A Novel Cast Removal Training Simulation to Improve Patient Safety

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OBJECTIVE: Cast application and removal are essential to orthopedics and performed by providers of variable training. Simulation training and practice of proper cast application and removal may reduce injury, optimize outcomes, and reduce health care costs. The purpose of this educational initiative was to develop, validate, and implement a novel simulation trainer and curriculum to improve safety during cast removal.

METHODS: In all, 30 thermocouples (Omega, Stamford, CT) were applied to a radius fracture model (Sawbones, Vashon, WA). After reduction and cast application, a saw (Stryker, Kalamazoo, MI) was used to cut the cast with temperature recording. Both "good" and "poor" techniques—as established by consensus best practices—were used. Maximal temperatures were compared to known thresholds for thermal injury; humans experience pain at temperatures exceeding 47°C and contact temperatures exceeding 60°C may lead to epidermal necrosis. Construct validity was evaluated by assessing novice (postgraduate year 1), intermediate (postgraduate year 3), and expert (pediatric orthopedic attending) performance.

RESULTS: With the "good" technique, mean peak temperatures were 43°C + 4.3°C. The highest recorded was 51.9°C. With the "poor" technique, mean peak temperature was 75.2°C + 17.3°C. The maximum temperature recorded with the "poor" technique was 112.4°C. Construct validity testing showed that novices had the highest increases in temperatures (12.9°C). There was a decline in heat generation as experience increased with the intermediate group (9.7°C), and the lowest heat generation was seen in the expert group (5.0°C).

CONCLUSIONS: A novel task simulator and curriculum have been developed to assess competency and enhance performance in the application and removal of casts. There was a 32.2°C temperature decrease when the proper cast saw technique was used. Furthermore, the "poor" technique consistently achieved temperatures that would cause epidermal necrosis in patients. Clinical experience was a predictor of decreased heat generation during cast removal. This task trainer allows instruction and safety monitoring of the casting technique. (J Surg Ed 73:7-11. © 2015 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: orthopedics, patient safety, surgical simulation

COMPETENCIES: Patient Care, Practice-Based Learning and Improvement

INTRODUCTION

Cast application and removal are extremely common procedures in orthopedics, often performed by providers of variable experience and training. Complications associated with cast application and removal are all too common, including fracture malunion, compartment syndrome, and cast saw burns (Fig. 1). Recent investigations have demonstrated that cast saw burns may occur in 1 in 50 to 200 instances in which a cast saw is used.[1,2] In addition to the clinical sequelae of cast saw burns, there are potential medicolegal and financial consequences of inadvertent cast saw injury; indeed, prior analyses suggest that insurers have paid upward of $100,000 (USD) per related malpractice claim.[1,3] For these reasons, efforts continue to be made to improve proficiency and safety with cast saw use.[4-6]

There is a growing emphasis on surgical simulation as a means of improving medical education, optimizing clinical outcomes, and promoting patient safety.[7,8] Orthopedic education is increasingly focused on simulation for a cquisition of fundamental skills and continuation of

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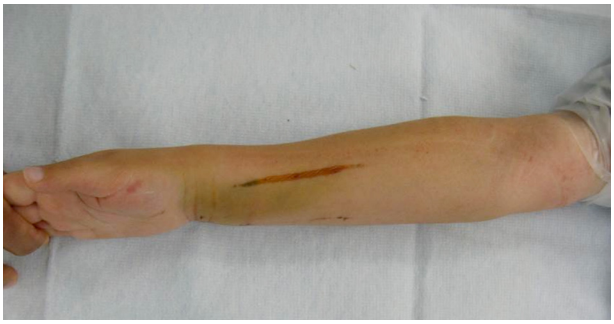

FIGURE 1. Clinical photograph of a child who sustained a cast saw burn during removal of a short arm cast. (Courtesy of Children's Orthopaedic Surgery Foundation, 2014)

proficiency.[9,10] To this end, simulation training of proper cast application and removal may prevent patient harm, optimize outcomes, and reduce costs to health care systems. The purpose of this educational initiative was to develop, validate, and implement a novel training tool to improve safety during cast removal.

