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Featured Article

Efficacy of Simulation for Caregivers of Children With a Tracheostomy

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competence;
human patient simulator;
tracheostomy emergency care

Abstract

Background: This study aimed to show simulation improves confidence and competence in caregivers of children with a tracheostomy and examined the impact on patient emergency department visits and mortality.

Methods: All participants received standard classroom training. One group also received training using simulation.

Results: Confidence at post-test was significantly greater in the simulation group. Correlation between post-test confidence and competency measures was not statistically significant. Mortality in family homes was almost five times higher for children whose caregivers did not participate in simulation.

Conclusion: Simulation should be considered an important adjunct when preparing caregivers to respond to tracheostomy emergencies at home.

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Parents of children who receive a tracheostomy must learn how to care for their child before discharge from the hospital. This includes cleaning the area around the stoma, changing the ties used to hold the tracheostomy tube in place, changing the dressing under the tube, suctioning the tube to keep the airway patent, and periodically changing the tube. They must also be able to recognize and intervene when something occurs that endangers the patency of the child's artificial airway, such as occlusion from secretions, accidental decannulation, respiratory distress, or cardiopulmonary arrest.

Problem

Skills needed for daily care of children with tracheostomies are typically taught in a formal classroom setting or with individualized instruction at the child's bedside. Skill acquisition is attained as the parent and other caregivers participate in the child's routine care throughout hospitalization. Verbal instruction on when and how to intervene in

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an emergency may also be provided during the hospitalization, but there is rarely an opportunity to practice these skills unless a real emergency happens at a time the parent is at the bedside. Any attempt to create a life-threatening situation to practice on the child would be unethical and would likely traumatize the child, parents, and other caregivers.

Key Points

- This study examines the impact of simulation training on the confidence and competence in the management of common tracheostomy emergencies in caregivers of children with a new tracheostomy. The study also measured the impact of simulation on Emergency Department visits and mortality rates related to a tracheostomy emergency in the home.
- All study participants received standard classroom training (two classes), cardiopulmonary resuscitation training, and had ample time to practice skills on their child before discharge to home. Simulation of common tracheostomy emergencies was provided to a subset of randomly selected caregivers.
- Findings suggest that simulation training may be an important adjunct in the preparation for discharge in this vulnerable population.

Tracheostomy-related deaths in pediatrics can be as high as 3.6% with many occurring because of a loss of the artificial airway from obstruction, decannulation, or misplacement of the tracheostomy (Agarwal et al., 2016). Simulation of common urgent and emergent situations provides an opportunity for parents and other caregivers to acquire competence and confidence in responding to them and could bridge this gap in preparing to take the child home from the hospital.

Using human patient simulation (HPS) for patient education has not been widely reported in the literature. In a study with parents of children with type 1 diabetes, Sullivan-Bolyai et al. (2015) compared the use of HPS with formal parent education conducted by a nurse. Although the overall effect was not statistically significant between groups, there were significant differences for parents of children younger than 6 years in the treatment (HPS) group in three specific outcomes: glycosylated hemoglobin (A1C), lower state of anxiety, and higher fear of hypoglycemia. A follow-up study cited generally positive results from interviews with parents enrolled in the treatment arm of this study (Ramchandani et al., 2016). Of interest was a frequent observation by these parents of how ‘‘scary’’ the hypoglycemic vignettes were to them.

Raines (2017) described the use of simulation in preparing parents to take home a baby from the Neonatal ICU including performing care and responding to emergencies. Fifteen parent dyads independently rated their confidence in performing care and responding to emergencies on a scale of 1 to 10 before and immediately after the simulation. The instrument was not described nor was validity or reliability reported. Overall, parents were more confident in performing care than in responding to emergencies.

