# Chapter 1
# Prehospital and Enroute Care

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*Deployment Experience*:

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**BLUF Box (Bottom Line Up Front)**

1. On the modern battlefield, the top three causes of death that the pre-hospital provider can prevent are extremity hemorrhage, tension pneumothorax, and airway loss.
2. Use of the mnemonics "CAB" or more preferably "MARCH" can ensure that all pre-hospital combat casualty provider tasks are accomplished.
3. Frequent training, both pre-deployment and in-theater, can minimize provider stress and maximize success in real world scenarios.
4. Tourniquets work; use them. Ensure hemorrhage is stopped AND distal pulse is eradicated. If initial tourniquet is inadequate, add a second proximal to the first.
5. Three and a half inch 14 gauge angiocatheters are now standard for needle decompression of tension pneumothorax.
6. If standard endotracheal intubation isn't working, move on. Use the airway with which you are most familiar.
7. Hemostatic dressings (i.e. Combat Gauze) are effective and superior to standard gauze, particularly for bleeding cavitary wounds: Use Them!
8. Hypothermia management should start in the pre-hospital setting; the Hypothermia Prevention and Management Kit (HPMK)™ works.
9. Minimize any non-lifesaving interventions that will delay transport to a facility with surgical capabilities, they waste time and lives.

*"The fate of the wounded lays with those who apply the first dressing."*

COL Nicholas Senn

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Prehospital and enroute care of a casualty can have a significant effect on both mortality and morbidity. The goal of a prehospital provider is to do whatever is possible to mitigate both of these outcomes. When reviewing the causes of death from the Vietnam War through Operations Enduring and Iraqi Freedom we see little change. The most common causes of death are: torso injury 35%, killed in action (KIA) from CNS injury 31%, Multi System Organ Failure (MSOF) 12%, extremity hemorrhage 9%, tension pneumothorax 5%, and airway 1%.

The most common cause of PREVENTABLE death on the battlefield is bleeding, followed by tension pneumothorax. These are the areas that a front line provider can influence and are therefore the reason that so much effort has been spent on prehospital and particularly Tactical Combat Casualty Care (TCCC) development and instruction. Although not an immediate cause of death, hypothermia has a critical effect on survivability both acutely and in the later incidence of MSOF. The first responders can greatly affect a patient's survival by taking steps to prevent hypothermia from the time of initial injury. The efficacy of TCCC has recently been demonstrated in the retrospective case analysis of several special operations units which found no instances of preventable prehospital deaths within those units once TCCC was fully utilized.

## Critical Tasks and Priorities

Critical tasks for a first responder involve addressing all of the potentially treatable causes of mortality. While standard civilian priority has been based on the ABCs, the present approach to combat trauma by military providers makes control of significant hemorrhage a first priority rather than airway issues. This is based on the fact that you can bleed out faster from an arterial injury than an airway issue can kill you. This is a paradox that is rarely ever encountered in civilian trauma care.

In all cases you must first control any life-threatening hemorrhage. This is done with either a tourniquet if an extremity is involved or a hemostatic agent and pressure dressing on an area not amenable to a tourniquet, such as the chest, abdomen, buttock, neck, axilla or high groin. The current conflicts have demonstrated the incredible impact of the simple extremity tourniquet, and you should familiarize yourself with the devices currently being used. Unfortunately we do not have so simple a solution for the control of non-compressible hemorrhage, which is now the number one potentially preventable killer on the battlefield. Once hemorrhage control has been addressed, the airway is the next priority; this will be discussed in more detail later. Breathing issues are treated third, with occlusion of chest wounds and needle decompression of suspected tension pneumothorax. Use them liberally, no one has died from a thoracic needle but many have died of a tension pneumothorax without them.

The secondary survey is then undertaken with consideration of all wounds, hypothermia prevention, pain control and use of antibiotics. As opposed to the

civilian ATLS approach mnemonic of "**ABC**" the TCCC approach to combat care is described by the mnemonic "**CAB**".

