Pediatric Tracheostomy Care Simulation: Real-Life Scenarios in a Safe Learning Environment

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BACKGROUND: Pediatric patients require tracheostomy tube placement as a last resort for critical airway management. Around-the-clock care is needed at discharge because of the high risk of morbidity and mortality associated with a tracheostomy. The potential for catastrophic sequalae can create a high stress home environment. A simulation program that used a high-fidelity manikin was implemented to reduce complications, morbidity and mortality, and improve skills for real-life medical scenarios. METHODS: A tracheostomy care simulation program was implemented at a large tertiary care children's hospital from October 2019 to October 2020. Caregivers participated in a pre-post program survey and rated 9 statements on a 5-point scale with regard to knowledge, confidence, and comfort level of taking care of their child at home. Emergency scenarios included accidental tracheostomy tube dislodgement, tracheostomy tube plugging, cardiac arrest, and ventilator failure. Classes were recorded for objective start-to-finish scenario time stamps and prompt rates. A medical chart review was performed 90 d after discharge. RESULTS: Eighteen caregivers for 10 children participated. For the 10 children, there was a 9.1% increase in the average total score agreement from pre to post survey, with scores going from "agree" to "strongly agree" ($P = .001$). Each subset of questions had a significant increase in scores after participation: knowledge, $P = .002$; confidence, $P = .006$; and comfort, $P = .01$. The caregivers required an average 20% prompt rate for the next step in the scenario. Children were 70% female, 80% white, and 60% had public insurance and had their tracheostomy tube placed at a median age of 4 months (range, 0 months to 24 years). Three children ($n = 3/9$ [33.3%]) were readmitted for tracheitis within 90 d after being discharged to home. CONCLUSIONS: Caregiver knowledge, confidence, and comfort levels were increased after participation. Pediatric patients with a tracheostomy are medically fragile, therefore, it is important for caregivers to be aware of and prepared for common tracheostomy emergencies and to "experience" emergency situations firsthand. *Key words: pediatric; tracheostomy; simulation; manikin; dislodgement; plugging; cardiac arrest; ventilator malfunction.* [Respir Care 2022;67(1):40–47. © 2022 Daedalus Enterprises]

Introduction

Pediatric patients require tracheostomy tube placement as a last resort for critical airway management. These patients often have numerous comorbidities that result in medically complex care. Around-the-clock care is needed because of the high risk of morbidity and mortality associated with a tracheostomy. Given national nursing shortages, changes in medical coverage, and occasionally family preference, much of this care falls into the hands of the family. The potential for catastrophic complications associated with having a tracheostomy, need for daily care, use of complex medical equipment, and ability to respond quickly and appropriately to life-threatening situations can create a high-stress home environment. Before discharge at our hospital, caregivers of patients with a tracheostomy are required to learn basic care on a doll and on their child, and to discuss emergency situations and treatment options if such events occur, and they are given a booklet of care procedures.

Despite the current precautions, there was a 25% mortality rate, including all pediatric patients who had a tracheostomy in 2015 to 2018 at University of Pittsburgh Medical Center (UPMC) Children's Hospital of Pittsburgh from a 3-year follow-up analysis. Most, if not all, these mortalities occurred with a trained caregiver or professional home-care

provider present. There was a median (range) of 52.5 (48–60) new pediatric tracheostomy tube placements per year, with a total of >200 at our hospital during the 2015–2018 period. Once discharged, nurse telephone calls; appointments to ear, nose, and throat specialists and to pulmonology specialists; emergency department visits; and hospital readmission related to tracheostomy complications were frequent.[1,2] Of a sample of 38 patients with tracheostomy in the 3 years at UPMC Children's Hospital of Pittsburgh, 50% had hospital readmissions within the first 90 d after discharge; 79% of these patients presented with a tracheostomy-related issue, such as tracheitis or a mucous plug. Most if not all of these tracheostomy-related issues could be prevented with improved care training.

