Outcomes From Two Forms of Training for First-Responder Competency in Cholinergic Crisis Management

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ABSTRACT Military and civilian first responders must be able to recognize and effectively manage mass disaster casualties. Clinical management of injuries resulting from nerve agents provides different challenges for first responders than those of conventional weapons. We evaluated the impact of a mixed-methods training program on competency acquisition in cholinergic crisis clinical management using multimedia with either live animal or patient actor examples, and hands-on practice using SimMan3G mannequin simulators. A purposively selected sample of 204 civilian and military first responders who had not previously completed nerve agent training were assessed pre- and post-training for knowledge, performance, self-efficacy, and affective state. We conducted analysis of variance with repeated measures; statistical significance $p < 0.05$. Both groups had significant performance improvement across all assessment dimensions: knowledge > 20%, performance > 50%, self-efficacy > 34%, and affective state > 15%. There were no significant differences between the live animal and patient actor groups. These findings could aid in the specification of training for first-responder personnel in military and civilian service. Although less comprehensive than U.S. Army Medical Research Institute of Chemical Defense courses, the training outcomes associated with this easily distributed program demonstrate its value in increasing the competency of first responders in recognizing and managing a mass casualty cholinergic event.

INTRODUCTION

Global conflict and the war on terrorism requires both military and civilian medical personnel to be able to rapidly and effectively respond to mass disaster casualties associated with unconventional weapons, including chemical weapons such as nerve agents.[1–14] Although these types of events are relatively rare, timely and accurate care for casualties, along with appropriate self-protection for clinician responders, can limit mortality and provide the best chance for full recovery after exposure. The challenge for clinical providers is that the opportunity to train for a mass casualty event associated with nerve agents is extremely limited. Uses of live animals as a feasible training alternative for learning human medicine are longstanding; however, ethical considerations for using live animals in these contexts are concerning.[15,16] Although live animals may provide a measure of physiological and tissue fidelity during training, anatomical differences and inexact fidelity lessen the extent that learned behaviors transfer to human medicine.[17–26]

Simulation technologies may provide sufficient fidelity to adequately facilitate clinical interactions with human patients because they are designed to reproduce human anatomy and physiological responses, as well as support the hands-on experiential learning aspects of training with live animals.[27–29] The opportunity for experiential learning is extremely important because knowledge-based training alone may miss the vital mastery of associated skills and affective elements embedded in the clinical contexts. Especially in a mass casualty environment, dissonance resulting from cognitive and affective overload can interfere in the application of knowledge and skills.[30–39] Experiential learning theory prescribes direct engagement in a contextually relevant environment to help learners create mental representations such as attitudes, mental models, scripts, and schemas, which correspondingly lead to the desired behavioral outcomes.[40–43] This theoretical framework serves crisis and emergency medical training well because the training environment supports the relevant factors that might otherwise lead to dissonance in the performance context.[15,44–46]

The few studies that have compared the effectiveness of simulation methods to live animal methods were inconclusive, likely because of the anatomical variations between humans and animals confounding a direct comparison between the two methods.[19,47–49] Because the performance context is human, a group trained using a simulated human mannequin might have an advantage over an animal-trained group, whereas the opposite might be true if tissue or dynamic physiological responses (e.g., diaphoresis) are essential to the clinical performance context. Controlling the specific factors that make both animal and simulation methods useful could provide important information about the relative value of those factors to training outcomes. For example, comparing the diagnostic value of symptoms experienced by a live animal to those dramatized by a patient actor would provide information about the value of witnessing the real and continuous clinical responses that are only possible with a live animal. Isolating factors between live animals and simulation that contribute to their impact in a training context, and controlling for them in

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comparison studies, would provide the data needed to assure ethical and effective training for medical personnel who must be able to recognize and effectively manage casualties during crisis situations, where timely and competent clinical performance is essential.

The purpose of this study was to capture the differential impact of witnessing a response to a nerve agent (cholinergic event) experienced by a live animal, compared to a dramatized nerve agent response by a human patient actor, on the ability of trainees to clinically manage patients during a simulated mass casualty cholinergic event.

