ITEC 2019 – Shaping Military Medical Simulation: Blending training technologies to objectively measure Casualty Response System Readiness

Abstract — The Department of Defense and Military Healthcare System (MHS) are rapidly approaching a critical training and readiness gap triggered by less armed conflict and fewer combat casualties. Line and military health system commanders alike must rely on simulation to bridge the gap between what is experientially available (very little in the absence of combat) and what is needed for safe first-time casualty response. The military must look at innovative training technologies designed to improve casualty response readiness and streamline how training is delivered. The authors present a novel approach to Tactical Combat Casualty Care (TC3) training utilizing intelligent tutoring based TC3 training delivered on smart mobile devices coupled with high fidelity combat trauma manikins tested with Soldiers from United States Army Alaska. Initial findings show an overall 95% acceptance rate for this new technology, reduced material presentation time, improved standardization of delivery and reduced training time utilizing a mobile training application when compared to traditional training models. High fidelity manikin data capture provides standardized methods to objectively measure TC3 skill performance across the different training cohorts to provide individual and cohort readiness metrics. These data capture capabilities create potential to move simulated casualty data across integrated, connected medical and nonmedical architectures making joint casualty response system readiness measurement possible.

Objectives

The military medical system has made monumental strides in improving combat casualty response in the past 15 years of war by carefully analyzing Joint Trauma Registry data and implementing lessons learned from casualties. Systemic training and application of the Committee on Tactical Combat Casualty Care's iteratively developed TC3 curriculum is central to this success. Despite these advances, 24% of casualty deaths were deemed preventable (1). Senior leaders have mandated TC3 training for all combatants in the National Defense Authorization Acts for 2017 and 2018, DoDI 1322.24 issued in March 2018, and US Central Command Orders in November 2017 in an effort to improve and sustain improved casualty response readiness. Unfortunately, these directives do not mandate how TC3 training will be implemented. Sauer et al note "The high degree of variance amongst deployed unit medical personnel, both in terms of clinical training and operational experience, results in inconsistent application and enforcement of TCCC compliance across the force."(2) Significant differences in TC3 interpretation and variability in training delivery methods make readiness measurement impossible. The authors objective was to demonstrate the feasibility of a novel approach to TC3 training that is scalable, objectively measurable, improves training efficiency and is sustainable across the Force.

Introduction

Traditional Army and TC3 training rely heavily upon synchronous lecture-based curriculum delivered by expert instructors, a hands-on crawl, walk, run training model, and subjective evaluation and measurement of performance. This runs counter to the Army's TRADOC Pamphlet 525-8-2 "The U.S Army Learning Concept for Training and Education (ALC-TE) 2020-2040 April 2017 which describes a fundamental change in the approach to learning that requires a "progressive, continuous, learner-centric, competency-based learning environment." The ALC-TE states, "The Army will accelerate the development of adaptive and predictive learning engines to reinforce and prevent the typical fading and decay of critical knowledge and skills and expand the permanence of knowledge to help achieve better outcomes and Soldier and civilian synthesis and adaptive capability." (3)

Effective medical training is difficult to execute and assess due to the lack of actual patients, training devices capable of capturing objective task performance and time constraints. Instructors, limited by time and resources, redact TC3 presentations and practice TC3 tasks on unrealistic training devices or each other. Instructors use noise and distractors to generate "battlefield stress" while verbally guiding the trainee through clinical findings and then subjectively assessing if the trainee's interventions were sufficient to "save" the casualty or meet the standard.

The Army's Program Executive Office for Simulation and Training and Instrumentation (PEO STRI) is responsible for the advance development and lifecycle management of training devices. PEO STRI's subordinate program office, the Joint Program Management Office for Medical Modeling and Simulation (JPM MMS) is dual chartered by the Army and the Defense Health Agency to meet the medical simulation training needs of the Department of Defense (DoD). JPM MMS and researchers from the Naval Air Warfare Center Training Systems Division (NAWCTSD) identified a unique opportunity to evaluate available COTS technologies that fully aligned with the ALC-TE and their ability to meet the TC3 training requirement.

