The American Journal of Surgery 217 (2019) 562–565

Contents lists available at ScienceDirect

The American Journal of Surgery

journal homepage: www.americanjournalofsurgery.com

The emergency surgical airway: Bridging the gap from quality outcome to performance improvement through a novel simulation based curriculum

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ARTICLE INFO

Article history:
Received 23 July 2018
Received in revised form
13 September 2018
Accepted 17 September 2018

Keywords:
Surgical education
Simulation
Emergency airway
Cricothyroidotomy
Quality improvement
Patient safety

ABSTRACT

Background: Emergency surgical airway is a low frequency, high risk clinical scenario. Implementing a simulation-based curriculum may bridge the gap in surgical training and address quality assurance/performance improvement (QAPI) needs.
Methods: We designed and implemented an Advanced Surgical Airway Curriculum (ASAC) modeled after proficiency-based training. General Surgery residents and student nurse anesthetists were enrolled. Evaluation consisted of cognitive tests, procedure checklists and questionnaire.
Results: In total, 78 participants successfully completed the ASAC. Trainees agreed that the curriculum provided the cognitive and psychomotor skills necessary to perform both an open and needle cricothyroidotomy.
Conclusions: In the age of increased patient safety concerns, QAPI initiatives can serve as a driver for simulation-based training curricula, with particular focus on individualized, active learning. This may be particularly useful in high risk, low frequency scenarios in which the traditional method of "See one, Do one, Teach one," is not feasible.

Introduction

Simulation has become a cornerstone in surgical education, with dedicated simulation experience now required by the Accreditation Council for Graduate Medical Education for all surgical programs. The advent of the 80-h work week, combined with the continued five-year training paradigm, has created a gap in surgical training and experience.[1] We have certainly observed a shift from the Halsted inspired, "See one, Do one, Teach one," to a more active, contextualized process of constructing knowledge and entrusting task performance. The role of simulation in education is evolving with strong and varying opinions as to the ideal how, when, and whom concerning design and implementation.[2] Several studies have strived to determine the best form of curriculum implementation and in the process, outline the various challenges faced.[3,4,5,6] While the ideal form of implementation is debated, it is likely that simulation will remain embedded in surgical education for many years to come.[2]

In addition to the gap in surgical training experience, a large driving force for surgical simulation is patient safety.[3] In the present healthcare environment, hospital administrators are now focusing on certain quality measures linked to patient outcomes and process of care, since payments are increasingly tied to outcome measures (i.e. catheter and central line related infections). Surgical simulation aims not necessarily to replace hands-on training and experience, but to augment the traditional taxonomy of learning by providing deliberate opportunities for practice outside of the operating room.[7] The goal is to decrease the learning curve in both low frequency and high risk surgical procedures, with the hope of improving patient safety and outcomes.

Materials and methods

Curriculum development

The residency advisory committee (RAC) of the department of Surgery at Rush University Medical Center initiated a proficiency based curriculum during the 2016/2017 Academic year. This

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https://doi.org/10.1016/j.amjsurg.2018.09.026
0002-9610/

curriculum, following guidelines from the American College of Surgeons (ACS) division of education, focused on common ICU procedures including needle cricothyroidotomy, arterial line placement, central venous catheter placement, and tube thoracostomy.[8] Initially, this curriculum focused on junior surgical residents (PGY-1 and 2). During this same year, the Institutional Quality Committee at our institution identified a quality gap in the care of patients requiring an emergency surgical airway. As this procedure can be considered a high risk, low frequency scenario, an opportunity for improvement arose.

A curriculum task force was formed, composed of members of a multidisciplinary team, each with at least five years of experience in healthcare simulation. We postulated that the development of a simulation-based curriculum could bridge the existent gap in multidisciplinary training for this procedure, hence, potentially improving patient safety. The committee expanded the airway component of our proficiency based curriculum to all surgical residents, anesthesia residents (pilot study) and the student nurse anesthesia program. In addition to needle cricothyroidotomy, open surgical cricothyroidotomy was included, thereby creating the Advanced Surgical Airway Curriculum (ASAC).

