

Optimizing Rapid Sequence Intubation for Medical and Trauma Patients in the Pediatric Emergency Department

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Abstract

Introduction: Rapid sequence intubation (RSI) is a critical procedure for severely ill and injured patients presenting to the pediatric emergency department (PED). This procedure has a high risk of complications, and multiple attempts increase this risk. We aimed to increase successful intubation within two attempts, focusing on medical and trauma patients separately to identify improvement barriers for each group. **Methods:** A multifaceted intervention was implemented using quality improvement methods. The analysis included adherence to the standardized process, successful intubation within two attempts, and frequency of oxygen saturations <92% during laryngoscopy. Trauma and medical patients were analyzed separately as team composition differed for each. **Results:** This project began in February 2018, and we included 290 patients between April 2018 and December 2019. Adherence to the standardized process was sustained at 91% for medical patients and a baseline of 55% for trauma patients with a trend toward improvement. In May 2018, we observed and sustained special cause variations for medical patients' successful intubations within two attempts (77–89%). In September 2018, special cause variation was observed and sustained for the successful intubation of trauma patients within two attempts (89–96%). The frequency of oxygen saturation of <92% was 21% for medical patients; only one trauma patient experienced oxygen desaturation. **Conclusion:** Implementation of a standardized process significantly improved successful intubations within two attempts for medical and trauma patients. Trauma teams had more gradual adherence to the standardized process, which may be related to the relative infrequency of intubations and variable team composition. (*Pediatr Qual Saf* 2020;5:e353; doi: 10.1097/pq9.0000000000000353; Published online September 25, 2020.)

INTRODUCTION

Rapid sequence intubation (RSI) provides definitive airway management for severely ill and injured patients presenting to the pediatric emergency department (PED). This procedure includes sedating and paralyzing a child to protect the airway and manage respiratory distress. When done correctly, RSI in the PED saves lives. However, because these patients are already compromised, they are at risk of



further deterioration. Furthermore, the ED setting is inherently high risk because a quickly assembled team must manage the airway while providing simultaneous resuscitation efforts. Based on current literature, some investigators estimate that 16–61% of cases^{1–3} have complications including hypoxia and associated cardiac arrest.^{1–9}

Multiple intubation attempts increase complication and mortality risk^{6,10–15} with >2

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attempts being significantly more associated with severe hypoxia.¹⁶ Because coordination of numerous tasks is critical for successful intubation, previous quality improvement (QI) initiatives focused on system and team factors such as team member roles, equipment preparation, and optimizing patient oxygenation.^{2,3,5,6,8,17–19} Standardizing the approach to RSI in the ED is associated with reducing the attempt number and complication incidence.^{2,3,5,6,8,16} Specifically, checklist utilization and inclusion of a second-team leader as a co-pilot has prevented the loss of situational awareness and improved teamwork.⁶

At our institution, multiple root cause analyses (RCA) involving trauma patients revealed suboptimal teamwork, delayed recognition of esophageal intubations, and failed intubation attempts resulting in patient harm. In response, we developed an evidence-based, multi-discipline QI initiative to improve RSI in our PED. Team composition and patient characteristics differ for medical and trauma patients. Therefore, we analyzed these groups separately to determine improvement barriers for each group.

Because a standardized process utilizing a checklist and co-pilot approach generated improvement at a similar academic center,⁶ we hypothesized this model would yield similar results for our institution. Our specific aim was to increase successful intubation within two attempts for medical patients from 77% to 95% and for trauma patients from 89% to 95% by December 31, 2018, and sustain for 6 months.

METHODS

Context

Nationwide Children's Hospital (NCH) is an urban, tertiary care center in central Ohio serving 2.8 million children. The main campus ED cares for >80,000 patients per year in its 62-bed facility, making it one of the busiest EDs in the country. NCH is a level 1 pediatric trauma center, with approximately 600 trauma alerts annually. All intubations occur in dedicated critical care rooms equipped with continuous audio and video monitoring utilized for QI and peer review.

Team leadership differs for medical and trauma patients. A pediatric emergency medicine (PEM) attending is the team leader for medical patients and level II traumas. Surgery attendings or fellows serve as the team leader for the more severely injured level 1 trauma alert patients. ED staff performing intubations include emergency medicine residents, pediatrics residents, PEM fellows, PEM attendings, anesthesiology residents, anesthesiology fellows, anesthesiology attendings, or certified registered nurse anesthetists. Anesthesiology providers per institutional policy intubate all level 1 neurotrauma alerts; the most appropriate provider attempts other intubations for the given clinical situation. Overall, in any given year, 250–300 different providers may potentially perform intubation in the ED.

