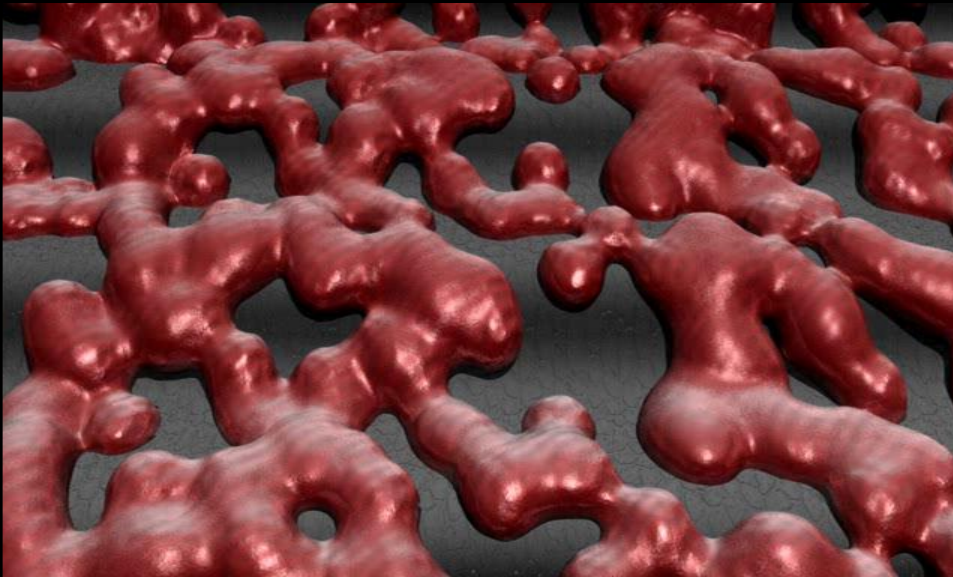


Life or Limb? Management of Extremity Injuries



Eric Hanchett NREMT-P, CCEMT-P, CIC

Extremity Trauma & Bleeding Control

- * Anatomy & Physiology
 - * Body and Blood
 - * Clotting Process
- * Hemodynamics
- * Details of Hypoperfusion
- * Blood Loss Estimate
- * Tissue/Extremity Injuries
- * Amputations
- * Care of parts
- * Bleeding control
- * Tourniquets
- * Tourniquets
- * Tourniquets



Disclaimer

I am **not** establishing protocol!

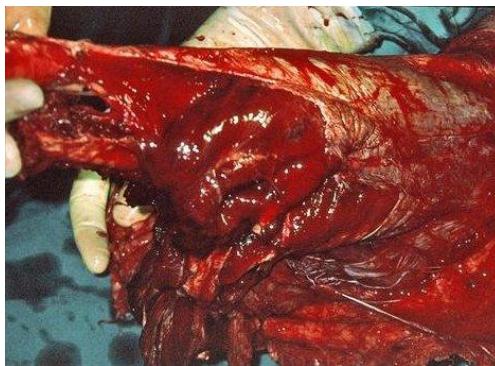
I am here to give you insight / information which you can apply to your assessments and treatment.

Keep in mind current state and regional protocol and guidance of your medical director.

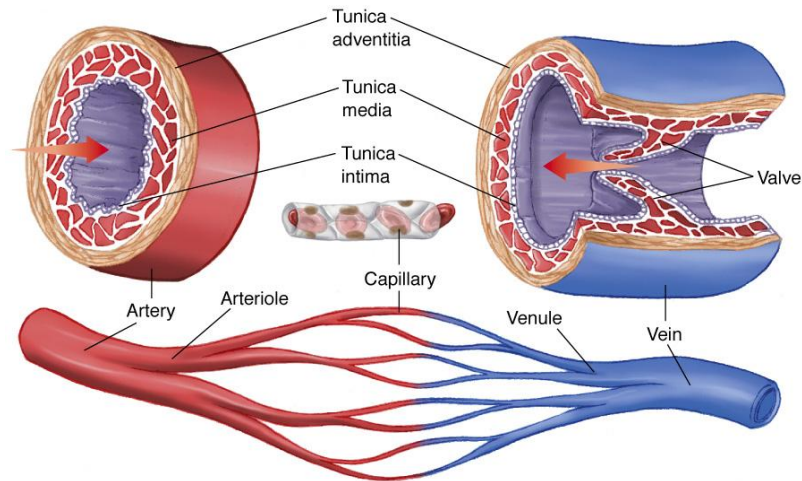


Factors Affecting Bleeding

- (1) Size of the vessel
- (2) Ability of injured vessel to go into spasm
- (3) Presence of Clotting Factors
- (4) Pressure in the vessel (Transmural Pressure)

