Individual QI projects from single institutions

Decreasing Time from Decision to Intubation in Premedicated Neonates: A Quality Improvement Initiative

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ABSTRACT

Introduction: Endotracheal intubation carries the risk of discomfort, decompensation, oral trauma, and endotracheal tube malposition. Treatment with premedications reduces complications, increases overall intubation safety, improves pain control, and improves first-pass success. However, time is frequently a barrier to administration. We aimed to decrease the decision-to-intubation time interval from a baseline of 40 minutes to less than 35 minutes over 6 months. **Methods:** We used the Model for Improvement with multiple plan–do–study–act cycles to reduce the time from decision to successful intubation in nonemergent neonatal intubations. Key drivers were timely administration of medications, availability of skilled personnel and equipment, and efficient use of time. **Results:** During this project, time from the decision to successful intubation decreased from a historical mean of 40 minutes to a new baseline of 27 minutes. This change represents a 33% decrease, with 80% of intubations occurring within 35 minutes. During this time, success rates remained stable, and medication errors and side effects did not increase. **Conclusions:** Standard processes to prepare and administer premedications decreased the time from decision to intubation without significant adverse effects, allowing the benefit of premedication administration in a safe and timely manner in nonemergent neonatal intubations. *(Pediatr Qual Saf 2019;4:e234; doi: 10.1097/pq9.0000000000000234; Published online November 12, 2019.)*

INTRODUCTION

Patients in the neonatal intensive care unit (NICU) frequently require intubation and

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mechanical ventilation as a treatment for respiratory failure. Traditionally, this procedure was performed without premedication in neonates. Over the past decade, many NICUs have adopted policies of premedication for nonemergent intubation, including adequate sedation, pain control, and muscle relaxation,[1–3] to increase the success of first-pass intubation while reducing complications and procedure duration.[4,5] Additionally, intubation is a distressing and painful procedure with the potential for airway injury, physiologic derangement, and destabilization of the patient.[6–8] To mitigate the side effects and decrease the risks, the American Academy of Pediatrics recommends the use of premedications for all intubations outside of life-threatening situations.[4]

Multiple studies have shown a reduction in physiologic derangements with intubation[9,10] as well as a reduction in the number of intubation attempts with premedication.[11–14] Several studies have evaluated varying regimens, and this area does require further study.[3,10,11,15–17] Many centers have standardized guidelines within their institutions to provide premedication.[2,16,18,19] Current recommendations include the use of analgesia along with consideration of a vagolytic agent and muscle relaxant.[4]

At this institution, premedication includes the use of atropine, fentanyl, and rocuronium. The clinician decides whether or not to administer premedication based on the urgency of the intubation and the stability of the patient.

Baseline data showed an average of 40 minutes (median 44 minutes) to complete the process from the decision to intubation when using premedications, based on data collected over 5 months (N = 45). In 1 published study that measured this time interval as a balancing measure, the authors found median times of 27 and 33 minutes (pre- and postintervention), which is about 20% lower than the baseline at this institution.[18]

In addition to physicians, the process of intubation involves many different caregivers, including respiratory therapists, nurses, nurse practitioners, and pharmacists. Given that the process is very efficient in emergent situations without the use of premedications, we focused on interventions for medication preparation and administration. This project aimed to decrease the decision-to-intubation time by 20% from the original median of 44 to 35 minutes over 6 months.

By increasing the efficiency of this process, the global aim included the provision of prompt respiratory support to infants in distress, ultimately improving intubation safety in this NICU. In the present study, we provide interventions and practical strategies for implementing a premedication protocol for intubation.

METHODS

Human Subjects Protection
This quality improvement project was reviewed by the University Hospitals Institutional Review Board, which determined that this project did not qualify as human subjects research.

Setting
We conducted this quality improvement project in an 82-bed level IV academic NICU, with approximately 1,200 annual admissions. The project included neonates requiring nonemergent intubations using premedications. We excluded delivery room intubations, emergent intubations without the use of premedications, and situations outside the normal protocol for our unit. We perform approximately 15 premedicated intubations per month in the NICU, including intubations performed solely for surfactant administration. Pediatric residents, neonatal–perinatal medicine fellows, and neonatal nurse practitioners performed most intubations. The majority of intubations are performed for respiratory distress or failure described as hypercarbia, hypoxia, or increased work of breathing. Other indications for intubation include surfactant administration, apnea, pulmonary hypertension, unplanned extubations, tube exchanges, or before procedures. This institution implemented a premedication protocol for nonemergent intubation 4 years before the start of this project, which included the use of atropine, fentanyl, and rocuronium. At that time, the team implemented certain interventions to aid in administration, including a medication kit, dosing worksheet, and data collection forms. The medication kit is stored in the automated medication dispensing cabinet and includes original vials of atropine, rocuronium, and naloxone and diluted fentanyl syringes. Nurses obtain and draw up medications directly from the kit at the bedside, and orders are signed off in the electronic medical record (EMR) after the procedure. At the initiation of this project, the vast majority of intubations in our unit were premedicated with all 3 medications.