In an effort to reduce complications, morbidity, and mortality, and to improve skills across many real-life medical scenarios, simulation training has become increasingly crucial to learn and practice in a low-stress and safe learning environment. Historically, medical simulation education programs have been offered to health-care providers but have recently been implemented for caregivers to improve patient safety in the home.[3] Medical simulation would be beneficial to both health-care professionals and caregivers of the pediatric tracheostomy population. We proposed to bring the first simulation program to our institution for caregivers to review 4 emergency scenarios that could happen at home when discharged. Overall, the goal was to decrease the mortality and complication rates for pediatric patients with tracheostomy at the UPMC Children's Hospital of Pittsburgh. Our objectives were to (1) improve caregivers' self-efficacy, competency, and comfort level of providing care to their child with a tracheostomy, (2) decrease in-hospital and at-home morbidity and mortality rates, and (3) decrease emergency department visits and hospital readmissions.

QUICK LOOK

Current knowledge

Pediatric patients with a tracheostomy tube placement have a high risk of morbidity and mortality associated with tracheostomy, which necessitates around-the-clock care. Once these patients are discharged to home, complications and readmissions to the hospital are common. Medical simulation has become critical for health-care providers to practice and improve skills in a low-stress and safe learning environment; more recently, simulation programs have been implemented for caregivers as well.

What this paper contributes to our knowledge

The implementation of a pediatric tracheostomy care simulation program for caregivers provided 4 emergency scenarios that could happen at home when discharged. Survey measures indicated caregivers increased self-reported knowledge, confidence, and comfort levels of emergency tracheostomy care from before to after simulation.

Methods

A prospective study protocol was approved by the University of Pittsburgh Human Research Protection Office's institutional review board (STUDY19030056). This project was grant funded by the UPMC Beckwith Institute. A tracheostomy care simulation program was implemented at a large tertiary care children's hospital from October 2019 to October 2020. Participants were included if they were parents or legal guardians of a child ages 0 to 26 years old with a new tracheostomy tube placement at UPMC Children's Hospital of Pittsburgh. Caregivers were excluded if they had previous formal experience with tracheostomy care and if they had another child who had been previously discharged to home after tracheostomy tube placement.

Classes were scheduled near the end of their child's hospital stay for tracheostomy tube placement. Caregivers were defined as legal guardians and biological parents of the child with a tracheostomy. Classes were taught by the

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Table 1. Caregiver Pre-Post Program Survey With 9 Statements About Knowledge, Confidence, and Comfort Level of Taking Care of Their Child at Home When Discharged

No.	Statement
1	I know in what situations to take my child to the emergency department.
2	I know what tools to use when taking care of my child.
3	I know what to do to take care of my child at home.
4	I am confident in my ability to take care of my child in an emergency situation at home.
5	I am confident that I would be able to use the tools necessary to take care of my child.
6	I am confident that I can take care of my child at home.
7	I am comfortable with taking care of my child in an emergency situation.
8	I am comfortable using the tools needed to take care of my child.
9	I am comfortable taking care of my child at home.

Caregivers were asked to rate each statement on a 5-point scale from strongly disagree to strongly agree before and after simulation.
At the University of Pittsburgh Medical Center (UPMC) Children's Hospital of Pittsburgh, Oct 2019 to Oct 2020.

respiratory education coordinator (JLS) and the otolaryngology advanced practice provider supervisor (KAW), and were evaluated by the senior research associate (JLM). At least one simulation specialist from the Peter M. Winter Institute for Simulation, Education and Research (WISER) Center was also present in the room during the class. Each class consisted of the simulation team as described above and up to 2 caregivers for each child with a tracheostomy. Families could take part in the simulation program without the research component; however, all the caregivers were willing to participate.

Caregivers participated in a pre-post program survey (Table 1). Nine questions were asked with regard to knowledge, confidence, and comfort level of taking care of their child at home when discharged. Responses were on a 5-point Likert scale, from strongly disagree to strongly agree. In addition, the participants were asked to rate the following statement on the post-simulation survey, "I think the simulation program was helpful for learning to take care of my child at home," as well as to answer two open-ended question "What did you like most about the simulation program?" and "How could we improve the simulation program?"

