Training NATO Special Forces Medical Personnel: Opportunities in Technology-Enabled Training Systems for Skill Acquisition and Maintenance

Human Factors and Medicine Workshop HFM-224

1.0 INTRODUCTION: NATO OPERATIONAL CONTEXT

NATO's ever increasing requirement to meet asymmetric threats and the expected ongoing International Security Force Afghanistan (ISAF) partnering mission have caused nations to refine and reinvent how to execute Special Operations missions. These operational demands are forcing senior leaders to consider how to best resource and train their SOF as well as their enablers to ensure the precise, flexible, agile, and speedy response options these forces provide to decision makers. The demanding SOF environment, characterized by austere clandestine conditions, with missions of strategic importance, requires not only the best-prepared and resourced Operators but also enablers that can meet these demands. The NATO Special Operations Headquarters (NSHQ) was created to help the Alliance build and refine its SOF capabilities, improve national interoperability, and serve as a point of SOF expertise. NSHQ sponsored the HFM-224 Research Workshop "Training NATO Special Forces Medical Personnel: Opportunities in Technology-enabled Training Systems for Skill Acquisition and Maintenance" to explore technology requirements for optimizing training the NATO Special Operations Combat Medic (NSOCM).

2.0 RESEARCH WORKSHOP ORGANIZATION AND PARTICIPATION

HFM-224 was unique because it partnered a NATO Allied Command Operations (ACO) operational headquarters, NSHQ, with the NATO Research and Technology Organization's (RTO) (now called the Science and Technology Organization [STO]) Human Factors and Medicine (HFM) Panel. The workshop proceedings are not only official NATO recommendations but also recommendations to NSHQ for inclusion in SOF doctrine. Program committee members from Germany, Estonia, the United Kingdom, Canada, and the United States steered the Research Workshop (RWS). The United States appointed COL (Dr.) Annette Hildabrand and NSHQ Medical Advisor, LTC (Dr.) Daniel Irizarry, as RWS co-chairs and Dr. Robert Foster (USA) as the HFM mentor.

The RWS design was also unique. Two expert panels were created to operate jointly during the RWS deliberations to reach actionable recommendations for NATO. The first expert panel was centered on the science and technology of training; the HFM medical simulation and training expert panel members (for this report, referred to as the HFM Expert Panel), composed of government, industry, and academia, collectively represented over 200 years of medical simulation, training and education experience. The second panel, the SOF Medicine Expert Panel (SOFMEP), consisted of designated SOF representatives selected by their national SOF Commanders and Surgeon's General. The SOFMEP representatives from 15 nations actively engaged in RWS discussions providing the HFM Expert Panel critical insight into NATO SOF challenges and constraints as they relate to national SOF medical training programs.

Topic presentations were carefully ordered to enable a logical discussion flow starting with NSOCM training curriculum, and then teaching requirements and whether simulation technology could meet those requirements. Next, the panels discussed various modalities available to meet those requirements and concluded with recommendations for validation and future development of medical simulation technology for combat trauma training.

The HFM Expert Panel presenters were carefully selected for their knowledge, expertise and experience. Dr. Frank Butler (USA), a former SOF physician, U.S. Navy Seal and author of U.S. Tactical Combat

Casualty Care (TCCC) Guidelines who currently chairs the Committee on Tactical Combat Casualty Care (CoTCCC), was the keynote speaker. Dr. Norman McSwain (USA), founder of the PHTLS course, was selected to share insight about the M-PHTLS curriculum and its influence on U.S. combat medic training programs. COL (Dr.) Annette Hildabrand (USA), Office of the Assistant Secretary of Defense for Research and Engineering, presented for COL (Dr.) Rob Lutz (USA), Commander, U.S. Joint Special Operations Medical Training Center (JSOMTC), discussed mapping SOF medic tasks to curriculum and skills acquisition. Dr. Marcus Rall (DEU), Director of the University of Tuebingen Medical Simulation Center, provided insights into matching curriculum and training to simulation. Mr. Tom Doyle (CAN), Chief Learning Officer for CAE Healthcare, a company producing high-fidelity combat simulators, provided an overview of simulation technology from a historical perspective. His presentation included a baseline of simulator classification based on fidelity, complexity, and capability. Balancing the technology discussion, COL (Dr.) Annette Hildabrand (USA) addressed the benefits and challenges of using live tissue models in medical training. Mr. John Pickup (U.K.), Managing Director of Amputees for Action, a corporate source for combat trauma actors used in many European SOF combat medical simulations, addressed the use of amputee role players in combat trauma training. Mr. Shannon Swain (USA), contractor representative from the PEO STRI, discussed logistical and management challenges in building U.S. Military Simulation and Training Centers (MSTC). These centers train conventional U.S. forces in basic combat lifesaver skills using simulation equipment. The RWS also included presentations on SOF operational issues by Australian Special Operations Forces and Norwegian Special Forces personnel. LTC Peter Anders Christensen (DEN) shared a curriculum concept for SOF medics, the “Nordic Initiative,” a joint training initiative being created by the nations of Denmark, Finland, Sweden, and Norway.

Determining how medical simulation technology could be used to validate skills acquisition was a key RWS concern. Dr. Robert Sweet (USA), from the University of Minnesota, and Dr. Howard Champion (USA), SimQuest Chief Executive Officer, a company specializing in creating virtual simulation, technology addressed this concept. Dr. Champion, an internationally recognized trauma medicine expert, spoke to the future of virtual reality applications in simulated combat trauma environments. Dr. Champion also served as an independent technical advisor providing detailed notes that are the basis of these proceedings.

In summary, every detail from content, to design, to speaker selection was carefully crafted to bring operational and academic acumen of the RWS participants to examine the challenges of medical training for NSOCMs. The ultimate goal of the RWS was to identify best practice and technologies that can improve NSOCM training and interoperability across the Alliance and make actionable recommendations to senior leaders that will improve NSOCM capabilities.

3.0 RESEARCH WORKSHOP OPERATIONAL RELEVANCE AND OBJECTIVES

To ensure maximum applicability and relevance of recommendations, the HFM Expert Panel presented to an audience of SOF personnel followed by discussions between the SOFMEP and HFM Expert Panel throughout the conference. This ensured that academic and civilian industry experts lacking experience had sufficient operational advice to tailor recommendations within the context of the SOF environment.

The HFM-224 RWS objectives included identifying current best technology and best practice in SOF medic training systems, researching opportunities for further NATO/PfP/MD/Contact Nation collaboration and developing means to increase conformity in training across the Alliance. A secondary mission was to provide senior leaders advice regarding the minimum necessary NSOCM skills, potential training curricula, and the medical simulation technology available to teach NSOCMs this curriculum. With 51 participants representing 17 nations, the workshop represents an example of a multinational collaborative effort with significant credibility. It is the panel’s desire that nations reading these proceedings will be able to implement recommendations to improve training quality, efficiency, and interoperability for NSOCMs.

4.0 INDEPENDENT ADVISOR'S REVIEW AND REPORT

Dr. Howard Champion (USA), CEO SimQuest, Independent Technical Advisor

The independent advisor's report is a comprehensive documentation of workshop events prepared as they occurred. The report is organized by presenter's comments summarizing the presenters' and panel's comments and discussions. It is intended to provide the reader the context from which the panel recommendations were derived. The reader is directed to the presenter's comments in the appendices for greater presentation detail.

4.1 Workshop Charge

Brigadier General Simon Hutchinson, NSHQ Deputy Commander, opened the workshop with a welcome to the NATO SOF Campus in Chievres, Belgium, during which he highlighted the significant importance medicine plays in the successful conduct of Special Operations missions. He thanked the participants for dedicating their time and expertise to address critical SOF medical training requirements and acknowledged that NSHQ and SOF commanders would carefully consider the workshop's recommendations in the future. Finally, he congratulated the NATO SOF medical community in the significant progress made in the past 2 years to form a vibrant collaborative network that shares ideas and concepts with the potential to transform NATO medicine. The workshop charge was given – to provide the best advice possible to the NATO Surgeon Generals (i.e., the NATO Committee of the Chiefs of Military Medical Services [COMEDS]) to build SOF medical training capability and enhance interoperability while ensuring optimal care of combat casualties.

After introducing his Co-Chair, COL (Dr.) Annette Hildabrand (USA) and RWS Mentor, Dr. Robert Foster (USA), LTC (Dr.) Daniel Irizarry, NSHQ Medical Advisor, introduced the HFM expert panel members and the 15 countries SOFMEP representatives selected by their national surgeon general and SOF command.

LTC (Dr.) Irizarry then reviewed the workshop's two-tiered design (Figure 4.1):

- The SOFMEP members and their national colleagues;
- The HFM Expert Panel – medical simulation and training experts selected from academia, industry, government, military, and SOF medical backgrounds with the advice and guidance of Dr. Foster representing the NATO Human Factors and Medicine Panel chaired by Dr. Eric Fosse (NOR).

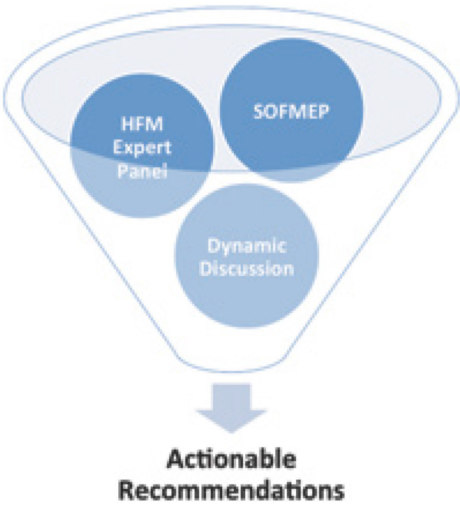

Figure 4.1: Workshop's Two-Tiered Design.

4.2 Summary of Presentations

4.2.1 NATO SOF Medicine Challenges and Opportunities

LTC (Dr.) Irizarry outlined the challenges individual national SOF medical leaders face developing and maintaining SOF medical systems commensurate to today's combat casualty requirements. These challenges include:

- Variable support efforts from SOF commanders and surgeons general;
- Relatively small size of SOF compared with their conventional counterparts;
- Limited number of SOF medics, physicians, and other healthcare providers;
- Financial and legal constraints.

National SOF elements require interoperability for joint multinational Alliance operations. Language differences, minimal shared doctrine, and variability between the nation's capabilities and authorities significantly impact NATO's ability to medically support SOF operations. The SOF fluid, unpredictable environment requires missions in austere conditions with limited personnel, infrastructure, and prolonged evacuation chains, which increases mission complexity.

The RWS discussed how these factors affect medical training. Nations noted that the lack of a standardization agreement delineating NSOCM training requirements is a key barrier to interoperability. Some progress was made toward this step at the October 2011 NATO SOF Medic Curriculum Workshop. At this workshop fifteen nations agreed on 164 minimum NSOCM tasks that serve as a basis for a standardized curriculum and standardization agreement. It was also agreed that 20 weeks' training time was the minimum time investment required to reliably train NSOCMs in these tasks and also the maximum training time most nations could afford.

A common problem across the Alliance is the small population of SOF medical personnel. Nations frequently have few qualified, available SOF medical instructors and a small numbers of medics, requiring initial and sustainment medic training. Justifying 20 weeks of training time is difficult with such small numbers of personnel, who must also be available for missions. Furthermore, training costs for these low-density skills can inhibit the creation of individual national training programs. Thus, nations look for alternative methods to train their personnel.

Several nations send SOF medics to the U.S. Joint Special Operations Medical Training Center's (JSOMTC) in Fort Bragg, NC, U.S., Special Operations Combat Medic (SOCOM) Course (32 weeks) or the longer Special Forces Medical Sergeants Course (18D) (52 weeks) for training. These "master medics" then return home to train their peers. However, national regulations may limit the scope of practice for some of the skills they have now learned. Other nations use the International Special Training Center in Pfullendorf, Germany, to train their SOF medical personnel. This is a great example of multinational collaboration, but some nations consider this joint training center, a non-NATO school, to be under resourced for the task and cannot presently provide the required 20 weeks of training. A third method is to recruit medics trained through conventional force training and provide SOF-specific training at the unit level through contracted courses or their own 10-week training programs, a costly but viable option.

Although the RWS's primary focus was NSOCM training requirements, some participants noted recent data showing that an SOF Operator is just as likely to provide trauma care as an SOF medic. The implication is that it is not sufficient for a nation to focus only on NATO SOF medic training when considering their medical training requirements; they must also consider the training SOF Operators.

Despite these challenges, the meetings leading up to this workshop clearly established the NATO SOF community's intense support to work on training and performance conformity and interoperability. There was also agreement that a consensus on NATO SOF medic capability could easily be reached. Such a consensus would identify training goals, curriculum, strategies, tactics, and techniques for both initial and sustainment NSOCM training. It was also agreed that national senior medical leadership and commander support are essential to successfully create interoperability in NATO SOF medicine.

4.2.2 Tactical Combat Casualty Care Curriculum

In 2001, the U.S. Defense Health Board (U.S. DHB) chartered the Committee on Tactical Combat Casualty Care (CoTCCC) chaired by CAPT (Ret.) Frank Butler, MD, USN, a former U.S. Special Operations Command (USSOCOM) Surgeon. The CoTCCC's mission is to identify contemporary operational challenges in casualty management and apply expertise and scientific rigor to establish and publish standards of practice for combat casualty care.

Three of the CoTCCC's founding members, Drs. Butler, Champion, and McSwain, served on the HFM Expert Panel, providing extensive experience and lessons learned from developing a political and academic system that effects change in U.S. combat casualty care guidelines. Dr. Butler, in particular, discussed the necessary steps over 10 years the CoTCCC took in navigating through a variety of administrative relationships within the U.S. Department of Defense (DoD) to establish its current advisory position. The CoTCCC now provides a forum for establishing standards of practice not only for all components of U.S. DoD, Coast Guard, and security agencies but also for many NATO and Allied armed forces. Dr. Butler explained that a strong contributor to CoTCCC's credibility is the fact that a large percentage of committee members are point-of-wounding care providers and that quarterly meeting agendas dedicate significant time to discussing contemporary case presentations from the active tactical environment.

The TCCC guidelines are updated quarterly and published on the U.S. Defense Health Board Military Health System and PHTLS websites. Many regard these guidelines as an international standard of practice for point-of-wounding care. They are also published in the U.S. National Registry of Emergency Medical Technicians (NREMT) PHTLS civilian and military textbooks, and both the NREMT and the American College of Surgeons (ACS) have endorsed them. Dr. Butler demonstrated that NATO SOF has a common curricular substrate for point-of-wounding healthcare, the TCCC guidelines, though this is not formalized in SOF doctrine. Dr. Butler also expressed the CoTCCC's desire to increase international contribution through committee membership participation. This would capitalize on experiences and research being conducted by Alliance partners. Finally, Dr. Butler reinforced the value of national senior political, military and medical leadership support when implementing TCCC guidelines in U.S. Forces as an important lesson learned for other nations trying to improve their national SOF systems.

4.2.3 Introduction to Military Prehospital Trauma Life Support (M-PHTLS®)

The October 2011 NATO SOF Medical Conference, sponsored by NSHQ and attended by representatives from 17 nations, agreed that an NSOCM must be able to treat and sustain casualties in an austere environment for 72 hours. These casualties included both combat casualties, addressed by TCCC standards, and additional illnesses that can affect mission success such as respiratory infections, diarrheal illness, and vehicular trauma. A number of prehospital curricula, including PHTLS, address this wider scope of medical pathologies. Dr. Norman McSwain (USA), a PHTLS program founder, reviewed the historical development of the PHTLS program's M-PHTLS branch. PHTLS added a military chapter to its civilian manual in 1999 to address special considerations for military environments. In 2003, the program published a full military edition with its 5th edition of the civilian manual. Both civilian and military manuals are scheduled for updating in 2015. Dr. McSwain highlighted the special relationship between the M-PHTLS program and the CoTCCC. The CoTCCC, with its evidence-based approach and ties to current combat trauma experts, partners with the PHTLS editorial board to ensure that the M-PHTLS program reflects the latest best practices in military medicine. The PHTLS/M-PHTLS curricula are updated biannually, whereas TCCC guidelines are reviewed and updated quarterly and published through websites. The PHTLS program manages a network of M-PHTLS instructors who receive up-to-date TCCC guidelines as they are released.

Dr. McSwain summarized two general educational models in current prehospital curricula: protocol-based and principle-based curricula. Protocol-based curricula tend to lessen the importance of understanding anatomy, physiology, and contributing factors in favor of protocol-driven decision-making processes. Proponents of protocol-based curriculums cite uniformity of care across a system and potential saved training time as benefits, since students do not learn a foundational fund of knowledge, but instead memorize a series of protocols. This approach works well in a homogeneous system with defined levels of healthcare and scopes of practice where protocols can be established and implemented easily, such as within a national healthcare system. The PHTLS program focuses on principles emphasizing an underlying fund of knowledge that learners can adjust and apply based on the situation. The PHTLS and M-PHTLS programs also emphasize preferences defined as how the individual, the local jurisdiction, or the country achieves that standard based on the situation they encounter, the condition of the patient, and the ability of the provider in terms of knowledge, skills, experience, and available resources.

The principle/preference framework provides several benefits when considering M-PHTLS as a potential unifying NATO SOF medical curriculum. The establishment of principles sets desired outcomes, frequently evidence-based, that most nations can agree on when treating casualties. The preferences allow nations to use differing measures to reach these outcomes consistent with cultural and legal guidelines. However, within the collaborative PHTLS organization, these differences can be examined and perhaps drive curriculum and practice improvement with global input.

Both RWS panels agreed that it is not sufficient for an NSOCM to use strictly protocol-based decision-making processes. The SOF environments' austerity and unpredictability require that NSOCMs have a strong fund of medical knowledge and developed critical thinking skills. Both PHTLS and M-PHTLS teach and train to levels of proficiency based on critical thinking and decision-making skills with practice (drill, drill, drill) of those skills on mannequins, live patients, and live tissue. The RWS agreed that adopting an accepted international standard as a baseline curriculum for NATO SOF medicine would be the most feasible option to rapidly improve interoperability across the Alliance SOF. Looking at potential prehospital curriculums, PHTLS has been taught in 20 European countries since 2008 with established PHTLS instructors in these countries. Additionally, TCCC training is currently under development in many European Union (EU) nations. PHTLS was introduced in Latin America in 2010 and TCCC in 2011. In considering the future global SOF partnering initiatives, M-PHTLS has a potential role in unifying the global military prehospital curriculum. Other courses such as International Trauma Life Support (ITLS) and Battlefield Advanced Trauma Life Support (BATLS) do not have the same global distribution, but for nations that already use one of these systems, a determination should be made of whether these provide sufficient NATO interoperability.

The process of establishing a national M-PHTLS training program requires a representative national agency to assume program responsibility and nominate between four and seven individuals as faculty members. The faculty members attend a training program for providers, instructors, and administrators held either in the United States or abroad. These trained personnel then return home to create their new training program. A U.S.-based PHTLS instructor attends the inaugural course and then the U.S. National Registry of Emergency Medical Technicians (NREMT) keeps a registry of all courses, instructors, and qualified trainees.

With the flexibility of *principles* vs. *preferences* and a proven curriculum that is continually updated by military and civilian experts and adaptable to local settings (e.g., South American drug trades), the PHTLS and M-PHTLS/TCCC combination offers a robust platform for propagating military SOF principles within initial, refresher, and sustainment training.

TCCC endorsement by both the U.S. NREMT and the American College of Surgeons provides a testament to the rigor and accuracy of the curriculum content. Although other national-level curricula are available (e.g., U.K. BATLS and ITLS), PHTLS offers a proven international capability with an administrative infrastructure to support the needs of SOF training.

Following Dr. McSwain's presentation, the SOFMEP was polled to determine if consensus was possible regarding a recommendation to senior medical leadership on NSOCM curriculum standardization. All SOFMEP members agreed that M-PHTLS could serve as an initial NSOCM standardizing curriculum. However, M-PHTLS alone would not completely meet necessary NSOCM capability, referring to the 164 NSOCM tasks and timeframe needed to train an SOCM to the desired standard. Dr. Robert Sweet (USA) contributed a visual representation of the problem and the potential solution. The paradigm of an NSOCM's complement of training can be visualized as a tree (Figure 4.2) with many branches, each branch representing an individual national scope of practice preferences. The concepts of TCCC and M-PHTLS as foundational training serve as the roots and trunk base, with the trunk remainder representing the portion of the NSOCM's 164 tasks not included in the M-PHTLS program.

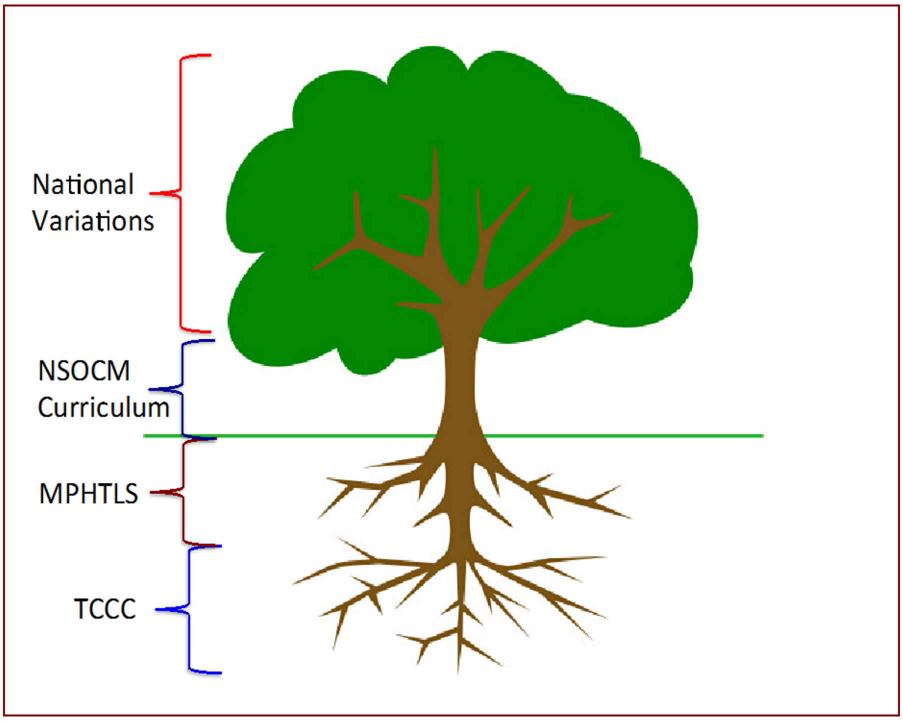

Figure 4.2: Paradigm of an NSOCM's Complement of Training Can Be Visualized as a Tree.