Planning the Interventions
We used the Model for Improvement framework for this improvement initiative. We assembled a multidisciplinary team with representatives from nursing, pharmacy, respiratory therapy, physicians, and nurse practitioners. We collected baseline data over 5 months with bedside recording of the timing of the decision and the intubation success. After that time, we studied the overall intubation process, mapped the process (Fig. 1), and identified possible drivers for change and interventions (Fig. 2). Plan–do–study–act cycles were used for continual evaluation of the effects of interventions. After collection of baseline data, we noted several deficiencies in the form. It was incrementally revised to include the timing of each step of the intubation process, duration of intubation attempts, and a detailed checklist for complications and side effects.

Another area to address was the efficient use of time by all team members. The team implemented a role sheet and a corresponding diagram for use during intubation (Fig. 3). After a trial of several methods, the form was adopted and placed in the intubation medication kit with the data collection form.

Nurses play a key role in medication preparation and administration. Before this project, the bedside nurse would locate another nurse for assistance and then calculate and prepare the medications. This act is extremely important to avoid medication errors that may result in harm to the patient. We transitioned this task to the charge nurse, who would also be familiar with the assignments of nurses in the vicinity of the patient undergoing intubation.

We felt that the majority of time was spent in medication preparation and administration. Therefore, several interventions focused on this process. After the start of improvement efforts, data were collected on the timing of the entire intubation process. Due to concern for the development of chest wall rigidity, the prior practice had been the administration of fentanyl with a medication pump over 2 minutes, followed by a 2-minute flush. Because all patients receive rocuronium directly after fentanyl, which treats chest wall rigidity, the process was changed to administer fentanyl over 30 seconds and eliminate the medication pump. This change required significant educational efforts to ensure safety. First, we focused on chest wall rigidity symptoms and treatment, including the administration of either naloxone or paralytic medication. Second, we emphasized that this should only be done when fentanyl is given as part of the intubation process followed by rocuronium, and not in any cases where fentanyl is given as an individual medication. Providers
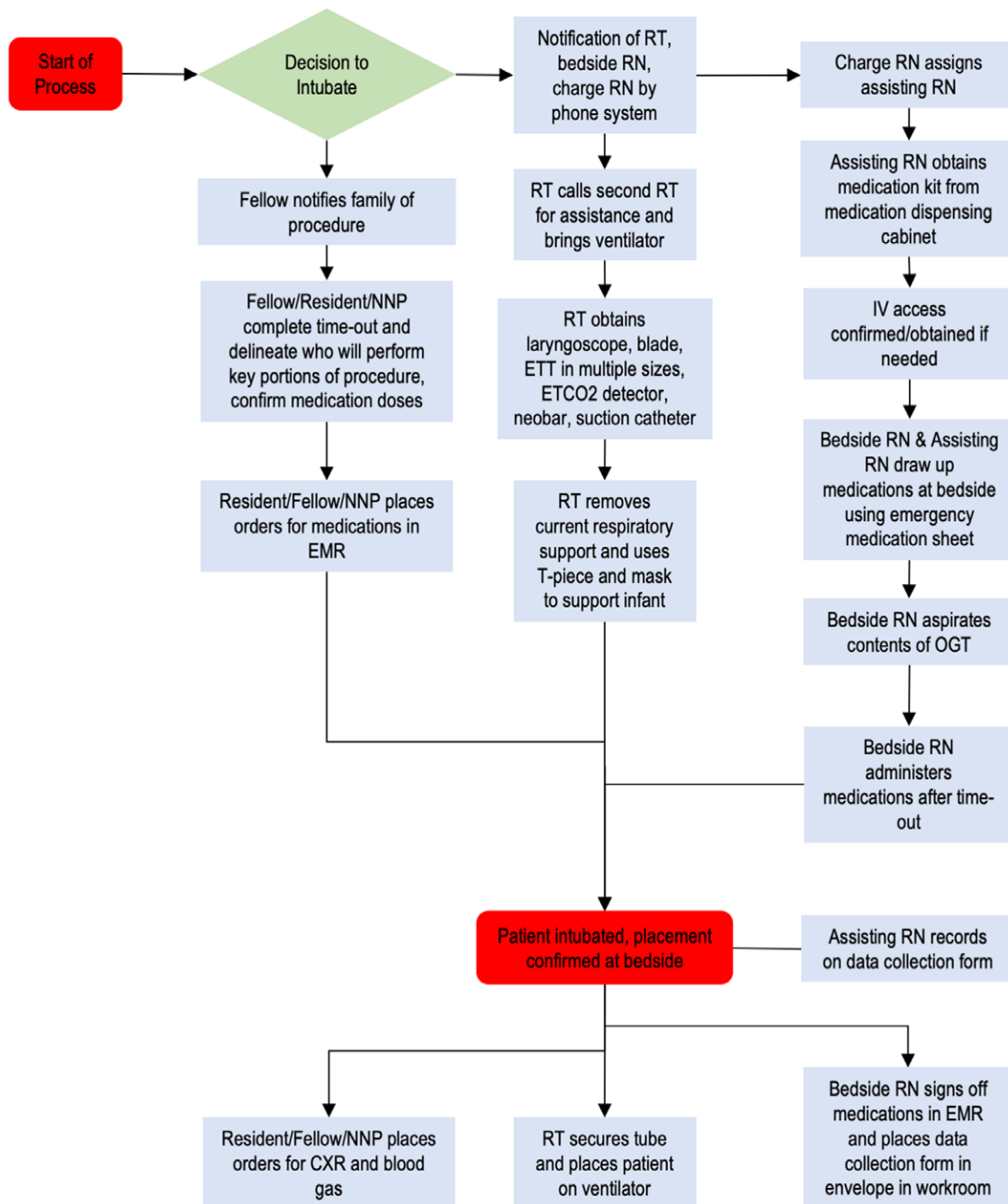
Fig. 1. Intubation process map. CXR indicates chest x-ray; ETT, endotracheal tube; ETCO$_2$, end-tidal carbon dioxide; IV, intravenous; NNP, neonatal nurse practitioner; OGT, orogastric tube; RN, registered nurse; RT, respiratory therapist.