METHODS

Study Design

Institutional review and approvals were secured from the University of Michigan, University of Minnesota, and U.S. Army Medical Research and Materiel Command. All study-related activities took place at the University of Michigan and the University of Minnesota. The study involved clinical activities and therefore a purposive sample of clinicians with varying levels of expertise recruited. We recruited first-responder clinicians from a 100-mile radius around the cities of Minneapolis and St. Paul, Minnesota. The sample (N = 204) was composed of nurses (N = 21), paramedics (N = 137), and clerkship-level medical students (N = 46). All subjects completed written informed consent before participating in study-related activities.

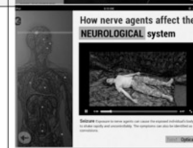
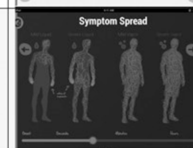
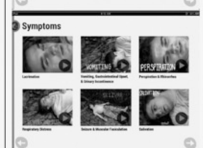
The study was designed to examine the impact of two forms of first-responder training in the management of a cholinergic event as measured by changes in knowledge, performance, self-efficacy, and affective behaviors of the participants. We implemented a quasi-experimental research design, using a purposively selected sample and stratified random assignment to two training groups: (1) live animal nerve agent response and (2) patient (actor) nerve agent response.

Instructional content was informed by the U.S. Army Medical Research Institute of Chemical Defense (USAMRICD) course materials for "Medical Management of Chemical and Biological Casualties," and "Field Management of Chemical and Biological Casualties." The training took place over a 4-hour period and was comprised of four components: (1) small group orientation, (2) self-paced multimedia content an iPad, (3) hands-on practice with simulators, and (4) hands-on performance with patient actors. We grouped participants into cohorts of 6 to 8 people during training; however, each participant independently completed all activities. All aspects of the training were common between the 2 groups, except for the examples of nerve agent response used in the multimedia component.

Training Context

The first component was a classroom-based orientation to present information about the training context and a brief introduction to casualties resulting from chemical weapons. During the second component, participants interacted with the foundational content of the training using a multimedia application (Table I). Half of the participants viewed examples of a nerve agent response in an African Green monkey,

TABLE I. Multimedia Content Sections for Cholinergic Crisis Training

Section	*Content*	*Illustration*
Introduction to Nerve Agent Casualties	Provides contextual purpose for the training.	
Anatomy & Physiological Response	Overview of relevant anatomy, physiological responses, and symptomology of human response to nerve agent exposure. Interactive "hotspots" on the patient plays the associated symptom video.	
Nerve Agent Exposure	Physiological response to nerve agent and antidote effects. A video shows the step-by-step synaptic responses inside the body.	
Liquid & Vapor Nerve Agents	In-depth information on the differences between liquid and vapor nerve agents in severity of response and onset of symptoms. Interactive animations illustrating the difference between vapor and liquid nerve agents in terms of the speed and severity of symptom onset, and progression of symptoms over time.	
Treatment Protocols	Interactive exploration of nerve agent treatment protocol, equipment, and medications.	
Symptoms & Treatment Effects	GROUP 1 An animal model serves to highlight symptom "hotspots" that facilitates discovery of treatment options for each symptom. OR GROUP 2 A human model serves to highlight symptom "hotspots" that facilitates discovery of treatment options for each symptom.	 
Medications	Interactive guide for determining the dose and time sequence for each medication, categorized for adult, child, and infant patients. Interactive quiz about medication dosing and time sequence for different patients.	
Assessment & Treatment Quiz	Interactive test to assess ability to respond to a specific nerve agent exposure case. Requires learner to diagnose exposure and administer the appropriate medications, doses, and time sequences per the treatment protocol.	
Summary	Summary of need and value of training in clinical management of nerve agent casualties.	

as well as the animal's recovery after correct treatment. The other half of the participants viewed examples of a simulated nerve agent response performed by a human patient (actor). Both forms of the multimedia application necessitated a high level of self-paced interactivity and provided formative feedback throughout to engage and inform the participants about their progress. After completing the multimedia component, participants reviewed the clinical protocols for diagnosing and managing a patient experiencing cholinergic crisis, and practiced associated clinical tasks using SimMan3G mannequin simulators (Laerdal Medical Corporation, Stavanger, Norway). Because nerve agent mass casualties require medical personnel to wear protective gear that simultaneously overtaxes and limits their perceptual capacities, we taught participants how to prepare themselves using Mission-Oriented Protective Posture Level IV to align the fidelity of the performance component of the training.[34–39] Finally, participants wore the protective gear to interact with patients (actors) who behaved as if they had been exposed to a chemical weapon as part of a simulated mass casualty event.

