

Hemorrhage control devices: Tourniquets and hemostatic dressings

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66] **H**emorrhage control is the highest priority in caring for an injured individual. To be maximally effective, hemorrhage control must occur as soon as possible after the wounding event. Unfortunately, uncontrolled hemorrhage remains the single most preventable cause of death after both military and civilian injuries. One of the most important lessons learned in the last 14 years of war is that using tourniquets and hemostatic dressings as soon as possible after injury is absolutely lifesaving.¹ The resulting sustained focus on hemorrhage control has evolved into the widespread use of two devices: commercially manufactured tourniquets and hemostatic dressings. Recent evidence from thousands of injured patients has demonstrated that the use of tourniquets does not lead to amputations and the use of tourniquets should be considered early on. Technological development has also resulted in wound dressings that are impregnated with materials that help stop bleeding more effectively than plain gauze. The U.S. military experience during the conflicts in Afghanistan and Iraq, with more than 50,000 combat casualties, taught the military trauma system that both tourniquets and hemostatic dressings are extremely important for quality care and improved outcome.

Tourniquets in the civilian setting

The wounding agents are usually different in battlefield and civilian trauma, but the lessons learned regarding hemorrhage control and optimal resuscitation are not. Recently, the American College of Surgeons Committee

on Trauma and the U.S. Department of Transportation working group evaluated the evidence for external hemorrhage control measures.² The group's conclusions on tourniquets were that: (1) commercial windlass-type tourniquets should be used in the prehospital setting for the control of significant extremity hemorrhage when direct pressure is ineffective or impractical, (2) improvised tourniquets should be used only if no commercial device is available, and (3) a tourniquet that has been properly applied in the prehospital setting should not be released until the patient has reached definitive care. The recommendations on hemostatic agents were that: (1) topical hemostatic agents should be used in combination with direct pressure for the control of significant hemorrhage in the prehospital setting when sustained direct pressure is ineffective or impractical, and (2) topical hemostatic agents in a gauze can be used to enhance wound packing.

Hemorrhage control with tourniquets

In the 26 years between the end of the Vietnam War in 1975 and 2001, little changed in prehospital hemorrhage control. As a result, preventable deaths from extremity hemorrhage also did not change in almost three decades. After the widespread implementation of the tourniquet recommendations from the Committee on Tactical Combat Casualty Care (CoTCCC), a 10-year review of 4,596 U.S. combat fatalities noted a significant decrease in combat fatalities from extremity hemorrhage.³ The dramatic decrease in deaths from extremity hemorrhage resulted from the now ubiquitous fielding

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of modern tourniquets and hemostatic dressings on the battlefield and aggressive training of all levels of responders in their effective use.⁴

As noted earlier, deaths from extremity hemorrhage can largely be prevented by early use of tourniquets. Because of their effectiveness at hemorrhage control and the speed with which they can be applied, tourniquets are the best option for temporary control of life-threatening extremity hemorrhage in the tactical environment when under fire. This concept can apply as well in the civilian arena, with its increasing number of mass casualty or active shooter events. These concepts become especially applicable in terrorist-style bombing events on our home soil. Direct pressure and gauze compression dressings can be effective; however, the lack of dedicated personnel to apply continuous direct pressure, a less-than-secure environment, and extremity injuries that could lead to exsanguination are all indications for rapid tourniquet application. In routine emergency medical services (EMS) care, the so-called pressure dressing for massive external hemorrhage is frequently inadequate and only effective when continuous direct manual compression is applied. Because of the personnel constraints on most civilian EMS runs, tourniquets and hemostatic dressings are both medically and logistically beneficial.⁵ Despite the overwhelming evidence of benefit from the military experience, recent data indicate that only a few EMS systems are using recommended commercially manufactured tourniquets and hemostatic dressings for exsanguinating hemorrhage.