were instructed to push the fentanyl over 30 seconds, followed by a flush over 30 seconds, then push rocuronium directly after ensuring adequate sedation. If there was a concern for chest wall rigidity at any point, rocuronium was to be administered immediately. If there was a concern with giving rocuronium, then naloxone was to be administered. The improvement team closely monitored this practice change and reviewed all possible cases of chest wall rigidity.

Previous practice had included a range of acceptable doses for premedication. After several trials, we modified the medication process to include standard doses. We placed these doses in the existing code medication sheets. Doses were calculated on admission for all patients and updated weekly. Initially, the doses were 0.02 mg/kg atropine, 2 µg/kg fentanyl, and 0.6 mg/kg rocuronium, based on what the majority of patients were receiving at the start of the project. As the project progressed, the fentanyl and rocuronium doses were adjusted due to the frequent need for repeated doses to achieve adequate sedation and paralysis. We increased fentanyl to 4-µg/kg initial dose for patients greater than
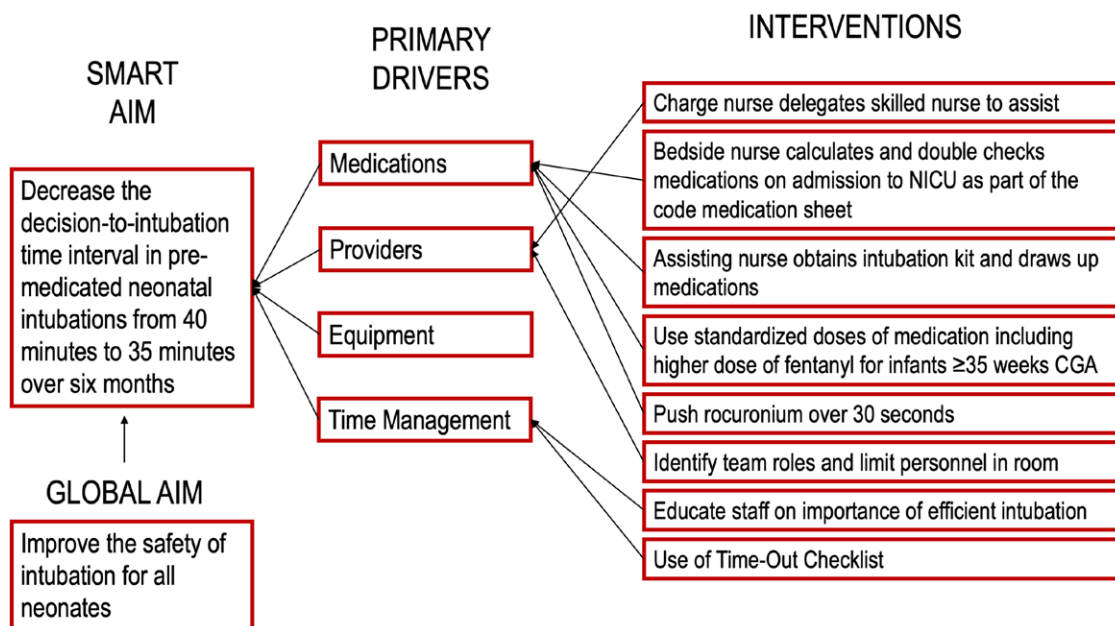
Fig. 2. Key driver diagram. CGA indicates corrected gestational age.

