Far Forward Feasibility: Testing a Cricothyroidotmy Simulator in Iraq.

Colonel Mark W. BOWYER[a,1], SFC Michael MANAHL[b], Eric ACOSTA[a], SFC Joshua STUTZMEN[b], and Alan LIU[a]

[a] *The Surgical Simulation Laboratory of the National Capital Area Medical Simulation Center, Uniformed Services University, http://simcen.usuhs.mil/*
[b] *The Jameson Combat Medic Training Center, Camp Anaconda, Iraq*

Abstract. This study describes our experience with using a virtual reality simulator, CricSim, to enhance the training of combat medics to perform a cricothyroidotomy (surgical airway) while in Iraq. Over a six month period, 65 medics used the simulator as part of a Combat Medic Advanced Skills Training class while in Iraq and were asked to evaluate it. Students self-assessed comfort level with the procedure improved dramatically from baseline ($p < 5.6 \times 10^{-17}$). The CricSim was rated highly on realism but only moderately on ease of use. The use of this simulator in a far forward setting was feasible, enhanced training, and provided necessary end-user feedback for future development of this training platform.

Keywords. Cricothyroidotomy, virtual reality, part task trainer, combat skills

1. Introduction

The performance of a surgical airway or cricothyroidotomy (Cric) is one of the few maneuvers of proven benefit in the initial management of battlefield casualties [1]. Additionally, civilian casualties of major trauma to the face or neck clearly benefit from early application of Cric when clinically indicated [2]. When performing a cricothyroidotomy, the cricoid membrane must be identified by palpation and an incision made through the skin of the neck overlying the membrane and through the membrane itself. The incision is enlarged usually with the handle of the scalpel and then a tube (preferably a tracheostomy or endotracheal tube) is placed in the trachea to secure the airway. In everyday clinical practice the need to do a surgical airway is very unusual and therefore opportunities to perform this procedure even for a busy trauma surgeon are rare. However, this low-frequency, high-stakes procedure is an expected skill set for all physicians, nurse practitioners, physician assistants, and medics especially in the military, but also in many civilian settings as well. Unfortunately, training for this procedure is currently highly variable and opportunities for practice are limited. Personal observation (MB) during a recent deployment to Iraq, revealed multiple failed or improper attempts at Cric, highlighting the need for alternative methods of initial and sustainment training for this high stakes procedure.

[1] Corresponding Author: Mark W. Bowyer, MD; mbowyer@usuhs.mil

Traditionally this procedure has been taught using animal models or human cadavers and is one of the skills routinely taught in the Advanced Trauma Life Support Course for doctors [3]. In the past several years high fidelity human patient simulators (HPS) and trauma specific mannequins have become available for teaching students to perform the Cric procedure as seen in Figure 1.

Figure 1. Performance of a crycothyroidotomy on a human patient simulator (left) and a trauma specific mannequin (right).

A novel model for teaching Cric, that uses animal tracheas obtained from a meat packing plant covered with the synthetic skins used with HPS trainers has also recently been described [4].

All of the methods described above have disadvantages. Animals do not have the same anatomy and there are ethical concerns with their use. Cadavers faithfully replicate human anatomy but can only be used once, do not bleed, and have fixed anatomy specific to that cadaver. Mannequins and HPSs have variable realism and fixed anatomy specific to the model. Given the fact that most emergent airways are done in patients who have altered anatomy- ie expanding hematoma, massive trauma to the face or neck, or on a short fat thick neck; these "fixed" models may not be the ideal method for training. To address some of the limitations of currently available trainers we have developed a prototype haptic-enabled bimanual virtual reality simulator to teach the Cric procedure [5]. This study describes our experience with using this simulator to enhance the training of combat medics in a far forward training center in Iraq.

2. Methodology

2.1 *Materials: The CricSim Cricothyroidotomy Simulator*

The CricSim hardware runs on a desktop PC with dual Intel Xeon 3.06 Ghz processors, 2Gb memory, and an nVidia Quadro FX 5500 graphics card. Trainees using our system can see and feel virtual objects within the working volume. A CRT monitor is used to generate 3D frame-sequential images of the environment. The trainee, wearing a pair of Crystal Eyes shutter glasses, perceives a a 3D sterescopic view of the patient. Two Phantom Omni haptic interface devices are used to provide the trainee with the ability for bimanual interaction. This is an improvement over our

original system [5] that had only one Phantom. The current system is capable of driving the visual display at better than 30 frames/sec, while the haptic loop runs at 1KHz.. Currently the system has a single clinical case running in which the trainee is presented with a 3D graphical representation of a human torso, head and neck in which there is a gun shot wound to the neck and the need to perform a surgical airway. The trainee is able to proceed through all the steps of performing a Cric (bimanually) in both a practice and time limited testing mode (Figure 2).

