Chapter 7

Shock and Resuscitation

Introduction

The goal of fluid resuscitation is to maintain adequate perfusion. Fluid resuscitation of the wounded combatant remains a formidable challenge on the modern day battlefield. Routine resuscitation using 2 L of crystalloid through two large bore IVs is not appropriate in all situations and **the vast majority of the casualties do not need any IV resuscitation prior to arrival at a forward medical treatment facility** (MTF).

This chapter will briefly address shock, including recognition, classification, treatment, definition, and basic pathophysiology. Initial as well as sustained fluid resuscitation and a review of currently available fluids and potential future products will be described.

Recognition and Classification of Shock

Shock is a clinical condition marked by inadequate organ perfusion and tissue oxygenation, manifested by poor skin turgor, pallor, cool extremities, capillary refill greater than 2 seconds, anxiety/confusion/obtundation, tachycardia, weak or thready pulse, and hypotension. Lab findings include base deficit > 2, and lactic acidosis > 2.5 mmol/L.

- Hypovolemic shock: Diminished volume resulting in poor perfusion as a result of hemorrhage, diarrhea, dehydration, and burns (see Chapter 28, Burns). This is the most common type of shock seen in combat soldiers (see Table 7-1).

Hypotension is a late finding in shock, after 30%–40% lost blood volume. Earlier signs are tachycardia, decreased pulse pressure, and mental status changes. Tachycardia is often not reliable; however, and relative bradycardia is common.

Table 7-1. Clinical Correlates in Hypovolemic Shock.

Blood Vol. Lost*	Heart Rate	Respiratory Rate	Blood Pressure	Central Nervous System
≤ 15%	Minimal tachycardia	No change	No change	No change
15%–30%	Tachycardia	Tachypnea	Decreased pulse pressure	Anxiety or combativeness
30%–40%	Marked tachycardia	Marked tachypnea	Systolic hypotension	Depressed mental status
> 40%	Marked tachycardia	Marked tachypnea	Severe systolic hypotension	Comatose

*Blood volume is approximately 7%, so a 70 kg patient has a blood volume of 4,900 mL.

- **Cardiogenic** shock: Pump failure from intrinsic cardiac failure or obstructive cardiac dysfunction from a tension pneumothorax, or cardiac tamponade with distended neck veins, or unilateral absence of breath sounds.
- **Distributive** shock: Poor perfusion due to loss of vascular tone; **neurogenic** shock: **bradycardia** with hypotension, seen with spinal cord injury.
  - **Treat hemorrhagic shock first.**
  - Volume resuscitation to maintain systolic BP > 90 mm Hg.
  - Consider the addition of a vasopressor to address the loss in vascular tone—phenylephrine (50–300 μg/min) or dopamine (2–10 μg/kg/min).
- **Septic** shock**:** Fever, hypotension, and warm extremities from massive vasodilation, usually seen 5–7 days after initial trauma.

Treatment of Traumatic Shock—Control Bleeding!

The goal in the treatment of shock is to restore tissue perfusion and oxygen delivery (dependent on hemoglobin, cardiac output, and oxygenation).

- Secure the airway and administer O_2 for $Sa_{O_2} < 92\%$.
- Diagnose and treat tension pneumothorax.
- Control obvious bleeding and assess for occult hemorrhage.
- Assess circulation and establish IV access.

- Consider cardiac tamponade even if no distended neck veins.

- Administer IV fluids.
  - Hemorrhagic shock: Initially, any fluid available.
    - LR: 1,000 mL expands intravascular volume by ~ 250 mL within 1 hour after injection.
    - 6% hetastarch: 500 mL expands intravascular volume by ~ 800 mL in 1 hour, is functionally equivalent to 3 bags of LR, and is sustained for at least 8 hours.
    - 7.5% hypertonic saline (HTS) results in the same physiologic response with 1/8th the volume of LR or saline. Two infusions of 250 cc can be used. Although this recommendation has been made by the Institute of Medicine (Washington, DC) and two military consensus groups, 7.5% HTS is not commercially available. 3% and 5% HTS can be used instead and are formulary stock items.
  - Nonhemorrhagic shock: Crystalloid is the fluid of choice.
    - Within 1 hour, resuscitate to a mean arterial pressure of > 60 mm Hg, a urine output of 0.5 cc/kg/h, and Sa_{O_2} of > 92%.

- Based on response to fluids, casualties will fall into 3 groups:
  - **Responders**: Casualties with a sustained response to fluids probably have had significant blood loss but have stopped bleeding. However, they may still require definitive surgery.
  - **Transient** and **nonresponders** are continuing to bleed. They need immediate surgical intervention.
    - Start blood transfusion as soon as possible.
    - For nonresponders, fluids may be given to keep the patient alive, but one should not attempt to restore pressure to normal. Consideration should be taken into account of the futility of the resuscitation depending on the tactical scenario.
    - Follow **controlled resuscitation** guidelines presented below.

