

## Permissive Hypotension: Changing Tide of Trauma Fluid Resuscitation

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### Objectives:

- ❖ Describe the history of fluids in trauma resuscitation
- ❖ Understand the pathophysiology of hemorrhagic shock
- ❖ Understand the rationale for limiting IV fluids during trauma resuscitation

### History of Fluid Resuscitation:

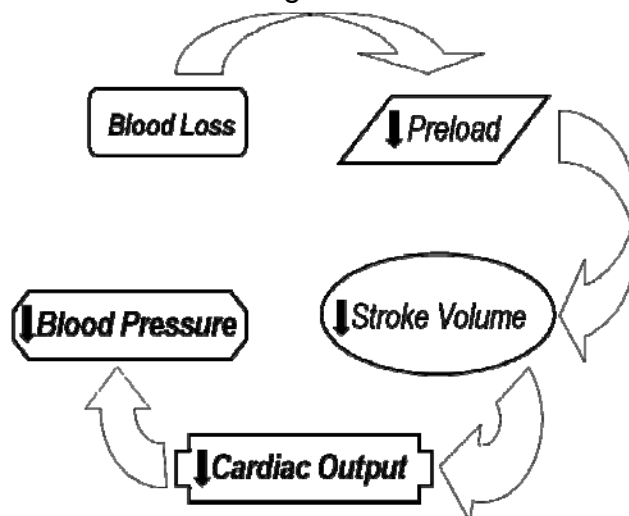
- ❖ Traditional resuscitation guidelines
  - 2 large bore IVs
  - Infusion of 2 liters normal saline or lactated ringers
- ❖ Hypotension in Trauma occurs in **10%** of both blunt and penetrating trauma victims. The civilian rate is approximately **6%-8%** and the recent military rate is **15%-18%**
  - Approximately **1/3** of victims of trauma who are hypotensive die early, either **at scene** or **in the trauma room** and are **victims of non-survivable trauma**

*This rate has been stable since the Crimean War and is not affected by trauma system development*
  - Approximately **1/3** of victims of trauma who are hypotensive are hypotensive from **non-hemorrhagic** causes. These causes include:
    - **pneumothorax**
    - **pericardial tamponade**
    - **gastric dilation**
    - **substance ingestion**
    - **medical conditions**
    - **spinal shock**
  - Approximately **1/3** of victims of trauma who are hypotensive are hypotensive secondary to **hemorrhage** and are the focus of the discussion.
- ❖ Cannon, Fraser, Cowell. *Preventative treatment of wound shock*. JAMA 1918 noted poor outcomes with IV Fluid resuscitation
  - “Inaccessible or uncontrolled source of blood loss should not be treated with intravenous fluids until the time of surgical control”

- ❖ Beecher. Resuscitation & anesthesia for wounded men, 1949 found adequate hemodynamics for surgery with limited fluid resuscitation.
  - “The young, healthy organically sound battle casualty will tolerate his wound and the strain of surgery without replacement of all blood lost.” p121
  - “A further principle that we established is that if surgery cannot be undertaken at once...the patient will not suffer as long as the systolic pressure is 80 mmHg and the skin warm and of good color. Neither will he lose as much hemoglobin as he will if plasma, say, is used to raise the blood pressure higher than necessary during the waiting period.” p125
- ❖ This early work suggested that hypotension in the setting of hemorrhagic shock may be protective. These findings were forgotten until later in the century.
- ❖ In the 1950s and 1960s much trauma research focused on **high volume resuscitation**. These studies were based on animal models of **controlled** hemorrhage, and thus did not translate to actual clinical conditions.
- ❖ During the Vietnam conflict, high volume resuscitation was used for hypotensive wounded soldiers. Many went on to develop what was called “Da Nang Lung”, which was **Acute Respiratory Distress Syndrome**. This was found to have been caused by an **inflammatory response** that took place in the lungs. This phenomenon had not been observed in prior conflicts.
- ❖ In the 1980s, the concept of limited fluid resuscitation returned. Animal models focused on **uncontrolled hemorrhage**, a more realistic model.
- ❖ First clinical study was performed by Bicknell, Wall, Pepe, et. al. in Houston reported in 1994. This study focused on **penetrating trauma** and concluded that limited fluid resuscitation **improved survival**.

