Original Article

Emergency Endotracheal Intubation in a Pediatric Intensive Care Unit: A Quality Improvement Study

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ABSTRACT

Background: Emergency Endotracheal Intubation (EEI) is a high-risk procedure with complications such as hypoxemia and hypotension. Despite these risks, EEI is routinely performed in Pediatric Intensive Care Unit (PICUs), which are complex and hazard-prone environments. Suboptimal intubation can lead to adverse outcomes, including brain injury, cardiac arrest, and death. Quality improvement (QI) measures, including system changes and standardized protocols, have been shown to improve first-pass success rates and reduce adverse events. This study describes a QI project aimed at enhancing safety EEI. **Objective:** To improve the first pass success rate of emergency endotracheal intubation in children in the PICU and reduce procedure related adverse events through QI interventions. **Method:** The study was conducted in the PICU over three months. A multidisciplinary QI team was formed. Baseline data were collected from 50 intubations using a structured checklist. Root cause analysis was performed using fishbone methodology. Based on identified deficits, interventions were developed and tested through Plan-Do-Study-Act (PDSA) cycles. Post-Intervention data were collected using the same checklist. Interventions were accepted, rejected, or modified based on results. Intubation parameters were reassessed one year later to evaluate sustainability. **Results:** Following interventions, the first-pass success rate improved from 62% to 88% ($p = 0.0004$). Preoxygenation compliance increased from 3% to 88% ($p = 0.00004$). Equipment checks improved from 55% to 90% ($p = 0.0005$). Complications decreased from 38% to 12%, reflecting better patient safety. One year later, the improvements remained sustainable: first-pass success rate 79%, preoxygenation 75%, and equipment checks 89%. **Conclusion:** The first-pass success rate should be adopted as a standard quality metric for auditing intubation care. Mandatory simulation-based training for all staff is essential.

Key words: airway management, critical care, endotracheal intubation, quality improvement

Emergency Endotracheal Intubation (EEI) is a lifesaving procedure in PICUs, but it carries significant risks. Complications such as hypoxemia and hypotension occur in up to one-third of cases and are strongly associated with poor neurological outcomes and airway-related mortality [1-7]. Achieving first-pass success is crucial, as multiple attempts significantly increase the risk of peri-intubation adverse events, including hypoxia, hypotension, and cardiac arrest [8].

Although the PICU provides a controlled environment, critically ill children often present with hemodynamic instability, prolonged ventilation, and anatomical challenges, making intubation complex and high-risk [9,10]. System-level interventions, such as structured airway management algorithms, standardized checklists, equipment preparation protocols, and simulation-based training, have been shown to improve first-pass success rates and reduce complications [11-17, 21, 22].

Recent studies highlight the importance of sustained QI strategies in pediatric airway management. These include team-based training [23], innovative preoxygenation techniques, videolaryngoscopy, and hybrid methods [24], as well as interventions targeting operator experience as a determinant of first-attempt success [25].

Recognizing this need, we implemented a QI initiative to increase first-pass intubation success and minimise complications in a resource-limited PICU. In addition to short-term gains, this study also evaluates the long-term sustainability of these interventions over a one-year follow-up period.

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MATERIAL AND METHODS

The study was conducted between January and March 2024 at a tertiary care hospital in New Delhi, India. The Institutional Ethics Committee approved the study and waived the requirement for informed consent (IECHR-2024-65-7-R1), as it was a QI initiative using de-identified data and posed no additional risk to patients.

A multidisciplinary QI team consisting of one team leader, two senior resident doctors, two staff nurses, and one nursing orderly was formed to improve the first-pass success rate of intubation in the PICU. A checklist covering crucial steps in EEI was prepared, and used to observe 50 intubations, collecting baseline data (Table 1).

