Improved Tracheostomy-Dependent Patient Outcomes After Implementation of the Pediatric Resident Education in Pulmonary (PREP) Boot Camp

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Abstract

Introduction: Children with tracheostomies are high risk for morbidity and mortality. Pediatric resident physicians are not routinely taught skills to care for this vulnerable patient population. Few reports link educational interventions to improved patient outcomes. This study evaluates the impact of an intensive educational training program on pediatric residents’ observed skills and tracheostomy-dependent patient outcomes. Methods: Pediatric post-graduate year 2 (PGY2) resident physicians rotating through the inpatient pediatric pulmonology month at Children’s Hospital Colorado July 2018-2019 participated in the Pediatric Resident Education in Pulmonary (PREP) Boot Camp, an intensive educational program with an interactive lecture and simulation experience on patients with tracheostomy-dependence. PGY2s who partook in PREP and PGY3s who rotated prior to PREP initiation were invited to be studied. Primary outcomes included: 1) resident skills assessed by direct observation during simulation encounters and 2) rates of intensive care unit (ICU) transfers in tracheostomy-dependent patients following acute events before and after introduction of PREP. We hypothesized that increased education would enhance resident skills and improve patient outcomes by decreasing the rate of ICU transfers. Results: PGY2 residents retained skills learned during PREP up to 11 months following initial participation, and significantly outperformed their PGY3 counterparts. There was a significant decrease in ICU transfer rate in patients with tracheostomies admitted to the pulmonary team during the 19 months following initiation of PREP. Conclusions: Enhanced early education improves resident physicians’ ability to care for complex patients with tracheostomies and improves outcomes in this high-risk population.
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Methods: Pediatric post-graduate year 2 (PGY2) resident physicians rotating through the inpatient pediatric pulmonology month at Children’s Hospital Colorado July 2018-2019 participated in the Pediatric Resident Education in Pulmonary (PREP) Boot Camp, an intensive educational program with an interactive lecture and simulation experience on patients with tracheostomy-dependence. PGY2s who partook in PREP and PGY3s who rotated prior to PREP initiation were invited to be studied. Primary outcomes included: 1) resident skills assessed by direct observation during simulation encounters and 2) rates of intensive care unit (ICU) transfers in tracheostomy-dependent patients following acute events before and after introduction of PREP. We hypothesized that increased education would enhance resident skills and improve patient outcomes by decreasing the rate of ICU transfers.

Results: PGY2 residents retained skills learned during PREP up to 11 months following initial participation, and significantly outperformed their PGY3 counterparts. There was a significant decrease in ICU transfer rate in patients with tracheostomies admitted to the pulmonary team during the 19 months following initiation of PREP.

Conclusions: Enhanced early education improves resident physicians’ ability to care for complex patients with tracheostomies and improves outcomes in this high-risk population.
to rapidly recognize these complications and provide appropriate intervention such as suctioning or replacing the tracheostomy tube is vital to reducing morbidity and mortality in this medically fragile population.

Studies have shown that standardized training for medical staff related to routine tracheostomy cares improves bedside provider comfort level.\textsuperscript{9-11} However, there is no standardized recommendation for instruction and training of tracheostomy cares for prevention of common complications. One study showed that more than 50% of hospitals transferring tracheostomy-dependent patients from intensive care units (ICU) to ward teams lacked standard training for medical staff members and only 6% had guidelines in place for common complications such as accidental decannulation.\textsuperscript{12} Additionally, resident physicians are not routinely taught tracheostomy cares.\textsuperscript{13,14} Patients with tracheostomy tubes transferring out of the ICU to ward teams have increased mortality rates as compared to non-tracheostomy dependent patients.\textsuperscript{15,16}

Tracheostomy-dependent children admitted outside the ICU have many more medical emergency team (MET) activations than the general pediatric ward population.\textsuperscript{17} Pediatric patients requiring multiple MET activations in a single hospital stay have increased mortality rates and prolonged length of stay.\textsuperscript{18} Airway-related complications and medical staff concerns are the most common cause of MET activations in patients with tracheostomies.\textsuperscript{19} Therefore, tracheostomy-dependent children admitted to the inpatient wards have a uniquely high risk of multiple and frequent MET activations, as well as increased morbidity and mortality. This increased risk is likely a result of frequent airway-related complications as well as a lack of standardized training for bedside medical staff providers.

