Crystalloids, colloids and the appeal for balanced solutions. What's the evidence and does it really matter?

Prof Andrew Shaw
Division of Cardiotoracic Anesthesiology, Tennessee, USA

2015 Disclosures

• Consultant for Grifols – manufacturer of colloid (albumin) products
• Consultant for Baxter – manufacturer of crystalloid and colloid products
• No off label comments

Is fluid amount important?

9g NaCl = 36 bags of chips, or 1 bag of saline
Organ function effects of volume overload

Is fluid amount important?

- Excess fluid leads to adverse outcomes
- When fluid given is blinded – the ratio of crystalloid : colloid is generally 1.3 : 1
- NOT 3:1 as is widely believed
- Why are fluids not afforded the same respect as other intravenous drugs?

Is crystalloid type important?

9g NaCl = 36 bags of chips, or 1 bag of saline
**Fluid Therapy Basics**

- A “balanced” fluid has the physiological electrolyte composition of plasma
- Balanced fluids do not cause the hyperchloremic acidosis associated with 0.9% saline

- Base excess after infusion is determined by the strong ion difference (SID) of the fluid infused.
- The red circle represents 0.9% NaCl, the blue circle represents balanced crystalloid

---

**Abnormal Saline**

- 0.9% saline contains Na and Cl in equal amounts (154 meq/l)
- Unlike plasma
- Adding NaCl to plasma increases the relative Cl concentration more than that of Na
- 0.9% saline reduces plasma SID and leads to hyperchloremic metabolic acidosis

---

**2L of Saline versus Balanced Crystalloid in Healthy Volunteers**

**Retrospective analysis of a prospectively collected data asset (Premier database)**

- Major (non cardiac) surgery
- >30,000 patients who received 0.9% saline or balanced crystalloid alone on day of surgery

---

**Risk adjusted major complications and resource use - All patients**

- Mortality
- Gastrointestinal
- Renal
- Cardiovascular
- Respiratory
- Major hemorrhage
- Major infection
- Comorbidity

---

**Association Between the Choice of IV Crystalloid and In-Hospital Mortality Among Critically Ill Adults With Sepsis**

Karthik Raghunathan, MD, MPH\(^1\); Andrew Shaw, MB, FRCA, FFICM, FCCM\(^3\); Brian Nathanson, PhD\(^3\); Till Stürmer, MD, PhD\(^7\); Alan Brookhart, PhD\(^7\); Mihadea S. Stefan, MD\(^7\); Soko Setoguchi, MD, DrPH\(^7\); Chris Beadles, MD, PhD\(^3\); Peter K. Lindenauer, MD, MSc\(^7\)

---

**Mortality Dose Response**

![Graph showing mortality dose response](image)


---

**Yunos et al 2012**

**PRELIMINARY COMMUNICATION**

**Association Between a Chloride-Liberal vs Chloride-Restrictive Intravenous Fluid Administration Strategy and Kidney Injury in Critically Ill Adults**

Yunos et al (2012) JAMA

---

**KDIGO 2&3**

**Figure 1. Development of Stage 2 or 3 Acute Kidney Injury (AKI) While in the Intensive Care Unit (ICU)**

![KDIGO 2&3 graph](image)

Yunos et al (2012) JAMA
Hyperchloremia After Noncardiac Surgery Is Independently Associated with Increased Morbidity and Mortality: A Propensity-Matched Cohort Study

Stuart A. McCluskey, PhD, MD,* Keyvan Karkouli, MSc, MD,† Duminda Wijeyesundera, PhD, MD,* Leonid Minkovich, PhD, MD,* Gordon Tait, PhD,* and W. Scott Beattie, PhD, MD*

- Observational cohort study
- Major (non cardiac) surgery
- 23000 patients
- 4266 of 4955 who developed high serum chloride propensity matched to patients who did not

Chloride and mortality

![Chloride and mortality graph](image)

**Hyperchloremia After Noncardiac Surgery Is Independently Associated with Increased Morbidity and Mortality: A Propensity-Matched Cohort Study**

Stuart A. McCluskey, PhD, MD,* Keyvan Karkouli, MSc, MD,† Duminda Wijeyesundera, PhD, MD,* Leonid Minkovich, PhD, MD,* Gordon Tait, PhD,* and W. Scott Beattie, PhD, MD*

* P<0.05

Anesth Analg 2013;117:412–21
Effect of volume adjusted chloride load on outcomes

109,836 adult patients with SIRS from Cerner health facts database
Baseline risk adjustment as well as APS included in outcomes model
Effect of volume adjusted chloride load on mortality

Shaw et al (2014) Int Care Med

Administered chloride

Probability of Receiving Balanced Crystalloids

Systematic review

Meta-analysis of high- versus low-chloride content in perioperative and critical care fluid resuscitation

M. L. Krajewski1, K. Raghumathram2, S. M. Palaszkiewicz3, C. R. Schermer4 and A. D. Shaw4

1Department of Anesthesiology, Duke University Medical Center, and 2Anesthesiology, Boston VA Medical Center, Durham, North Carolina, 3Boston Partners, Boston, Massachusetts, 4Banner Healthcare Corporation, Deerfield, Illinois, and 5Department of Anesthesiology, Vanderbilt University Medical Center, Nashville, Tennessee, USA

Correspondence to Professor A. D. Shaw, Division of Cardiothoracic Anesthesiology, Vanderbilt University Medical Center, Nashville, Tennessee 37212-8274 U.S.A (e-mail: andrew.shaw@vanderbilt.edu)

Effect of volume adjusted chloride load on baseline risk adjustment as well as APS included.

109,836 adult patients with SIRS from Cerner.


Blood transfusion volume


New cardiac surgery data (1)

Choice of Intravenous Crystalloid Therapy and Major In-hospital Outcomes among Adult Patients Undergoing Cardiac Surgery

- Cerner Healthfacts Database
- 5641 on-pump patients receiving 0.9% saline PS matched with 5641 receiving balanced fluids during first 72 hours
New cardiac surgery data (1)
Choice of Intravenous Crystalloid Therapy and Major In-hospital Outcomes among Adult Patients Undergoing Cardiac Surgery

New cardiac surgery data (2)

• 299 patients receiving Plasmalyte or Normosol matched with 299 who received LR
• OR for 90 day death 0.96 (0.94-0.97)

When should we give abnormal saline?

• Rarely
• Traumatic brain injury
• HCl loss (severe vomiting)
• i.e. Almost never in cardiac surgical practice
Fluids in 30 seconds

• Hydroxyethyl starch
  – Probably hazardous
  – Most have stopped using (China hasn’t…)
• Albumin
  – Safe but expensive
  – Not good for TBI
  – New data suggest possible benefit in heart surgery
• Crystalloid
  – 0.9% saline bad
  – Balanced solutions (including LR) good

Conclusions

• The circumstantial evidence that high chloride solutions are harmful continues to mount
• There are no data suggesting 0.9% saline is beneficial
• New multicenter cardiac surgical data suggest balanced crystalloids (and possibly albumin) are the fluids of choice for cardiac surgical patients.

Thank You