Exsanguinating hemorrhage is the cause of most preventable deaths during war. Combat casualties in shock should be assumed to have hemorrhagic shock until proven otherwise.

- Vasopressors have no role in the initial treatment of hemorrhagic shock.
- Fluid choices.

The ideal fluid for resuscitation is still debated despite decades of research that began during WW I (see chart on next page).

Concept of Controlled (Hypotensive/Limited/Balanced) Resuscitation

- Raising the blood pressure with fluid resuscitation may dislodge established clots leading to more blood loss. Prior to establishing definitive hemorrhage control, use controlled resuscitation to **achieve and maintain** adequate perfusion as demonstrated by at least one of the following prioritized goals:
  - o Regains consciousness (follows commands).
  - o Palpable radial pulse.
  - o SBP ~90 mm Hg.
  - o MAP of ~60 mm Hg.

Controlled resuscitation is NOT a substitute for definitive surgical control. It is an attempt to keep a very sick patient alive until he can get to definitive treatment.

- Endpoints of resuscitation.
  - o **Following definitive hemorrhage control**, more traditional endpoints of resuscitation include
    - ♦ Blood pressure: SBP > 120 mm Hg, MAP > 70 mm Hg.
    - ♦ Urine output: > 0.5 mL/kg/h (approximately 30 mL/h).
    - ♦ Correction of acidosis:
      - ◊ base deficit < 2.
      - ◊ serum lactate < 2.5 mmol/L.
    - ♦ Hypothermia: It is important to maintain normal body temperature. Fluids and patient care areas should be warmed. This is often not possible in the deployed environment. Patients frequently arrive at the facility already hypothermic. Keep patients covered when on litters, radiograph tables, and operating tables. External warmers (such as contained forced warm air devices, eg, Bair Hugger) should be employed in all patient care

Fluid/Initial Dose	Indication	Advantages	Cautions
Crystalloids Saline Ringer's Lactate	Hypovolemia, dehydration, hemorrhage, shock, burns	Easy to store Inexpensive Proven effectiveness Isotonic	Weight ratio – requires 3:1 for lost blood Dilution, edema, coagulopathy
Hypertonic saline (HTS) 3%–5% 7.5%* Hypertonic saline-colloid combinations* HTS dextran* HTS hetastarch*	Hemorrhagic shock: 4cc/kg or 250 cc bolus, may repeat once Burns—only one dose initially	Lighter weight Small volume = large effect Increased cardiac contractility Longer duration of effect than plain HTS?	> 500cc – Risk of hypernatremia, seizures Do not use for dehydration from vomiting, diarrhea or sweating, or heat injuries Do not repeat without addition of other fluids Must replace depleted extravascular fluid
Colloids Albumin Artificial colloids Dextran 6% hetastarch (Hextend, Hespan) 10% Pentastarch* Gelatin-based colloids*	Hemorrhagic shock 250-500 mL bolus Burns? Third day	Longer duration 1:1 replacement for blood Raises plasma oncotic pressure Recruits extravascular fluid Weight/cube better than crystalloids	Overuse may lead to "leak" into tissue Binds immunoglobulins and Ca++ Must replace depleted extravascular fluid Artificial colloids: Coagulopathy, allergic reaction, osmotic diuresis, interferes with crossmatching Hetastarch: ↑ fibrinolysis, ↑ Amylase Max dose: 20 mL/kg/d (about 1.5 L)
Oral rehydration fluids	Dehydration controlled hemorrhage Burns	Fluids of opportunity Nonsterile ingredients: 4 tsp sugar, 1 tsp salt, 1 L water	Austere option in abdominal wounds and unconscious patients, but use with caution
Blood	Hemorrhage—Type O universal donor	Carries oxygen Autotransfusion Walking blood bank	Storage, type and cross-match Transfusion reactions, infection, immunogenic
Artificial blood Hemoglobin based Fluorocarbon based	Hemorrhage	Easy storage No type and cross matching	Experimental only, not yet available for use Fluorocarbons require supplemental O_2 Future option?

*Not FDA approved

areas from initial emergency area through operating room and ICU. Hypothermia is much easier to prevent than it is to treat. See further discussion of hypothermia in Chapter 12, Damage Control Surgery.

Transfusion Therapy

- Blood transfusion.

Blood should be added to the resuscitation of patients who have lost 30%–40% of their blood volume. Blood may also be necessary in patients who have not reached this threshold but have ongoing blood loss. Whole blood has a greater risk for immunologic reactions than packed cells.