CAB

**C**irculation: Control arterial bleeding with a tourniquet or hemostatic agent and wound packing in areas not amenable to a tourniquet.

**A**irway: Treat airway issues.

**B**reathing: Seal chest wounds and treat tension pneumothorax.

A slightly different approach is taken by some special operations forces and several NATO countries, who utilize the mnemonic "**MARCH**" to give the appropriate, prioritized approach to casualties. This approach is more logical and utilitarian as it addresses everything the prehospital provider can do to treat a casualty, though either method will work.

MARCH

**M**assive hemorrhage – place tourniquet, or hemostatic agent in area that a tourniquet cannot be used.

**A**irway – control with simple technique vs. cricothyroidotomy vs. supraglottic airway or intubation.

**R**espiration – seal chest wound and decompress if needed

**C**irculation – place IV access, utilize intra-osseus access if needed, and utilize hypotensive resuscitation. WITHOLD fluids if awake, mentating, and palpable radial pulse.

**H**ypothermia – Put the patient in an HPMK™ (Hypothermia Prevention and Management Kit™) or "burrito" wrap.

## Psychology of Prehospital Care

The combat prehospital environment is often well outside the comfort zone of most providers and even trained civilian medics. The battlefield is dirty, chaotic, and dangerous with prehospital care often being delivered under adverse conditions or hostile fire (Fig. 1.1). As such, one may have initial difficulty in applying what one actually knows. While the knowledge of what to do has been learned, it has often never been practiced and it is therefore not uncommon, at least initially, for one to "vapor lock" with the first prehospital exposure to the injured individual. This can be minimized through the use of repetitive prehospital training utilizing simulations and animal models. Practice drills immediately on arrival in theater can help in this regard as well. When this has not been possible, the best advice is to narrow the thought process to **MARCH** and concentrate on following it. This will ensure the critical tasks are accomplished. You may have medics assigned to your unit or in close contact with your facility; many of them young and inexperienced. Share your knowledge and experience with them; training them as hard and as realistically as possible may save both their lives and that of their patients.


**Fig. 1.1** Images from prehospital care and evacuation in combat operations. (**a**) prehospital care being initiated while simultaneously returning hostile fire, (**b**) casualty awaiting helicopter evacuation in a dirty and dusty environment, and (**c**) helicopter evacuation from a rooftop in mountainous terrain

## Some Important Considerations for Treatment

### *Tourniquets (Fig. 1.2)*

Tourniquet use is now the standard for the military, and placement of tourniquets in the prehospital setting has been shown to decrease mortality 23% as compared to Emergency Department placement. They are the best initial choice for controlling