The dual panels achieved consensus in making the recommendation to COMEDS that nations move toward developing M-PHTLS training programs that support their SOF organizations. Where possible, a nation should leverage the already existing PHTLS infrastructure within the nation. Nations without a PHTLS program should consider partnering with nations that have an existing program. Senior leaders should note that this does complete the full complement of NSOCM training. It provides initial interoperability and a curriculum foundation on which to build a comprehensive SOCM medical curriculum. For nations already using a robust curriculum, a comparison should be made between the nation's curriculum training objectives and methods, to determine interoperability with NATO SOF standards.

4.2.4 Partner Nation Training Experiences Overview

The workshop had the opportunity to hear two nation's presentations, Australia and Norway, both with training programs for SOF medics. These presentations provided additional context for the HFM panel members with limited familiarity with SOF medical training programs. Other SOF members in the audience augmented discussion, providing a clearer picture of the nature of SOF medical training across the Alliance.

The Partner presentations highlighted the wide variability between nations and national SOF medic training capability. While there are some consistencies, such as TCCC as the field standard for battlefield care, there are many differences. These include the source of the medic, his skill level, and the origin of his training (internal or accrued elsewhere). Commitment to initial training is essential, but sustainment training is critical as well. Nations also varied considerably in the type and nature of sustainment training (Table 3.1).

The prevalence of simulation technology varies between nations, with a recurrent theme that most nations use moulaged actors, whether trained and paid or military personnel, to simulate casualties. Most have some access to rudimentary mannequins, but have found that the fragile nature of most high-fidelity mannequins makes them less desirable for SOF field training. High priority is placed on conducting training in realistic tactical settings. The nations that conduct training using the animal model believe this tool is critical for realistic training. Another concept of variable prevalence is training in the psychological effects of combat, emotional loss of friends and teammates.

Partner Nation Training Questions*

- Does your nation use TCCC curriculum guidelines?
- Is sustainment medical training required?
- Is predeployment medical training required?
- Are simulators being used in training?

Would you use M-PHTLS/TCCC as an international baseline curriculum for the SOF medic? Table 3.1. Summary of Participant Countries' Current Training Modalities

Questions *					
Country	1	2	3	4	5
Belgium	Yes	No	4 week every 2 years, ambulance every 2 years	SimMan	Yes
Romania	As a guideline	No	Not disclosed	None	Yes
Switzerland	Yes	Yes	3 week every 2 years	Cric, chest tube, IV, BLS	Yes
U.K.	Yes: BATLS with different medications	Yes	5 days every 18 months	SimMan and other modalities	Yes, subject to review
Norway	Yes	Yes	1 week every 6 months	CPR ResusiAnne	Yes as unified Nordic
Poland	Yes	No	1 to 2 days every year	Not disclosed	Yes
France	No	Not disclosed	2 weeks every year	Not disclosed	Yes
Turkey	No	Not disclosed	1 week every 1 year	Splinting fracture transport	Yes
Canada	Yes	Yes	No mandate but ATLS/ACLS	Multiple modalities and procedures	Yes
US	Yes	Yes	Every 2 years	Multiple modalities and procedures	Yes
Australia	Yes	Yes	Not disclosed	Multiple modalities and procedures	Yes
Denmark	Yes	Yes	Not disclosed	Multiple modalities and procedures	Yes
Sweden	Yes	Yes	Not disclosed	Multiple modalities	Yes
Italy	Yes	Not disclosed	None	Chest tube, needle decompression, BLS IV	Yes
Germany	Yes	No	Not disclosed	CPR/IV	Yes
Netherlands	Yes	Not disclosed	Not disclosed	Cric IV	Yes

Cric, cricothyroidotomy; BLS, Basic Life Support; BATLS, Battlefield Advanced Trauma Life Support;

CPR, cardiopulmonary resuscitation; ATLS, Advanced Trauma Life support; ACLS, Advanced Cardiac Life Support.

4.2.5 United States Special Operations Combat Medic (SOCM) Training

Speaking for COL Robert Lutz (USA), who was unable to attend, COL Hildabrand provided an overview of SOF medic training at the Joint Special Operations Medical Training Center (JSOMTC), in Fort Bragg, NC, U.S. As the global leader in Special Operations medic training and sustainment, JSOMTC provides training for all U.S. Special Operations personnel. This facility also trains international Special Operations medics in their 52-week program.

Based on the Dreyfus model of skill acquisition (novice, proficient, competent, expert, master), the U.S. SOCM training goal is to train to proficiency or competency. The SOCM training at Fort Bragg aims to provide the student with critical reasoning and reflexive decision-making knowledge to ensure reliable performance in the chaotic combat environment. Extensive use of cognitive and skill task deconstruction allows for individual learning styles and training tactics to optimize the process and create "resourcefulness" as the added value asset.

The JSOMTC is in the process of streamlining their curriculum to add more trauma skill content. The curriculum uses numerous modalities in a hybrid curriculum, using cadavers, task trainers, distance learning, practical application of concepts, and numerous evaluation points.

The formidable cost and time allotment for U.S. SOF medic training, sometimes greater than 1 year, is clearly a burden for many nations with numerically small Special Operations units. Collaboration in achieving interoperability along with cost efficiencies in training is, thus, not only plausible but also rational and desirable.

4.2.6 Australian SOF Medical Training and Combat Simulation

Australian SOF delegates, LTC Allison Berliotz-Notts and MAJ (Dr.) Daniel Pronk, provided a comprehensive briefing to enlighten the workshop on Australia's method of training medics and Operators for SOF medical support. In Australia, paramedic-trained personnel skilled in TCCC guidelines are selected to become SOCM's during a year-long training program that involves extensive use of simulators, live tissue training, and full mission tactical immersive training. There is an important emphasis on realistic tactical settings in an environment that has moulaged injuries, physical exertion, frequent cognitive interruption, increasing scenario complexity, full scene care, and patient movement and evacuation. Team training involves small unit commanders and requires proficiency in logistics for a variety of mission profiles and evacuation scenarios. Technical and training tactics include adult learning, double loop learning, debriefing, accelerated learning techniques (e.g., using scent), and prolonged tactical field time. Repetitive drills reinforce medic and first responder tactical and medical proficiency and competency. Once these basics are established, scenarios increase in complexity enhancing complex decision-making skills. Frequent cognitive interruption is used to further hone reactions to adverse environments.

A small-unit commander-specific course is also available as a component of predeployment training. Mass casualties, exposure to injured children, and death of a buddy in a tactical event were also used in the program, which culminates in a live tissue training exercise with extensive use of noise, darkness, temperature extremes, smoke, helicopters, and video observation and a full mission profile. Sustainment training in Australia is 1 week per year, with an intensive refresher course every 3 years. Of note, Australia has a comprehensive combat simulation capability operated by the conventional forces, which has been used by Australian SOF, less so in recent years, because of logistical challenges of getting to the center and security and mission profile limitations. This highlights the point that for SOF medical training, particularly Operator medical training, there is a requirement for quality unit-level simulation.

4.2.7 Norwegian Maritime SOF Medic Training Overview

Norway's SOF medic representative, a NORNAVSOC Operator, described an extensive selection process, which over a 1-year period, resulted in 5% to 15% of medic candidates being selected for SOCM training.

This small SOF element aspires to the U.S. Army 75th Ranger maxim of marksmanship, physical training, small unit tactics, and medical training for all Operators. In 1997, COL Stanley McCrystal instituted a paradigm shift while commanding the 75th Ranger Regiment. This paradigm shift included emphasis on casualties from a medical responsibility to a command responsibility. To increase survivability, non-medic Rangers were trained to provide critical life-saving procedures.

After operational selection, the SOCM candidate attends either a commercially contracted Operational Emergency Medical Skills (OEMS) course, training courses at the International Special Training Centre (ISTC) in Pfullendorf, Germany, PHTLS training, or training with U.S. Army Special Operations Forces at Fort Bragg, NC, U.S. The training emphasizes realistic operational simulation including snow and ice on roads and total tactical scenarios including evacuation. Training also includes physical model simulations, although these are now used only for automated external defibrillator (AED) and cardiopulmonary resuscitation (CPR) training. The point was made that high-technology human patient mannequins are unreliable. Thus, they have been abandoned for TCCC training by this nation's SOF. Moulaged actors are used with technologies that support pulse measurement and field cricothyroidotomy. Live tissue training (LTT) is highly valued, but challenging to conduct at the medic level, though authorized in Norway, because of administrative barriers. NORNAVSOC personnel feel the live animal model provides unparalleled realism critical for creating and sustaining medic skills. Additionally, they feel that the live animal training courses creates confidence in their own skills and their medic's skills that cannot be quantified but add significantly to the resilience that allows them to unhesitatingly go into harm's way.

4.2.8 Nordic Special Operations Combat Medic Initiative: A Model for Collaboration

A critical shortfall identified in NSOCM medical training in past NATO SOF medical meetings was the lack of a coherent, comprehensive program for NSOCM training. Some key findings were identified at the April 2011 NATO SOF RWS. These included the belief codified by the United States, Canada, New Zealand, and Australia that quality NSOCM training would require a significant investment of time, resources, and finances for a single nation to develop. Additionally, the April 2011 RWS participants agreed that a minimum of 20 weeks would be required to create a competent NSOCM, but that most nations could only go without their medic/Operators for a total of 10 weeks per year in a given year for initial medic training. Finally, it was determined that the yearly requirement in many nations for newly minted medics is relatively small, on average three to five medics per year, making the independent national investment in a comprehensive training system cost prohibitive for many nations.

In today's financially constrained environment, there has been great emphasis on "pooling and sharing" EU and NATO resources to meet common needs. LTC (Dr.) Peter Christensen, Danish SOF MEDAD, provided an overview of a novel approach to meeting the NSOCM requirement for the nations of Norway, Sweden, Denmark, and Finland. Driven by the desire to harmonize Nordic SOF medic training with the goal of closing the gap between Nordic SOF medics and their U.S. and U.K. counterparts, these four nations have agreed to create a Nordic SOF medic training program built on the 164 tasks defining the NSOCM requirement. This is a historic collaboration between national SOF medical elements. Equally important is the collaboration of the nation's conventional senior national medical leadership, who demonstrated their collective support of their SOF medical elements in a way never seen before. For the SOF elements, it is an opportunity to create interoperability and increase combat medical care quality and capability while sharing the cost burden. At the strategic level, this effort has been briefed to and supported by national senior conventional medical leadership, reinforcing the SOF truth that most SOF units require conventional support to be mission effective. Aided by Nordic senior leadership, the Nordic Initiative has gained significant support from the Nordic Agency for Development and Ecology (NORDEFCO). This multinational organization designed to increase Nordic collaboration has made the Nordic SOF Initiative a concept to emulate. The Nordic Special Operations Combat Medic course, currently scheduled to be launched in 2013, will be a historic and critical step in a positive direction for Alliance SOF.

4.2.9 State of the Art of Combat Medical Simulators

Any coherent discussion on NSOCM medical simulation needs requires an understanding of the history, present and future capabilities of medical simulation technology. Mr. Thomas Doyle, Vice President and Chief Learning Officer at CAE Healthcare, delivered an outline of the historical development of mannequin simulators from 1960 starting with ResusciAnnie®, Laerdal's initial resuscitation mannequin modeled after a young girl who drowned in the Seine River. He mapped the historical timeline for subsequent simulators, including the Human Patient Simulator (HPS) developed by METI, instrumented computer-driven mannequins, such as SimMan® (developed in 2001 with John Shaeffer in Pittsburgh and marketed by Laerdal), and CAE's Emergency Care Simulator (ECS) modified for combat with the help of Dr. David Gaba. Driven by simulation center demand and funded by the U.S. DoD, medical simulation technology improvement accelerated greatly between 2000 and 2010. At present, commercially available full-body mannequins include Laerdal's SimMan®, CAE/METI's CAESAR®, and Gaumard's HAL®. All commercially available human patient simulators have unique strengths and weaknesses compared with the live animal model.

Mr. Doyle addressed the need for a strong curriculum, a recurring theme of the workshop, and integration of adult learning principles as vital to the effective use of medical simulation technology. Training best practices included prebriefing, psychological fidelity, double loop training, limiting training sessions to three to five objectives, a debriefing, and a pre-/post-test of skills acquisition. He emphasized the need for properly trained instructors and content-appropriate material. He stressed that when developing technological solutions for learning, it is important to first identify the learner's needs, tied to the teacher's desired course-specific training outcomes, and then consider the factors of technology design such as fidelity, available robotics, niche marketing, dexterity, and synthetic tissues. Dr. Robert Sweet, Associate Professor of Urologic Surgery and Director of Medical School Simulation Programs, University of Minnesota, added that the old paradigm of engineers designing products for a perceived market has now been replaced by engineers developing products with the end users – the trainers and students. Dr. Rall also gave an example of a high-fidelity simulator with diminished usefulness because it added completely unrealistic seizure movements as a training feature. He highlighted the point that a simpler but more realistic simulator may be better than a highly complex simulator that is unrealistic. In fact, using the wrong simulator may result in negative learning. Mr. Doyle contributed a useful paradigm for classifying the fidelity, or realism, of simulators in terms of how they faithfully represent physical characteristics, the situational environment and the emotional buy-in, or psychological fidelity. This allows one to better understand the difference between "low-fidelity" and "high-fidelity" simulators (Table 4.2).

Table 4.2: Differences between Simulators.

Category	Equipment fidelity	Environment fidelity	Psychological fidelity
Case studies/role-plays	Low	Low	Low to medium
Partial task trainers	Medium	Low	Medium
Full mission or integrated simulators: Instructor-driven	Medium	Medium to high	High
Full mission or integrated simulators: Model-driven	High	Medium to high	High

As the simulation technology discussion evolved, the participants gained an appreciation of the complexities of technology integration into curricula. Medical simulation technology is a tool for learning but, as with any tool, it must be used effectively. COL Hildabrand indicated that the science of simulation training was rapidly expanding, noting that the U.S. Naval Postgraduate School will be offering an online degree in postgraduate medical simulation training. NSHQ is creating a course to teach combat medical simulation in the coming year to be taught at the NATO SOF Allied Centre for Medical Education (ACME), a medical simulation and training facility being constructed at Supreme Headquarters Allied Powers Europe (SHAPE), Belgium, in 2013.

Dr. Robert Foster wrapped up this discussion by introducing the role of the mannequin and computer in a blended environment. When one thinks of simulators, one typically thinks of mannequins, but a wider consideration must be given to the role of virtual reality (VR) and computer-generated patients in combat trauma simulation. Dr. Foster suggested that available data on the use of computer-generated simulations in civilian college training of nurses and emergency medical technicians (EMTs) may guide future research into the use of this educational medium.

Primary conclusions drawn from this section of the workshop are as follows. First, medical simulation technology is rapidly growing. This growth will continue to accelerate with the demand for better simulators. Medical simulation technology will improve with end-user feedback. Second, curriculum must drive appropriate integration of simulation based on clear and specific training objectives. This implies that the most expensive high-fidelity simulators may not be needed to reliably teach simple tasks. Technology with too much sophistication that lacks realism might actually be counterproductive to learning. Third, there is a growing requirement to train teachers in the art of simulation. As this applies to the training of NATO SOCMs, NSHQ has invested in a facility and curriculum that can start to meet this need. Finally, further workshops should consider the use of computer-blended simulation and, wherever possible, simulator and simulation purchase decisions should be influenced by available data.

4.2.10 Framework for Understanding Medical Simulation and Medical Simulators in Training

The preceding discussion on the state of the art of combat medical simulators naturally led to further consideration about the integration of simulators and simulation technology in medical training. This important topic was covered by Dr. Marcus Rall, who stressed the importance of human factors in developing cohesion, competency, and capability in the operational small unit (team) using concepts of crew resource management. Equally and perhaps more important is the management of the crew, or in this case the Special Operations team, in meeting the tactical demands of the situation as well as the medical ones. Dr. Rall emphasized that human factors analysis, which include things like fatigue, internal team communication, and stress management, is essential in clarifying why desired outcomes for patient care and tactical situations succeed or fail. To maximize effective use of simulation, some important concepts are as follows:

- Reality versus relevance;
- Importance of video debriefing (reflective learning experience);
- Positive team interventions as a self-sustaining factor;
- Blame-free culture;
- Double loop learning;
- Safety culture;
- Means of keeping the participant engagement alive to achieve a longer lasting, self-energized process of learning by using team training.

Dr. Rall concluded that curriculum developers must do the following:

- Set training performance goals;
- Design curricula that evaluate human factors and performance measures that can be measured at intervals and with cumulative metrics;
- Include well-planned scenarios that integrate team performance;

- Include measures of performance, measures of effectiveness, and leadership training using human factors.

Taking into consideration all the previous discussions, the SOFMEP and HFM combined panel reaffirmed that surgeons general should support and adopt an international SOCM standard to increase interoperability between SOF medics, providing standardization of training performance that includes sustainment training to guide simulation development and simulator procurement.

4.2.11 Evaluation of Live Animal Use in Combat Trauma Training Procedures

The role of the live animal model combat trauma training was a key concern for both panels. This is a sensitive issue fueled by ethical and political considerations. As noted by COL Hildabrand, experiential training has been the cornerstone of knowledge and skill acquisition in biological sciences and medicine for centuries. For a period of time (well over 100 years), animal tissue has been used to augment medical training. Combat medics face unique challenges. Civilian practical environments do not expose trainees to the type and severity of wounds encountered on today's battlefield. Trainees are expected to perform rapidly and effectively at the first encounter. Often this casualty is a friend and teammate in an adverse, noisy, dark, dirty environment and often under enemy fire. The challenge of training individuals to perform to this standard in this environment is the most significant one encountered in military medical training. It is therefore imperative that training should optimally prepare the trainee to perform under all the above named constraints. The U.S. 18D Special Operations Medical Sergeant Course is, perhaps, the highest level of training available for point-of-wounding care. This 18D paramedic engages in more than a year of additional training that includes immersive, cognitive, and practical skill development and testing to enable autonomous expert performance in the most adverse and unyielding of environments. The challenge for most nations, however, is the investment cost. An abbreviated training period means the depth of training must be optimal and as realistic as possible.

In a hybrid curriculum, students are introduced to the material didactically and then progress to hands-on practice of procedures using task trainers and other students. Coupling cognitive learning and psychomotor learning with challenging scenarios solidifies the concepts (Figure 4.3). The training progresses to live animal exercises, where the trainees combine all aspects of learning to include the affective component of stress and urgency of working on a living, breathing animal. Development of such a medical training program requires the following:

- Clear definition of the goal, i.e., to produce a speedy, non-hesitant, confident medic and leader;
- Optimization of student-teacher relationships and model student value;
- Skill level advancement - novice to proficiency is minimum skills progression required; once proficiency has been attained, realistic level of knowledge/capability must continue to be challenged;
- Outcome-driven - evaluation metrics such as timing accuracy, problem solving, and depth of learning, i.e., ability to function under stress (cognitive interruption during training).

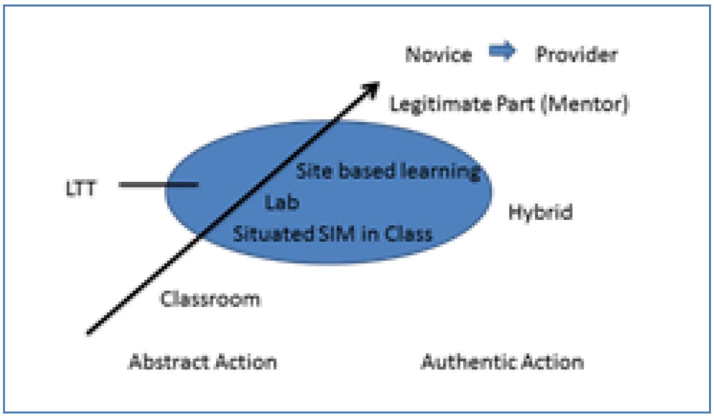

Figure 4.3: Coupling Cognitive Learning and Psychomotor Learning with Challenging Scenarios.

Selection of an Animal Model

While some nation's SOF Operators and SOF Commanders feel that live animal use is the best training modality available, it is important to maximize all other training tactics and techniques (Table 4.2) before a culminating live animal laboratory to maximize benefit of the live animal model. Proper scenario building can optimize the live animal laboratory and increase the relevant realistic nature of the training. Animal model selection should consider the following:

- Animal size and temperament;
- Equipment handling and care;
- Instructor experience;
- Anesthesia;
- Maximize animal use multiple trainees.

Table 1. Training Aid Options
▪ Mannequins
▪ Instrumented mannequins (less used because they tend to break in the field)
▪ Moulaged patients
▪ Moulaged actors with amputations
▪ Standardized cases
▪ Live animal use
▪ animal tissue or carcasses
▪ Human cadavers
▪ Immersive environment
- Noise, smoke, helicopter, darkness, temperature extremes
- Delayed evacuation, imminent catastrophic event (ICE), snow, pre-scenario physical exertion
▪ Cognitive interruption
- Logistics, team, operative care
▪ Mass casualty

Some of the advantages for the live animal provides in combat trauma training include the following physiological feedback to pathology and interventions:

- Physiological response to pathologies and intervention;
- Air release from a pneumothorax or injured lung;
- Bleeding, particularly from vessels and high-value vascular organs such as the liver, kidney, spleen, and heart;
- Measurable and reactive vital signs;
- Hemorrhage and amputation management can be trained with unparalleled realism;
- Appropriate physiological response to interventions like hemostatic agents not possible with simulated blood substitutes.

The animal model is not perfect – there are differences that must be addressed to avoid negative training transfer. These disadvantages include anatomic variation, single use, requirement for anesthesia and euthanasia use, zoonotic disease risks (e.g., Q fever), and emotional aspects of animal use.

Examples were given of animal use maximization by various nations entailing movement of patient models through the entire evacuation chain from point-of-wounding to surgery. Training goals must be considered when choosing which type of animal. When comparing goat vs. pig models, for example, goats are easier to handle but have fur and unique tissue properties that may make them less suitable than pigs for training certain procedures. The anatomy and physiology of ruminants add additional challenges. While under anesthesia, the ruminant gastrointestinal system will fill with gas and require the placement of a stomach tube to drain contents. The swine model may be ideal for vascular and cardiothoracic anatomy but is harder to handle and includes the risk of malignant hyperthermia.

This presentation concluded with general guideline recommendations for live animal model use in NSOCM training. First, because current technology cannot reliably and realistically reproduce natural physiological responses, the live animal continues to be the model of choice. Nations that choose to conduct live tissue training must have a system in place to ensure the humane treatment of the animals used. To maximize the benefit of the animal, training must be focused, specific, and quantifiable. Live animal use should not be undertaken lightly but implemented deliberately with scenarios highlighting and exploiting unique capabilities. The need for live animal use in NSOCM training is increased because of the condensed training schedule that NSOCMs have due to economic constraints. Additionally, European trauma centers have significantly less penetrating trauma or similar injury patterns as those seen in combat.

