Resuscitation 80 (2009) 674–679

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Simulation and education

An educational course including medical simulation for early goal-directed therapy and the severe sepsis resuscitation bundle: An evaluation for medical student training☆,☆☆

H. Bryant Nguyen[a,b,*], Lynda Daniel-Underwood[a,d], Chad Van Ginkel[d], Melanie Wong[a], David Lee[d], Anthony San Lucas[c], Janice Palaganas[c], Daryl Banta[b], T. Kent Denmark[a,c], Kathleen Clem[a]

[a] Department of Emergency Medicine, Loma Linda University, Loma Linda, CA, United States
[b] Department of Medicine, Division of Pulmonary and Critical Care Medicine, Loma Linda University, Loma Linda, CA, United States
[c] Medical Simulation Center, Loma Linda University, Loma Linda, CA, United States
[d] School of Medicine, Loma Linda University, Loma Linda, CA, United States

ARTICLE INFO

Article history:
Received 5 July 2008
Received in revised form 5 February 2009
Accepted 12 February 2009

Keywords:
Severe sepsis
Septic shock
Severe sepsis resuscitation bundle
Early goal-directed therapy
Medical simulation

ABSTRACT

Objective: Widespread application of early goal-directed therapy (EGDT) and the severe sepsis resuscitation bundle is limited by clinician knowledge, skills and experience. This study evaluated use of simulation-based teaching during medical training to increase future clinician knowledge in the above therapies for severe sepsis and septic shock.
Methods: A prospective cohort study was performed with medical students at all levels of training. A 5-h course including didactic lectures, skill workshops, and a simulated case scenario of septic shock were administered to the participants. A checklist including 21 tasks was completed during the patient simulation. An 18-question pre-test, post-test and 2-week post-test were given. The participants completed a survey at the end of the course.
Results: Sixty-three students were enrolled. There was statistical difference between the pre-test and each of the post-test scores: 57.5 ± 13.0, 85.6 ± 8.8, and $80.9 \pm 10.9\%$, respectively. 20.6% of participants thought the pre-test was too difficult, whereas all participants thought the post-test was either appropriate or too easy. The task performance during the simulated septic shock patient was $94.1 \pm 6.0\%$. The participants noted improvements in their confidence levels at managing severe sepsis and septic shock, and agreed that the course should be a requirement during medical school training.
Conclusions: Medical simulation is an effective method of educating EGDT and the severe sepsis resuscitation bundle to medical students with limited experience in patient care. The results suggest that our course may be of further benefit at increasing clinical experience with this intensive protocol for the management of severe sepsis and septic shock.

1. Introduction

After many years of unsuccessful clinical trials examining therapeutic strategies for severe sepsis and septic shock, we now have several treatment options with significant benefit for this illness.[1,2] Quality improvement efforts also advocate the implementation of hospital sepsis protocols and *bundles*.[3,4] Most important to the management of severe sepsis and septic shock is the early administration of appropriate antibiotics and early goal-directed therapy (EGDT) in the severe sepsis resuscitation bundle.[3,5,6] Several authors have reported the benefits of EGDT when applied in clinical practice.[7–11] However, the wide implementation of a sepsis protocol utilizing this time-sensitive intervention is fraught with many barriers, including lack of clinician knowledge, limited skills in hemodyamic optimization, and difficulty in recognition of disease severity.[12]

Medical simulation has become an integral part of medical education, patient safety, and crisis preparedness.[13–20] Research funding for simulation is also the ongoing focus of healthcare organizations.[21,22] Medical simulation can enhance physician

☆ This study was presented, in part, at the 8th International Meeting on Simulation in Healthcare, San Diego, California, January 2008; and the 12th International Conference on Emergency Medicine, San Francisco, California, April 2008.

☆☆ A Spanish translated version of the summary of this article appears as Appendix in the final online version at doi:10.1016/j.resuscitation.2009.02.021.

* Corresponding author at: Department of Emergency Medicine, Loma Linda University Medical Center, 11234 Anderson Street, Rm A108, Loma Linda, CA 92354, United States.
E-mail address: hbnguyen@llu.edu (H.B. Nguyen).

0300-9572/$ – see front matter © 2009 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.resuscitation.2009.02.021

knowledge and close the gap between research and clinical practice by performing several functions: "identifying unmet needs, identifying contextual barriers to change in practice, identifying changing cultural beliefs that may be barriers to behavior change, and raising physician and nursing awareness simultaneously".[23]

In this study, we applied a severe sepsis and septic shock course including medical simulation to medical students to show that simulation techniques can increase knowledge in EGDT for clinicians at the very beginning of their medical training, and possibly overcome some of the barriers in implementation of the severe sepsis resuscitation bundle.