In response to these concerns, we implemented the Pediatric Resident Education in Pulmonary (PREP) Boot Camp, an intense educational program for resident physicians on the pediatric pulmonary ward team, with the goal to enhance resident comfort level in routine tracheostomy cares and equip them with contingency planning in the event of common tracheostomy-related complications.\textsuperscript{10,11} The New World Kirkpatrick Model of educational evaluation identifies four progressively complex levels of impact on learners: reaction, learning, behavior, and results.\textsuperscript{20} In this study, we aimed to evaluate the effect of the PREP curriculum on resident physician behaviors and on patient outcomes, the highest two levels of educational impact according to the Kirkpatrick model.

Methods

At Children’s Hospital Colorado (CHCO), all pediatric residents rotate through the inpatient pediatric pulmonology service during their second year for a 4-week rotation, with daytime and nighttime patient care responsibilities. The service is covered by three post-graduate year 2 (PGY2) residents each rotation and there is no cross-coverage from outside residents. PGY2 residents take overnight call by themselves on the pulmonary unit. At CHCO, all ward patients with tracheostomies outside of the ICU or rehabilitation units are admitted to the inpatient pulmonary floor where nurses have specialized training to care for these patients. The pulmonology rotation is often the first time residents are tasked to care for patients with tracheostomy-dependence. In response to resident feedback, we implemented the Pediatric Resident Education in Pulmonary (PREP) Boot Camp in July 2018, an intense educational onboarding experience for all PGY2 resident physicians rotating through the inpatient pediatric pulmonology service at CHCO.\textsuperscript{10} During PREP, PGY2 residents participated in an interactive lecture followed by a case-based simulation session (SIM #1) covering common emergent scenarios that are known to occur in pediatric inpatients with tracheostomies and ventilators such as accidental decannulation, tracheostomy mucus plugging, hypoxemia, and cardiorespiratory arrest.\textsuperscript{11}

The New World Kirkpatrick’s training evaluation model was used to determine the impact of this curriculum. For this study we were interested in outcomes at the third level – behavior – and the fourth level – results – to examine the impact of this novel curriculum on residents’ actual skills in addressing tracheostomy and ventilator emergencies as well as the impact on patient outcomes.

The institutional review board approved the study and participants were required to provide verbal consent. To evaluate the impact of this curriculum on residents’ behaviors, PGY2 residents who completed an inpatient rotation in pediatric pulmonology from July 2018 through June 2019 participated in the didactic PREP
training and then were immediately assessed in a simulation experience (SIM #1).

Our center utilizes Academic Half-Day (AHD) experiences, where all PGY2 and PGY3 residents who are available attend bimonthly themed sessions. Residents who are post-call, off-site, or on certain rotations do not attend. Pulmonary hosts one themed session every other year. During the pulmonary-themed AHD in June 2019, PGY2 and PGY3 residents who were present and who consented to participate were assessed in a simulation experience (SIM #2) using the same assessment tool used during SIM #1. This included a subset of PGY2 residents who had previously participated in the PREP curriculum (2-11 months prior) and had been assessed during SIM #1. PGY3 residents completed SIM #2 as a control group, as they completed the pulmonology rotation during the academic year 2017-2018 before PREP was initiated (Figure 1).

All residents who participated in the simulation sessions were scored using the previously validated assessment tool. Each session consisted of three different simulation cases led by a single resident with five of the following required actions per case: visualization of the tracheostomy entering the stoma, correct tracheostomy suctioning procedures, successfully changing the tracheostomy tube, timely initiation of oxygen therapy, bag-tracheostomy ventilation, performing chest compressions, and activation of the “Code Blue” emergency response system. Successful completion of all five actions in a case without assistance earned the learner a maximum score of 10. PGY2 residents received a different case in SIM #2 than they had received during SIM #1. PGY2 residents were provided with unique identifiers to link their simulation scores from SIM #1 and SIM #2. We compared PGY2 SIM #2 scores to their own SIM #1 scores using Student’s paired t-test and to the PGY3 SIM #2 scores using Student’s unpaired t-test.