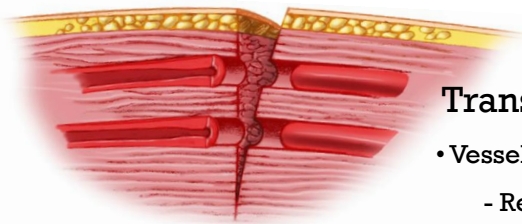


(1) Size of the Vessel



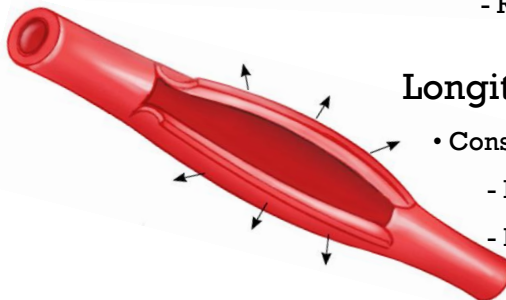
Circulating Blood Volume: 80 ml/kg

(2) Ability of vessel to spasm



Transverse (Clean Tear)

- Vessels constricts and draws inward
 - Reduction of lumen
 - Reduction of blood loss



Longitudinal (Crush Trauma)

- Constriction of smooth muscle
 - Enlarges wound
 - Increased blood loss

(3) Clotting Factors

Step 1 - Vascular Spasms

Vasoconstriction reduces lumen size = reduction blood loss

Step 2 - Platelet Phase

Tunica intima damaged, causing turbulent blood flow & frictional damage to platelets which adhere to collagen in tissue. This forms a loose, unstable clot.

Step 3 - Coagulation Phase (7-10 min)

Damage to vessels and turbulent blood flow starts the coagulation cascade to activate clotting factors. The clotting factors active fibrin proteins that trap RBC and more platelets to create a stable fibrin clot.

Blood Pressure

$$BP = (SV)(HR)(SVR)$$

Stroke Volume is a function of . . .

(1) Preload

- Regulated by venous return to the heart, most important to cardiac output
- Preload is the load (stretch, filling) on the ventricle before ejection
- ↓ Fluid Volume... ↓ Preload... ↓ Contractility... ↓ CO... ↓ BP

(2) Contractility

- Frank-Starling's Law: ↑ preload... ↑ ventricles stretch... ↑ contraction
- Epinephrine

(3) Afterload

- Pressure against which the LV ejects after the opening of the aortic valve
- Function of outflow resistance, arterial sympathetic tone
- ↑ VasoConstriction ... ↑ Vascular Resistance... ↑ Afterload... ↑ BP

Blood Pressure

$$BP = (SV)(HR)(SVR)$$

Heart Rate is a function of . . .

- (1) **Normal cardiac cycle**
 - 30% Systole, 70% Diastole - so... as HR ↑... Filling time ↓
- (2) **Endocrine system**
 - Epi. dump
- (3) **Central nervous system**
 - Hypoxia, ↑ sympathetic tone
- (4) **Baroreceptors**
 - As pressure ↑...Vagus nerve is stimulated to ↓ heart rate

Blood Pressure

$$BP = (SV)(HR)(SVR)$$

Systemic Vascular Resistance is a function of...

- (1) **Vasoconstriction**
 - Sympathetic Nervous System effects
 - Medications
- (2) **Arteriosclerosis**
 - Hardening of the arteries



Hypoperfusion = Shock

Inadequate Tissue Perfusion
 “Transition between homeostasis and death”



Causes of Hypoperfusion

Dependant on 3 components of circulatory system

Inadequate Pump

Reduced Preload
 Low Cardiac Contractile Strength
 High / Low Heart Rate
 Excessive Afterload

Inadequate Fluid

Hypovolemia

Inadequate Container

Anaphylaxis / Septic

Hypovolemic Shock

Hypoperfusion due to inadequate fluid

- ✓ Internal or External Hemorrhage
- ✓ Long Bones or Open Fractures
- ✓ Dehydration
- ✓ Plasma Loss from Burns
- ✓ Excessive Sweating
- ✓ Diabetic Ketoacidosis

Stages of Shock - Compensated Shock *(Hemorrhage Stage 1)*

- Early stage of shock during which the body's compensatory mechanisms are able to maintain normal perfusion.
-

≤15% loss of CBV (<750 ml)

- ✓ Normal Range: B/P, Pulse Press, Respirations
- ✓ Vasoconstriction (Venous)
- ✓ Epinephrine Release ("Epi Dump")
 - Slight Elevation of Pulse
 - Anxiety
 - Slightly pale & clammy skin



Stages of Shock - Decompensated (Early)

(Hemorrhage Stage 2)

Advanced stages of shock when the body's compensatory mechanisms are no longer able to maintain normal perfusion.

15-25% loss of CBV (750-1250 ml)

- ✓ Unable to maintain BP
- ✓ Big "Epi Dump"
- ✓ Tachycardia
- ✓ Pulse Strength ↓ Slightly
- ✓ Tachypnea
- ✓ ↑ Anxiety, Thirst, Restlessness



Stages of Shock - Decompensated (Late)

(Hemorrhage Stage 3)

Advanced stages of shock when the body's compensatory mechanisms are no longer able to maintain normal perfusion.

