

Blended Training for Combat Medics

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Abstract. Bleeding from extremity wounds is the number one cause of preventable death on the battlefield and current research stresses the importance of training in preparing every Soldier to use tourniquets. HapMed is designed to provide tourniquet application training to combat medics and Soldiers using a blended training solution encompassing information, demonstration, practice, and feedback. The system combines an instrumented manikin arm, PDA, and computer. The manikin arm provides several training options including stand-alone, hands-on skills training in which soldiers can experience the actual torque required to staunch bleeding from an extremity wound and be timed on tourniquet application. This is more realistic than using a block of wood to act as a limb, which is often how training is conducted today. Combining the manikin arm with the PDA allows instructors to provide scenario based training. In a classroom or field setting, an instructor can specify wound variables such as location, casualty size, and whether the wound is a tough bleed. The PDA also allows more detailed feedback to be provided. Finally, combining the manikin arm with game-based technologies, the third component, provides opportunities to build knowledge and to practice battlefield decision making. Not only do soldiers learn *how* to apply a tourniquet, but *when* to apply a tourniquet in combat. The purpose of the paper is to describe the learning science underlying the design of HapMed, illustrate the training system and ways it is being expanded to encompass other critical life-saving tasks, and report on feedback received from instructors and trainees at military training and simulation centers.

1.0 INTRODUCTION

Combat medics provide front line trauma care often in the heat of a battle, with limited resources, and under enormous stress. In modern warfare, medics serve as soldiers first, in keeping with the philosophy that "*The best medicine on the battlefield is fire superiority*"[6] but must be able to transition to a medic role quickly and decisively in accordance with the tactical situation. In these situations, medics respond to complex medical trauma. Most injuries on the battlefield are the result of explosions (from landmines and Improvised Explosive Devices) and gun shot wounds, each of which presents challenges. Combat medics must not only understand the nature of war related injuries but also the implications for procedures that will be effective. Moreover, as Mazurek and Burgess [5] point out, decisions

regarding casualty treatment are made based not only on the special knowledge of war-related injuries, but also on the understanding of the tactical environment, current location, resources available, and own capabilities. Clearly, there are significant training needs in regard to combat medics

The purpose of this paper is to describe the HapMed training system which is aimed at fulfilling at least some of the combat medic training needs. HapMed was designed to provide hands-on training to combat medics, addressing the three most common preventable point-of-injury deaths in combat: tourniquet application for hemorrhage control, needle chest decompression to relieve tension pneumothorax (air trapped within the chest cavity resulting in a collapsed or compressed lung), and creating an airway (this is generally a preventive measure to ensure a casualty airway remains open while

medic is treating another soldier). The Army has recently enhanced training of these and related tasks within combat medic training programs, including the Tactical Combat Casualty Care (TC3) courses [1]. TC3 was developed in response to the growing recognition that medical care on the battlefield requires different skills and mindsets compared to civilian approaches.

The design of HapMed was supported by cognitive engineering techniques including focused cognitive task analysis (CTA) to identify critical cues, decisions, and strategies that support task performance; observation of combat medic training; user feedback as prototypes and artifacts were developed; and training research. Our front end analyses revealed several challenges in regard to combat medic training [8]. Specifically, we faced challenges in four areas.

1.1 Challenge 1: Need for Hands-on Training

Despite the recent changes in medic training (e.g., TC3), there are few opportunities to receive hands-on practice. A well-practice skill such as tourniquet application may require at least tens, and maybe hundreds, of training trials, but there are few existing opportunities to get extensive hands-on practice. A common approach is to have students apply a combat application (CAT) tourniquet to a 2x4 board. While students may learn procedural knowledge this way, they do not receive tactile feedback on how tight a tourniquet must be to stop blood flow. This is a significant training need for tourniquet application as this quote suggests.

In the case of lower extremity wounds, which give rise to the most severe hemorrhage controlled by tourniquet, it has been my observation, that too few doctors, much less their assistants, have a concept of the constricting pressure required about the thigh to abolish the flow of blood. (*Emergency Treatment and Resuscitation at the Battalion Level by MAJ Meredith Mallory 1954*)

There are other related drawbacks to current training. Students do not gain the knowledge of

- how long it will take to apply a tourniquet;
- the influence of the size of the casualty on how long it will take to apply a tourniquet;

- complications that can arise when applying a tourniquet
- differences among the different types of tourniquets.

