

Apneic Oxygenation for Emergency Intubations in the Pediatric Emergency Department—A Quality Improvement Initiative

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Abstract

Introduction: Emergency airway management of critically ill children in the Emergency Department (ED) is associated with the risk of intubation-related desaturation, which can be minimized by apneic oxygenation. We evaluated the use of apneic oxygenation in the pediatric ED and reported a quality improvement initiative to incorporate apneic oxygenation as a routine standard of care during rapid sequence intubations (RSIs). **Methods:** A baseline period from June 2016 to April 2017 highlighted the practice gaps. Quality improvement interventions were subsequently developed and implemented as a care bundle consisting of a pre-intubation checklist, placing reminders and additional oxygen source in resuscitation bays, incorporating into the responsibilities of the airway doctor and the airway nurse (copiloting), education during airway workshops and simulation training for doctors and nurses, as well as enhancing documentation of the intubation process. We monitored a post-intervention observation period from May 2017 to April 2018 for the effectiveness of the care bundle. **Results:** Apneic oxygenation was not performed in all 22 RSIs during the baseline period. Among 25 RSIs in the post-intervention observation period, providers performed apneic oxygenation in 17 (68%) cases. There was no significant difference in the utilization of apneic oxygenation among emergency physicians and pediatric anesthetists performing RSIs in the pediatric ED. **Conclusions:** We successfully implemented a care bundle targeted at incorporating apneic oxygenation as a routine standard of care during emergency intubations performed in ED. This method could be adopted by other pediatric EDs to improve airway management in critically ill children. (*Pediatr Qual Saf* 2020;2:e255; doi: 10.1097/pq9.000000000000255; Published online February 13, 2020.)

INTRODUCTION

Emergency airway management of critically ill children in the Emergency Department (ED) may be associated with desaturation. Unstable airway, lung pathology, altered respiratory drive, risk of aspiration, anemia, and increased metabolic demand



contribute to the risk of developing desaturation.^{1,2} The incidence of desaturation during intubation has been reported to be 15% but can go up to 48% in difficult airways.³ Complications of cardiac arrhythmias and cardiac arrest may develop following desaturation.^{4,5} Therefore, it is important to prevent desaturation during emergency airway management.

Apneic oxygenation has been shown to prevent and delay desaturation during rapid sequence intubation (RSI) in the pediatric population.⁶⁻⁸ By providing continuous high-flow oxygen via a nasal cannula to the patient after the onset of neuromuscular blockade, apneic oxygenation extends the duration of safe apneic time, which is the time following cessation of breathing until arterial desaturation occurs. In healthy pediatric patients, the safe apneic time is about 4 minutes, but critically ill pediatric patients are likely to desaturate more quickly.^{9,10} Therefore, with apneic oxygenation, an oxygenation diffusion gradient between the hypopharynx and the alveoli is generated, allowing the pulmonary capillaries to continue absorbing oxygen in the absence of ventilation, thus preventing desaturation.^{1,2} Furthermore, apneic oxygenation, being a noninvasive procedure, is cost-effective with no reported complications.^{1,11}

However, despite the evidence for the use of apneic oxygenation in RSIs, the utilization of apneic oxygenation as a routine standard of care in pediatric EDs is

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unknown. To address this, we evaluated the use of apneic oxygenation in a pediatric ED of a tertiary hospital. We then implemented a quality improvement initiative to incorporate apneic oxygenation as a routine standard of care during RSIs.

METHODS

Setting

We conducted this study in the pediatric ED of a tertiary hospital in Singapore with an annual patient volume of >170,000 patients, with 1% being resuscitation cases based on the Singapore Paediatric Triage Scale.¹² The ED team was trained to perform resuscitations independently. The team consisted of a senior doctor as the team leader and airway doctor, a junior doctor as circulation doctor, as well as 3 nurses as airway, circulation, and documentation nurses, respectively. The pediatric anesthetists may be activated for emergent airway management as part of the airway code, code blue, or trauma code according to specific criteria.