Four emergency scenarios were created by the simulation team described above and approved by WISER specialists, two different intensive care physicians with several years' experience with simulation training, and were reviewed by a specialist with a Certified Healthcare Simulation Operations Specialist-Advanced certification to ensure that best practice standards were met. The scenarios included and were presented in the order listed: tracheostomy tube plugging, tracheostomy tube dislodgement, cardiac arrest, and ventilator failure. The class was ~1 h, including filling out the surveys before and after the program, performing the scenarios on the manikin, and scenario debriefing.

The SimBaby high-fidelity manikin (Laerdal Medical; Wappingers Falls, New York) was modified to fit a tracheostomy because, at the start of the program, no commercially available manikins with a tracheostomy were available. A light-skinned manikin was used because most of the Pittsburgh metropolitan area population is of white race. The manikin was coded by the WISER simulation specialists to breathe spontaneously, have age-appropriate pulse and breathing patterns, and exhibit cyanosis. An electronic screen that displayed blood pressure, temperature, heart rate, S_{pO_2}, and breathing frequency was placed near the ventilator or the head of the manikin, and was accompanied with a pulse oximetry alarm. Reusable and disposable tracheostomy tube items were available for the course. A working Trilogy 100 ventilator (Philips Respironics, Murrysville, Pennsylvania) was used during the scenarios for those with a child who was ventilator dependent. A backdrop was customized to portray a child's bedroom for the background of the simulation room (Supplemental Digital Appendix 1, see the supplementary materials at http://www.rcjournal.com).

In the development of each scenario, a template was made with the objectives, patient vitals coded with an events timeline, a checklist of participant actions, and debriefing note and questions. With the use of electronic tablets, the program evaluator checked off each step that the participant followed in real time during each scenario. Classes were also recorded for objective start-to-finish scenario time stamps and prompt rates. These recording were available for video feedback and/or debriefing and to review after the class.

A medical record review was performed for 90-d after discharge. The primary end point was completion of a medical chart review to assess complications and mortality rates for pediatric patients with tracheostomy within 90 d of discharge. The secondary end point was the responses from the pre- and post-simulation surveys. SPSS version 27 (IBM, Armonk, New York) was used for analysis, with $P < .05$ displaying statistical significance. Along with descriptive statistics, the Wilcoxon signed-rank test was used for repeated-measures continuous data.

Results

Eighteen caregivers participated in the simulation program for 10 different children with new tracheostomy tube placement. For 8 of 10 patients, the biological mother and father participated in the program together. Two patients had one caregiver participate, one being the mother and one being the grandfather, who was the legal guardian. As for demographics and characteristics of the child patients, a majority were female ($n = 7$ [70%]), white ($n = 8$ [80%]), and born premature ($n = 6$ [50%]). The median (range) age at tracheostomy was 4 (0–296) months. All the patients had

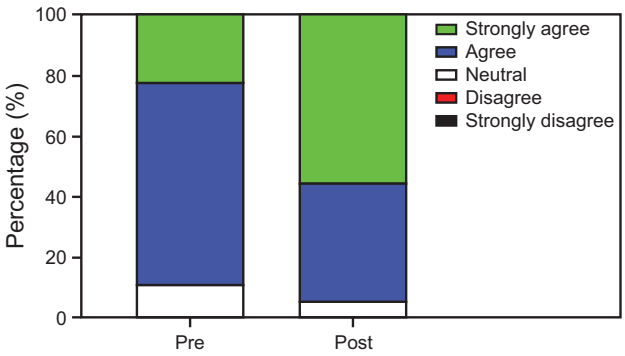

Fig. 1. Average total score agreement on 9 pre- and post-simulation statements for rating knowledge, confidence, and comfort level of caring for their child at home ($N = 18$ caregivers).

their tracheostomy tube placed in either 2019 or 2020. The primary reason for tracheostomy tube placement was chronic respiratory failure in 3 patients (30%), upper-airway obstruction in 4 patients (40%) , and chronic lung disease of prematurity in 3 patients (30%).

