Comparison of Manikin Versus Porcine Trachea Models When Teaching Emergent Cricothyroidotomy Among Emergency Medicine Residents

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ABSTRACT

Objectives: Emergent cricothyroidotomy (EC) is a rarely used yet lifesaving procedure that is important for an emergency physician to master throughout his or her training. We evaluated the difference in utilization of a manikin or porcine model among emergency medicine (EM) residents when teaching EC. We also evaluated the difference in the models using two different commonly utilized and taught techniques: “scalpel-finger-bougie” (SFB) technique and the Melker technique (MT).

Methods: This was a prospective crossover design. Instructions about the procedure were provided; study participants were randomly assigned to one of two groups and performed cricothyrotomy on both manikin and porcine simulators using both the Melker and the SFB techniques. Each group was started with the technique on the second simulator opposite what they started with on the first simulator. After the procedures, study participants completed a questionnaire that used the same format for both groups. All survey questions required a 7-point Likert scale response. Confidence, difficulty, reality of the anatomy, and landmarks were compared.

Results: Fifteen EM residents participated in the study. Compared to the porcine-first group, the manikin-first group rated the anatomy more realistic (question 5) after their first attempt (6.29 vs. 5.87) than their second attempt (using the porcine model; 4.29 vs. 5.62; main effect for attempts [first vs. second] $p = 0.027$; interaction $p = 0.074$). Interestingly, the porcine model–first group rated the landmarks (question 6) significantly easier to find in both attempts (6.87 vs. 5.86 on the first attempt and 6.50 vs. 5.57 on the second attempt; $p = 0.012$). Twelve participants (80%) chose SFB as their preferred technique to use in real-life scenario.

Conclusion: The Manikin model tends to be more realistic in cricothyrotomy simulation than the porcine model. The influence of fresh pig skin overlying the porcine model may require further research. Landmark identification during the procedure was easier on both models when participants start with the porcine model. Participants prefer the SFB over MT if faced with a real-life scenario.

Emergent cricothyroidotomy (EC) is a lifesaving procedure that is performed when endotracheal intubation has failed. This most commonly occurs when a patient has a difficult airway and cannot be intubated or ventilated. This procedure has been described using

several different techniques. EC has traditionally been described in an open technique using a tracheal hook and dilator.¹ This open technique is traumatic and may be difficult to perform in the emergency department (ED). A modified open technique utilizing a

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scalpel, gum elastic bougie, and finger as a dilator has been described. This procedure has been coined the “scalpel-finger-bougie” (SFB) technique and is frequently taught as it can be performed with minimal equipment. Also, multiple manufacturers make kits utilizing the Seldinger technique to perform this same procedure in efforts to reduce trauma. One of the more commonly used Seldinger techniques is referred to as the Melker technique (MT). Previous research evaluating which technique is superior has been limited and has been unable to show a significant difference in one EC technique over another.²

Emergent cricothyroidotomy has become very difficult to teach novice learners such as emergency medicine (EM) residents as they are sparsely exposed to this procedure in clinical practice. The majority of resident training on this procedure is simulation focused.³ The EC procedure is traditionally taught and practiced utilizing a manikin. To make this simulation more realistic it is also taught in cadaver labs; however, they are expensive and logistically difficult.⁴ Due to these limitations the use of porcine tracheas can be used to simulate this procedure in an effort to make it more realistic.⁵ Thus far, research comparing the use of different simulators has been limited.

The goal of our study was to evaluate the difference in utilization of a Manikin or porcine model among EM resident when teaching EC. We also evaluated the difference in the models using two different commonly utilized and taught techniques.

METHODS

Study Design

This was a prospective crossover design. Instructions about the procedure were provided at a didactic session explaining indications, contraindications, anatomy, and complications of each technique using a 20-minute video. Participation in the training experience and study was voluntary, and verbal consent was obtained prior to training. Participants were offered and could have had the training without study participation. Following the video session, study participants were randomly assigned to one of two groups and performed cricothyrotomy on both manikin and porcine simulators using both the Melker and the SFB techniques. To control for bias with respect to technique each group was started with the opposite technique on the second simulator than they started with on the first simulator.

Larynxes from slaughtered pigs were provided for the porcine simulator. Prelaryngeal tissue was eliminated from the larynx. Pig skin was not provided. All porcine models were provided utilizing preserved pig tracheas procured from a healthcare simulation wholesaler (Figure 1). The Simulab TraumaMan was used as the Manikin simulator. Intact synthetic skin was provided for each resident (Figure 1). Study participants were monitored during the entire procedure by the primary investigator to ensure proper technique.

After the procedures, each group was verbally consented for participation in the study. They then completed a questionnaire that used the same format for both groups. All survey questions required a 7-point Likert scale response. This study was approved by Charleston Area Medical Center Institutional Board Review.