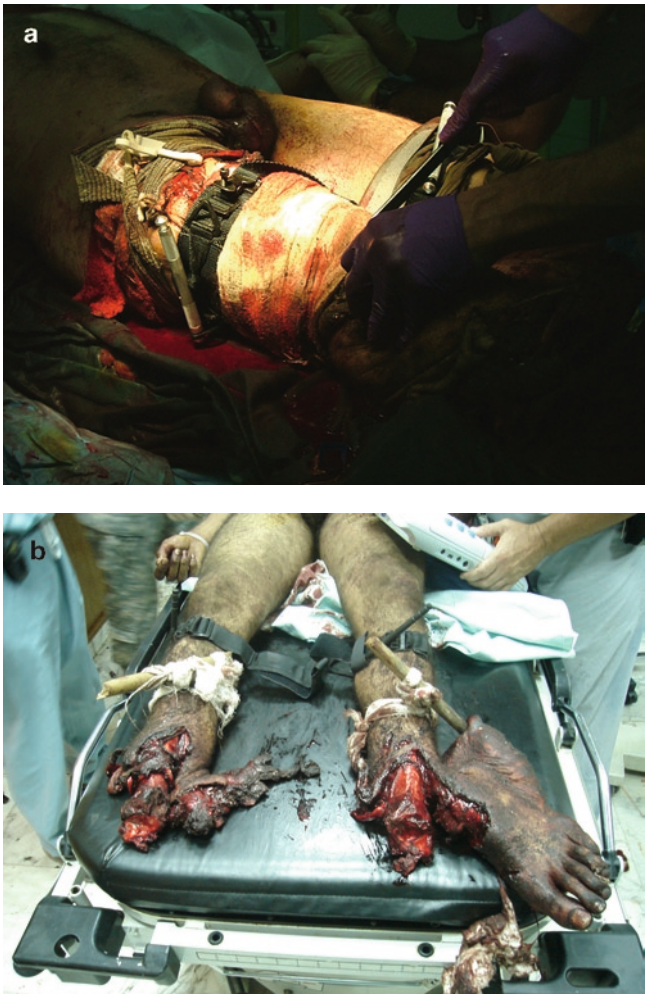


**Fig. 1.2** Extremity tourniquets on combat wounds. (**a**) Special operations forces tactical tourniquet (SOFT-T) correctly positioned on a mangled extremity. (**b**) Combat application tourniquet (CAT-1) placed by prehospital personnel on combat casualty with bilateral below knee traumatic amputations, full hemorrhage control provided for transport. Tourniquet can be placed and adjusted with one hand by the casualty if necessary

severe bleeding from an extremity. Do not use hemostatic dressings for the initial control of significant bleeding on an extremity. Place a tourniquet; control the bleeding; then during the secondary survey wounds can be specifically addressed. At this point the placement of a hemostatic dressing and bandage on an extremity can be tried and, if effective, then you can remove the tourniquet. You do not want to be losing blood initially while trying to get a good dressing in place; the prehospital provider strives to save the loss of every possible drop of blood! In combined cases of abdominal/chest penetrating injury and extremity hemorrhage, leave the tourniquet in place until the non-compressible injury is fixed.

Tourniquets must be placed with enough force to completely occlude the pulse if one is palpable distally. Failure to do so and apply only enough force to occlude venous flow can actually increase bleeding through a venous tourniquet effect. In the hypotensive individual with no distal pulse, crank the tourniquet up tight and be prepared to tighten it more as the casualty is resuscitated. If the initial tourniquet does not stop bleeding, place a second one proximal to the first. There have been rare problems reported with efficacy of a tourniquet on the forearm and tibia/fibula. If a tourniquet placed in these areas is ineffective then another should be placed proximally. The time of placement of a tourniquet should be noted in several locations: on the casualty as well as on the tourniquet (the new combat action tourniquets (CAT-1) have a location for this).

## *Thoracic Needle Decompression*

Needle thoracentesis of tension pneumothorax has several pitfalls. The most common problem with decompression is failure to reach the pleural cavity. This is the reason 3½in. 14 gauge catheters over a needle are now the Army standard. Another common issue that could lead to morbidity is placement of the needle too medially. It should be placed lateral to the mid-clavicular line, not medial to it. In cases of very large-chested individuals, the decompression can be attempted in the 5th intercostal space, mid-axillary line (the standard chest tube spot).

## *Airway Treatment*

Airway treatment usually requires either simple airway maneuvers or will require a surgical airway. In the data from Vietnam, airway compromise only represented 1% of preventable deaths. While this percentage increased to 11% in the small case series of SOF deaths in OEF/OIF, this study had a very small number of patients. This study's percentage may not represent the true percentage of casualties with airway compromise. Indeed, the last few years since this study was published seem to suggest that airway issues do actually represent only a small percentage of salvageable patients.

For most airway issues, patient positioning and the use of a nasal trumpet will be all that is required. When a more advanced airway is required, it is usually due to a head injury (with or without significant facial trauma) or burns with inhalational injury.