The population for this improvement work included medical and trauma patients who underwent RSI in our PED. “Crash” intubations, in which preintubation sedation and paralysis were precluded or contraindicated, were excluded as they did not meet the definition of RSI. We also excluded patients with known difficult airways requiring otolaryngologist expertise and newborns cared for by the neonatal intensive care team as they did not undergo a standard RSI procedure.

INTERVENTIONS

QI Team Formation

In February 2018, a multidisciplinary team assembled consisting of ED attendings and fellows, nurses, respiratory therapists, pharmacists, a pediatric resident, representatives from the trauma service, and anesthesiology. A formal QI project commenced following the Institute for Healthcare Improvement model.

RSI Checklist

Utilizing evidence-based literature and expert consensus, the QI team developed a standardized process using an RSI checklist (Fig. 1). One key aspect of our standardized RSI approach involves calling in a second attending or fellow level provider to assist with the intubation with the goal of one provider running the checklist while the other supervises the intubation.⁶ This co-pilot approach allows for the focus necessary with critical procedures without compromising team situational awareness.

Adherence to the checklist includes three important time intervals: 3 minutes of uninterrupted preoxygenation, a 45-second pause to allow the paralyzing medication to take effect, and limiting the duration of laryngoscopy to 45 seconds. Initially, we attached three separate timers to the clipboard holding the checklist so that preoxygenation, post-paralytic pause, and intubation duration could be monitored without resetting a timer. The timers proved cumbersome, so the process was adjusted instead to utilize a large digital clock in the room. This change proved beneficial as it encouraged the checklist physician to announce the time interval to the team to enhance team situational awareness.

The checklist dictates a change in approach for subsequent intubation attempts. The changes in approach are not standardized but may include: different size blades or endotracheal tubes, increased suctioning, or extraglottic manipulation. Trainees are allowed a second attempt as long as there is an identified element to change. Escalation from a trainee to a more experienced provider, and the number of attempts per provider, is at the discretion of the attending physician and is not standardized.

Education

The QI team educated all groups who care for these patients on elements of the checklist and incorporation into practice. Education efforts focused on the evidence

