4%) patients as presented in Figure 1. About 6 (6.8%) patients needed reintubation. The intubation related complications were further categorized as severe complication into major category while less severe complication into minor category as presented in Table 2. Instead of adverse events, the study found good patient's outcome after intubation, about 67 (76.1%) patients were recovered while mortality rate was 22.7% as shown in Figure 2.

Table 1
Characteristics of Study Participants

Variables		n=87 (%)
Age (years)		5.7 ± 4.8
Weight (kg)		18.2 ± 14.6
Gender	Male	55 (62.5%)
	Female	32 (36.4%)
Indication for intubation	Respiratory	59 (67%)
	Non-respiratory	28 (31.8%)
	Cardiac	3 (3.4%)
	Post-operative	3 (3.4%)
	Shock	7 (8.0%)
	Neurological	17 (19.3%)
Type of intubation	Elective	48 (54.5%)
	Emergency	39 (44.3%)
Size of endotracheal tube (mm)		4.6 ± 1.1
Number of intubation attempts	1	65 (74.7%)
	2	15 (17.2%)
	3	7 (8.0%)
Sedation used		87 (100%)
Muscle relaxant used		35 (39.8%)
Length of stay in PICU		11.9 ± 13.0

Figure 1
Adverse Events after Intubation

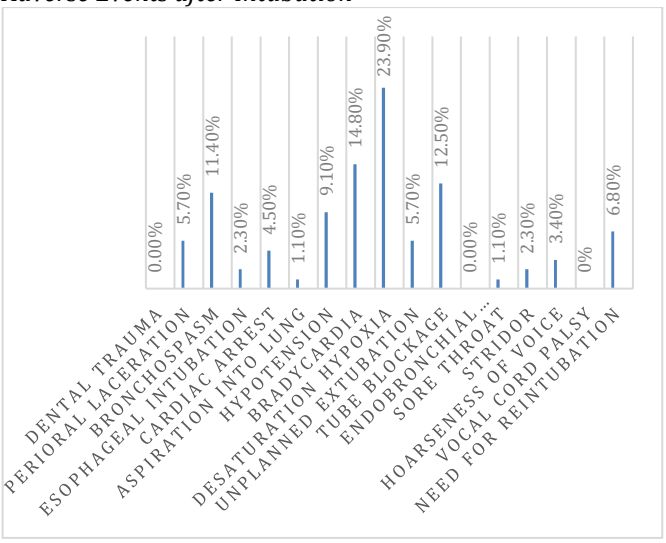
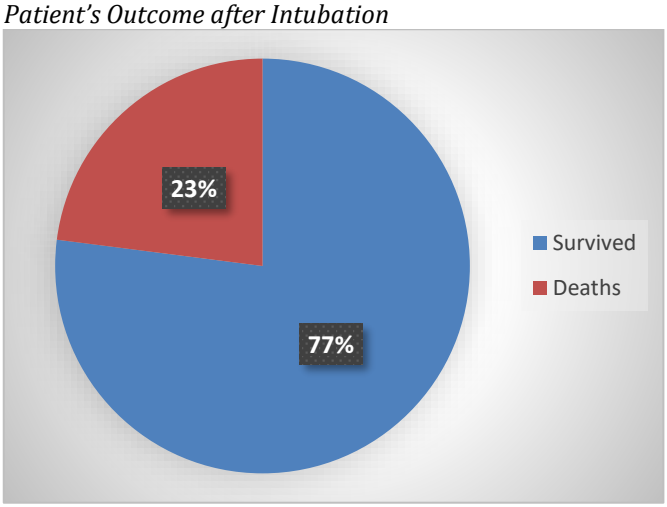


Table 2
Complications of Intubation

Variable		n=87 (%)
Major (Severe) Complications	Hypoxia	21 (24.1%)
	Bradycardia	12 (13.7%)
	Cardiac arrest	4 (4.6%)
	Hypotension	8 (9.2%)
	Bronchospasm	10 (11.5%)
Minor (Less Severe) Complications	Dental trauma/Laceration	5 (5.6%)
	Hypertension requiring medication	0
	Esophageal intubation	2 (2.3%)
	Dysrhythmia	0
Others	Unplanned/Invader extubation	5 (5.7%)
	Tube blockage	11 (12.6%)
	Sore throat	10 (11.5%)
	Stridor/Laryngeal edema	2 (2.3%)
	Hoarseness of voice/Dysphonia	2 (2.3%)
	Need for reintubation	10 (11.5%)

