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Prehospital Hemorrhage Control and Treatment by Clinicians: A Joint Position Statement

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Prehospital Hemorrhage Control and Treatment by Clinicians: A Joint Position Statement

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Exsanguination remains the leading cause of preventable death among victims of trauma, with nearly half of these patients dying in the prehospital setting.[1] This statement represents a joint consensus opinion on prehospital hemorrhage control and hemostatic resuscitation by the American College of Surgeons Committee on Trauma, the American College of Emergency Physicians, and the National Association of EMS Physicians. It is intended for use by emergency medical services (EMS) clinicians, EMS medical directors, emergency physicians, trauma surgeons, and nurses in their treatment of the acute trauma patient with severe, life-threatening external bleeding. As bystanders are included in the trauma chain of survival and often serve as the first link in the chain, this document also provides guidance for the layperson in managing hemorrhage in the prehospital setting. This document is not intended to be a comprehensive discussion of hemorrhage control and resuscitation in the trauma patient. Rather, it combines the collective expertise of the authors and represented organizations with current published evidence to offer unified guidance on techniques to control hemorrhage and provide hemostatic resuscitation in this patient population. All clinicians should be familiar with the American College of Surgeons Stop the Bleed program and ongoing continuing education to reinforce skills is strongly encouraged.

POINTS OF CONSENSUS

1. Direct pressure remains the first choice of treatment and effectively controls bleeding in most patients.
2. Bleeding control algorithm for life-threatening external hemorrhage (Figure)[2]
   a) Identify the source of bleeding and determine whether the bleeding is life threatening.
   b) When hemorrhage control with direct pressure alone is not possible or is ineffective, the use of gauze and/or hemostatic-impregnated dressings for wound packing and the use of tourniquets on extremities to address compressible arterial bleeding, are recommended.
   c) Bleeding from the torso or junctional wounds including the neck, shoulder/axilla, and groin can be controlled by direct pressure, packing the wound, and/or placing a junctional tourniquet (axilla or groin only).
      - Wound packing increases direct pressure on the vessels within the wound.[3] To pack a traumatic wound, a clean cloth, gauze, or hemostatic-impregnated dressing is pressed deeply and firmly into the wound. Packing should be added while maintaining direct pressure until the wound is completely filled. Once packed, the wound should be covered with a dressing and significant pressure should be applied by both hands and maintained until initial hemostasis is achieved.[3]
      - Scalp injuries are known to cause severe life-threatening bleeding and can be controlled with direct pressure or rapid wound closure with running nylon suture.
3. Local hemostatic-impregnated dressings
   a) Options for commercially available hemostatic-impregnated dressings include factor concentrators, mucoadhesives, and procoagulants.[4,5]