25-35% loss of CBV (1250-1750 ml)

- ✓ Compensatory mechanisms unable to cope
- ✓ Classic Signs of Shock:
 - Rapid Tachycardia
 - B/P ↓
 - Pulse barely palpable (VERY narrow pulse pressure)
 - Extreme Tachypnea / "Air Hunger"
 - LOC ↓
 - Pale, Cool, Clammy

Irreversible Shock

(Hemorrhage Stage 4)

Shock that has progressed so far that the body and medical intervention cannot correct it

>35% CBV Loss (>1750 ml)

- ✓ Pulse: Barely palpable
- ✓ Respiration: Rapid, Shallow & Ineffective
- ✓ LOC: Lethargic → Confused → Unresponsive
- ✓ GI/GU: Ceases
- ✓ Skin: Cool, Clammy & VERY pale
- ✓ Survival ...unlikely



Hypoperfusion Treatment

- * Airway / Breathing & Oxygen
- * Maintain Blood Pressure:
 - ✓ Control severe external bleeding...
 - ✓ Elevate legs 8-12"
 - ✓ Fluid replacement
- * Prevent loss of body heat !



Hypoperfusion Treatment

PASG/MAST May Have Benefits for:

- ✓ Suspected pelvic fractures with hypotension
- ✓ Profound hypotension
- ✓ Intraabdominal & Retroperitoneal hemorrhage

PASG/MAST Contraindications:

- ✓ Splinting lower extremity fractures
- ✓ Penetrating thoracic trauma
- ✓ Impaled abdominal objects
- ✓ Evisceration
- ✓ Pregnancy
- ✓ Trauma Arrest



Hypoperfusion Treatment

What HAS been shown by studies

Compression of the vessels reduces diameter and increases the SVR thus raising the blood pressure.

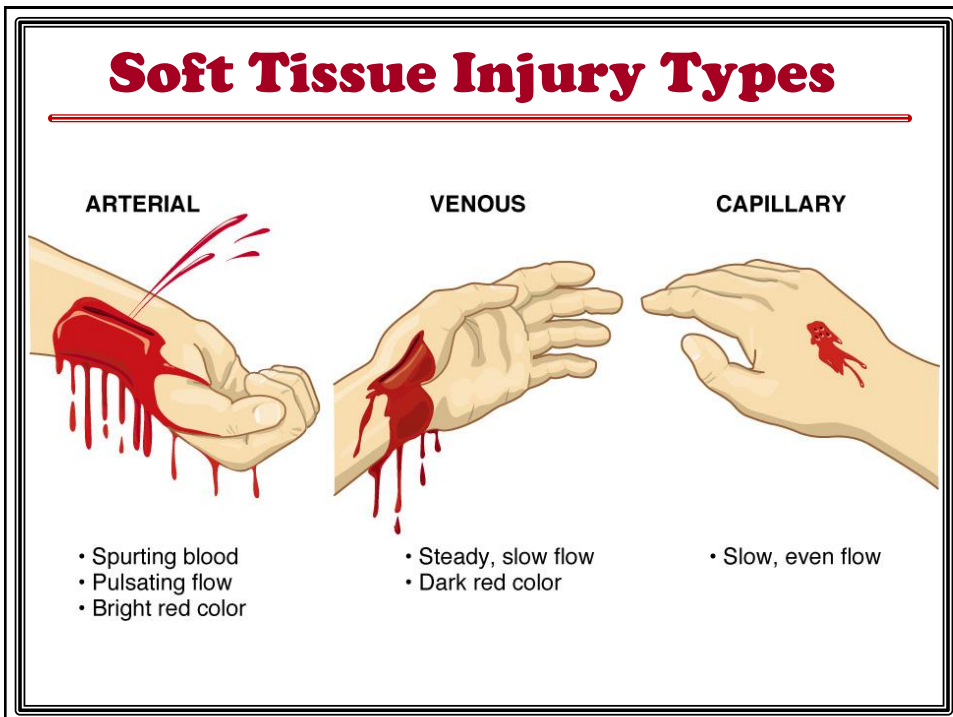
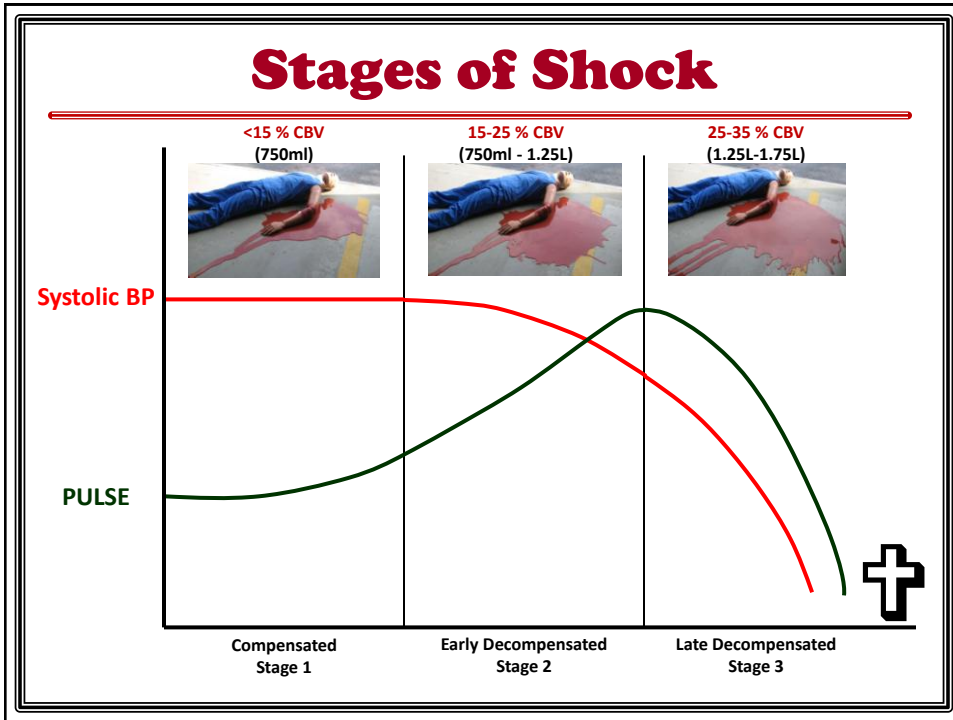
What HAS NOT been shown