Blood products fielded with forward medical units (FST, CSH) are predominantly group O packed red cells and FFP. Upon reaching a stabilization phase of operations, type-specific packed cells and platelets will be supplied through theater specific channels. Storage, shelf-life, and availability of these products are outlined in Table 7-2.

Table 7-2. Blood Products Available to the Theater.

Product	Unit of Issue	Storage	Shelf Life for Transfusion	Echelon Availability	Blood Group Availability			
					O+/-	A+/-	B+/-	AB+/-
Liquid PRBCs	~250mL	35d	35d	Second & third (MASH)	100%	—	—	—
				Third (CSH) & fourth	50%	40%	10%	—
Frozen/ deglyc-erolized RBCs	~250mL	10y	3d (postwash)	Third & fourth	100%	—	—	—
FFP	~250mL	1y	24h (postthaw)	Third & fourth	—	50%	25%	25%
Platelet concen-trate	~60mL	5d	5d	Third & fourth	50%	50%	—*	—*

* Will be provided by blood bank platoon and medical treatment facilities by in-theater blood collections.
CHS: combat support hospital; FFP: fresh frozen plasma; MASH: mobile army surgical hospital; PRBCs: packed red blood cells; RBCs: red blood cells
Adapted from US Department of the Army. *Planning for Health Service Support*. Washington, DC: Headquarters, DA; approved final draft January 1994. Field Manual 8-55: 8-6.

Familiarity with transfusion technique, patient-donor unit infusion connections, and walking blood bank connections, is essential and should be practiced routinely. Most serious transfusion reactions are the result of an error at the bedside, not an error in typing and cross-matching (ie, transfusing "the right unit to the wrong patient").

- **Transfusion reactions** may be difficult to recognize in severely or multiply injured casualties. Hemolytic (ABO mismatch) reactions present acutely (< 24 hours) with fever, chills, back pain, dyspnea, and renal failure. Delayed reactions may occur. Transfusion should be halted immediately in all cases, except minor allergic reactions (urticaria, fever, +/- mild bronchospasm), which are treated with diphenhydramine (25–50 mg IV or PO), H-2 blocker, methylprednisolone, +/- epinephrine.

Field Management of a Transfusion Reaction

- Stop the infusion of blood. Continue to infuse normal saline through the intravenous line.
- Examine the urine for hemoglobinuria. Examine plasma for hemoglobinemia.
- Maintain blood pressure and urinary output with saline. Consider administering mannitol or furosemide after volume repletion if the patient is oliguric.
- Reexamine the donor unit for seal integrity, evidence of hemolysis or infection, and recheck the transfusion log for clerical error.
- Annotate the field medical card with a description of the suspected reaction and the therapy provided. Transfer the unit suspected of causing the reaction to the next echelon of care with the casualty.

- **Clinical relevance of the Rh bloodgroup in female casualties**.
  Women, military and civilian, are becoming more frequent victims of conflict. Approximately 85% of the American population is Rh positive. Serious consequences to Rh incompatible blood are rare in men. Data predict that 10% of

group O blood transfusions will be of Rh positive units to Rh negative female recipients. An Rh negative woman transfused with Rh positive blood is very likely (approximately 80%) to produce anti-D (Rh positive) antibodies. This seroconversion can jeopardize a subsequent pregnancy when this Rh negative mother, now sensitized by Rh positive transfusion, conceives an Rh positive fetus. Chronic hemolytic disease of the newborn may result.

Under no circumstances should a life-saving transfusion be withheld because of Rh incompatibility; saving a life takes precedence over Rh immunization.

Prevention: When the supply of group O blood permits, group O Rh negative blood should be reserved for women.

- **Massive transfusions.**
  - Definition.
    - >10 Units of PRBC's in <24 hours.
    - Whole body blood volume transfusion in a 24-hour period.
  - Consequences of massive blood loss.
    - Shock.
    - Hypothermia.
    - Acidosis.
    - Decrease of coagulation factors.
    - Decrease of platelets.
  - Consequences of massive blood transfusions.
    - Dilution of coagulation factors.
    - Dilution of platelets.
    - Acidosis.
    - Hypothermia.
    - Hypocalcaemia (citrate toxicity) associated with rapid transfusions.
  - For every 10 units of PRBCs give:
    - 4 units of FFP.
    - 1 unit of platelets (6 pack of 1 aphresis unit).
    - Consider 1 dose of cryoprecipitate (10 single units of Cryo).
  - What blood to use?

- Type specific if at all possible.
- O positive (preferred) in males and postreproductive females.
- O negative (if available) in females of reproductive age.
- If still using O after 8 units, stick with O, even if blood type is determined. Stick with O until the patient's forward and back typed appropriately.