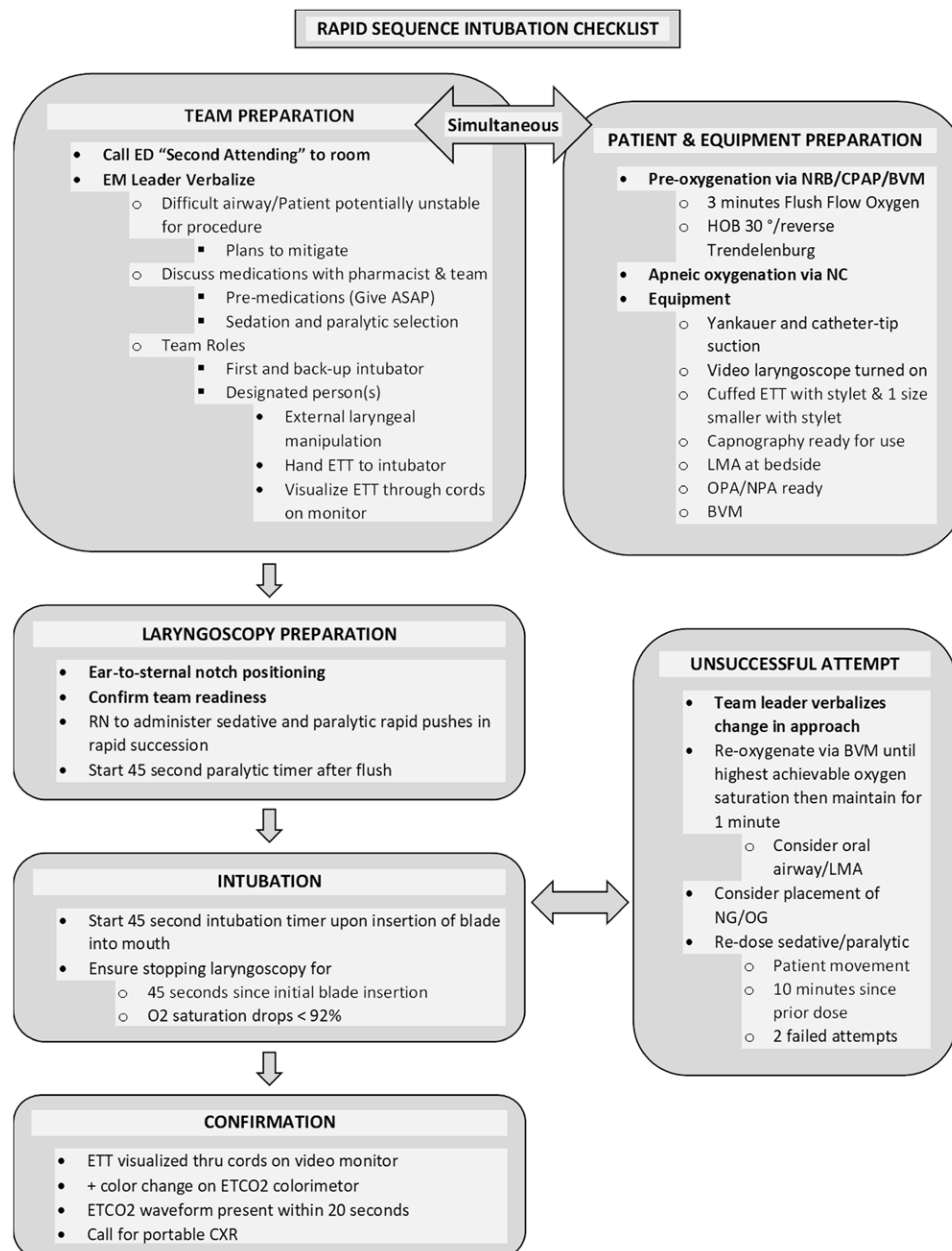


Fig. 1. Rapid sequence intubation checklist.

supporting the checklist to maximize team member understanding and adherence. Trauma surgeons initially had concerns that the standardized process would be unnecessarily time consuming and delay placement of the endotracheal tube. Education and experience with the standardized process gradually alleviated these concerns.

QI team members provided ongoing education at staff meetings for nurses, respiratory therapists, pharmacists, ED physicians, and trauma surgeons. The pediatric resident QI team member provided education at resident noon conferences. PEM attendings or PEM fellows provided education to emergency medicine residents immediately before the intubation procedure.

We also developed an online learning module based on the standardized process for ED physicians, surgeons, and anesthesiology providers who participate in trauma patient care. This module includes the designation of the ED attending/fellow as the airway team leader for trauma intubations with the specific role of facilitating the standardized process, even when the laryngoscopist is not an ED provider (eg, an anesthesiology provider).

Simulation

The checklist was tested via two simulations, followed by three small pilots using actual patients to ensure readiness for utilization on April 2, 2018. Two additional simulations, including PEM attendings and fellows, facilitated

rehearsal of the RSI process. The only significant change to the standardized process was utilizing a clock on the wall instead of the timers, as listed above.

Real-Time Documentation of Oxygen Saturations

Optimizing oxygenation and monitoring saturations is an essential part of the standardized process. However, oxygen saturation during laryngoscopy was initially challenging to determine when reviewing cases. Discussions with nurses revealed an opportunity to include oxygen saturation details as part of real-time documentation during the intubation. In November 2018, we modified our electronic health record (EHR) system (Epic Systems Corporation, Verona, WI) to prompt the documenting nurse to input the lowest oxygen saturation during laryngoscopy, thus enabling more reliable documentation of that process measure.

STUDY OF THE INTERVENTIONS

An automated daily EHR query for ED patients utilizing airway support identified potential patients. Manual screening of these records identified eligible patients intubated in our ED. Chart review of the 15 months before project initiation revealed the baseline frequency of successful intubations within two attempts for medical and trauma patients. After the QI initiative commenced, we used a combination of video and chart review to determine the completion of all data elements. When these methods could not obtain data, specific questions were sent to members of the care team. All data were entered into a secure Research Electronic Data Capture (RedCap)^{20,21} database.

MEASURES

Our primary outcome measure was successful intubation, defined as placement of the endotracheal tube into the trachea within two attempts. We defined an attempt as the laryngoscope blade passing beyond the teeth/gums, regardless of whether an effort to insert the endotracheal tube was made.