MATERIALS AND METHODS

In all, 30 T-Type thermocouples (Omega, Stamford, CT) were applied over the surface of a commercially available distal radius fracture model (Sawbones, Vashon, WA) to create a novel task trainer (Fig. 2). The thermocouple array was arranged in a wide field to capture generated temperature from a simulated volar and dorsal saw cut. Thermocouples were threaded through the substance of the fracture model and the sensor tip was affixed to the model with glue and clear tape. To ensure the fidelity of thermocouple measurement, initial standardized testing was performed. Using a stainless-steel block heated in a 60°C water bath, embedded thermocouples secured with and without tape showed high fidelity and minimal variation in recorded temperatures as compared with known controls.

Using this model, short arm casts were applied in the standardized fashion, using 3 to 4 layers of cast padding (Webril, Covidien, Mansfield, MA) and 3 to 4 layers of fiberglass casting material (Scotchcast Plus, 3M, St. Paul, MN). Face validity was assessed by continuously measuring temperatures generated on the surface of the model when dorsal and volar cuts were made using an oscillating cast saw (Stryker, Kalamazoo, MI) (Fig. 3). Both "good" and "poor" techniques, as described by Shuler and Grisafi,[6] were used during cast removal. The "good" technique uses an "in then out" cast saw motion with frequent cooling of the blade with a moist gauze. The "poor" technique included "dragging" the blade across the cast material (i.e., engaging the cast saw and translating the blade proximally or distally without withdrawing) without intermittent cooling of the saw blade. By using the "good"' technique 4 casts were removed and 5 casts removed with the "poor" technique. Maximal temperatures were recorded and compared to known thresholds for thermal injury; humans experience pain at temperatures more than 47°C. Temperatures exceeding 60°C may lead to epidermal necrosis.[11,12]

Construct validity was assessed by evaluating performance and surface heat generation by participants with varying levels of experience. In all, 12 novices (surgical interns in their first postgraduate year [PGY]), 9 intermediates (PGY-3 residents), and 3 experts (orthopedic attendings) performed cast application and removal while temperatures were recorded. Time to task completion (i.e., cast removal) was also recorded in efforts to calculate cumulative thermal energy generated.

A thermocouple data acquisition system (Omega, Stamford, CT) was used to record temperatures and generate a database. Initial pilot data showed that the electromagnetic signal from the oscillation caused minor variations in the recorded data. To correct for this phenomenon, a 5-point running average filter was used to smooth the minor variation caused by electromagnetic interference. Furthermore, the fracture model is constructed of a urethane-based plastic material that tends to hold onto heat generated by cast application and removal. To correct for a variable starting temperature, the initial temperature was subtracted from the highest generated temperature during cast removal to give a maximum difference for each participant.

Mean peak temperatures were computed along with standard deviations for "good" and "poor" technique groups. The mean maximum, maximum difference, and mean maximum difference were calculated for the expert, intermediates, and novice groups.

RESULTS

The model with thermocouples demonstrated appropriate fidelity of temperature detection. Measurements with and without tape overlying the thermocouples exhibited minimal variations in registered temperatures. With a 60°C metallic block applied to the surface of the model for 3

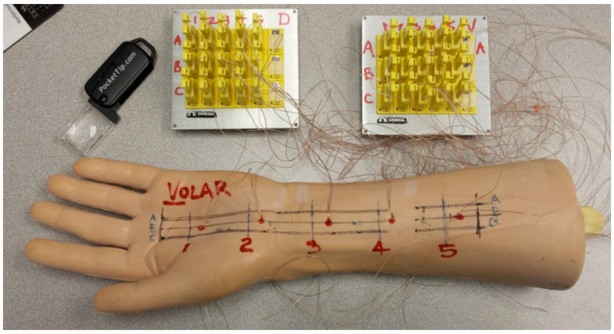

FIGURE 2. Prototype of the novel task trainer. Tip-insulated T-Type thermocouples (Omega, Stamford, CT) are embedded within a commercially available distal radius fracture model (Sawbones, Vashon, WA). (Courtesy of Children's Orthopaedic Surgery Foundation, 2014)