Caregiver Simulation

When assessing the simulation surveys, there was a 9.1% increase in the average total score agreement from pre- to post-survey, with scores that ranged from "agree" to "strongly agree"; $P = .001$ (Fig. 1). In addition, each subset of questions had a significant increase in mean ± SD scores after participation: knowledge pre-survey of 4.06 ± 0.47 to post-survey of 4.46 ± 0.53, $P = .002$; confidence pre-survey of 4.00 ± 0.56 to post-survey of 4.44 ± 0.54, $P = .006$; and comfort pre-survey of 4.06 ± 0.50 to post-survey of 4.44 ± 0.63, $P = .010$.

Before the scenarios, the caregivers were given an introduction about what to expect during the simulation, were shown all the tracheostomy supplies that they could use, and were instructed to pretend that the manikin was their child. Each of the 4 scenarios were broken down into an events timeline with specific steps (Table 2). Tracheostomy plugging, cardiac arrest, and ventilator failure scenarios each had 7 steps to completion and tracheostomy dislodgement had 6 steps. There was an average time stamp of 2 min and 56 s, including all 4 scenarios, with the tracheostomy tube plugging scenario taking 4:14 (min:s), tracheostomy tube dislodgement taking 1:28, cardiac arrest taking 2:11, and ventilator failure taking 3:51. Resolving tracheostomy tube plugging took the longest to perform but was also the first scenario in the simulation class. There was an average prompt rate for the next scenario step of 20% for all 4 scenarios combined. Tracheostomy tube plugging had a 23.2% prompt rate, 9.4% for tracheostomy tube dislodgement, 24.7% for cardiac arrest, and 20.4% for ventilator failure.

Open-ended questions and responses on the post-simulation survey for questions "What did you like most about the simulation program" and "How could we improve the simulation program" are presented in Table 3. All 18 participants (100%) gave positive responses with regard to the program. A total of 11 of 18 of the participants (61.1%) gave responses about improving the program. Approximately one third of these responses (36.4%) requested more scenarios during the class.

Patient Medical Record Review

Discharge and outpatient data were reviewed for the patients whose caregivers participated in the program. A total of 9 of the 10 patients' records were reviewed due to one child who was moved to an outside hospital in a different state. A third of the patients (33.3%) were discharged to home after the hospital stay in which the tracheostomy tube was placed. The rest of the patients were discharged to a rehabilitation unit or a care home for a median (range) of 51.5 (13–139) d. This was to continue tracheostomy and/or gastrostomy tube teaching and to arrange and establish home nursing in a non-ICU setting.

Six of 9 patients had at least 1 emergency department visit within 90 d after being discharged to home, with most of these patients ($n = 4/6$ [67.7%]) being readmitted to the hospital. Reasons included gastrojejunostomy tube dislodgement in 1 patient and tracheitis in 3 patients, which involved fever, increased work of breathing, desaturations, and increased tracheal secretions. Two patients had emergency department visits without readmission. One of these patients had 2 visits for separate primary diagnoses of acute viral syndrome and bronchiolitis, and the other patient had constipation. A separate patient was readmitted, without an emergency department visit, with leukocytosis and a shunt infection. None of the patients returned to the hospital for tracheostomy tube plugging, accidental tube dislodgment, cardiac arrest, or ventilator problems during this time period.

As for outpatient tracheostomy care within 90 d after being discharged to home, 5 of 9 patients (55.6%) had at least one otolaryngology nurse telephone call, 2 of 9 patients (22.2%) had an otolaryngology appointment for a tracheostomy-related problem, 5 of 9 (55.6%) had an appointment to the pulmonology department, and more than half ($n = 5/9$ [55.6%]) had a reported tracheostomy-related problem. All 5 patients had issues with granulation tissue, with 40% of them having blood-tinged secretions as well.