This situation continues despite numerous military publications documenting the lifesaving benefit and low incidence of complications from prehospital tourniquets and hemostatic dressings used in combat casualties. Although it is somewhat obvious, tourniquets are most effective in saving lives when applied early, before the individual has gone into shock from blood loss. Although tourniquet use has been discouraged by EMS systems in the past because of concerns about ischemic damage to the extremity, this

complication is actually very rarely seen. Prolonged use of a tourniquet can potentially result in amputation, but saving the life of the individual must always take precedence if the tourniquet cannot be removed. Because of their proven lifesaving value, tourniquets are now ubiquitous on the modern battlefield, yet adoption has been slow in many civilian EMS systems.

Although limited, there are reports that the adoption of the military practice of tourniquets and hemostatic dressings into civilian EMS and emergency medicine practice is increasing. One of the key concepts that emerged was placing the hemorrhage control devices in the hands of not only all medical providers, but also the much more numerous nonmedical first-responding personnel. In the civilian sector, many police officers and firefighters now carry these devices, making them widely and rapidly available. Effective training in, and use of, hemorrhage control devices by nonmedical personnel has been a critical element in reducing preventable deaths.

In patients with severe extremity bleeding, hemorrhage control is a priority. Most extremity injuries do not require tourniquets, but patients with life-threatening bleeding do require a tourniquet. As in most trauma situations, over-triage is acceptable, as tourniquets found not to be needed can be safely removed on arrival at a hospital. The following descriptions are provided as examples of trauma victims for whom tourniquet use is appropriate:

- There is pulsatile or steady bleeding from the wound.
- Blood is pooling on the ground.
- The overlying clothes are soaked with blood.
- Bandages or makeshift bandages used to cover the wound are ineffective and steadily becoming soaked with blood.
- There is a traumatic amputation of the arm or leg.

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- There was prior bleeding, and the patient is now in shock (unconscious, confused, pale).

When treating an individual who is in obvious shock from bleeding wounds, hemorrhage control should be the first priority, before fluid resuscitation. Effective hemorrhage control does not stop with the initial tourniquet application. The military experience with tourniquets has provided some key teaching points about their use:

- Waiting too long to place a tourniquet is a mistake.
- Tourniquets should be applied just proximal to the site of the severe bleeding and never placed directly over a joint.
- Tourniquets should be tightened as necessary to stop bleeding from the distal injury.
- If bleeding is not controlled with one tourniquet, a second tourniquet should be applied just proximal to the first.
- The need for a second tourniquet is especially applicable when applying tourniquets to generously sized lower extremities.
- The purpose of tourniquets is to stop arterial bleeding. If a distal pulse is still present, the tourniquet should be tightened or a second tourniquet applied just proximal to the first, and the pulse should be checked again.
- If a tourniquet is used, it should be an effective arterial tourniquet and not an ineffective venous tourniquet, as use of the latter can increase bleeding.
- Casualties with tourniquets in place should be rechecked periodically to ensure that the tourniquet is still working and that hemorrhage is controlled.

- Pulses distal to every tourniquet should be checked.

- Correctly applied tourniquets can cause significant pain, but this pain does not signify that the tourniquet has been applied incorrectly or that it should be removed.
- Pain should be managed with analgesics as appropriate, but not for patients in shock.

Mistakes regarding tourniquets include the following:

- Not having an effective commercial tourniquet available
- Not using a tourniquet when one should be used
- Using a tourniquet for minimal or minor bleeding when one should not be used
- Putting the tourniquet on too proximally
- Not making the tourniquet tight enough to effectively stop the bleeding
- Not using a second tourniquet if needed
- Waiting too long to put the tourniquet on
- Not reevaluating the tourniquet's effectiveness
- Periodically loosening the tourniquet to allow blood flow into the injured extremity

The time when a tourniquet is applied should always be noted on the individual's body, customarily by writing the letter *T* on the person's forehead, along with the time that it was tightened. This notation should be done with an indelible ink marker to ensure that this important information does not wash or wipe off. The

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information should also be recorded on the individual's run sheet and total tourniquet ischemia time recorded in the hospital chart. Finally, all manufactured tourniquets are designed for a single use. A separate group of tourniquets should be used for training, and training tourniquets should not subsequently be issued for actual casualty use.