Table 1. Endotracheal intubation checklist

Sr No.	Item	Mark YES/NO
1	Equipment check	
2	Pre-oxygenation with 100 % O2 for 3 min	
3	Sedation	
4	Muscle relaxant	
5	Position for intubation	
6	ET insertion until the black mark reaches the Vocal Cords	
7	Verify ET placement (by auscultation, improvement in saturation, and heart rate)	
8	Fixation Tube	
9	First pass success	
10	Complications (Hypotension, Hypoxia, bradycardia, cardiac arrest, esophageal intubation)	

The aim was to increase the first-pass success rate of EEI in PICU children by 25% over three months. Process mapping and fishbone analysis identified barriers during EEI. Four PDSA cycles were tested and implemented.

Definitions

First pass success: Passage of endotracheal tube through the vocal cords in the first attempt, with confirmation (adequate chest rise, improvement of saturation and heart rate, equal air entry on auscultation) [16].

First pass success rate: Number of first pass successes divided by the number of intubations multiplied by 100 [16].

First pass success rate = Total number of successful first pass intubations / Total no. of intubations observed x 100

Process Mapping and Fish Bone Analysis

EEI involves preparation of equipment, patient positioning, pre-oxygenation, administration of sedation and paralytic agents, and laryngoscopy with placement. A process map identified bottlenecks (Figure 1). The goal was to ensure the smooth conduct of emergency intubation from start to finish. A fishbone diagram categorizes root causes of failure into people, place, process, and policy (Figure 2), guiding interventions.

PDSA Cycles (Plan-Do-Study-Act)

After several discussions with team members, we finalized the change ideas, and PDSA cycles were used to test these ideas.

PDSA Cycle 1: Physical Training of Resident Doctors and Nurses

Residents and nurses underwent simulation-based training using mannequins. Posters and checklists were displayed in the PICU (Figures 3a, 3b).

PDSA Cycle 2: Improving Pre-oxygenation

Limited oxygen outlets hindered pre-oxygenation. We used BiPAP masks connected to the ventilator in NIV mode with 100% FiO2. Large wall clocks were installed to ensure three minutes of pre-oxygenation (Figure 3c).

PDSA Cycle 3: Proper Positioning

Wedge-shaped pillows were used for obese children to optimize airway alignment (Figure 3d).

PDSA Cycle 4: Preparing the Drugs

Nurses prepared emergency drugs at each shift; residents pre-checked emergency trolleys.

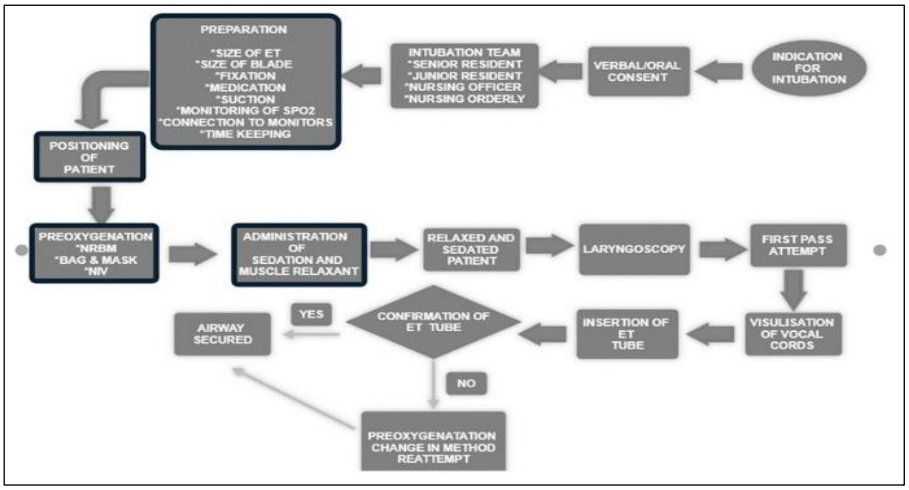

Figure 1. Process map of emergency endotracheal intubation steps

A step-by-step process map outlining each stage of emergency endotracheal intubation in the PICU. Key error-prone steps leading to first pass intubation failure are highlighted to identify opportunities for quality improvement.