Based on our earlier work, the incidence of emergency airway management was 3.4 per month with the main indications being decreased consciousness and loss of airway reflexes (60.9%), failure to ventilate (19.3%), failure to oxygenate (16.9%), and anticipated clinical course or deterioration (2.9%).¹³ RSIs constituted 67.6% of all emergency airway management. Intubation was performed using direct laryngoscopy in our ED, and supraglottic devices were not routinely used. Apneic oxygenation was not a standard of care during RSI but could be done at the physician's discretion.

Design

This study consisted of 2 parts. A baseline period from June to April 2017 provided the utilization of apneic oxygenation during RSIs, thus reflecting the current practice and highlighting any gaps. A post-intervention observation period from May 2017 to April 2018 provided the change in utilization of apneic oxygenation during RSIs, thus reflecting the effectiveness of the quality improvement interventions.

Baseline and Post-intervention Observation Periods

We included cases in both periods if RSI was performed in the pediatric ED. We reviewed the patients' electronic case records, collected on standardized forms, and analyzed data regarding demographics, diagnosis, personnel performing intubation, use of apneic oxygenation, and hypoxic events.

Interventions

We formed a workgroup consisting of emergency physicians, residents, nurse clinicians, and staff nurses in November 2016. The workgroup identified factors contributing to the low utilization of apneic oxygenation

during RSIs (Fig. 1). Intubation is a rare but critical event in pediatric resuscitation—there is a low tolerance for any error during the intubation process. Therefore, the workgroup adopted a conservative approach of using simulation instead of real-life cases to assess and review the proposed interventions for the care bundle through a series of plan-do-study-act cycles from November 2016 to April 2017.

Cycle 1 evaluated using a pre-intubation checklist, incorporating the performance of apneic oxygenation into the responsibilities of the airway doctor and airway nurse, reinforcing documentation of the intubation process, as well as separate training sessions for doctors and nurses. The need for an additional oxygen source and reminder for rates of apneic oxygenation, the lack of clarity in responsibilities of airway doctor and airway nurse, the requirement for mandatory fields to document apneic oxygenation, as well as need for team training of doctors and nurses surfaced in cycle 1. These were addressed and subsequently evaluated in cycle 2 (see Supplemental Digital Content at <http://links.lww.com/PQ9/A157>).

These interventions were selected based on a balance between their potential impact and ease of implementation. This care bundle was shared with and supported by other code team representatives, in particular, the pediatric anesthetists. We implemented the care bundle in May 2017. Pediatric apneic oxygenation was achieved in our pediatric ED during RSI via nasal cannula at an oxygen flow rate of 5–15 L/min depending on the age of the patient (Table 1).

Following the implementation of the care bundle, we monitored the utilization of apneic oxygenation. Audits were conducted regularly, and the entire team received reminders if apneic oxygenation was missed during RSI. We also obtained feedback to troubleshoot any problems.

Statistical Methods

We performed statistical analysis using SPSS version 22 (SPSS, Chicago, IL). Categorical and continuous data were presented as frequencies with percentages and medians with interquartile ranges, respectively. Statistical differences between continuous variables of 2 independent groups were determined using the Mann-Whitney *U* test, with 0.05 as the level of significance.

Statistical process control methodology was used to monitor and determine if our quality improvement efforts resulted in an improvement in the utilization of apneic oxygenation over time. We identified special cause variations that were not inherent in our pre-intervention process by applying the Nelson rules with the aid of a control chart. A g-chart was used in our context to verify any improvement in the utilization of apneic oxygenation due to the low occurrences of RSI in the pediatric population. We tracked the number of RSIs between those without apneic oxygenation. A desirable outcome would be defined as an increase in the number of RSIs between those without apneic oxygenation, thus relating to a higher utilization rate of apneic oxygenation.