Discussion

With limited health-care resources, much of the routine and emergency care falls on patients' family or other non-medically trained caregivers. The idea of having to care for medically fragile children, especially by a non-

Table 2. Pediatric Tracheostomy Simulation Scenario Events, Time Stamp, and Prompt Rate

Step	Criteria	Average Time Stamp, min:s	Prompted, %
No. 1 scenario: tracheostomy tube plugging			
0	Start	0:00	NA
1	Recognize alarms for changes in vitals	0:10	0
2	Check patient (changes in color and work of breathing)	0:28	20.0
3	Evaluate tracheotomy tube position	0:39	10.0
4	Attempt to suction	1:05	22.2
5	Attempt bag mask	1:46	30.0
6	Replace tracheotomy tube	2:38	40.0
7	Reattempt to bag mask	3:45	40.0
✓	End	4:14	NA
No. 2 scenario: accidental dislodgement			
0	Start	0:00	NA
1	Recognize alarms for changes in vitals	0:03	0
2	Check patient (changes in color and work of breathing)	0:17	25.0
3	Evaluate tracheotomy position	0:28	0
4	Note dislodged tracheotomy tube	0:38	11.1
5	Replace tracheotomy tube (same size or downsize)	0:46	0
6	Attempt bag mask	1:05	20.0
✓	End	1:28	NA
No. 3 scenario: cardiac arrest			
0	Start	0:00	NA
1	Recognize alarms for changes in vitals	0:04	0
2	Check patient (changes in color and work of breathing)	0:12	11.1
3	Evaluate tracheotomy tube position	0:21	0
4	Recognize no pulse	0:32	10.0
5	Attempt to bag mask	0:39	33.3
6	Cardiopulmonary resuscitation (CPR) – 1 round (4 cycles of 30 compressions and 2 breaths)	0:56	50.0
7	Call 911	1:45	66.7
✓	End	2:11	NA
No. 4 scenario: ventilator failure			
0	Start	0:00	NA
1	Recognize alarms for changes in vitals	0:04	0
2	Check patient (changes in color and work of breathing)	0:15	33.3
3	Evaluate tracheotomy tube position	0:33	28.6
4	Evaluate ventilator	0:59	33.3
5	Attempt to suction	1:39	33.3
6	Attempt to bag mask	2:14	33.3
7	Bag mask until the ventilator is fixed, get a backup ventilator or 911 arrives (state any of these)	3:07	11.1
✓	End	3:51	NA

NA = not applicable

medically trained caregiver, is anxiety provoking and can create a high-stress home environment. Ensuring that family and other non-medically trained caregivers are familiar with and able to provide appropriate care and response to certain life-threatening situations can decrease caregiver anxiety, improve the quality of home life, and result in better patient health. The overarching goal of creating and implementing the pediatric tracheostomy care simulation program was to decrease mortality and morbidity for pediatric patients with tracheostomy tube placement by increasing caregiver knowledge, confidence, and comfort levels of emergency tracheostomy care. This was the first study in the literature to our knowledge to provide an emergency care simulation program for caregivers of children with new tracheostomy tube placements and to prospectively follow up the children with tracheostomies during the global period of 90 d after discharge.

Table 3. Open-Ended Questions on the Post-Simulation Survey, Asked After the Pediatric Tracheostomy Simulation Scenarios at University of Pittsburgh Medical Center Children's Hospital of Pittsburgh