The NCH emergency department provides pediatric training for five residency programs, including four emergency medicine programs. The only pediatric airway management exposure for many of these residents occurs during their ED shifts at NCH. To continue to provide this critical educational experience, we selected two attempts as our goal because we did not want QI efforts to limit trainee intubation opportunities.

Because our primary intervention was the RSI checklist, a process measure included adherence to that standardized process. We considered RSI events compliant if a second provider was utilized to run the checklist. Each of the following six essential components was addressed: (a) team preparation, (b) patient and equipment preparation, (c) ensuring team and patient

readiness including a pause to allow the neuromuscular blocking medication to take effect, (d) monitoring duration of laryngoscopy and oxygen saturations during laryngoscopy, (e) confirming endotracheal tube placement, and (f) change in approach in the event of an unsuccessful attempt.

Frequency of desaturations <92% during laryngoscopy was selected as a process measure to determine the impact of the procedure on the patient's oxygenation status. The RSI checklist includes methods to optimize patient oxygenation and suggests aborting an attempt if saturations drop to 92%. We chose this cut-off because it is a threshold below which saturations drop precipitously,^{22,23} causing an increased risk for adverse events.

To ensure our interventions did not have unintended consequences, we evaluated the frequency of patients requiring anesthesiology for rescue intubation as a balancing measure.

ANALYSIS

Team leadership, team composition, indications for RSI, and the designated laryngoscopist differs for medical and trauma patients. Therefore, we looked at trauma and medical patients separately to better understand barriers to success for each group. Occasionally video footage could not be accessed, resulting in incomplete data not included in the analysis.

Statistical process control charts evaluated baseline data, outcome, and process measures. Special cause variation was determined following the American Society of Quality rules, using 10 out of 11 points above the centerline to signify a shift.²⁴

ETHICAL CONSIDERATIONS

Our institutional quality improvement guidelines determined this project to be non-human subject research. Therefore, review and approval by the institutional review board were not required.

RESULTS

Study Populations

The baseline population included 115 medical patients (median age 0.3 years) and 47 trauma patients (median age 2.5 years) intubated in the ED during the 15 months before project inception.

During the project period, April 2, 2018, through December 31, 2019, 334 patients were intubated in our ED. Thirty-five patients were excluded: 29 were crash intubations that did not utilize RSI, three were known difficult airways managed by the anesthesiology or otolaryngology teams, and three newborns were cared for by the neonatal intensive care team. The remaining 299 were included for analysis. There were 259 medical patients

and 40 trauma patients. The median age for medical patients was 1.1 years, and the median age for trauma patients was 4.0 years.

Laryngoscopists and Attempts

During the study period (not including the baseline), residents and PEM fellows performed the most attempts with 175 (38%) for each group. PEM attendings and anesthesiology providers performed 56 (12%) and 49 (11%) attempts, respectively. Details regarding the anesthesiology providers (resident, attending, CRNA) were not collected.

Successful intubations on the first attempt occurred in medical and trauma patients 62% and 85% of the time, respectively. Twenty-seven percent of medical patients required two intubation attempts; 5% of trauma patients had two attempts.

Process Measure for Primary Intervention

For the process measure of completed RSI checklist, the process stage mean for medical patients was sustained at 91% throughout the project (Fig. 2). This measure was initially 55% for trauma with a trend towards improvement approximately 14 months after initiation of the project (Fig. 3).

Outcome Measure

Special cause variation was first observed in May 2018 for successful intubations of medical patients within two attempts (77–89%), and this improvement was sustained (Fig. 4). Special cause variation was first observed in September 2018 for trauma patient successful intubation within two attempts (89–96%), and it also was sustained (Fig. 5).

Additional Process Measure and Balancing Measure

The process stage mean for oxygen desaturations was 21% for medical patients with no special cause variation. One trauma patient had oxygen desaturations in December 2018; none have occurred since that time. Escalation (change in approach that included more experienced laryngoscopist) occurred in 53 patients (18%) with 61 total episodes of escalation. Our balancing measure of not needing anesthesiology for rescue had a sustained baseline of 94% for medical patients and 93% for trauma patients throughout the project.