35 weeks corrected gestational age and rocuronium to 1 mg/kg for all patients.

To keep team members focused on the intubation and to delineate roles further, we implemented an intubation time-out, modified from a quality improvement project focused on improving patient safety during intubation (Fig. 3).[18]

This addition allowed for the review of each person's role and the patient's pertinent medical history before intubation, to ensure thoughtful use of medications.

Due to delays in notifying all members of the care team, a "NICU Intubation Team" was created and identified by a group on the communication system. At the time of

Fig. 3. Role sheet and time-out checklist. Modified from time-out checklist published by Hatch et al.[18] BPM indicates beats per minute; CHD, congenital heart disease; PEEP, positive end-expiratory pressure; ENT, ear, nose, and throat; $ETCO_2$, end-tidal carbon dioxide; GI, gastrointestinal; LMA, laryngeal mask airway; NNP, neonatal nurse practitioner; OGT, orogastric tube; PIP, peak inspiratory pressure; RN, registered nurse; RT, respiratory therapist.

the decision to intubate, the fellow or nurse practitioner can notify the whole group simultaneously. The group included neonatal fellows, nurse practitioners, respiratory therapists, and charge nurses. We ultimately abandoned this practice as members of the care team preferred thoughtful discussion about the need for intubation based on the clinical situation and a team-based decision.

Evaluation and Analysis

The primary outcome measure identified for assessing the impact of interventions was time from decision to intubation. The bedside team determined the time of the decision and recorded it on the data collection form. Most frequently, this time was based either on the time of a blood gas result, a conversation with an attending physician, or the decision at the bedside based on clinical appearance. The recorder noted the time of medication administration, first attempt, and final attempt during the intubation. The time from decision to final successful intubation attempt determined the time from decision to intubation. We used X-bar and S statistical process control charts to measure the mean time and standard deviation, respectively.

Additionally, P-charts were utilized to monitor the percentage of intubations performed in less than 35 minutes, based on the initial aim. Data were grouped by month. Due to the small number of baseline data points, an XBarR chart was created post hoc with data grouped semimonthly. This chart allowed for a closer examination of the baseline data period and the start of the improvement.

We monitored secondary outcomes for global aims of improving the safety of intubation and reducing the number of attempts. These outcomes included the number of attempts and rates of complications related to intubation, such as desaturation, bradycardia, cardiovascular decompensation, and airway trauma.

Process measures were monitored throughout the project and adjusted as the project continued. Initially, they included the presence of the assisting nurse at the bedside and the use of the revised medication sheet. Subsequently, additional measures included completion of the intubation time-out, notification of the NICU intubation team, and duration of each intubation attempt.

Balancing measures defined at the start of the project included medication errors, adverse effects of medications, and chest wall rigidity related to opioid administration. These measures were identified by the team at the bedside at the time of intubation and noted on the data evaluation form. We defined chest wall rigidity as desaturation and difficulty with bag-mask ventilation after administration of fentanyl that reversed with rocuronium administration. Desaturation and difficulty with bag-mask ventilation alone were not classified as chest wall rigidity.

We monitored these measures monthly and presented results to the division of neonatology every 6 months. Evaluation forms with data from each intubation were collected and correlated with the procedure note in the EMR, and any discrepancies were discussed with the fellow listed on the form. Due to discrepancies between the EMR documentation and data collection forms, the fellows were required to review and sign the form after the intubation.

Statistical process control charts were used to establish a mean centerline and control limits. Standard health care industry criteria were used to distinguish common cause variation from special cause variation.[20] We performed descriptive statistics using Microsoft Excel 2013 (Microsoft, Redmond, WA). Statistical process control charts were created using QI Macros 2018.04 (KnowWare International, Denver, CO). Study data were collected and managed using Research Electronic Data Capture Tools hosted at University Hospitals.[21]

RESULTS

Baseline data were collected between March 2016 and July 2016 and used solely to establish the time of the decision to intubation. During this quality improvement project, we collected data on 312 intubations from August 2016 to March 2018.