Participant No.	What Did You Like Most About the Simulation Program?	How Could We Improve the Simulation Program?
1	"A lot of scenarios"	ND
2	"Teaches you so much for care"	"I feel it's excellent"
3	"It mentally prepared me for situations that may come about."	"Add more simulations. Other than that it was extremely helpful!"
4	"It helped me to know what to look for in certain situations."	ND
5	"Build confidence and feedback"	"Even more scenarios"
6	"Practicing what it is like to have to keep in my head and properly deal with a crisis."	ND
7	"Everything"	"Nothing it was great:)"
8	"Very realistic"	ND
9	"Always check under clothes just in case the vent's not alarming but the baby is slowly desating"	"It was excellent."
10	"Always be able to get help if needed"	ND
11	"Real life scenarios, it definitely helps to see what it would be like at home"	"Nothing"
12	"Different scenarios"	"I think it is great how it is"
13	"The different issues that can happen"	ND
14	"Forcing us to think like an emergency was happening. Being forced to work together"	ND
15	"Having the opportunity to open conversation about emergency situations with all tools available, with no risk to our child"	"More obvious physical markers (color, etc):)"
16	"It showed different situations on what could happen"	"More situations on stuff that could happen"
17	"It gives you numerous scenarios to look at and how to handle them"	"Adding a few more scenarios depending on patients' needs"
18	"Refreshing real life scenarios"	"Really great so far. Wide variety of scenarios"

$N = 18$ Caregivers.
ND = no data

For evaluation of the simulation program, we administered the pre- and post-surveys to the caregivers and saw a 9.1% increase in total score knowledge, confidence, and comfort agreement on a Likert scale. However, most of the caregivers had high agreement in the subscales before the simulation program started. This may be attributed to the program taking place near the end of the child's hospital stay with most of the children who were critically ill having lengthy stays (median, 190.5 d). During the child's hospital stay, family members are encouraged to be highly involved and to practice tracheostomy tube changes on their child. The program assessed the self-perceived knowledge of caregivers because administering a "knowledge test" seemed inappropriate in this population, and the simulation team did not want the program to come across as a pass or fail class.

This study was also the first, to our knowledge, to assess prompt rates for the next step in each scenario. This part of the evaluation was important to understand where in each scenario the families were struggling most. The first scenario that was administered was tracheostomy tube plugging, and we saw a 40% prompt rate for replacing the tracheostomy tube. The caregivers were hesitant to physically remove the tracheostomy tube from the manikin and were unsure of how to proceed. In the following scenario, accidental dislodgement, none of the families needed prompting to replace the tracheostomy tube and performed the scenario steps an average of almost 3 minutes faster than when completing the first scenario. There also was a 13.8% decrease in average prompt rates from the first to the second scenario.

Overall, there was a slight decrease in the readmission rate within 90 d after discharge versus the 2015–2018 data from our hospital (44% vs 50%). Furthermore, there were no deaths during this time. Our sample size was small, and, over time and with a larger cohort, we expect the decrease in readmission to be significant. Not only does this reduction indicate improved patient care, but it also indicates reduced health-care costs, decreased family burdens, and

potential improve quality of life. Additional studies to formally assess these outcomes are needed. Analysis of these data suggested that more prompting requires an increased time to completion and perhaps more hesitation in continuing with the next step in the scenario, along with increased discussion.

Despite the reduced readmission rate, our patient cohort had a high rate of return to the emergency department for tracheitis, which made up 75% ($n = 3/4$) of those readmitted. Tracheitis is a frequent complication of tracheostomy and can be defined as a tracheal bacterial infection.[4] Due to the nature of the tracheostomy opening bypassing the nasal and oropharyngeal passages[5] and that many of the children with a tracheostomy have a multitude of comorbidities, this population is more susceptible to respiratory infections.[6,7] Previous data from our institution indicated that tracheitis had a frequent cause for emergency department visits and hospital admissions for our tracheostomy population, which suggests better education on routine tracheostomy care and management of tracheitis through simulation may be a future tool to reduce hospital admissions and emergency department visits.[8]

This was the first simulation program in collaboration with WISER that targeted caregivers instead of health-care professionals within our health system. However, other tracheostomy simulation programs for caregivers[3,9-12] and for health professionals[13-16] exist globally and are becoming increasingly popular due to the interest, demand, and likelihood of evidenced-based improved outcomes after discharge.[3] Thrasher et al[9] implemented a simulation training for caregivers of children with a tracheostomy and who were ventilator-dependent. The participants completed both pre- and post-surveys, trained on a manikin for two emergency-based scenarios, and completed the debriefing process. Interestingly, the debriefing after simulation was perceived to be more beneficial than the actual scenarios.[9] There is a plethora of recent literature that pertains to implementation of simulation programs and the importance of the debriefing process to reflect critically on what was learned.[17-20] Overall, it is important for each hospital with a simulation program to share its experiences and results to help other institutions create a program that fits their population and resources.

