Tactical Combat Casualty Care

Prehospital Care in the Tactical Environment

The Committee on Tactical Combat Casualty Care

For Chapter 17: Military Medicine, in The Prehospital Trauma Life Support Manual, Fifth Edition

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General Considerations

Throughout their careers, military medical personnel may be called upon to treat trauma victims in two types of situations – in combat, and in routine life on or off military installations. For non-combat situations, such as motor vehicle accidents, training accidents on the base, falls at home, and civilian acts of violence, the PHTLS guidelines described elsewhere in this manual apply. These guidelines should be followed and the appropriate EMS system activated. This chapter deals specifically with military combat trauma, and the recommendations herein apply solely to the tactical prehospital setting.

Ninety per cent of combat wound fatalities die on the battlefield before reaching a medical treatment facility. (1) This fact of war emphasizes the need for continued improvement in combat prehospital care. Trauma care training for military corpsmen and medics has been based primarily on the principles taught in the Advanced Trauma Life Support (ATLS) course. (2) ATLS provides a standardized approach to the management of trauma that has proven very successful when used in the setting of a hospital emergency department. The value of at least some aspects of ATLS in the prehospital setting, however, has been questioned, even in the civilian sector. (3-23) Military authors have voiced additional concerns about the applicability of ATLS in the combat setting. (24-31) Mitigating factors such as darkness, hostile fire, resource limitations, prolonged evacuation times, unique battlefield casualty transportation issues, command and tactical decisions affecting healthcare, hostile environments, and provider experience levels pose constraints different from the hospital emergency department. These differences are profound, and must be carefully reviewed when trauma management strategies are modified for combat application.

For example, Zajtchuk, Jenkins, Bellamy and their colleagues recommended combat casualty care guidelines for U.S. Army combat medics prior to the Gulf War that differed somewhat from ATLS guidelines. (25) Butler's "Tactical Combat Casualty Care in Special Operations" paper in 1996 provided a comprehensive review of prehospital care in the Special Operations tactical setting along with a set of recommended Tactical Combat Casualty Care (TCCC) guidelines for use by Special operations corpsmen, medics and pararescuemen (PJs). (31) These TCCC guidelines were published in the Fourth Edition of the Prehospital Trauma Life Support Manual. (32) Additionally, civilian medical organizations like the Wilderness Medical Society have published their own recommendations for the care of trauma patients in environments of interest to their members. (33) The ATLS course and its principles are well accepted as the standard of care once the patient reaches the Emergency Department of an MTF. Difficulties arise, however, as civilian ATLS principles are extrapolated onto the battlefield setting. This chapter addresses those difficulties, in light of the requirement to best achieve all ***three*** goals of TCCC: 1) Treat the casualty; 2) Prevent additional casualties; and 3) Complete the mission.

The Committee on Tactical Combat Casualty Care

Like all medical management strategies, the TCCC guidelines require periodic review and updating. Establishing a standing multi-service Committee on Tactical Combat Casualty Care (COTCCC) was first stated as a requirement by the Commander of the Naval Special Warfare Command. (34) This Committee was founded in 2002 by the U.S. Special Operations Command, and continued support of this effort has been approved by the Navy Bureau of Medicine and Surgery (BUMED). The committee comprises a tri-service group of trauma specialists, operational medical officers, and combat medical personnel. It will continue to monitor developments in the field of TCCC and propose changes to the guidelines as appropriate. The updated TCCC guidelines in Tables 1-3 and the explanatory text in this chapter are the results of the efforts of the COTCCC during workshops held in 2002.

Stages of Care in TCCC

Casualty management during combat missions can be divided into three distinct phases as described below. (31) This approach recognizes a particularly important principle – performing the correct intervention at the correct time in the continuum of field care. A medically correct intervention performed at the wrong time in combat may lead to further casualties.

1. "Care Under Fire" refers to care rendered at the scene of the injury while both the medic and the casualty are under effective hostile fire. The risk of additional injuries being sustained at any moment is extremely high for both casualty and rescuer. Available medical equipment is limited to that carried by each operator and the medic.

2. "Tactical Field Care" is the care rendered once the casualty and his unit are no longer under effective hostile fire. It also applies to situations in which an injury has occurred on a mission, but hostile fire has not been encountered. Medical equipment is still limited to that carried into the field by mission personnel. Time prior to extraction may range from a few minutes to many hours.

3. "Combat Casualty Evacuation Care" (CASEVAC) is the care rendered while the casualty is being evacuated by an aircraft, ground vehicle, or boat for transportation to a higher echelon of care. Any additional personnel and medical equipment pre-staged in these assets will be available during this phase. The term "CASEVAC" should be used to describe this phase since the Air Force reserves "MEDEVAC" to describe a non-combat medical transport.

Basic TCCC Management Plan

An updated basic management plan for each of the three phases of TCCC is presented in Tables 1, 2, and 3. This plan is a generic sequence of steps that serves as a starting point from which development of tailored, scenario-based management plans may begin. A detailed rationale for each step outlined in the basic management plan was presented in the fourth edition of this publication. (32) Modifications to the TCCC guidelines by the COTCCC are discussed below. As before, treatment principles in the ATLS course have been followed except where specific tactical considerations require a departure.

Care Under Fire

Very limited medical care should be attempted while the casualty and his unit are under effective hostile fire, as reflected in Table 1. Suppression of hostile fire and moving the casualty to a safe position are major considerations at this point. Significant delays for a detailed examination or consummate treatment of all injuries are ill advised while under effective enemy fire. Casualties who have sustained injuries that are not life threatening, and that do not preclude further participation in the fight, should continue to assist the unit in suppressing hostile fire, and in any other way possible to achieve mission success. It may also be critical for the combat medic or corpsman to help suppress hostile fire before attempting to provide care. This can be especially true in small unit operations where friendly firepower is limited, and every man's weapon may be needed to prevail. If hostile fire is not effectively suppressed, it may be necessary to move the casualty to cover. Casualties whose wounds do not prevent them from moving themselves to cover should do so to avoid exposing the medic or other aid givers to unnecessary hazard. Management of an impaired airway is temporarily deferred until the patient is safe, thereby minimizing the risk to the rescuer and avoiding the difficulty of managing the airway while dragging the casualty. Further discussion of casualty movement is presented in Figure 1.

The temporary use of a tourniquet to manage life-threatening extremity hemorrhage is recommended. This principle is supported by the wealth of Vietnam conflict combat casualty data indicating that exsanguinations from extremity injuries represented the number one etiology of preventable battlefield deaths (35). Direct pressure and compression dressings are less desirable than tourniquets in this setting because their application at the site of injury may result in delays getting the casualty and the rescuer to cover, and they may provide poorer control of hemorrhage while the casualty is being moved. Mabry et al reported on the lives saved in Mogadishu in 1993 by properly applied tourniquets. (36) In recent experience by the Israeli Defense Force (IDF), the use of tourniquets in combat settings confirmed that they are effective and safe even when their use is prompted by tactical rather than clinical indications. There were very few and minimal complications resulting from their use. (37) The standard "web belt through the buckle" tourniquet issued by the military for many years has not been well received by the combat medic community. Combat medics have often carried makeshift tourniquets composed of an encircling soft bandage tightened by a makeshift windlass. Some commercially available tourniquets were tested in a study sponsored by the U.S. Special Operations Command, and found to be unsatisfactory. (38) Several newly designed tourniquets are now being field tested by the U.S. Army, including a double-buckle tourniquet designed for ease of self-application with one hand in the event of a traumatic amputation of a hand or arm, and a ratchet design. Whatever tourniquet is selected must be both effective in controlling arterial bleeding and quickly applied under field conditions.