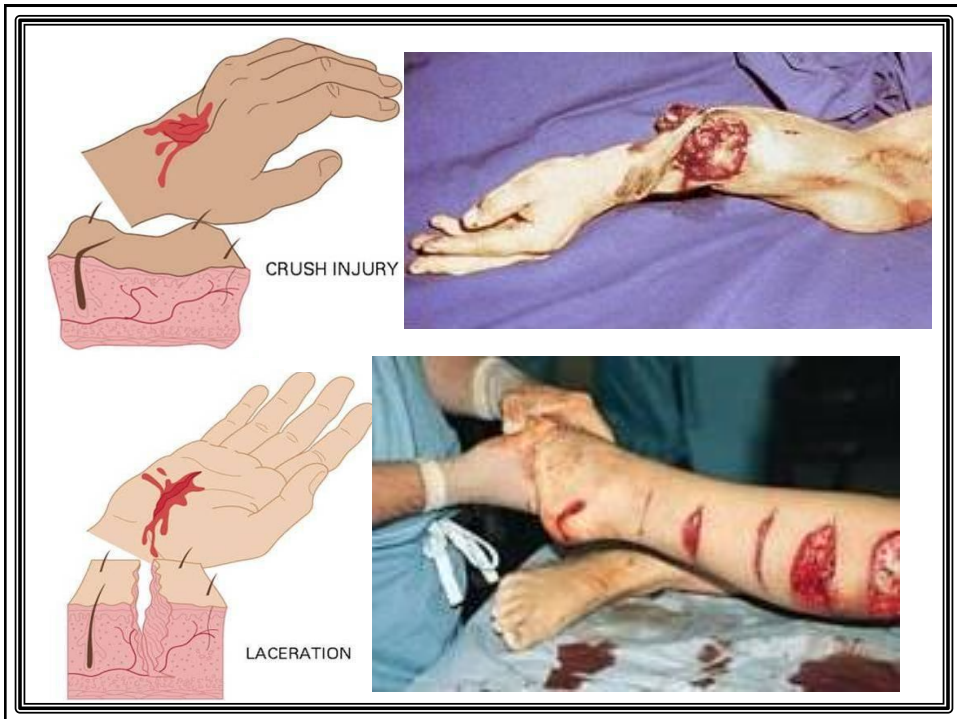
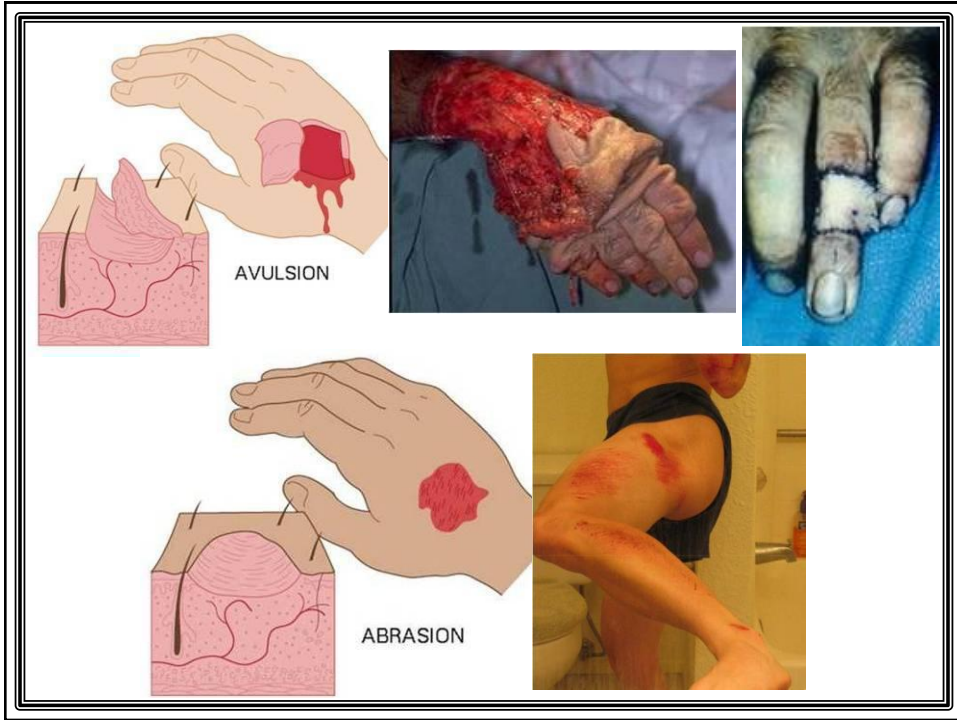
Significant shift of CBV