A head injury without facial trauma is the most common occasion you would want to use a supraglottic airway adjunct or perform intubation. One concern voiced with supraglottic airways (King LT, Combitube, LMA) is that they do not provide any airway protection from aspiration. This is a propagated falsehood. In all cases they provide some protection from aspiration and in many cases have been shown to provide nearly equivalent aspiration protection to endotracheal intubation, depending on the device. Concern for aspiration protection should not preclude the use a supraglottic airway in a patient who needs it, particularly in those who are not skilled in intubation. Don't let a patient die with an airway issue because you were afraid to put in a supraglottic device and instead tried several ineffective intubation attempts. **Use the airway that is most effective and with which you are most familiar**.

Head injury with facial trauma or facial trauma with airway issues alone will often require a cricothyroidotomy (Cric). This procedure can be performed with limited morbidity if one is trained. Crics should be practiced at every available opportunity, particularly when animal models are available. There is no simulator yet available that provides training similar to performing an actual cric. Special Forces medics who practice crics constantly have found that they can provide a definitive airway *in less than 1 min even when under fire*. A tracheal hook has been found to be essential for easing the difficulty of this procedure. The actual utility of the many cric kits available for use is unclear. The vast majority of crics actually performed in theater have been done with a #11 blade and a tracheal hook. What exact technique one uses is not important provided you have practiced it. Any adequately sized tube can be placed through the cricothyroid membrane to secure the airway, most commonly a small (6 or 7) cuffed endotracheal tube. **Make sure you secure this tube well or it will dislodge, usually at the worst possible time**.

In cases of facial trauma with bleeding, make sure you do something to protect the airway early, be it a supraglottic device, intubation if you are skilled at it, or a cric. The airway will become an issue if not addressed early. All burns with the potential for inhalational injury should also have a definitive airway placed early. A patient with burns and inhalation injury is the one case where you will need to go to intubation as soon as possible, as the supraglottic airways will not be effective as the airway becomes edematous and obstructed. In the case of a burn with long transport and inability to intubate, go to the cric.

## *IV Fluids for Resuscitation*

It is now accepted that low volume resuscitation is the standard in combat injuries with non-compressible hemorrhage. While ATLS still teaches full resuscitation with IV fluids in most cases, it now also provides for the provision of low volume resuscitation (also called hypotensive or hypovolemic resuscitation). Casualties with penetrating wounds of the abdomen or chest may have non-compressible hemorrhage.

In these cases resuscitation is minimized until definitive surgical care occurs. The goal is to provide enough resuscitation to prevent the onset of irreversible shock, and yet at the same time not increase blood pressure to the point where a forming clot is "blown off," thereby increasing bleeding. Rebleeding seems to occur at a systolic pressure above 85–90 mmHg, so this is the resuscitation goal for which to aim, but not higher. Thus in a hypotensive patient, intravenous fluid is given until this target BP of 85–90 mm is reached. Clinically (when no BP cuff is available) this is noted as the presence of a radial pulse and normal mental status. When this point is reached IV fluids are slowed to TKO unless the pressure drops again. The goal is to not overshoot this target blood pressure and cause increased bleeding.

## *Resuscitation Fluid Choice*

Most often, your choice of initial resuscitation fluid in the prehospital situation should be none, and the patient can be heplocked until hospital arrival. The choice of initial resuscitation with crystalloid vs. colloid in the combat prehospital setting is most often determined by its weight and size rather than by any science. At the present time, literature does not show a definitive advantage of one over another fluid type in the prehospital settings. The ideal fluid for prehospital resuscitation in combat should have the following properties: excellent volume expansion, lightweight and easily carried, durable packaging, and no adverse inflammatory or coagulation effects. The fluids that currently come closest to meeting these criteria are the hypertonic crystalloids (i.e. 3–7% saline) and colloid products, and have been recommended by several expert panels on combat fluid resuscitation.