The patient actors were trained to display symptoms associated with a moderate exposure to Sarin gas (nerve agent), as well as to mustard gas (vesicant). Actors who responded as if exposed to mustard gas were used as distractors during the simulated mass casualty in order to assess the abilities of the participants to correctly diagnose patients with nerve agent exposure. A professional special-effects make-up artist provided the formulas for creating the visual representations of symptoms for both exposure types. All training events were conducted at the City of Plymouth Fire Department (Plymouth, Minnesota); a two-story facility with classrooms, common areas, and a large bay for housing trucks and equipment. The large bay was used to create a mass casualty of 24 people; half of which exhibited symptoms associated with exposure to a nerve agent, the other half to mustard gas. Participants donned protective gear and entered the casualty area where they were instructed to select and treat the patients with nerve agent exposure. Actors were instructed to monitor any treatment provided to them by the participants in order to respond appropriately to any medications and physical interventions.

Instrumentation and Analyses

To examine the relative effects of training on the abilities of subjects to identify and manage a patient experiencing cholinergic crisis in a mass casualty situation, we used four validated assessment instruments: (1) knowledge, (2) performance, (3) self-efficacy, and (4) affective state. Subjects completed pretraining assessments before participating in any of the instructional activities, and post-training assessments immediately following the instructional activities.

We used validated assessment instruments to assess multiple performance dimensions associated with managing a nerve agent casualty. We assessed knowledge through 23 multiple-choice and short-answer questions, with a maximum score of 39 total points. Construct validity ($p = 0.003$), test–retest reliability ($r = 0.97$), and internal consistency ($\alpha = 0.69$) were previously established for the knowledge assessment.[50] Two pairs of trained raters used a performance assessment instrument to score trainees on their abilities to clinically manage nerve agent casualties (actors) at multiple points, and in aggregate with a maximum total score of 45 points. Raters were trained until they achieved and maintained inter-rater agreement above 0.90. Construct validity ($p = 0.000$), test–retest reliability ($r = 0.98$), and internal consistency ($\alpha = 0.90$) were previously established for the knowledge assessment.[50] To capture self-efficacy, we asked the subjects to self-report the extent to which they would be comfortable helping or independently managing patients in a nerve agent–related mass casualty. A 7-item, 6-point Likert scale (strongly disagree to strongly agree) was used for self-efficacy, for a total of 42 points. We measured state-related affect using a 19-item adaption of the State-Trait Anxiety Inventory.[51] All items were scored using a 6-point Likert scale (strongly disagree to strongly agree), for a total of 114 points. We inverse coded scores so that lower scores reflected greater anxiety. There is considerable evidence of construct and concurrent validity for the scale, reported internal consistency ranges between 0.86 and 0.95, with test–retest reliability coefficients between 0.65 and 0.75.[51]

All data were analyzed using SPSS-Statistics v21 (IBM, Armonk, New York). We conducted analysis of variance with repeated measures for within and between group comparisons. All calculations were conducted with statistical significance set at $p < 0.05$.

RESULTS

There were significant increases in scores ($p = 0.000$) for knowledge, performance, self-efficacy, and affect after

TABLE II. Pre-Post Scores for Both Training Models[a]

Assessment (Total Score)	Animal Group Pretraining Score[b]	Actor Group Pretraining Score[b]	Animal Group Post-Training Score[b]	Actor Group Post-Training Score[b]
Knowledge (39)	23.58 (3.66); 60%	23.25 (3.33); 60%	31.39 (3.18); 81%	31.78 (3.05); 81%
Performance (45)	6.78 (5.62); 15%	7.71 (5.52); 17%	30.94 (7.36); 69%	30.37 (5.73); 68%
Self-Efficacy (42)	20.96 (7.76); 50%	22.14 (7.36); 53%	36.60 (3.46); 87%	36.71 (3.16); 87%
Affect (114)	85.29 (12.49); 75%	85.27 (11.74); 75%	91.50 (11.32); 80%	92.34 (10.74); 81%

[a]No significant differences between groups for pre- or post-training outcomes. [b]Mean (Standard Deviation); Percent of Total Score.