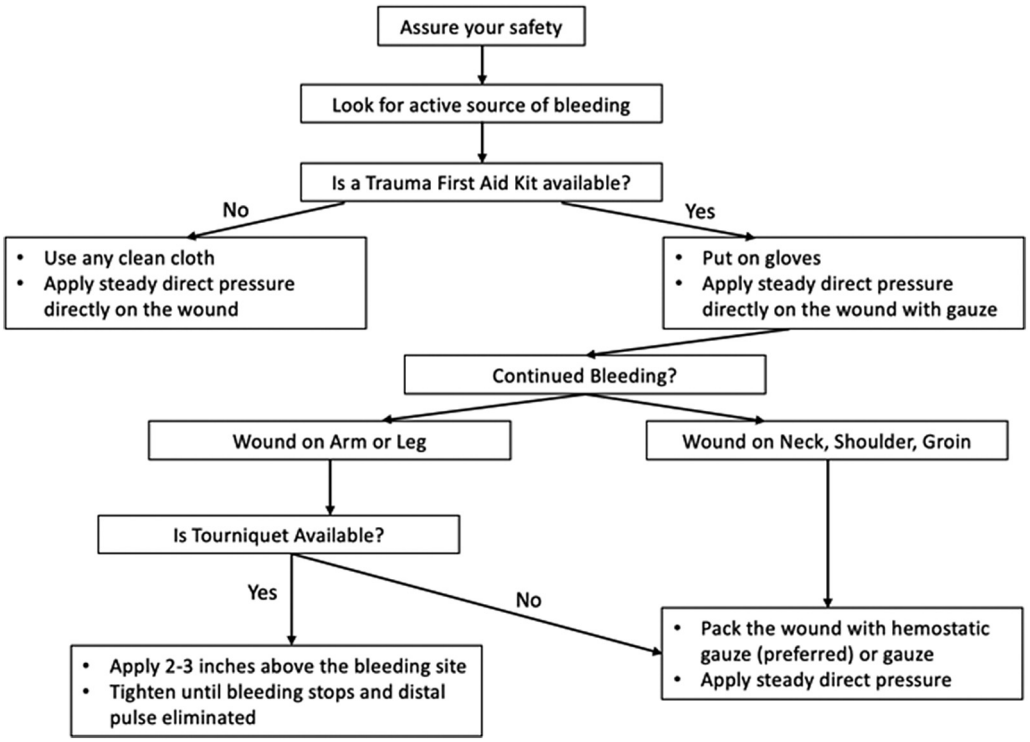

Figure.

b) Hemostatic-impregnated dressings should be applied followed by at least 3 minutes of direct pressure.[6]

4. Tourniquets
   a) There is greater chance of survival for the extremity trauma patient with life-threatening bleeding the earlier a tourniquet is applied.[7,8] Among patients who needed a tourniquet in the combat setting, mortality was universal when one was not applied.[9] Tourniquets should be stored where they can be rapidly accessed and applied.
      I. *Extremity tourniquet technique*[10]
         a. Apply at minimum 2 to 3 inches proximal to the wound.
         b. Placing a tourniquet as proximal and as tight as possible on the injured extremity ("high and tight" method) should be limited to circumstances where it is impossible or unsafe to determine the exact source of bleeding.
         c. Placement on bare skin is preferred whenever possible. Do not place over the elbow, wrist, knee, or ankle joints.
         d. Ensure that all slack is removed before tightening the windlass to avoid bunching and twisting.
         e. Tighten the tourniquet until bleeding stops and the distal pulse is eliminated.
         f. Note the time the tourniquet was applied and record this time, so the information is readily available. Preferably the time should be recorded on the patient or tourniquet.
         g. Do not loosen the tourniquet once applied.
         h. To maintain effectiveness of hemorrhage control, reassess the wound and tourniquet following any patient movement (eg, ground to stretcher and stretcher to ambulance) and during transport to ensure continued adequate hemostasis.
         i. If hemostasis is not obtained, add a second tourniquet 2 to 3 inches above the tourniquet in place. Do not remove the original tourniquet.
      II. *Reassess prior tourniquet application*
         a. Tourniquets placed by nonclinicians need to be further evaluated by trained medical professionals.
         b. Begin by determining whether a tourniquet is needed.[11] If the clinician believes that the tourniquet is needed, follow local guidelines. If it appears a tourniquet was not or is no longer indicated, see the

tourniquet conversion instructions that follow.
c. Ensure hemostasis.
d. Determine whether a distal pulse is present.

III. *Improvised tourniquet*
a. Improvised tourniquets are not recommended in the prehospital setting due to ineffectiveness and should be converted to a commercial-grade tourniquet as soon as possible.[12] If an improvised tourniquet must be used,[13] great care must be taken to ensure that the benefits outweigh the risks. Immediately when a commercial-grade tourniquet is available, it should be placed proximal to the wound and the improvised tourniquet removed.