Colloids or hypertonic saline are more commonly used in the prehospital setting when fluid must be borne on foot. This is because 1,000 cc of lactated ringers will result in only about 200–250 cc remaining in the intravascular space after its quick initial redistribution. Hetastarch, if given as a 500 cc bolus, results in 500–600 cc in the intravascular space as the colloid pulls fluid into this space. The literature to date also does not suggest any issue with giving a colloid to a dehydrated individual. The present TCCC recommends the colloid solution hextend. Hextend is hetastarch in a lactated ringer's solution. While hetastarch can inhibit platelet function, this is not an issue until approximately 1,500 cc have been given in a normal sized individual. Hence, a maximum dose of 1,000 cc of hextend is recommended by TCCC. Hypertonic saline has been recommended by the Institute of Medicine and several other expert panels. It provides excellent volume expansion with no coagulopathic effect, has a better inflammatory profile than standard crystalloid, and is also effective at lowering intra-cranial pressure in brain-injured patients. It should be given as a 100–250 cc bolus with repeat dosing as needed. Although serum sodium levels should be followed closely after administration, it has an excellent safety profile and the resultant hypernatremia is well tolerated and potentially even beneficial.

## En Route Considerations

There are several considerations prior to transport of a casualty and enroute. Secure the patient, the IV, the airway, and the tourniquet. They will come loose! You cannot do much on a helicopter! It is loud, constricted, and cold. At night you will have very little light available as most often you are flying under blackout conditions and cannot use white light which interferes with the pilot's night vision. A ground vehicle or ambulance, while less so, is also a difficult environment to work in. Anticipation and prevention are the keys to successful and safe patient transport.

### *Secure the Patient*

It seems axiomatic, but the frequency with which casualties are not secured in the transport vehicle is surprising. Perusal of the civilian literature reveals that the incidence in well-trained prehospital providers have been noted to be as high as 30%. In all cases the casualties should be secured to the stretcher, Skedco™, or whatever device they are being transported on. If the transport time is short and a tourniquet was placed, strongly consider leaving it on and in place. If bleeding has stopped prior to transport and it will be delayed, release the tourniquet but keep it in place so it can be reapplied in seconds. In a hypotensive patient with extremity wounds that are not bleeding consider placing a non-tightened tourniquet, so if bleeding starts during transport it can be cranked up immediately.

### *Airway*

Secure the airway!! While there are numerous devices out there to do so, none have been shown to be the best. Tape never works on its own – use it only to backup something else. Triple secure it. Make sure if you are using oxygen you have twice as much as you will need for the transport. While most casualties don't need oxygen, to run out during transport in those who do is an irretrievable error.

### *Be Wary of the IV Drip*

A bag will either stop working or will empty rapidly, which may not be what you want with low volume resuscitation. I have seen an individual with a chest wound who arrived hypotensive (SBP 80) and who initially put out only 150 cc of blood with chest tube placement at a level II facility subsequently lose over 1,000 cc from the chest tube when his IVs were inadvertently opened wide during helicopter transport. His BP increased to over 100 systolic with the above increase in bleeding. If you have a good working lines secure it very well and heparin lock any other lines. Excess lines pull, yank, or may give too much IV fluid.

## *Wound Dressing*

Dress all wounds before transport. Even small wounds may begin to bleed if a hypotensive patient becomes resuscitated just prior to or during transport. Apply a hemostatic dressing to any bleeding wounds and wrap securely. For cavitary wounds, pack the wound with a hemostatic dressing (i.e. Combat Gauze) and apply a pressure dressing or manually hold pressure.

## *Chest Decompression*

A needle decompressed chest may have the catheter kink during movement and transport. Keep an eye on the casualty and be prepared to decompress again. This is a place where on long transports a "decompression extender" such as an Urosil or other small gauge chest tube may have utility.

## *Hypothermia Prevention*

Prevention of hypothermia is crucial during transport. The air mass moving over a patient in flight causes significant convective heat loss even at high ambient temperatures. Remember this is one of the ways we cool patients in the ED, by fanning warm air over them!