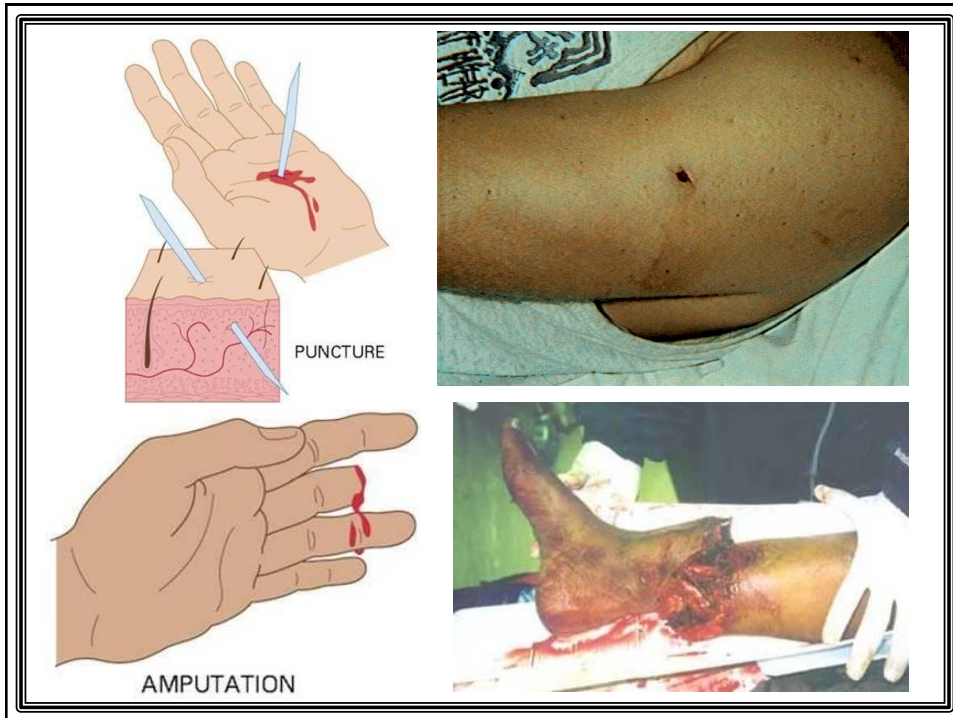












Amputated parts-n-pieces

- ✓ Never complete an amputation.
- ✓ Wrap part(s) in a moist sterile dressing.
- ✓ Place part(s) in a sealed plastic bag.
- ✓ Place the bagged part(s) in a pan/bag kept cool by cold packs/ice.
- ✓ Do not immerse part(s) directly in water or saline.
- ✓ Do not let the part(s) directly contact ice or it may freeze.
- ✓ Do not delay transport to locate amputated part!
Have a second unit transport the part.



NYS Practical Skills

akes, or verbalizes, body substance isolation precautions
✓ Applies direct pressure to the wound
✓ Elevates the extremity
Note: The examiner must now inform the candidate that the wound continues to bleed
✓ Applies an additional dressing to the wound
Note: The examiner must now inform the candidate that the wound still continues to bleed. The second dressing does not control the bleeding.
✓ Locates and applies pressure to appropriate arterial pressure point
Note: The examiner must now inform the candidate that the bleeding is controlled
Bandages the wound
Candidate controlled hemorrhage appropriately
Note: The examiner must now inform the candidate the patient is now showing signs and symptoms indicative of hypoperfusion
Properly positions the patient
Applies high concentration oxygen
Initiates steps to prevent heat loss from the patient
Indicates the need for immediate transportation
Candidate did not apply a tourniquet before attempting other methods of bleeding control
Candidate completed the station within the 5 minute time limit

NYS BLS Protocols

- II. Control bleeding by:
- A. Immediately applying pressure directly on the wound with a sterile dressing, and
 - B. Elevating the injured part above the level of the patient's heart (when possible), and
 - C. Applying a pressure dressing to the wound. If bleeding soaks through the dressing, apply additional dressings and *reapply pressure*. **Do not remove dressings from the injured site!**
 - D. Cover the dressed site with a bandage.
- III. If severe bleeding persists, apply pressure on the appropriate arterial pressure points. Splints and pressure splints may also be used to control bleeding. Use a tourniquet only if uncontrollable bleeding persists.
- IV. Assess for hypoperfusion. **If hypoperfusion is present, refer immediately to the hypoperfusion protocol!**

Direct Pressure

1. Apply pressure to the wound until bleeding is controlled. If the bleeding is mild, use a sterile dressing. If the bleeding is severe or spurting, immediately place your gloved hand directly on the wound.
2. Hold the pressure firmly until the bleeding is controlled. Remember your goal of limiting additional blood loss.
3. **Never remove a dressing once it has been placed on the wound. Removal of a dressing may destroy clots.**

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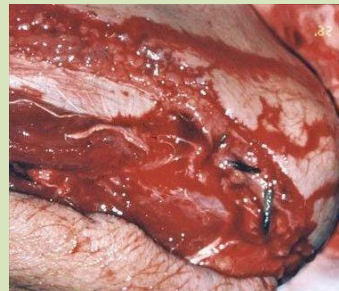
Direct pressure on the wound will control the vast majority of bleeding.