JPM MMS led an evaluation of two COTS technologies, the Cerego learning system and KGS Trauma FX APL-HEMO whole body Human Patient Simulator (HPS), as a means to teach and evaluate Soldier TC3 skills. Cerego is learning management and interactive training software that utilizes adaptive learning algorithms derived from neuroscience and cognitive science to optimize and measure learning. JPM MMS developed TC3 curriculum from the published Committee on Tactical Combat Casualty Care All Combatant Curriculum to be delivered to Soldiers via Cerego, the TC3 All Combatant Cognitive Trainer (TC3 ACCT). The KGS Trauma FX APL-HEMO casualty simulator is a rugged, multitask trainer that simulates severe trauma allowing Soldiers to practice treating the preventable causes of combat death. It represents and objectively captures performance data on clinical interventions including casualty assessment, control of massive bleeding from an extremity wound, control of massive bleeding from an inguinal wound, nasopharyngeal airway placement and needle chest decompression. This same device is being procured by the Army as the foundational training device for its TC3 Exportable (TC3X) simulation program.

Figure 1. Screenshot from TC3 ACCT on smart phone.

Figure 2. KGS Trauma FX APL-HEMO being evaluated and treated by a Soldier during training in Alaska.

Approach

To conduct this technology demonstration, the authors enlisted the assistance of the 1st Battalion 5th Infantry Regiment at Fort Wainwright, Alaska. The chain of command at all levels strongly supports realistic casualty response training and requires all Soldiers to attend its Bobcat First Responder Course, developed from the TC3 for All Combatants Curriculum, but modified by the unit's medical leadership.

Student demographic questionnaires indicated student MOS were primarily 11B (66%) Infantryman and 11C (24%) Indirect Fire Infantryman; only 10% held a different MOS. Sixty-six percent held the rank of PV2/PFC, 17%, SPC, 10%, PVT, and 7%, SGT. Eighty-two percent had HS/GED level education, while 11% had some college but no degree, and 7% had a 2-year degree. Forty-eight percent of students had prior CLS training.

The evaluation included three training conditions: 1) Bobcat First Responder (BFR) course – as traditionally taught – didactic and HPS hands on training interwoven throughout the course (n=25), 2) TCCC knowledge trained via the Mobile app (n=29), followed by HPS training, and 3) BFR course with all knowledge presented first (2 days), followed by HPS hands on training (BFR-didactic, n=26).

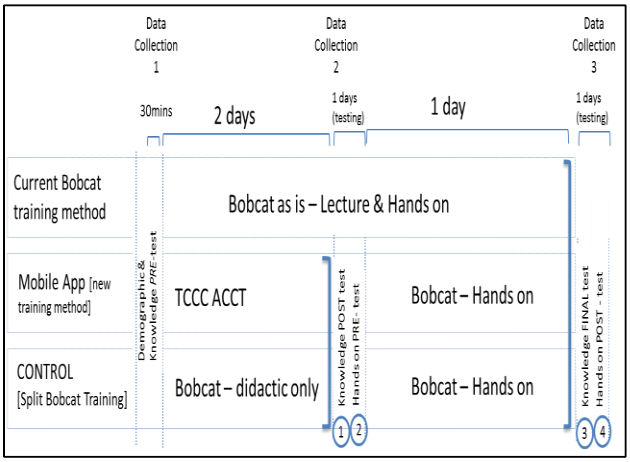

*Figure 3***.** Study conditions, timeline and assessments.

All didactic training materials were derived from the CoTCCC TC3 All Combatant Curriculum delivered in three different forms. Current Bobcat training method utilizes a modified CoTCCC TC3 All Combatant Curriculum revised by the Battalion Surgeon and Physician Assistant based upon their priorities and taught by a seasoned 68W Combat Medic Non-Commissioned Officer. The Mobile App method, TC3 ACCT, used the Cerego platform to deliver a modified version of TC3 All Combatant Curriculum adapted to be delivered through this medium. The TC3 ACCT curriculum was developed by Cerego educational development specialists and meticulously cross referenced by the authors to ensure all TC3 concepts were presented. The Control method utilized directly downloaded CoTCCC's TC3 All

Combatant curriculum website and delivered without deletion of content by a seasoned 68W NCO as didactic lectures.