Improvised tourniquets

Noncommercial, or so-called improvised, tourniquets are not nearly as effective as tested and recommended tourniquets. In 2001, at the start of war in Afghanistan, the U.S. military's plan was to use improvised tourniquets. Improvised tourniquets have been found to be difficult to assemble and secure. Military experience has shown that improvised tourniquets sometimes result in preventable deaths. After unnecessary deaths early in the war, the military's strategy changed. By 2005, thousands of commercial tourniquets had been sent to the battlefield and were carried by medical and nonmedical personnel.⁶ Transitioning this experience and lessons learned to the civilian arena is extremely important.⁷

Hemorrhage control with hemostatic dressings

Dressings in various forms have been used for thousands of years to help stop bleeding. At the start of the war in Afghanistan in 2001, the U.S. military used a gauze dressing that had not changed appreciably since World War I. Early in the war in Afghanistan, hemostatic dressings were developed that were lightweight, durable, and much more effective than standard gauze at stopping bleeding. After significant feedback from experienced military medics, in 2003 the CoTCCC recommended a hemostatic dressing that could be packed into a wound but that had hemostatic performance that was superior to standard gauze. These dressings were often used in conjunction with tourniquets but were especially useful in wounds not amenable to tourniquet use.⁸

Hemostatic dressings have been clearly shown to be a valuable adjunct in external hemorrhage control when the source of the bleeding is from a site not amenable to tourniquet placement. As with all devices, to ensure maximum effectiveness, the application of hemostatic dressings requires training. Critical elements are to ensure a correct packing technique and sustained manual compression for a minimum of three minutes. Simply applying the agents without maintaining pressure is not adequate to achieve the best possible hemostatic effect. Afterward, a standard pressure dressing can be applied to cover both the wound and the hemostatic dressing.

Selection of tourniquets and hemostatic agents

As civilian EMS systems make decisions about hemostatic agents, they need to be aware that research has shown that not all tourniquets and hemostatic agents are equally effective despite the manufacturers' claims and advertising. During the wars in Iraq and Afghanistan, the Department of Defense developed standardized models and techniques for evaluating tourniquets, hemostatic dressings, junctional tourniquets, chest seals, and other items designed to be used in prehospital trauma care. A review of this literature should be part of the selection process for any agency making procurement decisions about prehospital trauma equipment. Any item selected for procurement should ideally be (1) reasonable in price; (2) laboratory tested for safety and effectiveness; and (3) experience proven for safety and effectiveness.

Individual and pre-positioned trauma kits

Military experience suggests that there should be at least two lists of trauma equipment: large kits that are pre-positioned for multiple people and smaller mobile kits for officers or first responders. All professional first responders should be equipped with bleeding control kits. Firefighters and law enforcement officers should

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carry tourniquets and hemostatic dressings in a kit on their person when responding. EMS equipment in the ambulance or helicopter should include hemorrhage control kits. All trauma centers should have these devices in their emergency departments. Training is paramount. Larger pre-positioned trauma kits should be placed at optimal locations for medical coverage of local events or locations. These larger kits would supply immediate needs in an active shooter event or mass casualty situation. Examples of locations where pre-positioned trauma kits would be of value are malls, movie theaters, schools, and sporting events. There is a growing recognition that the hemorrhage control kits should be positioned next to automated external defibrillators.

Recommendation

70 | External hemorrhage control can be accomplished easily by well-trained and well-equipped people, whether they are professional first responders or civilians. Tourniquets and hemostatic dressings should reduce preventable deaths from external hemorrhage in the civilian sector, just as they have done in the military. The recommendations for early effective hemorrhage control with commercial devices are important and similar to those of the CoTCCC, the U.S. military, the American College of Surgeons Committee on Trauma, the American College of Emergency Physicians, the National Association of Emergency Medical Technicians, and the Hartford Consensus III. The lessons learned in early hemorrhage control have been gained and applied in the crucible of battle. Widespread application of tourniquets and hemostatic dressings for hemorrhage control after civilian injury will save lives. ♦

Disclaimers

The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of Defense. This recommendation is intended to be a guideline only and is not a substitute for clinical judgment.

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