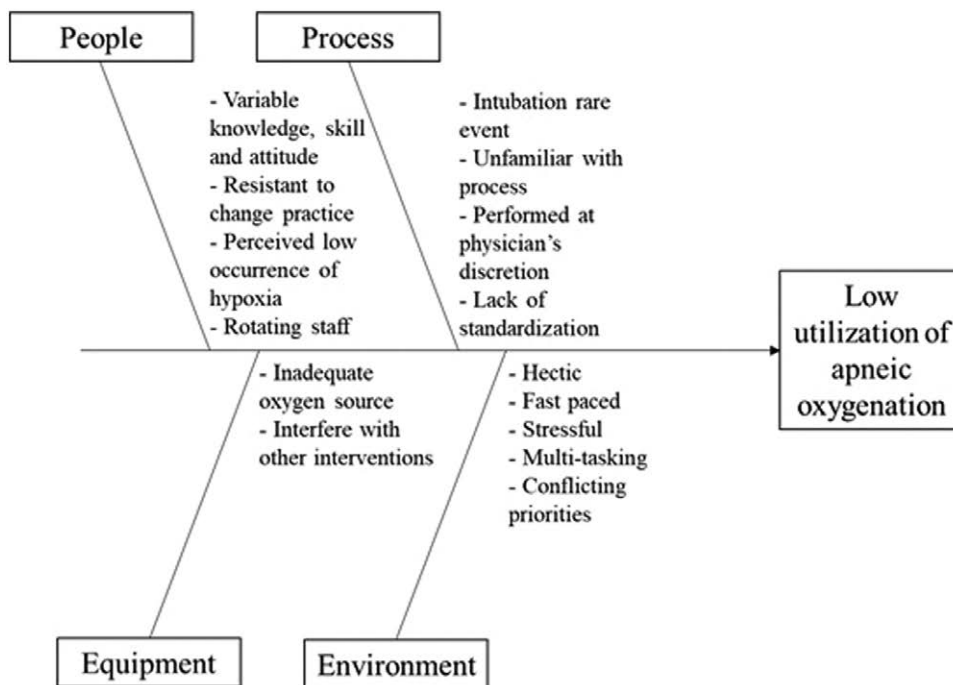


Fig. 1. Ishikawa diagram of factors contributing to low utilization of apneic oxygenation.

RESULTS

Table 2 shows the characteristics of the patients in the baseline and post-intervention observation periods.

In the baseline period, 22 (73.3%) RSIs were performed out of 30 emergency intubations. However, apneic oxygenation was not performed in any of these RSIs. There was 1 (4.5%) patient who desaturated during RSI. In the post-intervention observation period, 27 (79.4%) RSIs were performed in 34 emergency intubations. We excluded 2 patients in whom the attending team suspected the presence of basilar skull fracture as this would be a contra-indication for apneic oxygenation. Therefore, the utilization of apneic oxygenation occurred in 17 (68.0%) out of 25 RSIs. Among these, emergency physicians performed 14 (82.4%) RSIs with apneic oxygenation. Pediatric anesthesiologists performed the remaining 3 (17.6%) cases. No desaturation was documented with the use of apneic oxygenation.

Figure 2 showed the g-chart for this quality improvement initiative. In the baseline period, apneic oxygenation was not utilized in all 22 patients undergoing RSIs. Following the implementation of the care bundle, there was an increase in the number of RSIs with apneic oxygenation performed. The initial improvement was gradual, and apneic oxygenation was missed every 1–2 cases of RSI. However, with time, there was a marked

improvement, as evidenced by the less frequent occurrence of missed cases.

On further analysis of the post-intervention observation period, there was no significant difference in the utilization of apneic oxygenation among emergency physicians and pediatric anesthesiologists performing RSIs in the pediatric ED. The median for both groups was 100% ($P = 0.28$), indicating that apneic oxygenation was established as a routine standard of care for RSI performed within the department.

DISCUSSION

Although there was good evidence for utilizing apneic oxygenation during RSIs, we found that this evidence from the literature did not translate into actual clinical practice. Therefore, we developed and implemented a departmental quality improvement initiative that used a care bundle to bring about a sustained change in practice in which apneic oxygenation during RSIs became a routine standard of care.

The initial low and inconsistent use of apneic oxygenation by emergency physicians could be due to the unfamiliarity with the evidence for apneic oxygenation or knowledge of the technique, the low incidence of emergency intubations, the perception of a low incidence of intubation-related desaturation, as well as the need to multi-task and prioritize management issues during resuscitation.¹⁴ However, the barriers of translating evidence to clinical practice would be different in every ED. Therefore, a setting-specific needs assessment should be carried out before deciding on which interventions should be implemented for quality improvement.