Thus, training systems are needed that provide hands-on training and support the acquisition of this type of knowledge.

1.2 Challenge 2: Tourniquets are Associated with Misinformation

Until recently, the tourniquets carried by soldiers were ineffective – they did not provide a mechanical advantage that would help apply enough force to stop bleeding from a significant extremity wound and their narrow widths resulted in excessive damage to limbs. As a result, tourniquet use was shunned by civilian medicine and myths abounded in both military and civilian sectors, some of which are summarized in Table 1. Recent tourniquets, including the CAT and the Special Operations Forces Tourniquet greatly minimize or eliminate these problems and recent research suggests they are highly effective [7]. Thus, our analysis indicated that hands-on training should be supplemented by didactic instruction that addressed misconceptions surrounding the use of tourniquets.

Table 1: Misinformation associated with tourniquet use

Myth	Current Guidance
It is good to occasionally loosen a tourniquet to allow some blood to get to the damaged limb.	The tourniquet should remain in place with the blood flow completely stopped until it can be removed. Occasionally loosening the tourniquet may result in death of the casualty.
Once a tourniquet is applied the casualty will lose his or her limb.	A tourniquet can remain in place for several hours without causing major damage to the limb.
Tourniquets should only be used as a last resort.	Tourniquets should be applied to extremity wounds as soon as tactically feasible.

1.3 Challenge 3: Medics serve in low density MOS assignments

Medics are one of the most common military occupational specialties, yet perhaps 70% of

medics serve in low density assignments, meaning that they are assigned to infantry or armor battalions and their numbers are small compared to other MOSs in their units. One consequence is that training resources are limited. Thus, training systems supporting medics must be low cost, durable, and reliable.

1.4 Challenge 4: Combat medics must learn to perform under intense battlefield stress

During the CTA, the harsh realities and complex environment in which combat medics work became clear. Medics perform in environments defined by intense time pressure, danger, complex and sometimes horrific injuries, and the many factors that impede or play a part in tactical decision making including tactical, medical, interpersonal, and environmental stressors. The importance of training medics to work effectively under these conditions was reinforced through interviews with subject matter experts and reviews of lessons learned. However, in examining existing curricula, we found few opportunities to systematically practice combat medicine under these “fog of war” conditions. Lane training and field exercises provide immersive, realistic practice, yet there are a very limited number of these opportunities. Moreover, in field exercises with their assigned units, it is often the case that combat medicine is not the primary focus of training and sometimes it is not addressed at all.

2.0 HAPMED TRAINING SYSTEM

Our solution to the challenges we uncovered during our front end analyses was to design and develop a blended training solution. By blended solution we mean incorporating complementary training interventions linked to the challenges or training needs discussed above. The HapMed training system, currently in prototype form, includes an instrumented manikin arm to provide hands-on skills training for tourniquet application, a PDA that wirelessly controls the arm to provide scenario-based training; and game based didactic instruction to further build knowledge and skills required of medics on the battlefield. Finally, we performed training research from which we determined that haptic and audio stimuli can be combined inexpensively to serve as surrogate stressors. These components are described below.

2.1 HAPMED Manikin Arm for Tourniquet Training

The HapMed manikin arm, pictured in Figure 1, was designed to provide stand-alone, hands-on skills training (as well as interact with the other system components) in which trainees can experience the actual torque required to staunch bleeding from an extremity wound and be timed on tourniquet application [4]. The features designed into the arm were based on the essential cues for tourniquet application identified from the CTA. The hardware components were based on our assessment of low cost technologies that could be sufficiently ruggedized. In the current design of the prototype,

- Bleeding is depicted through LED arrays clustered at four different locations to represent four possible wound areas. Wound sites can be selected by the trainee or instructor.
- Pressure sensors within the arm gauge the amount of pressure being applied via a tourniquet (or through other source of pressure such as squeezing with the hands at pressure points). The sensors were calibrated from data obtained from surgical applications of tourniquets. (e.g., [3])
- As the tourniquet is tightened, LED lights on the arm indicate to the trainee that the bleeding is being slowed by the tourniquet. When the trainee has tightened the tourniquet enough, per amount of torque needed on an actual human, the red lights turn to green indicating that the bleeding has been successfully stopped.
- A timer on the arm shows the number of seconds that it took to stop the bleeding.
- If a tourniquet is loosened once having been applied, the “bleeding” will begin again (and the timer will start again).