2. Methods

2.1. Study design and setting

This study was a prospective cohort, performed at a university-based medical simulation center (MSC). The study was exempt from the Institutional Review Board review. The MSC is located in a 2500 ft^2 facility at the School of Medicine, and includes several simulation labs with infant, pediatric and adult patient simulators, a skills lab, multiple computer-based simulators, two multimedia debriefing rooms, and a high fidelity communication and control room. Simulation sessions are digitally recorded and available for immediate playback and review. The MSC has a wide range of simulation mannequins. The simulation system includes simulation software for electrocardiogram, invasive and non-invasive blood pressure, arterial (SaO_2) and venous oxygen saturation ($ScvO_2$), central venous pressure (CVP), cardiac output, pulmonary artery pressure, and intracranial pressure monitoring.

2.2. Study participants

Medical students from each level of medical school were invited to participate in the simulation course (see below) from August 1, 2007 to March 1, 2008. Participants were grouped according to their level of education, medical student (MS) I, MS II, MS III, and MS IV. A description of the study and course objectives were provided to the participants, who then gave verbal consent to be included in the data collection. A gift certificate was given to each participant for his or her contribution in the study.

2.3. Severe sepsis and septic shock simulation course

A 5-h course including didactic lectures, skills workshops on central line placement and intubation technique, and a simulation of a septic shock patient, was administered. A pre-test, post-test, and 2-week post-test were also given to each participant. An example of a course session starting at 14:00 h would include:

14:00–14:10 h Course Introduction of Goals and Objectives
14:10–14:30 h Pre-test
14:30–15:00 h Central Line Placement & Intubation Technique Lecture
15:00–16:00 h Severe Sepsis, Septic Shock and EGDT Lecture
16:00–16:10 h Break
16:10–17:10 h Central Line Placement & Intubation Simulation Workshop
17:10–17:15 h Break
17:15–18:35 h Septic Shock Patient Simulation (4 groups, 20 min per group)
18:35–18:40 h Break
18:40–19:00 h Post-test
Repeat Post-test in 2 weeks

2.3.1. Didactic lectures

Lectures describing the indications, contraindications and techniques in central line placement and endotracheal intubation were given to the participants. Fundamental concepts on severe sepsis and septic shock were described including definitions, pathophysiology and early management utilizing the bundle. The EGDT protocol was specifically emphasized, including CVP and $ScvO_2$ monitoring, fluid resuscitation, transfusion threshold, vasopressor management and inotrope support. A case scenario was also included in the lecture to illustrate the use of EGDT in a clinical setting.

2.3.2. Skills workshops

Participants were given instructions and hands-on practice at inserting a central line using the Seldinger technique via the internal jugular vein approach on a mannequin. Proper techniques such as hand washing, chlorhexidine prep, and sterile field were also emphasized.

Participants were given instructions and hands-on practice at endotracheal intubation on a mannequin in a separate workshop. Techniques and indicators of success included equipment preparation, cross-finger method to open the mouth, and visible chest rise post-intubation.

2.3.3. Septic shock patient simulation

The Laerdal SimMan® high fidelity patient simulator (Laerdal Medical, Stavanger, Norway) provided a realistic patient in septic shock. The computer-controlled mannequin interfaced with actual patient monitors, providing hemodynamic responses to interventions necessary to treat severe sepsis and septic shock. Each intervention (e.g. fluid bolus, intubation, norepinephrine) had a hemodynamic consequence, affecting changes in heart rate, blood pressure, respiratory rate, SaO_2, and CVP. The simulation also included the Vigileo™ Simulator (Edwards Lifesciences, Irvine, California) to provide continuous $ScvO_2$ monitoring.

The septic shock scenario began with a 61-year-old male having a history of hypertension, diabetes and coronary artery disease. His chief complaint was a productive cough for 2 days associated with shortness of breath, fever and malaise. He denies any other symptoms. His vital signs included temperature 38.3 °C, heart rate 102 per minute, blood pressure 80/50 mmHg, respiratory rate 22 per minute, and SaO_2 92%. The voice of the patient was played by the simulation operator and projected through a speaker located in the head of the mannequin. The patient was then treated by a team of 3–4 medical students, all at the same level of medical school. The team members played the role of a leader, a nurse, a proceduralist for central line placement, and a second proceduralist for intubation. The team was given 20 min to complete the simulation.

The course instructor (HBN) assumed the role of family members, paramedic, consultant, and lab technician, as needed. The instructor was present in the room to assist the participants with tasks and provided general guidance as appropriate. The participants performing the intubation or central line placement verbalized key steps as they were performing them. The course instructor did not prompt them for each step. Another course instructor (LD) evaluated the team performance by completing a 21-item task checklist (Table 1) throughout the patient simulation.

2.3.4. Cognitive testing and participant survey

The participants completed a pre-test at the beginning of the course, a post-test immediately at the end of the course, and another post-test at 2 weeks after the course. The three tests contained the same questions and answers (Appendix B). Three questions were given to test knowledge on central line placement, three questions on intubation technique, six questions on EGDT