4.2.12 Amputee Actors in Combat Casualty Simulation

Many nations' SOFMEP representatives reported that they have participated in training using moulaged actors to increase training realism. Frequently, these actors are members of their own unit or requisitioned soldiers from other units moulaged and prepositioned for mass casualty events. Using trained actors for clinical skill evaluation is not a new phenomenon, with the late 1990s seeing the creation of the Objective Structured Clinical Examination (OSCE). In OSCE simulation, a specially trained actor is used to interact with a clinical provider. The event is recorded, observed and used for both student feedback and evaluation of clinical skills. A recent trend in combat simulation is the use of amputee actors to simulate combat casualties. Mr. John Pickup is an upper extremity amputee and managing director of Amputees in Action, a company that provides amputee actors for movie productions and training events. Mr. Pickup provided technical information to the combined panel on the benefits, limitations, and constraints of this type of simulation.

Since 2005, a group of amputees from the United Kingdom, many of whom are disabled combat veterans, have banded together to form a company called ***Amputees in Action***. Their intent is to provide a unique capability to the movie industry to simulate combat wounded. An example of this is the Omaha Beach landing scene portrayed in the movie, “Saving Private Ryan.” Over time, the company has expanded into training environments such as the U.K. predeployment training center combat field hospital in York, England.

The company works with program directors to develop techniques for realism and relevance to training goals and then provides moulaged actors and augmented capabilities such as physiological variation and the ability to perform medical interventions and realistic patient responses during the treatment and evacuation process. In many cases, the group provides standardized patient scenarios replete with numerous distracters to provide the cognitive interruptions and stressors typical of combat. Training aids can be attached to the actors for tactical training of techniques such as cricothyroidotomy, pumping arterial blood, and packing wounds.

A common concern raised is the ethical employment of amputees as combat trauma patients in the context of taking advantage of their disability and the potential psychiatric damage caused by graphic reliving of traumatic events. Mr. Pickup related that all company actors employed were self-referred volunteers. During an initial training phase, the employees are exposed to the nature of the job and evaluated by others to see if they have a suitable personality and both the physical and emotional capability to do the job. The potential employees do not undergo formal psychological screening during the hiring phase or at any time during their employment. Anecdotally, Mr. Pickup related that employees, frequently former military personnel, take special pride in being able to provide this unique service to prepare others for treating similar injuries. They relate gaining the satisfaction of knowing that this training may save another life somewhat validates their own personal loss. He is not aware of any psychological harm that has resulted from employment, though he has had employees who resigned early from employment saying that this was just too similar to the actual event where they were injured for comfort. Thus, it would seem that at least in this group of amputees, there is some self-selection. He relates that the employees gain social benefits as well, being closely aligned with other amputees, which may have therapeutic effects in the form of mentoring, as well as the unique opportunity of being able to serve on movie sets and meet famous actors.

Mr. Pickup presented several benefits of employing amputees for simulated combat trauma that were corroborated by SOF RWS participants who had attended training with these individuals. These amputees bring a high level of realism to scenarios when augmented with moulage. Clearly a reactive, conscious patient gives immediate feedback both to treatment and handling. With the addition of a cut-suit, a recent simulation product worn by an actor that allows for invasive procedures to be performed, or other augmentation, medics can perform some simulated surgical procedures on the actors such as intravenous catheter placement, cricothyroidotomy, or deep wound packing. Another advantage of using actors is their portability. Unlike sophisticated mannequins that must be moved often at great expense due to fragility, actors are mobile. Their autonomy negates the need for additional personnel needed to operate a mannequin. From a cost perspective, hiring an actor for 1 day of training was estimated at $1000 (USD) plus travel expenses, significantly less than the purchase and maintenance of a high-fidelity simulator currently being marketed at a retail price of $45,000–$70,000 (USD). In general, actors perform reliably, but there can be variability between actors.

Drawbacks to the use of actors without equipment augmentation include the inability to perform certain procedures on the actor. For example, proper tightening and maintenance of a tourniquet would be too painful to an actor. Wound packing is another area that lacks realism. As realistic as wounds initially may appear, the learner, after rapid evaluation, quickly sees that they are artificial, unlike wounds seen with live tissue training. The company does not follow patient standardization principles, so their actors are not trained sufficiently at the present time to conduct validation exercises. The actors are susceptible to environmental conditions. Thus, there are some additional planning requirements to consider when employing actors as casualties in a combat environment scenario.

Overall, the combined panel concluded that moulaged actors present a viable option for traumatic amputation simulation as well as other injuries. The inability to actually treat the wounds was a drawback. The ability to actually interact with a patient in real time and get immediate appropriate and relevant feedback with the ability for flexible response was a significant plus. This modality is best saved for capstone exercises where immersion and realism of the scenario are required, not for partial task initial training. This modality would not substitute for live tissue, because of the treatment limitations and constraints. For the same reason, some high-fidelity mannequins might be superior to the use of actors.

4.2.13 Future of Combat Medical Simulation and Simulators

Examining future simulation options is an important consideration for a comprehensive assessment of NSCOM training simulation requirements. To discuss this, Drs. Robert Sweet and Howard Champion addressed the likely future directions for medical simulation technology.

Dr. Sweet gave an overview of the University of Minnesota Simulation Sciences Center and the MEDSIM Combat Training Consortium grant, funded by the U.S. Department of Defense (U.S. DoD). Like previous workshop presenters, he emphasized the shift from engineering-led simulation design to end-user integration into design concepts, definition of training outcomes, safety and performance metrics, and the need to identify which learning domain dominates the tools to be created. Dr. Sweet emphasized that the end-user trainers, particularly in the physician domain, need to focus on what is acceptable and safe practices instead of a particular approach to performing a task or partial task. This is important to combat medical providers, who may have to improvise with different available equipment and procedures in order to achieve the same outcome.

Dr. Sweet's department is involved in a complete spectrum of simulation-focused scientific endeavors including basic sciences, translational research, and curriculum development and assessment. In the basic sciences domain, the center is developing a database on tissue mechanical properties. The group developed its own biofidelic data using stress/strain (Young's modules), indentation, and thermoelectric conductivity on tissues, and then comparing data with the properties in available mannequins. Not surprisingly, the group found that the majority of tissue simulations do not compare with real mechanical properties. Dr. Sweet's team has evaluated arteries, veins, and bowels, and is using the data to provide an engineering basis for artificial tissue creation, particularly in pediatric and airway simulators. This important basic science is critical to making simulated tissues more lifelike, increasing realism, and tactile response to manipulation.

The MEDSIM Consortium is composed of a number of institutions and U.S. DoD agencies, and is involved in identification of simulators for point-of-wounding care training. It is undergoing a systematic science-based process to compare simulator-based training with the live animal model for various point-of-injury procedures. This process involves task deconstruction to develop appropriate quantifiable metrics. Expert medical trainers selected human patient mannequins and for comparison with the live animal model based initially on face and content validation criteria. The research study is in progress using trainees at both Fort Bragg, NC, and Fort Sam Houston, San Antonio, U.S. The study is designed to quantify the added learning value of the animal models in the training process. It is expected that the findings of these studies will identify gaps in technology and allow for targeted development of better simulation technology. Dr. Sweet's conclusions emphasized the need for continued basic research to support the engineering and development of future simulators and the current U.S. efforts to have end user input into the future design and the evaluation process of simulation technology.

Need for Simulators

Simulation tools for medical training have increased in complexity and capability. Simple plastic mannequins and physical surrogates have advanced to sophisticated computer enhanced mannequins that provide physiological and pathological responses to intervention. The appearance and feel of these mannequins have also improved. However, these computer-enhanced mannequins require resource-intensive environments in which to stage, process, and evaluate student performance. Computer-enhanced mannequins are costly and have limitations for repeated use and training content variation. They have been found to be of limited value in certain immersive settings, due to extremes of temperature, precipitation, and dust.

Integration of computer software that allows physiology and case scenarios to be used with physical mannequins produces task trainers that can vary and intensify the training experience and result in less reliance on instructional personnel. Examples of this are the Virtual IV™, which has several hundred case scenarios of increasing difficulty, and the limb hemorrhage simulator, ElSim™, which is used in combat medic training. These task trainers incorporate bleeding and physiological responses available in many physical mannequins; they enhance the training process by varying the scenarios in presentation and clinical course and can provide limited programmed performance feedback to users and instructors.

Computationally based simulators, which often feature high-fidelity computer graphics and primitive haptic feedback, are widely available for a variety of endovascular, endoscopic, and minimally invasive procedures.

Recently, true virtual reality (VR) computational capabilities are allowing the development of virtual reality medical scenarios. These are based on physics simulations derived from real tissue material properties and can be modified and enhanced to provide a variety of training experiences. The inexpensive availability of significant computational power and many types of consumer electromechanical devices has made it possible to interface haptic devices with this digital environment, especially in the use of surgical instruments. Thus, for the first time, the ability to present normal and pathological human anatomy in a virtual space and allow normal instrument interactions with virtual pathology now exists, though none are commercially available. Even less-expensive devices can use optical tracking as the sensory interface. Merging the virtual environments with physical mannequins yields hybrid simulators providing augmented reality learning experiences where the human hand interacts with the physical mannequin and produces vision and movement in the virtual space. When combined with advanced sensorized physical mannequins, the richness of the simulated training experience is further enhanced.

Interacting with a VR simulator is a digital experience. A permanent record of these interactions can be captured, allowing the tracking and assessment of student progress using objective metrics. Training with VR simulators can allow students to work at their own pace in a convenient time and location without the presence of a proctor and allows users to make mistakes and learn from them. The ability to "fail" and learn from mistakes is vitally important for developing complex decision-making skills in case management, where error recognition and evaluation of alternatives for correction are essential to the skill development process.

A hybrid limb hemorrhage simulator uses computer-based case scenarios that provide an array of hemostatic responses from direct wound interventions and tourniquet placement. Commercial device manufacturers are now launching devices side by side with training simulators for insertion into desired markets. A new cricothyroidotomy set, for example, might be launched with a hybrid-training device that has embedded performance metrics for certification purposes.

In summary, simulation technology is on the brink of a new generation that will alter the paradigm for development and documentation of knowledge and skills. Because of their enhanced features, especially the ability to provide practice and feedback, however, this new generation of VR simulators will be particularly applicable to combat casualty care training, facilitating rapid deployment of skills and enhancing patient outcomes.

4.2.14 Simulation Acquisition: The NATO SOF Allied Center for Medical Education (ACME) and PEO STRI Partnership

As noted by previous presenters, current simulator technology requires both educated Operators and an environment conducive to operating simulation hardware. The U.S. Army has invested in establishment of Medical Simulation Training Centers (MSTCs). Mr. Shannon Swain from Program Executive Office for

Simulation, Training, & Instrumentation (PEO STRI), the U.S. Army's acquisition agency for simulation, briefed the Research Workshop on the establishment of a medical simulation training center. PEO STRI is responsible for the U.S. Army's MSTCs, which will soon number 26. These MSTCs teach basic self and buddy aid to U.S. Army first responders as well as augment the training and testing of conventional medic skills to support local commander medical training requirements as requested. PEO STRI establishes contracts to operate and equip the MSTCs; these contracts include lifecycle management of the adjuvant training aids including simulators. MSTCs work from the training requirements identified for the training of combat medics and combat first responders to acquire and sustain the training capabilities. There are no live animal laboratories conducted at the MSTCs. Mr. Swain's presentation highlighted key points associated with nations considering building an MSTC-like training center. First, a clear curriculum should be established to determine what training aids are needed. Second, specifically trained staff should operate the center in order to enhance training value and provide full-time availability to the customer. Where possible, the MSTC should be located in relatively isolated areas to allow for noise, smoke, and other training scenarios. Finally, when contracting for equipment, it is critical that customers consider the long-term maintenance and sustainment needs of both the facility and its equipment, especially where warranties are concerned.

Mr. Swain pointed out that a standard MSTC cost is predicated on teaching 2500 soldiers per year in prehospital care. The cost of a facility and its equipment is determined by the anticipated use of the facility. A small student population requires fewer mannequins and less floor space, significantly reducing the cost. Wherever possible, indoor facilities with open spaces that can be easily transitioned and modified to vary scenarios are preferable. Additionally, there should be a training area for realistic outdoor training.

The cost of simulation technology can be reduced by purchase in volume. Joint international acquisition of medical simulators is possible through the NATO Supply Agency (NSA), formerly the NATO Acquisition and Maintenance Agency (NAMSA), which can create a NATO-wide contract, significantly improving national buying power and reducing per-item costs. PEOSTRI has foreign military programs that a nation might also leverage. Alternatively, nations may consider pooling and sharing resources into regional SOF training centers.

The NSHQ used a similar process when outfitting the NATO SOF Allied Center for Medical Education (ACME) by leveraging purchase power through a partnership with PEO STRI. Because PEO STRI purchases products for MSTCs, NSHQ was able to receive the same bulk discount afforded the U.S. centers. The ACME will provide NATO SOF Medicine Development Initiative (NSMDI) courses classrooms and a state-of-the-art combat medical simulation center where nations can learn to create quality medical simulation for SOF medical training. The ACME will serve as a research and testing capability, testing SOF-specific medical equipment in the simulated environment in partnership with industry, thereby implementing the RWS recommendation for customer involvement in the design process. Once established, nations' SOF elements may be able to borrow ACME simulators for short-term training support through NSHQ's NATO Capability Enhancement Program (NCEP) or evaluate current simulator and simulation products at the ACME prior to investment in these products. The NATO SOF ACME, through its collaborative partnerships with the SOF community, industry, universities, NATO, and government agencies, will serve as a primary source for SOF combat medical training expertise.

There is little doubt that as NATO and partner nations coordinate and cooperate in medic, Operator, and small unit commander training, their collective purchasing power and experience of agencies like the NSA or PEOSTRI could be of great value.

5.0 SUMMARY OF DISCUSSIONS AND CONCLUSIONS

During the 3-day workshop, numerous discussions took place. There was 100% support for increasing interoperability among NATO's SOF medical support. To achieve this goal, a clear understanding of interoperability is required, as is a capability-based definition of NATO Special Operation medics. Achieving such interoperability requires standards of training and a common proficiency-based curriculum.

The CoTCCC promulgated TCCC guidelines as embodied in the M-PHTLS manual is an excellent foundation for a proficiency-based curriculum. It could be used in the context of individual nations' medical training and licensing requirements for initial, sustainment, and predeployment training for SOF medics and Operators. The level of "expert," achieved through multiple teaching modalities, is required for skills to prevail in the tactical environment. The integration of tactics, techniques, and technologies enables optimal training curriculum within the constraints of the individual country's applicable laws and customs. Final recommendations were that NSHQ should proceed to facilitate interoperability of medical support for NATO SOF operations. Specific suggestions including the following:

- Implementation should include adoption of TCCC *principles,* which should be taught to all NATO SOF personnel and TCCC *guidelines* to all NATO SOF medics;
- A proficiency-based curriculum that achieves training goals meeting these interoperability goals for SOF medics as embodied in M-PHTLS and TCCC curricula should be created.

Additional skill training should include the use of adjuncts such as live animal use, manikins, moulaged actors, and realistic scenario-based learning.

5.1 NATO SOF Medic Curriculum Recommendations

NSOCMs need a standardized curriculum before addressing teaching modalities. PHTLS is currently taught in 20 NATO Nations; M-PHTLS, the military version of PHTLS, which incorporates TCCC Guidelines through a direct connection with the CoTCCC, would be an acceptable, feasible, attainable goal for initial NSOCM standardization for most nations. The panel considered International ITLS as an alternative, but ITLS is only represented in 10 NATO Nations, only recently created a military version, and is not directly linked to the CoTCCC. ITLS was considered by the panels to be more protocol-based than M-PHTLS. The panels recommend COMEDS endorse national SOCM training using M-PHTLS as a starting point for NSOCM training. Nations will need to build on this foundation to reach the full NSOCM capability. Four nations (Norway, Denmark, Finland, and Sweden) are currently developing a curriculum to attain full NSOCM capability, called the "Nordic Initiative," and plan to use M-PHTLS in training exercise.

Good combat medical training starts with a good curriculum where modality is matched to training objectives. Adopting M-PHTLS as a standardized baseline curriculum allows senior medical leadership to establish the necessary curriculum foundation for planning the procurement of simulator technology.

The panels achieved consensus that NSOCM training will require a combination of simulation modalities, including the live animal model, as there is no single technological solution that can meet all the NSOCM training needs.

5.2 Medical Simulation Technology Opportunities

Industry will strive to meet the demand for combat medical simulation technological solutions if funding is available. Early SOF and government involvement in the development process will increase the chances of producing quality products that meet training needs. Current technology is available to meet some NSOCM training requirements. However, no specific piece of technology is advanced enough to meet all needs. Therefore, it is premature to recommend a NATO-wide acquisition of a single product.

Because NSOCM training requires multiple simulation modalities, and the current SOF missions in Afghanistan and elsewhere are ongoing, nations must invest in current available technology to begin meeting their SOF commander's requirement for skilled SOF medics. Nations should partner in purchasing to increase purchasing power and reduce prices, a good example of Smart Defence.

Both the NATO Supply Agency and the U.S. Army PEO STRI are positioned to assist nations with bulk purchases of medical simulation technology. The NSHQ medical section can assist nations in coordinating purchases through these entities to increase national buying power. Cooperative agreements between nations for use of these training tools should also be considered to save resources and increase interoperability.

5.3 Co-Chairs' Closing Comments

HFM-224 was unique because it convened two expert panels simultaneously to create recommendations for COMEDS regarding NATO SOF medical simulation training needs for NSOCMs and the modality best suited to meet these needs. Panel I consisted of 11 experts from academia, government, and industry on SOF and combat medical simulation. Panel II consisted of 15 representatives from the COMEDS SOFMEP representing their SOF commanders and surgeons general. The SOFMEP political and operational insights augmented the HFM panel's academic approach, leading to high-quality, practical recommendations. The joint meeting led to significant cost savings and reduced timelines for creation of a NATO recommendation.

The candid discussions held at the NSHQ's NATO SOF Campus, in Chievres, Belgium, yielded key outcomes including the recommendation that nations adopt an established curriculum for all NSOCMS as a foundation for standardization. This curriculum could serve as the basis for determining current training simulator and simulation needs for NSOCM medical training. Finally, nations should consider collaboration in programs and procurement to maximize resources for training and simulation. Both panels achieved consensus on key elements presented here that, with COMEDS support, can bring actionable improvements in current SOF medical capability and interoperability leading to improved mission success and lives saved.

This RWS represents significant national contributions, and we believe that this gives credence and validity to the recommendations presented. Of note, 17 nations were represented at the conference. Five nations served on the program committee (CAN, DEU, EST, U.S., and GBR). Five nations served on the HFM expert panel (NOR, AUS, DNK, U.S., and DEU). Fifteen nations served as representatives from the COMEDs SOFMEP (BEL, CAN, CHE, DEU, DNK, FRA, GBR, ITA, NLD, NOR, POL, ROM, SWE, TUR, and U.S.) Attendees included physicians, medics, nurses, and medical operations officers from SOF and conventional forces, SOF Operators, academic experts in medical simulation, and industry experts in combat medical simulators and simulation centers – in total, 51 participants.

This RWS is dedicated to the support of the NSOCM, the healthcare provider assigned to provide Special Operations Task Unit (SOTU) medical support in austere environments. NSOCM capability requirements differ from conventional medical capability requirements because of the austere, often clandestine, and physically challenging SOF environment. To operate in this environment, the provider requires greater medical autonomy and critical decision-making skills than those required by most conventional medical providers at the same tactical level. We believe that the HFM 224 participants have successfully met the Technical Activity Proposal (TAP) objectives of sharing best technology and training practices, improving training conformity, and providing actionable recommendations for senior leaders that will improve NSOCM training.

6.0 PRESENTERS' CONTRIBUTIONS

6.1 NATO SOF Medicine Challenges and Opportunities

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The NSHQ has three primary missions: to provide a deployable core Special Operations Command Center (SOCC) for the Supreme Allied Commander-Europe (SACEUR), to serve as a primary source of SOF expertise, and to increase interoperability and synchronization across the Alliance. The NSHQ medical branch's mission is to support these lines of development. This article will introduce readers to NSHQ's

NATO SOF Medicine Development Initiative (NSMDI) designed to address current and future challenges facing NATO SOF Medicine and NATO SOF as it undergoes transformation.

Allied Administrative Publication-6 NATO Glossary of Terms and Definitions defines Special Operations as “Military activities conducted by specially designated, organized, trained and equipped forces using operational techniques and modes of employment not standard to conventional forces.” From this statement, one can imply a need for specialized enablers that increase the effectiveness of small teams against relatively superior elements in unconventional environments. NSMDI is an overarching program developed to improve NATO SOF medical leadership, develop SOF medical enablers, and improve NATO SOF tactical care while creating synchronization and interoperability across the Alliance and its partners. These elements will lead to improved SOF mission success and improved casualty survival in SOF forces. To understand how NSMDI will reach these goals, one must understand the challenges facing SOF medicine today and in the future.

Challenges in SOF Medicine

“In every difficult situation is potential value. Believe this, then begin looking for it.”

– Norman Vincent Peale

A Serpent with Two Heads

NATO SOF medicine faces multiple challenges as it continues to grow and develop as an Alliance capability. Central to these challenges is the fact that two governing bodies, the SOF commander and the unit’s military and civilian medical authorities guide SOF medicine. As a military tool, SOF medicine must respond to the SOF commanders’ requirements, as the commanders’ medical enabler, to improve and sustain force health, ensure critical medical capability is present where needed, and maximize unit effectiveness in meeting its objectives. Simultaneously, SOF medicine must interface within civilian medical leadership’s guidance to ensure that medical support is ethical and within each nation’s medicolegal framework. SOF medical leaders face the challenge of balancing the SOF commanders and senior medical leaders’ expectations and the mission to provide quality care to patients. Successful SOF medical support enables the SOF mission while maintaining appropriate medical standards. This task is made more difficult by the complexity of the SOF operating environment.

Good Medicine in Bad Places

SOF medicine’s second challenge is the SOF environment. SOF operations, because of their strategic nature, are often high-stakes, high-risk missions. They frequently occur under extreme battlefield conditions in remote areas with security limitations that limit communication and coordination; the deployed SOF medical provider is required to operate independently with less medical support and/or oversight than conventional counterparts. Evacuation may be delayed. Some nations have developed extensive training programs and legal mechanisms to allow appropriate latitude in the SOF medical provider’s scope of practice to meet these unusual operational requirements. This requires significant financial and manpower investment. Nations with limited inherent SOF medical capability are forced to provide a higher level of medical supervision at the point of injury, accept risk in patient outcome if that supervision is not present, or advise the supported SOF Commander of his medical vulnerability and its potential effect on operations.