Curriculum content

The ASAC consists of (1) a cognitive component: online videos, slide presentations, and atlas chapters; and (2) a psychomotor component: proctored practice session using pig larynxes and inanimate models for the needle and surgical cricothyroidotomies. Formative and summative assessments consisted of a written test, based on the didactic component and a hands-on simulation based mastery examination, utilizing a pre-defined checklist. This checklist was modified from the ACS educational resource section (Fig. 1).[8]

Participants first reviewed the online didactic component and practiced the procedure on a simulated model, followed by a multiple-choice test and a hands-on surgical airway procedure. The effectiveness of training and demonstration of mastery was documented via both a performance checklist, as well as a global assessment rating of the trainees completed by the proctor. Proctors were members of the curriculum task force or trained staff within the Simulation Center. This global assessment rating tool was based off both Objective Assessment of Technical Skills (OSATs) and Global Rating Scales used by the ACS[8] (Fig. 2). All participants completed a post-training survey.

Resources

The development and implementation of our ASAC incurred an estimated cost of six thousand dollars for equipment and supplies with a cost of eight to nine thousand dollars for staff time. Our institution houses a Center for Clinical Skills and Simulation with funding budgeted to each department on a yearly basis by the Medical College and the University, assisting with these costs. Total time for curriculum development was 10 h. The active time commitment for the learners (two hours per year) is built into protected educational time and thus does not interfere with clinical responsibilities. The proctoring time commitment for staff is also two hours per year, with most staff having teaching/simulation responsibilities clearly established.

Statistical analysis

Data was analyzed using SPSS. Surgery resident and student nurse anesthetist global rating scores were compared using paired *t*-test. This study was categorized as Quality Improvement and was therefore considered exempt by our institutional review board.

Results

Following a pilot course given to senior anesthesia residents, 78 participants completed the ASAC, out of which thirty-two participants were junior (PGY-1 or PGY-2) surgical residents: nine (9) PGY-2 categoricals, eight (8) PGY-1 categoricals, and fifteen (15) PGY-1 preliminary residents. Twenty-four participants were senior (PGY-3, PGY-4, or PGY-5) surgical residents, all of them categorical. The remaining 22 participants were student nurse anesthetists. Within the junior resident group, the ASAC was embedded in the introduction to a proficiency-based curriculum. Both the student nurse anesthetist and senior surgical contingents completed the formalized ASAC near the mid-year point.

The written test was completed by 82% of participants. The Student Nurse Anesthetists had the highest completion rate at 100%, followed by junior surgery residents (88%), and finally by senior surgery residents (42%).

Every participant completed the required identified steps on the mastery check list during the final proctored exam within the allotted time (300 s for surgical cricothyroidotomy and 180 s for needle cricothyroidotomy). Posttest survey showed that the junior residents and student nurse anesthetists had no prior experience performing any type of emergency surgical airway, while senior residents had limited exposure.

Using the global assessment tool (Fig. 2), all 24 senior surgical residents obtained a 5 for needle cricothyroidotomies, with each PGY class (3–5) achieving a median score of 5. The mean score for the Student Nurse Anesthetist's for needle cricothyroidotomy was 4.86. There was no statistical difference between scores from surgery residents and student nurse anesthetists for needle cricothyroidotomy ($p = 0.065$). For open cricothyroidotomies, the PGY-3 class had a mean score of 4.75, the PGY-4 class had a mean score of 4.875, and the PGY-5 class had a mean of 5. The Student Nurse Anesthetist's had a mean score of 4.72 for open cricothyroidotomies. Again, no statistical difference was seen between scores from surgery residents and student nurse anesthetists ($p = 0.245$). Trainees agreed that the curriculum provided the cognitive and psychomotor skills necessary to perform both an open and a needle cricothyroidotomy on the posttest survey.

