Putting the Clamp on Hemorrhage

How a simple, effective point-of-injury tool will transform the way bleeding is controlled in the field

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Every Red Blood Cell Counts

Early & effective hemorrhage control is essential to saving lives

By Dennis Filipps, MD, CEO & founder, iTraumaCare

Uncontrolled bleeding is one of the leading causes of death in civilian and military environments, second only to central nervous system injury. Every red blood cell counts; effective hemorrhage control at the earliest moment is critical to patient survival. Early control of hemorrhage reduces the negative downstream consequences associated with substantial blood loss, including shock, late mortality and multiple organ failure.

Both Tactical Combat Casualty Care guidelines and the Hartford Consensus for Mass Shooter Events identify controlling compressible hemorrhage as the highest medical priority for improving survival. Now there is a new, simple and effective tool that will transform the way bleeding, particularly difficult-to-control bleeding, is managed in the field: the iTClamp50, an FDA-cleared hemorrhage-control device that causes blood to clot rapidly beneath the skin where it is applied. The pressure that results under the clamp site causes the natural compression of “bleeders” beneath the skin surface and coagulates blood, resulting in the important cessation of bleeding. It can be used as a first-line device or combined with other hemorrhage-control strategies, such as hemostatic agents, tourniquets, junctional tourniquets and tranexamic acid.

The iTClamp adds a critical new adjunct to the hemorrhage control toolkit, allowing first responders and other BLS/ALS team members to address critical bleeding. The speed of application (<5 seconds) allows you to rapidly treat a patient and then deal with additional injuries on that same patient or other patients, such as in a mass-casualty, disaster or USAR situation.

Read this in-depth advertorial supplement to JEMS carefully and discuss the iTClamp with your medical director, because it represents a new form of rapid hemorrhage control that could make a big impact on trauma morbidity and mortality in your EMS operation.

STOP THE BLEEDING
Understanding the history & epidemiology of hemorrhage control
By Alison Kabaroff, CD, MD, FRCPC

POINT-OF-CARE HEMORRHAGE CONTROL
Historical perspective & the need for a common-sense approach
By Edward T. Dickinson, MD, NREMT-P, FACEP

FROM BATTLEFIELDS TO CITY STREETS
The application of recent military trauma concepts to civilian EMS
By Peter P. Taillac, MD, FACEP & Gerard S. Doyle, MD, MPH

A NEW TOOL IN THE BOX
First U.S. field use of the iTClamp proves its value in treating hypoxia from a hemorrhagic standpoint
By Jason L. Clark, CMTE, NRP, FP-C, CCEMT-P

HOW THE iTCLAMP WORKS
Life-saving power in a small, easy-to-use hemorrhage-control device
By Joe Holley, MD, FACEP

TRAINING & SPEED ARE CRUCIAL
Options, issues & training to prevent death from massive blood loss
By Joe Holley, MD, FACEP
From the beginning of the evolution of humans, the ability to stop bleeding has been paramount to our survival. Humans have managed to survive severe trauma for thousands of years. Written records of medical interventions date back to the ancient Greeks and Romans.

In the first century AD, Greek physician Rufus of Ephesus described all methods of hemorrhage control known to exist in the ancient world: digital compression, styptics (i.e., hemostatic agents), cautery, torsion/tourniquet and ligature, or ligation of blood vessels.1 His assessment was very detailed and, in fact, the same techniques are still used today in prehospital and hospital settings.

In some respects, little has changed for first responders regarding their options for hemorrhage control, and yet the problem of major bleeding continues to stymie both prehospital and hospital care providers.

Worldwide Killer
Traumatic and non-traumatic causes of hemorrhage carry significant mortality and morbidity. Approximately 5 million people die every year around the world from accidental and non-accidental trauma, making trauma the leading cause of death in people under the age of 45.2

Exsanguination accounts for approximately one-third of these deaths and the majority, which are due to exsanguination, occur within the first 48 hours.3,4 Massive hemorrhage is second only to neurologic injuries as a cause of death due to trauma.5

Hemorrhage carries with it not only the threat of immediate death due to blood loss, but also increased mortality due to multi-organ failure and sepsis.6 Massive blood loss often starts a cascade of shock, inflammation and coagulopathy that can worsen blood loss and foil attempts at resuscitation. Despite advances in transfusion medicine and medical care, massive blood loss is
still a major cause of mortality—whether you’re in a third-world country or even a first-world one.

In addition, significant morbidity is associated with massive blood loss. Massive transfusion is defined as replacement of a patient’s entire circulating blood volume in less than 24 hours. One recently published study looked at more than 900,000 patients undergoing massive transfusion and non-cardiac surgery. The researchers found more than 54% had at least one major, non-fatal complication.7

Complications of massive transfusion include coagulopathy, hypocalcaemia, hyperkalemia, hypothermia and transfusion-related lung injury (TRALI).8 Coagulopathy may be dilutional if the patient is only transfused with packed red cells or secondary to disseminated intravascular coagulation (DIC) if the patient has delayed resuscitation or inadequate perfusion.

Hypocalcaemia can occur when citrate is used in packed red cells, platelets and fresh frozen plasma. Citrate binds calcium, and though it’s metabolized by the liver, this is slowed if the patient is hypothermic. Hypocalcaemia can also cause hypotension, further exacerbating inadequate perfusion.

Hyperkalemia is rare but can occur if the patient is acidic or hypothermic. Hypothermia can occur because packed red cells are stored at 4 degrees Celsius and may be difficult to rewarm quickly.9 TRALI occurs as an immune or non-immune related process and presents as acute respiratory distress syndrome (ARDS) during or within six hours of transfusion.10

Massive transfusion protocols have been developed to try to combat some of the complications associated with massive hemorrhage and transfusion. Despite this, patients who undergo massive transfusion are more likely to suffer infectious and respiratory complications and more likely to die.7

One Canadian study of deaths due to trauma at a Level 1 trauma center found that up to 16% of deaths would have been preventable with earlier recognition of bleeding and more rapid and effective hemorrhage control.11 In Canada, that would amount to approximately 2,400 additional lives saved per year (an equivalent of approximately 24,000 U.S. deaths).