DISCUSSION

Interpretation

Before the initiation of this project, RCAs identified possible deficiencies in the RSI process for trauma patients. In response to these concerns, we implemented a standardized approach for RSI and included both medical and trauma patients to optimize safety for both populations. Interestingly, the baseline success rate for trauma patients was higher than the rate for medical patients. Our trauma patients are typically older (baseline median 2.5 years) than the medical patients (baseline median 0.3 years), and we believe this, in part, explains the higher baseline success rate. Infants are more challenging to intubate due to a smaller airway and larger head. They are more prone to complications because they have less physiologic reserve.²⁵ Furthermore, trauma patients are often electively intubated due to the anticipated need for airway protection without the confounding difficulties of respiratory disease. Medical patients with respiratory illnesses have increased secretions and decreased

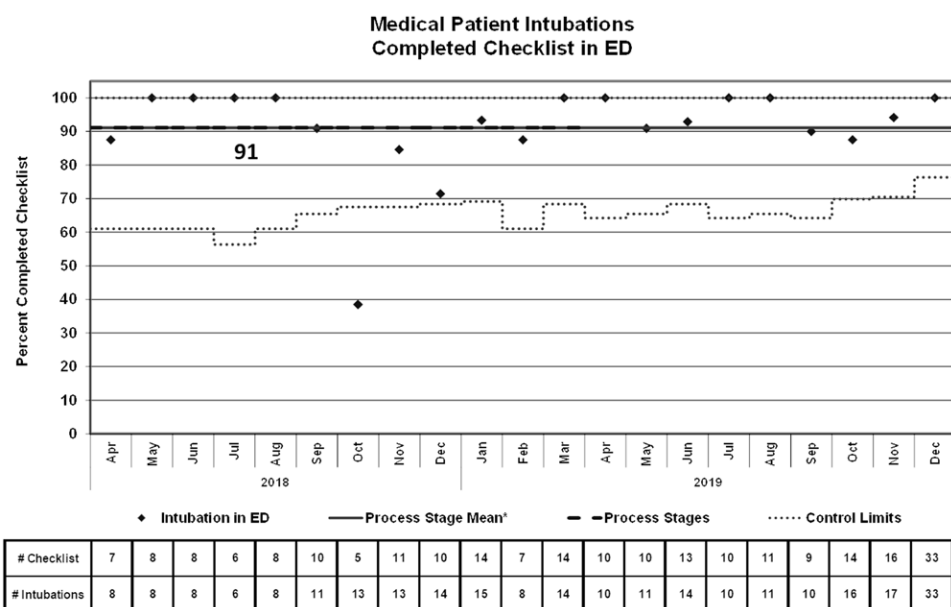


Fig. 2. Medical patient intubations completed checklist in ED.

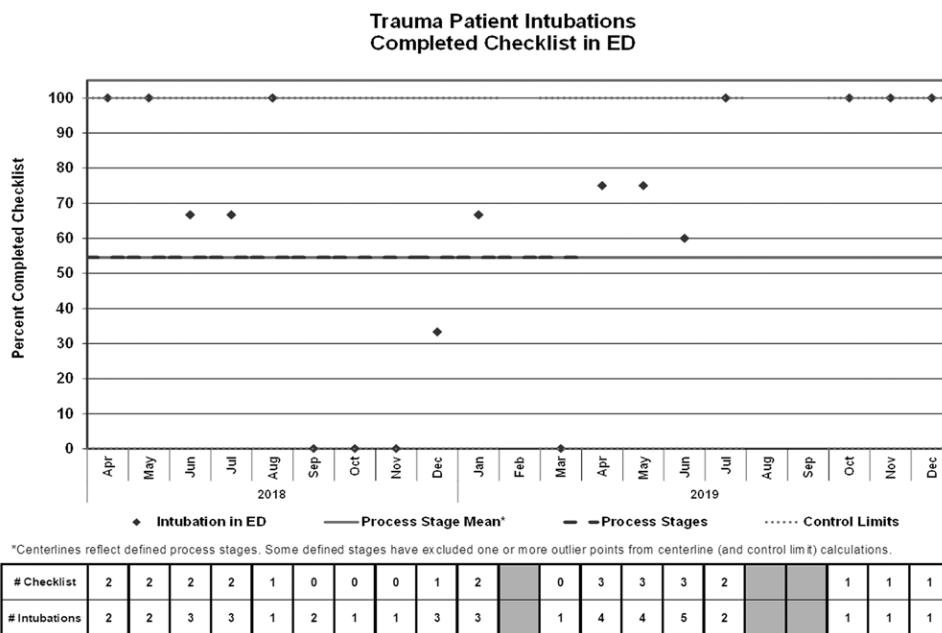


Fig. 3. Trauma Patient Intubations Completed Checklist in ED.