Figure 1: HapMed manikin arm prototype.

- A pulse can be felt that weakens as the tourniquet is applied.
- The arm will respond realistically to almost any tourniquet. This provides a tool to be used

by medical personnel to try out or compare different tourniquets.

- The arm can be affixed to a full body manikin or to a wall (see Figure 3).

During the course of development a great deal of feedback was obtained from the combat medic community regarding the arm. In addition, we conducted a more formal try out with a National Guard unit during which the arm was incorporated into combat medic and combat lifesaver training. This work has resulted in the design of a system suitable for use by the military.

2.2 HapMed PDA

The sensitivity of the pressure sensors on the HapMed arm can be manipulated through wireless connections so that different body sizes can be simulated, a feature that we incorporated into a PDA interface. The HapMed PDA provides a portable and intuitive interface to specify training scenario parameters such as wound location, casualty size, and whether the wound will require more than one tourniquet---these are all distinctions a medic or combat lifesaver needs to know when applying a tourniquet in combat. The PDA also provides performance feedback to trainees. Specifically, the PDA shows the location of the tourniquet(s) applied to the arm and indicates whether they have been placed correctly (2-4 inches above the wound site), the amount pressure being applied relative to the amount of bleeding, time to control bleeding, and status of the casualty. Finally, the PDA provides prompts that can be used by an instructor to facilitate discussion about the variables important in tourniquet application. The PDA can be used by an instructor to control the manikin arm in a classroom or in the field as part of lane training.

Figure 2 shows one of the PDA screens. Figure 3 shows an instructor using the PDA to wirelessly control the arm during combat medic training. Our usability evaluations showed that instructors could easily and immediately use the PDA. Much of the feedback we obtained pertained to additional controls and features that instructor's would like to see incorporated into the PDA.

2.3 Game-based Training

A computer-based training framework was designed that would allow trainees to access game-based training modules, combat medic

stories, and demonstrations that would interact wirelessly with the manikin arm. The game-based training modules were the components that we initially developed for the HapMed prototype. These included training modules focused on myths associated with tourniquet applications and identification of injuries suitable for tourniquets (screen for which is shown in Figure 4). In addition, a scenario-based decision making exercise was created. To

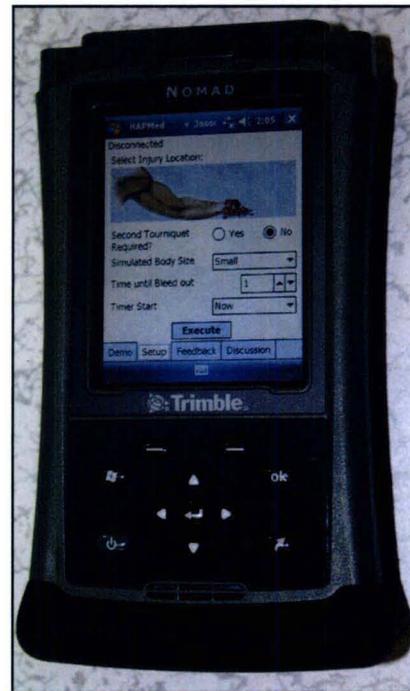


Figure 2: HapMed PDA scenario control screen.



Figure 3: Instructor using the PDA.

enhance the training, each of the training modules sets the stage for the trainee through an advanced organizer, provides performance performance feedback, and concludes with a guided reflection exercise. The game-based instruction has, thus far, received the least attention in terms of validation work. We intend to evaluate the effectiveness of the game-based training format compared to more traditional methods for information presentation in future work.



Figure 4: Card sort game-based training module screen.

