Live tissue versus simulation training for emergency procedures: Is simulation ready to replace live tissue?

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Background. *Training of emergency procedures is challenging and application is not routine in all health care settings. The debate over simulation as an alternative to live tissue training continues with legislation before Congress to banish live tissue training in the Department of Defense. Little evidence exists to objectify best practice. We sought to evaluate live tissue and simulation-based training practices in 12 life-saving emergency procedures.*

Methods. *In the study, 742 subjects were randomized to live tissue or simulation-training. Assessments of self-efficacy, cognitive knowledge, and psychomotor performance were completed pre- and post-training. Affective response to training was assessed through electrodermal activity. Subject matter experts gap analysis of live tissue versus simulation completed the data set.*

Results. *Subjects demonstrated pre- to post-training gains in self-efficacy, cognitive knowledge, psychomotor performance, and affective response regardless of training modality* ($P < .01$ *each). With the exception of fluid resuscitation in the psychomotor performance domain, no statistically significant differences were observed based on training modality in the overall group. Risk estimates on the least pretest performance subgroup favored simulation in 7 procedures. Affective response was greatest in live tissue training* ($P < .01$) *and varied by species and model. Subject matter experts noted significant value in live tissue in 7 procedures. Gap analysis noted shortcomings in all models and synergy between models.*

Conclusion. *Although simulation has made significant gains, no single modality can be identified definitively as superior. Wholesale abandonment of live tissue training is not warranted. We maintain that combined live tissue and simulation-based training add value and should be continued. Congressional mandates may accelerate simulation development and improve performance. (Surgery 2016;160:997-1007.)*

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THE TRAINING OF MEDICAL PERSONNEL in high-acuity, low-frequency, life-saving procedural interventions is challenging. An ideal model for training does not exist presently, and the debate between live tissue (LT) and models of inanimate simulation continues. Research designed to compare the educational effectiveness of LT versus simulation training is difficult to perform, and the time needed to assess long-term impacts of training interventions coupled with the fluid landscape of simulation development contributes to a paucity of information on which to base best practice.[1-4] Political pressures about the use of LT in medical training are substantial and have resulted in

Supported by the US Human Research Protections Office of the United States Army Medical Research and Materiel Command Grant W81XWH-10-JPC-MEDSIM-CCTC.

Presented at the Central Surgical Association Annual Meeting, Montreal, Quebec, Canada, March 10–12, 2016.

Accepted for publication April 13, 2016.

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0039-6060/$ - see front matter

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http://dx.doi.org/10.1016/j.surg.2016.04.044

legislation limiting effectively the use of funds for LT training in the Department of Defense, despite current training practices relying heavily on this modality.[5,6]

Medical modeling and simulation technology, while advancing rapidly, still present technical challenges for faithful replication of human anatomy, physiology, and pathology. LT use does not lend itself to repetitive training or extensive throughput and carries with it complex regulatory requirements, extensive life-cycle and logistical support, and the physiologically confounding effects of general anesthesia. The Advanced Trauma Life Support course developed by the American College of Surgeons shifted from LT to simulation-based surgical skills training in the early 2000s; this shift occurred despite an American College of Surgeons position statement classifying animals as "an indispensable element of biomedical research, education, and teaching... and that, wherever feasible, alternatives to the use of live animals should be developed and employed," further highlighting the friction between abandonment of animal models used traditionally and the wholesale adoption of simulation that persists in medical education and training today.[7] The mandated transition from LT to simulation-based skills training in the military has exposed strong views from advocates of both LT and simulation, with the potential for training models to change without solid evidence to guide best practice.

Given the current state of medical simulation technology, the importance of effective training for optimal patient outcomes and the disagreement about the superiority of either LT or simulation-based training environments, the University of Missouri Combat Casualty Training Consortium (MU CCTC) was established to investigate the comparative effectiveness of LT and simulation-based training across a spectrum of 12 emergency trauma procedures.

METHODS

The MU CCTC represents a national coalition of subject matter experts (SMEs) encompassing the areas of battlefield/trauma surgery, surgical education, prehospital/battlefield medical care and training, educational practice and design, statistical analysis, and simulator design. The primary goal of the study was to identify best training practices and modalities to decrease preventable mortality on the battlefield and in civilian practice. This multiacademic and industry effort hypothesized that relevant differences in self-efficacy, cognitive performance (COG), psychomotor performance (PSY), and affective response (AFR) would be observed between subjects trained with LT versus simulation in 12 lifesaving emergency procedures (Table I). In 11 of the 12 procedures (P1−P11), the research design randomized subjects into LT or simulation training arms. For procedure P12 (nerve agent casualty), subjects were randomized into 3 training groups: LT, simulation, or a high-resolution video of the LT training exercise. Additionally, procedure P12 in the PSY assessments were separated into 3 subgroups representing the varying presentations of nerve agent exposure (Fig 1).

Standardization of training was achieved through scripted curricula. LT and inanimate simulation models were selected based on consensus input from the consortium (Tables I and II). To isolate the effect of each training modality, subject performance was assessed in a controlled setting without external stressors. Four animal models were utilized, and related procedures were grouped for sequential performance in both training and testing. Group 1 consisted of procedures P1–P5, group 2 included procedures P6–P10, and groups 3 and 4 each contained a single procedure, P11 and P12, respectively (Table I). This study design was based on logistical considerations and a desire to limit overall LT use. All training and testing was performed in a single day.

The subjects comprised a heterogeneous population of both military and civilian medic volunteers. Self-efficacy was measured through surveys administered pre- and post-training on a 10-point Likert scale. COG was measured by multiple choice assessments given pre- and post-training. PSY was scored by trained observers utilizing standardized checklists composed of readily identifiable and observable decomposed steps for each procedure. These assessments were procedure-specific, scored dichotomously, and designed to capture each subject's ability to perform a related action. PSY was analyzed in 2 ways: the total number of steps completed and the total number of critical steps completed. Step criticality was determined by consensus of the SMEs.

To account for potential inter-rater variation in the scoring of PSY assessment checklists, inter-rater concordance was used as a measure of consistent judgment between raters within each procedural grouping. Observational concordance was aided by strict definition of successful completion of each decomposed, readily identifiable, and observable item in the PSY performance checklist. Concordance between individual raters was achieved and documented via repeated scripted performances with planned omissions for rater training, both

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