First responders can also achieve hemostasis in some cases of non-extremity hemorrhage using hemostatic agents in conjunction with direct pressure, if the site of the bleeding is accessible without surgical incision. A number of external agents have been approved by the U.S. Food and Drug Administration (FDA) for this indication, and have recently been evaluated in a standardized fashion in tactically relevant animal models. The Rapid Deployment Hemostat® (RDH) bandage is a proprietary formulation of poly-N-acetyl glucosamine that has not proven as efficacious as other options in trials at the United States Army Institute of Surgical Research (USAISR).(39) TraumaDex is a starch polymer that has been shown to reduce bleeding in some trauma models, but has not been proven at this time to equal the other options in severe bleeding models. (40) QuickClot ™ is an FDA-approved powder of proprietary formulation. This agent was introduced by the Marine Corps in mid-2002; the first combat test and evaluation of an active hemostatic agent by the U.S. Armed Forces. QuickClot ™ has been found effective in severe bleeding models (41), but when not meticulously applied, it can produce an exothermic reaction with temperatures up to 90^{o}C. The heat produced under this circumstance could potentially cause pain and collateral tissue damage. (42) To minimize the risk posed by this exothermic potential, excess blood and fluid must first be removed from the application site. The powder format may prove difficult to apply properly on the battlefield, especially at night. In November 2002, another active hemostatic agent, the HemCon® dressing, was approved by the FDA for external use. The HemCon® dressing is another proprietary formulation of poly-N-acetyl glucosamine that has proven effective in a severe bleeding model in trials at the USAISR. (43) Recombinant Factor VIIa is another hemorrhage control agent currently under evaluation in a multi-center trial. It has anecdotally proven efficacious in cessation of bleeding in trauma patients with severe bleeding and acquired coagulopathies. (44) It is currently not recommended for field use, but may ultimately prove valuable in forward surgical units for some patients.

Further evaluation and development will yield more information on currently approved external hemostatic agents, and intense research in the area of other agents that can control hemorrhage in the field is underway. New agents are likely to be available soon. Efficacy will be demonstrated in severe hemorrhage models, and in the durability, ease of use, cost, tactical relevance, and shelf life of the product. As of this writing, there is currently no direct data to demonstrate that either QuickClot ™ or the HemCon® dressing is more effective at achieving hemostasis. However, because of its safety and ease of application, the HemCon® dressing represents the best current option for external hemostasis on the battlefield in casualties whose bleeding sites are not amenable to the use of a tourniquet.

A casualty may exsanguinate before any medical help arrives (45), so the importance of achieving rapid, definitive control of life-threatening hemorrhage on the battlefield cannot be overemphasized. Furthermore, standard field dressings and direct pressure may not work reliably to control exanguinating extremity hemorrhage. (45) Therefore, every combatant should carry both a tourniquet and a hemostatic dressing as part of his personal gear loadout, and should be trained in their use.

There is no requirement to immobilize the spine prior to moving a casualty out of a firefight if he has sustained only penetrating trauma. Arishita, Vayer, and Bellamy examined the value of cervical spine immobilization in penetrating neck injuries in Vietnam. They determined that only 1.4% of patients with penetrating neck injuries might have benefited from cervical immobilization (24). Hostile fire poses a much more significant threat in this setting, to both casualty and rescuer, than spinal cord injury from failure to immobilize the C-spine. (24) For casualties with significant blunt trauma in the Care Under Fire phase, the risk of spinal cord injury remains a major consideration. (36) In this circumstance, the risk of cord injury from neck movement must be weighed against the risk of additional hostile fire injuries while immobilizing the C-spine.

Combat is a frightening experience, and being wounded, especially seriously, can generate tremendous anxiety and fear. Engaging a casualty with reassurance is therapeutically beneficial, and communication is just as important in patient care on the battlefield as it is in the MTF.

Tactical Field Care

Recommended guidelines for this phase of care are shown in Table 2.

In the combat setting, there are four primary reasons for an individual to exhibit an altered state of consciousness: traumatic brain injury, pain, shock, and analgesic medications. An armed combatant suffering an altered state of consciousness poses a serious threat of injury to others in his unit should he employ his weapons inappropriately. Anyone noted to have an altered state of consciousness should be disarmed immediately, to include secondary weapons and explosive devices. (46)

Unconscious casualties should have their airways opened with the chin-lift or jaw thrust maneuvers. If spontaneous respirations are present and there is no respiratory distress, further airway management is best achieved with a nasopharyngeal airway. It is more easily tolerated than an oropharyngeal airway if the patient suddenly regains consciousness (2), and it is probably less likely to be dislodged during transport. (31) These casualties should be placed in the semiprone recovery position (Figure 2) to prevent aspiration of blood, mucous, or vomitus.

Should an airway obstruction develop or persist despite the use of a nasopharyngeal airway, a more definitive airway will be required. The ability of experienced paramedical personnel to perform endotracheal intubation has been well documented. (6,47-56) Most studies reported use of cadaver training, operating room intubations, supervised initial intubations, or a combination of these methods in teaching the skill. They also stressed the importance of continued practice to maintain proficiency. This technique may be prohibitively difficult in the tactical environment, however, for a number of reasons (31): 1) there have been no studies examining the ability of well-trained but relatively inexperienced military medics to accomplish endotracheal intubation on the battlefield; 2) many corpsmen and medics have never performed an intubation on a live patient or even a cadaver; 3) standard endotracheal intubation techniques entail the use of a tactically compromising white light in the laryngoscope; 4) endotracheal intubation can be extremely difficult in a casualty with maxillofacial injuries (25); and 5) esophageal intubations are probably much less recognizable on the battlefield. Endotracheal intubation may be difficult to accomplish even in the hands of more experienced paramedical personnel under less austere conditions. (57) One study, which examined first-time intubationists trained with mannequin intubations alone, noted an initial success rate of only 42% in the ideal confines of the operating room with paralyzed patients. (54) Another study examined basic EMTs who had been trained in intubation and found that only 53 of 103 patients were successfully intubated. (58) Even in civilian settings with experienced paramedical personnel, another report documented that in 27 of 108 prehospital intubations, the tube was misplaced upon arrival in the Emergency Department. (59) Some reports of successful intubation by military combat medical personnel use mannequin intubation by just-trained corpsmen as an outcome measure (60), which may not be an accurate indicator of success under actual battlefield conditions. The usefulness of this procedure was further questioned in a study in which prehospital endotracheal intubation was not found to improve outcome in patients with severe head injuries. (61)

Significant airway obstruction in the combat setting is likely to be the result of penetrating wounds of the face or neck in which blood or disrupted anatomy precludes good visualization of the vocal cords. Cricothyroidotomy is therefore preferable to intubation in these cases, if the combat corpsman or medic has been trained in this procedure. (25,31) Cricothyroidotomy has been reported safe and effective in trauma victims (62), but is not without complications (63,64). Even so, it is felt to provide the best chance for successful airway management in this setting. Furthermore, it can be performed under local anesthesia with lidocaine in an awake patient.

Thermal or toxic gas injuries are important considerations in certain tactical situations. Airway edema is aggravated by fluid administration, and this may lead to acute upper airway obstruction. Airway burns should be suspected if fire occurs within a confined space, the patient has cervicofacial burns, singeing of the nasal hairs, carbonaceous sputum or complaints of sore throat, hoarseness or wheezing. Cricothyroidotomy is the airway of choice in the Tactical Field Care Phase for these casualties.

A presumptive diagnosis of tension pneumothorax should be made when significant respiratory distress develops in the setting of torso trauma. The diagnosis of tension pneumothorax on the battlefield should not rely on such typical clinical signs as decreased breath sounds, tracheal deviation, or hyperresonance to percussion because these signs may not always be present (65), and even if they are, they may be exceedingly difficult to appreciate on the battlefield. A patient with penetrating chest trauma will generally have some degree of hemo/pneumothorax as a result of his primary wound, and the additional trauma caused by a needle thoracostomy would not be expected to significantly worsen his condition should he not actually have a tension pneumothorax. (56) Paramedics are authorized to perform needle thoracentesis in some civilian emergency medical services. (51,56) Combat corpsmen and medics should also be proficient in this technique. Chest tubes are not recommended in this phase of care for the following reasons: 1) they are not needed to provide initial treatment for a tension pneumothorax; 2) they are more difficult and time-consuming for relatively inexperienced medical personnel, especially in the austere battlefield environment; 3) chest tube insertion is probably more likely to cause additional tissue damage and subsequent infection than needle thoracostomy; and 4) no documentation of benefit from battlefield tube thoracostomy by paramedical personnel was found in the literature. (31) Tube thoracostomy is generally not part of the paramedic's scope of care in civilian EMS settings (51,56), and no studies were found that address the use of this procedure by corpsmen and medics in combat settings.

Needle thoracentesis with a 14-gauge needle was found to rapidly relieve elevated intrapleural pressure in a swine model of traumatic tension pneumothorax. (66) The therapeutic effect was sustained for 4 hours, and this procedure was found to be equivalent to tube thoracostomy with a 32F chest tube for the observation period. (66) The ease and speed of performance, and the decreased likelihood of complications make needle thoracentesis the procedure of choice for relieving tension pneumothorax on the battlefield. Cannula length is an important consideration here (67), as the pectoral muscles must be penetrated, and in young soldiers, they can be very thick. Even though it may be difficult to appreciate in field settings, if there is no rush of air when the needle is inserted, then either it didn't go in far enough, or there was no tension pneumothorax there. Medics of the 75th Ranger Regiment currently pack 10ga 3-inch needle/catheters for this procedure. (Personal communication – SFC Rob Miller) Any patient who has undergone needle thoracentesis for relief of tension pneumothorax must be continually re-assessed. Catheters used for this purpose are subject to occlusion by clotting and kinking.