The HPMKs™ work (Fig. 1.3). Use them for initial evacuation after injury, or whenever you are transporting patients between facilities. Open the heater element

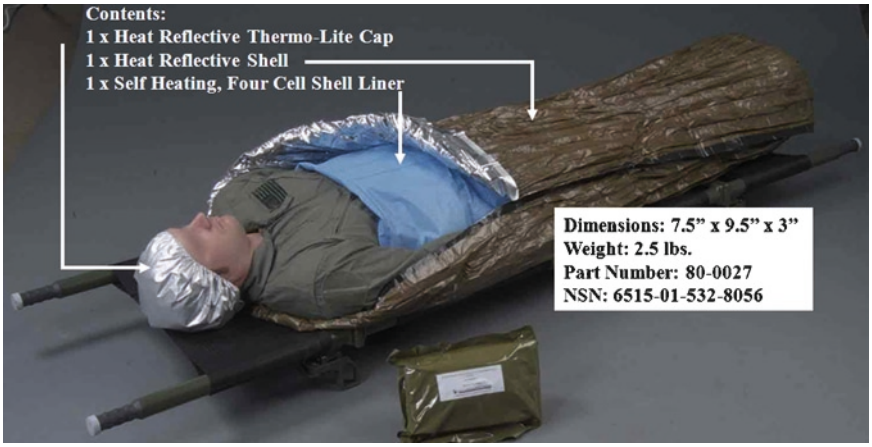


**Fig. 1.3** The currently fielded hypothermia prevention and management kit (HPMK™) provides excellent control of body temperature and prevention of heat loss during medical evacuation or inter-facility transfers

up ahead of time to allow it to "breathe" and activate. It is worth "burning through" heat cells you will not use to ensure you have one that will actually provide some heat. If you don't have an HPMK™, utilize a "burrito" hypothermia wrap using whatever blankets, sheets, etc that you have. Due to the psychological effects as well as the possibility of mis-triaging a casualty, **do not utilize actual body bags**.

## General Considerations

There are a number of general considerations for prehospital care.

### *Chest Seals*

There is still not a great chest seal available for pre-hospital treatment of open pneumothorax. Wipe and clean the chest as best as possible before using one. Do not let them dry out during storage, because they don't work as well. The original Asherman Chest seal, because of its poor adhesive, is basically worthless. This device would never stick to the chest of an actual casualty. The newer Asherman chest seal with the new military grade adhesive, as well as the newer chest seals such as the Bolin, HALO, Hyfin, H and H, and EOD grade hydrogel all have supporters and detractors. At the present time no one can be recommended over any other. In all cases, one side does not need to be left open. If respiratory distress develops, you will needle decompress the chest or place a chest tube.

### *Hemostatic Dressings (Fig. 1.4)*

The efficacy of all hemostatic agents previously and presently used has been great in animal studies, while in actual combat/patient use the efficacy has been variable. Hemostatic dressings can be broken down into generations of development. The first generation was the dry fibrin dressing which is no longer available. The second generation dressings are the original QuikClot powder and QuikClot sponge, the Hemcon chitosan bandage and chitoflex dressings, and Celox powder. All work in the right circumstances, all have good and bad anecdotal reports, and both Hemcon and QuikClot have human/combat case series of success. The original QuikClot powder has the problem of being painful and causing burns ranging from mild to severe. The original Hemcon works primarily through "sealing of a wound" and needs to be cut to a size that will allow it to seal the wound. Chitoflex is designed to be packed into a wound. This should be done quickly as it has been found to stick to the gloved hands if done in a slow methodic fashion.