To evaluate the impact on patient outcomes, we reviewed rates of ICU patient transfers in tracheostomy-dependent patients following MET activations, including both Code Blue and Rapid Response Team (RRT) acute events. We reviewed the CHCO Code Committee comprehensive database of all patients admitted to inpatient pulmonary team with a MET activation and an associated diagnosis of tracheostomy-dependence from December 2016 to January 2020 (consisting of the 19-month pre-PREP period and the 19-month post-PREP period). In this population, there were 83 MET activations. We divided these into “pre-PREP” (events occurring prior to initiation of PREP on July 2, 2018) and “post-PREP” (events occurring after initiation of PREP) study groups. We then reviewed patient outcomes data, including ICU transfer occurring within 12 hours of the MET activation event. The decision to transfer to the ICU was based on the clinical assessment of the medical teams. Information regarding the specific reason for transfer to the ICU was not available in the database and therefore could not be reviewed. Our primary outcome measure was the ICU transfer rate, defined as the number of ICU transfers divided by the number of MET activations in this population. As a comparison, we also reviewed ICU transfer rate on all patients admitted to the pulmonary floor during our study period, including pulmonary patients without a tracheostomy tube and tracheostomy-dependent patients admitted to other medical services for non-respiratory related reasons. ICU transfer rates were analyzed using a Chi squared test. P-values of 0.05 or less were considered statistically significant.

Results

PREP was initiated in July 2018 and monthly sessions were held with 2-3 residents participating each month. All PGY2 resident physicians (35/35) were scored in SIM #1, the initial simulation session immediately following educational intervention during PREP. Due to scheduling constraints during the pulmonary themed AHD in late June 2019, 13 PGY2 and 12 PGY3 residents attended this session. Of those in attendance, 12 of 13 PGY2 residents and 10 of 12 PGY3 residents agreed to participate in the study and were scored in SIM #2.

There was no significant difference comparing PGY2 SIM #1 and SIM #2 scores (p=0.2936). However, the SIM #2 scores of the PGY3 controls were significantly lower than PGY2 SIM scores, both immediately after PREP (SIM #1, p=0.0005) and 2-11 months following PREP (SIM #2 p=0.0051; Table 1). There were 38 MET activations on patients with tracheostomies admitted to the pulmonary team during the 19-month pre-PREP period and 45 MET activations during the 19-month post-PREP period (Table
2). There was no statistically significant difference in the absolute number of MET activations during pre-PREP and post-PREP (p=1.0). However, the ICU transfer rate was significantly decreased after PREP was initiated from 84% to 56% (p=0.01). In contrast, the overall ICU transfer rate for all patients on the pulmonary floor did not change during the study period (pre-PREP 60% versus post-PREP 58%; p=0.54).

Discussion

PGY2 residents who participated in a single targeted educational intervention, PREP Boot Camp, retained skills up to 11 months following the educational program, and significantly outperformed their senior PGY3 resident counterparts who had completed the inpatient pediatric pulmonary rotation prior to the initiation of PREP. One might expect that graduating PGY3 pediatric resident physicians would be equally or more equipped than their PGY2 counterparts to handle acute patient scenarios. The unique nature and timing of PREP provided just-in-time learning with the opportunity to practice skills learned at PREP during their inpatient experience. This allowed our PGY2 residents to demonstrate sustained and improved behavioral changes during simulation encounters, reaching the third level of evaluation impact on the Kirkpatrick model. This documented skill improvement aligns with the prior evaluation of the PREP curriculum in which we found that both PGY2 residents and pediatric pulmonology physicians felt that resident skills and patient care improved with the specialized training, especially when caring for patients with tracheostomies.10

Residents often self-reported that their ability to intervene on common tracheostomy complications was enhanced following PREP, especially during events encountered on overnight shifts. One learner stated “I recall running over there...and thinking I had a sense of what might be going on. Like, we are going to do a trach change. If we hadn’t had [PREP], I don’t know what my first thought would have been...and you know, we did a trach change and he was stable.”