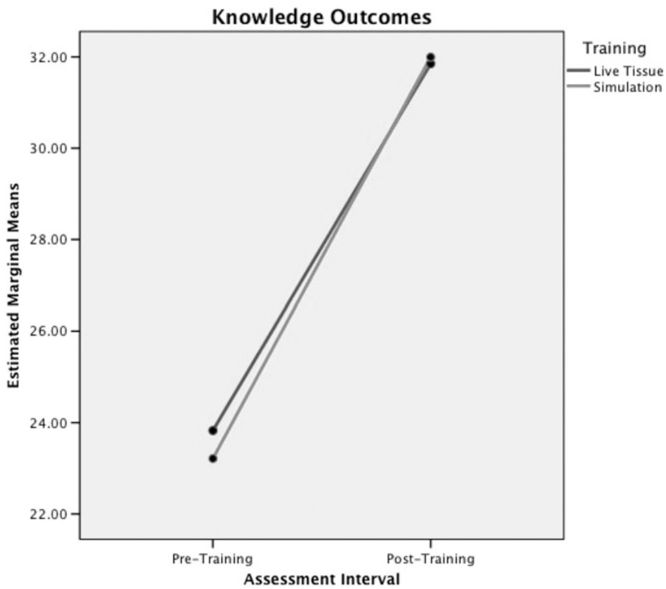


FIGURE 1. Pre- and post-instruction knowledge scores by training model.

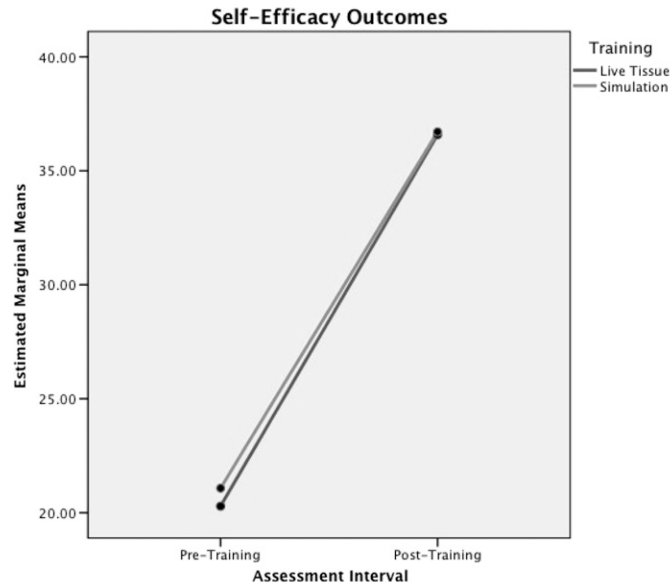


FIGURE 3. Pre- and post-instruction self-efficacy scores by training model.

training for both groups. Assessment scores associated with training outcomes for each group are presented in Table II.

There were no significant differences in any of the post-training outcomes for the two groups. Differential outcomes for each assessment are illustrated in Figures 1 to 4. There were significant positive correlations between post-training self-efficacy scores and those for performance and affect, as well as between knowledge and performance scores ($p < 0.05$) for the live animal trained group. The post-training scores for the patient actor trained group had significant positive correlations between self-efficacy scores and those for knowledge, performance, and affect ($p < 0.05$).

DISCUSSION

The results of this study demonstrate the effectiveness of a 4-hour training intervention on first-responder trainees to identify and clinically manage patients experiencing cholinergic crisis after exposure to a nerve agent in a simulated mass casualty setting, across four dimensions: knowledge, performance, self-efficacy, and affective state. These results provide

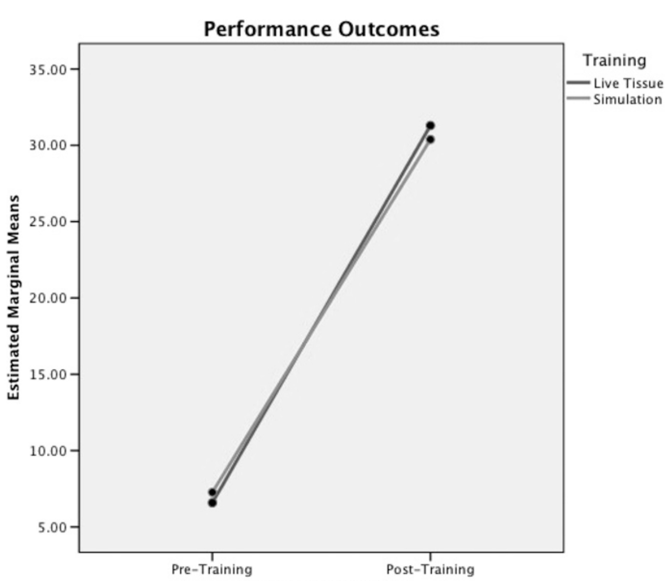


FIGURE 2. Pre- and post-instruction performance scores by training model.