The majority of these preventable deaths are from unrecognized bleeding in the abdomen and pelvis. There are, however, preventable deaths due to isolated extremity trauma every year as well. A review of trauma patients presenting to two U.S. trauma centers suggests that death due to isolated extremity hemorrhage is rare (0.02% of traumas), but greater than 50% of those deaths were potentially preventable with tourniquets.12

**History of Hemorrhage Control**

Getting medical personnel to recognize the seriousness and significance of hemorrhage has been a problem throughout the history of trauma care. Oddly, from the ancient world until the early 20th century, “bloodletting” was actually prescribed to treat a multitude of ailments including hemorrhage. It was common practice prior to surgery, and prior to amputation, for doctors to first “bleed” a patient the approximate amount of blood contained in the limb in an effort to decrease inflammation and infection.13

Bloodletting was considered an effective treatment to “cause hemorrhages to cease” until the late 1800s, and Sir William Osler still advocated bloodletting in the *Principles and Practice of Medicine* in 1923.14 Interestingly, this was at the same time that transfusion medicine and blood-banking was becoming safe and an accepted practice.15

George Washington is a famous example of how death was hastened by bloodletting. After becoming ill, Washington called for a physician to bleed him. He underwent the procedure three times, having approximately 3.7 L of blood removed in 10 hours. He died shortly thereafter.16 Although therapeutic phlebotomy is still in use to treat hemochromatosis, it thankfully is no longer part of trauma care.

Methods of controlling hemorrhage have fallen into and out of favor throughout history, but the proven principle of direct pressure has been in use for thousands of years. Some of the
earliest written accounts of the management of wounds by direct pressure go back to Homer’s Iliad. Application of salve and dressings are described after irrigation. Cautery and the use of “seething oil” were popular for control of hemorrhage for centuries—right up until the American Civil War, when ligature and amputation became favored.17

The Controversy of Tourniquets
Tourniquets, now returning to EMS units throughout the world, have been a source of controversy since the birth of medicine. During the Roman Empire, the surgeon Galen of Pergamon denounced them as “forcing more blood from the wound.” During the Civil War, Confederate surgeon Julian John Chisolm described them as “of no avail.”18

In the Second World War and Korean War, pressure dressings became first-line therapy, with tourniquets reserved for last resort. In the past several years, tourniquets have come back into favor with the knowledge gained during the wars in Iraq and Afghanistan.19

In recent articles relative to the conflicts in Iraq and Afghanistan, no cases of amputation were found to be a result of tourniquet application alone, and one case report described a soldier with prolonged tourniquet application of 16 hours with no neurovascular complications.20,21

Research from the wars in Iraq and Afghanistan would suggest that not only are there low complication rates with tourniquet use but also significant survival benefit in patients with severe extremity trauma associated with their early use, particularly if the tourniquet is applied before the onset of shock. An article by Kragh et al in 2009 suggests that survival rates when tourniquets are applied are as high as 90% vs. only 10% when shock is present.22

Hemostatic Dressings
The wars in Iraq and Afghanistan have also seen the development of a variety of hemostatic dressing agents. These agents vary from powdered granules poured into a wound, such as early versions of QuikClot, to impregnated gauze, such as HemCon and CombatGauze. These agents all require direct pressure for 2–5 minutes for maximum effectiveness and have not been found to be more superior to plain gauze for wound packing in many instances.23

Our Current Approach to Trauma Care
Just as the agents used for hemostasis have evolved, so too has the approach to trauma and bleeding. The first description of the airway, breathing and circulation (ABCs) approach to patients was in the 1950s by Peter Safar, MD.24 This was followed until James Styner, MD, FACS, pioneered the advanced trauma life support (ATLS) approach of airway, breathing, circulation, disability and exposure (ABCDE) in 1976.25

In the years since, the emphasis has been that airway and breathing issues take priority over circulation issues and dressing wounds. Although this approach may be the right one for the majority of trauma patients, it can create delays in managing hemorrhage if providers are too focused on the airway and not enough
on controlling active bleeding. A concurrent approach, if possible, is best, and most trauma teams are designed with that in mind.

Recently there’s been another shift back toward prioritizing the control of massive hemorrhage even before dealing with airway or ventilation issues. The military has taught the massive hemorrhage, airway, respirations, circulation and hypothermia (MARCH) concept since the mid-1990s, but this approach has really come to the forefront in the past decade. This is a result of the recent finding that most battle casualties die within 10 minutes of being wounded and the majority of those die from exsanguination.26,27 By placing the emphasis on stopping major bleeding first, the aim is to reduce the need for massive transfusion and prevent complications associated with major blood loss.

This necessitates a shift in thinking. For years, EMS providers have been taught that there’s no point in dressing a wound if there’s no airway. And it’s true that 2–5 minutes of direct pressure is too long if the patient is apneic or has an airway obstruction. However, quick tourniquet application takes only seconds and then allows a practitioner to have both hands available for other treatments.

**Conclusion**

Despite major advances in trauma care and medical devices, massive hemorrhage continues to have significant morbidity and mortality to this day. Early recognition and appropriate action is necessary to prevent complications and loss of life.

Adequate hemorrhage control must take place in the prehospital environment, and EMS systems must keep pace with changing protocols. Waiting until the emergency department or operating room to try to achieve hemostasis is like closing the barn door after the horses have escaped.

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**References**


Putting the Clamp on Hemorrhage

By Edward T. Dickinson, MD, NREMT-P, FACEP

It was a cold January morning in 1979 at Colgate University when I was handed my copy of the American Red Cross Advanced First Aid Manual as part of my National Ski Patrol training. Although I had never seen severe bleeding in my life, my instructor assured me that four simple steps would stop almost any bleeding. They were:

1. Application of direct pressure;
2. Elevation of the bleeding site above the heart;
3. Compression of a pressure point (femoral, brachial or temporal), and
4. Use of a tourniquet—only as a last resort (if all the above fail).

Almost 35 years later, I’ve treated thousands of lacerations, hundreds of gunshot and stab wounds, and scores of amputations. Based on that experience, I know one fact for certain: External bleeding can kill your patient unless you stop it. What it takes to control dangerous external bleeding is case-dependent and needs to be accomplished with the right sequence of interventions, coupled with common sense.

But are those four cardinal step-by-step interventions that I was taught in 1979 (both in that first aid course and again in my initial EMT course later that year) really effective interventions for bleeding?

Fast-Forward to 2010

In 2010, the journal Circulation published evidenced-based recommendations for hemorrhage control as part of the 2010 American Heart Association (AHA) and the American Red Cross (ARC) Guidelines for First Aid.1 These guidelines, which were based on current evidence, stated that only direct pressure was a definitively proven intervention (Class I) and that a tourniquet “is indicated only if direct pressure is not effective or not possible” (Class IIb).

Note: Remember that Class I means that the procedure should be performed, and Class IIb means that the benefits are equal to or greater than the risks of the procedure and the intervention may be considered.

Finally, the use of pressure points and elevation were deemed to be Class III interventions—meaning that the risks are greater than the potential benefits and the procedures should not be performed.

Many in EMS consider these guidelines to be etched in stone and have adopted the concept of two-step hemorrhage control (direct pressure,
then tourniquet application) as the definitive steps in hemorrhage control. Most importantly to an EMT student, this is the position that has been taken by the National Registry of EMTs and is reflected in their testing process, including the practical station of “bleeding control/shock management.”