An open pneumothorax (sucking chest wound) may result from large defects in the chest wall, and may interfere with respiration. These wounds are treated by applying a vaseline gauze during expiration, covering the gauze with tape or a field dressing, placing the casualty in the sitting position, and monitoring for the possible development of a tension pneumothorax.

Tourniquets applied during the Care Under Fire phase should be replaced with direct pressure and/or HemCon® dressings when the tactical situation allows, with care to assure continued hemostasis.

Although ATLS teaches starting two large bore (14- or 16-gauge) intravenous catheters for fluid resuscitation in trauma cases (2), the 18-gauge catheter is preferred in the field setting because of the ease of cannulation. (31) Crystalloid and colloid solutions can be administered rapidly through an 18-gauge catheter and blood products requiring the larger cannulae aren't given in the field (68,69). Blood products may be administered in the CASEVAC phase or later at an MTF, but field-placed IV cannulae will normally be replaced there anyway due to the risk of contamination. (70)

Despite its ubiquity, the benefit of prehospital fluid resuscitation in trauma patients has not been established. (3,6-8,10-12,14,16,19,21,25,71) The ATLS course proposes initial fluid resuscitation with two liters of a crystalloid. Other options are no fluid resuscitation until hemorrhage is definitively controlled, or limited (hypotensive) resuscitation to achieve a perfusing systolic blood pressure of about 70 mm Hg. Additionally there has been controversy over the fluid to be used. Choices have included crystalloid, colloid, synthetic colloid, blood products, and the new hemoglobin solutions. The beneficial effect from crystalloid and colloid fluid resuscitation in hemorrhagic shock has been demonstrated largely in animal models where the volume of hemorrhage is controlled experimentally and resuscitation is initiated after the hemorrhage has been stopped. (21,22) Multiple studies using uncontrolled hemorrhagic shock models have found that aggressive fluid resuscitation before surgical repair of a vascular injury is associated with either no improvement in survival or increased mortality when compared to no resuscitation or hypotensive resuscitation. (9,10,15,17-21,72,73) This lack of benefit is presumably due to interference with vasoconstriction as the body attempts to adjust to the loss of blood, and interference with hemostasis at the bleeding site. Two studies were found in which aggressive fluid resuscitation improved the outcome of uncontrolled hemorrhagic shock. (74,75) Both of these studies used rat tail amputation models, which may not correlate well with uncontrolled hemorrhage on the battlefield from intra-thoracic and intra-abdominal injuries. Some studies have noted that fluid resuscitation proved to be of benefit only after previously uncontrolled hemorrhage was stopped. (76-78)

Three studies were found which address this issue in humans. One large study of 6,855 trauma patients found that although hypotension was associated with a significantly higher mortality rate, the administration of prehospital IV fluids did not reduce this mortality. (14) A retrospective analysis of patients with ruptured abdominal aortic aneurysms showed a survival rate of 30% for patients who were treated with aggressive preoperative colloid fluid replacement in contrast to a 77% survival rate for patients in whom fluid resuscitation was withheld until the time of operative repair. (79) The author strongly recommended that aggressive fluid resuscitation be withheld until the time of surgery in these patients. Bickell and colleagues published a large prospective trial examining this issue in 598 victims of penetrating torso trauma. (4,13) They found that aggressive prehospital fluid resuscitation of hypotensive patients with penetrating wounds of the chest and abdomen was associated with a higher mortality than seen in those for whom aggressive volume replacement was withheld until the time of surgical repair. Further analysis of this data found that this difference was most significant in those patients with wounds of the chest, with abdominal wounds showing little difference in survival between early and delayed fluid resuscitation. (80) Although confirmation of these findings in other randomized, prospective human studies has not yet been obtained, no human studies were found which demonstrated any benefit from fluid replacement in patients with ongoing hemorrhage. Continuing hemorrhage must be suspected in battlefield casualties with penetrating abdominal or thoracic injury until surgical repair is effected.

Hespan (6% hetastarch) was recommended in the 1996 TCCC paper as better alternative for fluid resuscitation in the Tactical Field Care phase than lactated ringer's (LR) solution. (31) LR is a crystalloid, which means that the primary osmotically active particle is sodium. Since the sodium ion distributes throughout the entire extracellular fluid compartment, LR moves rapidly from the intravascular space to the extravascular space. This shift has significant implications for fluid resuscitation. For example, if a trauma patient is infused with 1000 cc of LR, only 200cc of that volume will remain in the intravascular space one hour later. (81-83) This is not a problem in the civilian setting, since the average time for transport of the patient to the hospital in an ambulance is less than 15 minutes (13,14), after which surgical control of hemorrhage can be rapidly achieved. In the military setting, however, where several hours may elapse before a casualty arrives at an MTF, effective volume resuscitation may be difficult to sustain with LR.

In contrast, the large hetastarch molecule is retained in the intravascular space and there is no loss of fluid into the interstitium. Hetastarch osmotically promotes fluid influx into the vascular space from the interstitium such that an infusion of 500cc of Hetastarch results in an intravascular volume expansion of almost 800cc (83), and this effect is sustained for eight hours or longer. (84) Although concerns have been voiced about coagulopathies and changes in immune function associated with the use of hetastarch (23,85-88), these effects are not seen with infusions of less than 1500cc. (86-90) Several papers have found hetastarch to be a safe and effective alternative to LR in resuscitating patients with controlled hemorrhagic shock. (91,92) Hetastarch is also felt to be an acceptable alternative to LR for intraoperative fluid replacement. (93)

The 1993 Ben Taub study mentioned previously (4) found that aggressive prehospital fluid resuscitation of hemorrhagic shock resulting from penetrating trauma to the chest or abdomen produced a greater mortality than KVO fluids only. This resulted in a recommendation in the original TCCC paper to withhold aggressive fluid resuscitation from individuals with penetrating torso trauma. (31) At the 1998 Special Operations workshop on Urban Warfare casualties, however, there was a clear consensus among the panelists that should a casualty with uncontrolled hemorrhage have mental status changes or become unconscious (correlating to a blood pressure of 50 systolic or less), he should be given enough fluid to resuscitate him to the point where his mentation improves (correlating to a systolic blood pressure of 70 or above.) Panel members stressed the importance of not trying to aggressively administer IV fluids with the goal of achieving "normal" blood pressure in casualties with penetrating truncal injuries. (46)

The consensus conferences held in 2001 and 2002 under the sponsorship of the Office of Naval Research and other agencies (94) promoted the concepts of minimal fluid resuscitation in the setting of uncontrolled hemorrhage and the use of alternative fluids that yield logistical advantages of lighter weight and smaller volume in the ruck sack. The report from the Institute of Medicine in 1999 titled "Fluid resuscitation; state of the science for treating Combat Casualties and Civilian injuries" recommended that 7.5% hypertonic saline be initially used for fluid resuscitation. The rationale for this recommendation was that Lactated Ringers has been shown to have detrimental immunological effects and that further research was needed to find the optimal resuscitation fluid. (95-112) HTS was recommended as it has been used in numerous clinical trails with minimal consequences and in patients with traumatic brain injury, it may have potential benefits. HTS has also been shown to be immunosuppressive which may effect the complications (such as ARDS) often seen after massive resuscitation. However, the main reason for the recommendation of HTS was due to its logistical advantage. The problem with the use of 7.5% HTS is that it is not currently manufactured and so is not available. Therefore, in the consensus conferences in 2001 and 2002, the recommendation was that a colloid solution such as hetastarch be used until HTS is more readily available. It is also unclear if the resuscitative effect of a single infusion of HTS lasts as long as that of a comparable infusion of a colloid solution, and this point deserves further investigation.