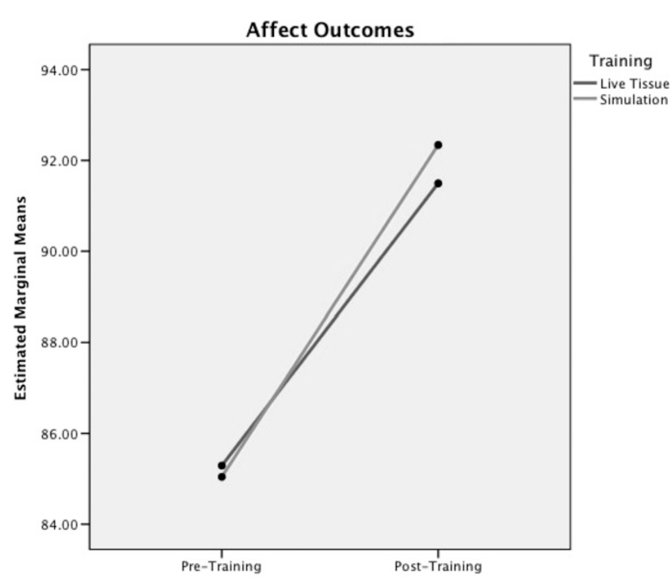


FIGURE 4. Pre- and post-instruction affect scores by training model.

critical information for determining optimal, evidence-based training practices that serve to reduce or eliminate the uses of live animals without diminishing the quality of training. First-responder medical personnel must acquire and maintain critical competencies associated with the management of mass disaster and rare-event casualties; however, there are limited opportunities to learn and practice skills. Training and certification programs may help providers learn knowledge and skills, but without evidence of performance abilities, the extent to which that knowledge transfers into applied practice cannot be determined. Gaps between training outcomes and applied performance data suggest that there is room for improvement in how we facilitate training to assure clinical competency.[52,53]

The data suggest several key considerations for training of first-responder medical personnel. The substantial increase in post-training performance scores by both training groups exceeded the differential scores for the other assessment domains. This highlights the value of performance-based assessment, but also the opportunity for hands-on practice of applied skills for both initial and refresher training. A passing rate of 70% is typical for demonstrating competency as a civilian first responder and although the knowledge scores exceeded that rate, the post-training performance scores for both groups were slightly below at 68% and 69%.[54] This is likely because of limitations on the extent of time allotted to deliberate practice during the training and with increased time these scores would likely improve further.

Simulation-based training provides an easily accessible, on-demand option for prescribed and standardized instruction that facilitates deliberate practice and allows clinicians to develop and improve their performance abilities.[55] However, technology-based simulation methods have limitations which other hands-on methods of instruction support, such as living tissue and dynamic physiological responses.[56] For interventions that require direct interaction with human tissues (e.g., thoracotomy, hemorrhage control, etc.), the fidelity of simulated tissues may not adequately represent the performance context to the extent that transfer is supported to an applied clinical setting. Improvements in the technological characteristics of mannequin simulators, such as anatomical, physiological, and tissue fidelity, would substantially add to their prospective benefits for all forms of mass disaster and rare-event casualty situations.[56] However, this study demonstrates the relative equivalence of witnessing a response to a nerve agent (cholinergic event) experienced by a live animal and a dramatized nerve agent response by a human patient actor on the ability of trainees to clinically manage patients during a simulated mass casualty cholinergic event.