There are several problems with the 2010 AHA/ARC guidelines and their effect on EMS. First, the guidelines were written for the first aid provider level of care, not that of an EMT, advanced EMT, or paramedic.

For example, the guidelines state when discussing tourniquet use that they have been “shown to control bleeding effectively on the battlefield, and during surgery and have been used by paramedics in a civilian setting without complications.” The intervention is proven for EMS providers, so shouldn’t it at least be considered a Class IIa intervention (i.e., the benefits greatly outweigh the potential risks and the procedure is reasonable to perform)?

My second major criticism of the AHA/ARC first aid guidelines is their dismissal of limb elevation as a means of hemorrhage control. When combined with direct pressure, the elevation of a bleeding extremity is an effective intervention to abate bleeding.

It’s true that there has never been a published, peer-reviewed study that proves the effectiveness of limb elevation. But there has also never been a study that shows it to be ineffective either. This is a fundamental gap in “evidence-based” protocol development. Specifically, just because something hasn’t been studied doesn’t mean it’s always necessarily bad—and the combination of simultaneous direct pressure limb elevation is a perfect example.

The use of limb elevation is a common-sense intervention based on the basic physics of gravity and hydrostatic pressure. We know that a dependent limb has a greater venous pressure and blood volume than a limb that is elevated. That’s why you hang a patient’s arm down off the side of the stretcher when trying to start an IV in a rig so that the veins plump with greater blood volume and pressure, making the IV start easier.

Now, I completely agree that in the midst of a gun battle or in the setting of multiple patients with potentially life-threatening extremity bleeding, limb elevation (and perhaps even direct pressure) is impractical. This is an environment for liberal tourniquet use until the threat is neutralized or the scene stabilized.

The bottom line on the simultaneous use of limb elevation with direct pressure can be found in the lyrics of the Lee Brice song: “Don’t try to outsmart your common sense.”

I do agree with the AHA/ARC recommendation that the use of pressure points is likely to be ineffective and is logistically difficult because it’s hard (if not impossible) for a rescuer to simultaneously provide direct pressure to a wound and find and compress a pressure point.

The application of hand or finger pressure to arteries against underlying bones proximal to a bleeding site as an intervention to stop bleeding had been taught for years in EMT textbooks, including the original EMT textbook, the 1971 American Academy of Orthopaedic Surgeons “orange book,” *Emergency Care and Transportation of the Sick and Injured.*

The classic sites of compression were at the femoral artery as it crossed the inguinal crease, the brachial artery against the underlying medial humerus and the temporal artery against the skull.

The technique really boiled down to a pseudo-tourniquet effect and never seemed logistically feasible. In all my years of clinical work, I’ve used a pressure point only once effectively to control bleeding, and that was while I had an assistant compress a branch of the temporal artery against the skull while I repaired a facial laceration in the ED.

**Arriving in 2013**

Two new commercial interventions have become mainstays of my management of external hemorrhage: commercial tourniquets and hemostatic dressings.

*Commercial tourniquets:* Traumatic limb injuries/amputations have pushed the envelope on tourniquet use and the development of newer
commercial tourniquet technology that allows for more rapid and predictable application. (Read a related JEMS article at www.jems.com/article/major-incidents/tourniquet-first.)

Hemostatic dressings: Early hemostatic agents were somewhat problematic due to the exothermic reaction they caused when they came in contact with blood. The current generation of hemostatic dressings has corrected this issue and should be considered a part of the standard armamentarium of hemorrhage control and used in selective cases. In my capacity as an emergency department physician in a busy inner-city trauma center and, at scenes as an active EMS medical director, I use hemostatic dressings in cases of continued bleeding when direct pressure and elevation have not been fully effective in bleeding control and the circumstances don’t immediately justify the risks of a tourniquet.

A perfect example was a case in which a young man hobbled into the ED with an isolated gunshot wound to his lower leg (see photo below). His heavy non-arterial bleeding from multiple fractures and a major vein injury couldn’t be controlled despite direct pressure with elevation. Application of a hemostatic dressing almost immediately stopped the bleeding and made use of a tourniquet unnecessary. Hemostatic dressings are useful in heavily bleeding wounds in areas where a tourniquet can’t be used, such as the head, neck or torso.

A gunshot wound to the lower leg that required a hemostatic agent to control the bone and saphenous vein bleeding.

perfect example of this potential use of hemostatic dressing is in an elderly patient on an anti-coagulant medication (e.g., warfarin) with a badly bleeding scalp laceration after a fall.

Summary

Based on my clinical experience in the field and in the ED, evaluation of the medical literature and use of common sense, the following is my routine approach to external hemorrhage control in 2013.

1. Apply direct pressure, first with a gloved hand followed by a dressing and bandage to continue necessary wound compression. This will control the vast majority of external bleeding.
2. Elevation should still be used in conjunction with direct pressure in extremity bleeding whenever feasible. This is especially helpful with wounds distal to the elbow or knee.
3. Consider use of hemostatic agents in the subset of patients whose bleeding can’t be completely controlled with direct pressure and elevation, when the patient does not immediately require a tourniquet or when the wound is in a location where you cannot use a tourniquet, such as the head, torso or neck.
4. Rapidly apply a tourniquet(s) to any patient with evident massive extremity bleeding that isn’t immediately controllable with direct pressure or at MCI s or in tactical situations to stop bleeding until triage is completed and you have the time and personnel to remove them and use other hemorrhage control modalities. Remember to always visually “announce” that a tourniquet has been applied via the traditional notation of a “T” on a patient’s forehead.

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References

The decade of war in Iraq and Afghanistan has been unique from prior American conflicts because of a new partnership between military medicine and civilian trauma experts, combined with an innovative data collection system, the Joint Theater Trauma Registry (JTTR), which has tracked soldiers’ injuries throughout the war. This has allowed researchers to monitor the usefulness and safety of trauma treatments used by the military.

Several “combat tested” therapies have begun to be adapted by civilian trauma centers and EMS providers back home, most often related to treating victims of multiple traumas. Injuries caused by IEDs span the spectrum of trauma. They produce huge concussive forces, which cause blast injuries, particularly to the air-filled organs (i.e., ears, lungs and bowels) as well as to the brain, which is a common cause of traumatic brain injury (TBI) in soldiers. Often packed with shrapnel, IEDs also produce multiple penetrating injuries, similar to multiple simultaneous gunshot wounds.

The lessons learned from dealing with these horrendous combat wounds have begun to be translated to our daily care of our trauma patients in American EMS systems.

**Tourniquets**

The tourniquet is now, once again, an important tool in the toolbox of EMS providers.