A technique of minimal fluid resuscitation in the field in casualties with uncontrolled hemorrhage was promoted in a recent paper by Holcomb. (113) Whereas the 1996 TCCC guidelines called for Special Operations medics to give 1000 ml of Hespan® to all casualties meeting the requirement for resuscitation, Holcomb proposed the that all casualties in shock (as defined by absent peripheral pulses or altered mental status in the absence of brain injury) be given a 500cc bolus of Hextend. If no improvement is noted in 30 minutes, the bolus is repeated once. This modification has several advantages: 1) logistics: not all casualties will require 1000 ml of hetastarch, thus saving fluid and time for other casualties; 2) rebleeding; titration of fluids based upon a monitored physiologic response may avoid the problem of excessive blood pressure elevation and fatal rebleeding from previously clotted sites; 3) training; basing the fluid therapy on the premise of responders vs. nonresponders follows the lead of the ACS Committee on Trauma in the ATLS course, and allows for a single approach to patients with both controlled and uncontrolled hemorrhage. Interestingly, this recommendation for "hypotensive" resuscitation is a rebirth of similar principles employed in World War II by Beecher. (114)

Although hetastarch has a theoretical advantage over crystalloids for resuscitating combat casualties on the battlefield because of its sustained intravascular presence, there is little convincing clinical evidence in trauma patients that any one crystalloid or colloid works better than others. However, a multifold reduction in medical equipment weight is achieved by substitution of hetastarch solution for LR (31), and this is clearly of logistical benefit to military medics, enabling them to carry the smallest volume and weight of resuscitation fluid consistent with effective practice. (113, 115)

The Hextend® formulation of hetastarch has not been widely used as a front-line resuscitation fluid, thus clear evidence of its superiority is lacking. However, hetastarch solutions mixed in saline (Hespan®) increase blood loss compared to the identical hetastarch mixed in a balanced electrolyte solution, a lactate buffer, and physiological levels of glucose (Hextend®). (116) A protective influence of Hextend against multiple organ injury after hepatoenteric ischemia-reperfusion has been reported, and the effect attributed to a potential anti-oxidant effect of the hetastarch molecule. (117) For the near future, hypertonic saline dextran is not available, so Hextend is the recommended resuscitation fluid for the Tactical Field Care phase. The 500cc boluses recommended should be administered as rapidly as possible using manual pressure on the IV bag or inflatable IV bag cuffs.

The most significant concern with the proposed battlefield resuscitation algorithm is that it cannot be rigorously evaluated in clinical trials. It is based upon a combination of historical information, recent animal studies, civilian and military trauma experience, and expert opinion. The realities of war prevent prospective randomized blinded resuscitation studies on the battlefield, so now, as in the past, insightful recommendations from those knowledgeable in trauma physiology and experienced in trauma care must provide the basis for military medical doctrine. (114, 118, 119) Further modification will be warranted as ongoing research and development efforts yield new and relevant information. This issue was extensively discussed during the combat fluid resuscitation conferences (94), with unanimous agreement that this approach is sound. Optimally, future analysis will also include review of injury data prospectively collected in a military trauma registry.

It may be difficult to establish intravenous access in casualties in shock. A sternal intraosseous (IO) device offers an alternative route for administering fluids and medications in this situation. (120, 121) This allows the medic to avoid more difficult and invasive techniques like central venous cannulation or saphenous cutdown. IO access is far easier to obtain in the dark, and requires minimal aseptic technique.

An additional change from the previous recommendations entails the administration of oral fluids to casualties with penetrating trauma. This recommendation is based upon observations from trauma surgeons attached to forward-deployed MTFs, noting that many casualties are kept NPO for prolonged periods in anticipation of eventual surgery. With transportation delays superimposed upon the dehydration often present in combat operations before wounding, these casualties come to surgery markedly dehydrated. This may adversely affect their chance of survival, and the observed risk of emesis and aspiration is remarkably low. Under the new guidelines, therefore, PO fluids are recommended for all casualties with a normal state of consciousness, including those with penetrating torso trauma.

The last recommended change to the fluid resuscitation guidelines is a modified fluid regimen for an individual with traumatic brain injury (TBI) and shock. In this individual, decreased state of consciousness may be due to either the TBI or hemorrhagic shock from associated injuries. Hypotension in the presence of brain injury has been found to be associated with a significant increase in mortality. (122) Because of the need to ensure adequate cerebral perfusion pressure, this casualty should receive IV or IO fluids until he has a palpable radial pulse, commensurate with a systolic blood pressure of at least 80 mm Hg.

The optimal resuscitation fluid for use by combat medics remains an open question and is currently a topic of great interest in military medical research. Studies planned in the near future at the USAISR and other laboratories will evaluate hetastarch solutions, crystalloids, 5% hypertonic saline, and hemoglobin-based oxygen carrying solutions in combat-appropriate trauma models. Animal models used in studies performed to address fluid resuscitation issues on the battlefield should include a significant delay to surgical repair to simulate the prolonged evacuation times combat operations often entail. Care should be taken in attempting to extrapolate the results of resuscitation fluid studies in the civilian sector to the battlefield, since average prehospital time in urban areas is usually very short. However, civilian studies may provide all the available human trauma data. Additionally, resuscitation studies must address both controlled and uncontrolled hemorrhagic shock as the pre-operative clinical objectives may be different.

It is common for intravenous lines started in the field to become dislodged during casualty transport. One system for securing IV lines that has proven useful in TCCC is inserting an 18-gauge 1¼" catheter along with a saline lock. The saline lock is then secured with Tegoderm® over the site. Fluids and medications are then given by inserting a second 18-gauge 1¼" needle and catheter through the lock, and withdrawing the needle. The catheter is left in place and secured with a circumferential velcro wrap (Linebacker®) to prevent it from being dislodged. (Personal communication – SFC Rob Miller – 75th Ranger Regiment).

As in civilian settings, the type of analgesic given in TCCC depends on the severity of the casualty's pain. Beecher noted in his WWII survey (123) that many men were fairly unruffled by seemingly horrific wounds sustained in battle, though the same wounds in a civilian setting would be expected to produce agonizing pain. If the wounds are not significantly painful, no analgesia is indicated. For mild to moderate pain, 50 mg of rofecoxib po qd and 1000 mg of acetaminophen po q6h are given with the goal of preserving normal sensorium and allowing the casualty to continue as a combatant. Rofecoxib (Vioxx®) is a cyclo-oxygenase-2 (Cox-2) inhibitor and does not cause the platelet dysfunction seen with non-selective NSAIDs. (124, 125) It also provides a more favorable side effect profile than seen with other Cox-2 inhibitors. It does not exhibit the same hypersensitivity responses in sulfa-sensitive individuals that have been reported with valdecoxib (Bextra®) (126) and celecoxib (Celebrex®) (127), and carries no such contraindication. It is important to realize that platelet dysfunction is an important consideration even for individuals with relatively minor wounds until they have been evacuated to a medical treatment facility or their operating base. The first wounds sustained by a casualty in combat may not, unfortunately, be the last.

If the casualty's wounds require more potent analgesia (bony injuries and burns are typically the most painful), it should be achieved with morphine, preferably administered intravenously. (31) Intravenous administration allows for much more rapid onset and more accurate titration of narcotic dose than the intramuscular route. An initial dose of 5 mg is given and repeated at 10-minute intervals until adequate analgesia is achieved. It is common for individuals who have received high doses of morphine to experience nausea and vomiting, so promethazine 25 mg IV/IM/IO should be given to prevent this side effect.

Infection is an important late cause of morbidity and mortality in battlefield wounds. Cefoxitin was previously proposed (31) because of its excellent spectrum of action, low incidence of side effects, and low cost. Several significant changes in the antibiotics used in TCCC have recently been proposed by O'Connor and Butler. (128)

The logistical burden of reconstituting and injecting parenteral medications makes the use of oral antibiotics an attractive alternative when possible. In some casualties, oral antibiotics are clearly not an option (penetrating abdominal trauma, unconsciousness, shock). In patients without contraindications, however, oral antibiotic prophylaxis is feasible. The USSOCOM-sponsored workshop on Tactical Management of Urban Warfare Casualties held in Tampa in December, 1998 focused on the Battle of Mogadishu, and identified a number of potential improvements in the battlefield care of combat casualties (46). Participants in this workshop noted that an orally administered antibiotic would have several advantages. Giving antibiotics to a wounded teammate would require no more than having him swallow a tablet with a gulp of water from a canteen, and would eliminate the need for mixing and parenteral administration. With a long-acting oral antibiotic, SOF combat medics could easily carry an adequate supply of antibiotics to cover the entire unit for several days.