Implications

This training provides an alternative for military medical personnel who are unable to attend more comprehensive training at USAMRICD, as well as for civilian first-responder personnel who may be tasked with responding to a terrorist attack on the general population. The design of the training makes it easily portable to multiple locations, which is advantageous for initial instruction, but also for refresher training as needed. The multimedia module is suitable for on-demand training, and the simulation-based modules could be facilitated with any mannequin simulator, standardized patients (actors), or even between peers acting as patient and provider. Additionally, the content could be modified or adapted for casualties resulting from exposure to other types of chemical or biological agents. The combination of multimedia content and hands-on simulation-based training methods provides versatility for prescribed and standardized instruction that facilitates the deliberate practice clinicians need to develop and improve their performance abilities. Additionally, the value of being able to measure performance to the extent that it provides feedback to clinicians about their abilities at any point in time can provide information about when refreshment training or practice is recommended to maintain these critical competencies. These performance data could facilitate standard setting so that individuals can hone their performance until they achieve a predetermined level of mastery, or threshold, for critical competencies. Training content could then be tailored to an individual's competence in order to make best use of resources and training time.

Limitations and Next Steps

A limitation of this study is that we did not evaluate retention after training; however, a study examining retention after training at 6 weeks, 18 weeks, and 52 weeks is in process. Another limitation of this study is that we did not attempt to evaluate performance during applied clinical care, so the extent to which performance in the simulated context transfers to competent performance managing actual patients in crisis remains to be quantified. Theoretically, the mental models created from a relevant training environment will transfer to a clinical care setting; however, future work to characterize the extent of transfer in different clinical contexts is merited, if challenging. Finally, we conducted the study using a purposive sample of first-responder clinicians that did not include emergency medical personnel with advanced training, such as physicians, and results are best interpreted in accordance with the described sample characteristics.

CONCLUSIONS

The findings from this study demonstrates the relative equivalence of witnessing a nerve agent response in a live animal and dramatized by a human patient actor on the ability of trainees to clinically manage patients during a simulated mass casualty cholinergic event. The study outcomes provide information toward the aim of reducing or eliminating the uses of live animals for clinical instruction without diminishing the quality of training. Additionally, the study outcomes could aid in the selection of instructional methodologies available to a broad community of first-responder personnel in military and civilian service. Although less comprehensive than the USAMRICD courses, the combination of multimedia and simulation-based methods created an experiential learning environment that yielded significant improvements in knowledge, performance, self-efficacy, and affect. These outcomes demonstrate the value of this easily distributed program to increase competency of first responders in recognizing and managing a mass casualty cholinergic event.