Figure 2
Patient's Outcome after Intubation



DISCUSSION

Current study found that the main indication for intubation was of respiratory cause (67%) while the non-respiratory causes (31.8%) were cardiac (3.4%), post-operative (3.4%), shock (8%) and neurological (19.3%). Elective intubation was the common type (54.5%) than emergency intubation. About 74.7% study participants were intubated in first attempt followed by second attempt in 17.2% participants and even third attempt in 8% participants. A study by Butragueno et.al found that the first-pass success rate was 60% (2), which is similar to findings from other investigations in the PICU setting, including large registry-based studies such as the National Emergency Airway Registry for Children (NEAR4KIDS). However, data, have demonstrated that factors such as younger age, prior history of a difficult airway, or signs of upper airway obstruction are linked to an increased number of intubation attempts. The skill and experience of the physician performing the procedure also play a significant role in first-pass success (12, 13). Patients admitted to intensive care units often require multiple attempts at intubation (14). The incidence of difficult intubation reported by Butragueno et.al was 12.4% (2), slightly higher than the 7% reported in the NEAR4KIDS registry (12).

Adverse events related to tracheal intubation are relatively common, occurring in up to 20% of critically ill pediatric patients, and are linked to poorer outcomes, extended mechanical ventilation, and higher mortality (4). Desaturation was the most frequent complication and the primary reason for discontinuing intubation attempts

(15). Previous studies by Nishisaki et al. and Lee et al. reported desaturation rates (SpO_2 < 80%) of 13.5% and 27%, respectively (13, 16). Children are more prone to desaturation than adults due to lower functional residual capacity and higher oxygen consumption (17). Likewise, current study reported desaturation hypoxia in 21 (23.9%) of the study participants. The likelihood of desaturation increases with the number of attempts and is associated with hemodynamic complications such as cardiac arrest, hypotension, hypertension requiring intervention, and arrhythmias (5, 18).

Cardiac arrest has been reported in 7% and death in 1.6% of intubations in cardiac PICUs (19); but another study found only one patient (2%) experienced cardiac arrest, but no intubation-related deaths occurred (2). Matettore et.al found that hypoxia was common (4.1%) while the desaturation was linked with hemodynamic unstability and prolonged hospital stay. Other adverse event reported was cardiac arrest (1.62%) (7, 20). Similarly, current study reported that about 14.8% patients had bradycardia, followed by hypotension (9.1%) and cardiac arrest (4.5%). Nishisaki et al. documented adverse events of intubation in 19% of all cases, with severe events noted in 3%, based on data from a tertiary-care academic pediatric hospital. Their findings also identified esophageal intubation with immediate detection as the most frequent adverse event, accounting for 9% of cases (16). In contrast, Carroll et al. reported higher complication rates (41%) in their retrospective single-center study conducted in a free-standing children's hospital PICU. That study analyzed 137 urgent and emergent non-operation theater intubations over a two-year period, noting that emergent procedures were more common. The leading complications were oxygen desaturation below 90% (29%), hypotension (16%), and bradycardia (7%). Their multivariate analysis revealed that complications were more likely with three or more intubation attempts, emergency intubations. Notably, these complications did not correlate with longer ICU stays or extended mechanical ventilation (21).

Literature review revealed that the esophageal intubation was the most common adverse event in pediatric age group (13, 22). Current study found esophageal intubation in 2 (2.3%) patients while endobronchial intubation in only 1 (1.1), patient.

Oxygen desaturation and tracheal intubation–associated events frequently occur during intubation in the PICU and are linked to prolonged mechanical ventilation. Severe adverse events are further connected to an increased risk of mortality as there is a strong relationship between these acute events and poorer ICU outcomes (4). But the current study contradicts this finding by reporting good patient's outcome after intubation, about 67 (76.1%) patients were recovered while mortality rate was 22.7%.

A key factor in interpreting these findings is the potential preventability of intubation related adverse events. Certain events, such as esophageal intubation or repeated intubation attempts, may reflect the technical proficiency of the airway provider. Others, like cardiac arrest (with or without recovery of spontaneous circulation), are more likely linked to the patient's unstable condition than provider skill. While some adverse events may be unavoidable, their frequency could potentially be reduced by enhancing provider technical expertise, optimizing patient management, and ensuring adequate resuscitation before airway interventions (23).

CONCLUSION

It can be concluded that the main indication for intubation was of respiratory cause (67%) and 74.7% study participants were intubated in first attempt. Adverse tracheal intubation–associated events are frequently observed during intubation of critically ill children admitted in PICU, with over half of the patients experiencing at least one adverse event. Desaturation hypoxia was the most frequent adverse event (23.9%) followed by bradycardia (14.8%), tube blockage (12.5%), bronchospasm (11.4%) and hypotension (9.1%). Multiple intubation attempts were the strongest predictor of adverse outcomes, highlighting the critical importance of achieving first-pass success. The results of this study may guide future quality improvement initiatives aimed at lowering the risk of severe tracheal intubation–associated adverse events and enhancing outcomes for critically ill children in the PICU.

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