In October 2011, 21 nations’ SOF medical representatives were surveyed during the NSHQ sponsored NATO SOF Medical Conference at Supreme Headquarters Allied Powers Europe (SHAPE), Belgium. The survey asked participants if they thought that their SOF medical provider’s current scope of practice was sufficient to meet operational requirements. The respondents unanimously agreed that NATO SOF medics must have an enhanced scope of practice to meet current and future operational demands. They also concurred that current medical skill sets fall short of requirements. Recognizing this shortfall, most nations are struggling with obtaining the support of SOF commanders and their national medical leadership to make necessary changes in the legal system to fix this problem. Also hampering solutions to this problem is limited consensus on a NATO SOF medic's appropriate scope of practice and, as important, the minimum training requirements to reliably validate and sustain these skills.

Multinational Standards and Capabilities

SOF medicine's third challenge is the lack of NATO SOF medical training standards on which nations can build their training and sustainment programs of instruction. Because NATO doctrine defines medical support as a national responsibility, there is significant variability between nations' scopes of practice, medic training standards, and methods. The result is imbalance, creating barriers to synchronization and interoperability in the Alliance. NATO's new expeditionary demands and the new concept of SOF employment at the NATO headquarters level bring new requirements for SOF medicine. NATO SOF medical doctrine development, NATO standardization agreements (STANAG), and NATO standardization recommendations (STANREC) may serve the Alliance well in leveling this variability. The NSHQ, as the NATO Special Operations Coordination Center (NSCC), took tangible steps toward addressing this issue with publication of the SOF Medical Standards and Training Directive Version 1.0, OCT 2009. However, this document lacks the doctrinal weight of more formal NATO documents and the specificity required to help nations achieve the level of interoperability. NSHQ medical branch, in conjunction with the national SOF medical leadership, places high priority on revising this document and elevating it to a more formal NATO document.

The Leadership Gap

The absence of an SOF medical leadership-training program is a fourth challenge facing NATO SOF medicine. Most nations draw their SOF medical leadership from their conventional medical branch officers. Some nations rely on SOF Operators with variable amounts of medical training to guide their medical systems. Still other nations do not have dedicated SOF medical leadership and assign unprepared conventional medical leaders with short notice to support immediate operational requirements. This variability inhibits an SOF element's ability to develop cohesive, functional, reliable, and self-improving medical support programs. To address this deficit, NSHQ has developed a Special Operations Medical Leaders Course under the umbrella of NSHQ's NATO SOF Training and Education Program (NSTEP). This 5-day course provides the Alliance a mechanism to train current and future SOF medical leadership in basic concepts of SOF medical support. Participants learn in a collaborative multinational environment the fundamentals of SOF operational planning and the specifics of how to medically support direct action, special reconnaissance, and military assistance missions. This initial course is followed by an advanced course highlighting SOF medical systems' capability development, including training management, human performance improvement, SOF medical logistics and product procurement, and medical research and development in SOF units. Through this mechanism, SOF commanders will have a means to educate their medical leaders and improve the overall effectiveness of their medical support.

Opportunities in SOF Medicine

"Accept the challenges so that you can feel the exhilaration of victory."

– George S. Patton

NATO SOF medicine is at a critical moment in development and positioned better than ever to aggressively tackle the challenges we face and improve SOF operational medicine. TCCC guidelines have matured to an international standard with a growing body of research and development support, including national and international trauma registries that guide standards development. NSHQ's growing programs, like the BICES communication network and the NATO SOF Training and Education Program (NSTEP), are postured to support increased communication and collaboration in the NATO SOF medical community. NSHQ Medical Branch's strategic plan, the NATO SOF Medicine Development Initiative (NSMDI), seeks to link, collaborate, develop, and facilitate the NATO SOF Community of Interest (COI) for comprehensive improvement in SOF medical support capability within the Alliance and our partners.

Link the Community

National SOF elements are frequently resistant to openly sharing information due to security concerns. The medical community, however, has a long tradition of openly sharing practices to improve patient care. NSHQ Knowledge Management Branch, in coordination with the NSHQ Medical Branch, has created the Special Operations Medical Branch (SOMB) website (www.nshq.bices.int/somb/somb) for this purpose. This password-protected, unclassified website is for the NATO SOF medical community. Website registration provides members a secure platform for dialogue within the community of interest, fostering communication to build synergy and synchronization. Select working groups have been established to tackle the tough problems facing NATO SOF medicine today. NSHQ Medical Branch is linking the NATO SOF medical community to encourage discussion, foster information sharing, and guide NSHQ strategic direction to develop future initiatives that enable multinational objectives. Maximization of Internet use is one of the cornerstones of NSMDI. Internet collaboration is a cost-efficient mechanism to reach the widely dispersed audience that is the NATO SOF medical community.

Collaborate to Meet Critical Needs

NSHQ serves to facilitate and synchronize national SOF elements, not supplant them. Thus, collaboration is a foundational platform of the organization. To foster collaboration, the NSHQ Medical Branch is maximizing the Adobe Connect Pro meeting platform to create Internet meetings for the NATO SOF medical community of interest. This software does not require installation on the user's computer. NSHQ's Adobe Connect Pro platform, an unclassified, web-based solution, allows real-time video and audio teleconferencing in specifically designated web meeting rooms. NSHQ medical branch has simultaneously collaborated with elements in the U.S., Belgium, Germany, and Afghanistan to test the limits of the system with great success. NSHQ Medical Branch is seeking to leverage this technology to create working groups that can produce tangible results in a cost-constrained environment. Under the NSMDI program, the plan exists to advance this capability to be able to teach online courses to personnel who provide SOF medical support, establishing a NATO SOF online medical training capability for initial and continuing medical education specific to SOF medical support.

Develop Initiatives

One function of a higher headquarters is to identify capability gaps between elements and ensure that the elements are linked. As mentioned, a gap in NATO SOF medicine today is a leadership training pipeline. The first product produced under the NSMDI program is the Special Operations Medical Leaders Course (SOMLC). SOMLC is an introductory course to SOF, geared for NATO medical leaders directly assigned to SOF elements as well as those periodically assigned to support SOF elements. Thus, SOMLC will not only improve SOF medical leadership capability but also impact the wider conventional NATO medical leadership capacity. Other areas where linking national initiatives will foster synergistic improvement in NATO SOF medical capability. An example is the development of Special Operations Surgical Teams (SOST). At present, multiple nations are developing or refining their specialized surgical teams. SOSTs are designed to provide lifesaving surgical intervention in environments where rapid evacuation is not possible. This is critically important for future areas of operation where medical support may not be robust but equally important to current operations in Afghanistan as nations begin to decrease their medical footprints and overall forces. This operational reality makes funding the development of SOF surgical support an urgent priority to save SOF lives. NSHQ Medical Branch has established an SOST workgroup on the Special Operations Medical Branch website where nations can collaborate and learn from each other's experiences as they continue to develop their national capability. Additionally, NSHQ's biannual NATO SOF Medical Conferences will focus on SOST and other SOF-specific lessons learned and applications. NSHQ plans to launch in late 2013 the Special Operations Surgical Team Course, which will help nation's fast track capability development and interoperability by teaching the fundamentals of SOST development and employment.

Developing SOF elements medical engagement and military partnering skills is another area where NSHQ Medical Branch is taking an active role. The development of Military Assistance mission capability and non-kinetic engagement strategies has been identified by the NSHQ commander and SACEUR as an area for future growth to improve NATO's strategic capability. To meet this requirement, NSMDI launched the Special Operations Medical Engagement and Partnering Course (SMEPC), teaching students how to plan medical engagements and host nation partnering programs that align with medical ethics standards and SOF commanders' objectives.

Facilitate NATO SOF Medicine

The challenges Alliance SOF medical organizations face provide opportunities to facilitate NATO SOF medical capability. Creating online resources and technology and maximizing collaborative efforts can enhance NATO SOF medicine development. Synergistic relationships between NATO military and academic institutions can open doors to improvements in medical education. A problem facing most NATO SOF units today is the challenge of providing realistic medical training using currently available medical simulation technology. NSHQ Medical Branch is exploring opportunities to partner with academia to develop medical simulation options and methods to validate their effectiveness. Lessons learned from these studies, with participation by NATO SOF medical organizations, could lead to better medical simulators and wiser use of medical simulation options.

Conclusion

This is an exciting time for NATO SOF medicine. NSHQ and the NSHQ Medical Branch is deeply committed to serving the Alliance and its partners as a primary source for SOF expertise, creating a deployable SOF command and control element and improving synchronization and interoperability in the NATO SOF community. The NATO SOF medical community of interest is essential in guiding strategic direction that meets the requirements of NATO SOF commander while empowering the NSOCM so they can save lives on the battlefield. The NSHQ Medical Branch will continue to foster communication and partnerships that grow capability in the Alliance. Improving patient care and enhancing mission accomplishment must be at the heart of every initiative.

6.2 Tactical Combat Casualty Care: Saving Lives on the Battlefield

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The opinions and assertions expressed by the authors are theirs alone and do not necessarily reflect the views of the Department of the Army or the Department of Defense.

Maughon[1] wrote in 1970 that very little had changed with respect to the management of casualties on the battlefield in the last 100 years. As a sobering postscript to that observation, there was also little improvement seen in battlefield trauma care for the ensuing 25 years after these words were written.
In the mid-1990s, however, the Special Operations medical community began a research effort aimed at improving battlefield trauma care in the prehospital tactical environment. Through the combined efforts of

the U.S. Special Operations Command, the Naval Operational Medicine Institute, the U.S. Army Institute of Surgical Research, the Joint Trauma System, the Office of the Surgeon General of the Army, the Prehospital Trauma Life Support Executive Council, and the Defense Health Board, the standard of care for managing casualties in the prehospital combat environment has changed dramatically in the last 10 years.

The decade of war that the U.S. and its coalition partners have just experienced has seen the introduction of a remarkable array of innovations designed to improve battlefield trauma care: phased care in the combat environment in order to combine good medicine with good small-unit tactics; aggressive tourniquet use for control of extremity hemorrhage; hemostatic dressings; needle decompression for suspected tension pneumothorax; intraosseous infusion techniques; tactically appropriate management of the injured airway; improved battlefield analgesia; hypotensive resuscitation with Hextend for casualties in shock; an increased focus on hypothermia prevention and avoidance of the coagulopathy of trauma; prehospital antibiotics; prehospital pulse oximetry monitoring; tranexamic acid for noncompressible hemorrhage; the Combat Ready Clamp (CRoC)™ for junctional hemorrhage; prehospital damage control resuscitation using 1:1 plasma and PRBC ratios on evacuation platforms; and improved techniques for optimizing prehospital care for casualties with traumatic brain injury.

These innovations and the coordination required to introduce them to the military services have been pioneered largely through the efforts of the CoTCCC, a group of subject matter experts that includes trauma surgeons, emergency medicine specialists, intensivists, medical educators, combatant unit physicians, and physician assistants, as well as combat medical personnel. This group is tri-service with participation from civilian trauma experts as well. It functions as a working group of the Trauma and Injury Subcommittee of the Defense Health Board. The CoTCCC meets quarterly to review the success of the current TCCC Guidelines, to evaluate new information that has become available, and to consider opportunities for improvement.

The success of TCCC at reducing preventable deaths in combat has been unprecedented. In 2001, TCCC was being used only by the Navy SEALs, the Army Rangers, the Army Special Missions Unit, and a few isolated other military units. As a result of its success on the battlefields of Afghanistan and Iraq, TCCC has now become the standard of care for the management of combat trauma in the prehospital tactical setting. TCCC is presently used by all services in the U.S. military and many coalition partner nations. In 2011, TCCC was recommended as the standard of care by the ABCA (America, Britain, Canada, Australia, and New Zealand) Armies' Program.

The chosen metric for TCCC is reducing or eliminating preventable death on the battlefield. During the initial phase of the war on terrorism, the incidence of preventable deaths among U.S. combat fatalities was reported to be approximately one in four. The incidence of preventable deaths due to extremity hemorrhage was essentially the same as it had been in Vietnam a quarter-century earlier. In contrast, the units that have used TCCC since the start of the current conflicts have reported remarkable success in avoiding preventable deaths on the battlefield. The report by Tarpey in 2005 calls TCCC a remarkable success in Task Force 1-15 of the Third Infantry Division, which was leading the drive to Baghdad in the Iraq war. Kragh's landmark reports confirm the dramatic success of battlefield tourniquets in TCCC. In the *Archives of Surgery*, Kotwal and his colleagues note a virtual elimination of preventable death on the battlefield among Army Rangers in Iraq and Afghanistan.[2] Physicians from the Canadian Forces have reported dramatic success with TCCC during these conflicts as well. Both of the latter reports, as well as the CoTCCC and the Defense Health Board, have emphasized the need to train all combatants in deploying units in TCCC techniques in order to achieve this level of success in avoiding preventable deaths. All combatants should know the basics of hemorrhage control, tactical airway management, and combining good tactics with good medicine.

The CoTCCC maintains a list of TCCC skill sets by provider level for the various types of individuals who may be called on to provide care on the battlefield. The question of how best to train for specific TCCC skills is made more complex by the challenge of defining objective metrics that will reliably predict success in combat. The list represents next the author's views on the best training modalities for each of the enumerated skills:

- Casualty movement - buddy training
- Tourniquet application - buddy training
- Combat Gauze application - live tissue training
- Combat Ready Clamp application - live tissue training
- Sit-up-and-lean forward airway positioning - buddy training
- Nasopharyngeal airways - manikin
- Surgical airways - live tissue training
- Needle decompression - live tissue training
- Intraosseous access - manikin/device trainer
- IV access - buddy training
- Scenario-based casualty response - computer-based training

The best solution is likely to be training that employs a combination of the modalities listed above, such as the very successful TCCC training program developed at Madigan Army Medical Center as described by Sohn in 2006.[3]

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6.3 Military Pre-hospital Trauma Life Support History and Discussion

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Introduction

Trauma in combat results from a wide variety of causes. While the primary cause is from penetrating wounds of various types, modern conflicts have demonstrated that blunt force injury and blast related trauma produce an ever-expanding spectrum of injuries that the combat medic must be prepared to manage. The situations (environment, remote area, and imminent danger) require that the SOF medic be well trained and practiced for immediate response in the harshest environments.

The development of an education program for the SOF medic must ensure that individuals from various countries and military/medical backgrounds have similar understanding of military and medical principles, to accomplish the military mission, while caring for the patients under combat and noncombat situations. The charge of the HFM 224 NATO SOF Medical Simulation RWS group is to address the training of SOF medics.

There are two philosophies of prehospital medic training. One is that the medics require only minimal education and that protocols can direct their care much like a robot. The other is to give the medic a foundational medical understanding of the principles of physiology and pathophysiology of combat injures so that they are able to think in the field and address the specific situation, recognize the trauma conditions sustained by their patients, and, using this knowledge, apply their own personal medical skills, experience, and the equipment that is available to meet the patient's medical needs in a inaccessible region in which not medical support is available. The MILITARY PREHOSPITAL TRAUMA LIFE SUPPORT (M-PHTLS)® course addresses this concept: Decisions based on knowledge.

History of PHTLS

Good outcomes for trauma patients are dependent on a seamless continuum of care from field (prehospital) care through in-hospital care including flow through the emergency department, the operating room and the intensive care unit and ultimately rehabilitation. This was the impetus for development of the Advanced Trauma Life Support (ATLS) course (1980), by the American College of Surgeons (ACS). ATLS was developed as a 'physician only' course and is focused on in-hospital care of the trauma patient. The comparable field provider course was developed in 1981 by the National Association of Emergency Medical Technicians (NAEMT) and is called Prehospital Trauma Life Support (PHTLS). The PHTLS course is a combined effort of the ACS and NAEMT and follows the principles of the ATLS program. Each edition of the PHTLS manual is published 1 year after the ATLS manual to ensure prehospital providers are taught the same principles as in-hospital providers. Similar terminology and stepwise procedures are used to ensure consistency of approach. PHTLS is the only prehospital trauma course that is endorsed by the ACS, the ACS committee on Trauma, the NAEMT, and the CoTCCC.

Military History

The goal of M-PHTLS is to minimize preventable death on the battlefield. COL Ron Belamy stated, "90% of combat deaths occur on the battlefield before the casualty ever reaches a medical treatment facility." The military aspects of PHTLS are exemplified in these volumes:

- PHTLS 3rd edition - Appendix D "Tactical Aspects of Emergency Medical Services Operating in the Hostile Environment," written by Josh Vayer, Uniform Services University of Health Sciences (USUHS);
- PHTLS 4th, Military Edition 1999 - Chapter 17 "Military Medicine";
- PHTLS 5th, Military Edition, 2003 - M-PHTLS textbook;
- PHTLS 6th, Military Edition, 2007 - M-PHTLS textbook;
- PHTLS 7th, Military Edition, 2011 - M-PHTLS textbook.

These last three editions contain the entire Military PHTLS training program exemplified by TCCC and encompass penetrating, blunt and blast related injury. The Committee on Tactical Combat Casualty care (CoTCCC) develops the military component. PHTLS and TCCC courses work in combination to yield the military PHTLS course. Each edition is a revision and update of the previous edition.

International Promulgation

PHTLS is taught in 59 countries. Sixteen NATO countries currently teach PHTLS. Within the PHTLS curriculum, three are teaching TCCC guidelines in their civilian and military communities.

The process for PHTLS development in each country is similar to ATLS: The country will identify a lead agency. That agency sends four to seven individuals to the United States for the initial training as both instructors and administrators/leaders. These individuals return to their country, set up the system, and plan the inaugural course. Alternatively, PHTLS may be requested to send faculty to the country to present the initial training, certification and instructor education.At the time of the inaugural course, two members of the PHTLS Executive Council (one physician and one educator/administrator) monitor an instructor and a provider course and review the process for continuation of the courses. The indigenous providers report to NAEMT on numbers of students trained. PHTLS-Europe has been developed and is a cooperative to support the continued growth of the program. There are currently 20 countries in this group (Table 6.1).

Table 6.1: Countries and Numbers of Courses and Students Trained Ministry of Defence or Medicine.

Country	No. of Courses	No.of Students Trained
Belgium	5 PHTLS	56 PHTLS
Canada	27 PHTLS, 2 TCCC, 2 TFR	273 PHTLS, 17 TCCC, 25 TFR
Denmark	50 PHTLS	759 PHTLS
France	32 PHTLS	514 PHTLS
Germany	50 PHTLS, 1 TFR	1,067 PHTLS, 18 TFR
Greece	10 PHTLS	179 PHTLS
Italy	25 PHTLS	297 PHTLS
Lithuania	1 PHTLS	16 PHTLS
Luxembourg	1 PHTLS, 3 TFR	14 PHTLS, 43 TFR
Netherlands	54 PHTLS	350 PHTLS
Norway	54 PHTLS	511 PHTLS
Poland	3 PHTLS	41 PHTLS
Portugal	1 PHTLS	7 PHTLS
Spain	20 PHTLS, 8 TCCC	267 PHTLS, 123 TCCC
United Kingdom	~150 PHTLS	~3,000 PHTLS

The civilian course is taught to all prehospital providers. Each country has its own rules as to who serves as the provider in the ambulance. This could be a physician, nurse, or EMT (basic or paramedic). The PHTLS program provides the trauma educational goals, objectives, text, and educational material. For those countries that have a less well-developed non–physician/nurse/EMT or nonexistent prehospital provider system, the PHTLS committee has developed a Trauma First Responder (TFR) course for the initial introduction of responding fire and law enforcement personnel to trauma care. The TFR is designed for the prehospital provider with minimal to no medical education.

Principles and Preferences

The critical conceptual basis underlying all PHTLS education is the philosophy of "Principles and Preferences." A principle is a goal or standard of patient care. How an individual provider achieves this principle is the preference and depends on four specific components: the environment, the patient's condition, the skill, and the resources at hand (Figure 6.1).

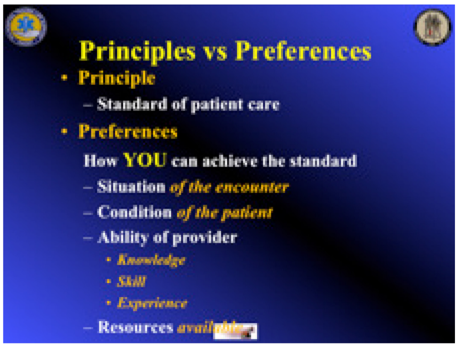

Figure 6.1: Principles and Preferences.

The noncombat PHTLS principles are taught in the first section of the book. The PHTLS paradigm in the noncombat incident is such that the patient is the mission and there is minimal threat to the provider. The mission is a military goal and the patient is secondary. The priority of the SOF medic is to complete the mission while protecting the other war-fighters; the patient is a secondary priority. The Tactical Combat Casualty Care course defines and describes how the medical principles are applied in the combat situation. These are divided into the separate situations: under fire; when there is no major threat to the warrior; and moving the casualty to a higher level of medical care. These are called "Care Under Fire," "Tactical Care," and "Casualty Evacuation Care or 'Casevac' Care." The principles (M-PHTLS) apply to medical care for blunt and penetrating trauma.

Discussion

The SOF medical working environment is similar to civilian counterparts except when active combat necessitates multitasking mission in addition to care of patients. The priority of an SOF medic is to complete the mission and protect himself from harm in order take care of injured companions. A good foundation of knowledge and cognitive skills helps the medic survive and maintain the ability to provide patient care in stressful environments. To accomplish this, the SOF medic must have a working knowledge of anatomy, physiology, and basic pharmacology. The training must be of sufficient depth to understand pathophysiological processes that may occur and accomplish the needed and appropriate intervention quickly, given the tactical situation. The foundation of anatomy and physiology of injury will allow the SOF medic to recognize critical medical issues and best apply the interventions necessary to provide patient care so the injured war-fighter is given the best chance of survival. The extreme austerity and adversarial nature of combat casualty care in a tactical setting require the highest intensity of training available so that even cognitive processes decremented by near darkness, adversity, and caring for a friend and colleague allow for optimal treatment to be rendered. The motto of PHTLS is "decisions based on knowledge." PHTLS and the TCCC program provide this foundation of knowledge and teach the needed decision-making to use these skills in the combat environment.

The Military PHTLS update (PHTLS and TCCC) continuing education program can be accomplished in 5 days of education with skills practice. However, a comprehensive foundation of understanding of basic medicine/trauma requires several weeks. This includes anatomy, physiology, pharmacology, pathophysiology, shock/resuscitation management, hemorrhage control, assessment, IV fluid administration, and splinting and bandaging). Many countries have taught this knowledge and skills in a basic medic course. The Military PHTLS textbook includes all of the basic and advanced information required by an SOF medic. The Military PHTLS textbook has two parts: basic trauma knowledge, assessment, and care in the first half of the text and provides instruction in Tactical Combat Casualty Care in the second half.

