

Fluid or No Fluid, That is the Question: Hypotensive Resuscitation

James Eakins, MD FACS
Director, Trauma and Surgical Critical Care
Hahnemann University Hospital

Introduction

- Traditional resuscitation
 - What does it consist of
 - How did we get there
- Hypotensive resuscitation
 - Concept
 - Scientific basis
 - Animal and human studies

“When internal hemorrhage persisted, for instance, there could be no resuscitation without surgery and it was wasteful of both time and blood to attempt to raise the patient’s blood pressure to normal before operation. The blood or plasma which was administered was wasted, while at the same time the patient was submitted to the hazards of an unnecessary number of transfusions.”

- Office of the Surgeon General, Medical Department, United States Army
- “Resuscitation of men severely wounded in battle”
- 1955 – *Surgery in World War II: general surgery*

“Hemorrhage in the case of shock may not have occurred to a marked degree because blood pressure has been too low and flow too scant to overcome the obstacle offered by a clot. If the pressure is raised before the surgeon is ready to check any bleeding that may take place, blood that is sorely needed may be lost”

- Cannon WB, Fraser J, Cowell EM
- The preventive treatment of wound shock
- JAMA 70:618 – 621
- 1918

Traditional Resuscitation

- Prompt establishment of large-bore intravenous access
- Rapid infusion of 2 liters of warmed, isotonic crystalloid
- Follow with packed red blood cells
- Goal is restore intravascular volume and blood pressure to normal range
- Hemorrhage control via direct pressure or operative intervention

Evolution of Management

- Began with fixed-pressure hemorrhage studies of Wiggers (1940s)
- Blood withdrawn via intravascular catheter and re-infused as needed to maintain a constant, hypotensive state
- State of irreversible shock achieved in lab after a certain period of hypotension
- Quickly became the standard for resuscitation research

Early studies

- Shires et al and Dillon et al – 1960s
- Used modified Wiggers model to demonstrate that adding large volumes of isotonic crystalloid to re-infused blood enhanced survival over blood alone
- Also showed that irreversible shock would develop if resuscitation was delayed beyond a certain point

Doubts about Wiggers

- Wiggers model was questioned
- Not an accurate model for trauma
- Trauma usually results in death rapidly from exsanguination, not as a result of prolonged hypotension
- Blood pressure in Wiggers model is completely controlled and maintained at a constant level independent of animal's physiologic response

A new model

- Fixed-volume model proposed
- Predetermined volume of blood rapidly withdrawn
- Believed to more closely resemble the trauma patient who is bleeding

Results

- With both fixed-pressure and fixed-volume models, results were the same
- Aggressive fluid administration resulted in improved blood pressure, cardiac output, oxygen delivery, and survival
- Adapted into clinical practice
- Aggressive, early fluid resuscitation was the accepted routine by the 1970s
- Coincidentally, the Vietnam war, around this time, was when ARDS began to be commonly described

Aggressive resuscitation questioned

- No controlled clinical trials to support early, aggressive resuscitation
- Relevance to traumatic hemorrhage of both fixed-pressure and fixed-volume models were called into question
- Some felt that aggressive fluid administration before surgical control of bleeding could be harmful
 - Dilutional coagulopathy
 - Contributes to hypothermia
 - Clot disruption due to increased flow / pressure
 - Decreased blood viscosity
- This led to the vascular injury, or uncontrolled hemorrhage, models

Vascular injury models

- Involve a discrete vascular injury rather than withdrawing blood from a catheter
- Volume and duration of hemorrhage depends on the physiologic responses of the animal
- Potential for ongoing hemorrhage
- Allows assessment for the effects of intervention on bleeding and clot formation

Results – vascular injury models

- Opposite results from classic studies
- IV fluids caused increased blood loss and mortality compared to untreated controls
- Some investigators suggested that fluids be withheld, or at least limited, until bleeding is controlled
 - Bickell et al: Journal of Trauma 1989
 - Bickell et al: Annals of Emergency Medicine 1993
 - Stern et al: Annals of Emergency Medicine 1993
- This led to the landmark study by Bickell et al

Bickell et al (1994)

- Penetrating torso trauma randomized to immediate (including pre-hospital) or delayed (in OR) fluid resuscitation
- Delayed group did better
 - Decreased length of stay
 - Lower mortality

Bickell et al (1994)

- Limitations
 - Urban center with rapid transport times
 - Short time to OR
 - Only for penetrating torso trauma
 - Fluids were withheld only until the patient got to the operating room, then administered liberally even before bleeding was controlled
 - Fluids given in all-or-nothing fashion
- Promising study but important not to get carried away

Hypotensive resuscitation

- AKA permissive hypotension
- Give only enough fluids to maintain a lower than normal target blood pressure
- Supported by many animal studies

Kowalenko et al (1992)