When data were plotted on an XBarS chart grouped by month, the initial baseline mean time was 40 minutes. A new baseline was established with special cause variation starting in August 2016 with 8 points below the previous mean, with a subsequent shift to 27 minutes (Fig. 4). We maintained this new baseline through March 2018. We also noted special cause variation on a p-chart with the percentage of intubations completed in less than 35 minutes starting at a mean of 38% with resulting in a shift in the mean to 79% of intubations completed in less than 35 minutes (Fig. 5). An XBarR chart was created post hoc with data grouped semimonthly to evaluate the baseline data. This chart includes data through June 2018 and shows a shift from 44 minutes at baseline to 27 minutes (Fig. 6). Median time from decision to administration of medications was 15 minutes, from the administration of medications to the first attempt was 5 minutes, and from the first attempt to the final successful attempt was 2 minutes.

A new checklist was implemented for monitoring of complications starting in January 2017, after which 39% of intubations were noted to have 1 or more complications. The most common complication was oxygen desaturation to less than 60%, which occurred in 38% of intubations. One of the balancing measures was chest wall rigidity due to the rapid push of fentanyl, which is not standard practice for fentanyl administration. There was 1 documented case of chest wall rigidity in 238 intubations after the implementation of the checkboxes for complications. No patients received naloxone for the treatment of chest wall rigidity. Other balancing measures included medication errors and adverse effects of medications. Other than the complications above, there were no
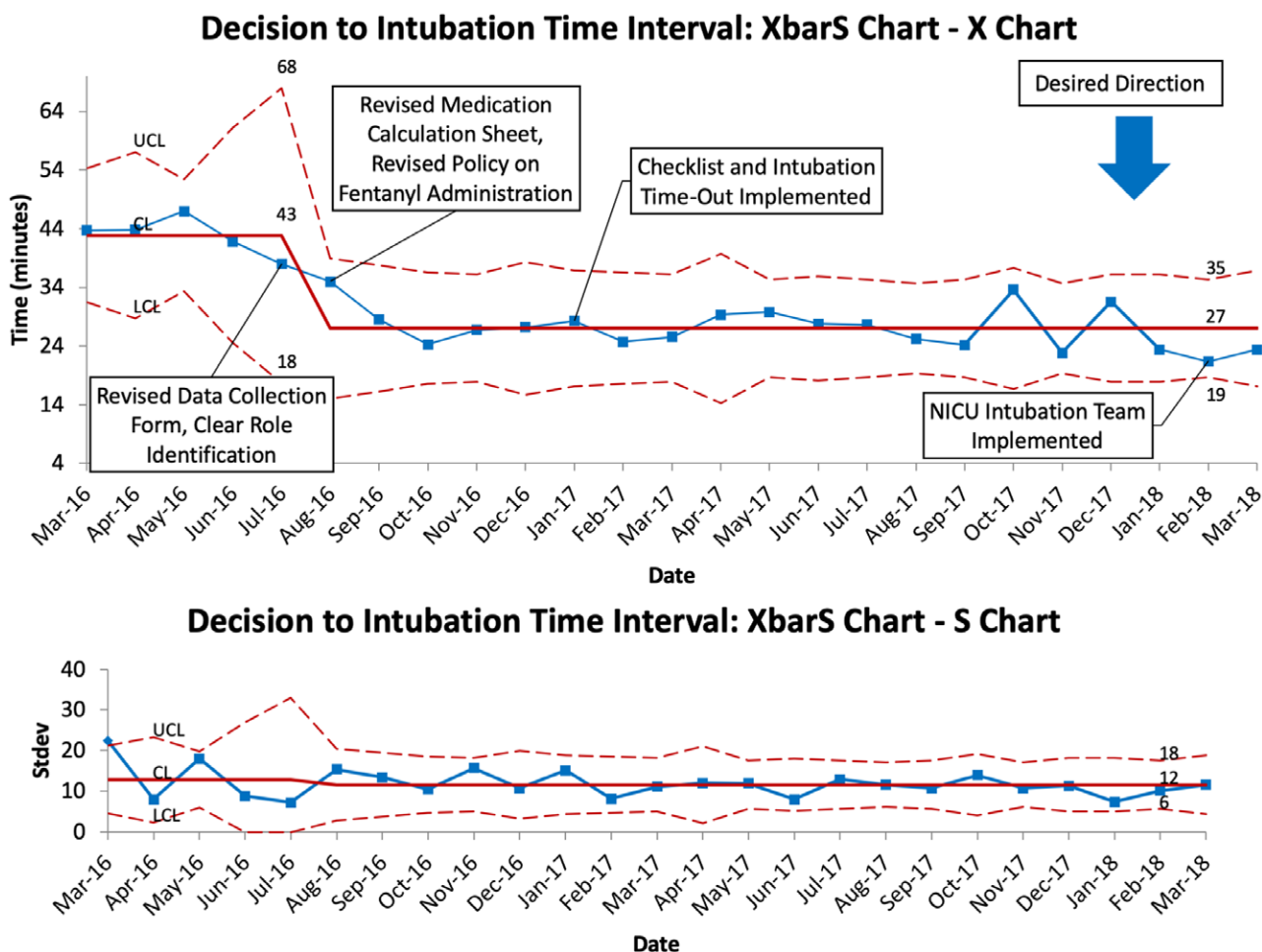
Fig. 4. XbarS Chart: decision-to-intubation time interval. Special cause criteria were met with 8 points below the centerline starting in August 2016 after clear role identification, revision of medication calculation sheet, and revision of policy on fentanyl administration.

