Simulation is an accepted teaching tool that focuses on active learning and is used to solidify cognitive, motor, critical thinking, and communication skills. This method of experiential learning was introduced and integrated into the distance-based degree completion program for practicing anesthetists at the University for Development Studies (UDS), Tamale, Ghana. Because of scarce resources, a simulated trachea was created for teaching students how to perform a needle cricothyrotomy and use a retrograde wire to secure an airway. Students were oriented to the materials, taught to construct the simulated trachea, and encouraged to consider local, inexpensive resources for equipment substitutions as necessary. Students were guided through the steps of performing a needle cricothyrotomy and retrograde wire intubation using the simulated trachea. Following deliberate practice, the practicing anesthetists were encouraged to instruct fellow anesthesia colleagues on the use of these techniques and create additional simulation equipment that would aid in teaching or refining various skills of Ghanaian anesthetists and training future anesthetists.

Appropriate for their initial simulation-based learning, the low-fidelity simulated trachea was a reasonable, low-cost approach that aligned with the established learning objectives. All participants reported satisfaction with and increased confidence levels following the simulation-based learning experience.

Keywords: Education, needle cricothyrotomy, retrograde wire, simulation, trachea.
Because of scarce resources, faculty in developing countries are challenged to provide their students with simulation experiences. With this in mind, the simulated trachea was created for teaching students how to perform a needle cricothyrotomy and use a retrograde wire as last resorts for securing a difficult airway.

**Materials and Methods**

Supplies needed to create the simulated trachea included the following: inner cardboard tube of a toilet tissue or paper towel roll, 3.8-cm ribbed pencil grippers ($1.39 per 5-pack), adhesive tape ($2.35 for 2 rolls), Esmarch bandage (Tetra Medical Supply Corp) donated by U.S. stateside hospitals (7.6 × 270 cm [3 in × 9 ft] = $2.73), 3-mL syringe (donated), 14- or 16-gauge angiocatheters or needles (donated; approximately $3.24 per angiocatheter in the United States), optional small balloon (bag of 20 = $4), guidewire (donated), and scissors (Figure 1).

The steps to create the simulated trachea are as follows:

- **Step 1.** In the center of the cardboard tube, cut a 2 × 0.5 cm rectangular hole (Figure 2). Paper towel rolls may be divided in half (13.9 cm [5.5 in]) before cutting the center hole.
- **Step 2.** Cut the pencil gripper in half longitudinally (Figure 3).
- **Step 3.** Spread the pencil gripper and place it over the rectangular hole in the cardboard tube (Figure 4).
- **Step 4.** Tape the pencil gripper to the cardboard tube with one piece of tape at each end but not in the center of the pencil gripper (Figure 5).
- **Step 5.** Cut a 6 × 6 cm piece of Esmarch dressing, wrap it around the entire cardboard tube and tape it on the side opposite the rectangular hole and pencil gripper (Figure 6).
- **Step 6 (Optional).** In attempts to simulate the surge of air release that occurs when the needle enters the trachea, inflate a small balloon with minimal air such that once inflated, it does not exceed the inner diameter of the cardboard tube. Tie off the balloon and place it in the center of the cardboard tube under the rectangular hole (Figure 7).

See Figures 8, 9, and 10 for the initial cricothyrotomy puncture, advancement of the angiocatheter cover in lieu of an endotracheal tube, and advancement of the endotracheal tube over the retrograde wire.

In the Ghanaian classroom, UDS anesthesia students, comparable to student registered nurse anesthetists in the United States, were oriented to the materials and taught to construct the simulated trachea using the steps listed. They were encouraged to consider what inexpensive resources were readily available in their own country if equipment substitutions were necessary. Students were
then guided through the steps of performing a needle cricothyrotomy and a retrograde wire intubation using the simulated trachea.

**Results**

A total of 15 UDS students participated in the simulation activity. Following the completion of the exercise, students were asked to fill out an anonymous survey to assess their simulation experience. The Student Satisfaction and Self-Confidence in Learning survey consisted of 13 questions, with data collection at the ordinal level as follows: strongly agree, agree, undecided, disagree, and strongly disagree. The purpose of the survey was to obtain information about each participant's personal attitudes...
regarding satisfaction with the learning experience and his or her perception of self-confidence in the skill taught using simulation. Additional demographic information was gathered from surveys conducted during associated projects. The data collected were entered into a spreadsheet and analyzed.

Of the 15 participants, 9 were men and 6 were women. The average age was 35.6 years (range, 30-54 years), and the average years of experience as a nurse anesthetist was 5 (range, 2-12 years). Overall, the students in this group reported the experience as a positive learning opportunity. When addressing satisfaction with the simulation, all students reported that the teaching methods were helpful and effective (93.3% strongly agree, 6.7% agree), believed that they were provided with a variety of learning materials to promote learning (73.3% strongly agree, 26.7% agree), and the simulation was taught suitable to the way they learned (66.7% strongly agree, 33.3% agree). Most students enjoyed the experience (66.7% strongly agree, 26.7% agree) as well as found the materials motivating and helpful (80.0% strongly agree, 13.3% agree). In addition, all students reported increased confidence in mastering content (33.3% strongly agree, 66.7% agree) as well as developing skills for clinical practice (73.3% strongly agree, 26.7% agree).

Discussion
The goals for this simulation exercise were 5-fold and aimed to teach UDS students and faculty how to: (1) prepare a simulated trachea; (2) perform a needle cricothyrotomy; (3) develop confidence in the use of a retrograde wire; (4) instruct fellow anesthesia students and colleagues on the use of these techniques; and (5) unleash their creativity for future development of additional simulation equipment that would aid in teaching and learning.

Simulation equipment is expensive and not readily available to students in developing countries. Creative solutions are needed to provide students with simulation-based learning opportunities. This simulation experience not only allowed Ghanaian students to create and use a tool for deliberate practice in learning the steps of needle cricothyrotomy and retrograde wire intubation but also stimulated their creativity for developing additional simulation tools at little to no cost with locally available and donated resources.

It is recommended that the introduction of simulation be a gradual process beginning with low fidelity and progressing to high-fidelity simulated learning experiences. For the students’ initial simulation learning experiences, the low-fidelity simulated trachea was an appropriate, low-cost approach for the established learning objectives. The self-reported increased confidence suggests that students learning objectives were met, although reassessment of skill and confidence is needed to ensure long-term learning outcomes.

Conclusion
The simulated trachea made from a cardboard toilet tissue roll was an innovative creation used to introduce UDS students to not only new skill sets for critical airway management but also a new teaching/learning method of simulation. This trachea allowed deliberate practice of a new skill that would advance the clinical and educational component of anesthesia practice. Although this simulated trachea was designed in preparation for simulation training in a developing country, it is a low-cost item that has utility for students and providers across the globe who wish to further develop their skills.

REFERENCES

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