The textbook begins with an explanation of the difference between principles and preferences. It contains the philosophy of decision-making, establishing priorities, assessment of the scene, and then assessment of the patient(s). It also presents the necessary anatomy and physiology content to develop judgmental and practical skills to appropriately manage the patient. This includes shock and resuscitation and airway, circulation, mental, and secondary assessment to include management of the entire patient. In the civilian environment, the primary assessment is all that is usually done, since the hospital is only minutes away. In combat casualty care, the SOF medic may be required to care for the patient for prolonged periods of time, if evacuation is delayed. This includes pain management, antibiotic administration, fluid balance, and wound closure. These skills are covered in the Military PHTLS textbook.

Additional skills to provide standard patient care in a long-term or routine care environment such as back pain, urinary tract infections, upper respiratory infections, and sprains and strains must also be part of the SOF medic's repertoire. Telemedicine and the Internet have helped to assist with reference material, but this is not reliably available in the environment frequented by SOF missions.

Ideally, the entire course is taught to a proficient SOF medic: PHTLS in 2 days and TCCC in 2½ days. On successful completion of each part, the SOF medic will be registered in the PHTLS/TCCC registry and receives a wall certificate and a wallet card for each component. This 5-day course is an update and refresher course that requires that the student have had both military and basic medical education.

For the nonmedical SOF Operator, the PHTLS/TCCC text can be used for primary education. Time is required teaching these principles; the U.S. standard of EMT-Basic education, requires approximately 40 hours of trauma education out of a total of 110 hours. Other components of the course include medicine, obstetrics, defensive driving, ethics, report writing, etc. The U.S. standard of the EMT-Paramedic level involves at least 1000 hours of education. Approximately 200 hours of this time are devoted to trauma, advanced airway, and fluid administration. Internationally, each country has its own standards for prehospital training. Some countries use physicians, and others use nurses or train nonmedical personal; however, the general number of hours of education are similar.

Conclusion

The medical education of the SOF medic varies from country to country. For representatives from these countries to work together as a team for the benefit of the injured war-fighter, it is important that there be standard goals and objectives throughout the NATO SOF medical corps. There is a distinction between care rendered in a civilian environment and the training available outside combat with the actual combat experience – where capability under duress is only achieved by drill, drill, drill. M-PHTLS provides such a standard. It is used and accepted in many countries throughout the world as a civilian training program and in an increasing number of military services.

6.4 Curriculum, Tasks, and Skill Development

COL Rob Lutz, Special Warfare Medical Group (A)

Curriculum is a prescribed course of study to reach a defined skill set and knowledge base. It includes both training and education. We traditionally think of military training as the development of "hands-on" skills and education as the theory behind those skills. Medics need to be "educated" in why skills are needed, how they affect patient outcomes, and the underlying anatomy, physiology, and mechanisms of injury. NSOCM curriculum must include both training and education considering all these areas.

Defining the "end-state" is important in curriculum development. If you cannot define what you want, you have no firm grasp of how to get there. Beginning with the end in mind, one can then back the plan on how to get there through task deconstruction. This important step is often overlooked. SOF medic curriculum development should start with identifying patient scenarios that you expect the medic to address (end-state) and to what level the medic will address them.

After defining end-states, performance measures for successful completion are identified. Each performance measure must be broken down into specific tasks with the level of skill acquisition required (task analysis). How the task is performed (steps) and why it is performed (education) are equally important. Each scenario that an NSOCM is expected to address must be mapped by task analysis and education required. At the end of this process, there will be a specific list of tasks and educational requirements that form the basis for the curriculum. Many scenarios will have overlapping tasks, such as patient assessment, IV start, hemorrhage control, etc., and the final list is a combination of these tasks.

Skill acquisition is the next step to address when developing SOF medic curriculum. Skill development progresses in stages as experience and training progresses. The desired level of acquisition needs to be determined, ideally using an accepted model, such as the Dreyfus model of skill acquisition (Table 6.2). This model divides skill acquisition into five stages: Novice, Competent, Proficient, Expert, and Master and describes specific requirements of each stage. Trying to "leap" stages to develop a student will not work. Training and education must be coordinated to advance through each stage, with each new stage introducing new situations of increasing patient care complexity that develops an organized approach to patients adaptable to many situations.

An important part of curriculum development is deciding which tasks need to be trained to what level. With unlimited time and resources, all tasks would be trained to the highest level, but this is not feasible for most nations. For the SOF medic, most tasks will be trained to the Competent or Proficient level. Critical tasks need to be identified that must be taught to the Proficient level, while others may be taught to the Competent level. The Expert and Master levels require experience and are not levels that can be achieved in a short defined course.

By starting with the effective management of defined patient scenarios as the end-state, one can identify the training and education needed to understand and reliably treat injuries. Breaking training tasks into steps and then rebuilding them based on the level of skill acquisition expected, coupled with foundational education will define a curriculum map needed to successfully train NSOCMS. Matching the task with the most effective method of training is critical (Figure 6.2).

Table 6.2: Dreyfus Stages of Skill Acquisition. From Stuart E. and Hubert L. Dreyfus, "A Five Stage Model of the Mental Activities Involved in Directed Skill Acquisition," February 1980, http://www.dtic.mil/dtic/tr/fulltext/u2/a084551.pdf.

	Skill Level				
Mental Function	Novice	Competent	Proficient	Expert	Master
Recollection	Nonsituational	Situational	Situational	Situational	Situational
Recognition	Decomposed	Decomposed	Holistic	Holistic	Holistic
Decision	Analytical	Analytical	Analytical	Intuitive	Intuitive
Awareness	Monitoring	Monitoring	Monitoring	Monitoring	Absorbed

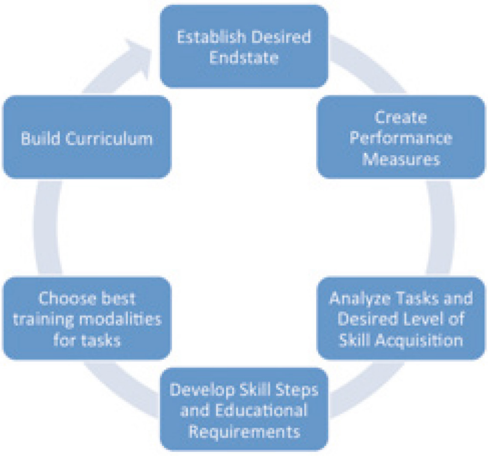

Figure 6.2: Graphic Representation of the Curriculum Development Process.

6.5 SOF Combat Medical Simulation: An Australian Viewpoint

MAJ (Dr.) Daniel Pronk and LTC Alison Berliotz-Notts

Combat simulation is used extensively in Australian (AS) SOF medical training, with low fidelity mannequins and basic moulage being the predominant modalities employed. While higher-fidelity mannequins are available to SOF and there exists an excellent simulation center, these modalities are seldom used for purposes, which will be described next.

Environmental Simulation Training Facility (ESTF)

The ESTF is a purpose-built simulation center owned and operated by the Army School of Health in Albury, New South Wales. It is used primarily in the instruction of regular Army medics when they undertake their initial period of training. The facility was built in 2007 at a cost of $11 million AS and has a large main floor area as well as several side training rooms. It can be temperature regulated between 4 and 40 degrees Celsius and can be completely blacked out allowing for low light and night training serials during the day. The ESTF has a comprehensive speaker system with programmable combat noise and aircraft simulation, as well as a series of jets in the roof to simulate helicopter rotor wash and a winching platform to simulate rotary wing winch extraction. Rain can be simulated from a light mist to a torrential downpour through plumbing in the roof with smoke machines in the floor area allowing for low visibility environments to be generated. There are a series of control rooms and viewing platforms overlooking the main training floor with CCTV able to capture training serials for playback in assistance with debriefing activities. The side rooms of the ESTF are set up with resuscitation bays and tethered SIMMAN mannequins for resuscitation training. Adjacent rooms to these side rooms contain the control systems for the SIMMAN and view the side room through one-way mirrors. Communication systems allow the directing staff in the control rooms to communicate with the students in the side room either through speakers or through SIMMAN himself. The main floor of the ESTF can be set up with lanes containing various obstacles and distractions for the students, up to and including cars and armored vehicles. The ESTF is suitable for blanks to be fired within assuming appropriate cautions are taken. Thus, TCCC drills from Care under Fire, through Tactical Field Care, and, to a lesser degree, Tactical Evacuation Care can be trained in the one complex in all light and weather conditions with realistic combat and aircraft noise simulation. This in conjunction with moulaged casualty actors provides a high-fidelity training environment for the combat medic.

Environmental Simulation Training Facility Australian SOF Usage

In recent years, AS SOF has moved away from the use of the ESTF. Up until 2010, the ESTF was used by AS SOF medical elements during their predeployment validation activities. While the ESTF is an excellent facility, a variety of reasons have led to AS SOF performing their predeployment validation activities in alternate locations since 2010. The primary reason was the travel involved and inconvenience of relocating and storage of weapons and equipment in Albury. Operational security was another issue for SOF training on a regular Army training base, with a reluctance to exercise certain techniques, tactics, and procedures in that environment. Other considerations included the inability to run Live Tissue Training (LTT) within the complex and its limited size. While the ESTF is a large complex in itself, there exists limited ability to patrol tactically up to the complex and assault it, leading into casualty treatment scenarios. In recent years, SOF owned training complexes have been used in preference to the ESTF for medical predeployment training. While the level of simulation is far reduced, these facilities allow for larger-scale tactical scenarios, incorporating field LTT, in a realistic Afghan village environment. Training fidelity is maintained through use of smoke grenades and blanks to simulate combat scenarios and limited moulage on casualty actors. While efforts could be made to improve casualty moulage, it is considered that the *relevance* of the training is far more important than the *realism* of the training. Scenarios are, therefore, frequently exact recreations of actual AS SOF combat casualties and fatalities and, when briefed as such, it is noted that the student involvement in the scenario improves significantly.

As the training complexes currently used are SOF owned, there exist no OPSEC concerns and weapons and equipment can be drawn and stored on nearby SOF bases.

Small SOF Medical Element Challenges

Australian SOF medical consists in its entirety of approximately 50 personnel, including medical and nursing officers, underwater medics and advanced medics. While not included in Medical Corps, Operators, after a short course in trauma response and basic primary healthcare, augment AS SOF medical support. These Combat First Aiders or Patrol Advanced First Aiders represent approximately one in five Operators in AS SOF fighting units.

There are currently no formal entrance requirements other than a basic psychological screen to be posted into a medical role within AS SOF. Once posted to an SOF unit, the medic will undergo a basic 2-week SOF induction course for weapon and equipment familiarization before assuming their role in the unit. Further tactical and medical training is done within the unit and is variable depending on posted unit and role. While the medical staff is posted to an SOF unit, they always belong to regular Army Medical Corps and hence can be posted out at any time. There currently exists a mentality among Australian Army career agencies that a rounded career must involve postings to regular Army, SOCOMD, and training institutions. While the requirement to share experiences and the benefits of having operationally experienced medics in training roles are unquestionable, the regular posting of medics out of SOF makes retention of corporate knowledge difficult. Further to this, owing to the small size of AS SOF medical, there are limited senior positions for physicians and medics, alike, making career progression through the ranks of SOF medical difficult, if not impossible, for many members.

In the recent years of the Afghan conflict, the operational tempo of the AS SOF units has been extremely high. This has allowed for a huge amount of combat medical and point of injury forward AME experience to be gathered among AS SOF medical. As a downside to this high operational tempo, there is often limited time and opportunity to pass this knowledge onto junior SOF medics. Thus, as above, often our most experienced medics will be posted out of SOCOMD without reinvesting their hard-won corporate knowledge. Also, due to the operational tempo, many TTPs and equipment changes have been made quickly and often authorized and purchased for Afghan use. Efforts must be made to ensure that these changes for the better are represented in policy that will endure the Afghan conflict as not to regress back to pre-conflict capabilities when we withdraw from Afghanistan.

As with any nation's SOF medical elements, AS SOF medics are required to maintain currency in a vast array of technical competencies on top of their medical skills. This challenge is of course not unique to SOF medical elements, with all Operators facing the same challenges. Recertification courses are mandated for all medically trained Operators annually to maintain currency. For AS SOF physicians and medics, there exists no such mandated annual skills recertification and these skills are maintained on an opportunistic basis through attachments to local hospitals and ambulance ride-along sessions. Owing to the current operational tempo, time to attend such skills maintenance sessions are scarce and for this reason deploying physicians and medics are validated prior to deployment in mandated medical training. During this training, the deploying physician and medics are put through several weeks of theoretical refresher training, lessons learned from recently returned medics, and simulated scenarios of increasing complexity. The culminating activity is a field LTT MASCAL scenario exercising all levels of deploying medical assets. The deploying physicians and medics are validated informally by senior AS SOF medical elements that instruct on the course. Owing to AS SOF medical being a small, close-knit community, it is acknowledged that there exists the potential for bias in the validation of deploying medics. Without a peer organization within Australia to independently validate the deploying medical element, it is difficult to avoid this situation.

Despite being a very small element, AS SOF medical is fortunate in its funding and while not expensive, high-fidelity simulators are owned by AS SOF, accessibility to equipment and training is sufficient. Worthy of particular note is the robust ethically approved structure that exists for AS SOF LTT. Owing to the tireless efforts of a small number within the community, AS SOF medical elements, down to the medically trained Operator level, have annual access to LTT refresher training. This is considered to be the highest value training available for AS SOF medical elements and negates the need for high-fidelity simulators for procedures including arterial hemorrhage control, surgical airways, chest tubes and needle decompression of tension peumothoraces. Between LTT sessions, these skills can be maintained on lower-fidelity simulators, including SimMan® and TraumaMan®, in casualty treatment scenarios run in the barracks environment.

Australian SOF Medical Training Lessons Learned

AS involvement in the Afghan conflict has allowed for many medical lessons learned. The primary way for these to be captured is by narrative-based clinical learning. This is achieved by ensuring all instructors on AS SOF medical predeployment training have current operational experience to draw from. A closed-door session is held at each predeployment course where an uncensored version of events surrounding AS SOF casualties and fatalities is briefed to the medical element due to deploy. In the session, techniques that worked well and those that did not are discussed in detail in an attempt to prevent lessons being relearned in future casualty scenarios. As described here, casualty scenarios on the course are then based upon actual casualty events to add relevance to the training. Where appropriate, helmet camera footage of casualty scenarios is played for the deploying medical element to allow them to directly visualize and to better prepare for similar situations.

The majority of AS SOF medical training is done in an adult learning style, employing double-loop learning. This allows the student to self-critique his performance followed by another attempt at any given scenario to correct their actions. Complexity of scenarios and tactical situations surrounding them is gradually increased in a controlled fashion to allow the student to build confidence in a graduated manner. The ultimate goal is to have the student performing their basic TCCC responses with unconscious competence to allow their higher though to be dedicated to the tactical situation and functions such as generation and transmission of a timely 9-Liner. There is a strong emphasis on the "train as you are going to fight" theory with all scenarios being done with in full combat load, with weapons and involving heavy physical activity such as fire and movement and patient drags and carries. This allows the student to master required skill sets, including fine motor skills, with an elevated heart rate and adrenaline levels. The use of their usual combat equipment and medical packs allows them to program their muscle memory to reach for certain pieces of equipment in the location it will be on the battlefield. Not only does this improve performance in low light conditions, but also, if practiced sufficiently, it allows the student to program a subconscious response in reaching for and applying interventions such as tourniquets, Quikclot®, and decompression needles.

Recommendations for Nations Developing Simulation Capability

The biggest recommendation from the Australian experience for nations developing their simulation capability is to focus on the *relevance* of their training rather than the *realism*. A well-choreographed scenario using a convincing, screaming actor covered in tomato sauce in the field can provide a better training outcome than a multi-thousand dollar simulator used poorly.

It is also considered that where available, LTT should be pursued as a priority. Should ethical considerations preclude the training in any given country, the opportunity to travel abroad for the training should be explored. Should this not be an option, the used of cadaveric animal models can provide excellent training in certain procedures. Examples of this used in the AS SOF context include pig throats used for surgical airway training and pig or sheep rib cages for needle decompression and chest tube training.

Training with regular military elements should be encouraged and explored as an option of cost sharing where finances are an issue. While protocols might vary slightly between regular and SOF medical elements, it is the same conditions that are killing soldiers on the battlefield regardless of their unit of origin. Training in arterial hemorrhage control, tension pneumothorax identification and decompression, and airway maneuvers and intervention should be universal across regular and SOF elements. The bulk of these skills could be taught and practiced in a communal regular/SOF medical environment, using shared resources if funding was limited. Niche SOF capabilities could then be trained independently.

6.6 Norwegian Maritime SOF Experience

Norwegian Naval SOF optimizes medical training through extensive use of professional actors, augmented by technology that allows for vital signs assessment, and live tissue training.

– Lieutenant Commander (OF 3) Geir Strandenes, Lieutenant (OF 2) Jens H Gløersen

Marine Jeger Kommandoen, Norwegian Naval Special Operations Command (NORNAVSOC), is a premier Special Operations element whose mission includes standard NATO SOF missions of direct action, special reconnaissance, and military assistance and extends to hostage rescue, combat search and rescue, counterterrorism, and other missions not deemed appropriate for conventional forces. Like other SOF elements, NORNAVSOC requires highly trained Operators and support personnel capable of working and surviving in the complex SOF environment. Like most NATO nations, the NORNAVSOC medical community deals with the challenges of national limitations, financial constraints, scope of practice limitations, and training resource deficits. Still, the maritime NORSOF community strives to keep pace with the challenging SOF environment through a number of mechanisms leveraging multiple training modalities and simulation capabilities. The intent of this presentation is to provide an overview of the NORNAVSOC training program and lessons learned through years of training SOF medics and "non-medics" and on operations.

The NORNAVSOC medical program starts with command support. Borrowed from the U.S. Army Rangers, NORNAVSOC is committed to Operator excellence in four key areas: marksmanship, physical training, small unit tactics, and medical training.1 Medical training is incorporated from early in the 1-year selection program and continues throughout the career. During the initial training phase, each Operator receives a total of 90 hours of medical skills training using multiple training modalities. This initial training is divided into three modules where skills obtained in intensive courses are put into practice during all other tactical training.

SOF medics, selected after Operator selection and basic education, attend multiple medical courses. Some courses are civilian provided, such as the Operational Emergency Medicine Course or Prehospital Trauma Life Support Course. Some medics attend the U.S. Army Special Operations Combat Medic Course at Fort Bragg, NC, U.S. From 2013 the main body of NORNAVSOC medics will get their initial training at the newly established Nordic NATO Special Operations Medic (N-NSOCM) education.

Once NORNAVSOC medics have completed their initial training, they participate in sustainment training and train NORNAVSOC Operators using a host of simulator modalities. NORNAVSOC medical training places high priority on the diversity of simulation experiences because, at present, all skills cannot be adequately trained and tested by one modality. Based on current literature from the OEF/OIF on potentially preventable deaths, a major focus is on initiatives to mitigate bleeding.[2–4] This includes an extensive RDCR protocol using freeze-dried plasma as primary resuscitation fluid together with tranexamic acid (TXA). The unit's medical leaders have initiated a 3-year research program focused on buddy transfusion and field blood-banking. The program is named Blood Far Forward (BFF); more information can be found on the Traumatic Hemostasis and Oxygenation Research network's webpage: rdcr.org.[5,6]

NORNAVSOC training also places strong emphasis on training the entire operational system through complex medical scenarios. In operations, the successful treatment of casualties is not a medical only operation. It requires the coordinated effort of the higher-level command and control element, communications, tactical evacuation platforms, team level leadership, medics, and Operators (Figure 6.3) All can have significant impact on patient care.

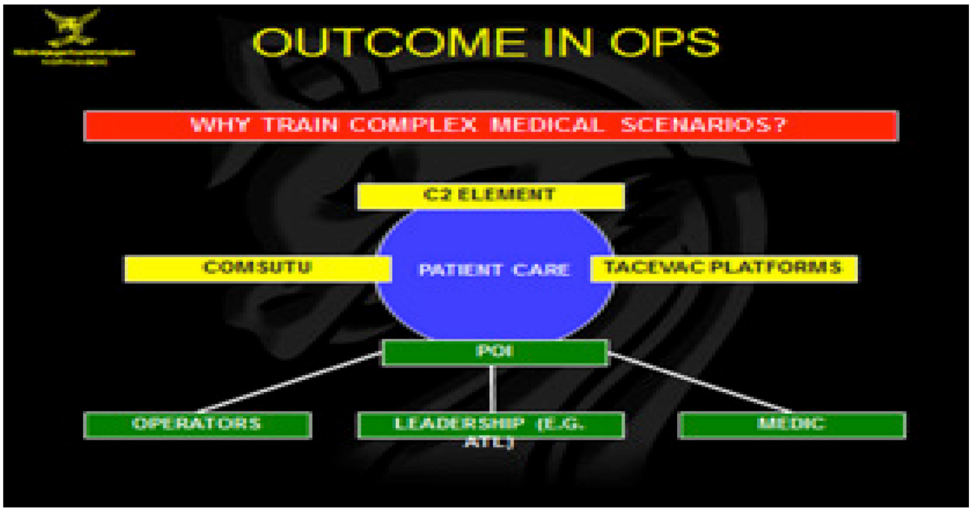

Figure 6.3: Operational Outcomes.

NORNAVSOC uses professional actors, live tissue, dead tissue, and manikins to simulate patients in the combat environment. Moulaged actors are used regularly providing realism, flexibility, emotional engagement, and patient interaction but still require instructor support to "play" vital signs. Actors provided by one company charge £250 per person/day plus plane airfare, housing, and food. NORNAVSOC has also established a pool of professional actors from the civilian emergency medicine services to act as dummy patients. They are recruited, contracted, security cleared, and trained by the unit. These actors, as medical professionals used to the prehospital environment, provide excellent acting, whereas clinical development and response to treatment is concerned.

NORNAVSOC requires live tissue training yearly for medics and every 2 years for non-medics, typically conducted outside Norway, though this type of training is now authorized in Norway. This training is indispensable for preparing and maintaining medic skills as there is no simulator on the market that can reliably reproduce the tactile responsiveness seen in LTT for certain surgical procedures and critical for building Operator self-confidence, both in their own skills and in the skills of their medics. Administrative challenges, however, make conducting this training to the frequency desired not possible. In Norway, if LTT is executed, the role models must be transferred through the entire evacuation chain, requiring significant coordination for patient transfer with other non-SOF entities such as Norwegian surgical teams. Medics cannot perform point-of-wounding care only. While this has benefits, such as testing the entire Norwegian patient care system; it puts severe limitations on the frequency with which LTT can be conducted at the medic level with adverse impacts to the sustainment of medic skills.