- Which FFP to use?
  - There is no such thing as emergency release FFP.
  - Type specific if at all possible.
  - AB when in doubt.
  - A as a second choice.
  - Unless you KNOW that the patient is Type O blood, **DO NOT use Type O FPP**.

- **Walking blood bank.**

When standard blood component therapy is unavailable, the use of fresh whole blood can be lifesaving. Because whole blood contains clotting factors, it is effective for treating dilutional coagulopathy associated with massive blood loss and fluid resuscitation.

- Equipment.
  - Blood recipient set (bag), indirect Tx Y-type (NSN 6515 01 128 1407).
  - Stopcock, IV therapy 3 way, with Luer lock (NSN 6515 00 864 8864).
- Cautions.
  - Field conditions increase the risk of bacterial contamination.
  - Definitive testing of blood for transfusion virus diseases is not available.
  - "Dog tag" blood typing wrong 2%–11% of the time.
  - Donor performance may be impaired by donation.
    - Good for small numbers of patients—large numbers lead to doubling of unit ineffectiveness.
    - Should not be the "default" answer for standard blood program planning.
    - Donate only once a month.
    - Avoid donation at high altitudes.

Even in an emergency, try to get regularly issued blood products.

- ◊ Women—ideally on supplemental iron before/after donation.

- o Planning.
  - ♦ Predeployment.
    - ◊ Develop a current prescreened donor roster.
      - ▪ Blood type and Rh.
      - ▪ Nonreactive transfusion transmissible disease tests (if available).
  - ♦ Onsite.
    - ◊ Update prescreening donor roster.
      - ▪ Tent/cot location.
      - ▪ Duty location.

- **Emergency (no roster in place).**
  - o Establish blood types with local testing or previous donor history.
  - o Choose prior blood donors in preference to nondonors because they have been tested for the infectious diseases in the past.
  - o Rely on "dog tags" only as a last resort.
  - o Draw only type "O" universal donors in mass casualty situations to reduce the confusion of handling.
  - o Draw universal or type specific donors in case of single patient incidents. (Type O donors are 46% of the US population.)
- Procedure for walking blood bank.
  - o Clean donor's arm with povidone iodine for at least 1 minute.
  - o Draw the blood from an arm vein into an unexpired, intact commercial blood bag.
  - o The bag has a 600 ml capacity and contains 63 mL of CPD or CPDA-1 anticoagulant.
  - o Draw about 450 mL, a "pint," so that the bag is almost full.
  - o Draw tubes for typing, cross-matching, and transfusion transmissible disease testing (if available).

  - Send tubes to a supporting laboratory (if available). Even after-the-fact testing is useful to provide reassurance of safety or explanations of untoward events.
  - Label the bag clearly with blood type and donor identification information.
- Whole blood crossmatching.
  - The white tile method uses a drop of the donor blood mixed with the recipient serum on a white ceramic tile and is examined in 4 minutes.
  - If no agglutination occurs, the blood is suitable for transfusion into that recipient. A hand lens may be useful.
- Storage.
  - Keep at room temperature no longer than 24 hours.
  - Blood stored warm for more than 24 hours has a significant risk of bacterial growth and clotting factors will be lost. If the blood has been kept at room temperature for less than 8 hours, it can be kept in a refrigerator or on wet ice for up to 3 weeks.
  - Although RBCs remain viable, platelets may become inactive in whole blood stored cold (1°C–10°C) for greater than 24 hours, losing one of the main benefits of fresh whole blood.
  - Ensure that anesthetist/anesthesiologist and surgeon are aware that this is an emergency-drawn unit and tell them the history of the unit.
  - After 24 hours, destroy warm-stored, whole-blood units. (Stateside hospitals would do so after exceeding 10°C for 30 minutes.) They are no longer safe or fresh. You may save cold-stored units until a regular supply of tested blood is reestablished.
  - Keep a record of donors and patients transfused so they can be tested on return to stateside.
  - Keep a record of number of units transfused, donor names, and outcome.
- Autotransfusion.
  - Blood collected into sterile containers (eg, suction, chest tube, among others) may be returned to the patient through a blood filter.

- Blood from sterile cavities, such as the chest or abdomen without visceral injuries is preferred.
- Blood from contaminated abdominal wounds can be used at an increased risk of systemic infection.
- Blood may be filtered through sterile gauze as a field expedient method.

The Future

Because the definition of shock is inadequate oxygenation at the cellular level, the most ideal fluid would provide volume expansion and oxygen-carrying capacity. For this fluid to be useful in deployed settings it needs to be stable at a variety of temperatures and have a low-risk profile. Hemoglobin based oxygen carrying compounds (HBOCs) currently under investigation may be such fluids. There are HBOCs derived from either bovine or human sources that require no refrigeration, have a shelf life of up to 3 years, are disease free, and require no crossmatching.