The top choices at present are the third generation of agents. Combat Gauze, Celox Gauze, Chitogauze and possibly Traumastat. The current TCCC recommendation


**Fig. 1.4** Topical second (*top row*) and third generation (*bottom row*) hemostatic dressings. *Clockwise from top left*; (**a**) Hemcon chitosan wafer dressing, (**b**) QuikClot crystal zeolite powder, (**c**) Combat Gauze kaolin impregnated roll, and (**d**) Chitoflex dual-sided Chitosan roll dressing

based on available data is to use Combat Gauze, a gauze roll treated with kaolin. While a recommendation for treatment when Combat Gauze is not available is not specifically addressed by TCCC, we recommend you use whatever other third generation agent you have. If you don't have any third generation bandages use a second generation agent. You should also consider the type of wound that you are dealing with and whether it would be more amenable to a bandage-type dressing, a gauze-type dressing, or a topical powder. Whatever agent is used you should then cover it with a standard pressure dressing. Do not place the hemostatic agent and expect it to remain in place without a pressure dressing. Apply it and only remove and/or examine if it appears bleeding is continuing through it and the pressure dressing.

## *Chest Tubes*

There appears to be little support for the placement of chest tubes in the prehospital environment. Needle decompression will treat a tension pneumothorax. A simple pneumothorax will not kill someone. The lung will neither re-expand nor provide tamponade for pulmonary bleeding without added external suction. A chest tube placed in a dirty chaotic environment increases the likelihood of infection and improper placement. The time to consider prehospital chest tube placement would be in those cases where you will have a patient for a very prolonged time before they can be transported to a medical site with surgical capability. Present animal studies support the efficacy of needle decompression alone for up to 4 h.

Prehospital chest tubes or needle decompression extenders should be considered in cases where: evacuation is significantly delayed or will be extremely prolonged, in cases where needle decompression is ineffective despite multiple attempts, or when catheters recurrently clog or kink. Needle decompression extenders are smaller-sized devices used in lieu of a needle decompression or full-size chest tube. The Urosil, an 11 French trocar-placed device (FDA-approved for treatment of spontaneous PTX), has been used by at least one SOF unit. One allied country reports using neonatal chest tubes. The experience with these devices is limited, but theoretically they would be much more stable than a 14 gauge decompression catheter. All of these prehospital devices would be expected to be replaced with a true chest tube when the patient reaches definitive care.

## *Pre-hospital Antibiotics*

All combat wounds are inherently dirty, and while not replacing the requirement for adequate irrigation and cleaning, the provision of antibiotics early after wounding may improve ultimate outcome. TCCC presently recommends the provision of antibiotics if a casualty will be held for greater than 4 h. However many special operations units are giving oral antibiotics to any casualty who can take them shortly after wounding regardless of the time to transport. This inherently makes sense and more importantly there does not seem to be any evidence of a downside to this (such as increased antibiotic resistance). Based on this thought process, prehospital antibiotics may be given orally if the patient is conscious and does not have an abdominal wound. This is accomplished at present with the inclusion of antibiotics in the “combat pill pack” carried by some units. The antibiotic carried in the packs presently is moxifloxacin. This is an ideal agent, as quinolones are 99% bio-available orally, have a very low incidence of allergy, and cover the standard bacteria initially encountered in wounds. In cases where an individual cannot take oral agents, IV antibiotics can be given if time allows. Do not delay transport to do so.

## *Pain Control*

Pain control should be given if at all possible to all casualties. As mentioned, combat wound pill packs are being utilized by some units. For pain control these contain 1,000 mg of Tylenol and a 15 mg dose of meloxicam. Meloxicam is a predominantly Cox-2 non-steroidal anti-inflammatory drug so it does not affect platelet function. If a wounded soldier can take something by mouth, he opens the pill pack and takes all the medications. This provides some immediate pain relief without any negative effect on the CNS. This can enable the soldier to either continue the mission or at least aid in his care.