NORNAVSOC uses manikins sparingly for training primarily for CPR and AED training. The reasons for this include the assessment that most manikins do not communicate, do not move, can be expensive, and lack durability. The unrealistic nature of materials means they do not handle like a human and high-tech manikins require additional education before use. Lower-tech manikins require too much instructor focus during training and are frequently unrealistic. What is the optimal training solution for NATO SOF medic training? NORNAVSOC suggests that the optimal training solution includes a diversity of training mediums. Professional actors, augmented by technology that allows for vital signs assessment, can maximally stress the medic/Operator medical skills, tactical leader skills, and the casualty response system in complex tactical medical scenarios and may have a significant role in training prolonged field care scenarios. For LTT, the ideal situation for SOF medical training would include participation in national-level LTT training that can stress the entire system from point-of-wounding to higher level of care, but administrative barriers should be streamlined to allow more frequent point-of-wounding training to ensure medical skills are as sharply honed as possible. The simple reality is that if point-of-wounding care is not successful, because skills are insufficiently trained and maintained, it makes little difference how robust higher-level care is because you cannot treat "dead on arrival." Manikins will have a limited role in SOF medic training until the technology improves and highly realistic manikins become more affordable.

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6.7 The Nordic Special Operations Combat Medic and the Nordic Initiative

LTC (Dr.) Peter A Christensen (Denmark), LTC (Dr.) Kjell Boman (Sweden), COL (Dr.) Matti Lehesjoki (Finland), LT (Dr.) Tore Tveitstul (Norway)

In this challenging time of global asymmetric threats, coupled with dwindling economic resources, there is a now, more than ever, a requirement to increase cooperation between nations. As the NATO web page on Smart Defence states, "In these times of austerity, each euro, dollar or pound sterling counts. Smart Defence is a new way of thinking about generating the modern defense capabilities the Alliance needs for the coming decade and beyond. It is a renewed culture of cooperation that encourages Allies to cooperate in developing, acquiring and maintaining military capabilities to undertake the Alliance's essential core tasks agreed in the new NATO strategic concept. That means pooling and sharing capabilities, setting priorities and coordinating efforts better" (http://www.nato.int/cps/en/natolive/topics_84268.htm).

Recognizing Special Operations national and international roles in future conflicts, NATO created the NATO Special Operations Headquarters to improve interoperability and coordination across the Alliance and Partner Nation SOF community. A key element of NSHQ policy is to foster the enhancement of SOF enablers like communications, intelligence and medical support. NSHQ's NATO SOF Medicine Development Initiative (NSMDI) is a command-sponsored program designed to help nations build their SOF medical systems. In October 2010, the NSHQ initiated the concept of NATO SOF medic standardization at the NATO SOF Medical Research Symposium. Seventeen nations' SOF medical representatives participated in a 3-day working group to establish a consensus for the NATO SOF medic's minimum capability requirements. The working groups outcome was the validation of approximately 164 medical tasks that a NATO SOF medic must reliably be able to perform in order to sustain a casualty in an austere environment for 72 hours.

It was proposed that nations could create or compare their current SOF medic training programs to these 164 tasks, now internationally validated, as a measure of current interoperability. If so inclined, nations could build or modify current curriculum from these tasks that would raise SOF medic standards for most nations at the national level while moving toward interoperability at the NATO level. The nations of Denmark, Norway, Sweden, and Finland all participated in this conference.

At that time, the Nordic nations recognized the need for better interoperability with coalition forces. They also noticed that conventional defense forces medic educational standards were increasing, but SOF standards had not been keeping pace. There was political desire to improve national instructor capability and create a more cost effective program to train national SOF medics, as each Nordic nation only has two to four new medics per year to train. Realizing cultural similarities would enhance the ability to build quality joint training using traditional Nordic educational teaching principles, the idea was born that the four Nordic nations might be able to pool and share resources to train Nordic SOF medics. These medics would have improved skills and interoperability across the geographical area at a cost savings to each nation.

The Nordic nation's Special Operations medical elements selected representatives to serve on a research committee to explore the art of the possible. Careful review of current training programs identified that the Nordic countries already complied with many of the October 2010 NATO SOF Medic recommended training tasks, but in a fragmentary, cost-ineffective manner. It was felt that current Nordic SOF medics were not optimally combat ready when compared with these standards. Analysis also revealed a significant capability gap between U.S./U.K. medics and existing Nordic SOF medic standards and training that the nations wished to close. However, the committee acknowledged any solution proposed must be a shorter time commitment and be less expensive than the current training processes, which entailed sending medics to training through U.S. SOF medic training programs. Finally, the committee felt a better training program must be created as modern medic standards and treatments are increasingly complex.

The research committee conducted working group meetings in Denmark, Finland, and Norway as well as on

NSHQs Adobe Connect video collaboration platform to identify common needs and begin potential curriculum design. The Danish SOF Command (Army) issued a formal Letter of Intent to the Nordic SOF, on request from the Danish Medical Command, asking for interest in continuing the development.

The Nordic SOF senior medical officers continued, in parallel, to ascertain their national SOF and medical commands level of ambition and desires. It was decided to propose a Nordic SOCM training program that would pool all Nordic SOF medics for initial training. At the same time, the Nordic Defense Cooperation, NORDEFCO, was informally approached as a potential partner in the project. NORDEFCOs Human Resource and Education Subcommittee favorably recognized the projects potential benefit and have elevated its status to a “Common Course” idea for Scandinavia with the Nordic SOF working group as a subordinate “Task Group” within NORDEFCO.

At present planning stages, the Nordic SOCM course would be modular, with each country responsible for teaching specific modules within their own nation for all four nations’ medics (Figure 6.4). A common instructor pool from the Nordic countries would be created to support the training programs, sharing this burden amongst the nations. This also helps counterbalance the effect a nations operational tempo can have on instructor availability. A centralized Nordic training system enhances the possibilities for coordination with potential expert support within the Nordic nation’s civilian medical expertise pools or international SOF medical expertise, such as that provided by the NATO Special Operations Headquarters. To bring this to fruition and to maintain the program, a lead Nordic nation with secretary functions would be identified.

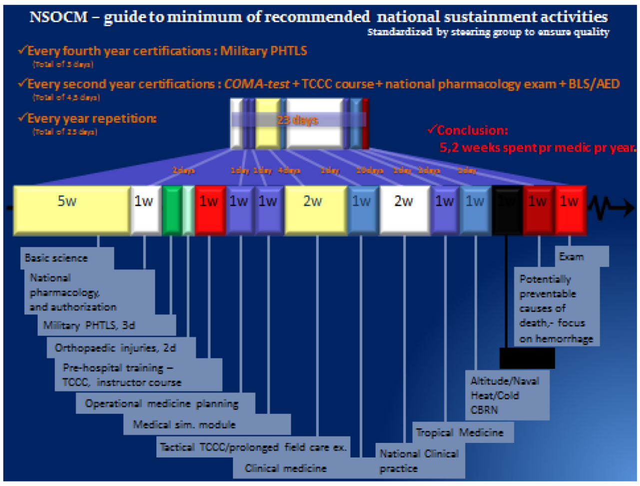

Figure 6.4: NSOCM Guide to Minimum of Recommended National Sustainment Activities.

In practice, the curriculum would cover all of the 164 tasks identified by the OCT 2010 NATO SOF research workshop as critical for NATO SOF medics to be interoperable and capable of sustaining casualties in austere environments for 72 hours. The curriculum would include Military Prehospital Trauma Life Support certification, which includes TCCC guidelines. The curriculum would also provide the baseline fund of knowledge to manage common sick call illnesses encountered on deployment, including the dispensation of medications as well as some wilderness medicine specific training like tropical medicine and other areas peculiar to the SOF environment.

To ensure Nordic SOF medics were qualified, the planning committee is considering a series of both written and practical examinations. Written examinations would be associated with the modules, but a final examination would be administered to NSOCMs called a Consensus of Medic Approval test. This test would cover the entire Nordic SOCM curriculum and serve as a gateway for “credentials” similar to that taken by physicians for board certification. A final practical examination would be part of this written examination that would be case based and may include various aspects of medical simulation and simulators. Developed in cooperation with the NSHQ medical branch, this two-part test model might serve as a model for other nations to demonstrate NATO SOF interoperability and the capability to meet NATO SOF standards.

Because medical skills are perishable, there is a requirement for sustainment of Nordic SOF medics. Under the current proposal, each Nordic country is responsible for its own sustainment courses. However, every 2 years NSOCMs would be required to take a recertification exam and demonstrate in a simulated clinical environment the skills required to maintain their favorable status as NSOCM.

While it is premature to predict the future success of the NSOCM Training Initiative, at present the future looks positive for a successful collaboration that will meet many of the challenges faced by smaller countries in NATO with a requirement to train their SOF medics. Educationally, the similar cultures can optimize the adult learning model increasing knowledge gain. Clinically, similar medical practices and culture provide a measure of continuity that can be capitalized upon to increase interoperability and limit friction from senior medical leadership. Economically, the shared cost between nations makes the per-student cost far more affordable for each individual nation. Finally, linking this initiative to NATO standards creates a bond that leverages the Alliance medical network ensuring Nordic SOF medics are both gaining from and contributing to the vast pool of growing medical research in operational medicine that will help keep the NSOCM training program at the cutting edge of SOF medicine.

The NSOCM initiative has the potential to tangibly demonstrate some of the key elements proposed by NATO's senior leadership at the recent Chicago Summit 2012. Article 11 of the Summit Declaration on Defence Capabilities: Toward NATO Forces 2020 states, "We will build on that success through the Connected Forces Initiative. We will expand education and training of our personnel, complementing in this way essential national efforts. We will enhance our exercises. We will link our networks together even more. We will strengthen the bonds between NATO Command Structure, the NATO Force Structure, and our national headquarters. We will also enhance cooperation among our SOF including through. We will strengthen the use of the NATO Response Force, so that it can play a greater role in enhancing the ability of Alliance forces to operate together and to contribute to our deterrence and defense posture. As much as possible, we will also step up our connections with Partners, so that when we wish to act together, we can." The NSOCM initiative, if successful, could serve as a model for other nations of similar cultural background, military requirements and political will to pool and share resources in as a tangible expression of Smart Defence.

6.8 White Paper on Current and Future Medical Simulation Technology

Thomas Doyle and Antonio Rita, CAE Healthcare

Introduction

Within healthcare, simulation technology uses virtual, live, and gaming constructs for training simulations. Simulation provides the tools necessary to train effective medics, nurses and physicians through real-life experiences and interventions. High-fidelity simulation has pioneered the simulation frontier with its advanced technology stemming from the Human Patient Simulator (HPS®) in the early 1990s. The HPS provides a physiological engine for training in anesthesia, respiratory and critical care and has been extended to today's high-fidelity mannequins and trauma patient simulators developed in part from lessons learned from recent conflicts. Industry's technology has paved the way with the help of both civilian and military expertise to provide medical simulation tools and training solutions fitting the requirements and increasing the needs of the medical community.

Medical simulation has come a long way in a relatively short time and all indications are that advances in medical simulation will continue at an even faster pace in the future. Today, simulation allows the military to train its medical forces to a much higher level – to prepare for the medical outcomes of war and conflict –

with the ultimate outcome of saving lives and minimizing life-altering trauma. Traumatic injuries on the battlefield, in field hospitals, and across all echelons of care can now be taught and practiced in the safety of simulation laboratories before soldiers are faced with real injuries under fire and in austere environments.

Medical Simulation Background

Medical simulation has been defined as a "technique – not a technology – to replace or amplify real experiences with guided experiences that evoke or replicate substantial aspects of the real world in a fully interactive manner."[1]

The first uses of medical simulation can be traced back to the early 1980s where anesthesiologists found that they could use this form of education to reduce accidents. The use of medical simulation technology has evolved rapidly since that time.

The first simulators were two-dimensional models that offered information in narrative and graphic formats and included some minimal replication of human anatomy. By the mid to late 1990s, several companies – including Medical Education Technologies, Inc. (now part of CAE Healthcare), Mentice, Laerdal, Simbionix, etc. – were developing computer-based medical simulators, with varying degrees of sophistication, that aided in the initial and ongoing training of healthcare professionals. Many U.S. academic institutions formed simulation groups such as the Center for Integration to Medicine and Innovative Technology (CIMIT) and Stanford University Medical Media and Information Technologies (SUMMIT) that continue to press the technology envelope. With the ongoing advances in computer and medical graphics, software design and hardware manufacture. Additionally, medical simulators have been refined to offer virtual, life-like replication of medical and surgical procedures.[2]

During the same time period, military organizations using simulation technology for combat training scenarios were instrumental in developing medical simulators and by using them in medic training. This process has been assisted by U.S. Department of Defense (DoD) funding allocations for medical simulation research and development.

Lesson Learned from the Military

The medical simulation industry has been working with the military services since the early 1990s with first high-fidelity mannequin to improve fidelity and refine functionality. This has given the medical simulation industry the ability to provide medical training equipment to fit the needs of personnel across all echelons of duty and care. The DoD's commitment to research and development has given better insight on medical training objectives of various Programs of Instruction (POI). Medical simulation companies have received many research and development contracts with the U.S. Army Research, Development, and Engineering Command (RDECOM), and the U.S. Army Medical Research and Materiel Command (MRMC), which created the Combat Trauma Patient Simulation (CTPS) program. Considerable knowledge and experience has been gained from being part of these programs such as the CTPS, which was a nine-year program funded by the U.S. government to leverage the science of simulation for military combat casualty care. Desirable patient simulator features developed for the CTPS program included: anatomically realistic mannequin features, a Distributed Interactive Simulation (DIS) for combat medicine with multiple nodes, hematology model-based replication, and realistic physiological responses for life saving procedures such as needle decompression, chest tube insertion and management, difficult airway management, and medical response to weapons of mass destruction. The advanced features created in the HPS were then transferred to the development of newer high-fidelity human patient simulators. This was the first attempt at simulator portability but the simulator was still tethered to hardware and electronics. The industry has brought its position in the military to a new level when it was selected to service and support the U.S. Army Medical Simulation Training Centers (MSTCs) with a requirement in 2005 to provide a fleet of high-fidelity combat medical simulators, which has led to standardization within the services worldwide to include 22 MSTCs currently that provide training to over 309,604[3] U.S. and Allied Forces today.

The medical simulation industry has learned a great deal from working with military personnel deployed around the world. One of the most recent endeavors, driven from lessons learned in Iraq, Kuwait and Afghanistan, has been to replicate battlefield wounds (such as gunshot wounds to the face and legs, compound factures, shrapnel wounds, and entry and exit bullet wounds) on a patient simulator. This allows soldiers to visualize and learn to treat the injuries they will see on the battlefield before they deploy, thereby improving their preparation and ability to respond.

The most recent impact from lessons learned from Afghanistan and Iraq is the simulation of surgical interventions to keep skills sharp for disaster situations worldwide. Today, we learn lessons on a daily basis. As a team writer who wrote the case studies in "War Surgery in Afghanistan and Iraq" has stated, "Refinement of medical-surgical practice is ongoing rather than gleaned decades after the conflict ends."[4]

In 2011, the Canadian Forces published *Tactical Combat Casualty Care in the Canadian Force: Lessons Learned from the Afghan War.*[5] Canadian Forces deployed in 2002 to Kandahar, Afghanistan – the first time Canada had deployed forces since the Korean War. Soldiers took with them the prehospital trauma training from the Canadian Forces known as TCCC. Based on feedback from the Canadian Forces, CAE Healthcare designed a simulator in 2003 called the Emergency Care Simulator (ECS), which provides sensor pressure points for tourniquet application and assessment.[6]

Current Simulation Capabilities

Medical simulators today provide accurate and useful simulation capabilities for all levels of care situations and range from task trainers to high-fidelity ruggedized field simulators that provide realistic battlefield injuries. Today simulators as well as standardized patients are used in hospitals, medical schools, universities, battlefield training sites, mission flights, and flagship medical centers. Moreover, the use of standardized patients (actors acting as real patients) in clinical programs and during military exercises has enhanced the simulation training experience of first responders, medics, nurses, and medical students, allowing them to practice and improve their clinical and conversational skills during actual patient encounters.

Situational awareness drives the development of innovative technology. The medical simulation industry, in particular, uses the useful and actionable requirements of medical situational awareness to further enhance technology to support various operational missions of the military worldwide. Situational awareness allows the medical simulation industry to design and develop high-fidelity patient simulators, educational software, and curriculum specifically tailored for various military programs of instruction.

Dr. Steven Dawson, an Interventional Radiologist from Massachusetts General Hospital, was the lead physician tasked with identifying enabling technologies for medical simulation for Center for Integration of Medicine and Innovative Technology (CIMIT). CIMIT originally set out to develop a chest trauma simulator for chest tube insertion. Dr. Dawson and his team identified the need for a simulator. In speaking with the combat medic instructors and their instructor trainers, it was determined that the existing simulators for teaching combat casualty care were far too labor intensive to set up, operate and reset, and break down, and they were not ruggedized for field training. What was needed was a simplified simulator that was computerized yet autonomous as the instructors required ease of use so they could focus on instructing, not running the simulator. The simulator also needed to be ruggedized and water resistant to stand the rigors of use in austere field training environments. Finally, the simulator had to be realistic and focus on combat casualty care. Out of those conversations came the Combat Medic Training System or COMETS.

In the early to mid-2000s, CIMIT presented the plan for COMETS and requested Department of Defense funding. A licensing agreement was signed between the parties and COMETS became Caesar™. After further research, development, testing, and contributions from military and civilian subject matter experts, CAE Healthcare launched its Caesar™ Trauma Patient Simulator at the 2011 International Meeting of Simulation in Healthcare (IMSH) Conference held in New Orleans.

Caesar is one of several simulators designed to be a point of injury simulator. CAE believes this system provides a realistic, ruggedized, and dependable tactical combat casualty care platform. It can provide automated verbal feedback to learner interventions, integrated physiologically based training in hemorrhage control, advanced airway management, thoracic trauma, and fluid resuscitation controlled by a wireless platform with reinforced infrastructure to improve durability with realistic tactical movement. Its design has been heavily influenced by customer demand, demonstrating the value of customer involvement in development.

Medical simulation is also expanding into areas such as ultrasound training; the use of portable ultrasound equipment for diagnostics has increased in civilian and military organizations including use by SOF medics in the field.[7] Ultrasound simulators and virtual trainers facilitate the achievement and maintenance of ultrasound competency.

Future of Medical Simulation

Caesar will continue to evolve to become a simulation platform capable of employment from the point-of-injury, through the continuum of care. CAE Healthcare envisions Caesar's evolution to include advanced airway management. Technology continues to evolve at an extremely rapid pace. With the advent of miniaturization and improvements in electronics, allow for less use of energy, which prolongs utilization in an untethered, wireless environment. Another promising advancement is incorporating emerging artificial intelligence into simulation. Imagine a human patient simulator that learns from questions and recognizes patterns and relationships, thus leading to more complex responses. Additionally as robotics become less expensive, human patient simulators may be enabled with facial expressions, which to increase realism in training.

If aviation simulation is an indicator of the future of medical simulation, it can be anticipated that medical simulation may play a role in the future for pre-licensure and ongoing competency validation. The Accreditation Council for Graduate Medical Education (ACGME) in 2011 began requiring of resident anesthesia programs one annual simulated clinical experience.[8] Moreover the American Society of Clinical Oncology has mandated simulation training for hematology/oncology fellowships.[9]

Conclusion

In a world of asymmetric threats and global awareness, there is an ever-increasing need for a coordinated effort to prepare healthcare professionals for the challenges ahead. We have learned throughout the history of medical simulation that these challenges have proven vital catalysts for change and innovation. The future of medical simulation technology in civilian and military applications will continue to evolve to provide medical professionals the pedagogy to support the collective experience of their day-to-day operations. With the continued help from military organizations and national security agencies, technology will evolve to incorporate these lessons and drive exponential increases in the level of performance of our medical professionals.

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Antonio Rita is a military clinical educator at CAE Healthcare. Tony has 26 years' experience as a United States Air Force independent duty medical technician. In this capacity, he served his country as a senior enlisted leader. As a medical provider, he cared for U.S. and coalition war fighters on two deployments to Iraq and earthquake victims in Haiti. As a military clinical educator, Tony utilizes his military experience and background in ground combat readiness instruction to improve the ability of CAE Healthcare customers to provide realistic and effective simulation.

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6.9 Pros and Cons of Live Animal Use in Training Combat Trauma Procedures

COL Annette Hildabrand, Office of the Surgeon General, USA

Unaided, medics provide care with limited resources in austere hostile stressful and isolated environments, without the capability of timely patient evacuation. The scope and standards of SOF medical missions are radically different from those found in a fixed, fully equipped and staffed hospital in peaceful America.

– 2008 SOF Medical Handbook, Introduction by COL Warner (Rocky) Farr.

Since ancient times, educators of the medical arts have turned to the animal model to unlock the secrets of human anatomy and physiology. From Vesalius' dissections to contemporary high schools, the live animal model continues to add depth to the learning experience. Since 1952, the U.S. Army Special Forces have used the live animal model for training combat trauma management. Over the years, the courses have been refined and augmented by a multitude of adjuncts that include cadavers, videos, moulage, task trainers, and full body manikins, but the live animal continues to be a critical component of SOF medic training.

The success of these training methods is reflected in the recent publication of casualty data from the 75th Ranger Regiment.[1] Over a 10-year period, the Regiment sustained over 400 casualties and 38 deaths. A thorough review of each death reveals that no Ranger died from a lack of emergency treatment. In each case, the deceased Soldier could not have been saved even if they were wounded at the entrance of a major trauma center. Ranger medics have achieved a 100% success rate in the face of daunting injuries. Their unparalleled success [survival rate] is directly attributable to a comprehensive training program of which the live animal model is a critical part.

Specific attributes of the live animal make it ideal for demonstrating anatomy, interactive physiology, biokinetics, and tissue reactivity. The model of choice for SOF medic training is the castrated male goat. Its size, ease of handling, relative lack of zoonotic disease, and availability make it the ideal model for training large numbers of medics. In some areas where Q-fever is endemic, the pig is used in place of the goat.

When training specific combat trauma interventions, such as life-threatening hemorrhage and amputation management, the live animal offers fidelity in hemostatic pressure, coagulability, size and shape of extremities, and immediate feedback on accuracy of tourniquet placement and pressure bandaging. The flow characteristics of blood and its smell, consistency, and coagulation cascade have not been replicated outside of the living being. Pulse and pressure vary with venous or arterial flow as well as with volume and hydration parameters of the patient. These mirror conditions found in a severely injured patient that may be hypovolemic as a result of shock. In managing a traumatic amputation, the animal model has the same bone, muscle, and ligament characteristics as the human patient. The tissue planes, skin turgor, and innervations provide immediate reaction to stimuli.