- Swine model of uncontrolled hemorrhage (aortotomy)
- Three groups based on resuscitation / target BP
 - Group I: Target MAP 40 mm Hg
 - Group II: Target MAP 80 mm Hg
 - Group III: No resuscitation
- Resuscitation was saline, followed by blood

Kowalenko et al (1992)

- Survival
 - Group I: 87.5%
 - Group II: 37.5%
 - Group III: 12.5%
- Blood Loss
 - Group I: 8.2 mL/kg
 - Group II: 39.9 mL/kg
 - Group III: 6.7 mL/kg
- Conclusion: Hypotensive resuscitation led to improved mortality over aggressive or no resuscitation, and dramatically less blood loss than aggressive resuscitation

Capone et al (1995)

- Rat study using uncontrolled hemorrhage model
- Prehospital phase and hospital phase
- Four groups
 - Group I: Untreated controls
 - Group II: No fluid during prehospital phase
 - Group III: Prehospital resuscitation to MAP of 40 mm Hg
 - Group IV: Prehospital resuscitation to MAP of 80 mm Hg
- Groups 2 – 4 received resuscitation to 80mm Hg with fluid and blood in addition to hemorrhage control

Capone et al (1995)

- Results
 - Group I (untreated): all died
 - Group II (no prehospital fluid): 5 rats survived 90 minutes, only 1 survived 3 days
 - Group III (hypotensive prehospital resuscitation): All rats survived 2.5 hours, six survived 3 days
 - Group IV: 8 died within 90 minutes, none survived long-term
- Conclusion: Hypotensive resuscitation resulted in improved long-term survival

Stern et al (1993)

- Swine uncontrolled hemorrhage model
- Resuscitated with saline, then blood
 - Group I: Target MAP of 40 mm Hg
 - Group II: Target MAP of 60 mm Hg
 - Group III: Target MAP of 80 mm Hg

Stern et al (1993)

- Results
 - Intraperitoneal hemorrhage: Group I < Group II < Group III (difference between I and II not statistically significant)
 - Mortality: Group I < Group II < Group III
- Conclusion: Attempts to restore normal BP results in increased blood loss and higher mortality

Mapstone et al

- Journal of Trauma 2003; 55(3):571 – 587
- Systematic review of animal trials
- Hypotensive resuscitation improved mortality compared to traditional resuscitation in all 9 studies evaluated
- Kowalenko et al (1992)
- Stern et al (1993)
- Capone et al (1995)
- Stern et al (1995)
- Capone et al (1995)
- Marshall et al (1997)
- Talmor et al (1999)
- Burris et al (1999)
- Stern et al (2000)

Dutton et al (2002)

- Randomized, prospective study comparing target SBP>100 with target SBP=70 in patients presenting with hemorrhagic shock
- 55 pts in each group
- Results
 - Significant difference between groups in SBP (114 vs. 100)
 - No statistical difference in ISS, duration of hemorrhage, or mortality

Dutton - limitations

- Failure to achieve BP goals: SBP=70 group actually had SBP of 100
- Both groups may have received more attentive care as it was known they were in the study
- Lower than expected mortality

Hypotensive Resuscitation - Concerns

- Blunt trauma
- Neurologic injury
 - Brain
 - Spinal cord

Stern et al (2000)

- Swine study of combined uncontrolled hemorrhage and brain injury
- Three groups
 - Group I: Goal MAP of 60 mm Hg
 - Group II: Goal MAP of 80 mm Hg
 - Group III: Control, not resuscitated
- Mortality and cerebrovascular hemodynamics monitored

Stern et al (2000) - results

- Mortality significantly better in groups I and II than group III. No statistical difference I vs. II but group I trended toward better mortality (11% vs. 50%)
- Group II: significantly increased intraperitoneal hemorrhage
- Over time ICP did not differ significantly between groups
- Aggressive vs. limited (hypotensive) resuscitation did not significantly improve CPP
- Group II animals did not demonstrate improved cerebral blood flow compared to group I

Stern et al (2000)

- Conclusions: aggressive resuscitation prior to hemorrhage control led to increased bleeding, failure to improve cerebrovascular parameters, and trend toward increased mortality
- Limitations
 - Cannot rule out focal areas of cerebral ischemia
 - Looked only at short-term mortality and cerebrovascular parameters, not long-term neurologic outcome

Conclusion

- Traditional strategy of early, aggressive fluid resuscitation is based on models that do not approximate the bleeding trauma patient and is not supported by any good clinical studies
- Hypotensive resuscitation has been clearly shown in animal studies of uncontrolled hemorrhage to decrease blood loss and improve survival
- Penetrating truncal trauma: hypotensive resuscitation definitely recommended
- Blunt trauma without head injury: hypotensive resuscitation probably a good idea
- Head injury: worry about secondary brain injury but literature suggests that hypotensive resuscitation may be OK