Each training cohort underwent pre and post testing of cognitive knowledge and hands on skills. Hands on posttest evaluation utilized the KGS APL-HEMO operated in a simulated combat environment by seasoned 68W NCOs with a standardized scenario.

Results

Learning using the App

Time on task

Students in the mobile app condition spent an average 5.37 hrs on the app to complete the didactic training (and approximately 1 hour of instructor scenario review on day 2). Students in the BFR classroom condition spent approximately 12 hours in face to face instruction time.

Knowledge gain

Students using the App demonstrated a significant increase in TCCC knowledge from pre-test to post test ($t=11.14$; $p<.00001$). In separate analysis, even students with prior CLS training demonstrated significant knowledge gain using the mobile app ($t=8.75$; $p<.05$). Students learning through face to face didactic instruction also demonstrated a significant increase in TCCC Knowledge from pre-test to post-test ($t=4.9$; $p<.05$) Similar gains in knowledge were seen for both App and face to face cohorts as measured by the change in knowledge scores from pre to post test ($X_{gainApp}=5.31$; $X_{gainBFR-D}=5.33$; $F=.0005$; $p<.05$).

Student knowledge gains after an average 5.37 hrs using the app (plus 1-hour scenario review) was comparable to knowledge gains after 12 hours face to face instruction.

Hemorrhage control performance

Sample size is limited due to challenges associated with data collection protocols and HPS technical operations. Complete data sets were captured from 28 students, 15 in the BFR-didactic condition, 9 in the mobile app conditions and 4 in the traditional BFR condition. Descriptive data are provided in Figure 2 and 3.

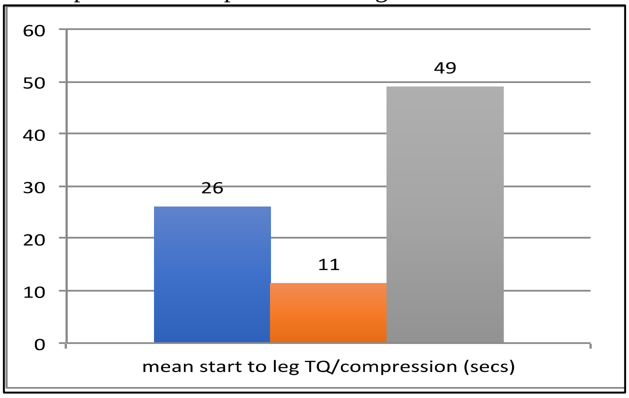

Figure 4. Mean time to start bleeding control.

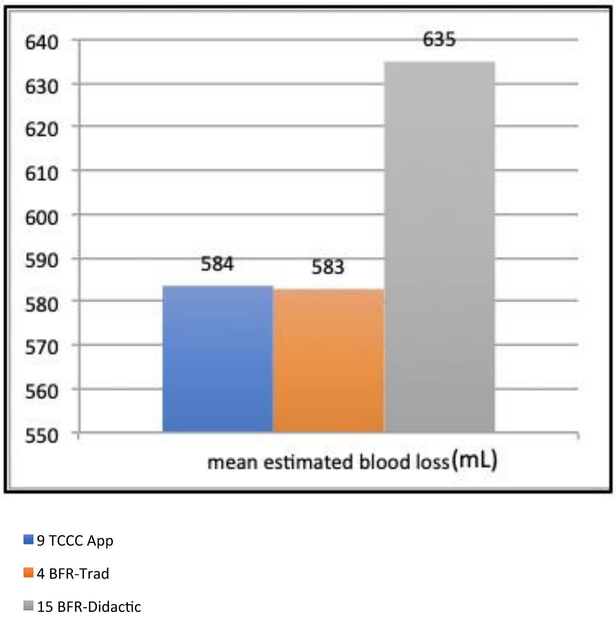

Figure 5. Mean estimated blood loss.