lung compliance that must be mitigated for successful intubation.²⁶

Trauma teams had a slower adaptation of the standardized process. Providers for trauma patients requiring intubation can include a surgery resident, fellow and attending, representatives from the anesthesiology service, and the ED resuscitation team. The attending surgeon or fellow can act as the team leader or share leadership responsibilities with the ED attending.

In contrast, medical teams are led by the ED attending. The team includes the ED resuscitation group, the only

variable being the addition of an anesthesiology provider for an anticipated challenging airway. Medical intubations occurred six times more often than trauma intubations allowing this relatively stable group of providers to more frequently practice the teamwork that is critical to intubation success. Given the complexity of trauma teams, variable team leadership, and the relative infrequency of intubations, it is not surprising that consistent use of the RSI checklist in trauma patients would take more time to achieve.

Our improvement to 89% and 96% of successful intubations within two attempts for medical and trauma

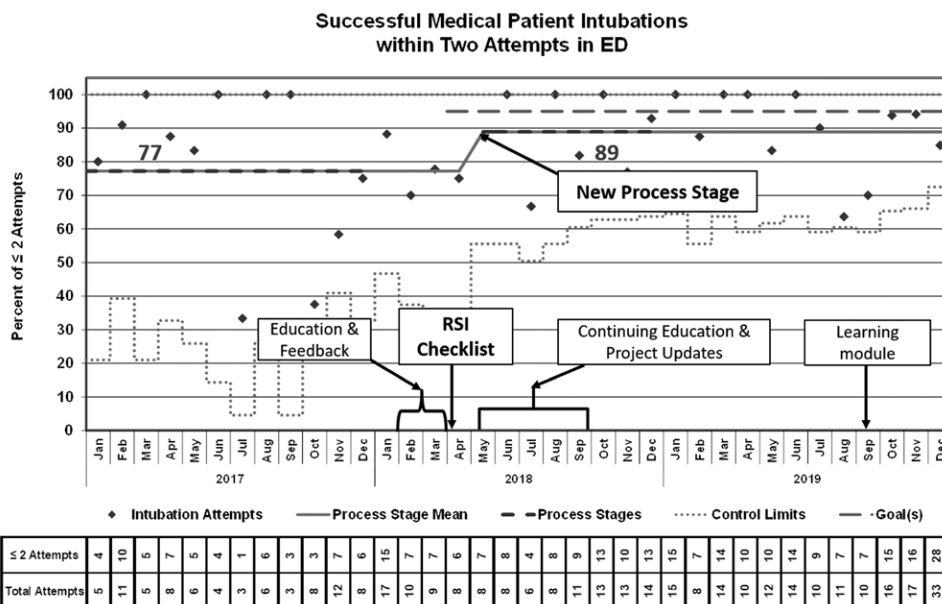


Fig. 4. Successful medical patient intubations within two attempts in ED. Arrows within the figure illustrate the timing of interventions.