Table 1. Flow Rates for Apneic Oxygenation

Age	Flow Rate (L/min)
<1 year old	5
1–10 years old	10
>10 years old	15

Table 2. Characteristics of Patients Undergoing RSI

	Pre-intervention Cohort (n = 22)	Post-intervention Cohort (n = 25*)	P
Age, n (%)			0.278
<1 year old	12 (54.5)	8 (32.0)	
1 to <8 year old	7 (31.8)	13 (52.0)	
≥8 year old	3 (13.6)	4 (16.0)	
Gender, n (%)			0.562
Males	12 (54.5)	16 (64.0)	
Females	10 (45.5)	9 (36.0)	
Diagnostic category, n (%)			0.602
Neurological	7 (31.8)	9 (36.0)	
Respiratory	3 (13.6)	6 (24.0)	
Infectious disease	7 (31.8)	5 (20.0)	
Trauma	4 (18.2)	3 (12.0)	
Cardiology	0 (0)	1 (4.0)	
Metabolic	0 (0)	1 (4.0)	
Endocrine	1 (4.6)	0 (0)	
Intubation performed by, n (%)			0.180
Pediatric emergency physician	14 (63.6)	21 (84.0)	
Anesthetist	8 (36.4)	4 (16.0)	

*Two patients were excluded due to concern of basilar skull fracture as this would be a contra-indication for apneic oxygenation.

Education to create awareness and change beliefs, training to equip staff with skills and procedure know-how, as well as frequent reminders and readily available references, were key elements when introducing new practices. However, the turnover of medical staff in the ED was high due to training rotations of the junior doctors. Therefore, there was a requirement for more frequent teaching sessions so that all doctors could be cognizant of and competent in this practice. Another way used to circumvent this issue was to incorporate apneic oxygenation into the roles of both airway doctor and airway nurse. This “copiloting” gave airway nurses the

autonomy to initiate and facilitate apneic oxygenation and would significantly reduce the cognitive load of the resuscitation team leader and airway doctor.¹⁵ Furthermore, this would help reduce noncompliance when the airway doctor was either a rotating or new physician who may be unfamiliar with apneic oxygenation or a physician (eg, anesthetist) who was not intrinsic to the department and may thus not be aware of departmental initiatives and processes.

Another important aspect that contributed to the success of the care bundle was the nature of apneic oxygenation. It is a safe and noninvasive procedure that can be performed at a minimal cost. The provision of an additional oxygen source required only minor modification to the existing setup of the resuscitation bay. The additional equipment used was already available in the department. This intervention removed the barriers of cost and training associated with the purchase of new equipment.

We decided to first evaluate the interventions in a simulated setting through a series of plan-do-study-act cycles before implementing them in the clinical setting, as emergency intubation was a rare event in the pediatric population. Simulation provided a safe environment that was both immersive and experiential.¹⁶ Thus, it was ideal and appropriate for recreating pediatric resuscitation scenarios involving RSI, which were infrequent and challenging for the ED team.¹⁷ The workgroup was able to examine the process of apneic oxygenation during RSI for the simulated cases. The initial simulation allowed the establishment of safer care as problems with the interventions could be identified and addressed before implementation. This approach kept the margin of error of our care bundle to a minimum, as pediatric intubation is a high-stakes event for critically ill children and their providers.