### Pathophysiology of Hemorrhagic Shock:

- ❖ Hemorrhagic Shock is **inadequate tissue perfusion secondary to acute blood loss**.
- ❖ What happens when we hemorrhage?



- ❖ The body has several compensatory mechanisms in response to hemodynamically significant hemorrhage. All of these mechanisms lead to **sympathetic nervous system stimulation** and involve:
  - Vasoconstriction & Venoconstriction **skin, skeletal muscles and gut circulation.**
  - Preferential **coronary** & **cerebral** circulation
  - Increased **central venous** blood flow
  - Decreased **renal** blood flow occurs last
- ❖ Specific Compensatory Mechanisms
  - Baroreceptors are located in the **carotid arteries** & **aortic arch** and sense central arterial **pressure**. Their function is to **moderate the autonomic nervous system** and increase **heart rate**.
  - Circulating vasoconstrictors consist of **epinephrine** and others and cause an **increased vascular tone and heart rate**.
  - The **loss** of capillary pressure causes a fluid shift from the **cells** into the **capillaries** to help restore volume.
  - Stimulation of the thirst mechanism **increases fluid intake** and causes the kidneys to absorb **sodium** & **water absorption**.
  - Chemoreceptors are Important when MAP drops below **60** mmHg. These receptors are stimulated by **acidosis** and **hypoxia**. When activated, chemoreceptors produce **peripheral vasoconstriction** and **hypoxia**.
  - Cerebral ischemia occurs when the MAP falls below **60** mmHg. Cerebral ischemia causes an **intense sympathetic discharge** and is a last ditch effort to increase perfusion.
  - Hematopoiesis is the production of **new red blood cells** and is a **long term** mechanism not helpful in acute hemorrhage.
- ❖ These compensatory mechanisms work well, however at some point the patient will decompensate. When this happens, the following occurs:
  - Cardiogenic shock occurs due to **myocardial ischemia** and **hypoxia**. Myocardial dysfunction causes **dysrhythmias** and **pump failure**, worsening perfusion.

- The loss of sympathetic activity has significant systemic effects. Decreased vascular tone results in **hypotension**, **organ ischemia** and **organ failure**. Increased capillary pressure will cause **fluid leak** from **vessels** and worsening hypovolemia.
- Once the sympathetic burst caused by cerebral ischemia finishes firing, there is a **loss of autonomic nervous system outflow**.
- At some point, Systemic inflammatory response syndrome (SIRS) begins. **Inflammatory mediators** are released causing **cellular damage**, **small vessel plugging** and **capillary leak**, all of which contribute to the worsening hypotension.

### **Permissive Hypotension: *The Concept of limited fluid resuscitation***

- ❖ Hypotension is protective because the decreased blood pressure **allows clots to stabilize**. Hypotension is considered helpful in other conditions where bleeding is not controlled, including **aortic dissection** and **uncontrolled GI bleed**. In **pulmonary contusion**, controlled resuscitation decreased lung injury.
- ❖ The coagulation cascade is activated by a **break in the vessel wall**. A **platelet plug** forms which attracts additional circulating **platelets**. This clot transforms to a rigid plug in **20 – 30** minutes.
- ❖ A dilutional coagulopathy is caused when IV fluids (saline or lactated ringers) are infused, causing the concentration of platelets and clotting factors to drop. This can occur with an infusion as little as **750** ml of crystalloid infusion. The dilutional coagulopathy is worsened by the **cytokine activation** that is incited by the crystalloid infusion, lactated ringers more than normal saline.
- ❖ Raising the blood pressure rapidly places additional fluid stresses on the clot. Based upon several uncontrolled hemorrhage animal studies (pigs, rats, dogs), the hemostatic plug will rupture at an SBP of **80-90** mmHg or an MAP of **60** mmHg. In one study, there was a **76%** re-bleed rate when the SBP increased above **80** mmHg. As opposed to the controlled hemorrhage model used in the 1950s and 1960s, the animals were bled and the hemorrhage continued for a realistic period of time after resuscitation began. Most recent research has

focused on varying fluid treatment regimes including normal saline, lactated ringers, hypertonic (3% and 7%) saline, hetastarches, dextrans and combinations of these fluids.