Discussion

K. Anders Ericsson in his address “Deliberate Practice and the Acquisition and Maintenance of Expert Performance in Medicine and Related Domains.” defined principles that are applicable to the use of simulation in surgical education.[9] Several other authors have described the crucial elements required in simulation-based curriculum design, including Aggarwal, Stefanidis and Heniford.[3,10] They describe a framework that combines cognitive learning with simulation, allowing for training to proficiency using Ericsson's deliberate practice via a regimented practice schedule.

More recently, both Cristancho and Zevin have detailed specific frameworks with the hopes of standardizing the design and implementation of simulation based curriculum, noting the numerous challenges in successfully implementing such curricula.[3,5] Zevin and colleagues attempt to standardize this process and develop, “A Consensus-based framework for design, validation, and implementation of simulation-based training curricula in surgery”.[3] Using international expert consensus based on the Delphi method, a final framework was derived. This included predevelopment analysis; cognitive, psychomotor, and team-based training; curriculum validation and improvement; and maintenance of training.[3] We applied these principles by deconstructing each procedure into key steps, building a checklist, and providing cognitive material to further cement a safe implementation of the ASAC.

Procedural Skills Evaluation
Surgical Cricothyroidotomy

FACE MASK with SHIELD, GOWN AND STERILE GLOVES MUST BE WORN.

1. Wash Hands	__Done __Not Done
2. Perform "Time Out" immediately before beginning procedure (can be omitted – urgency of procedure)	__Done __Not Done
3. Assemble and prepare all necessary equipment	__Done __Not Done
4. Prep patient by placing patient supine, with neck in neutral position	__Done __Not Done
5. Clean patient's neck with Chlorhexidine or Betadine swabs	__Done __Not Done
6. Stabilize larynx with left thumb and middle finger, while moving index finger down till you palpate cricothyroid membrane anteriorly between the thyroid and cricoid cartilage	__Done __Not Done
7. Make a 2 to 3cm midline vertical incision through the skin from the caudal end of the thyroid cartilage to the cephalic end of the cricoid cartilage ***DO NOT LET GO OF LARYNX OR LET IT MOVE****	__Done __Not Done
8. Make a 1 to 2cm transverse incision through the cricothyroid membrane	__Done __Not Done
9. Insert the scalpel handle into the incision and rotate 90°. *(A hemostat may also be used to open the airway)*	__Done __Not Done
10. **"At what depth do you extend the blade down into the trachea to avoid going through the trachea into the esophagus?"** Correct Response: "No more than 1.3cm deep"	__Done __Not Done
11. Insert a tracheal hook into the opening (if available), hooking the caudal end of the opening, and lift, allowing for passage of an appropriately sized cuffed endotracheal or tracheostomy tube (usually No. 4). Directing the tube distally. *Alternatives:* • Insert the tube through the opening produced by the opened hemostat • Holding the handle of the scalpel straight down in the opening, slide handle cephalically and insert the tube straight down along the handle until it hits the back of the trachea. Then, angle the tube caudally and advance the tube.	__Done __Not Done
12. Inflate cuff with 10cc of air with syringe.	__Done __Not Done
13. Attach BVM to tracheotomy and ventilate patient. **"What must you check next?"** Correct Response: "Auscultation lung sound and check for equal chest rise and fall, Check Pulse Ox and/or End tidal CO2 readings"	__Done __Not Done
14. Secure the airway **"Once completed what do you order and why?"** Correct Response: "A chest x-ray to confirm placement."	__Done __Not Done
15. Dispose of all Sharp and Biohazard material into appropriate containers	__Done __Not Done
16. **"What must you do after procedure and orders are placed?"** Correct Response: "Document in chart."	__Done __Not Done

Total Missed = _____

Fig. 1. Procedural skills checklist for surgical airway.

