The Journal of Emergency Medicine, Vol. ■, No. ■, pp. 1–6, 2017
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0736-4679/$ - see front matter

http://dx.doi.org/10.1016/j.jemermed.2017.02.016

Education

SECURING A CHEST TUBE PROPERLY: A SIMPLE FRAMEWORK FOR TEACHING EMERGENCY MEDICINE RESIDENTS AND ASSESSING THEIR TECHNICAL ABILITIES

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☐ **Abstract—Background: Quality-improvement efforts at our institution have identified chest tube dislodgement as a preventable complication of tube thoracostomy. Because proper fixation techniques are not well described in the literature and are seldom formally taught, techniques vary among residents. Objective: Our aim was to develop and test a framework for teaching and assessing chest tube securement. Methods: A repeated-measures study design was used. At baseline, 19 emergency medicine residents (program years 1–3) placed and secured a chest tube in a cadaver. After a 45-min proficiency-based teaching session using a low-cost chest tube simulator (approximate cost, $5), each resident again placed and secured a chest tube in a cadaver, followed by 3-month retention testing. All securements were evaluated by two raters using a four-point checklist and a five-point global assessment scale (GAS). The checklist addressed suture selection, tying knots down to the tube, wound approximation, and tube displacement relative to skin. Results: After the initial educational intervention, median scores for the group improved significantly over baseline for the GAS ($p < 0.001$), checklist ($p < 0.001$), and amount of displacement ($p = 0.01$). At 3 months, GAS, checklist, and displacement scores did not differ significantly from the immediate post-test scores. Inter-rater reliability was substantial, with weighted κ values of .77 for the GAS and .70 for the checklist. Conclusions: Quality of chest tube securement by emergency medicine residents can be significantly improved with an inexpensive chest tube simulator and a brief workshop. The four-point checklist served as a reliable and effective means for teaching and assessing chest tube securement.** **© 2017 Elsevier Inc. All rights reserved.**

☐ **Keywords—chest tube placement; chest tube securement; low-cost; low-fidelity; resident training; simulation**

Presented at Minnesota Surgical Society Spring 2013 Meeting, St. Paul, Minnesota, May 24–25, 2013.

INTRODUCTION

Percutaneous tube thoracostomy (PTT) is a commonly performed procedure within the disciplines of surgery, critical care, and emergency medicine. Despite the frequency with which it is performed and its perceived relative simplicity compared with other invasive procedures, complication rates of PTT have been reported to be as high as 30% and range in severity from benign (e.g., subcutaneous placement) to catastrophic (e.g., cardiac perforation) (1,2).

An increasing focus on quality improvement at our institution revealed chest tube dislodgement as a source of preventable PTT-related complications, having accounted for 6 of the 19 (32%) reported PTT-related complications during the 12 months before this study was conducted.

RECEIVED: 17 March 2016; FINAL SUBMISSION RECEIVED: 22 February 2017;
ACCEPTED: 25 February 2017

We identified the elements considered essential by experts for adequate chest tube securement and designed a low-cost, low-fidelity, simulation-based teaching intervention based on the framework of these elements. Our primary outcome was the immediate and 3-month effectiveness of the intervention to improve technical performance.

METHODS

Study Design and Setting

This repeated-measures study took place in a simulation center and cadaver laboratory at an academic institution that serves as a tertiary care facility and Level I trauma center. The study was approved by the Mayo Clinic Institutional Review Board.

Assessment Tool

By expert consensus, eight attending-level physicians (five trauma surgeons, one general surgeon, and two emergency physicians) developed a four-point framework that served as the basis for teaching and assessing PTT securement. The four factors deemed essential to proper chest tube securement were 1) suture selection (1-0 nonabsorbable suture or heavier); 2) wound approximation (wound must form a seal around the tube); 3) knot quality (knots must be tied down to the tube, i.e., no "air knots"); and 4) displacement (tube should not be able to slide freely in or out of the wound by > 1.5 cm) (Figure 1). A five-point global assessment scale (GAS) was added to define passing (acceptable in patient-care scenario) versus failing performances (unacceptable, requiring removal and re-securement). The GAS is an overall measure of how well the task was performed—a subjective assessment of the degree of success or failure as defined by expert evaluators.

1) Suture selection Inadequate__ Adequate__

2) Wound approximation Inadequate__ Adequate__

3) Knot tied down to tube Inadequate__ Adequate__

4) Displacement relative to skin Inadequate__ Adequate__

4a) _____ cm of displacement

5) Global Assessment Score (GAS)

1(Low Fail) 2(High Fail) 3(Pass) 4(High Pass) 5(Exceptional)

Figure 1. Assessment tool for chest tube securement.

Intervention

A 45-minute, low-fidelity, hands-on teaching session was developed on the basis of the expert-derived checklist, emphasizing the essential elements of chest tube securement, including adequate suture strength, wound approximation, knot quality, and tube securement. Heavy-gauge sewing thread was used to simulate silk suture and to teach principles of one- and two-hand knot-tying (depending on learner preference), as well as advanced techniques, such as the slip knot. Learners with minimal experience were taught a securement method involving simple interrupted sutures placed on either side of the tube with the tag ends encircling and tied to the tube. Those with prior experience or alternative techniques were not instructed to change their method but rather to incorporate the aforementioned principles to achieve reliable securement. A low-cost (<$5) model constructed of wooden dowels and household items was used to simulate the chest wall (Figure 2).

Data Collection and Outcome Measures

Overall, the primary performance outcome measure is represented by GAS scores, which define a passing versus failing securement. To examine the effectiveness of the teaching intervention with respect to GAS and checklist scores, 19 consenting residents in emergency medicine (five postgraduate year (PGY) 1, seven PGY2, and seven PGY3) placed and secured chest tubes in cadavers immediately before (pretest) and after (post-test) the teaching session. Residents were not informed before the session of the planned PTT curriculum, which was included as part of a recurring educational session. Residents were allowed to anonymously decline use of their data for the study, but none did. During a subsequent simulation training session 3 months later, residents were retested for retention of proper PTT securement technique, again without advance notice of the planned assessment. All securement procedures (pretest, post-test, and retention) were videorecorded and deidentified for evaluation by two raters (B.D.K. and D.S.M.) who were masked to resident identity. Raters underwent a 5-min training session, during which specific questions related to grading criteria were addressed. Raters were instructed that credit (i.e., 1 point given for "adequate," vs 0 given for "inadequate") should only be given for knots tied tightly to the tube and also for wounds that were completely approximated (Figure 3). Instruction was also provided regarding the GAS, with an emphasis on the cutoff between passing and failing (i.e., failing scores should be given to any securement that would necessitate re-securement in a real-world patient). Tube displacement was assessed by measuring the length in centimeters that tubes would

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