The skin of the goat allows the trainee to experience the tactile properties of cutting and suturing reactive tissue. The trainee experiences the ooze of capillaries, the subtle tension needed to approximate skin edges, and the dexterity needed to place sutures and tie knots. Veins and arteries can be palpated just below the skin, which allows for accurate venipuncture and catheter placement. Proper placement of a needle for venipuncture can be felt and visualized by the flash of blood that appears in the needle hub providing immediate feedback.

Accurately evaluating a patient’s condition and applying critical reasoning when vital signs change is a critical SOF medic skill. Repeated monitoring of vital signs in the living animal model allows for accurate assessment of heart rate, character and depth of respiration, perfusion, temperature, hydration status, and mentation. During the course of the combat trauma training, the animal’s vital signs will change with respect to their overall condition. This sharpens the medic’s reasoning skills and prompts them to adjust care according to changes in vital signs. The animal model provides the complexity of interacting physiological systems necessary to challenge the care provider when faced with a multisystem trauma.

The live animal model is also ideal for training airway interventions. Placement of a chest tube or needle thoracentesis requires that the trainee have familiarity with anatomy of the lung with respect to the ribs. The correct placement requires knowledge of underlying intercostal space, avoidance of major vessels and a pressure response to puncturing the pleura as well as recognizing the correct physiological response. These high-stakes procedures require the medic to recognize air flow sounds by auscultation as well as the concept of negative pressure needed for proper lung inflation. Ability to position a cricothyroidotomy accurately requires knowledge of surrounding anatomy specifically with respect to large vessels of the throat. The goat trachea has similar structure and tissue properties to the human patient.

Above are a few examples of life saving interventions for which the live animal is the optimum model. There are differences in anatomy, physiology and size that the trainers must take into account to ensure negative training does not occur. When using the live animal model for training purposes, the laws and policies protecting animals do apply. Animal use has become increasingly sensitive and controversial; thus, whenever possible, alternatives should be explored and integrated to give the trainee the ability to practice and perfect techniques before culminating in a live animal exercise. This ensures the least number and best use of the animal model.

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6.10 Amputee Role Models at Human Patient Simulators

John Pickup, Managing Director, Amputees for Action, Ltd.

There are many methods of simulation currently used for medical training, from computer software to sophisticated manikins that have a pulse, breathe and react to treatment through programming or remote control. These methods are often used in clinical and sterile conditions. Another simulation method is the use of "live casualties." In the past, the military used its own personnel as casualties during training. Although this gives medics live patients to work with, these patients frequently have poorly simulated injuries and are untrained in how to accurately portray the injuries they were supposed to reenact. Casualty and medic guidance delineating injury signs and symptoms were on a casualty card pinned to the casualty or strung around the neck. There was no effective "acting" and the emotional impact of managing a trauma injury was lost. Furthermore, this method required constant referral by the medic to an assessor/instructor for information pertaining to the injuries and casualty response to treatment. The spontaneity of competent and confident treatment was disrupted.

The use of static unsophisticated but inexpensive manikins in these exercises presents similar challenges to live untrained actors. Casualty cards must be attached to the mannequins detailing what is wrong with the patient. The artificial nature of the mannequin and unresponsiveness leads to medic behaviors that would not happen with a live person, from rough movement to missed vital drills because of mannequin limitations. The realism is nonexistent in these cases and the value of these as a training tool is limited.

In recent years, "intelligent" manikins have come into use and provide an excellent training tool in the right environment. They can be programmed to exhibit certain signs and symptoms that the medic can then treat, such as variable pulse rate and blood pressure, while allowing the medic to perform invasive procedures directly on the casualty. A limiting factor for this method of simulation is manikin battery life and durability. Charging batteries and manikin repairs can be difficult if the training exercise is in a remote area or the weather conditions are inhospitable to electronic machinery.

The use of actors/role players portraying live patients has increased the spontaneity of medical simulation and has worked very well in controlled hospital conditions. H.S. Barrows introduced the first standardized patient (SP), "Patty," a paraplegic woman with multiple sclerosis, in 1963. His definition of an SP is "a person who has been carefully coached to simulate an actual patient so accurately that the simulation cannot be detected by a skilled clinician."[1] Barrow's SP principles can be adopted and applied to battlefield trauma casualties in medical exercises. Properly trained, the live casualty can emotionally engage with the medic – and help put them in to the "zone" (i.e., believing they are in a different place and not in a controlled, contrived environment). Standardized patients also allow for a continuation of care and some reproducibility between different medics during skills evaluation. Realism is especially important in simulated medical training so participants are better prepared to deal with the situations that they will actually face in the future. Kneebone et al.[2] noted that using actors in simulation trains skills in patient–provider communication and professionalism that other simulator modalities do not.

Since 2005, Amputees in Action has provided trained amputee actors for military and emergency services globally to be used in casualty simulation exercises to provide the realism needed to test and train medical staff. These actors are a unique class of disabled individuals. Many have experienced the injuries that they now portray providing credibility in presentation. Many of the actors benefit as well, believing they are providing a valuable service that is helping others to save the lives of those who suffer traumatic incidents.

The actors are drawn from a variety of backgrounds including those who have served with the military and have lost limbs as a consequence of their service.

The actors can perform in sterile classroom environments, but are best inserted in to exercises where the scenes/scenarios often depict real medical situations, replicating actual injuries sustained, resolving errors made from real experiences. In order to do this, the following is prepared:

- Special effects applied to depict the injuries sustained relevant to the environment of the incident;
- Scene set - the environment the incident has occurred in, props used;
- Script - injuries and their symptoms, responding to correct and incorrect medical procedures, understand the background for the setting.

Realistic Injuries/Special Effects

The use of special-effects makeup is imperative in helping to complete the illusion that (although it is an exercise) it is seen as a real situation. Expert moulage, in addition to the actor shouting, screaming, crying, etc., adds realism that increases the participant’s emotional response testing their skills more fully. They need to thoroughly check the actor during the preliminary survey to ensure nothing is missed, something that presents a challenge as the casualty is able to move around the scene/roll around the floor. Current injury patterns, relevant to current conflicts and armory used, can be applied to the actor efficiently and accurately. The injuries can be replicated from actual photographic imagery or through researching and resourcing from the plethora of imagery available in libraries or the World Wide Web. The materials used are manufactured for the film and theatrical industry, which have stringent controls as they are for human use/consumption, so are safe to use. By adapting the materials and techniques for the film and theatre, they become bespoke for the needs of simulation and are lifelike and durable, withstanding numerous applications of treatment (i.e., tourniquet and field dressings).

Although trained casualties can be used in many situations, they do have their limitations. The first, and probably most obvious of these, is that it is not practical or desirable to perform invasive procedures on actors. In order for skills to be tested thoroughly, medics need to be able to practice venipuncture, chest decompression, airway insertion, etc. Through the research and development of special effects prosthetics, new ideas are being developed by Amputees in Action, Ltd. which will allow more of these invasive procedures to be performed on live patients without loss of realism while still maintaining relevance. One such prosthetic developed includes a device that allows cannulation without actually inserting a needle in to the persons arm.

Wounds can also be created on customer demand to address real life shortfalls. For example, a wound has recently been developed allowing packing with hemostatic bandages in response to a medical training wing request after a real situation where a secondary check missed an injury to the buttock. The casualty had traumatic injuries to legs and groin, requiring tourniquets and dressing. By stemming the blood loss from these injuries, the blood stem was redirected to the buttock injury and out of the body. Due to this oversight, the casualty was nearly lost.

Another such development of Amputees in Action, Ltd. is a prosthetic named the “Crike,” which is fitted over the throat of the live casualty, allowing medics to perform a cricothyroidotomy through locating the landmarks around the neck, cutting into the prosthetic and then inserting the endotracheal tube allowing the casualty to breathe once again. This is quite a challenge for most medics who never get the opportunity to practice such a procedure on a live patient. The closest that they might come to this is via live tissue training.

Environment/Scene

The actors trained by Amputees in Action are able to work in all conditions anywhere in the world and have the flexibility to work on land, sea, and air. In recent years they have been used in extreme climates such as deserts (+45°C) and north of the Arctic Circle (–20°C). This gives the exercise planners many more options when it comes to planning these types of medical scenario and allows them to test medical staff in different situations and environments.

Acting

Amputees in Action, Ltd. has developed its own training program for the amputee actors on how to reenact the role of a casualty with traumatic injuries and how to respond to the treatments given by the medics. This greatly adds to the realism of the exercise, allowing the medic to focus his efforts entirely on the patient without the need to continually refer to directing staff for information. This allows the medic to apply more skills that can be verified for competency.

Quality health care is greatly increased by communication with patients. Therefore, it is optimal wherever possible to enable direct communication between medical providers and their casualty throughout the incident. This two-way communication helps the medic to (1) treat the patient and (2) continually assess the patient (levels of consciousness, etc.) and, finally, able to reassure the casualty as to what is happening. This is vital in casualty treatment and a skill that must be practiced just as much as some of the actual treatments themselves.

The use of live, trained actors presents a realistic challenge in other areas such as triage of multiple patients. People are much more difficult to deal with and are able to cajole, demand and question the clinical judgment of candidates, a likely scenario in a mass casualty incident. Distracting techniques can be deployed to further test the medic.

Simulated Exercises

The simulated exercise enables the replication of real scenarios and injuries sustained in an incident, working in "real time," moving through the casualty care system. There are many considerations for a medic to factor in to a short space of time that will prove their competency and give the medic confidence in any situation they encounter, by applying the skills learned. It can measure:

- Patient/Casualty Care - Was the casualty attended to quickly, kept safe (care under fire), warm, transported (carried) correctly and communicated with?
- Procedures:
  - Speed/accuracy payoff - follow procedures prioritizing treatment in accordance with the procedures;
  - Secondary injuries - ensure the patient is checked as more patients are lost through these being overlooked as primary, acute injuries take precedence;
  - Medical intervention - practice when and how this is used with tools available;
- The application of tourniquets, field dressings, pain control, hemostatic bandaging, pelvic splints, cricothyroidotomy, and cannulation;
- Triage - Prioritizing, delegation and responsibility within a team, working on protocols, strengths, and weaknesses;
- Communications - Passing on the correct information to the next phase of the Casualty Care System - ATMIST/MISTAT;
- Evacuation process and equipment, the use of stretchers, ponchos, helicopters, and ambulances;
- Identifying and understanding errors made - As the simulation is executed in 'real time' a complete debrief can be given to the medic of good points and bad. Live casualties, in scenarios, are well placed to provide feedback post scenario.

This perspective can be invaluable when reviewing the performance of individual candidates, teams and standard operating procedures that may require adjustment as a result of identifiable failures.

The Way Forward – Standardized Patient

Amputees in Action places a high priority on actor training for casualty simulation exercises. We recommend that those seeking this type of support from companies should review the companies training practices as this is tied not only to realism but also standardization, accuracy, and validation. We feel an effort should be made toward standardization of training using live casualties. This is an important issue for many reasons:

- It is potentially dangerous to use someone who is not trained to be working on a military training area;
- A medic receiving TCCC training using live casualties in the United Kingdom should expect the same level of skill and expertise from the casualty as someone would find who was training in the same type of exercise in Norway;
- Any training should closely follow the courses that are already being taught such as TCCC.

We feel it is important that any standardized training with live casualties is rolled out NATO-wide and should follow closely the medical courses that are currently taught within the military (TCCC, TACCCT, PHTLS, etc.). This will ensure that everyone can expect the same high standard of actor/special effect, ensuring the training has that important element of realism and relevance, so that its medics can get the most from the experience.

Acting is obviously an important skill that the live casualty should have and be able to develop further. It's no good having an actor on an exercise that is unable to remain in character for long periods of time. This is especially important when it comes to some of the longer exercises which might start at the incident, move on to the transportation of the casualty and then through the hospital system (role 1 through to role 3). This ability and skill has to be trained along with everything else and again all feeds in to the reality of the exercise.

The training of live casualties should not, however, only look at the medical side of what they do. The health and safety aspects of the job that they perform are just as important. Casualties should be familiar with weapons and weapon safety, aircraft safety (including dunk tank training), basic tactics especially when looking at care under fire situations, and finally having some basic sea survival knowledge/training. Without this knowledge, it would be dangerous to allow any actor (no matter how well trained on the medical side) on to the exercise ground.

Box 1. Advantages of using SPs

Available anytime, any place
Comparable with real patients (valid)
Faculty can control the learning objectives
Faculty can integrate psychosocial issues into a case
Learners can receive immediate and constructive feedback
Learners can practice invasive examinations (pelvic or breast examinations)
Learners can rehearse clinical situations they are not ready to manage alone
Learners performance can be compared
Limits inconvenience, discomfort, or potential harm to real patients
Provides a longitudinal experience in a compressed time frame
Portrayals are standardized and reproducible (reliable)
Reduces time demands on physician teaching faculty
Safe environment minimizes learners anxiety

Figure 6.5: Advantages of Using SPs. (Box 1).

The use of trained actors in medical simulation is an important facet of today's training capabilities. Cantrell and Deloney list some of the advantages they identified when incorporating standardized patients into physician training, many of which are applicable to NSOCM training (Figure 6.5 [Box 1]). There are also disadvantages to the use of this asset, but whatever the simulator modality, when considering optimal training, one must start with the curriculum and desired end states, and then introduce simulators that will most cost effectively and operationally meet those objectives.

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6.11 Modern Human Factors–Based Simulation Concepts for Medical Team Training and Double-Loop Learning

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70% of errors are due to human factors.

It is a well-accepted fact that up to 70% of errors in medicine are *not* due to a lack of medical knowledge or skills, but due to problems in translating the medical knowledge and skills into meaningful team activity in the not ideal world of medical emergency care. Human factors are the main reason for not applying existing knowledge and skills in the real patient care under normal peaceful conditions. How much more will these factors then apply for TCCC conditions?

Unfortunately, most current combat medical training does not deal with human factors or human error countermeasures (like CRM, etc.; see Figure 6.6 [Box 2]). It is high time to include these topics in training (and therefore the train-the-trainer concepts such as CRM training as performed in Veterans Affairs hospitals based on the approach of David Gaba or TeamSTEPPS, etc.).

In order to achieve that goal, instructors need to be trained in human factors and CRM and how to apply this knowledge in observing teams and to debrief (facilitate learning) in an adult learning style.

Box .2. The 15 Principles of Crisis Resource Management (CRM)

1. Know your work environment.
2. Anticipate and plan ahead.
3. Ask for help early rather than too late.
4. Either assume leadership or always be a good team member.
5. Distribute the work-load (10-for-10).
6. Use all available resources (personnel and equipment).
7. Communicate confidently and effectively – say what you are thinking.
8. Be aware of and use all available information.
9. Prevent and recognize fixation errors.
10. Be uncertain and always double check – never assume anything.
11. Use memory aids and check them.
12. Keep re-evaluating the situation (employ the 10-for-10 principle).
13. Ensure good team work – help your colleagues and coordinate your work with theirs.
14. Keep your attention consciously focused.
15. Be dynamic when setting priorities.

Adapted from Rall and Gaba in Miller's Anesthesia 2009.[1]

Figure 6.6: The 15 Principles of Crisis Resource Management (CRM). (Box 2).

Superficial (Phenotype) Learning or Deep Systematic (Genotype) Learning

Modern simulation training concepts should focus on human factors and CRM associated learning topics. Instructors should focus on a deep and systematic analysis of "why" things went wrong and not so much on "who" made errors. Finding out why things happened is the key to "golden learning nuggets." Only when we find out exactly why things were not done as would have been expected (root causes), can we look for powerful and reliable solutions to guarantee better performance in the future.

To learn why things went wrong is called "double-loop learning" (Figure 6.7). It is much more effective and long lasting than traditional single-loop learning, which focuses on telling participants "what" they did and "what they should have done differently." Single-loop learning is like painting a piece of rusted metal with new paint. It covers the problem rather than addressing the root causes. The new double-loop learning approach removes the rust, builds up the structure again, and then paints anew.

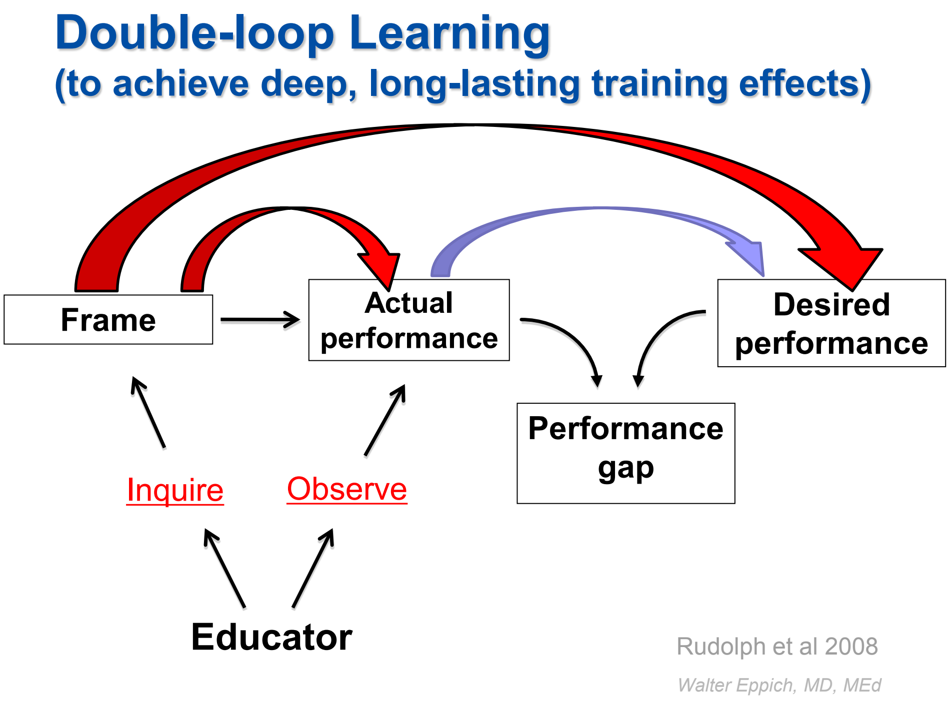

Figure 6.7: Double-loop Learning.

What Are the Underlying Error-Provoking Factors under Real World TCCC Conditions?

In my opinion, much is known about the kind of injuries that occur during combat operations, what went wrong with treatment, and what should have been done (performance gaps). I feel that there is a lack of understanding of the root causes that lead to observed performance gaps. As previously stated, many causes of errors are due to human factors. So in order to better target our training efforts (with or without simulators, actors, or animals), we should try to analyze more deeply the human factors in combat medical treatment that lead to poor treatment performance such as the failure to apply tourniquets or why a conscious patient is not transported in a "sit up lean forward" position with a partially occluded airway from facial injury. Did the team not know that this is the right thing to do or did they know but deviated for some (good) reasons? Did they want to do it, but could not achieve the desired goal? If so, why not? Only if we know the root causes of battlefield treatment failure can we target our most advanced trainers and training facilities to develop training programs to counteract the problems. Thus, root cause analysis must complement curriculum development before one considers the simulator or simulation required to teach better performance.

Relevant Simulation Team Training Is Ideal for Human Factor Teaching

Simulation is a very effective educational tool for patient safety*(BEME, Flanagan).[2-3] From an educational point of view, it must be pointed out that it is of utmost important that instructors running simulation are trained in facilitating CRM-oriented debriefings in order to maximize training sessions. The debriefing as described in aviation and introduced and refined for medicine by Gaba et al. requires a completely new instructor attitude regarding their role in learning.[4] The teaching and learning philosophy in CRM-based simulation course debriefing is very different from the traditional clinical teaching style. Many classical teaching sessions focus on the instructor telling participants what is right and wrong and how they should do things differently. The instructor in a debriefing focuses primarily on eliciting self-reflection among the professional adult learners (participants).

Facilitation is a new way of teaching and must often be learned de-novo by instructors, even though they have many years of traditional teaching experience. The use of video for debriefing requires additional expertise to integrate it successfully with self-reflection. Therefore, it is recommended that faculty intending to use modern simulation training concepts receive special training and practice in this teaching method. Several simulation centers conduct instructor training that emphasizes these debriefing skills. The biggest and most difficult task for traditional medical teachers is to learn to stop "instructing" and start "facilitating" – guiding participants towards a deep learning experience.

A recent BEME review by Issenberg et al. concluded that high-fidelity medical simulations are educationally effective, but only if the right conditions are met, which are:

- Educational feedback is provided;
- Repetitive practice is used or is allowed;
- Simulation is integrated sensibly into the standard curriculum;
- The range of task difficulty can be adapted to the level of the learner.[2]

Flanagan et al. provide a very thorough review of the literature, which is available online (http://www.health.vic.gov.au/workforce/research.htm) to date on the efficacy and effectiveness of simulation based training for learning and assessment. The conclusion was that "simulation makes a valuable contribution to learning for students, trainees, and clinicians. It enables learning of both routine and non-routine procedures and management of patients."[3]

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6.12 Framework for Understanding Medical Simulation and Simulators in Healthcare: Ensuring Learning and Measuring Effectiveness

Robert M. Sweet, MD, FACS, Associate Professor Urologic Surgery, General Surgery, Principal Investigator, UMN CCTC Consortium, Director of Medical School Simulation Programs, University of Minnesota

Understanding medical simulation and the use of simulators in healthcare professional education involves ensuring learning and measuring effectiveness. The backbone of the use of simulation in medical education is a methodical approach to curricular design and validation involving task deconstruction and the development of adequate assessment tools. The approach seeks to provide evidence that the training curriculum successfully trains *what* it is supposed to train *to whom* it was designed to train. However, the actual design of a simulator/instrument/program being built would ideally be guided by the outcomes of this approach.

The first step in designing simulation curriculum is to define the desired outcome/intent and establish a roadmap to achieve the outcome. What questions need to be satisfied to achieve this? Safety, efficiency, and proficiency metrics need to be defined. Task deconstruction examining the relative cognitive, psychomotor, communication, and environmental influences on performance are an effective way to aid in curriculum development and the choice in the training task, condition, standard, models, and means of assessment.

When designing the curriculum one should collect representative examples for each subtask ahead of time. Verification studies of simulation models and evaluation tools should be undertaken that define the objective criteria for procedural evaluation. Care should be taken to establish conformity and interrater reliability for assessment. Studies are also needed to verify models as they are developed. Finally, transition the group from "What I do" to "What is safe" and integrate simulation for high stakes assessment. Such assessment must take a system-based approach as almost impossible to assess the impact of simulation/education.

The Holy Grail in assessing the impact of training programs is improved patient outcomes. This can be done; in an AHRQ study titled "In Situ Simulation to Detect and Prevent Near Misses during Critical Events," we looked at the effect of simulation training on perinatal morbidity and mortality in three medium-sized hospitals with three randomized interventions – no intervention (control), curriculum with didactics (TEAM STEPPS) only, and didactics plus in-situ team-based simulation to criterion.