Not surprisingly, the traditional BFR cohort applied the tourniquet the quickest of the 3 groups (x=11secs) because the teaching modeled has instructors perform no notice "Tourniquet Drills" on themselves during lectures to keep students awake and build muscle memory for this task. This was followed by students in the mobile app condition (x=26secs), and finally the control condition (x=49secs). In terms of volume blood loss, differences between students in the mobile app condition and the traditional BFR group were negligible ($X_{app}=584$; $X_{BFR}=583$), and substantially less than the control condition ($X_{BFR\text{-}didactic}=635$).

Confidence

Students reported ratings of confidence in ability to perform TCCC tasks, including: move a casualty, apply a tourniquet, assess AVPU, apply a hemostatic dressing, apply an eye patch, assess shock, prevent hypothermia, complete a casualty card, and adhere to treatment priorities (MARCH) resulted in no significant differences in post training confidence across the 3 training cohorts. Figure 3 reports the mean level of confidence from 1 not confident to 5 completely confident. No significant differences were found across conditions, in self-reported, post training levels of confidence in ability to performance TCCC tasks.

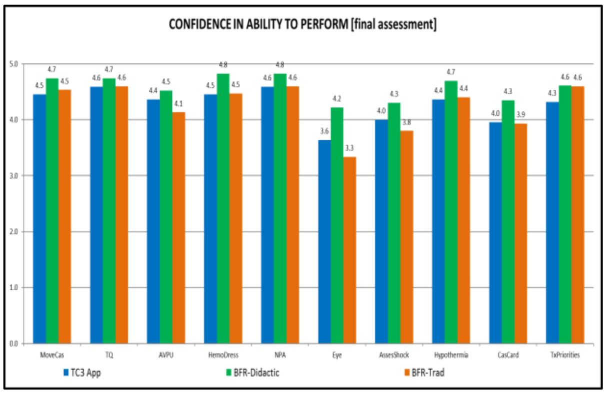

Figure 6. Confidence in the ability to perform TC3 Tasks.

Perceptions of the learning experience

Students were asked ten questions related to 1) their experience learning via the app, 2) ease of use and immersion when using the App, and 3) generalizability of the learning method. Ninety-six percent of students using the mobile app reported that it was easy to learn TCCC knowledge using the app, 92% reported the app was easy to use, and 88% would like other courses to be delivered using the app.

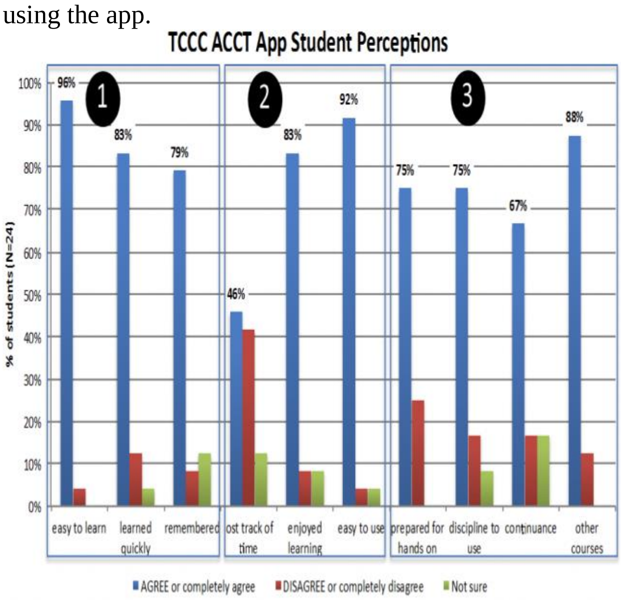

Figure 7. Mobile app perceptions of training (n=24).