specific adverse effects of medications and no medication errors since the start of the project.

We monitored the number of attempts per intubation throughout the project. The total number of attempts was recorded and on average, remained at 2 per intubation throughout the project, with a total of 612 attempts for 312 intubations.

Process Measures
There was good compliance with the presence of an assisting nurse or charge nurse with 93% of intubations having either charge nurse or assisting nurse present based on a box checked on the evaluation form. There was 100% compliance with the use of the revised intubation medication sheet completed during the admission after the integration of this form into the admission packet. The intubation time-out was completed 87% of the time after implementation. The NICU Intubation Team broadcast was performed about 60% of the time. The most common reason for not broadcasting was that all team members were already aware at the start of the procedure, or it was a planned procedure such as a tube exchange. We ultimately abandoned this practice in May 2018, as it did

not decrease time, and it was not thought to be helpful by the clinical team.

Data for the timing of the decision to intubate were available for 294 of 312 total intubations after implementation of the new data collection sheet. We excluded data for situations where the provider could not accurately estimate when the time of decision had taken place and situations which were outside the normal protocol. These additional exclusions included intubations requiring coordination with other subspecialties such as otolaryngology; the need to complete another procedure before proceeding with intubation; or emergent situations where medications were not administered. The return rate of data collection forms was estimated based on orders placed for rocuronium in the EMR because this medication is almost exclusively ordered for intubation. We collated data for two 3-month periods at the start and end of the project. The overall return rate was 94%.

DISCUSSION
The specific aim of this project was to decrease the time from decision to successful intubation to 35 minutes. We noted a
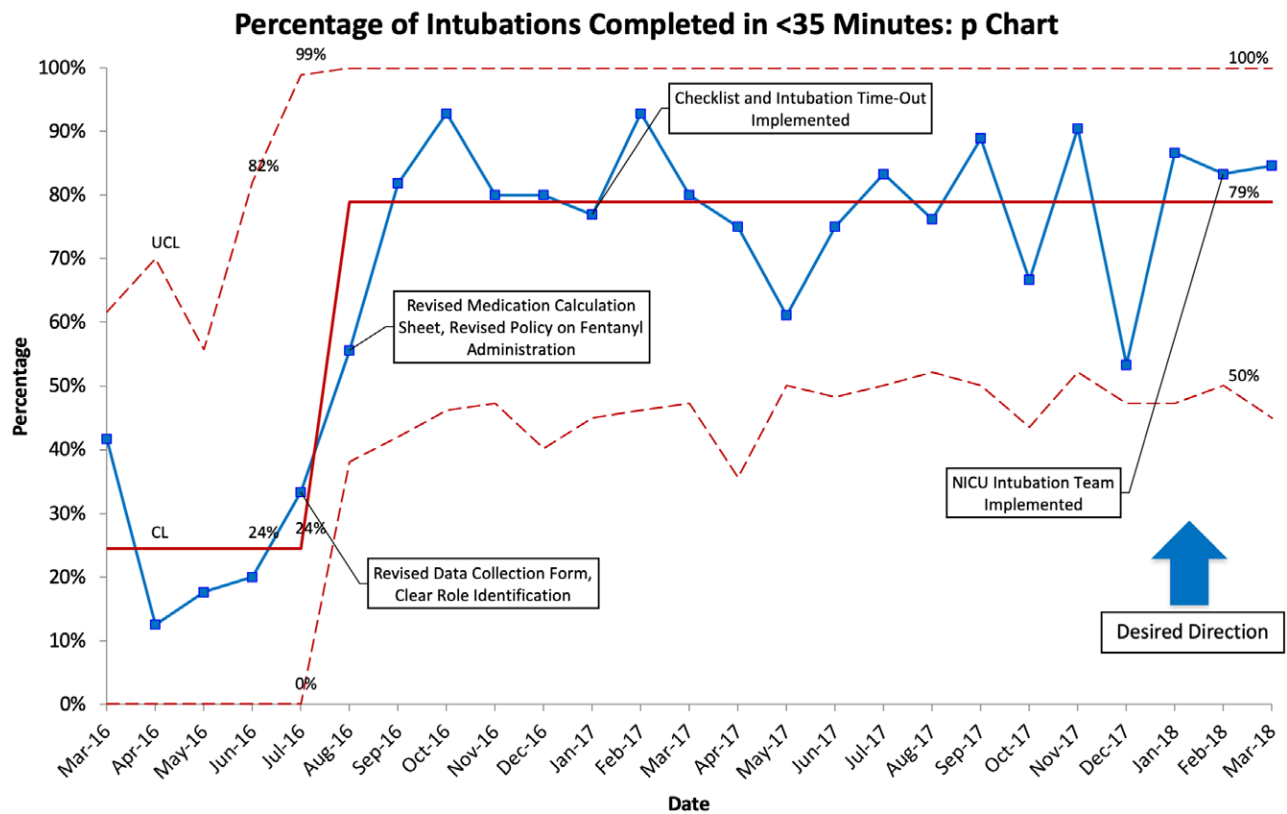
Fig. 5. P-chart: percentage of intubations completed in <35 minutes. Special cause criteria were met with 8 points below the centerline starting in August 2016 after clear role identification, revision of medication calculation sheet, and revision of policy on fentanyl administration.