Debriefing is critical to learning and/or understanding that results from simulation. By using the cardiac arrest scenario as an example, the following notes and questions were reviewed with each caregiver:

- What about the clinical scenario makes cardiac arrest the obvious issue?
- Highlight the need for chest compressions as soon as possible
- Clinical signs that indicate impending decompensation (cyanosis, quick change in vitals)

Many moving parts went into designing and implementing the pediatric tracheostomy care simulation program at our hospital. Until recently, there was not a commercially available pediatric manikin that would accommodate a tracheostomy. The manikin required modifications and a custom-made trachea and tracheotomy. Simulation specialists were necessary as well to code each scenario criteria to make the scenarios come to life. During the coronavirus disease 2019 pandemic, we had to temporarily suspend the program due to hospital restrictions but have since implemented a research restart plan to safely conduct the program and in compliance with the hospital and university guidelines. Our sample size was also limited by the fact that not all families were a good fit for the program because some children with tracheostomy were not expected to be discharged home for some time due to being critically ill.

Another limitation of the research component was order bias of the scenarios. Although tracheostomy tube plugging had the longest time stamp, this scenario was presented first because we had to use a different prop tracheostomy that was plugged. Most of the children with tracheostomy were of the white race and a light-skinned manikin was used. However, we acknowledge that this possibly impedes the skill transfer of minority race caregivers because these learners may have a harder time perceiving the simulation as real. Conigliaro et al[21] highlighted the limited diversity in simulation, which may result in the hindrance of exposure and training for clinical scenarios. In addition, it would be helpful to have caregiver data after their child's discharge. Paper copies of a post-discharge survey were mailed out but not returned. For families in the future, it would be helpful for the researchers to obtain the post-discharge survey in-person at a routine follow-up otolaryngology appointment.

Caring for a child with a tracheostomy is a tremendous responsibility because a caregiver must be with the child 24 hours a day, 7 days a week. In helping caregivers prepare for taking care of their child at home when discharged, we successfully implemented a simulation program that reviewed 4 common emergency scenarios. Although disheartening for caregivers to even think that these scenarios could happen to their child, the program allowed caregivers to practice in a low-stress environment where questions were encouraged. Moving forward, we hope to include as many caregivers with a child with a new tracheostomy as possible, and to include additional scenarios that would be beneficial. It would be helpful to review tracheitis symptoms and care, and when to report to the emergency department as opposed to home care because this was a critical issue in our sample and hospital-wide. Furthermore, the implementation of the simulation program for emergency scenarios will be used on a larger scale to teach and train health-care

providers at our hospital, specifically those who provide direct critical care to patients with tracheostomies (ie, neonatal ICU and emergency department personnel).

Conclusions

Caregiver self-perceived knowledge, confidence, and comfort levels were increased after participation in the pediatric tracheostomy care simulation program. Due to pediatric patients with tracheostomy being medically fragile, it is important for caregivers to be aware of and prepared for common tracheostomy emergencies and to "experience" emergency situations firsthand.