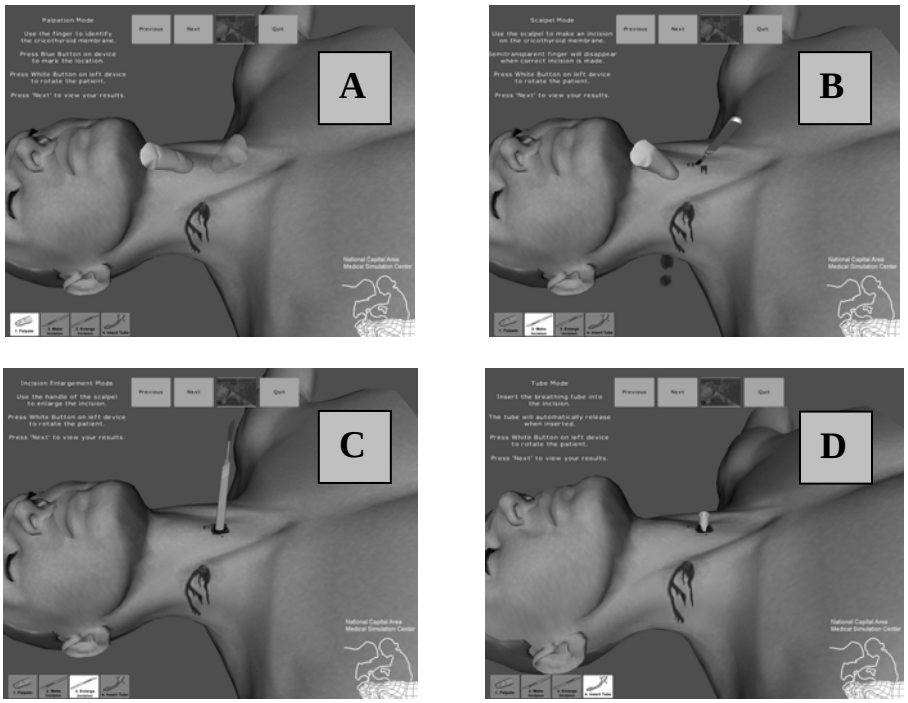

Figure 2. The steps of the cricothyroidotomy can be performed in sequence on the CricSim to include Palpation (A), Incision (B), Enlargement of Incision (C), and placement of the tracheostomy tube (D).

2.2 Participants

The participants in this study were sixty-five combat medics who participated in a Combat Medic Advanced Skills Training class conducted at and by the Jameson Combat Medic Training Center (JCMTC), Camp Anaconda, Balad Air Base, Iraq over a six month period. These medics were assigned to duty as primary responders to battlefield casualties in the current war in Iraq.

2.3 Procedure

To test the feasibility of using the CricSim in a far forward training platform, the simulator was deployed to Iraq during a recent deployment of one of the authors (MB). The simulator was placed in the JCMTC and the hospital emergency room and used as an adjunct to the standard airway skills taught in the skills class. Each student was

asked to fill out a questionnaire (5 point likert scale with 1 being low and 5 being high) as to the realism and ease of use of the simulator, as well as their perceived level of comfort to perform a Cric prior to and after using the simulator. In addition, each of the participants was asked (yes-no) if they had previously performed the procedure on a human and also if they believed that the training on the CricSim actually prepared them for doing a Cric. Students were allowed multiple opportunities to practice and use the CricSim during the course and during free time (Figure 3).

Figure 3. The CricSim set up in the Emergency Room in the Air Theatre Hospital In Balad Iraq (left) and a Combat Medic practicing the procedure while wearing protective "battle rattle" (right).

3. Results

The majority of the participants (62/65) related having never done a Cric on a live patient. When asked to rate the simulator the trainees rated it very highly on realism (4.32 ± 0.71), and only moderately on it's ease of use (3.4 ± 1.3). The majority of comments regarding usability had to do with the user interface for moving to the next step of the procedure which was not considered to be intuitive by many users. The trainees were asked to rate their self perceived comfort level with performing a Cric prior to and after training/practicing on the CricSim. This self perceived comfort level improved dramatically from a baseline of 2.51 ± 1.3 to 4.0 ± 0.88 ($p < 5.6 \times 10^{-17}$ by student t-test). Upon completion of the training, 50/65 (77%) of the medics felt that they were better prepared to perform a Cric on a real patient if called upon to do so.

4. Discussion/Conclusions

In an ideal world, all medics deploying to Iraq would be fully trained to perform all of the procedures that they might be called upon to do in the care of the injured soldier. Unfortunately, this is not always the case, and many medics are deployed who have had little to no training on the proper performance of a surgical airway. Additionally, even those who have been trained, usually have never seen nor done an actual procedure and there are limited opportunities to practice or refresh this skill, especially when deployed. Cricothyroidotomy, when properly performed, is one of the few skills that have been shown to make a significant difference in the initial treatment of individual injured on the battlefield. This low-frequency, high-stakes procedure must often be performed under austere conditions without physician back-up. As such it makes great sense provide high fidelity training of this procedure both initially and repetitively for

sustainment. The focus of this study was to determine if the feasibility of using high fidelity simulation technology such as the CricSim in a far-forward combat training setting. In this regard the study was a success. The simulator held up well in the harsh environment of Iraq and was well received by the learners. The learners found the CricSim to be realistic and importantly identified flaws in the usability of the system which will allow the development team to further refine the training platform. It is encouraging that the medics who trained on the system had improved self-perceived comfort with this vital skill and that they felt better prepared to perform a Cric if called upon to do so. The translation of these skills and perceived comfort into improved performance awaits further investigation. The lessons learned from this pilot study will be used to improve the CricSim. We will use the usability feedback to improve the user interface. Additionally, we will continue to add combat relevant cases to the platform that will provide challenging high-fidelity practice for initial and ongoing training.

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