decrease to 27 minutes, with approximately 80% completed within the goal time frame of 35 minutes. Additionally, there were no increased complications, adverse medication effects, or medication errors during this project. One of the strengths of this project is the demonstration that the process of premedication administration can be performed quickly, providing the benefit of these medications for nearly all nonemergent intubations in the NICU. One observation noted by NICU staff and the improvement team was an increase in the use of premedications for urgent reintubations following unplanned extubation. Although we do not have data to quantify this practice, we observed that in the past, premedications were rarely used in these situations. After the implementation of this project, we recognized that if the patient could undergo successful bag-mask ventilation with stable vital signs, medications could be prepared and administered in a timely fashion.

Our statistical process control chart demonstrates substantially decreased time from the decision to successful intubation. The intervention that appeared to have the most impact was standardization of the premedication protocol in the NICU with integration into the code medication sheet. Additionally, elimination of the medication pump for fentanyl administration reduced time and was safe in this sample of patients with planned administration of rocuronium. Due to the side effect of chest wall rigidity, this should be implemented only with careful monitoring of side effects along with education about the symptoms and

treatment of chest wall rigidity before implementation. The role diagram helped to streamline roles for all providers involved in intubation, and the time-out checklist[18] helped to focus the team, review the premedication plan, and highlight any significant medical history for the patient before the procedure. These interventions did not impact our primary outcome measure but did receive positive feedback as an overall improvement to the intubation process. Adding data points regarding timing to the data collection form increased awareness of the project, and measurement alone may have served to have some effect on decreasing the time before the start of other interventions.

Our timing is now consistent with 1 published study in which the authors aimed to improve patient safety during intubation. Time from the decision to intubation was a balancing measure in that study and was 27 minutes pre intervention and 33 minutes post intervention.[18] There are no other standards for the optimal expected time from decision to intubation, and ultimately, the patient's stability is the deciding factor in how quickly to act and whether or not to provide premedication. The American Academy of Pediatrics recommends that intubations happen as expeditiously as possible in as controlled of an environment as possible.[4] As a result of these interventions, the system for intubation with premedication in this NICU has become more streamlined for all providers involved.