To link our educational intervention to patient outcomes and reach the fourth and highest Kirkpatrick level, we found a stable numbers of MET activations for patients with on the pulmonary floor yet a significant decrease in ICU transfer rates for tracheostomy-dependent patients admitted to the pulmonary team following the initiation of the PREP Boot Camp. Given the high patient acuity, frequent comorbidities, and the lack of provider training for pediatric patients with tracheostomies admitted to hospital ward teams, this specific patient population not surprisingly has increased morbidity and mortality.1,5,6,12,15,16,21 These patients carry a high risk of multiple and frequent MET activations, most often due to acute airway or pulmonary events and bedside provider concerns.18,19 Such events frequently require ICU transfer. Each patient is unique, and reasons for ICU transfers following MET activations are not standardized or widely reported. We speculate that increased resident physician training for tracheostomy-related emergencies via PREP was associated with an improved ability to rapidly and appropriately intervene during MET, resulting in positive patient outcomes and decreased ICU transfer rates following MET activations.

Our research has a number of important limitations. Though ICU transfer rates among patients with tracheostomies on the inpatient pulmonary team dropped significantly following our intervention, we cannot prove causality. We isolated our review to patients with tracheostomy-dependence on the inpatient pulmonary team that were directly cared for by pediatric residents who either did or did not receive PREP training. During our study time, there were no changes to continuing education for other members of the pulmonary care team such as nurses or respiratory therapists. We did not directly measure resident performance during the actual acute encounters. Although actions observed during simulation imply that PGY2 residents gained skills, the causal link to their actions in real-life scenarios is speculative. This could be evaluated in the future by improving documentation during MET activations to include specific learner actions and performance.

In summary, our enhanced PREP Boot Camp educational program for the pediatric pulmonology clinical rotation significantly improved resident physician performance during simulated encounters. Residents retained knowledge and skills learned during PREP for up to 11 months following initial education. Rates of ICU transfer among patients with tracheostomies cared for by our resident cohort decreased significantly following our educational intervention.
Conclusion
It is difficult to link a medical educational intervention with patient-centered outcomes. However, we provide initial evidence that enhanced early education in pediatric pulmonology improves resident physician performance, as seen in direct observation during simulated encounters. Moreover, enhanced education leads to improved patient outcomes, as demonstrated by decreased ICU transfers in a targeted patient population.

References


**Table 1.** Mean simulation assessment scores.

<table>
<thead>
<tr>
<th>PGY2 SIM #1 Score Mean (SD) n=35</th>
<th>PGY2 SIM #2 Score Mean (SD) n=12</th>
<th>PGY3 SIM #2 Score Mean (SD) n=10</th>
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<tbody>
<tr>
<td>8.81 (1.12)</td>
<td>8.50 (1.17)*</td>
<td>5.17 (2.32)**, ****</td>
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*p=0.2936, **p=0.0005 as compared to PGY2 SIM #1 Score, ***p=0.0051 as compared to PGY2 SIM #2 Score SD, standard deviation

**Table 2.** MET activations on tracheostomy-dependent patients admitted to the pulmonary team during study period of Pre-PREP 12/2016-6/2018 and Post-PREP 7/2018-1/2020.

<table>
<thead>
<tr>
<th></th>
<th>Pre-PREP</th>
<th>Post-PREP</th>
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<tbody>
<tr>
<td>MET Activations</td>
<td>38</td>
<td>45*</td>
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<tr>
<td>ICU Transfer Rate</td>
<td>32 (84.2%)</td>
<td>25 (55.6%)</td>
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*p=1.0, **p=0.01

**Figure 1:** Timeline of PGY cohort on pediatric pulmonary inpatient rotations and timing of simulation experiences (SIM #1 and SIM #2) in relation to initiation of PREP (Pediatric Resident Education in Pulmonary) Boot Camp.