For decades, tourniquets were considered dangerous because common thought was that they cause tissue damage. Major Blackwood, a British field surgeon in World War I, called them “instruments of the Devil” because of the ischemic damage caused to limbs by indiscriminate use and by the lack of a field evacuation system for injured soldiers. Today, better-designed tourniquets and focused training in prehospital tourniquet use have proved that short tourniquet times of less than two hours are safe and result in few cases of ischemic limb injury.

One 2011 military study demonstrated that early tourniquet use, prior to the onset of hemorrhagic shock, resulted in a 96% survival—compared to 4% survival when applied after shock onset. Few (if any) permanent limb ischemic injuries have been shown to have resulted from military tourniquet use.

Published tourniquet use and benefits of protocols also describe the use of a tourniquet on a victim who has sustained multiple injuries and has severe extremity hemorrhage, but also needs stabilization of the ABCs. This became a common encounter during the care of patients after the Reno airshow disaster; the mass shootings in Aurora, Colo.; the Arizona shooting involving Congresswoman Gabby Giffords; and the Boston Marathon bombing.

In these situations, tourniquets rapidly placed by the provider immediately, saved lives. The provider can then turn their attention to airway management, interventions to improve breathing like needle thoracostomy, as well as IV/IO placement and fluid administration as needed to restore circulating intravascular volume. After the patient has been stabilized and the “safety net” established, the medic can then turn their attention to re-evaluating and possibly...
removing the tourniquet and replacing it with a pressure dressing.

Bottom line: The use of tourniquets to quickly stop severe bleeding should be an important part of the prehospital care of patients.

Hemostatic Adjuncts

Hemostatic adjuncts have occupied a “niche market” for both military and civilian EMS providers. These products, designed to be placed into a bleeding wound to assist the body’s ability to form a clot, are effective. Such agents as kaolin, chitin and zeolite are used in either granular form or incorporated into gauze. They work by giving the bleeding vessel a substrate on which to form a clot. In addition, some products may augment the body’s intrinsic clotting mechanisms.

Hemostatic adjuncts have been used by military medics throughout the Iraq and Afghanistan wars. Given the effectiveness of a simple pressure dressing and the widespread availability of tourniquets, these specialized products have not been required often. However, these agents can be lifesaving, particularly in difficult-to-manage wounds, such as those of the groin or axilla. They provide effective hemorrhage control for wounds that aren’t amenable to other methods of hemorrhage control and which might otherwise be fatal. Current products, especially those impregnated into gauze for packing into the wound, have proven effective and safe in the battlefield and civilian environments.

Hypotensive Resuscitation

The concept of hypotensive resuscitation, which is also known as “permissive hypotension,” has actually been around since first proposed by Walter B. Cannon during World War I. Cannon recognized the importance of having a surgeon “ready to check any bleeding” that resulted from the improved blood pressure after fluid infusion. In World War II, Henry K. Beecher, MD, stated that a systolic blood pressure of 85 was adequate for those waiting surgery for long periods.

However, during the Vietnam War, the concept of using large volumes of crystalloid fluid and restoring the injured patient’s blood volume to “normal” became an accepted practice. It has been taught to several generations of EMS providers, surgeons and ED physicians.

More recently, other concepts have gained acceptance in military and civilian trauma communities. These include the concept of allowing the trauma patient to be moderately hypotensive and only replacing enough volume to treat shock. This is based on the theory that the body’s natural response after trauma is to minimize hemorrhage by forming a fragile clot on the bleeding vessel. Excessive IV fluid administration can actually result in increased bleeding from the injured vessel by the following proposed mechanisms:

• A rise in blood pressure, which results in increased pressure on the delicate clot, causing it to rupture;
• An increase in the intravascular volume, which stretches the vessel and increases tension on the clot, causing it to fail; and
• The body’s ability to clot, which is the result of clotting factors and platelets circulating in the blood. When excessive amounts of crystalloid are administered, these critical factors are diluted, interfering with clot formation and strengthening.

Evidence now suggests that allowing the patient to remain moderately hypotensive (systolic BP in the 80–90 range or the maintenance of a radial pulse) maximizes the body’s ability to slow bleeding using these intrinsic mechanisms. So, “Don’t pop the clot” is the current recommendation for penetrating trauma of the torso.

A common protocol for permissive hypotension in trauma is the following: In a patient with penetrating trauma who is maintaining a systolic blood pressure at or above the 80–90 range or who has a radial pulse, IV access should be obtained with a saline lock but no IV fluid administered. If the systolic BP falls
below 80–90, or if the patient loses the radial pulse, then calibrated fluid boluses of crystalloid, 500–1,000 ccs at a time, should be administered, then the patient reassessed.

When the systolic BP or radial pulse is restored, no further fluid is necessary. The goal is not to restore BP to “normal,” but to maintain perfusion of vital organs and avoid shock while simultaneously allowing the body to avoid increasing hemorrhage.

Several cautions must be stated regarding the hypotensive resuscitation strategy for trauma. First is that this has only been studied with confidence in adults. Although studies of permissive hypotension in children are ongoing, currently the Pediatric Advanced Life Support (PALS) protocol should be followed. This includes giving 20 cc/kg boluses of crystalloid to maintain or restore a normal BP for age.

Children, particularly those younger than 8 years old, respond differently than adults to hemorrhage. Children tend to increase pulse rate and systemic vascular resistance to maintain a normal BP for as long as possible. When hypotension finally occurs because of a failure of these compensatory mechanisms, the shock state can be difficult or impossible to reverse. Therefore, hypotension/shock should be avoided in children by restoring intravascular volume with crystalloid until BP is normal or near normal.

Another precaution regarding this permissive hypotension strategy is that it shouldn’t be used in patients with a head injury. In the face of a cerebral injury, the swelling and increased pressure in the skull makes it difficult for the brain’s auto-regulatory mechanisms to maintain critical brain perfusion. Keeping the blood pressure at normal levels promotes cerebral perfusion in the face of this increased intracranial pressure, minimizing secondary injury of the brain.

The benefit of permissive hypotension in blunt trauma patients is still under study. Researchers recently reported an analysis of blunt trauma patients that demonstrated a more favorable outcome for blunt trauma patients who aren’t in shock and who receive less IV fluids. But more information is needed to confirm the findings.

**Tranexamic Acid**

Tranexamic acid (TXA) is an antifibrinolytic medication that inhibits the body’s natural breakdown of clots after injury. In a large international study (CRASH-2), followed by a study of British and American soldiers (MATTERS), this medication decreased mortality in patients with traumatic hemorrhage.

TXA has been used safely by surgeons for orthopedic procedures and is FDA approved for use in heavy menstrual bleeding (in Great Britain, it’s actually available over the counter for this indication). It’s cheap, easy to administer and has few side effects.

Importantly, the CRASH-2 data demonstrated that TXA had the largest mortality benefit when used as soon as possible after the injury—ideally less than one hour. However, when use was delayed more than three hours, the benefit to the patient disappeared and an increased mortality was observed.