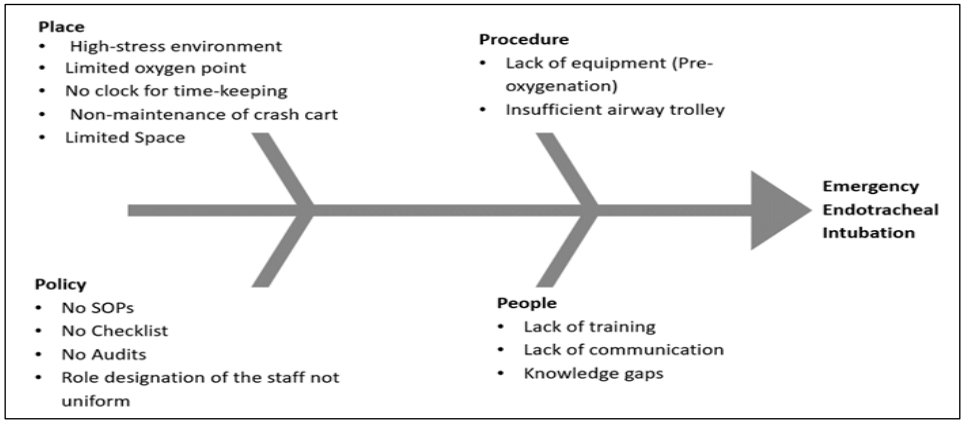

Figure 2. Fishbone diagram of root causes of intubation failure

A cause-and-effect analysis diagram categorizing contributing factors to first pass intubation failure into four domains: people, place, process, and policy. The visual tool guided the development of targeted interventions.

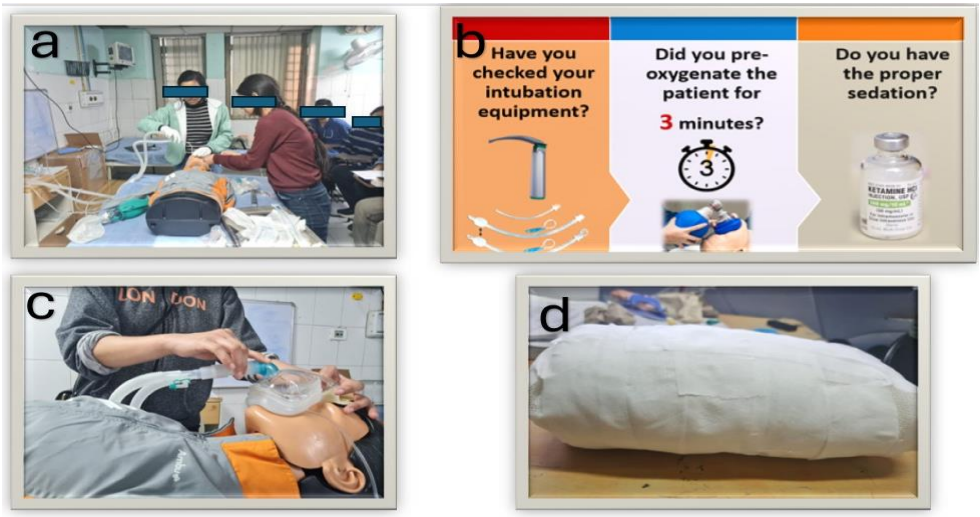

Figure 3. Quality improvement interventions.

A. Simulation-based training sessions for residents and nursing staff to improve skills and preparedness.

B. Posters displayed in the PICU reinforcing essential steps of intubation

C. Use of a BiPaP mask directly connected to the ventilator circuit for preoxygenation, addressing oxygen port limitations.