Although confidence and competency are typically assumed to be complementary, the literature is inconsistent. For example, Morgan and Cleave-Hogg (2002) found clinical experience and level of confidence lacking predictive value in performance assessments of medical students in standardized anaesthesia simulation scenarios. In more recent work, Phadraig et al. (2017) found low levels of knowledge and skills in basic life support among dental students despite self-reported high basic life support confidence. Likewise, Shah, Haisch, and Noland (2018) found confidence increased with number of cases logged for surgical residents but did not correlate with residents' technical ability (see also, Brinkman, Tichelaar, van Agtmael, de Vries, & Richir, 2015). Consequently, relations between competency and confidence and ultimately their implications for clinical assessment are currently unclear.

In general, simulation is widely used to train clinicians to perform skills in health care settings and has occasionally been used in training patients or their caregivers to perform skills for the patient to be discharged. The use of HPS with parents of children who will be going home with a tracheostomy tube was intended to answer the following questions:

1. Does simulation improve caregiver confidence in managing emergencies?
2. In caregivers of children with tracheostomies who are trained with simulation, how are confidence and competence related?
3. Does training method (didactic with skills validation on child versus didactic with skills validation on child plus HPS) decrease visits to the emergency department (ED) or mortality?

Theoretical Framework

This study of the use of HPS in preparing parents for tracheostomy emergencies in the home was based on a theoretical model developed by Chen, Ryan-Henry, and Bezruczko (2004) called Functional Caregiving that integrates self-confidence measurement with a philosophy of human needs (Maslow, 1943). This construct asserts that caregiving tasks occur within a social context, and the purpose of caregiving is to provide for basic human needs. Caregiving addresses three levels of need: advocacy, personal caregiving, and community relations, and Functional Caregiving requires assessment tasks to fulfil this expected hierarchy. A caregiver's confidence is influenced by personal factors such as their own physical and mental health, social support, and financial resources for which to care for their child. Functional Caregiving asserts that as caregivers gain confidence in providing care to the child in the home, they will begin to advocate for and seek experiences for their child outside of the home in the neighborhood and the larger community.

Empirical implementation of this approach to caregiving has demonstrated a qualitative assessment hierarchy defined by easier and harder caregiving tasks that are centered in the home but radiate into neighborhood and community as caregiving confidence increases (Bezruczko, Chen, Gulley, Maher, & Lawton, 2011a). This convergence of confidence and humanistic caregiving is central to the Functional Caregiving construct.

Originally developed to assess home caregiving of children with intellectual disabilities (Chen et al., 2004; Chen, Bezruczko, & Ryan-Henry, 2006; Chen, Ryan-Henry, Heller, & Chen, 2001), Functional Caregiving was later adapted to medical technologies for mothers of children with a tracheostomy (Bezruczko et al., 2009, 2011a,c; Bezruczko, Chen, & Hill, 2011b). Those results in the studies cited previously confirmed strong measurement properties including convergent, construct, and content validities, although psychometric reliability was high, alpha $\geq$ 0.88. This consolidation of caregiving and confidence in a parameterized framework provides an opportunity to investigate the complex relations between self-confidence and competency and their contribution to decreasing patient mortality.

Methods

Sample

Institutional review board approval was obtained for this study. All caregivers of children who received a new tracheostomy at a children's hospital in the Midwestern United States were invited to participate in this research. Participants who consented (n = 101) were typically the child's parent and all were undergoing tracheostomy training and planning to take their child home. All participants identified English as their primary spoken and written language and provided written consent. The children (n = 54) ranged from one month to 16 years of age, with a median age of 33 months.

Measures

Self-Reported Confidence Ratings

Self-reported caregiver confidence ratings were collected with 54 Functional Caregiving items, which consolidated two published assessment forms (Bezruczko, Fatani, et al., 2016). Additional questions were incorporated into the original (Chen et al., 2006) survey to differentiate confidence between standard education and standard education plus simulation. Although the 2011 study (Bezruczko, Chen, Hill, & Chesniak, 2009) had specific survey questions for mothers of three subsets of children assisted with medical technologies (tracheostomy alone, tracheostomy with mechanical ventilation, and pressure-assisted ventilation), the present study used only the survey questions for caregivers of children with a tracheostomy and tracheostomy with mechanical ventilation. In addition, the sample population was expanded to include mothers and other caregivers of children with a tracheostomy.