Because of this one-hour window, this medication may be best administered by prehospital providers. In fact, EMS providers in Europe and Asia have been using TXA for years, and several North American EMS agencies, such as those in Alberta, Canada, Oklahoma City and New York City, have begun using TXA for severely injured trauma patients. (Read a related JEMS article at www.jems.com/article/patient-care/role-tranexamic-acid-ems-preoperative-tr.)

**Freeze Dried Plasma**

Underlying the evidence of benefit of the hypotensive resuscitation strategy is evidence suggesting that in all types of trauma, excessive crystalloid IV fluid is harmful and that resuscitation with blood products is superior. This makes clear intuitive sense. In traumatic hemorrhage, the body has lost blood, not crystalloid. So blood would be the ideal resuscitation fluid, replacing exactly what the body has lost.
Although crystalloid can replace intravascular volume (which may be lifesaving), blood replaces all of the important components that the body has lost, including oxygen-carrying red blood cells, as well as platelets and clotting factors to stop hemorrhage. So clearly, the ability to replace what the body has lost would be naturally superior to simply replacing volume with crystalloid, diluting all of the body’s blood components and rendering them less effective.

The use of blood products in trauma, in the proportions that they are lost (the proper ratio of red blood cells, clotting factors and platelets) has become the goal of trauma care in the hospital. This concept is reflected in the “massive transfusion protocols” developed by civilian trauma centers and based on battlefield success with using whole blood transfusions for injured patients.

Although whole blood is available on the battlefield via immediate transfusions from other soldiers to the injured patient, it isn’t easily available in civilian facilities. There, donated blood is broken down into three components: red blood cells, platelets and plasma. Therefore, these massive transfusion protocols call for the following actions:

1. Minimizing crystalloid administration to trauma patients, and
2. Replacing blood products in a specified ratio of red blood cells, platelets and fresh frozen plasma to come close to replacing “whole blood.”

With the exception of some hospital-based air ambulance agencies, the capability to use blood products in the field is still a futuristic concept. However, work continues to develop “artificial blood,” which will replace some of the capabilities of blood in trauma. Already, French and German military medical providers in Afghanistan are using a novel dried plasma product for resuscitation of prehospital and ED trauma patients. This human plasma is “freeze dried” or “spray dried” into a powder containing the clotting factors lost by the body in hemorrhage. This can be reconstituted with saline by EMS providers and administered in the place of crystalloid, providing the patient with volume resuscitation as well as replenishment of critical clotting factors.

In a 2011 Journal of Trauma article, researchers demonstrated this lyophilized plasma to be as effective as the standard “fresh frozen” plasma commonly used in the hospital. After further study and clearance by the Food and Drug Administration (FDA), this product could well be stocked by civilian EMS agencies to be used for severe trauma.

Other Hemorrhage-Control Devices

Functional hemorrhage control “tourniquets” (such as the Combat Ready Clamp (“CRoC”)) discussed in this supplement (see p. 23) are currently being field tested by the military and showing promise for the control of hemorrhage in the groin, an area where bleeding can be severe and very difficult to control. A new hemorrhage control device, the iTClamp, also holds promise for use both in civilian EMS and for the military.

Conclusion

The decade of war that the U.S. and other military forces have experienced in Iraq and Afghanistan has resulted in revolutionary improvements in military trauma care. These improvements can be attributed to the use of a military trauma registry and the cooperation between civilian and military trauma researchers.

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References

A New Tool in the Box

First U.S. field use of the iTClamp proves its value in treating hypoxia from a hemorrhagic standpoint

By Jason L Clark CMTE, NRP, FP-C, CCEMT-P

In classrooms all across the nation, students are taught that hypoxia is inadequate oxygen supply for the body. Although that’s true, we sometimes fail to explain to students the multiple types of hypoxia that our patients could be encountering. In fact, in most commonly utilized textbooks for EMT and paramedic programs, the four types of hypoxia are not addressed.

Understanding the etiology of the four types of hypoxia—hypoxic, hypemic, stagnant and histotoxic—is crucial in providing care that will result in the most desirable outcome for the patient.

Patients experiencing significant hemorrhage are an excellent example. Despite a provider’s best effort to gain an airway and provide high-flow oxygen, these patients will experience hypemic hypoxia due to a lack of hemoglobin, which serves as the transport mechanism for oxygen molecules to reach the body’s tissues. As a result, the human body experiences anaerobic metabolism, resulting in the production of lactic acid and leading to the onset of shock. Controlling the patient’s bleeding, then, becomes the priority in preventing hypoxia in hemorrhage patients.

Military and tactical providers have long recognized the importance of early and aggressive hemorrhage control and treatment to prevent their patients from going into shock. They are well aware that once a patient goes into shock, it is difficult to reverse their downward spiral.

Therefore, unlike their civilian counterparts, military and tactical providers are trained to address massive hemorrhage control prior to airway and breathing. The frequency of mass-hemorrhage injuries is more common for our active-duty military providers; however, the physiology is no different than the injuries that civilian prehospital providers encounter.

What about Tourniquets?

Tourniquer application is fast, efficient and controls bleeding by applying circumferential pressure to an extremity. The pressure exerted compresses vessels in the extremity, resulting in blood flow being stopped to the tissues distal of the application site.

However, the tourniquet works because it stops blood flow. As a result, the tissues distal of the applied site experience stagnant hypoxia, which results when blood is no longer being circulated adequately or starts to pool in a certain area. Stagnant hypoxia can be a result of cardiac failure or a blockage in the circulatory system.

(Above) Providers with Hospital Wing in Memphis, Tenn., transport a patient to a Level 1 Trauma Center after using the iTClamp to stop the bleeding from a chainsaw injury. PHOTOS COURTESY HOSPITAL WING
Following tourniquet removal, hospital personnel often have to treat the patient due to an overall change in their systemic circulatory system following the release of stagnant blood with increased levels of lactic acid, potassium and other chemical imbalances.

Ironically, tourniquets can also play a positive role as an adjunct in the prehospital setting to prevent complications from stagnant hypoxia in victims with crush injuries. As the object crushing the limb is removed, the tourniquet can be used to prevent the stagnant blood from being returned to central circulation.

**A Better Way?**

Although tourniquets are certainly useful, life-saving tools to control blood loss, the optimal tool is one that effectively controls the hemorrhage but also allows for distal blood flow to the uninjured parts of the extremity. Clinicians should perform a rapid assessment of each injury to determine the most effective method to control bleeding. The assessment should include the type of wound, length, approximate depth and type of vessels involved. The provider should also determine whether the edges of the wound can be approximated and if the wound was sustained in a compression-able area.