The study's results (Figure 6.8) show that only the hospital with in-situ simulation that "put into practice" the concepts of TEAM STEPPS improved patient outcomes with a sustainable 37% drop in perinatal morbidity and mortality. In military medicine as in civilian medicine, it is important to train the healthcare team. When one considers NATO SOF medic interoperability, it is highly unlikely that NATO SOF medics will train together in a common setting. Therefore, to achieve interoperability, the training approach must entail a common curriculum and the training systems must be set up to be able to be measurable by a standardized assessment tool in order to demonstrate impact on outcomes.

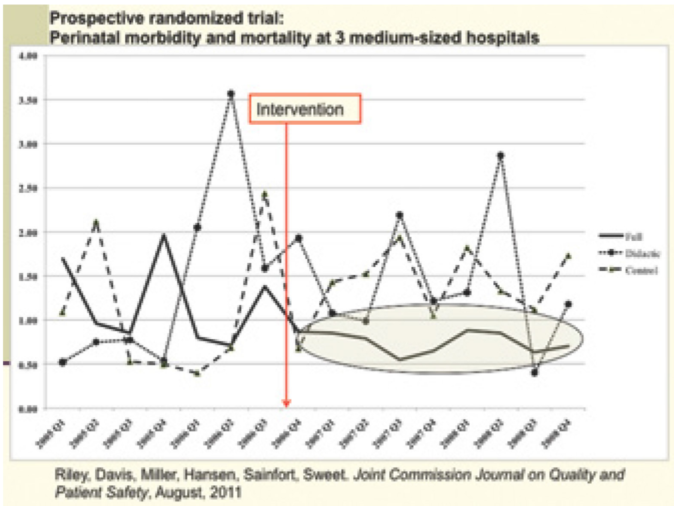

Figure 6.8: The Study's Results.

The University of Minnesota MedSim Combat Casualty Training Consortium (CCTC) study of simulation and live tissue training for combat medics is an example of the use of a simulation framework in healthcare. Current U.S. basic medic training is very good, but there is still preventable morbidity and mortality in the areas of emergency airway and traumatic hemorrhage management. Joint forces have an interest in looking for improved technologies to enhance training and replace live animals where possible. Recent studies suggest no significant objective differences in training with simulation models. There is a lack of a thorough understanding of the human factors contributing to success or failure for skills related to hemorrhage control and airway management. Verification of existing simulation systems' (including animal models) ability to replicate the behavior and anatomic variation of relevant live human tissue behavior is lacking.

The MedSim CCTC study is important to:

- *Reduce* preventable deaths on the battlefield due to poor hemorrhage control and airway management;
- *Optimize* the curriculum and use of live tissue training for first-responder medics using a methodical series of studies, capped by a large controlled experimental study;
- Has the potential to confirm/improve best training models available to programs;
- Gap analysis toward the development of superior training tools.

Our study is using the framework for curricular development to provide an assessment tool validated across the different "levels" of combat medic skill and experience as well as a clear understanding of which teaching modalities are best for each element of the curriculum and a roadmap for the development of new teaching tools (non-live tissue trainers [NLTT]). A multi-institutional face and content validity study has provided great insight into the usefulness and applicability of all currently NLTT modalities for airway and hemorrhage control skills as represented in U.S. Brigade Combat Team Trauma Training. NLTT models with superior comparative validity, and considering cost and usability factors have been assembled together into a "Frankenstein" simulator. We are preparing to launch a sophisticated large prospective comparative study focused on comparing Frankenstein and live tissue modalities as both training and assessment tools at AMEDD center and schools in November 2012.

Application to NATO SOF: While the constituents of NATO SOF represent a heterogeneous group and a diverse set of programs with variable access and ability to employ simulation and/or live tissue training resources, the overall mission of saving preventable deaths in the battlefield remains the common thread. One solution I propose is to create a common basic medic curriculum, like a trunk of a tree, which all members agree to use as a method of initial standardization. Such training and assessment should be based on the TCCC curriculum and could be conducted in partnership with nations at the NATO SOF Allied Center for Medical Education, structurally modeled after the US Medical Simulation Training Center (MSTC) concept. Such a facility could also assist a nation in developing their capability to provide more advanced, specialized training as desired by the nation. Thus, NATO SOF medics would have the same trunk, providing interoperability, but still be able to have the individuality of branches, defined by national desires and requirements.

6.13 Building NATO SOF Medical Simulation Capability: The NATO SOF Allied Center for Medical Education (ACME) and PEO STRI Partnership

LTC Wilson Ariza, Program Executive Office for Simulation and Training Integration, and LTC (Dr.) Daniel Irizarry, NATO Special Operations Headquarters Medical Advisor

NATO SOF elements will require realistic quality medical training as long as they continue to go in harm's way. Conducting realistic medical training can be challenging because of national legal limitations, budgetary considerations, commanders' and surgeon generals' emphasis, time constraints, and limited doctrine. Individual national resources, limitations, and constraints can lead to different training methods and training objectives that create barriers to Alliance SOF interoperability. For this reason, it is important to establish NATO SOF medical standards and assist nations in adapting national training objectives and gaining access to necessary training tools to reach these standards.

Historically, medical skills, particularly trauma skills, have been taught through lectures and participation in direct patient care, but the role of medical simulation in emergency medicine training and validation is increasing.[1] Recent meta-analysis of the literature suggests that simulation based medical education with deliberate practice is in fact better than the traditional Halesedian “see one, do one, teach one” approach for clinical skills acquisition.[2]

A challenge in teaching combat trauma management, particularly in Europe, is the lack of similar injury patterns in civilian hospitals.[3] This has created a demand for realistic military trauma simulators and simulation that will only increase for NATO as current operations transition to less combat oriented engagements. Medical simulation requirements will increase as nations shift their operational commitments from battlefields like Afghanistan, where many nations are getting their best combat medical experiences, to less volatile theatres or to home station training.

For SOF, it will be critically important, as operational focus shifts, to maintain the hard earned training edge honed by the battlefield with realistic simulated training. A question facing NATO and nations will be how to meet future combat medical simulation needs in a cost-effective manner, with adequate quality and quantity to ensure student proficiency. Secondarily, how will nations keep pace with the rapidly changing world of medical simulation to make prudent investments in maintaining and upgrading simulation capabilities?

Some nations have already established military medical simulation centers to meet their combat medical training needs.[4,5] The United States operates 23 Medical Simulation Training Centers (MSTCs), discussed later in this article, manned by simulationists and equipped with the latest combat medical simulation technology.[6] The United Kingdom operates a simulation center recreating its field hospitals to train hospital staffs prior to deployment.[7] However, many nations have not considered how to most effectively address their combat medical simulation requirements. For these nations, a simulation capability investment decision is at hand.

National combat medical simulation centers have significant benefits. They allow national standardization of curriculum, tailoring it to authorized scope of practice while reinforcing national standards and improving internal interoperability. They provide a consistent training platform that realistically and reliably produces a training environment designed to enhance the chances of meeting training objectives. Properly manned and equipped, they can maximize training benefit by focusing simulation expertise and streamlining logistical training support requirements allowing troops and students to focus on training. Sharing these assets across services and specialties can cut costs and maximize utilization. Finally, they can be used to test techniques, tactics and procedures before implementation across a wider force formation.

There are significant detractors to building national combat simulation capability. Building adequate infrastructure, procuring simulators, and manning them with trained personnel can be expensive. NATO SOF Headquarters market research found that high-fidelity combat trauma simulator costs vary, but it is not uncommon to spend $50K (USD) for one simulator. All too often, units purchase simulators with no clear plan or curriculum for how they will be incorporated into training resulting in disuse. This is particularly true for complicated, and frequently expensive, simulators that require trained personnel to operate and maintain them. In addition to the initial investment, nations must also consider the long-term maintenance costs of simulation facilities and equipment.

Looking at the larger Alliance SOF picture, individual national simulation initiatives, without unifying leadership or guidelines, can run counter to improving Alliance SOF medical interoperability and be fiscally wasteful. For example, if nation A invests in a computer modulated high fidelity simulator with physiologic responses to train and validate its SOF medics, but nation B choses a partial task trainer with minimal realism and no physiologic response, can the two nations SOF medics be considered equally skilled and interoperable? From a financial perspective, if both nations had pooled with other nations to procure the same simulators, they would have increased both interoperability and enjoyed cost savings through bulk purchasing.

Establishing standardized simulation protocols could be very helpful in determining compliance with NATO standards and validating interoperability. An example of this can be found in recent studies comparing medical simulator use in Advanced Trauma Life Support Program surgical skills stations.8 As individual nations procure simulators, it could be helpful to have a NATO center of expertise that would help nations individually decide what simulators best meet its national requirements while maximizing Alliance interoperability. The same center could guide bulk procurement of similar products across the Alliance for cost savings.

With this in mind, the NATO SOF Headquarters (NSHQ) has committed to building the NATO SOF Allied Center for Medical Education (ACME) in partnership with the U.S. Army Program Executive Office for Simulation Training and Research Integration (PEO STRI). The ACME will serve Allied SOF, and through SOF, the Alliance, by providing market research, advice and facilitate procurement of national combat medical simulation capability while assist SOF elements in integrating this technology into the unique SOF training environment.

The NSHQ-PEOSTRI partnership leverages PEO STRI Medical Simulation program management office's (MEDSIM PMO) unique experience in medical instruction, program management and acquisition services by capitalizing on its expertise and buying power gained by supporting 23 similar U.S. training centers. The MedSim office is helping NSHQ establish equipment and technology requirements to support ACME's simulation-based medical education programs and the larger NATO SOF Medicine Development Initiative (NSMDI). It is also managing procurement and fielding of this equipment to the center in SHAPE, Belgium. Dr. James T. Blake, the program executive officer for PEO STRI, sees a tremendous benefit in the contracting and programmatic expertise that his organization is providing to support NSHQ and NATO: "The same level of medical simulation expertise that U.S. combat medics and combat lifesavers receive will be shared to train NATO medical personnel and vice versa. It's really a good news story for the future for the U.S. and our NATO partners."

Headquartered in Orlando, Florida, U.S. PEO STRI executes an annual budget of nearly $3 billion (USD) providing interoperable training and testing solutions, program management and life-cycle support for the Army's most advanced training systems around the world. PEO STRI is dedicated to putting the power of simulation into the hands of U.S. and, now, Alliance forces.

The Army's Medical Simulation Program Management Office, a core component of PEO STRI's portfolio, provides unprecedented medical training in the U.S. Army with a standardized training platform using classroom and simulated battlefield conditions. The MedSim program, as it is called, has helped saved lives by implementing MSTCs, facilities that train servicemembers, medical professionals, and combatant commanders engaged in combat operations.

The MEDSIM PMO deployed the first MSTCs for contingency operations in 2005 to support Operation Iraqi Freedom, and since then has continued to combine tactical skills and technology to lead the way to an integrated training platform by deploying the most comprehensive training and educational medical system available today. The MedSim staff has fielded 23 MSTCs across the U.S. and abroad, with plans for up to 34 fixed site locations and several mobile facilities. To date, the MedSim Office has trained more than 500,000 U.S. servicemembers, providing medical units with advanced knowledge to assist the war-fighter in accomplishing difficult missions under extraordinary circumstances.

In an MSTC, varying degrees of combat chaos may be added to scenarios to increase stress levels adding to the MSTC capabilities as a powerful individual trainer and a team-building tool for medical soldiers. Using a combination of lessons learned from current military operations and friendly engagement, MSTCs simulate battlefield stressors to test a student's ability to perform trauma management tasks under realistic conditions. The ACME will have similar simulation capabilities using indoor simulation environments within the facility and outdoor facilities at a nearby Military Operations and Urban Terrain (MOUT) site in Chievres, Belgium.

The arguments for the value of combat medical simulation are anecdotal at present, but studies are being conducted to validate these concepts. Intuitively, successful medical care frequently depends upon a medical provider's knowledge and skill-sets and their ability to make accurate assessments and prioritize interventions under stress. MSTC experience suggests that medical simulation saves lives because the MSTC ensures each Soldier is trained in Tactical Combat Casualty Care concepts and evaluated by the best instructors available to ensure proficiency in combat lifesaver skills and Tactical Combat Casualty Care skills. U.S. Defense Health Board Memorandum entitled "Tactical Combat Casualty Care and Minimizing Preventable Fatalities in Combat," dated 6 August 2009 states the "incidences of potentially preventable deaths among U.S. combat casualties in Iraq and Afghanistan may be as high as twenty percent." The Defense Health Board memorandum further states that the widespread availability of tactical combat casualty care has resulted in "an estimated 1,000 battle-injured lives saved in the current conflict."[9] MSTCs, as a source for quality TCCC training, have undeniably contributed to the widespread availability of these concepts on the battlefield. The NATO SOF ACME will have serve as an Alliance information hub for TCCC, helping Alliance partners achieve the same results.

A unique characteristic of the PEO STRI MedSim Office is its involvement in the research and development of emerging technology in key medical competency areas, including communication, teamwork, emergent conditions, leadership, and tasks requiring well-practiced manual skills such as diagnostic and treatment procedures. MedSim must deliver systems capable of training medical tasks to joint, multicomponent, interdepartmental, and coalition partner organizations. It provides the medical Soldier with standardized training, and unit-specific modules may be added based on the contemporary training environment. As such, MED SIM stays abreast of changing industry capabilities and a wide range of customer requirements matching the right industry products with the right customers where possible and encouraging new developments in industry for emerging customer needs. For NATO SOF, the ACME can serve as a similar clearinghouse for matching training requirements to industry capability that will be enhanced by a continued partnership with PEO STRI.

The MedSim program office works in collaboration with the U.S. Army Medical Command as it develops future plans to expand simulations beyond the battlefield and into all levels of care. These simulation and training aids will specifically focus on the skills that nurses and physicians must master during patient evacuation to definitive treatment. NATO forces face the same problems in this complex area of treatment and training. As the NATO SOF Air Wing Concept develops, the ACME will be able to assist nations in improving their evacuation training capabilities as well. Linked with MedSim program initiatives, the ACME will be postured as a conduit for emerging training technology in evacuation healthcare.

A significant contributor to MedSim success is its partnerships with civilian simulation leaders based in Central Florida. MedSim works closely with leaders from Lake Nona's Medical City, one of the fastest-growing, most innovative projects in Orlando, encompassing 650 acres. Lake Nona Medical City represents a deliberate strategy to create a centralized focus of sophisticated medical treatment, research and education in Central Florida thereby expediting innovation through facilitated collaboration.[10] The Medical City collaborative pool includes Nemours Children's Hospital, M.D. Anderson Orlando's Cancer Research Institute, Orlando VA Medical Center, University of Central Florida's College of Medicine and Health Sciences campus, Burnham Institute for Medical Research's east coast campus, and a University of Florida research facility. MedSim's collaboration with civilian innovators is a model for the potential role ACME will play in collaborative efforts with European civilian medical institutions and simulation centers.

In the 21st century, the future of medical training is tied to medical simulation. However, combat medical training will be even more reliant on simulation than its civilian counterparts because of the relative scarcity of combat trauma and the significant differences in combat injuries and the combat environment. To provide effective, budget conscious simulation, nations will benefit from the advice of leading experts who can guide investment in this complicated environment. The NATO SOF Allied Centre for Medical Education supported by an enduring partnership with PEO STRI has the potential to serve Alliance SOF and NATO conventional forces as a focal point for combat medical training simulation collaboration. The ACME will bring to life NSHQ's motto of providing "UNCONVENTIONAL and CONVENTIONAL expertise synchronized to optimize the employment of Allied and Partner Special Operations Forces."

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7.0 RESEARCH WORKSHOP: TECHNICAL ACTIVITY PROPOSAL (TAP)

UNCLASSIFIED / UNLIMITED

Technical Activity Description (TAD)

Activity reference number	HFM-224	**Activity Title** Training NATO Special Forces Medical Personnel: Opportunities in Technology-enabled Training Systems for Skill Acquisition and Maintenance	**Approval** 2011
Type and serial number	RWS		**Start** September 2011 IS
Location(s) and Dates		18-20 April 2012, Chievres (BEL) at NATO/Spec-OPS HQ.	**End** January 2014
Coordination with other bodies		ACT, ACO, COMEDS, SACEUR, NATO SPEC-OPS HQ	
NATO Classification of activity		UU	**Non NATO Invited** Yes
Publication Data		MP	UU
Keywords		Medical, Simulation, Simulators, Special Forces Medics, Training, Validation, Design, Education, ATLS, PHTLS, TCCC, Hemorrhage, Airway management.	

I. Background and Justification (Relevance to NATO):

In its current military missions, NATO Special Operations medical professionals face complex operational situations that are not encountered in civilian health care practice. These situations span a continuum of the challenging complexity of combat casualty care to providing public health support in peacekeeping to women and children. Of critical importance is the acquisition of skills for combat medics (i.e., special operations medics) in the area of prehospital trauma care. As a specific example, NATO COMEDS has identified the importance of managing haemorrhage and airways in the first 10 minutes after combat injuries. Special Forces may well have to sustain life for several hours in remote settings with difficult access and egress. These injuries and the timeframe is the critical domain of the special operations combat medic. NATO Special Operations medical leaders are keenly interested in the opportunities that technology-enabled training might offer in assuring that their special operations medics have similar skills and competencies in critical prehospital procedures/interventions. The resultant interoperability is deemed vital to future small unit operations.

There is no existing assessment of the opportunities that modern medical training technology might offer to special operations medic training. A NATO Research Workshop (RWS) will be convened with participants from academia, industry and relevant government entities in order to assess the opportunities available. Technologies in both the development phase and the commercially available phase will be sought and reported. The context for this reporting and assessment will be the internationally recognized prehospital trauma life support (PHTLS) curriculum with an emphasis on the "tactical combat casualty care" (TCCC) subcomponent of the PHTLS curriculum. In addition, NATO Special Operations Headquarters Medical Branch Office will provide specific examples of medical challenges and skill demands that will be used to solicit participants and technical contributions to the RWS. The output of the RWS will be a first ever assessment of training systems availability for training NATO special operations medics and the identification of relevant research issues that the NATO nations could take on in their various research program agendas.

The nature/classification of this subject will be NATO Unclassified/Unlimited and as such non-NATO countries (PfP; MD; Contact Nations) may also be invited.

II. Objective(s):

To identify current best technology and best practice in medic training systems and to identify research opportunities for further NATO/PfP/MD/Contact Nation collaboration and conformity in training.

III. Topic To Be Covered:

1. Current Applications of Simulations and Simulators for medic training
2. Training effectiveness validation
3. Mapping special operations medic skill requirements to existing training systems availability
4. Role of live animal training versus simulators and simulations
5. Training systems acquisition and procurement
6. Cultural issues affecting adoption of technology for training
7. End-user specifications for future technology-assisted training
8. RDT&E agenda

IV. Deliverable (e.g. S/W Engage Model, Database,...) and/or end product (e.g. Final Report):

Meeting Proceedings, other deliverable(s) : none

UNCLASSIFIED / UNLIMITED

Technical Activity Description (TAD)

V. Technical Team Leader And Lead Nation:

Chair : Col Annette HILDABRAND United States
Co-Chair : LTC Dr Daniel IRIZARRY United States

Lead Nation: United States

VI. Nations Willing/Invited to Participate:

NATO Nations and Bodies : Belgium, Canada, France, Germany, Italy, Norway, Poland, United States

PfP Nations : all PfP invited

MD Nations : all MD invited

ICI Nations : none

Global Partners : Australia, Japan, New Zealand, Republic of Korea

Contact / Other Nations : Singapore

VII. Nations and Bodies Really Participating:

Canada, Estonia, Germany, United States

VIII. National And/Or NATO Resources Needed (Physical and non-physical Assets):

NATO Special Operations Headquarters -- logistics and meeting support
Belgium – RTO National Coordinator visa processing (if required for non-Schengen Agreement countries)
National -- Input to and participation in the preparatory activities and support for participation in the Research Workshop itself.

IX. RTA Resources Needed:

PfP and/or MD participation support; funding for 2 Keynote Speakers (Industry) and Technical Evaluator (TER)

8.0 LIST OF ABBREVIATIONS

ACME	Allied Center for Medical Education
ACS	American College of Surgeons
AED	Automated External Defibrillator
ATLS	Advance Trauma Life Support
BATLS	Battlefield Advanced Trauma Life Support
COMEDS	Committee of the Chiefs of Military Medical Services
CoTCCC	Committee on Tactical Combat Casualty Care
CPR	Cardiopulmonary Resuscitation
DA	Direct Action
DoD	Department of Defense
EMT	Emergency Medical Technician
EU	European Union
ISAF	International Security Force Afghanistan
ISTC	International Special Training Center
ITLS	International Trauma Life Support
JSOMTC	Joint Special Operations Medical Training Center
LTT	Live Tissue Training

MA	Military Assistance
MD	Mediterranean Dialogue
M-PHTLS	Military Prehospital Trauma Life Support
MSTC	Military Simulation Training Center
NAEMT	National Association of Emergency Medical Technicians
NAMSA	NATO Acquisition and Maintenance Agency
NCEP	NATO Capability Enhancement Program
NORDEFCO	Nordic Agency for Development and Ecology
NREMT	National Registry of Emergency Medical Technicians
NSA	NATO Supply Agency
NSCC	NATO SOF Coordination Center
NSHQ	NATO Special Operations Headquarters
NSMDI	NATO SOF Medicine Development Initiative
NSOCM	NATO Special Operations Combat Medic
NSTEP	NATO SOF Training and Education Program
OEMS	Operational Emergency Medical Skills
OSCE	Objective Structured Clinical Examination
PEO STRI	Program Executive Office For Simulation Training and Instrumentation
PfP	Partners for Peace
PHTLS	Prehospital Trauma Life Support
RTO	Research Technology Organization
RWS	Research Workshop
SACEUR	Supreme Allied Commander Europe
SHAPE	Supreme Headquarters Allied Powers Europe
SMEPC	Special Operations Medical Engagement and Partnering Course
SOCC	Special Operations Command Center
SOCM	Special Operations Combat Medic
SOCOM	Special Operations Command
SOF	Special Operations Forces
SOFMEP	Special Operations Forces Medicine Expert Panel
SOMB	Special Operations Medical Branch
SOMLC	Special Operations Medical Leaders Course
SOST	Special Operations Surgical Team
SOTU	Special Operations Task Unit
SR	Special Reconnaissance

STANAG	Standardization Agreement
TAP	Technical Activity Proposal
TCCC	Tactical Combat Casualty Care
U.S. DHB	U.S. Defense Health Board

9.0 ACKNOWLEDGMENTS

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