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REFERENCES

1. DeYoung K: Kerry says ‘raw data’ indicate recent use of chemical weapons by Syrian government. Washington Post, 2014. Available at http://www.washingtonpost.com/world/middle_east/kerry-says-raw-data-indicate-recent-use-of-chemical-weapons-by-syrian-government/2014/05/15/7ca7d3fa-dc50-11e3-a837-8835df6c12c4_story.html; accessed May 15, 2014.
2. Human Rights Watch: Syria: Strong Evidence Government Used Chemicals as a Weapon. Available at http://www.hrw.org/news/2014/05/13/syria-strong-evidence-government-used-chemicals-weapon; accessed May 13, 2014.
3. Khan AS, Morse S, Lillibridge S: Public-health preparedness for biological terrorism in the USA. Lancet 2000; 356: 1179–82.
4. Waeckerle JF: Domestic preparedness for events involving weapons of mass destruction. JAMA 2000; 283: 252–4.
5. Okumura T, Takasu N, Ishimatsu S, et al: Report on 640 victims of the Tokyo subway sarin attack. Ann Emerg Med 1996; 28: 129–35.
6. Sidell FR: Nerve agents. In: Medical Aspects of Chemical and Biological Warfare, pp 129–80. Edited by FR Sidell, ET Takafuji, DR Franz. Washington, DC, Office of the Surgeon General and Department of the Army and Borden Institute, 1997.
7. Rodgers JC: Chemical incident planning: a review of the literature. Accid Emerg Nurs 1998; 6: 155–9.
8. Kadivar H, Adams SC: Treatment of chemical and biological war fare injuries: insights derived from the 1984 Iraqi attack on Majnoon Island. Mil Med 1991; 156(4): 171–7.
9. Macilwain C: Study proves Iraq used nerve gas. Nature 1993; 363(6424): 3.
10. Morita H, Yanagisawa N, Nakajima T, et al: Sarin poisoning in Matsumoto, Japan. Lancet 1995; 346(8970): 290–3.
11. Ohbu S, Yamashina A, Takasu N, et al: Sarin poisoning on Tokyo subway. South Med J 1997; 90(6): 587–93.
12. Brennan RJ, Waeckerle JF, Sharp TW, Lillibridge SR: Chemical warfare agents: emergency medical and emergency public health issues. Ann Emerg Med 1999; 34(2): 191–204.
13. Cannard K: The acute treatment of nerve agent exposure. J Neurol Sci 2006; 249: 86–94.
14. Murray CK: Development of a deployment course for graduating military Internal Medicine residents. Mil Med 2006; 171(10): 933–6.
15. Filner B: Battlefield Excellence through Superior Training Practices Act. Washington DC, H.R.4269. Library of Congress, October 12, 2009. Available at http://www.thomas.gov/cgi-bin/bdquery/z?d111:h.r.04269; accessed October 15, 2010.
16. Vandiver J, Kloeckner M: German ruling puts USAREUR plans for live-animal medical training on hold. Stars and Stripes, 2010. Available at http://www.stripes.com/news/german-ruling-puts-usareur-plans-for-live-animal-medical-training-on-hold-1.114989; accessed August 17, 2010.
17. Wagh MS, Waxman I: Animal models for endoscopic simulation. Gastrointest Endosc Clin N Am 2006; 16(3): 451–6.
18. Roberts KE, Bell RL, Duffy AJ: Evolution of surgical skills training. World J Gastroenterol 2006; 12(20): 3219–24.
19. Chapman DM, Rhee KJ, Marx JA, et al: Open thoracotomy procedural competency: validity study of teaching and assessment modalities. Ann Emerg Med 1996; 28(6): 641–7.
20. Fried GM, Derossis AM, Bothwell J, Sigman HH: Comparison of laparoscopic performance in vivo with performance measured in a laparoscopic simulator. Surg Endosc 1999; 13(11): 1077–81.
21. Korndorffer JR Jr, Dunne JB, Sierra R, Stefanidis D, Touchard CL, Scott DJ: Simulator training for laparoscopic suturing using performance goals translates to the operating room. J Am Coll Surg 2005; 201(1): 23–9.
22. Cisler JJ, Martin JA: Logistical considerations for endoscopy simulators. Gastrointest Endosc Clin N Am 2006; 16(3): 565–75.
23. Anastakis DJ, Wanzel KR, Brown MH, et al: Evaluating the effectiveness of a 2-year curriculum in a surgical skills center. Am J Surg 2003; 185: 378–85.
24. Wanzel KR, Ward M, Reznick RK: Teaching the surgical craft: from selection to certification. Curr Probl Surg 2002; 39: 574–659.
25. Powell DA, Gonzales C, Gunnels RD: Use of the ferret as a model for pediatric endotracheal intubation training. Lab Animal Sci 1991; 41(9): 86–9.
26. Custalow CB, Kline JA, Marx JA, Baylor MR: Emergency department resuscitative procedures: animal laboratory training improves procedural competency and speed. Acad Emerg Med 2002; 9(6): 875–86.
27. Tait C: On the differences between a child and a kitten. J Emerg Nurs 2010; 36(1): 78–80.
28. McCarthy M, Ranzinger MR, Nolan DJ, Lambert CS, Castillo MH: Accuracy of cricothyroidotomy performed in canine and human cadaver models during surgical skills training. J Am Coll Surg 2002; 195: 627–9.
29. Vadodaria BS, Gandhi SD, McIndoe AK: Comparison of four different emergency airway access equipment sets on a human patient simulator. Anaesthesia 2004; 59(1): 73–9.
30. Smith R, Nye S: Comparison of induced affect and covert rehearsal in the acquisition of stress management coping skills. J Couns Psychol 1989; 36(1): 17–23.
31. VanGemmert A, VanGalen G: Stress, neuromotor noise, and human performance: a theoretical perspective. J Exp Psychol Hum Percept Perform 1997; 23(5): 1299–1313.
32. Mandler G: Thought processes, consciousness, and stress. In: Human Stress and Cognition: An Information Processing Approach, pp 179–201. Edited by V Hamilton, DM Warburton. New York, John Wiley & Sons, 1979.
33. Humara M: The relationship between anxiety and performance: a cognitive-behavioral perspective. Athletic Insight 1999; 1(2): 1–14.
34. Smolander J, Louhevaara V, Korhonen O: Physiological strain in work with gas protective clothing at low ambient temperatures. Am Ind Hyg Assoc J 1985; 46(12): 720–3.
35. King JM, Frelin A: Impact of the chemical protective ensemble on the performance of basic medical tasks. Mil Med 1984; 149(9): 496–501.
36. Fine BJ, Kobrick JL: Effect of heat and chemical protective clothing on cognitive performance. Aviat Space Environ Med 1987; 58(2): 149–54.
37. Arad M, Berkenstadt H, Zehlinger J, Laor A, Shemer J, Atsmon J: The effects of continuous operation in a chemical protective ensemble on the