Data Analysis

Data are reported as a number (%) or mean. The survey score of each model were compared with a repeated-measures analysis of variance test using SPSS (IBM Corp., Released 2010, IBM Statistics for Windows, Version 19.0). A p-value of <0.05 was considered statistically significant. The current study resulted in a 2-by-2 factorial design where the first factor was the type of model (manikin vs. porcine) and the second factor was the order of the attempts (first vs. second). Therefore, the results were tested for main effects for each factor (type of model and order of attempt). The main effect for each factor was the effect of one independent variable on the dependent variable, ignoring the effects of other independent variable. In addition, the results were tested for a possible interaction between the two independent variables (type of model and order of attempt). A statistical interaction could occur if the effect of one independent variable on the dependent variable is influenced by the level of the other independent variable.

RESULTS

Study participants consisted of 15 EM resident physicians, four PGY-1 (26.7%), four PGY-2 (26.7%), four PGY-3 (26.7%), and three PGY-4 (20%). Eight (53.3%) participants had previous cricothyrotomy training experience with manikin model only; five (33.3%) participants had previous cricothyrotomy training experience with both manikin and porcine models one (6.7%) participant had previous cricothyrotomy training experience with manikin, porcine model, and actual patient; and

Figure 1. (A) Cricothyroidotomy performed on a porcine simulator using the MT. (B) Cricothyroidotomy performed on a porcine simulator using the SFB technique. (C) Porcine simulator: a pig larynx and trachea. (D) Manikin simulator: the Simulab TraumaMan. (E) Manikin simulator: the Simulab TraumaMan with intact synthetic skin. MT = Melker technique; SFB = scalpel-finger-bougie.

one (6.7%) did not have any previous cricothyrotomy training experience. Eight (53.3%) candidates started with the porcine model first and then switched to the manikin; the other seven (46.7%) started with manikin first then switched to the porcine model.

We found no significant differences between the two groups (manikin model first or porcine model first) in terms of the questions that related to confidence and difficulty (the first four questions of the survey; Table 1). All participants performed both techniques (SFB and MT) on both types of models (manikin and porcine; see Figure 2).

The porcine model–first group rated the landmarks (question 6) significantly easier to find (6.69 vs. 5.71,

$p = 0.012$; see Table 2). There was a significant reduction for both groups for rating the models as being realistic to the human anatomy (question 5) after performing two attempts ($p = 0.027$; see Table 3). The manikin-first group rated the anatomy more realistic (question 5) after the first attempt (6.29) compared to

Table 1
Survey Questions for Each Model

Q1	Confidence after the MT
Q2	Confidence after the SFB technique
Q3	Difficulty after the MT
Q4	Difficulty after the SFB technique
Q5	Realistic anatomy
Q6	Landmarks

Final question: “After taking this training, which technique would you prefer to use in a real-life scenario?”
MT = Melker technique; SFB = scalpel-finger-bougie.

Figure 2. Emergent cricothyroidotomy training flow chart. MT = Melker technique; SFB = scalpel-finger-bougie.

Table 2

Mean Survey Scale Scores by Type of First Model, Manikin Versus Pig (Main Effect for Model)

	Manikin First		Porcine Model First		Overall		p-value
	Mean	SD	Mean	SD	Mean	SD	
Q1	6.00	0.96	5.81	1.11	5.90	1.03	0.737
Q2	6.29	0.61	5.94	1.06	6.10	0.88	0.460
Q3	1.86	0.86	2.00	1.37	1.93	1.14	0.817
Q4	1.71	1.07	1.94	1.29	1.83	1.18	0.701
Q5	5.29	1.90	5.75	0.86	5.53	1.43	0.366
Q6	5.71	1.14	6.69	0.60	6.23	1.01	0.012

Mean scores are presented without accounting for other independent variables.

Table 3

Mean Survey Scale Scores by Order of Attempt First Versus Second (Main Effect for Attempt)

	First Attempt		Second Attempt		Overall		p-value
	Mean	SD	Mean	SD	Mean	SD	
Q1	5.93	0.96	5.87	1.13	5.90	1.03	0.616
Q2	6.13	0.83	6.07	0.96	6.10	0.88	0.616
Q3	1.93	1.10	1.93	1.22	1.93	1.14	1.000
Q4	1.87	1.19	1.80	1.21	1.83	1.18	0.835
Q5	6.07	0.70	5.00	1.77	5.53	1.43	0.027
Q6	6.40	0.74	6.07	1.22	6.23	1.01	0.337

Mean scores are presented without accounting for other independent variables.

Table 4

Mean Survey Scale Scores by Type of First Model and by Order of Attempt

	Manikin First			Porcine Model First			Interaction p-value
	First	Second	Delta	First	Second	Delta	
Q1	6.00	6.00	0.00	5.87	5.75	0.12	0.616
Q2	6.29	6.29	0.00	6.00	5.87	0.13	0.616
Q3	1.86	1.86	0.00	2.00	2.00	0.00	1.000
Q4	1.71	1.71	0.00	2.00	1.87	0.13	0.835
Q5	6.29	4.29	2.00	5.87	5.62	0.25	0.074
Q6	5.86	5.57	0.29	6.87	6.50	0.37	0.895

Mean scores are presented after accounting for both independent variables and test for interaction.