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REFERENCES

1. Gaudreau PA, Greenlick H, Dong T, Levy M, Hackett A, Preciado D, et al. Preventing complications of pediatric tracheostomy through standardized wound care and parent education. JAMA Otolaryngol Head Neck Surg 2016;142(10):966-971.
2. Shay S, Shapiro NL, Bhattacharyya N. Revisits after pediatric tracheotomy: airway concerns result in returns. Int J Pediatr Otorhinolaryngol 2018;104:5-9.
3. Arnold J, Diaz MCG. Simulation training for primary caregivers in the neonatal intensive care unit. Semin Perinatol 2016;40(7):466-472.
4. Watters KF. Tracheostomy in infants and children. Respir Care 2017;62(6):799-825.
5. Cline JM, Woods CR, Ervin SE, Rubin BK, Kirse DJ. Surveillance tracheal aspirate cultures do not reliably predict bacteria cultured at the time of an acute respiratory infection in children with tracheostomy tubes. Chest 2012;141(3):625-631.
6. Tan C-Y, Chiu N-C, Lee K-S, Chi H, Huang F-Y, Huang DT-S, et al. Respiratory tract infections in children with tracheostomy. J Microbiol Immunol Infect 2020;53(2):315-320.
7. Russell CJ, Mack WJ, Schrager SM, Wu S. Care variations and outcomes for children hospitalized with bacterial tracheostomy-associated respiratory infections. Hosp Pediatr 2017;7(1):16-23.
8. Tarfa RA, Morris J, Melder KL, McCoy JL, Tobey ABJ. Readmissions and mortality in pediatric tracheostomy patients: are we doing enough? Int J Pediatr Otorhinolaryngol 2021;145:110704.
9. Thrasher J, Baker J, Ventre KM, Martin SE, Dawson J, Cox R, et al. Hospital to home: a quality improvement initiative to implement high-fidelity simulation training for caregivers of children requiring long-term mechanical ventilation. J Pediatr Nurs 2018;38:114-121.
10. Tofil NM, Rutledge C, Zinkan JL, Youngblood AQ, Stone J, Peterson DT, et al. Ventilator caregiver education through the use of high-fidelity pediatric simulators: a pilot study. Clin Pediatr (Phila) 2013;52 (11):1038-1043.
11. Stanley TA, Battles M, Bezruczko N, Latty C. Efficacy of simulation for caregivers of children with a tracheostomy. Clin Simul Nurs 2019;31:9-16.
12. Prickett K, Deshpande A, Paschal H, Simon D, Hebbar KB. Simulation-based education to improve emergency management skills in caregivers of tracheostomy patients. Int J Pediatr Otorhinolaryngol 2019;120:157-161.
13. Khan KE, Lockspeiser TM, Liptzin DR, Meier M, Baker CD. "When in doubt, change it out": a case-based simulation for pediatric residents caring for hospitalized tracheostomy-dependent children. MedEdPORTAL 2020;16:10994.
14. Agarwal A, Marks N, Wessel V, Willis D, Bai S, Tang X, et al. Improving knowledge, technical skills, and confidence among pediatric health care providers in the management of chronic tracheostomy using a simulation model. Pediatr Pulmonol 2016;51(7):696-704.
15. Nguyen LHP, Bank I, Fisher R, Mascarella M, Young M. Managing the airway catastrophe: longitudinal simulation-based curriculum to teach airway management. J Otolaryngol Head Neck Surg 2019;48 (1):10.
16. Dorton LH, Lintzenich CR, Evans AK. Simulation model for tracheotomy education for primary health-care providers. Ann Otol Rhinol Laryngol 2014;123(1):11-18.
17. Arnold JL, McKenzie FRD, Miller JL, Mancini ME. The many faces of patient-centered simulation: implications for researchers. Simul Healthc 2018;13(3S Suppl 1):S51-S55.
18. Colman N, Doughty C, Arnold J, Stone K, Reid J, Dalpiaz A, Hebbar KB. Simulation-based clinical systems testing for healthcare spaces: from intake through implementation. Adv Simul (Lond) 2019;4(1):19.
19. Motola I, Devine LA, Chung HS, Sullivan JE, Issenberg SB. Simulation in healthcare education: a best evidence practical guide. AMEE Guide No. 82. Med Teach 2013;35(10):e1511-e1530.
20. Sawyer T, Eppich W, Brett-Fleegler M, Grant V, Cheng A. More than one way to debrief: a critical review of healthcare simulation debriefing methods. Simul Healthc 2016;11(3):209-217.
21. Conigliaro RL, Peterson KD, Stratton T. Lack of diversity in simulation technology: an educational limitation? Simul Healthc 2020;15 (2):112-114.