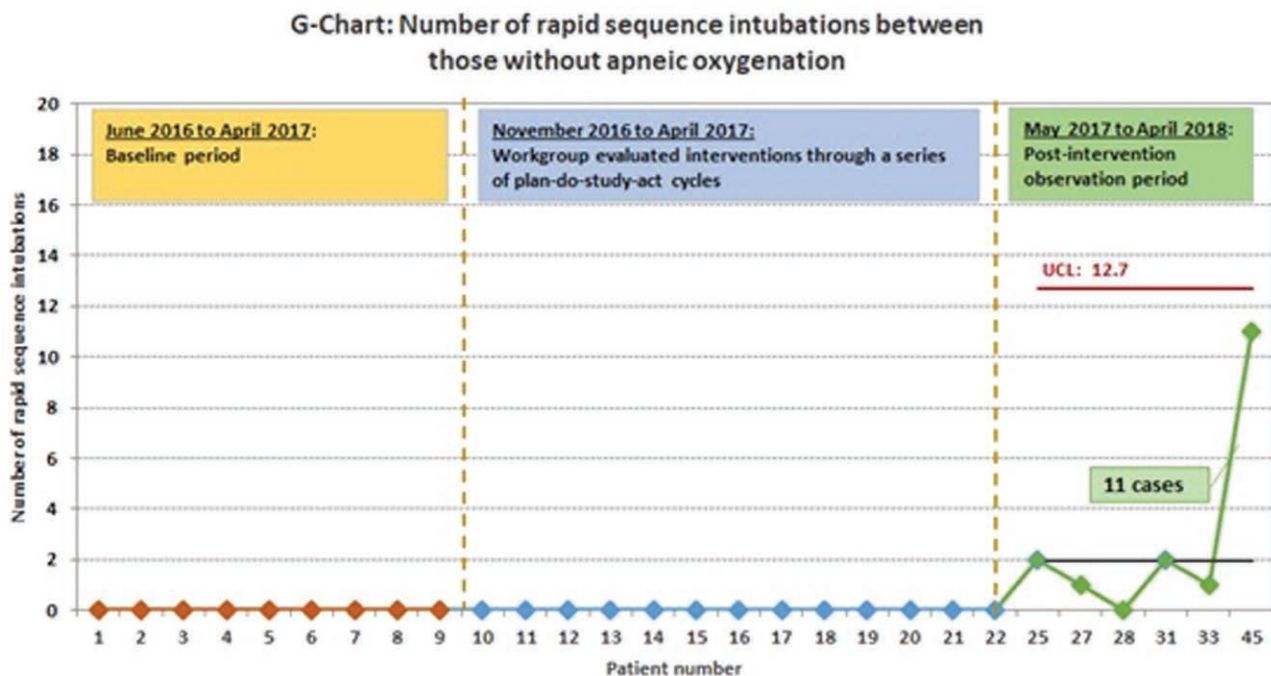


Fig. 2. G-chart for utilization of apneic oxygenation.

Finally, with the introduction of a new practice, documentation of the intubation process would require enhancement. Other than for capturing medical information in procedure documentation, this was also necessary to facilitate monitoring and audit to track the outcome and sustainability of the care bundle.

Limitations

Being a single-center study, our project to establish apneic oxygenation as a routine standard of care in our ED was largely based on specific interventions. The care bundle and its specific interventions may have limited applicability in other settings. Nonetheless, the general methodology described in this article would be useful and serve as a reference for EDs that are trying to promote the apneic oxygenation as a routine standard of care in RSIs for pediatric patients.

The low frequency of emergency intubations in our unit also limits the study of the clinical correlations of apneic oxygenation. As the study aimed to evaluate the use of apneic oxygenation and proposed a quality improvement initiative that would help EDs to incorporate apneic oxygenation as a routine standard of care during RSIs, we did not report on clinical correlations but focused on the practical application instead. The significant body of evidence supporting the use of apneic oxygenation allowed our work to focus on investigating the translation of evidence to clinical practice.^{18,19}

Lastly, the nature of each intervention was different and would affect a different amount of time to reach stability. For instance, putting up reminders and providing an additional oxygen source could be done much faster than educating and training of all medical and nursing staff. Also, we were unable to ascertain the compliance to and hence, the effectiveness of each intervention on the outcome of interest. Also, although we have grouped our interventions and implemented them under a care bundle. We should mention that not all the interventions were always required each time an RSI was performed. For instance, the pre-intubation checklist, “copiloting” of airway doctor and airway nurse, as well as enhanced documentation, were core components of the care bundle for performing apneic oxygenation during RSI. However, placing reminders and additional oxygen sources were one-time interventions, while education during airway workshop and simulation training were ongoing efforts made to help achieve our aim at quality improvement.

CONCLUSION

Apneic oxygenation is an effective strategy at preventing desaturation during RSI. However, there still exists a gap between this evidence from the literature to actual clinical practice. A care bundle consisting of using a checklist, placing reminders and additional oxygen source, “copiloting” by airway doctor and airway nurse, training of staff, as well as enhancing documentation could be

implemented as a quality improvement initiative in the ED to introduce, sustain, and establish this as a routine standard of practice to improve emergency airway management in critically ill children.

DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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