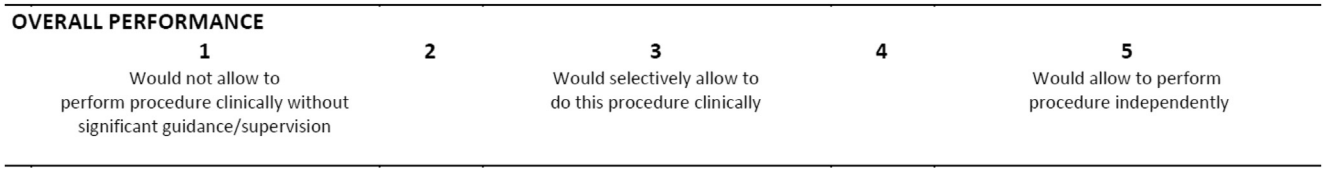

Fig. 2. Global rating assessment. Borrowed from ACS/APDS surgery resident skill curriculum.

The difficulties in successfully designing, implementing and maintaining a simulation based curriculum are well documented. Cristancho and colleagues report issues specific to implementation. These include a lack of objective identification of training needs, lack of systematic design methodology, lack of structured assessments of performance, and lack of research-centered evaluation.[5] In "Simulation in Surgery: What's Needed Next?" Stefanidis and colleagues identified three challenges: the first was inadequate allotment of human resources, the second was that of integrating simulation based training into the educational curriculum in a meaningful and effective manner, and the final challenge was logistical barriers commonly faced, specifically that of cost.[4]

We faced many of the challenges discussed above. While the design of our ASAC was not difficult based on past research, excellent framework designs available, and resources available through the division of education of the ACS; implementation, validation, and maintenance remained most challenging. We feel this is especially true in the scenario we chose to address, the emergency surgical airway. This scenario constitutes a great example of a high risk, low frequency situation. While this is an ideal scenario for simulation in the fact that we can create high volume opportunities for deliberate practice, challenges exist in validation and maintenance.

Our study has several limitations. The first is in the reproducibility and practicality of such a curriculum. The authors acknowledge that our ASAC may not be reproducible at other institutions for a variety of reasons, including both financial and staffing. This is especially true for a scenario that is infrequently encountered. It is our vision to offer this curriculum to smaller hospital systems at our Center for Clinical Skills and Simulation, obviating the need for them to develop this on their own. Another limitation is that of skill degradation over time. It is well established that one time interventions are susceptible to this. To address this, we have added the ASAC to our yearly curriculum for the surgery residents.

As discussed earlier, the gold standard in outcomes remains improved patient safety.[3] Another limitation is that while theoretically we feel this simulation based curriculum should translate into enhanced safety, we have no data to support this. It is unlikely that significant data to support this assertion can be gathered, given the low frequency of these situations. We identified five instances of need for an emergency surgical airway in the past 8 years at our institution. It is difficult to track these occurrences in real time as Electronic Medical Record data regarding emergent airways is fraught with challenges and often not documented correctly by common identification methods (CPT and ICD-9/10 codes). Furthermore, the frequency of these occurrences is so low, it would likely take both a significant time period and multi-institutional cooperation and incorporation of our ASAC to ever reach statistical significance. While we feel the development of this novel curriculum is both logical and appropriate, the true translation to improve outcomes in patient care may be nearly impossible to ascertain. Our focus should be on trainee knowledge, practical skills, and comfort level in assessing the effectiveness of the curriculum and allowing for further improvement and maintenance.

Conclusion

In an age of increased safety concerns and measures, QAPI initiatives can serve as a driver for simulation-based training curricula. We demonstrated the feasibility of designing and implementing a mandatory surgical airway course, highlighting the challenges faced. While clinical scenarios that are high risk, low frequency are well suited for simulation based training, measuring the effectiveness of the simulation via patient outcome metrics remains elusive.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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