IV. *Tourniquet conversion*
a. Tourniquet conversion is the deliberate process exchanging a tourniquet for a pressure dressing or hemostatic agent–this applies to both commercial *and* improvised tourniquets. Tourniquet conversion must only be performed by trained medical professionals.
b. When is the best time to attempt conversion of a tourniquet?
Recommendation: Assuming that the commercial or improvised tourniquet has been applied for a correct indication, a candidate for conversion is one who meets all the following recommendations:
i. Anticipated transport time to a place where surgical support is immediately available is > 2 hours.[14]
ii. Patient is not in shock (shock defined by systolic blood pressure [SBP] <90 mmHg if aged 10 to 64 years, SBP < 110 mmHg age if aged 65 years and up).
iii. The wound can be monitored for rebleeding during the entire patient transport.
iv. Absence of complete or near complete amputation.
v. Tourniquet has been applied for less than 6 hours.[15-17]
c. How do you convert a tourniquet?
Recommendation:[15]
i. Place a new tourniquet, referred to as "Tourniquet Plus 1," 2 to 4 inches proximal to the wound and keep it loose. If the original commercial or improvised tourniquet is in this same area, place the new loose Tourniquet Plus 1 proximal to the original tourniquet.
ii. Apply a pressure dressing to the wound. A hemostatic-impregnated dressing may be utilized if available.
iii. Loosen/release the windlass rod on the original commercial or improvised tourniquet.
iv. Monitor the wound for bleeding.
v. If no bleeding occurs, successful conversion to bleeding control without a tourniquet has been accomplished. If bleeding recurs despite the pressure dressing, tighten Tourniquet Plus 1. Resolving arterial spasm causing delayed bleeding during tourniquet conversion is a possible cause of rebleeding so careful monitoring of the wound once the tourniquet is off is required.
vi. If bleeding continues despite tightening Tourniquet Plus 1, tighten the original tourniquet (if commercial), and replace any improvised tourniquet with a commercial tourniquet.
vii. Continue to reassess any tightened tourniquet(s) for effectiveness.
d. Tourniquet pitfalls to avoid[15,18]
i. Delaying or avoiding a tourniquet for life-threatening extremity bleeding.
ii. Applying a tourniquet to control bleeding when other methods such as direct pressure and wound packing would suffice.
iii. Applying a tourniquet over a joint. Application over the peroneal nerve (knee or ankle) or ulnar nerve (elbow) may result in nerve damage or paralysis.
iv. Applying a tourniquet over clothing. Fully expose the involved limb(s), removing clothing from the limb(s), and do not cover a tourniquet with bandages or any other material.
v. Applying a tourniquet too close to the wound. Tourniquets placed near/over the wound can increase risk of additional tissue damage.
vi. Applying a tourniquet loosely. This may decrease bleeding but if the distal pulse remains, ongoing arterial flow with

obstruction to venous return can result in an increase in venous bleeding. The consequences may include avoidable pain due to venous congestion and compartment syndrome. If pulses are present and there is no hemorrhage, it is likely the tourniquet is not controlling true arterial hemorrhage.

vii. Delaying or avoiding a second tourniquet when arterial bleeding continues.

viii. Loosening a tourniquet periodically. This is different than loosening a tourniquet as part of a tourniquet conversion as outlined previously.

ix. Failing to reassess a tourniquet that may have loosened during transport.

x. Removing a tourniquet in a patient in shock and/or ongoing, uncontrolled bleeding.

xi. Allowing patient pain to interfere with proper bleeding control.

V. *Junctional tourniquet*[19,20]

a. Junctional regions are where extremities join the torso, such as the shoulder/axilla or the groin, and are too proximal for extremity tourniquet application.

b. Junctional tourniquets are external compression devices that occlude blood flow from the aorta, axillary artery, or iliac artery to prevent hemorrhage.[21]

c. Junctional tourniquet options include[21]:

i. A belt that uses a windlass to tighten and stabilize its position on the axilla, abdomen, or groin. Once in place, a pneumatic bladder is inflated to provide targeted compression by occluding the axillary artery (recommended application time < 4 hours), the aorta (recommended application time < 1 hour), or the iliac artery (recommended application time < 4 hours).

ii. A vice-like compression clamp that can be secured to the axilla or groin and tightened with a hand crank to occlude the underlying vasculature (recommended application time < 4 hours).

iii. A belt that can be placed around the pelvis with 2 mechanical pressure pads or an inflatable bladder that occludes the iliac or femoral artery (recommended application time < 4 hours).

d. Junctional tourniquets are approved by the Food and Drug Administration (FDA) and Department of Defense. Currently, there is inadequate clinical experience and data in civilian trauma to routinely recommend these.