- ❖ As you have surmised by this point in the discussion, there are several consequences to fluid administration. These include:
  - Hemodilution causing a drop in **hemoglobin** and **clotting factors**.
  - A rapid rise, then fall in blood pressure, resulting in **cyclic resuscitation & over resuscitation**, loss of **hemostasis** and a **reversal of the protective vasoconstriction**.
  - Cytokine activation occurs with all types of crystalloid fluids, setting off the **inflammatory cascade** which may result in **renal failure** and **ARDS**.
  - Coagulopathy occurs from dilution and from the cytokine activation, leading to **decreased clotting factors**, impaired coagulation factor function and **increased bleeding time**.
  - The inflammatory process also causes **increased gut wall permeability (leakiness)** which not only can cause **abdominal compartment syndrome** but allow a pathway for **bacterial invasion**.
  - High volume fluid administration also has an effect at the cellular level. The cellular environment becomes **acidotic (especially with Ringers)** and large **fluid shifts** occur which **disrupt cellular mechanisms**.
- ❖ The only controlled prospective study that has been performed was in Houston Bickell, Wall, Pepe, et.al. They enrolled 598 patients who sustained penetrating torso trauma who were hypotensive between November 1, 1989 and December 22, 1992. Patients on even days were in the immediate resuscitation group and received standard (at the time) prehospital and ED fluid resuscitation to normalize blood pressure. Patients on odd days were in the delayed resuscitation group and received no intravenous fluids until in the operating room and then only enough to maintain an SBP ~90mmHg.
- ❖ The results:
  - Immediate fluids group
    - 62% survival to D/C
    - 30% with complications
  - Delayed fluids group
    - 70% survival to D/C
    - 23% with complications
    - Shorter hospitalization

- ❖ The “Permissive Hypotension” camp has the following recommendations:
  - If normotensive administer **no fluids or little fluids**.
  - If hypotensive, administer controlled IVF (**25–500** ml boluses) until goal of:
    - **Radial pulse**
    - **Appropriate mentation in non head injured patient**
    - MAP **40-60** mmHg (SBP **80-90** mmHg)

❖ Controversy Remains:

- Permissive Hypotension:
- ✓ Don't pop the clot!
  - ✓ Hypotension can be tolerated until surgical control

- Standard Fluid Resuscitation:
- ✓ Organ ischemia bad!
  - ✓ Optimize organ perfusion



*It is a question of balance...*

- ❖ But what about patients who have sustained a head injury? We know from good research that **hypotension** and **hypoxia** are bad for the brain. An MAP above \_\_\_\_\_ mmHg is needed to provide an adequate cerebral perfusion pressure (CPP = MAP – ICP). Normal ICP is between 5 and 15 mmHg.
- ❖ In the case of head injury, studies suggest minimum **MAP > 60 to improve cerebral perfusion pressure** but also caution against over resuscitation.
- ❖ In reality, what is lacking are clinical trials. These type of trials are logistically difficult to perform. Most of this information is extrapolated from animal models.
- ❖ Open areas in question include:
  - Is permissive hypotension appropriate for patients who have received blunt trauma? The Bicknell study focused on penetrating trauma.
  - What are the balanced resuscitation goals in patients with a head injury?
  - Does permissive hypotension work in the pediatric & geriatric populations who do not have the compensatory mechanisms young adults have?
  - Patients with near morbid severe hypotension verses those with mild hypotension

**References:**

- 1) Alam HB, Rhee P. New developments in fluid resuscitation. Surgical Clinics of North America 2007;87(1):55-72.
- 2) Beecher HK. Resuscitation and anesthesia for wounded men: the management of traumatic shock. Springfield, IL. Charles Thomas 1949.
- 3) Bicknell WH, Wall MJ, Pepe PE, et al. Immediate verses delayed fluid resuscitation for hypotensive patients with penetrating torso injuries. NEJM 1994;331(17):1105-1109.