Discussion

Efficient, effective combat casualty response is critical to winning in a complex world. The moral imperative to save lives on the battlefield is obvious. What is less obvious is the deleterious effects poor casualty response has on unit combat efficiency and speed of action. These are critical elements required to rapidly create and sustain the combat power necessary to win.

Army Field Manual 3-0 Operations defines the elements of combat power. It is not difficult to imagine how poor, inefficient casualty response, fostered by ineffective training, unnecessarily affects combat power by limiting maneuver, stressing sustainment, increasing protection requirements, taxing leadership and creating battlefield friction that impact mission command while diminishing morale, fighting spirit and casualty survival.

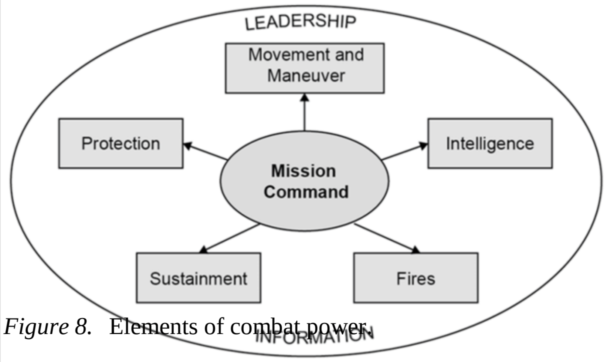

Figure 8. Elements of combat power.

This demonstration shows how TC3 ACCT and high-fidelity casualty simulators combined can be used to provide realism and measurability to casualty response training to ultimately improve the Commander's ability to generate and sustain combat power.

By integrating casualty response into almost every training event, gathering casualty response data that shapes training and prioritizing casualty response training on par with physical fitness, small unit tactics and marksmanship, units like the 75th Ranger Regiment have significantly lower preventable combat death (3%) than the general-purpose force (16%). GEN James Mattis, CENTCOM Commander on 18 January 2013 writes, "Findings on the difference between the Ranger experience and DoD at large appear attributable to the Ranger Casualty Response System, which is a command-directed program that aggressively teaches the Tactical Combat Casualty Care curriculum to all unit personnel, integrates TCCC into small unit tactics and battle drills, and uses a unit based trauma registry for performance improvement and directed procurement." (5) This demonstration provides a potential way forward to operationalize and scale casualty response training.

Critics may argue that special operations units like the Rangers have more time and dedicated resources to accomplish casualty response training. One way to increase training opportunities in the general-purpose force is to maximize "downtime" by decentralizing and personalizing training. TC3 ACCT provides a scalable option for "adaptive and predictive learning" that moves closer to the "Army's Vision to immerse Soldiers and Army Civilians in progressive, continuous, learner centric competency-based learning environment from their first day of Service." Properly placed trauma manikins could provide Soldiers opportunities to get the "sets and reps" required to create muscle memory when evaluating and treating casualties.

TC3 ACCT demonstrates a novel capability to build and master cognitive knowledge, but that is not enough to ensure readiness. That knowledge must be demonstrated through objectively measured action. Commanders would never accept cognitive marksmanship training alone to verify readiness. On the contrary, Soldiers must objectively qualify on a standardized range by firing their weapon. The same standards must be applied to casualty response. While perhaps easier and more readily available, Soldiers training on each other or on low fidelity casualty care training devices do not provide sufficient realism to prepare the Soldier, nor do they provide sufficient objective measurement to inform the commander about readiness. The trauma manikin used in this demonstration provided objective measurement of individual skill performance, created a common standard tied to clinical relevance, and allowed the Soldier to build realistic confidence in their ability to use their Individual First Aid Kit to save casualties. The trauma manikin in this demonstration fills a critical experiential gap because in the absence of war, these casualties simply do not exist. It also provides first responders the ability to mentally, psychologically, and technically prepare for severe, emotionally disturbing decisions and wounds common in combat.