Examples of items in the survey for this study are provided in Table 1. Responses were collected with rating scales (1 = none, 2 = a little, 3 = somewhat, 4 = a lot, and 5 = completely) and a total score was summed for each participant. Maximum score on this set was 270 and published reliabilities are typically > 0.90 (Bezruczko, Stanley, Battles, & Latty, 2016).

Competency Ratings

Caregiver competency assessment was based on a standard task checklist (11 items). Caregivers were observed responding to three tracheostomy emergencies outlined below. The caregivers' responses were scored dichotomously (pass/fail) by trained observers and a total score summed for each caregiver. Maximum score on this set was 11.

The competency checklist was developed by the investigators in collaboration with clinical experts at the facility and content is supported by the literature (Frank et al., 2010; Tuttle et al., 2007).

- Respond appropriately when a child with a tracheostomy becomes decannulated (four items).
- Perform cardiopulmonary resuscitation (CPR) on a child with a tracheostomy (two items).
- Alleviate respiratory distress for a child with a tracheostomy (five items).

ED Visits and Mortality

Information about children who returned home was collected during follow-up phone surveys between 6 and 18 months after discharge to identify frequency of tracheostomy emergencies, ED visits, and hospital readmissions. Caregivers self-reported their response to emergencies based on what was taught during training. Surveying was the best way to capture when a caregiver responded correctly in an emergency because the child did not usually require an ED visit or readmission. Mortality was captured by review of patients' electronic medical records.

Procedures

All study participants (n = 101) (baseline) completed the Functional Caregiving confidence assessment before attending standard classroom training (two sessions). The nonsimulation group (46 of 48 participants) completed their

Table 1 Sample Questions from Survey "Taking Care of a Child with a Tracheostomy"

I Feel Confident in My Ability to:	None	A Little	Somewhat	A Lot	Completely	Does Not Apply
Give tube feedings	1	2	3	4	5	NA
Show others how to help me care for my child	1	2	3	4	5	NA
Report changes in my child's health condition	1	2	3	4	5	NA
Name everything that needs to be with my child wherever he goes	1	2	3	4	5	NA
Oversee my child's care	1	2	3	4	5	NA
Work with my child's school to focus on his special needs	1	2	3	4	5	NA
Tell others how my child communicates	1	2	3	4	5	NA
Take care of my home	1	2	3	4	5	NA
Set up a tracheostomy collar with humidity at home	1	2	3	4	5	NA
Know how to care for my child's tracheostomy	1	2	3	4	5	NA
Know what to do if my child's tracheostomy tube gets plugged (clogged)	1	2	3	4	5	NA
Know when my child is getting sick	1	2	3	4	5	NA
Make sure my child eats well	1	2	3	4	5	NA
Know who to call in an emergency	1	2	3	4	5	NA
Call the home health agency about my child's nursing services	1	2	3	4	5	NA
Find support groups in my community	1	2	3	4	5	NA
Encourage my child to take part in activities he/she can do	1	2	3	4	5	NA
Move, lift, and carry my child around	1	2	3	4	5	NA
Call the doctor to talk about my child's health care needs	1	2	3	4	5	NA
Watch for changes in my child's condition	1	2	3	4	5	NA
Keep calm during emergencies	1	2	3	4	5	NA
Name community agencies that coordinate care for children with a tracheostomy	1	2	3	4	5	NA

post-test confidence survey after the conclusion of standard classroom training. The simulation group (23 of 53 participants) completed their post-test confidence survey after simulation.

Standard classroom training was conducted at the hospital by trained instructors. Caregivers practiced skills on manikins and received verbal instructions about how to respond to common tracheostomy emergencies. Standard training also included CPR. All caregivers had ample opportunity to practice skills on their child under clinical supervision.