Penicillins are not a good choice in this setting because they: 1) cause too many severe allergic reactions; 2) require too frequent dosing, and 3) are not active against most gram-negative organisms. The fluoroquinolones, on the other hand, have an excellent spectrum of antibacterial action. Ciprofloxacin has good coverage against Pseudomonas species (129), but little activity against anaerobes. (129,130) Levofloxacin has more action against gram-positive organisms than ciprofloxacin, but is less effective against Pseudomonas, and is also not reliably effective against anaerobes. Levofloxacin does have some activity against Pseudomonas and is indicated for urinary tract infections caused by this organism. (131) Trovafloxacin is effective against gram-positive, gram-negative, and anaerobic organisms. (129) Moxifloxacin and gatifloxacin are also fourth generation fluoroquinolones that have an enhanced spectrum of activity. Trovafloxacin, gatifloxacin, and moxifloxacin yield low minimum inhibitory concentrations against most groups of anaerobes. (130,132) One study found that moxifloxacin's activity against Clostridium and Bacteroides species was in the same range as metronidazole's, and superior to that of clindamycin. (133) Another study found that "In general, moxifloxacin was the most potent fluoroquinolone for gram-positive bacteria while ciprofloxacin, moxifloxacin, gatifloxacin, and levofloxacin demonstrated equivalent potency against gram negative bacteria. (134) A third study found that moxifloxacin was almost as active as trovafloxacin, as active as gatifloxacin, and more active than levofloxacin and ciprofloxacin against the anaerobes tested, including Clostridium species. (135) Blood levels of the fluoroquinolones achieved with oral dosing are similar to those achieved with IV dosing, so oral administration does not significantly reduce the bioavailability of these agents.

Use of a fourth generation fluoroquinolone has an additional benefit for use in Special Operations. Since these operations often entail immersion in sea or fresh water, infections with pathogens found in these environments must be considered as well. Wounds contaminated with seawater are susceptible to infections with Vibrio species, gram negative rods that can result in an overwhelming gram-negative sepsis with 50% mortality. (138) Contamination of wounds with fresh water may result in infections with Aeromonas species, also a gram negative rod. (136) The excellent gram negative coverage of fourth generation fluoroquinolones makes them a good choice in these circumstances.

In addition to the advantage of oral administration, the fluoroquinolones require less frequent dosing. Both moxifloxacin and gatifloxacin are given as a single daily 400mg dose. Imagine a SOF unit with 3 seriously wounded individuals that cannot be extracted for 48 hours. To maintain antibiotic coverage with cefoxitin for all 3 casualties would require 24 doses – a quantity that Special Operations medics are not likely to carry. In contrast, 6 tablets of one of the fluoroquinolones would suffice for the same period.

The fluoroquinolones also have an excellent safety profile. A review in the October 1999 Mayo Clinic Proceedings states that the they are tolerated as well or better than any other class of antibacterial agents. (129) The best-known toxic effect of the fluoroquinolones has been the severe hepatotoxicity seen with trovafloxacin use, but this was seen in only 140 patients out of 2.5 million prescriptions, and was usually seen after long-term (more than 28 days) use of the medication. Another disadvantage of trovafloxacin is that its absorption is delayed by morphine, which may be used in combat casualties. (129) Gastrointestinal upset is seen in about 5% of patients treated with fluoroquinolones, and mild allergic reactions (rash, urticaria, and photosensitivity) are seen in 1-2% of patients. Mild CNS symptoms (headache and dizziness) are also encountered in 5-10% of patients treated with the fluoroquinolones. (129)

One of the considerations in a medication chosen for use by ground troops in the field is its ability to maintain its activity in hot and cold environments. The recommended storage temperature for gatifloxacin is 77^{o} F with 59^{o} F to 86^{o} F listed as the acceptable temperature range. If true, this would limit the drug's usefulness to ground combat troops. Correspondence on this issue with the manufacturer, Bristol-Myers Squibb, has indicated that gatifloxacin tablets have excellent stability at higher temperatures with documented maintenance of efficacy for 6 months at 104^{o} F and 3 months at 122^{o} F (personal correspondence – Mr. Brett Schenk and Mr. Steve Sharpe, BMS).

Gatifloxacin is a good choice for single-agent therapy based on its excellent spectrum of coverage, good safety profile, and once-a-day dosing. Moxifloxacin would be an acceptable second choice. A third choice might be levofloxacin, but since levofloxacin has only limited activity against anaerobes, another drug must be added to achieve coverage against these organisms. The most active drugs for the treatment of anaerobic infections are clindamycin and metronidazole. (137) Relatively few anaerobes are resistant to clindamycin, and few, if any, are resistant to metronidazole. (137) Metronidazole has the advantage of having a less severe side effect profile than clindamycin.

Based on the discussion above, either moxifloxacin or gatifloxacin would be a good choice for an oral antibiotic for use on the battlefield. A cost comparison of these two agents performed by the Naval Hospital Pensacola pharmacy in August of 2002 found that the cost to the U.S. government for a single dose of moxifloxacin was $5.09 while a single dose of gatifloxacin was only $1.86. This cost comparison is based on DOD-wide pricing schedules (personal communication – LT Roger Bunch and LCDR Tony Capano). Based on the much lower cost of gatifloxacin with other factors being approximately equal, gatifloxacin emerges as the best choice for an oral antibiotic.

The use of oral antibiotics is not advisable in some casualties. An unconscious casualty is not able to take the medication. An individual in shock will have a reduced mesenteric blood flow that might interfere with absorption of an oral agent. Casualties with penetrating abdominal trauma may have a mechanical disruption of the GI tract that would impede absorption of an oral antibiotic. Effective antibiotic prophylaxis is especially important in this group of patients. A large group of patients (338) with penetrating trauma to the abdomen was reported by Dellinger et al. (138) Even in this civilian trauma center setting, 24% of patients developed wound infections and nine died as a result.

Use of cefotetan as an alternative to cefoxitin as a battlefield antibiotic was first proposed by O'Connor. (139) Cefotetan is a similar medication with the same broad spectrum of action, but with a longer half-life that allows q 12 hour dosing. Both cefoxitin and cefotetan were recommended by Osmon as prophylactic agents for adults undergoing colorectal surgery (140) and by Conte for trauma victims with a ruptured viscus. (141)

Luchette et al published a meta-analysis of antibiotic prophylaxis in penetrating trauma in 2000. (142) The more successful regimens included: cefoxitin, gentamycin with clindamycin, tobramycin with clindamycin, cefotetan, cefamandole, aztreonam, and gentamycin alone. Nichols and colleagues compared cefoxitin to a gentamycin/clindamycin combination in penetrating abdominal trauma and found them to be equivalent. (143) Jones and colleagues compared cefoxitin, cefamandole and a tobramycin/clindamycin combination in patients with penetrating colon trauma. (144) They concluded that both cefoxitin and the tobramycin/clindamycin combination were superior to cefamandole. In 1992, Fabian compared cefoxitin to cefotetan directly. His study included 515 patients, and he found no difference in efficacy between the two agents. (145)

While cefoxitin and cefotetan appear to be equal in efficacy, the longer half-life and comparable cost make cefotetan a better choice. Cefoxitin remains a viable alternative and a good second choice.

Cardiopulmonary resuscitation of a battlefield casualty who has suffered blast or penetrating trauma is not appropriate. (31,146) Prehospital resuscitation of trauma patients in cardiac arrest has been fraught with futility even in urban settings where the victim is in close proximity to trauma centers. For example, Branney and colleagues reported a 2% survival rate (14 of 708) among patients receiving emergency department thoracotomy who arrived at the emergency department with absent vital signs. (147) In a more recent study, Rosemurgy, Norris, et al reported no survivors out of 138 trauma patients who suffered a prehospital cardiac arrest in whom resuscitation was attempted. (148) The authors recommended that resuscitation of trauma victims in cardiopulmonary arrest not be attempted even in the civilian prehospital setting, primarily because of the large economic cost entailed in these uniformly unsuccessful attempts. In the tactical combat setting, the cost of attempting to resuscitate patients with inevitably fatal wounds will be measured in additional lives lost as combat medical personnel are exposed to hostile fire during resuscitation efforts, and care is withheld from casualties with potentially survivable wounds. Successful completion of the unit's mission may also be unnecessarily jeopardized by these efforts. Only in the case of non-traumatic disorders such as hypothermia, near drowning, or electrocution, should cardiopulmonary resuscitation be performed in the tactical prehospital setting.