Lessons Learned/Future Work

Several lessons can be drawn from this technology demonstration. First, today's technologically savvy Soldier is a different type of learner than trainees of the past. The Army can capitalize on this opportunity by rapidly adopting COTS technologies geared to millennials. Second, the importance of command emphasis on casualty response training cannot be overstated. Third, today's combat trauma manikins fill a critical requirement for realistic casualties to train on and learn from. The alternative, to learn on real casualties from the next war, which is historically how we have practiced, is morally bankrupt with today's technology. These technologies provide Commanders scalable, distributive capability to measure and maintain Soldier readiness and observe collective readiness while gathering actionable data to influence training priorities.

However, it is not enough that these technologies exist as stand-alone capabilities. The future of Army training is the incorporation of live, virtual and constructive simulation into a comprehensive, lifelong learning process. Medical knowledge, skills and readiness cannot exist alone and in isolation from the Commanders training paradigm. These technologies must be linked to a Medical Simulation Training Architecture that is interwoven with the larger Army and DoD simulated training environment. The JPM MMS has already taken significant steps toward this connectivity through prototype efforts currently underway.

Conclusions

The authors present a successful, scalable, novel approach to point-of-need TC3 training that educates Soldiers while objectively measuring individual cognitive and haptic skill readiness. Taken in aggregate, this data can be used to estimate the knowledge, skills, abilities and weaknesses of a unit and guide scarce training resources to unit weaknesses. Casualty response training is not only morally required, but also contributes to the unit's ability to maximize combat power and ultimately Soldier and unit lethality. Given the existence of these technologies, it is no longer morally acceptable to use real world casualties in future combat operations as a learning curve for readiness.

References

R.S. Kotwal, H.R. Montgomery, B.M. Kotwal, H.R. Champion, F.K. Butler Jr, R.L. Mabry, J.S. Cain, L.H. Blackbourne, K.K. Mechler, J.B. Holcomb, Arch Surg. 146(12):1350-8 (2011)

CENTCOM Report Saving Lives on the Battlefield (Part II)- One Year Later: A Joint Theater Trauma System & Joint Trauma System Review of Pre-Hospital Trauma Care in Combined Joint Operating Area – Afghanistan (CJOA-A)14 May 2014 http://www.naemt.org/docs/default-source/education-documents/tccc/10-9-15-updates/centcom-140530-saving-lives-on-the-battlefield-ii-final.pdf

TRADOC Pamphlet 825-8-2 The U.S. Army Learning Concept for Training and Education 2020-2040 APR 2017

DoD Instruction 1322.24 Medical Readiness Training (MRT) March 16, 2018 http://www.esd.whs.mil/DD/

J. Mattis, CENTCOM Commander Memorandum to Chiefs of Services "Killed in Action (KIA) Reduction Initiative." 18 JAN 2013

FM 3-0 Operations. Headquarters, Department of the Army. OCT 2017

Author/Speaker Biographies

Dr. Dan Irizarry, MD, COL(R)

Dr. Irizarry is KGS Trauma FX's Senior Medical Simulation Advisor, an expert in special operations medicine, simulation, and technology acquisition, served in the US Joint Project Manager for Medical Modeling and Simulation Office and founded the Allied Centre for Medical Education, NATOs only SOF medicine simulation center.

Dr. Dawn Riddle (PhD)

Dr. Riddle is a Naval Air Warfare Center Training Systems Division Senior Research Psychologist with experience in instructional design and performance measurement of complex aviation and combat medical tasks.

Dr. Jon-David Hague (PhD)

Dr. Hague is Cerego Vice President for Solutions and ensures the platform delivers training and analyzable data for customers ranging from retail stores to the US Department of Defense.

Mr. Alex Hill, BA, MBA

Mr. Hill is a KGS Trauma FX Research Engineer, original patent holder and software developer for the trauma manikin product line tasked with creating control interfaces driving realistic bleeding, movement, and physiologic response and data capture to measure clinical interventions.

Dr. Howard Champion, MD

Dr. Champion is SimQuest CEO and an internationally known trauma surgeon with 40+ years shaping civilian and military surgical trauma care and training. He now leads efforts to increase objectivity and standardization thru simulation-based training systems for emergency and non-laparoscopic surgical procedures.