Those caregivers who participated in simulation were first briefed on the expected scenarios. Each simulation participant entered a room where the HPS was either decannulated or had an occluded tracheostomy tube. Participants were instructed to react without prompting and caregiver proficiency was evaluated with the standard competency task checklist described previously. If the caregiver's actions were incorrect, the instructor reviewed the correct steps and the scenario was repeated. All simulation participants completed each scenario; both scenarios concluded with the initiation of CPR.

Analysis

Caregiver Confidence and Competence

Distortions measuring change between baseline and post-test with ordinal ratings (Bezruczko, Fatani, & Magari, 2016) were addressed in this research by transforming rating scale responses (54 items) to a linear, logit (log-odds) Rasch scale (Wright & Masters, 1982) with Winsteps software (Linacre, 2015). Mean confidence differences were then examined in a quasiexperimental 2 (time) $\times$ 2 (training) repeated measures ANOVA where time (baseline and post-test) and training (simulation and nonsimulation) were independent factors. For this research, 53 simulation caregivers provided baseline ratings, which were matched with 23 post-test ratings, whereas 48 nonsimulation caregivers were matched with 46 post-test ratings (see Table 2.) Summed competency ratings were also transformed to linear measures and correlated with confidence measures. All analyses were conducted with IBM SPSS version 23.

Missing Values

After matching baseline and post-test cases, missing values appeared in less than 3% of confidence ratings, which were distributed completely at random across standard training and simulation groups. Therefore, mean value substitution was implemented to accommodate those missing values and a caregiver with several missing competency ratings. Inspection-indicated variances and covariances were unaffected by imputations.

Obtained baseline and post-test confidence ratings were compared for 69 caregivers. However, only a subset provided baseline competency ratings ($n = 32$, 46%). Consequently, a hot deck regression method using baseline confidence ratings was implemented to predict missing baseline competency measures (Little & Rubin, 2002).

Table 2 Participants

$n = 103$	Completed Confidence Survey—Baseline	Completed Confidence Survey—Post-test	Attrition
Simulation group	53	23	30 (45%)
Nonsimulation group	48	46	2 (4%)

Results

Caregiver Confidence Measures

Simulation ($M = 192.01$, $SD = 47.63$, $SE = 6.54$, n = 53) and nonsimulation ($M = 201.27$, $SD = 44.15$, $SE = 6.37$, n = 48) confidence means did not differ significantly at baseline, which ranged between 89 and 267 raw score points. Post-test simulation confidence was higher ($M = 254.42$, $SD = 14.17$, $SE = 2.95$, n = 23, 95% CI [239.40, 270.24]) than nonsimulation ($M = 239.99$, $SD = 26.24$, $SE = 3.89$, n = 46, 95% CI [228.81, 251.70]). A time × training interaction was statistically significant, ($F_{(1,166)} = 3.68$, $p < .05$), indicating simulation ratings shifted significantly at post-test. Standardized effect size of post-test difference was large ($d = 0.78$). Hierarchical regression of time, training, and time × training interaction accounted for approximately 30% of confidence variance, and R^2 change attributed to interaction was significant ($R^2 = 1.1\%$, $F_{(1,\ 166)} = 24.2$, $b = -16.09$, $p < .05$),