CASEVAC Care

The use of a CASEVAC asset to evacuate the wounded from the battlefield presents the opportunity to bring in additional medical equipment and personnel to treat the casualties. This opportunity led to the recommendation to establish designated Combat Casualty Transportation Teams for Special Operations forces. (31) This additional medical expertise and equipment will allow for the expanded diagnostic and therapeutic measures outlined in Table 3 for the CASEVAC phase of care.

Care in this phase more closely approximates ATLS guidelines. The opportunity to carry additional equipment and a (possibly) more favorable environment in which to work make a more varied selection of airway management interventions possible. Endotracheal intubation, the laryngeal mask airway (149), the intubating laryngeal mask airway (150), and the esophageal-tracheal combitube (151) are all potentially feasible alternatives in this phase if the nasopharyngeal airway is insufficient to manage the airway. Schwartz and his colleagues reported success in performing endotracheal intubation with the aid of night vision goggles. (152) Surgical cricothyroidotomy remains a valuable option if needed. (153)

Several improvements in fluid resuscitation may be possible in the CASEVAC phase. Electronic monitoring, if available, may yield a better understanding of the casualty's status. Casualties with traumatic brain injuries should be maintained with a systolic blood pressure of 90 mmHg or higher in this phase. Asanguinous fluids restore blood volume, but do not replace oxygen-carrying capacity. When logistically feasible, O-positive or negative packed red blood cells should be available in this phase for use when indicated and under appropriate protocols. Rhesus factor compatibility is an issue only in females with reproductive capability. Both the British Special Air Service (personal communication – Dr. John Naevin, former 22cd SAS Regimental Surgeon) and the IDF (154) have used PRBCs successfully in casualty transport platforms. Israeli medical personnel store the PRBCs in a special field refrigerator that maintains a temperature between 1^{o} C and 6^{o} C, and expand them with 250 ml of saline solution before administration. (154) Use of PRBCs in the field has had an excellent safety record in the IDF. (154)

The potential for casualties to develop hypothermia and a secondary coagulopathy (155) makes adequate warming an important function in preparation for and during CASEVAC. Concomitant use of the Thermal Angel™ device, the Rescue Wrap™, and gel heaters has been employed in combat operations in both fixed-wing and rotary aircraft. This combination has proven able to increase a casualty's temperature in ambient temperatures below freezing. (Personal communication – TSgt Steve Cum)

The proposal for Combat Casualty Transportation Teams and the additional care that they provide should be evaluated by the conventional forces for applicability in their units.

Scenario-Based Training

Despite the effort that has gone into developing a combat-appropriate trauma management plan, the bottom line remains that no single plan will suffice for all situations. This realization led to the concept of scenario-based management plans (31). Representative scenarios are presented in Figures 3-10. The medical and tactical issues to be addressed in most of these scenarios have been addressed previously (156, 157). Figures 3 and 4 are from the Mogadishu action on 3 October 1993. This engagement resulted in the greatest number of US casualties in a single firefight since Vietnam (18 dead, 73 wounded). In addition, there was a delay of 15 hours before the first wounded were evacuated to a Combat Support Hospital. Scenarios like these, based on actual past events, help to raise the level of interest in ensuing discussions.

Figures 5-7 deal with a parachute insertion and subsequent land warfare phase, with injuries of different magnitudes sustained upon landing. The medical care of these casualties is relatively straightforward, but they require difficult tactical decisions of the mission commander.

Figures 8-10 deal with casualty scenarios that occur during diving operations. This is a very important aspect of the training for SEAL and Marine Reconnaissance mission commanders because the underwater environment has such a large impact on casualty management, and because this area is not addressed in civilian medical literature.

As one examines these scenarios, it becomes apparent that the appropriate care for a casualty may vary based on how critical the mission is, the anticipated time to evacuation, and the environment in which the casualty occurs. Any management plan for a combat casualty discussed in the planning phase should be considered advisory rather than directive in nature, since only infrequently will an actual casualty situation unfold exactly as anticipated. It is obviously not possible to plan for every casualty scenario that may occur, but review of several casualty scenarios most appropriate for an impending operation is a valuable exercise in the planning process.

TCCC Skills List

Individuals other than medics may be called upon to provide medical care on the battlefield. Each combatant should be able to perform life-saving interventions such as the application of a tourniquet, and simple tasks such as self-administration of oral antibiotics and analgesics. This is the goal of an Army program called "Combat Lifesaver" in which non-medics receive basic medical training in specified life-saving skills. A list of each type of potential first responder, and the skills that each should possess is provided in Table 4.

Tactical Medicine for Small Unit Mission Commanders

Although the TCCC protocol is gaining increasing acceptance throughout the U.S. Department of Defense and allied military forces (158-165), this protocol by itself is not adequate training for the management of combat trauma in the tactical environment. Since casualty scenarios in small-unit operations entail tactical problems as well as medical ones, the appropriate management plan for a particular casualty must be developed with an appreciation for the entire tactical situation. (31) This approach has been developed through a series of workshops carried out by SOF medical personnel in association with appropriate medical specialty groups such as the Undersea and Hyperbaric Medical Society, the Wilderness Medical Society, and the Special Operations Medical Association. (156, 157, 46)

The most recent of these workshops, which addressed the Tactical Management of Urban Warfare Casualties in Special Operations, noted that several of the casualty scenarios studied from the Mogadishu action in 1993 (166) had very important tactical implications for the mission commanders. (46) The unconscious fast-rope fall victim in Figure 3 resulted in a decision by the mission commander to split the forces in his ground convoy, detaching 3 of the 12 vehicles to take the casualty back to base immediately, leaving the remaining 9 to extract the rest of the troops. The helicopter crash described in Figure 4 resulted in the pilot's body being trapped in the wreck. Several discrete elements from the target building suffered multiple casualties as they moved towards the crash site to assist. The casualties eventually outnumbered those who were able to maneuver, forcing the elements to remain stationary, and preventing them from consolidating their forces. When a rescue convoy finally reached the embattled troops at the crash site, there was a delay of approximately 3 hours while the force worked feverishly to free the trapped body. Several hundred troops and over 25 vehicles were vulnerable to counterattack during this period. These scenarios made it obvious to members of the workshop panel that training only combat medics in tactical medicine is not enough. McRaven has compiled accounts of a number of special operations that may be used for scenario development. (167) If tactical medicine involves complex decisions about both tactics and medicine, then we must train the tactical decision makers – the mission commanders - as well as combat medical personnel in this area. (46) A customized course in Tactical Medicine for SEAL and Ranger Mission Commanders has been developed and incorporated into the training for mission commanders in those units. The Tactical Medicine course provides a rationale for why mission commanders need training in this area. While it is true that the combat medic takes care of the casualty, the mission commander runs the mission, and ***what's best for the casualty and what's best for the mission may be in direct conflict.*** The question is often not just whether or not the mission can be completed successfully without the wounded individual(s); the issue may well be that continuing the mission will adversely affect the outcome for the casualty. If the mission is to be successfully accomplished, the mission commander may have to make some very difficult decisions about the care and movement of casualties. Additional reasons to train mission commanders in tactical medicine include: 1) the importance of having the commander know that the care provided in TCCC may be substantially different than the care provided for the same injury in a non-combat setting; 2) the unit may be employed in such a way that there is no corpsman, medic, or PJ immediately available to the injured individual; and 3) the corpsman, medic or PJ may be the first team member shot.

Although the use of helmets and body armor are not feasible for every combat operation, the Mogadishu experience documents the efficacy of individual protective clothing in preventing potentially lethal injuries. (36) Tactical Medicine training should emphasize the benefits of these devices where operationally feasible.