performance of medical tasks in trauma management. J Trauma 1998; 35(5): 800–4.

38. Berkenstadt H, Arad M, Nahtomi O, Atsmon J: The effect of a chemical protective ensemble on intravenous line insertion by emergency medical technicians. Mil Med 1999; 164: 737–9.
39. Hendler I, Nahtomi O, Segal E, Perel A, Wiener M, Meyerovitch J: The effect of full protective gear on intubation performance by hospital medical personnel. Mil Med 2000; 165: 272–4.
40. Bruner J: Acts of Meaning. Cambridge, MA, Harvard University Press, 1990.
41. Dewey J: How We Think (Revised edition). Boston, MA, Houghton Mifflin Company, 1933/1998.
42. Harnad S. Neoconstructivism: A unifying theme for the cognitive sciences. In: Language, Mind and Brain, pp 1–11. Edited by T Simon, R Scholes. Hillsdale, NJ, Erlbaum, 1982.
43. Vygotsky L: Mind in Society. Cambridge, MA, Harvard University Press, 1978.
44. Inzana CM, Driskell JE, Salas E, Johnston JH: Effects of preparatory information on enhancing performance under stress. J Appl Psychol 1996; 81(4): 429–35.
45. Dandoy AC, Goldstein AG: The use of cognitive appraisal to reduce stress reactions. J Soc Behav Pers 1990; 5: 275–85.
46. Andreatta PB, Maslowski E, Petty S, et al: Virtual reality triage training provides a viable solution for disaster-preparedness. Acad Emerg Med 2010; 17(8): 870–6.
47. Cho J, Kang GH, Kim EC, et al: Comparison of manikin versus porcine models in cricothyrotomy procedure training. Emerg Med J 2008; 25(11): 732–4.
48. Cummings AJ, Getz MA: Evaluation of a novel animal model for teaching intubation. Teach Learn Med 2006; 18(4): 316–9.
49. Stewart RD, Paris PM, Pelton GH, Garretson D: Effect of varied training techniques on field endotracheal intubation success rates. Ann Emerg Med 1984; 13(11): 1032–6.
50. Andreatta P, Klotz J, Madsen JM, Hurst CG, Talbot JB. Assessment instrument validation for critical clinical competencies: pediatric-neonatal intubation and cholinergic crisis management. Interservice/Industry, Training, Simulation and Education Conference Newsletter (in press).
51. Spielberger CD, Gorsuch RL, Lushene R, Vagg PR, Jacobs GA: Manual for the State-Trait Anxiety Inventory. Palo Alto, CA, Consulting Psychologists Press, 1983.
52. Nestel D, Groom J, Eikeland-Husebø S, O'Donnell JM: Simulation for learning and teaching procedural skills: the state of the science. Simul Healthc 2011; 6 Suppl: S10–3.
53. Irvine S, Martin J: Bridging the gap: from simulation to clinical practice. Clin Teach 2014; 11(2): 94–8.
54. National Registry of Emergency Medical Technicians. About NREMT examinations. Available at http://www.nremt.org/nremt/about/about_exams.asp; accessed May 18, 2014.
55. Steadman RH, Coates WC, Huang YM, et al: Simulation-based training is superior to problem-based learning for the acquisition of critical assessment and management skills. Crit Care Med 2006; 34(1): 151–7.
56. Klotz JJ, Dooley-Hash SL, House JB, Andreatta PB: Pediatric and neonatal intubation training gap analysis: instruction, assessment, and technology. Simul Healthc 2014; 9(6): 377–83.