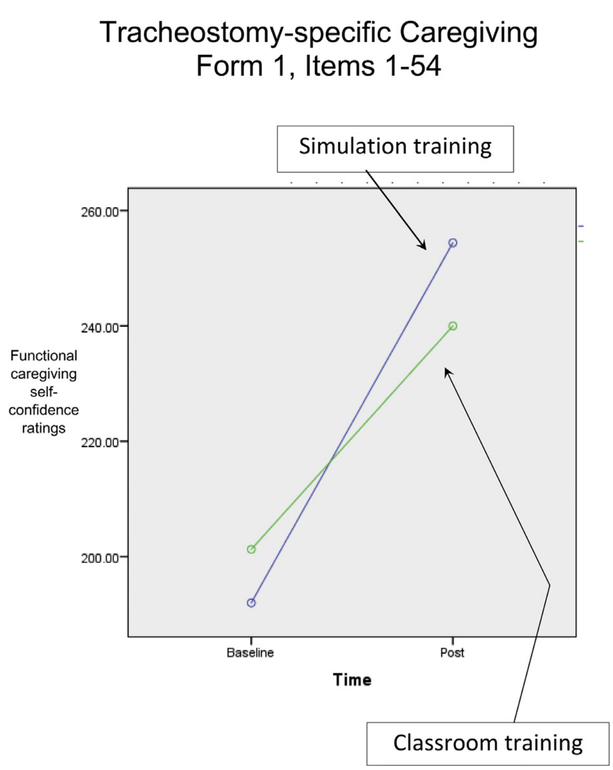

Figure Plot of caregiver self-confidence ratings at baseline and post-test assessments.

95% CI [−35, 2.98]. Figure presents time × training interaction. These results replicate several prior studies (Chen et al., 2006; Bezruczko et al., 2009, 2011) that investigated hierarchical invariance across key socioeconomic factors. Alpha reliability of caregiver confidence in the present research was 0.98. To accommodate concerns about violation of homogeneity, Levene's test, $p < .001$, and the χ^2 test of independence were conducted, which confirmed post-test simulation confidence was proportionately greater than nonsimulation, $\chi^2 = 4.73$, $df = 1$, $p < .05$. Likewise, point-biserial correlation between confidence ratings and training group after post-test was significant ($r = 0.30$, n = 71, $p = .01$). These results were replicated when baseline and post-test simulation participants were matched to eliminate unequal n's.

Competency

Although the emphasis in training was to establish competency on all tasks in the standard checklist, few caregivers were successful on their first attempt. Although all caregivers were ultimately able to demonstrate proficiency on all skills before leaving the simulation, competency ratings in this research were only based on results of their first attempt at completing the standard checklist collected at baseline.

Reliability of a competency total score in the present study based on 11 items was 0.76, which is generally considered adequate for research purposes. After standard training, overall competency mean was 8.93 ($SD = 1.48$, n = 69). Three caregivers performed below the test floor, whereas nine exceeded the ceiling. Correlations of obtained baseline competency measures (nonsimulation = 17, simulation = 15) with baseline confidence ($r = 0.002$, n = 32, $p = .99$) and post-test confidence ($r = -0.20$, n = 32, $p = 26$), respectively, were not statistically significant. Likewise, correlation between baseline competency and gain (post-test−baseline confidence = gain) was not significant ($r = -0.13$, n = 32, $p = .46$). When missing competency data were imputed, baseline competency and post-test confidence increased significantly ($r = 0.52$, n = 69, $p < .001$), and the correlation between competency and gain was also significant ($r = -0.8$, n = 69, $p < .001$).

ED Visits and Mortality

The mortality odds ratio (OR) of simulation and nonsimulation was significant ($p < .05$). Observed OR was

4.71, SE (log OR) = 0.247, 95% CI [0.19, 1.13] (see Bland & Altman, 2000). Mortality in family homes was almost 5 times higher for children whose caregivers did not participate in simulation than for those who did. Two children of 12 whose caregivers attended simulation died because of a tracheostomy emergency, whereas only one child of 25 whose caregivers attended simulation died because of a tracheostomy emergency. Results of the follow-up survey of children in homes are presented in Table 3. Correlation between Functional Caregiving confidence measures and child mortality in homes was in the expected direction ($r = -0.15$, n = 37, $p = .38$); likewise, correlation between confidence and training was positive ($r = 0.22$, $p = .20$, n = 37) when coded dichotomously (nonsimulation = 0, simulation = 1).