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Table 1

Basic TCCC Management Plan
Care Under Fire

1. Expect casualty to stay engaged as a combatant if appropriate

2. Return fire as directed or required

3. Try to keep yourself from being shot

4. Try to keep the casualty from sustaining additional wounds

5. Airway management is generally best deferred until the Tactical Field Care phase

6. Stop any life-threatening external hemorrhage:
    - Use a tourniquet for extremity hemorrhage
    - For non-extremity wounds, apply pressure and/or a HemCon® dressing

7. Communicate with the patient if possible
    - Offer reassurance, encouragement
    - Explain first aid actions

Table 2

Basic TCCC Management Plan
Tactical Field Care

1. Casualties with an altered mental status should be disarmed immediately

2. Airway management
   - Unconscious casualty without airway obstruction:
     - Chin-lift or jaw-thrust
     - Nasopharyngeal airway
     - Place casualty in recovery position
   - Casualty with airway obstruction or impending airway obstruction
     - Chin-lift or jaw-thrust
     - Nasopharyngeal airway
     - Place casualty in recovery position
     - Surgical cricothyroidotomy (with lidocaine if conscious) if above measures unsuccessful
   - Spinal immobilization is not necessary for casualties with penetrating trauma

3. Breathing
   - Consider tension pneumothorax and decompress with needle thoracostomy if casualty has torso trauma and respiratory distress
   - Sucking chest wounds should be treated by applying a vaseline gauze during expiration, covering it with tape or a field dressing, placing the casualty in the sitting position, and monitoring for development of a tension pneumothorax

4. Bleeding
   - Assess for unrecognized hemorrhage and control all sources of bleeding
   - Assess for discontinuation of tourniquets after application of hemostatic dressing (HemCon®) or a pressure dressing

5. IV
   - Start an 18-gauge IV or saline lock, if indicated
   - If resuscitation is required and IV access is not obtainable, use the intraosseous route

Table 2

Basic TCCC Management Plan
Tactical Field Care
(continued)

6. Fluid resuscitation
    Assess for hemorrhagic shock; altered metal status in the absence of head injury and weak or absent peripheral pulses are the best field indicators of shock
    - If not in shock:
        No IV fluids necessary
        PO fluids permissible if conscious
    - If in shock:
        Hextend 500cc IV bolus
        Repeat once after 30 minutes if still in shock
        No more than 1000cc of Hextend
    - Continued efforts to resuscitate must be weighed against logistical and tactical considerations and the risk of incurring further casualties
    - If a casualty with TBI is unconscious and has no peripheral pulse, resuscitate to restore the radial pulse

7. Inspect and dress known wounds

8. Check for additional wounds

9. Analgesia as necessary
    - Able to fight:
        Rofecoxib 50mg po qd
        Acetaminophen 1000mg po q6h
    - Unable to fight:
        Morphine 5 mg IV/IO
        Reassess in 10 minutes
        Repeat dose q10min as necessary to control severe pain
        Monitor for respiratory depression
        Promethazine 25 mg IV/IO/IM q4h

10. Splint fractures and recheck pulse

11. Antibiotics: Recommended for all open combat wounds
    - Gatifloxacin 400 mg PO qd
    - If unable to take PO (shock, unconscious, or penetrating torso injuries)
        cefotetan 2 gm IV (slow push over 3-5 minutes) or IM q12 hours

Table 2

Basic TCCC Management Plan
Tactical Field Care
(continued)

12. Communicate with the patient if possible
    - Encourage, reassure
    - Explain care

13. Cardiopulmonary resuscitation

    Resuscitation on the battlefield for victims of blast or penetrating trauma who have no pulse, no respirations, and no other signs of life will not be successful and should not be attempted.

Table 3

Basic TCCC Management Plan
Combat Casualty Evacuation (CASEVAC) Care

1. Airway management
   - Unconscious casualty without airway obstruction:
     - Chin-lift or jaw-thrust
     - Nasopharyngeal airway
     - Place casualty in recovery position
   - Casualty with airway obstruction or impending airway obstruction:
     - Chin-lift or jaw-thrust
     - Nasopharyngeal airway
     - Place casualty in recovery position
     - or
     - Laryngeal mask airway/ ILMA
     - or
     - Combitube
     - or
     - Endotracheal intubation
     - or
     - Surgical cricothyroidotomy (with lidocaine if conscious)
   - Spinal immobilization is not necessary for casualties with penetrating trauma

2. Breathing
   - Consider tension pneumothorax and decompress with needle thoracostomy if casualty has torso trauma and respiratory distress
   - Consider chest tube insertion if no improvement and/or long transport anticipated
   - Most combat casualties do not require oxygen, but administration of oxygen may be of benefit for the following types of casualties:
     - Low oxygen saturation by pulse oximetry
     - Injuries associated with impaired oxygenation
     - Unconscious patient
     - TBI patients (maintain oxygen saturation > 90)
   - Sucking chest wounds should be treated with a vaseline gauze applied during expiration, covering it with tape or a field dressing, placing the casualty in the sitting position, and monitoring for the development of a tension pneumothorax

3. Bleeding
   - Reassess for unrecognized hemorrhage and control all sources of bleeding
   - Assess for discontinuation of tourniquets after application of hemostatic dressing (HemCon®) or a pressure dressing

Table 3

Basic TCCC Management Plan
Combat Casualty Evacuation (CASEVAC) Care
(continued)

4. IV
   - Reassess need for IV access
   - If indicated, start an 18-gauge IV or saline lock
   - If resuscitation is required and IV access is not obtainable, use intraosseous route

5. Fluid resuscitation
   - Reassess for hemorrhagic shock
     Altered mental status (in the absence of brain injury) and/or abnormal vital signs
   - If not in shock:
     IV fluids not necessary
     PO fluids permissible if conscious
   - If in shock:
     Hextend 500cc IV bolus
     Repeat after 30 minutes if still in shock
     Continue resuscitation with PRBC, Hextend, or LR as indicated
   - If a casualty with TBI is unconscious and has no peripheral pulse, resuscitate as necessary to maintain a systolic blood pressure of 90mm Hg or above

6. Monitoring
   - Institute electronic monitoring of pulse oximetry and vital signs if indicated

7. Inspect and dress wound if not already done

8. Check for additional wounds

9. Analgesia as necessary
   - Able to fight:
     Rofecoxib 50mg po qd
     Acetaminophen 1000mg po q6h
   - Unable to fight:
     Morphine 5 mg IV/IO
     Reassess in 10 minutes
     Repeat dose q10min as necessary to control severe pain
     Monitor for respiratory depression
     Promethazine 25 mg IV/IO/IM q4h

10. Reassess fractures and recheck pulses

Table 3

Basic TCCC Management Plan
Combat Casualty Evacuation (CASEVAC) Care
(continued)

11. Antibiotics: Recommended for all open combat wounds
    - Gatifloxacin 400 mg PO qd
    - If unable to take PO (shock, unconscious, or penetrating torso injuries)
        IV cefotetan 2 gm IV (slow push over 3-5 minutes) or IM q12 hours

12. MAST trousers may be useful for stabilizing pelvic fractures and controlling pelvic and abdominal bleeding. Their application and extended use must be carefully monitored. They are contra-indicated for casualties with thoracic and brain injuries.

Table 4

Tactical Combat Casualty Care Skills List

Skill	Individual Operator	Combat Lifesaver	Medic
Overview of Tactical Medicine Training	X	X	X
Hemostasis			
Apply tourniquet	X	X	X
Apply direct pressure	X	X	X
Apply HemCon® dressing	X	X	X
Apply MAST trousers			X
Casualty Transport Techniques	X	X	X
Airway			
Chin-lift/Jaw-thrust	X	X	X
Nasopharyngeal airway	X	X	X
Cricothyroidotomy			X
ILMA			X
Endotracheal Intubation			X
Combitube			X
Breathing			
Needle thoracostomy		X	X
Treat open pneumothorax	X	X	X
Chest tube			X
Administer oxygen			X
Intravenous access/therapy			
Assess for shock	X	X	X
Start an IV/saline lock		X	X
Obtain intraosseous access			X
IV fluid resuscitation		X	X
IV analgesia			X
IV antibiotics			X
Administer PRBCs			X

Table 4

Tactical Combat Casualty Care Skills List

(continued)

Skill	Individual Operator	Combat Lifesaver	Medic
Intramuscular therapy			
IM morphine	X	X	X
IM antibiotics			X
Oral antibiotics	X	X	X
Oral analgesia	X	X	X
Fracture management			
Splinting	X	X	X
Traction splinting		X	X
Electronic monitoring			X

Figure 1

Movement of Casualties

Care Under Fire

Usually, the best first step in saving a casualty is to control the tactical situation. Casualties who are able to, should move to cover without assistance so as not to expose a rescuer to unnecessary risk. If a casualty is unable to move and is unresponsive, he is likely beyond help, and risking the lives of rescuers is not warranted. If a casualty is responsive and unable to move, then a rescue plan should be developed. First, determine the potential risk to the rescuers, keeping in mind that **rescuers should not move into a zeroed-in position**. Did the casualty trip a booby trap or mine? Where is fire coming from? Is it direct or indirect (i.e. rifle, machinegun, grenade, mortar, etc.)? Are there electrical, fire, chemical, water, mechanical, or other environmental hazards? Next, consider assets. What can rescuers provide in the way of covering fire, screening, shielding, and rescue-applicable equipment?. Third, make sure everyone understands their role in the rescue and which movement technique is to be used, i.e. drag, carry, rope, stretcher, etc. If possible, let the casualty know what the plan is so that he can assist as much as possible by rolling to a certain position, attaching a drag line to web gear, identifying hazards, etc. The fastest method for moving a casualty is dragging along the long axis of the body by two rescuers. This drag can be used in buildings, shallow water, snow, and down stairs. It can be accomplished with the rescuers standing or crawling. The use of the casualty's web gear, tactical vest, a drag line, poncho, clothing or improvised harness makes this method easier. However, holding the casualty under the arms is all that is necessary. A one-rescuer drag can be used for short distances, but is more difficult for the rescuer, is slower, and is less controlled. The great disadvantage of dragging is that the casualty is in contact with the ground, and this can cause additional injury in rough terrain. The fireman's carry can be used, but it may expose too much of the rescuer and the casualty to hostile fire. Otherwise, it can be used over rough terrain with potentially less injury to the casualty from contact with the ground.