5. Blood products (when available)

a) Prehospital blood product resuscitation has demonstrated greater than predicted survival with a 37% reduction in 30-day mortality among severely injured civilian patients.[22-26]

b) Among military patients, prehospital transfusion within minutes of injury was associated with significantly reduced 24-hour and 30-day mortality.[16]

c) Damage control resuscitation includes permissive hypotension (allowing for lower than physiologic levels as long as mental status is maintained) if defined in local protocols in non–brain-injured patients minimizing crystalloid volume,[27,28] and adhering to the balanced transfusion of packed red blood cells (PRBCs), plasma, and platelets, to decrease the risk of trauma-induced coagulopathy and endothelial injury. Whole blood may be used as well.

d) Recommendation: Patients with signs of hemorrhagic shock should receive prehospital blood products whenever available.[24-26,29]

i. Establish a prehospital transfusion protocol utilizing a multispecialty collaborative approach, including field and hospital clinicians.[30]

ii. Whole blood is preferred over PRBC. If only component blood products (PRBC, plasma) are available, transfuse in a 1:1 ratio.

iii. Supply and storage

- Ensure an adequate supply is readily available.
- Ensure that any vehicle carrying these products is equipped to maintain appropriate storage conditions.
- Consider reallocation of older blood products to high-use areas to avoid expiry waste.
- Blood transfusion should ideally be performed utilizing a blood warmer to achieve a delivery temperature of 38 °C/100 °F but no higher than 42 °C/108 °F.[28]

iv. Indications for administration

- Blood products should be strongly considered when a patient has a penetrating truncal mechanism,[31] external signs of hemorrhage, and a positive abdominal Focused Assessment with Sonography for Trauma when available with vital signs suggestive of hemorrhagic shock (SBP < 90 mmHg, heart rate > 120 beats per minute, or another quantitative measure such as the shock index).[32-35] Systems that wish to integrate prehospital administration of blood and blood products into their practice should work with all appropriate stakeholders to ensure successful delivery.

v. Tracking
- Protocols should be in place for tracking all units transfused as well as managing and reporting transfusion-related complications.

vi. Prehospital transfusion of women of childbearing age
- Given that most of the blood products available in the field are Rh positive, this can pose a risk of isoimmunization where the mother's red blood cells are incompatible with the baby's red blood cells resulting in hemolysis or destruction of the baby's red blood cells if the patient is early in a pregnancy and EMS is unaware.
- However, despite this risk, most systems have decided that the benefits of out-of-hospital transfusion outweigh the risks in this scenario, but there must be a plan for coordination with the trauma centers to ensure that the patient gets Rho (D) immune globulin (RhoGAM) if indicated.[35]

vii. While blood products in the field are helpful, the resources utilized can be challenging and logistically not possible for many EMS organizations. Currently, blood product transfusion by civilian EMS for hemorrhagic shock is not widespread.

e) If both PRBC and plasma are available, patients should receive both, starting with plasma, in a 1:1 ratio, to result in the greatest potential reduction in mortality.[36-41]

i. Resuscitation-induced hypocalcemia[42]
- Prehospital blood product transfusion in civilian trauma is associated with hypocalcemia, which in turn predicts decreased survival and the need for massive transfusion.
- 1 g (10 mL) of calcium gluconate should be given for every 1 to 2 units of blood products transfused in the prehospital setting.