Wound closure has been the hemorrhage control practice for many years in the hospital setting for wounds that have edges that can be approximated. In the prehospital setting, however, field suturing has never been a common practice. In the past, the timeframe in which it would take to close most wounds appropriately wasn’t conducive to the prehospital environment and the sometimes tedious process of closing wounds has been considered an unacceptable risk of needle stick injury for providers, particularly those working in moving ambulances.

But with the introduction of the iTClamp50, EMS providers can now perform a field wound closure technique that works very similar to suturing in the field but in a faster and safer manner. The iTClamp50 incorporates small needles (four on each side) on a clamp device that allows clinicians to quickly provide temporary closure of a wound by approximating wound edges and creating a “watertight” seal. The bleeding then creates a hematoma under pressure beneath the skin as it fills the wound cavity with blood and creates a clot to control blood loss. (For more on how the iTClamp works, see p. 18.)

The iTClamp50, designed to be used in areas that are compression-able, is an ideal device for the control of arterial, venous or capillary bleeding in wounds to the extremities, axilla and inguinal areas.

When used appropriately, the iTClamp50 offers a benefit over tourniquets because it allows distal blood flow to the intact vessels of the injured extremity, which in turn greatly reduces or eliminates the possibility for stagnant hypoxia.

**The iTClamp in Use**

Hospital Wing, a non-profit air medical transport based in Memphis, Tenn., that provides inter-hospital transfers as well as emergency scene calls, was the first program in the United States to adopt the iTClamp50 as part of its hemorrhage-control protocol.

Prior to the device receiving FDA clearance, Hospital Wing had the opportunity to work with staff from Innovative Trauma Care in testing the application of the device at the Medical Education Research Institute (MERI) in Memphis. Following FDA clearance, Hospital Wing acquired the devices and provided in-service training for the flight crewmembers, who provided positive comments on the easy operation of the device. Following in-service training, the devices were used.

Providers used two iTClamps due to the length of the wound. Within minutes following their application, the bleeding was under control.

To view a short video related to the first U.S. use of the iTClamp, scan the QR code below or visit www.jems.com/video/news/tennessee-medics-using-it-clamp.
placed on the aircraft for patient use.

Hours after placing the devices in service, Hospital Wing received a flight request from an outlying hospital to transport a patient who had been injured in a chainsaw accident. When Hospital Wing flight crewmembers arrived, they found a 64-year-old male with serious bleeding to his left upper arm. The crew removed the blood-soaked dressings that were applied by hospital staff in efforts to assess the wound. Upon assessment it was noted the patient had an approximate 7-inch-long, 1-inch-deep wound that was bleeding profusely.

Flight Paramedic Jennifer Miller and Flight Nurse Jan Weatherred made the decision to deploy the iTClamp50. Due to the size of the laceration, two iTClamps were utilized. Within two minutes following their application, the bleeding was under control (see photo, p. 16). The patient was then flown to the regional Level 1 Trauma Center and, approximately 35 minutes after application, the iTClamps were removed with the trauma team at the patient’s bedside.

Following removal of the iTClamps, the bleeding was confirmed to have subsided and the patient was hemodynamically stable and able to be treated in the critical care assessment portion of the trauma center instead of requiring a shock trauma room. Physicians were able to suture the wound (see photo, above right) and provide antibiotic therapy. The patient was discharged approximately eight hours following arrival at the trauma center.

Quick and effective control of the patient’s severe hemorrhage allowed the Hospital Wing flight crew to preserve precious red blood cells and resulted in the patient not requiring a blood transfusion or experiencing a hypoxic event.

The patient was discharged with normal wound care instructions. Two days after discharge, a follow-up with the patient was conducted, during which the patient reported a minimal pain level during application of the iTClamp and described feeling only a slight pressure sensation following application.

**Conclusion**

As more equipment and pharmaceutical agents become readily available to prehospital professionals, we must first remember to sharpen our critical thinking and patient-assessment skills, understand the four types of hypoxia situations and how to treat them and save as many red blood cells as possible.

With multiple tools to control hemorrhage, it is also important to understand and utilize the most appropriate method or methods to control bleeding, such as packing a wound with a hemostatic dressing prior to applying the iTClamp if the wound is large and open.

Tourniquets have been adopted as the standard of care for mass hemorrhage control due to evidence-based medicine obtained from our military healthcare providers. Now, we have a tool that may be even more effective than tourniquets for certain situations.

As civilian EMS professionals, we should follow the footsteps of our military and tactical providers and educate our clinicians to rapidly identify and effectively treat uncontrolled, life-threatening bleeding prior to becoming deeply engaged in providing airway and breathing care. Without red blood cells to transport oxygen molecules to the tissues, all is lost.

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Essentially all mechanical hemorrhage-control techniques work by applying pressure, either directly or indirectly to the bleeding vessels (or proximal to the bleeding vessels in the case of tourniquets). The iTClamp also relies on pressure to control hemorrhage, but does so in a novel manner. It essentially converts an open bleeding wound into a closed wound, which then allows a stable clot to form in the contained space, ultimately tamponading the bleeding vessel.

The iTClamp is packed sterile and features two pressure bars with four 21-gauge 4-mm-long needles. During application, needles puncture the skin about 4.5 mm on average. As the iTClamp is closed, the edge of the skin is everted between the pressure bars.

Life-saving power in a small, easy-to-use hemorrhage-control device

By Joe Holley, MD, FACEP

Once the iTClamp seals the wound closed, the blood will fill the wound pocket, forming a hematoma under pressure. As the pressure builds, the wound pocket will stretch slightly until the pressure in the wound equalizes with the pressure in the bleeding source. At this point, flow into the wound pocket will stop and hemorrhage will be controlled.

How the iTClamp Works

The iTClamp is packed sterile and features two pressure bars connected by a hinge. Within this hinge is a one-way clutch, which allows the device to be closed and maintain pressure, but which prevents it from opening unless the release buttons are pressed. Along each pressure bar are four 21-gauge 4-mm-long needles, which serve to evert the skin edges during application and hold the device in place once closed.

During application, needles puncture the skin about 4.5 mm on average. As the iTClamp is closed, the edge of the skin is everted between the pressure bars.
the pressure bars. When fully closed, the pressure bars seal the wound along their surface horizontally and vertically, creating a completely air/fluid tight seal.

Once the iTClamp seals the wound closed, the blood will fill the wound pocket, forming a hematoma under pressure. As the pressure builds, the wound pocket will stretch slightly until the pressure in the wound equals with the pressure in the bleeding source. At this point, flow into the wound pocket will stop and hemorrhage will be controlled. Wounds that also have a tissue loss can be packed with gauze and/or a hemostatic agent before application of the iTClamp, ultimately lessening the amount of blood loss before a tamponading clot forms.