Pressure Dressing

Gauze pads are placed on the wound and a bulky dressing is placed over the pads. A self adherent roller bandage is wrapped tightly over the dressing and above and below the wound. Distal pulse must be checked and frequently rechecked, and you may need to readjust the pressure to ensure distal circulation.

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- ✓ The key is to apply the pressure right **on top** of the bleeding source, not around it.
- ✓ An effective pressure dressing requires time, hands and supplies to apply.



Elevation

...may be used at the same time as direct pressure. When you elevate an injury above the level of the heart, gravity helps reduce the blood pressure in the extremity, slowing bleeding.

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NO EVIDENCE



Pressure Points

...is a site where a large artery lies close to the surface of the body and directly over a bone. Compress the artery against the underlying bone by pressing your finger *onto the site*.

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Pressure points and elevation to stop bleeding have not been shown to be helpful, and may be harmful as the patient continues to bleed profusely while the rescuers struggle to gain control.

Art Hsieh, MA, NREMT-P Chief Executive Officer & Education Director of the San Francisco Paramedic Association

...in the absence of compelling data, these interventions can no longer be recommended for situations where direct pressure or a pressure dressing has failed to control hemorrhage.

PHTLS - Prehospital Trauma Life Support (NAEMT) 6th Edition (181)

NREMT-P Practical Skills

Takes, or verbalizes, body substance isolation precautions	1
Applies direct pressure to the wound ✓	1
Note: The examiner must now inform the candidate that the wound continues to bleed	
Applies tourniquet ✓	1
Note: The examiner must now inform the candidate the patient is now showing signs and symptoms indicative of hypoperfusion	
Properly positions the patient	1
Administers high concentration oxygen	1
Initiates steps to prevent heat loss from the patient	1
Indicates the need for immediate transportation	1

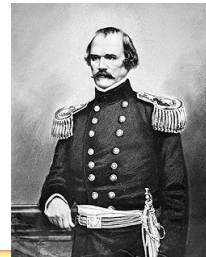
Tourniquet History

Civil War

Soldier issued

>60,000 field amputations during the war

Gen Albert Sydney Johnston



Tourniquet History

WWI

1914 - 1918



Prolonged time in "no mans land"

4 recommendations:

- (1) Never cover
- (2) Write "TQ"
- (3) Conscious soldier verbalize they have TQ
- (4) Limb necrosis if placed for >6 hr

WWII

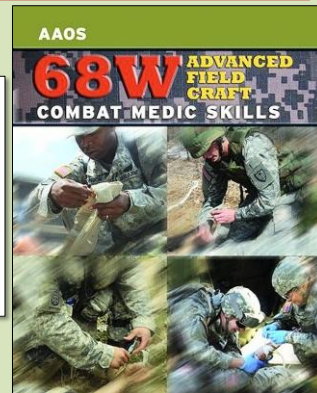


U.S. Army Medical Department review:

- (1) Regularly misused
- (2) Applied unnecessarily
- (3) Kept unloosened for too long
- (4) Concealed with blankets or clothing

Tourniquet History

Extremity hemorrhage is the leading cause of preventable combat death. Over 2,500 deaths occurred in Vietnam secondary to hemorrhage from extremity wounds; these casualties had no other injuries. These were preventable deaths.



"Tourniquets are being used on almost every extremity injury, and they are saving lives. Tourniquets were rarely seen early in the war, and now it's abnormal to see a severe extremity injury without a functional tourniquet in place. There is no pre-hospital device deployed in this war that has saved more lives than tourniquets."

Holcomb, 10th Combat Support Hospital in Iraq

Tourniquet History

A review of civilian extremity trauma from 1994-99 noted that: ⁽²⁾

- * 86% of patients who died from an isolated exsanguinating penetrating limb injury **had signs of life at the scene but no discernible pulse or BP on arrival to the hospital.**
- * **No** patient in this study had a prehospital tourniquet placed.
- * Factors that account for the reluctance of EMS personnel to use tourniquets include:
 - ✓ Perceived complications of nerve injury
 - ✓ Deep vein clot formation
 - ✓ Notion that ischemia could increase risk of future amputation

Tourniquet Use

- * Evidence...lots-n-lots
- * Ischemic complications related to time in place. Established as <2 hours by military and operative studies.



Tourniquet Use

- * Applied quickly...few hands...minimal equipment
- * Quick hemorrhage control allows more rapid ABCs
- * Leave tourniquet uncovered
- * Transport to Trauma Center
- * "Life over limb" rule



Tourniquet Use

- * Pain management ?
- * Fancy **Commercially Available** or Old School ?
- * Use of BP Cuff ?



What about the A&B of ABCs ?