- 4) Champion HR. Combat fluid resuscitation: introduction and overview of conferences. *J of Trauma* 2003 54(5S):S7-S12.
- 5) Cotton BA, Guy JS, Morris JA, Abumrad N. The cellular, metabolic and systemic consequences of aggressive fluid resuscitation strategies. *Shock* 2006;26(2):115-121.
- 6) Cannon WB, Fraser J, Cowell EB. The preventative treatment of wound shock. *JAMA* 1918;70(9):618-621.
- 7) Dubick MA, Atkins JL. Small volume fluid resuscitation for the far-forward combat environment: current concepts. *J of Trauma* 2003 54(5S):S43-S45.
- 8) Holcomb JB. Fluid resuscitation in modern combat casualty care: lessons learned from Somalia. *J of Trauma* 2003;54(5S):S46-S51.
- 9) Klabunde RE. The pathophysiology of hemorrhagic shock. Lecture Notes available at: <http://www.oucom.ohiou.edu/dbms-witmer/Downloads/Klabunde-08-10-00.pdf>
- 10) Ledgerwood AM, Lucas CE. A review of studies on the effects of hemorrhagic shock and resuscitation on the coagulation profile. *J of Trauma* 2003 54(5S):S68-S74.
- 11) Lu YQ, Cai XJ, Gu LH, et al. Experimental study of controlled fluid resuscitation in the treatment of severe hemorrhagic shock. *Journal of Trauma* 2007;63(4):798-804.
- 12) Madigan MC, Kemp CD, Johnson C, Cotton BA. Secondary abdominal compartment syndrome after severe extremity injury: are early aggressive fluid resuscitation strategies to blame? *Journal of Trauma* 2008;64(2):280-285
- 13) Moore-Olufemi SD, Xue H, Attuwaybi BO, et al. Resuscitation induced gut edema and intestinal dysfunction. *Journal of Trauma* 2005;58(2):264-270.
- 14) National Institutes of Health. NHLBI stops enrollment in study of concentrated saline for patients with traumatic brain injury. May 12, 2009. Retrieved on 6/10/09 from [https://roc.uwctc.org/tiki/tiki-download\\_file.php?fileId=6424](https://roc.uwctc.org/tiki/tiki-download_file.php?fileId=6424)
- 15) National Institutes of Health. The NHLBI halts study of concentrated saline for patients with shock due to lack of survival benefit. March 26, 2009. Retrieved on 6/10/09 from [https://roc.uwctc.org/tiki/tiki-download\\_file.php?fileId=6059](https://roc.uwctc.org/tiki/tiki-download_file.php?fileId=6059)
- 16) Orlinsky M, Shoemaker W, Reis ED, Kernstein MD. Current controversies in shock and resuscitation. *Surgical Clinics of North America* 2001 81(6):1217-1262
- 17) Owens TM, Watson WC, Prough DS, et al. Limiting initial resuscitation of uncontrolled hemorrhage reduces internal bleeding and subsequent volume requirements. *J of Trauma* 1995 39(2):200-209.
- 18) Pepe, PE. Current issues in resuscitative trauma management: an overview. *Curr Opin Crit Care* 2001 7(6):409-412
- 19) Revell M, Greaves I, Porter K. Endpoints for fluid resuscitation in hemorrhagic shock. *J of Trauma* 2003 54(5S):S63-S67.
- 20) Roberts I, Evans P, Bunn F, et al. Is the normalization of blood pressure in bleeding trauma patients harmful? *Lancet* 2001 357:385-387.
- 21) Søreide E, Deakin CD. Pre-hospital fluid therapy in the critically injured patient – a clinical update. *Injury* 2005;36(9):1001-1010
- 22) Stern SA. Low volume fluid resuscitation for presumed hemorrhagic shock: helpful or harmful? *Curr Opin Crit Care* 2001;7:422-430.