The CT angiography on p. 18 illustrates the formation of the hematoma within the wound pocket. In this case, since the vessel was only nicked (an arteriotomy) rather than transected, distal flow through the vessel was maintained. The clamp can effectively stop ongoing blood loss as long as the wound is amenable to a contained clot formation. Through-and-through wounds can be managed by application to both external wounds. The iTClamp is less likely to be effective in situations where the wound enters a large body cavity, as external containment will not stop internal hemorrhage.

The iTClamp can be applied within seconds, and can control hemorrhage within minutes. Utilized as a rapid, simple intervention, it should be considered as a life-sustaining intervention in situations such as those involving SALT triage. Although currently approved for extremity use only, an indication for the scalp should soon be approved, providing an effective means of quickly controlling significant bleeding, even in children.

A question that’s often raised during discussions of the iTClamp is how much pain results from application. Since the needles are small and penetrate simultaneously, and because they penetrate only superficially, pain is reported to be very tolerable. Generally, the needles are small and penetrate simultaneously, and because they penetrate only superficially, pain is reported to be very tolerable. The device can actually wick blood and its clotting components from the wound, thereby actually worsening bleeding. The device can also replace the need for a provider to maintain pressure on a bleeding site, freeing them to provide other life-saving care. Pressures formed within the now-sealed wound cavity will equalize with the bleeding vessel, automatically resulting in just enough pressure to control the hemorrhage.

The iTClamp can be removed and replaced in the field to ensure adequate wound sealing, but can also be left in place for several hours until definitive surgical care can be rendered. Animal studies have shown no short-term injury or damage to the wound where the clamp has been placed.

The iTClamp provides a novel way to quickly control life-threatening hemorrhage in a compact and easy-to-use device. Utilizing the body’s own natural processes, it is safe and effective. Training is intuitive and straightforward.

Joe Holley, MD, FACEP, is medical director for Memphis Fire, Shelby (Tenn.) County Fire and multiple municipalities in the area. He is also medical director for FEMA’s Tennessee Task Force One Urban Search and Rescue Team, and has been deployed over 20 times to such events as the Pentagon during 9/11 and Hurricane Katrina. Holley is also the senior medical team manager for the Incident Support team for FEMA and a long-standing member of the Eagles Coalition, an organization composed of the medical directors of the top-performing EMS systems in the country.
Exsanguination accounted for more than half of the preventable deaths in Vietnam; almost 50% of combat fatalities before evacuation from Iraq were attributed to uncontrolled hemorrhage. Uncontrolled hemorrhage also results in the death of a large number of civilian trauma fatalities each year.

Recent military conflicts have led to many new and novel approaches to control hemorrhage. Many of these new devices and substances will soon be added to your kits and ambulances. This article, therefore, will discuss the variety of new products available to control hemorrhage, as well as how to effectively train on their use in the civilian prehospital setting.

Pressure
As discussed in this supplement, direct pressure is an easy and effective initial way to control hemorrhage and should be the first method for hemorrhage control. We know that if direct pressure fails to control hemorrhage, it signifies deep, massive or arterial injury, which usually needs surgery or a more effective bleeding control measure.

When training on direct pressure, use methods that simulate difficult-to-control hemorrhage and stress to your students and crews that:
1. Direct pressure should be held for at least 5 minutes before checking to see if it’s effective.
2. Application of direct pressure requires two hands pushing against the injured patient while they’re lying on a flat, hard surface.
3. A bandage does not equal direct pressure. In fact, they may “wick” or absorb blood from the wound without actually aiding in clotting. And they often hide ongoing bleeding.
4. Dressings must cover the entire wound, and a bandage is used to hold the dressing in place. The bandage can provide additional pressure if it is applied tightly enough.
5. Leaning into the delivery of direct pressure may be required to stem aggressive arterial flow. Impaled foreign bodies should not be removed because profuse bleeding can occur.
6. Elevation of an affected extremity will decrease most bleeding and should be used as an adjunct with direct pressure. However, even after splinting, elevation of an extremity can make transportation problematic.
7. Compression of the artery proximal to the wound can also decrease bleeding, but pressure points are may be difficult to access and maintain, especially during patient movement and treatment. Note: The use of pressure points and elevation were deemed by the AHA to be Class III interventions—meaning that procedures should not be performed.
8. Splinting the extremity can decrease bleeding, especially if the limb is restored to an anatomical position, and may improve hematoma formation, especially with fractures.
9. Blind clamping is more likely to cause additional injury than to control bleeding and
should therefore be avoided.

10. Neurovascular compromise distal to the wound site must be continuously assessed.

11. The iTClamp and other tools that maintain direct pressure and hasten clotting can be extremely useful during triage, mass-casualty incidents or when wounds are deep or beyond the normal “reach” of the rescuer.

12. Significant blood losses are associated with coagulopathy (impaired blood coagulation). Coagulopathy combined with hypothermia and acidosis forms the lethal triad of death. The control of hypothermia and acidosis are vital to prevent morbidity and mortality for severe hemorrhage.

13. All patients should be resuscitated to prevent shock.

14. Patients who are hemorrhaging should be carefully protected from heat loss and hypothermia. Although these practices are not directly related to the control of life-threatening hemorrhage, they’re vitally important to the ultimate recovery of the patient and should be part of any efforts to control severe bleeding.

The education (and re-education) of your personnel about hemorrhage control must include proper description of each device, realistic simulation of severe hemorrhage and repetitive practice to ensure their proper and rapid use in the face of severe hemorrhage. It is equally important that your crew understand how each of these devices, substances or processes work, when they should be used and any obstacle to their use or complications that may be encountered.

**Hemostatic Agents**

Several hemostatic agents are currently on the market, and although they have seen some success in the combat arena, much of the scientific data regarding the efficacy of these agents is animal-based, or in the form of case reports from the battlefield. Educators must teach their personnel the applicability and limitation of these agents.

- **Trauma Dex:** Trauma Dex is a sterile, plant-based starch agent that’s poured directly into a bleeding wound. The hemostatic effect of the product is achieved by absorbing water from the blood and plasma and facilitating clot formation. The powder is bio-inert and doesn’t generate exogenous heat. It performs as advertised in small wounds in animal models, but it wasn’t shown to have significant benefit over standard gauze dressings when used in a lethal animal groin wound model.6

- **QuickClot:** QuickClot (QC), a granular hemostatic agent, is also placed directly into the wound. The composition of the product is proprietary but is free of botanical or biological products, which may reduce the chance of allergy or disease transmission. Animal studies have shown some success, and there are multiple case reports in the military arena.6 QC has the potential to cause burns due to an exothermic reaction, but it has been modified to reduce this effect. The U.S. Marine Corps deploys QC for life-threatening hemorrhage not responding to standard therapy.