The immediate aim of the applicant is to stop bleeding, thereby making the other goals attainable.

Data indicates that tourniquets prevent shock onset if used promptly for hemorrhage control in bleeding casualties and may prevent the worsening of shock.

If used after shock onset, most of the survival benefit is lost. Tourniquet use lengthens the survival time and provides more time for resuscitation or other lifesaving interventions.

Use of Tourniquets and Their Effects on Limb Function in the Modern Combat Environment - John F. Kragh Jr, MD

Tourniquet Placement

- * Remove clothing from placement site
- * Placement site proximal to injury...
- * Do not place over bony prominence or any area where skin / nerves & vessels are compressed against a hard bony surface
- * Tighten till bleeding controlled
- * Splint Injury
- * Mark TQ/TK and time
- * Do not cover tourniquet



How much is too much?

Minimum tourniquet pressure required to maintain hemostasis depend on:

Limb Size:

- ✓ Greater mass of subcutaneous tissue
- ✓ Lower pressures needed in thin patient vs. obese patients

Cuff type and cuff width:

- ✓ Pressure required ↓ as cuff width ↑
- ✓ Wider cuffs allow ↓ pressures and helps minimize complications

Peripheral vascular disease:

- ✓ Hypertension
- ✓ Arteriosclerosis - calcified less compressible vessels

Clin Ortho Rel Res, 1983;177:230

How much is too much?

Minimum tourniquet pressure required to maintain hemostasis depend on:

Tourniquet Pressure*

ARM: (SBP) + (50-75 mmHg)

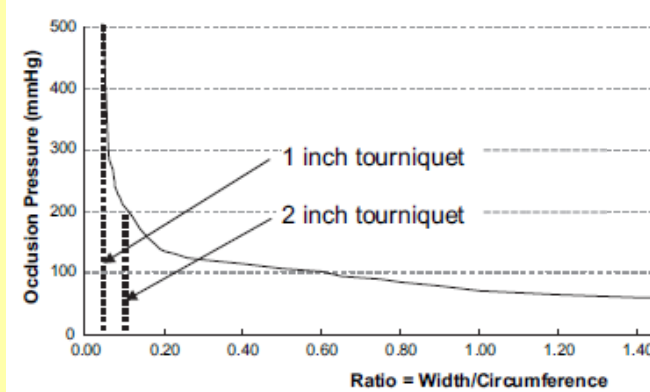
LEG: (SBP) + (75-100 mmHg)

* Technique has been shown effective in a prospective study of 84 surgical patients

Clin Ortho Rel Res, 1983;177:230

How much is too much?

- ✓ Pressure required is related to tourniquet width vs. limb circumference.
- ✓ Wider tourniquets reach effective pressures more easily and very wide tourniquets are effective at sub-systolic pressures.
- ✓ Safe pressure limited to 300mmHg, and nerve injury occurs at 500mmHg.



Adapted from Graham B, Bresault MJ, McEwen JA, et al. Occlusion of arterial flow in the extremities at subsystolic pressures through the use of wide tourniquet cuffs. Clin Orthop 1993;286:257-61

Potential Side Effects

- ◆ Pulmonary Embolus
- ◆ Skin Trauma
- ◆ Tourniquet Failure - *Venous tourniquet, loss of hemorrhage control*
- ◆ Tourniquet Pain
- ◆ Ischemia / Necrosis - *The capacity of ischemic tissue to recover is often better than clinicians suspect.*
- ◆ Vessel Damage
- ◆ Muscle Damage - *Apical tissue such as digits recover well (4hrs)*
- ◆ Nerve Damage - *Proportional to the scale of pressure gradient (8hr)*
- ◆ Tourniquet palsies - *Temporary 98% of the time. Most common is weakness and decreased sensation.*
- ◆ Compartment syndrome

How much is too much?



If one tourniquet does not control hemorrhage, another tourniquet added adjacent to the first has been shown to increase clinical effectiveness from 82% to 92%.

Adapted from Graham B, Breault MJ, McEwen JA, et al. Occlusion of arterial flow in the extremities at subsystolic pressures through the use of wide tourniquet cuffs. Clin Orthop 1993;286:257-61

C-A-T Tourniquet Use

- (1) Apply the tourniquet band above the bleeding wound
- (2) Adjust the friction adaptor buckle until the tourniquet is securely in place
- (3) Twist the windlass rod to provide direct pressure to the extremity; twist until the bleeding stop.
- (4) Lock the windlass rod in place with the clip

68W Combat Medic



Tourniquet Use

- * What about releasing and re-assessing the hemorrhage?
- * What about tourniquets WITH hemostatic dressings?