There are several limitations to this study. There were no data available on time of decision before the
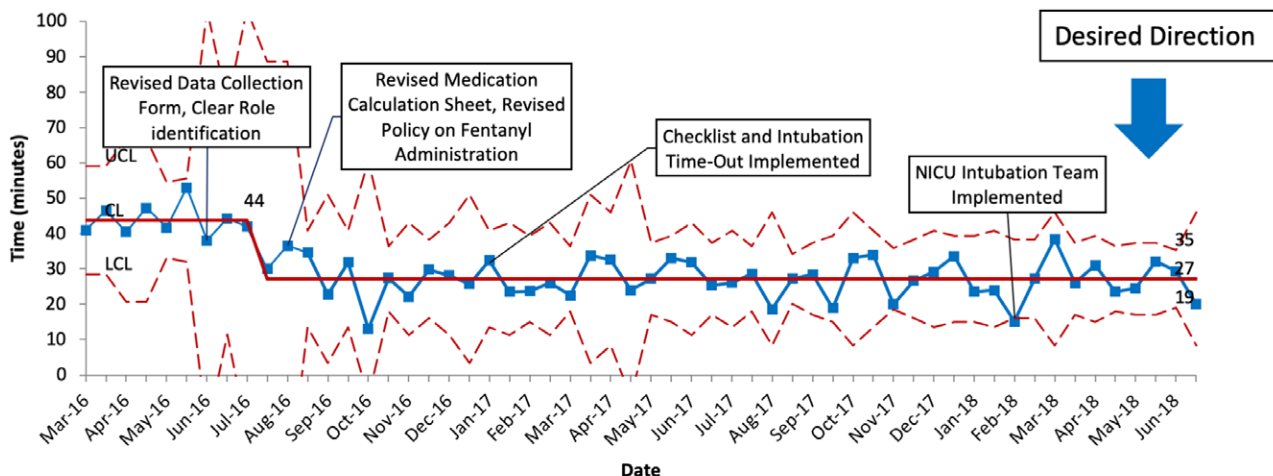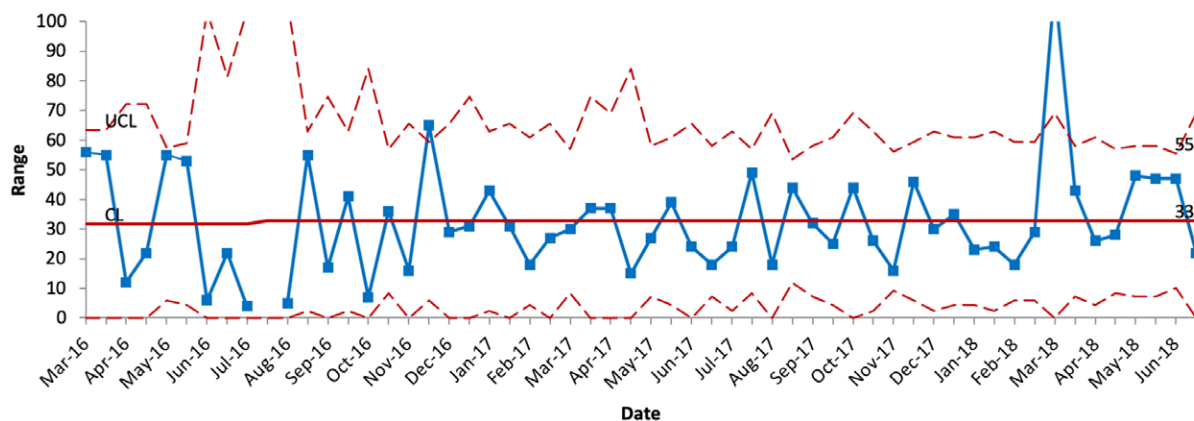
Fig. 6. XBarR chart: decision-to-intubation time interval. Special cause criteria were met with 8 points below the centerline starting in August 2016 after clear role identification, revision of medication calculation sheet, and revision of policy on fentanyl administration.

implementation of the premedication protocol. Most likely, the time from the decision to successful intubation was shorter, given that preparing medications takes time. Additionally, the premedication protocol was well established at the time of project initiation, and therefore, the need to improve the process was unrelated to timing before the implementation of a premedication protocol. Another limitation includes the accuracy of data for the time of the decision. We based these data on reports from the fellow and bedside nurse at the time of the intubation. There may be some inaccuracy based on short-term recall, but the authors believe this was minimal and consistent throughout the project. Data are not routinely collected on emergent neonatal intubations, and there is no information regarding the proportion of intubations in this NICU that were completed in an emergent fashion without premedications. These intubations are less frequent and not indicative of the improvement aim of this project. Another limitation includes baseline data collection, which was shorter than the ideal length of time. Given that we did not collect data before the start

of the project, the team did not want to delay the start of interventions and felt that it was sufficient to establish a baseline and interpret results. An additional XBarR statistical process control chart was created post hoc with data grouped semimonthly, which allowed for a closer examination of the baseline data period.

CONCLUSIONS

This project streamlined the process for intubation, standardized the approach to premedication, and provided timely treatment. We have sustained interventions throughout the project, and the time to intubation has been consistent without special cause variation since the mean shift to 27 minutes. Ultimately, more patients who may be at risk for decompensation can benefit from premedication with streamlined drug administration processes. The concepts used in this project can also be applied to other situations where rapid resource mobilization and medication administration are needed. Many aspects of intubation that require ongoing improvements,

such as complications and success rates, were highlighted during this project and could serve as a foundation to launch other initiatives to improve intubation safety for this vulnerable population.

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DISCLOSURE

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

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