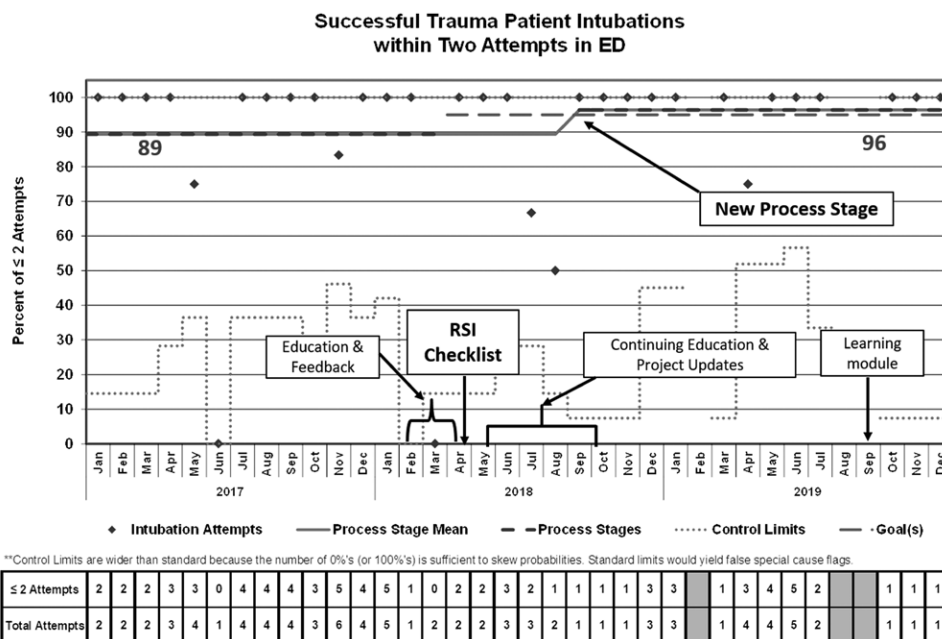


Fig. 5. Successful trauma patient intubations within two attempts in ED. Arrows within the figure illustrate the timing of interventions.

patients, respectively, are similar to reported rates of success in other settings. A similarly sized PED reports 85% of successful intubation within two attempts.²⁷ A multicenter pediatric intensive care unit (PICU) study had a rate of 84%.¹² Goto et al had an 88% rate of successful intubations within two attempts in an adult ED.²⁸ Kim et al revealed a 79% success rate within two attempts in a multicenter study of adult ED patients,²⁹ and Nishisaki et al revealed a rate of 86% in another multicenter study of PICUs.³⁰ Thus, our study fits within the broader literature and provides specific data on medical and trauma teams.

The ability to accurately determine oxygen saturations during laryngoscopy occurred seven months after the initiation of the standardized process. Our data show that oxygen desaturations remained stable for medical patients at 21%; we do not know if this represents an improvement from baseline. Compliance with the RSI checklist averts oxygen desaturation by robust preoxygenation, apneic oxygenation, and limiting duration of attempts. Our process measure evaluated oxygen desaturations *during* laryngoscopy to determine the intubation procedure’s immediate impact on the risk for hypoxia. We designated oxygen levels <92% as desaturations because of the known precipitous drop that occurs below this level.^{22,23} In other settings, Kerrey et al defined desaturation as <90% and decreased their defined desaturation rate from 33% to 16%.⁶ A multicenter study of 31 PICUs found 19% of all intubated patients to have moderately severe desaturations defined as <80%.³¹ Our relatively conservative definition of desaturation likely contributes to our slightly higher rate compared to other settings.

Limitations

This project was limited to a single center and may not be generalizable to other settings. However, our data fit within the broader literature. Our institution has robust quality improvement support, including more than 50 individuals dedicated to QI work. Other institutions without these resources may not be able to duplicate our work.

We achieved data collection through a combination of chart review, video review, and follow-up with individual providers. Missing data that persisted after these efforts were noted as “incomplete.” While previous studies demonstrated high-quality video review is more reliable than self-report,^{1,32} limited ability to abstract data from the video at our institution necessitated the use of chart review and self-reporting. Although many national studies use self-reporting,^{12,25,30} the ability to exclusively obtain data via video review would have been ideal. The adherence to the standardized process may not have been as robust as reported; however, the combination of data collection techniques likely mitigated this limitation.

The median ages were lower for baseline medical and trauma patients compared to study patients. This difference may be related to the retrospective nature of obtaining the baseline data. Young age is a known risk factor for multiple attempts and complications associated with RSI. Therefore, our improvement compared to baseline may be impacted by the difference in age and not completely related to improvement efforts.

The next steps include strengthening trauma team adherence to the standardized process through simulation and case review. Further investigation into techniques to

optimize intubation success and reduce oxygen desaturations will be valuable for medical teams.

CONCLUSIONS

We modified a published RSI checklist⁶ to increase the number of successful intubations within two attempts at our institution. This outcome was a composite of multiple key processes, and a high bar for compliance indicates the relative strength of the work. Medical teams adhered more consistently to the standardized process and showed improvement that was sustained throughout the project. Trauma teams had a higher baseline success rate, slower adoption of the standardized process, with improved success over time. Variability in team composition and leadership may have impacted adherence rates for trauma teams. We feel that adherence to a standardized process in the context of this variability is associated with increased RSI success.

DISCLOSURE

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

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