Discussion

Simulation Effect on Confidence

A challenge in this research was demonstrating the unique contribution of simulation to confidence when standard classroom training was already perceived to be very effective. In general, some caregivers declined simulation for that reason. Although standard training confidence ratings increased substantially between baseline and post-test, results here showed a significant incremental increase for caregivers participating in simulation. In the context of Functional Caregiving, these caregivers felt confident enough in caring for their child's tracheostomy needs; they began to seek out community resources such as parent support groups and tracheostomy programs. Additional qualitative research is needed here to clarify and elaborate simulation benefits beyond the parametric results reported here.

How are Confidence and Competence Related?

The prevailing expectation in nursing research that competency and confidence converge as caregivers gain experience remains reasonable, yet results here suggest their inter-relations are probably not uniform across homes. The low correlation between competency and confidence after classroom training was unexpected, but realistic imputations suggest larger studies may find a stronger relationship between them. Imputed results here also suggest confidence increases more for those lowest in baseline competency. In general, these results are consistent with a growing literature on self-perceptions and objective performance pointing to complex relations between confidence and competency. Clinical implications raise concerns about validity of caregiving assessments based solely on competency or confidence in isolation.

Table 3 ED Visits and Mortality From Tracheostomy Emergencies

DATA	Simulation (n = 25 Patients)	Nonsimulation (n = 12 Patients)
ED visits due to tracheostomy emergency	8	4
Caregiver responded appropriately to emergency (self-reported)	7	2
Mortality due to tracheostomy emergency	1	2

Note. ED = emergency department.

Effect of Training on ED Visits and Mortality

A surprising result was that ED visits increased after simulation (Table 3). Despite a small sample, these results suggest simulation may make caregivers more sensitive to their child's distress and more likely to use the ED than expected.

A major outcome of this research is recognition that simulation significantly decreased mortality of children with tracheostomies. Mortality in this study was almost five times greater for children whose caregivers only had traditional classroom training. Further research is needed with larger samples to verify this outcome and clarify clinical implications of simulation for caregiver and patient education.

The high percentage of caregivers who completed standard training but were unable to perform emergency skills during their first simulation evaluation is cause for concern. Based on outcomes reported here, caregivers who do not receive simulation training may not be able to optimize their response in an emergency. A benefit of simulation may be enhancement of caregiver readiness to respond appropriately in a "real" emergency.

Limitations

A central concern in understanding the implications of this research is clarifying differences between those caregivers who attended simulation and those who did not. Participants who did not attend simulation declined for various reasons including (a) preparations related to taking their child home overwhelmed some participants; (b) other caregivers already felt comfortable in knowing what to do; (c) the child was transferred to another hospital or extended care facility; (d) the child was discharged to a caregiver who had not consented to participate in the study; and (e) the child died during the hospitalization before completion of training. In general, we did not detect any specific themes or characteristics that would define an inferential link between this sample and the broader population of simulation participants.

The timing of the phone surveys was between 6 and 18 months after discharge so was not the same for all. This contributed to variation in the length of time a child might have had to experience an emergency. Therefore, return visits to the ED or the caregiver's self-reported confidence and competence at responding to an emergency may be underrepresented.

Finally, competency in this study was based on a psychometric subset of more diverse items that were originally developed for clinical evaluation. While the assessment here cast doubt on common assumptions about confidence and competency, substantial research is needed to extend this construct and demonstrate its instrumental role in preparing caregivers and reducing mortality.

Conclusions

Simulation increases confidence, comfort, and may contribute to caregivers' appropriate responses during common tracheostomy emergencies. Relations to competency are less clear.

Practical clinical implications of this research are both higher caregiver confidence after simulation and lower child mortality in family homes. Simulation appeared to improve caregiver competency to respond to common tracheostomy emergencies after discharge.

Learners remember about 50% of what they see and hear from passive instruction, such as watching a demonstration, whereas they remember 90% of what they say and do from active instruction such as taking part in a simulation (Dwyer, 2010). If caregivers encounter a tracheostomy emergency, simulation may increase their ability to respond appropriately.

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