2.4 Stress Training

Training research was conducted examined to how noise and vibrating tactile devices, or factors, can be used as surrogate sources of stress during the performance of a primary tourniquet application task and a secondary task requiring participants to identify pictures of soldiers as friendly or enemy. In combat, soldiers encounter stress from multiple sources including loss of sleep, extremely high levels of physical and psychological discomfort, extended periods of increased vigilance, and intense danger. The research examined the interactions between vibration stress (vibration presented through a haptic vest), audio stress (white noise) and time pressure on task performance for a tourniquet application task. Participants were 33 male and 12 females.

The results showed that the combined stress condition caused worse performance than the single-stress conditions, which caused worse performance than the control condition. Data for

the time to apply a tourniquet for each of the conditions is shown in Figure 5. Also, time pressure caused worse performance than no time pressure. This was true on both the primary task (tourniquet application) and secondary tasks (identifying images as friendly or foe), which indicates that resources were so limited that participants could not maintain performance on the primary task, even if they neglected the secondary task.

The performance decrements obtained in this research are operationally significant. For example, tourniquet application time was increased on the order of 10-15 seconds for the vibration and noise conditions, and on the order of 20-30 seconds for the combined condition. For a task in which casualties can die within four minutes, 30 seconds is a significant loss of time. This decrement, combined with the time distortion that occurred, is startling. If a medic's performance is slowed by 30 seconds, and he thinks he has been applying a tourniquet for one minute instead of two, grave consequences could likely be seen. Thus, the results indicate that vibration, audio, and time pressure, all of which are inexpensive interventions, could be added to the HapMed system to provide surrogates for battlefield stress. By adding system components, trainees could 1) observe stress effects in themselves, and learn strategies for coping with stress.

3.0 CONCLUSION AND FUTURE PLANS

Combat medicine lessons learned from recent engagements have led to a heightened awareness within the Department of Combat Medic Training of the need for incorporating warrior tasks during medical skills training and increased immersion in relevant combat medic training scenarios. In response, training interventions are being explored, many of which involve simulation [7]. The HapMed system was based on a needs analysis to design a training system that met some of the current requirements and that complemented other training approaches.

We are implementing HapMed within an overall "build a body" concept, in which different user groups can select the components of the training system that are relevant to their training needs. For example, through ongoing work we are adding instrumented torso and head manikins to support the cricothyroidotomy training in which a medic surgically opens an airway on the battlefield, and we are laying the hardware and

software foundations to support nasopharyngeal and needle chest decompression training. As these components are added, we plan to continue the evaluation research efforts to determine training system effectiveness, identify usability issues, and identify useful training niches such as was accomplished through the stress research. We believe a blended training solution, providing opportunities for information, demonstration, practice and feedback, in an inexpensive training suite, will be one key to the effectiveness of the HapMed system.

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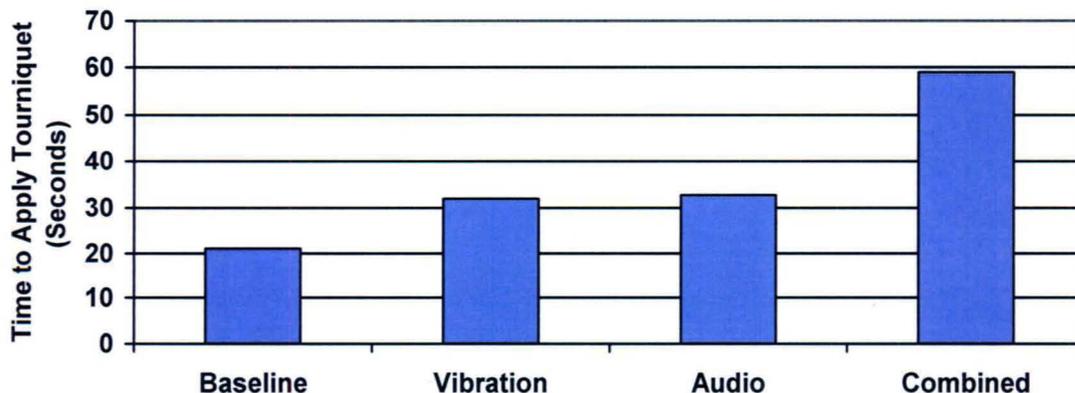


Figure 5: Results from the stress research.