Tactical Field Care

Once the tactical situation is controlled or the casualty has been moved to cover, further movement should be easier. The casualty can be disarmed, and mission essential gear distributed to other team members. Here again, the fireman's carry can be used for short distances, but is very exhausting for both the casualty and the rescuer. If the casualty is conscious, a saddleback carry can be used. It, however, is less stable and more difficult for the rescuer. The two-man carry is accomplished by having the casualty sit on a rifle, board, pack-frame or other object, which is then carried by a rescuer on either side. If the casualty can hold on to the rescuers, then each rescuer will have one arm free to fire a weapon or move obstacles. If the casualty cannot hold on, then the rescuers can take turns holding the casualty. The two-man fore-and–aft carry can be used in narrow areas, but it does not allow either rescuer a free hand. For longer distances, a conventional or improvised litter should be used. Either the Sked™ or Stokes™ basket make better litters for rough terrain, building interiors, or areas where the litter must be raised or lowered more than 3 meters. These litters can be dragged by two rescuers if necessary,

Figure 1

Movement of Casualties

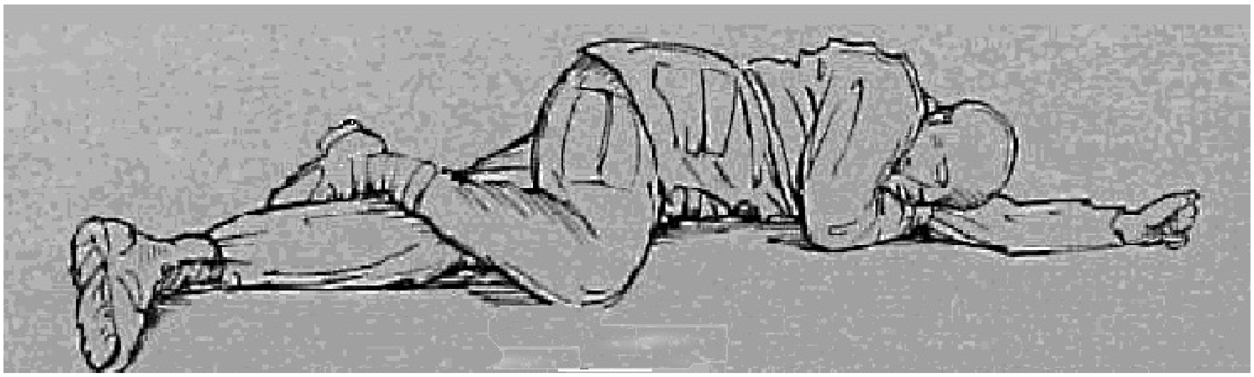
(continued)

rather than carried by four. The folding litter or a body bag are the next best options, but have little or no support for the casualty's spine, and are difficult to drag by two rescuers. The Army litter has no good way to restrain the casualty and is difficult to use over rough terrain. An improvised litter can be made from a poncho, poncho liner, blanket, field jackets, doors, or many other materials that may be available. If the casualty is a victim of blunt trauma and spinal injury is suspected, then rigid support may be better than non-rigid. A cervical collar can be improvised from a SAM splint or other material and applied to the casualty before moving. When moving casualties long distances, tourniquets, dressings, splints and IV lines should be checked periodically to assure they are intact. Casualties should be protected as much as possible from the elements (sun, rain, wind, cold, snow, blowing sand, insects) during transport, and observed for signs of hypothermia, dehydration and heat illness.

CASEVAC Care

Conventional litters should be available during this phase. The casualty should be made as comfortable as possible, and kept warm and dry. If an improvised litter is used, it should be padded and field expedient material replaced with conventional splints, tourniquets, dressings, etc. as soon as feasible. If decontamination is needed, it should be carried out prior to evacuation, if tactically feasible.

Figure 2



The semiprone recovery position.

Figure 3

Urban Warfare Scenario – Fast Rope Casualty

- **16 man Ranger team – security element for building assault**
- **70 foot fast rope insertion**
- **One man misses rope and falls**
- **Unconscious**
- **Bleeding from mouth and ears**
- **Taking fire from all directions from hostile crowds**
- **Anticipated extraction by ground convoy in 30 minutes**

Figure 4

<u>Urban Warfare Scenario - Helo Hit by RPG Round</u>

- **Hostile and well-armed (AK-47s, RPG) enemy in urban environment**
- **Building assault to capture members of a hostile clan**
- **In Blackhawk helicopter trying to cover helo crash site**
- **Flying at 300 foot altitude**
- **Left door gunner with 6 barrel M-134 minigun (4000 rpm)**
- **Hit in hand by ground fire**
- **Another crew member takes over mini-gun**
- **RPG round impacts under right door gunner**
- **Windshields blown out**
- **Smoke filling aircraft**
- **Right minigun not functioning**
- **Left minigun without a gunner and firing uncontrolled**
- **Pilot**
  Transiently unconscious - now becoming alert
- **Co-pilot**
  Unconscious - lying forward on helo's controls
- **Crew Member**
  Leg blown off
  Lying in puddle of his own blood
  Femoral bleeding

Figure 5

Tib/Fib Fracture on Parachute Insertion

- **Twelve man SF team**
- **Interdiction operation for weapons convoy**
- **Night parachute jump from a C-130**
- **4-mile patrol over rocky terrain to the objective**
- **Planned helicopter extract near target**
- **One jumper sustains an open fracture of his left tibia and fibula on landing**

Figure 6

<u>Multiple Trauma from Parachute Collapse</u>

- **16 man SF team**
- **Interdiction operation on a weapons convoy**
- **Night static line jump from C-130**
- **4 mile patrol over rocky terrain to objective**
- **Planned helicopter extraction near target**
- **One jumper has canopy collapse 40 feet above the drop zone**
  Open facial fractures with blood and teeth in the oropharynx
  Bilateral ankle fractures
  Open angulated fracture of the left femur

Figure 7

<u>Fatality from Parachute Malfunction</u>

- **16 man SF team**
- **Interdiction operation on a weapons convoy**
- **Night static line jump from C-130**
- **4 mile patrol over rocky terrain to objective**
- **Planned helicopter extraction near target**
- **One jumper has streamer**
  Obviously dead on DZ

Figure 8

Underwater Explosion on Ship Attack

- **Ship attack**
- **Launch from PC 12 miles out**
- **One hour transit in two Zodiacs**
- **Seven SEAL swim pairs**
- **Zodiacs approach to within one mile from the harbor**
- **Turtleback half mile, then purge and go on bag**
- **Charge dropped in water by hostile forces at target ship**
- **Swim buddy unconscious**

Figure 9

CNS Oxygen Toxicity during Ship Attack

- **Launch from PC 12 miles out**
- **One hour transit in two Zodiacs**
- **Seven SEAL swim pairs**
- **Zodiacs approach to within one mile from the harbor**
- **78 degree water - wet suits**
- **Turtleback half-mile, then go on bag**
- **Very clear, still night - transit depth 25 feet**
- **Diver notes that buddy is disoriented and confused with arm twitching**

Figure 10

<u>Gunshot Wound Prior to SEAL Delivery Vehicle Extraction</u>

- **Two SEAL Delivery Vehicle operation**
- **Insertion from Dry Deck Shelter with two-hour transit to beach**
- **Target is a heavily defended harbor in a bay**
- **43 degree water - divers wearing dry suits**
- **Air temperature 35 degrees**
- **Boats bottomed for across-the-beach radio beacon placement**
- **One man shot in chest at the objective**
- **Hostile forces in pursuit**