D. Wedge-shaped pillows to optimise airway positioning in obese or anatomically challenging patients.

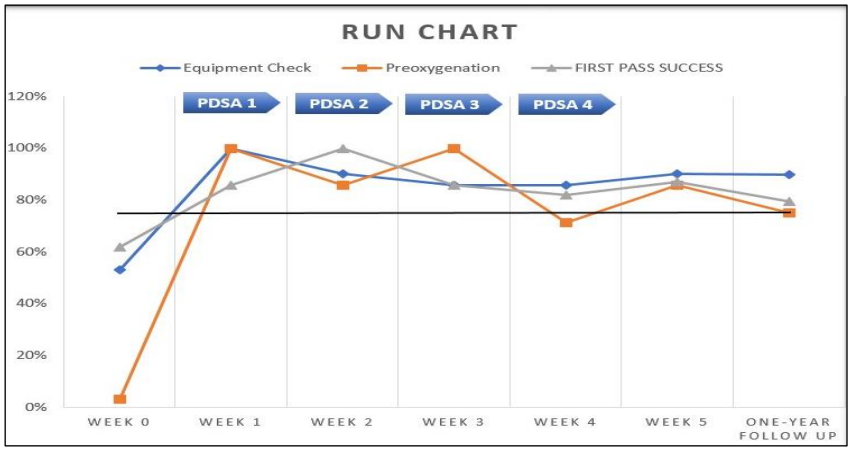

Figure 4. Run chart of intubation quality metrics over time.

Weekly trends in first pass success rates, equipment checks, and complication rates for baseline, post-intervention, and one-year follow-up phases, demonstrating sustained improvement.

Statistical Analysis

Data was recorded using the checklist and entered in Microsoft Excel. First-pass success rates were calculated and plotted on run charts. Data are reported as percentages. The McNemar test compared pre and post-intervention outcomes (equipment checks, first-pass success, pre – oxygenation.

RESULTS

We observed 50 intubations pre-intervention and 50 in the post-intervention. The first-pass success rate was 62%. Pre-oxygenation was performed in only 3% cases. Equipment checks were done in 53%, and complications occurred in 38%.

Post-intervention, pre-oxygenation improved to 88% (p=0.00004), equipment checks to 90% (p=0.0005), and first-pass success to 88% (p=0.0004), surpassing the 77.5% target. Complications decreased to 12%. The novel pre-oxygenation method contributed most to improved outcomes (Figure 4).

Improvements peaked in week 2, declined slightly in weeks 3-4, but remained above target. One year later, the first-pass success rate was 79%, pre-oxygenation 75%, and equipment checks 89%.

DISCUSSION

This QI initiative improved first-pass success and reduced complications, with sustained benefits over one year. Our team identified deficits in pre-intubation resuscitation, sedation, and oxygen availability. Similar barriers were reported by Hwang et al. and Moisier et al. [17, 18], who also improved success rates with structured training and checklists. Posters and wall clocks in our PICU reinforced adherence.

Bakhsh et al. addressed poor laryngoscopic view with videolaryngoscopy [19]. Within our resource limits, wedge-shaped pillows enhanced positioning. Pre-oxygenation challenges have been noted in other studies [5, 17, 19]. We introduce BiPAP masks via ventilator circuits with 100% FiO2, a novel and resource-efficient method feasible in low-resource settings. Our findings align with previous QI initiatives [17, 19, 20], which improved first-pass success and reduced complications using multi-pronged interventions. Sustained improvements in our study confirm that QI strategies, particularly training and innovative pre-oxygenation, have a lasting impact.

Limitations: Single-center, short-term study with a small sample size (100 intubations). Observer bias was possible, as the intervention team collected data. Staff variability and stressful conditions may also have influenced outcomes.

CONCLUSION

QI interventions improved first-pass success and reduced complications, with benefits sustained over one year. First-pass success should be a standard quality metric for auditing intubation care. Simulation-based training is essential. Quality improvement is a continuous process that must be cultivated.

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