(4.29) after the second attempt (i.e., with the porcine model). In comparison, to a lesser degree, the porcine-first group rated their first attempt higher (5.87) than their second attempt (5.62; interaction $p = 0.074$; see Table 4). The delta differences between the first and second attempts for the two groups are illustrated in Figure 3.

The majority of the participants (12 of 15, 80%) chose SFB as their preferred technique to use in a real-life scenario. Technique preference did not differ

based on whether the candidate started on the porcine (6/8, 75%) or the manikin model (6/7, 85.7%) first ($p = 1.00$).

DISCUSSION

The study survey found no significant difference between utilization of the Manikin or porcine simulators with respect to questions related to confidence and difficulty. This finding is somewhat similar to the only previous study to compare utilization of manikin versus porcine simulators. Cho et al.⁵ previous study compared the simulators using only the Poretex cricothyroidotomy kit technique while our study utilized SFB and MT.

A previous study by Klock⁶ found that while a manikin can simulate the likeness of a real airway anatomically, the compressibility of the tissues and the frictional component of the manikin materials need to be taken into consideration. There is a difference between the actual physical fidelity versus how functionally realistic these manikin simulators are with respect to the realism of the tissues. In the previously mentioned study by Cho et al., they found that the porcine model had a higher visual analog scale for overall reality and preference among the participants.⁵ In our study, when participants started on the Manikin first they felt that the manikin was more realistic than the porcine model. When participants started on the porcine model first there was less of a difference in realism between the two models (interaction $p = 0.074$; Figure 3). The differences in realism of the porcine model in our study may be due to utilization of fresh pig skin by Cho et al. overlying their porcine model. We believe that it may be logistically difficult for most simulation centers to obtain and dispose of fresh pig skin.

Identification of landmarks when performing EC is important for proper technique and success. Our study showed that participants who started with the porcine model first found the anatomical landmarks easier to identify on both the porcine and the manikin models than participants who started on the manikin model first (Figures 1 and 2). This finding is also different than that of Cho et al. where porcine landmarks were rated more difficult to find. As we mentioned, this could be due to fresh pig skin. However, the disparity in findings could also be due to the prior experience of participants. In our study, the majority had previous training (14/15 = 93.3%), with

Figure 3. Mean score (range 1 to 7) to survey questions about realistic anatomy (A) and location of landmarks (B) by group (mannequin first vs. porcine first).

only five (33.3%) having experience with porcine and manikin models, and only one participant (6.7%) had experience with an actual patient, while all participants had previous training and nearly half (46.7%) had actual patient experience in the study by Cho et al. Our survey results also showed that after completing the training on both models 12 of 15 participants stated that they would prefer the SFB technique over the MT in a real-life scenario.

Although our main interest was to evaluate the types of training models (manikin vs. porcine) and techniques (SFB and MT), it is possible that participants could have perceived that their competence or skill level was also being measured. Our survey instrument did not contain identifiers; participants used both models in one-setting and were randomized to the order of the first model encountered. These safeguards were in place to reduce the apprehension surrounding participant responses to the survey questions. However, to be fair, this type of simulation training is based not only on participant preference, but self-perception and/or self-assessment. Effects of training can be short-lived.⁷ We were not specifically measuring the degree of learning or skill, but at the same time we must mention that other factors could have influenced participants' perceptions. It has been reported that "self" rating objectivity is difficult because it is an emotional response.⁸ Sargeant and colleagues⁹ suggest that there are four phases of self-assessment: 1) receiving feedback from external sources, 2) reflecting on feedback to reconcile with self-assessment, 3) plan to use feedback, and 4) use feedback for improvement and learning. Often during simulation training feedback from instructors can be important, and researchers have suggested that debriefing is beneficial.¹⁰

Students can perceive peer and faculty debriefing as equally effective.¹¹ Recently researchers have put forth "a toolbox for simulation educators" for difficult debriefing situations.¹² The authors list types of learners and provide information on how to deal with different types of debriefing situations. Anyone or a multitude of these factors, intrinsic or extrinsic, could have influenced the perceptions of the participants in our research study. Perhaps a more complete and sensitive survey instrument along with debriefing could have allowed for some of the factors to have been identified and controlled for during statistical testing.

LIMITATIONS

Besides the self-perception issues mentioned, this study is limited by a small sample size from a single simulation center. In an attempt to overcome this limitation, we used a repeated-measures statistical test, so each study participant served as his or her own control to reduce error variance. The study used an unvalidated survey instrument that has been developed by our study team. However, we were only asking questions concerning confidence and difficulties with each technique, and we believe that these questions and responses to be straightforward. We also applied the crossover effect to decrease the bias of taking the same survey questions twice (one for each model). Finally, in the porcine model, fresh pig skin was not provided, which might affect the realistic anatomy of the procedure.

CONCLUSION

Our study results, which are based on self-perception, suggest that the manikin model tends to be more

realistic in cricothyrotomy simulation than the porcine model. Influence of fresh pig skin overlying the porcine model may require further research. Landmark identification during the procedure was easier on both models when participants start with the porcine model. Participants prefer the scalpel-finger-bougie technique over the Melker technique if faced with a real-life scenario.

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