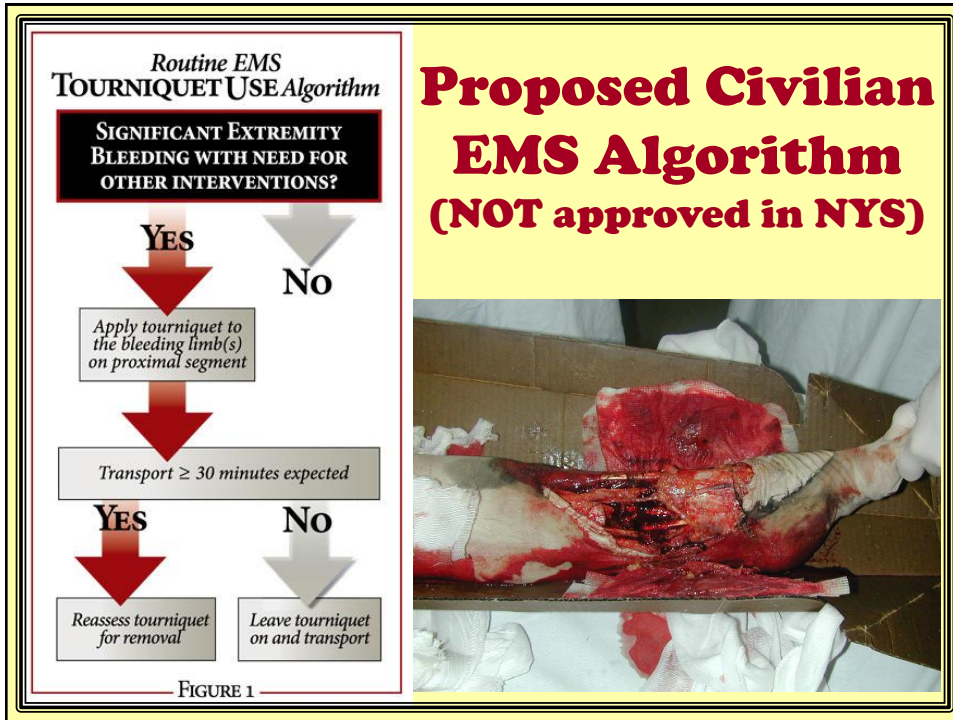


Hemostatic Agents

Celox/HemCon (Chitosan based)*
Quick Clot (Zeolite based)
TramaDex
Wound Stat (Smectite)

- ✓ Useful in situations where a person has serious external injuries that cannot easily be controlled by direct pressure or a tourniquet
- ✓ Must be applied to the source of the bleeding (vessel tear itself). This is often accessible in an open laceration, but may be deeply buried /inaccessible
- ✓ Foreign material or accumulated blood may have to be washed out to provide access to the bleeding vessel

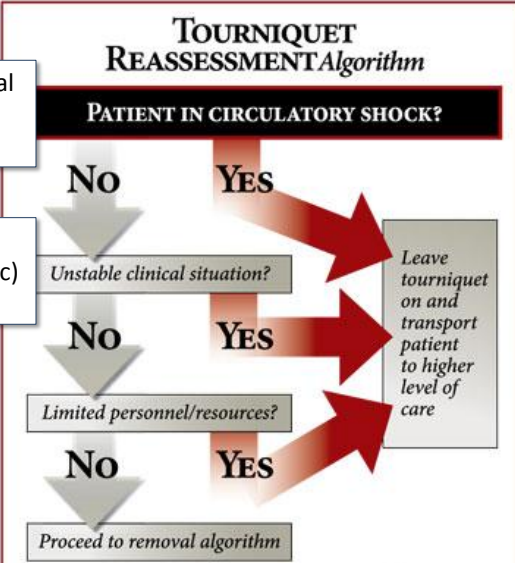




Proposed Civilian EMS Algorithm (NOT approved in NYS)

Proposed Civilian EMS Algorithm

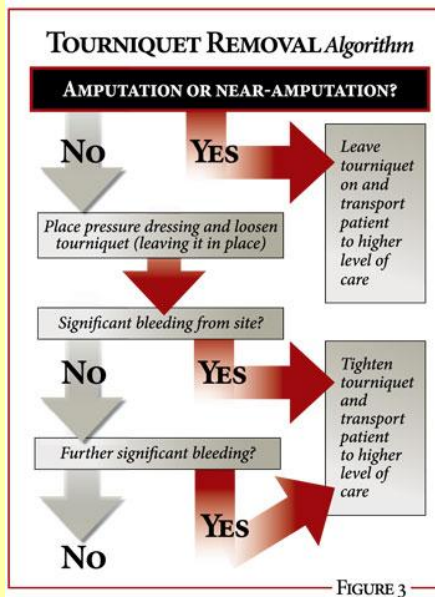
- ✓ Pale / Pallor
- ✓ BP vs. Pulse
- ✓ Cool / Clammy Skin
- ✓ Altered Mental
- ✓ Weak pulses
- ✓ Unconscious / Unresponsive
- ✓ Hypotensive (<90mmHg Systolic)
- ✓ SOB



Taillac PP. Tourniquet first! Safe & rational protocols for prehospital tourniquet use. JEMS October 2008. Retrieved May 2009 from http://www.jems.com/resources/supplements/the_war_on_trauma/tourniquet_first.html

FIGURE 2

Proposed Civilian EMS Algorithm



“The tourniquet is to be regarded with respect because of the damage it may cause, and with reverence because of the lives it undoubtedly saves. It is not to be used lightly in every case of a bleeding wound, but applied courageously when life is in danger”

Hamilton Bailey
Surgery of Modern Warfare
1941

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