ii. While currently only FDA approved for military use, freeze-dried plasma may also mitigate the costs and storage challenges of traditional cold-stored blood products.[43,44]

iii. The use of prothrombin complex concentrate in the prehospital setting is not recommended, unless it is administered as goal directed reversal of anticoagulants.[45]

iv. Prehospital tranexamic acid (TXA) administration (1 to 2 grams intravenously in 100 mL normal saline or lactated Ringers over 10 minutes by intravenous infusion) should be considered within 3 hours of injury.[46-49] The evidence on TXA is evolving.

v. Hypothermia is a marker for poor prognosis after hemorrhage; thus, maintaining normothermia is recommended.[50]

6. Resuscitative endovascular balloon occlusion of the aorta

a) Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) is a percutaneous procedure for life-threatening abdominal and/or pelvic hemorrhage that temporarily occludes the aorta utilizing an endovascular balloon.[51]

b) There is insufficient data to support recommendation of REBOA to be used in the prehospital setting.[52]

7. Pelvic circumferential compression devices

a) These devices are most likely to benefit a patient with an open book pelvic fracture. Recognizing the diagnostic limitations in the field, it is often not possible to differentiate a stable from an unstable fracture pattern in the prehospital setting.[53-56] There is no clinical evidence that pelvic compression worsens displacement of certain fracture patterns, particularly lateral compression fractures or causes injuries to internal structures through fracture fragment motion. Suspected pelvic fractures should be treated with circumferential pelvic compression.[57-59]

b) Pelvis examination by compression of the iliac crests toward the midline (NOT distraction) should be assessed in the secondary survey. If any instability or crepitus is felt, the patient should be placed in a circumferential wrap centered over the greater trochanters.[60] Prehospital pelvic circumferential compression device (PCCD) is recommended in suspected pelvic fracture based

on a mechanism of severe blunt force trauma or one of the following: pain on examination, hypotension, a compromised examination by altered mental status or distracting injury, or blast- or high-energy injury with lower extremity amputation.

c) Prolonged use or overtightening of PCCD may cause pressure ulceration.[58]

8. Pediatric considerations
   a) Pediatric circulating blood volume is approximately 80 mL/kg. A child may lose up to 45% of circulating blood volume before exhibiting hypotension.[59] Therefore, hypotension is a late sign of shock. Hypotension in children is determined by age and SBP (SBP < 70 mmHg + (age in years $\times$ 2) for ages 0 to 9 years; SBP < 90 mmHg for ages 10 years and up).[61] Direct pressure at or immediately proximal to the site of injury should always be the initial technique for hemorrhage control.[62]
   b) If direct pressure fails to control exsanguinating hemorrhage, a tourniquet should be applied.[62]
   c) Except children less than 2 years, the same tourniquet used for adults can be used for children. The tourniquet should be placed 2 to 3 inches proximal to the bleeding site with enough proximal pressure to impede arterial blood flow.[62] There are published studies in children aged 2 to 7 years and 6 to 16 years where adult tourniquets were successfully used, although 3 windlass turns were often needed. If the tourniquet fails to provide occlusion, direct pressure should be used.[63-65]
   d) Junctional tourniquets may work on teenagers and larger children but there is limited information in the current literature to give guidance.
   e) If commercial tourniquets are too large, apply direct pressure on the wound. For large, deep wounds, pack the wound. Hemostatic-impregnated dressings should be applied with at least 3 minutes of direct pressure.[6]
      a) Tourniquets should frequently be reevaluated after placement for appropriate positioning and adequate control of bleeding.[62]
      b) The principles of tourniquet conversion are identical for children and adults.
9. Mass casualty situations
   a) The above guidance is not designed to be used in mass casualty situations.
   b) In all situations where the number of patients outweighs the available resources, hemorrhage control and treatment should be done as quickly as possible and focused on the most-acute patients using triage principles.

SUMMARY

- Consensus-based guidance on prehospital hemorrhage control and hemostatic resuscitation is described.
- Where variations and differences of opinion are present, local protocols should be developed and followed.
- Update local protocols based on a performance improvement process.
- Ongoing continuing education to reinforce initial training skills is strongly encouraged.

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