- **Dry fibrin sealant dressing:** This FDA approved dressing is composed of two layers of clotting proteins sandwiching a layer of calcium chloride and human thrombin, freeze-dried to a dexon mesh backing. The fibrinogen and thrombin react to form an adherent fibrin layer, staunching blood flow. Combat theater use has shown these dressings to be fragile, and they are expensive.7,8 Civilian use is not currently widespread due to cost and complexity of use.

- **Modified Rapid Deployment Hemostat Dressing:** This dressing is currently FDA approved but not widely used in the civilian sector. It’s composed of an algae-derived protein. Its mechanism of action is red cell aggregation, activation of platelets and the clotting cascade, as well as local vasoconstriction. It has shown some promise in animal models, and some success in military and civilian use.9

- **HemCon:** HemCon Chitosan Bandage is a biodegradable complex carbohydrate product of Chitin, a naturally occurring glucosamine. It works via its mucoadhesive properties, but may also enhance platelet function. Animal studies have shown promising results, and there are multiple case reports from the U.S. Army’s combat operations.10,11

- **Celox:** Celox is made with chitosan, a natural polysaccharide, and is broken down into glucosamine. It is derived from shellfish, but does
not appear to cause skin reactions in those hypersensitive to fish or shrimp. It works via a direct interaction with the blood, not through the clotting cascade, and has shown effectiveness in patients on anti-platelet and anti-coagulation therapy. It comes in a granular form as well as impregnated gauze. All hemostatic agents require proper wound packing and pressure.

### Tourniquets
Several tourniquets are currently commercially available, with the C.A.T. most frequently used by the military. Lessons learned include:

- The need to apply the tourniquet before the onset of shock and use by all personnel, including self-use—a basic-level skill.
- If a single tourniquet doesn’t eliminate distal pulses, then a second should be applied just proximal to the first. This effectively increases the tourniquet width, controls bleeding more effectively and reduces complications.
- The Velcro band should be as tight as possible before the application of the windlass. Three 180-degree turns of the windlass should be sufficient to occlude arterial flow if the Velcro strap has been effectively tightened.
- Military researchers have carefully studied the routing of the friction band through the buckle of the C.A.T. The band can be routed through one or both slits of the buckle. Recommended routing depends on the application by one or two hands and the placement on upper or lower extremity. The friction band should always be placed through both slits in the buckle when applied with two hands or when used on the lower extremity. This prevents the tourniquet from slipping when more torque is applied, as is usually the case on the lower extremity. Use of a single slit is only acceptable in upper extremity use.

### Transexamic Acid
Transexamic acid (TXA) is an anti-fibrinolytic that blocks the action of plasminogen, an enzyme that dissolves blood clots. TXA is now used by both the U.S. and Britain to treat severe wartime injury and hemorrhage. Current guidelines recommend that patients receive a 1 g loading dose of TXA in the first three hours after injury, followed by IV infusion of another gram over eight hours. The earlier the initial dose is administered, the more likely it is to prevent fibrinolysis. For more information on TXA, see p. 13.

### Combat Ready Clamp
The Combat Ready Clamp (CRoC) is an FDA-approved device for control of hemorrhage in junctional areas, where tourniquet application is impossible, and in the axillary. Sites such as the inguinal, axillary, and pelvic areas are difficult areas to provide hemorrhage control. This device applies direct pressure over packed inguinal injury sites and applies pressure midway between anterior superior iliac spine and pubic tubercle (occluding the external iliac artery).

The CRoC is placed in the inguinal area to stop circulation to the pelvic and femoral region when a casualty is in danger of bleeding to death from wounds that are poorly accessible to treatment by traditional bandages or tourniquets.

### SAM Junctional Tourniquet
The SAM Junctional Tourniquet for hemorrhage control is designed to control bleeding where tourniquets would not be effective, such as with IED/blast injuries or high-level amputations. It is compact, easy to use (only four steps), and quick to apply (typically under 25 seconds).

The target compression device (TCD) is placed at or near the injury site and pumped up until the bleeding stops. Two TCDs can be used to occlude blood flow bilaterally if needed. The patented buckle provides the clinically correct force every time, taking the guesswork out of tightening.

### iTClamp
The FDA-approved iTClamp Hemorrhage Control System, developed by Canadian trauma surgeon Dennis Filips, MD, who served in Afghani-
Training Focus, Adjuncts & Approaches

With all these new options, training can prove to be overwhelming. First, EMS providers should be well versed and competent with the basic techniques of direct pressure, elevation and splinting. Providers must properly demonstrate the basics on manikins or simulators, and also on each other where safe and applicable. Artificial skin/body organ props can be obtained to augment your training. Ideally, training should include live tissue active bleeding. Students should use training devices in a realistic setting to ensure proper understanding of the limitations of these products and to practice their use under stress.

Simulated bleeding, whether via high-fidelity simulation or flow-generating cadaveric specimens, often isn’t practical because the hemostatic products require the elements in fresh blood to work—something that can be obtained only from animal subjects or human victims.

However, a recent product that offers realism to training is LUNA’s TrueClot Blood Simulant. This non-toxic, non-stain, realistic “blood” actually clots when used in conjunction with simulated wound clot dressings and the iTClamp.

Unlike hemostatic agents, devices that work through a compressive mechanism such as tourniquets, the CROc, and the iTClamp can be taught through the use of high-fidelity simulation (HFS). Models that are capable of generating arterial level pressures and flow can serve as good trainers. Emphasis on proper placement, technique and complications is important, and HFS is capable of meeting these requirements.

My experience is that, despite the high quality of these simulators, they don’t impart the same sense of confidence as cadavers and live tissue. Although cadaveric training is more expensive, I believe it provides the best training available, resulting in the best retention and highest skill level, and ensuring the most appropriate use of devices and techniques.

As with any techniques or tool, it must be used as part of the overall care of the patient, and any training should include the additional principles of body heat retention and avoidance of acidosis.

Joe Holley, MD, FACEP, is medical director for Memphis Fire, Shelby (Tenn.) County Fire and multiple municipalities in the area. He is also the EMS medical director for the state of Tennessee. Holley is the medical director for FEMA’s Tennessee Task Force One Urban Search and Rescue Team, and has been deployed more than 20 times to such events as the Pentagon during 9/11 and Hurricane Katrina.

References

FAST. SAFE. EFFECTIVE.

Introducing an innovative breakthrough in hemorrhage control! The iTClamp™ is a trauma clamp device for the temporary control of severe bleeding. The device seals the edges of a wound closed to create a stable clot to mitigate further blood loss until the wound can be surgically repaired. Pre-clinical trials showed the iTClamp to be superior to wound packing in terms of patient survival, survival time and total blood loss.1 Applied within seconds, the iTClamp is ideal for emergency medical personnel.

Visit iTraumaCare.com, email us at info@iTraumaCare.com or call 1-855-774-4526, option 3 and find out more.