Narcotics remain the mainstay for significant pain relief. While IV and IM morphine are well-known and utilized, their use has been supplemented and superseded in some cases by the use of Oral Transmucosal Fentanyl Citrate (OTFC). The use of OTFC has become standard in SOF for those who can swallow and are conscious. Common side effects seen with the use of OTFC include nausea and pruritis, (up to 30 and 15% incidence in some studies). For this reason, ondansetron oral dissolving tablets are often routinely given with the OTFC lozenge. Experience to date indicates that 800 mcg is usually needed to help with pain. This can be given as a 400 mcg lozenge repeated ×1 or as a single 800 mcg. An example of OTFC use from early OIF:

> Nine patients required care for extremity fractures simultaneously. Due to the tactical situation, the placement of IVs was, at best, difficult. Of the nine patients, seven had significant fractures and all had significant pain. All were given OTFC with 90% plus reduction in pain within 15 minutes. Several fell asleep but maintained airway reflexes and oxygen saturation. Two, however, fell asleep with the "lollipop stick" hanging out of their mouth.

Based on this episode and similar experiences, it is recommended that the lozenges should be taped to the finger of the user in the event the individual becomes somnolent.

## *Ketamine*

Another agent to consider utilizing is low dose ketamine. It is effective at pain control in doses much lower than that utilized for sedation. The usual dose used for pain is 0.1–0.2 mg/Kg titrated to effect. It is an ideal agent as it protects airway reflexes and has a huge therapeutic window. While not specifically studied, its use for pain control should be avoided in those with head and ocular injuries. Those given ketamine should have weapons removed from them due to its dissociative affects.

## *Recombinant Factor VIIa*

The prehospital use of recombinant factor VIIa has been advocated by some, and in at least one case utilized, but this is only by very highly trained individuals with intimate knowledge of factor VIIa. There is not yet a definitive protocol that

balances the benefits vs. the risks of prehospital factor VIIa. The determination of when it has benefit in the prehospital setting requires significant experience and training and its use is not recommended for most prehospital providers.

There are some considerations with factor VII storage and transport. Previously factor VII was considered to require refrigeration; however, the new shelf-stable version is good if maintained at room temperature. Even with the original factor VII, prior to reconstitution it would maintain decreasing efficacy for up to 72 h after it had been removed from refrigeration. The hotter it is, the quicker it degrades. Possibly, the sooner after wounding the factor VII is given the more efficacious it is, as it does not work well at all in an acidotic or thrombocytopenic patient. Its efficacy is not readily affected by hypothermia, at least down to a core temperature of 28°C.

### *Prehospital Blood and Plasma*

Neither blood nor plasma are utilized routinely in the prehospital environment due to the storage requirements. In limited cases where a casualty has to be held for a prolonged period of time (weathered out at a CCP in the Afghanistan mountains), there is benefit to having blood and plasma available. In pre-planned circumstances, several devices are currently available for appropriate short term storage of blood products. In these cases, a plan for warming and thawing must be generated. In situations that are unplanned, the best option would be to provide whole blood. For this reason transfusion sets should be available and whole blood donation and transfusion practiced!! Literature to date shows no cases of severe transfusion reaction when whole blood use is matched based solely on dog tag data. Whole blood offers the advantage of giving oxygen carrying capacity, clotting factors, and warmth to the casualty, though at the slightly increased risk of a blood-borne infection.

One of the most promising areas of current research that will likely translate to battlefield use involves blood product preparations that are suitable for forward use. This involves processing and packaging that eliminates the need for refrigerated or special storage while preserving function and bioactivity. Lyophilized or "freeze-dried" plasma products are now in advanced testing, and have been demonstrated to be safe, easy to reconstitute, and retain full coagulation factor activity compared to stored products. Work is also in progress on similar red cell and platelet products. The future combat medic will very likely have some of these or newer products at his disposal, which will greatly improve the ability to carry the concept of "Damage Control Resuscitation" to the prehospital combat or disaster environment.

## Summary

There is much the prehospital provider can do to both save the life of those injured in combat as well as decreasing the morbidity of those injured. The priority of treatment is: (1) control of hemorrhage, (2) airway control, (3) treatment of chest injury,

and (4) prevention of hypothermia. Many other considerations also come into play for proper casualty care as have been discussed. You should familiarize yourself with these concepts and practices in order to understand and continue your part in this “chain of survival” for the combat casualty.