FLUID RESUSCITATION: NEW CONCEPTS AND CONTROVERSY

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Allina Health Clinical Nursing Conference
February 25, 2020

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DISCLOSURE

- None

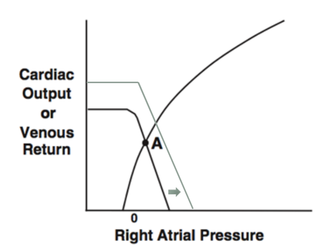
Outline

- Case
- Learn Empiric Evidence for Specific Fluid Management Strategies
- Better Understand the Physiologic Basis of Fluid Therapy
- Return to case

Case

72yo 80kg woman s/p MVC polytrauma (L 7-10 rib fracture, and T4 posterior column fx) with h/o CRI (Cr 1.2), HTN, hypothyroidism and LVH with diastolic dysfunction. She was normotensive with HR 90s in the ED, and is admitted to the TICU. On HD2 she undergoes PSIF for spine fracture and receives 2u RBC and 3L crystalloid in the OR. EBL was 750mL. The evening of HD2/POD0 you are called to treat hypotension to SBPs 90 and UOP 10mL/hr over the last 2 hrs. What will you do?

…you'll use venous return physiology!



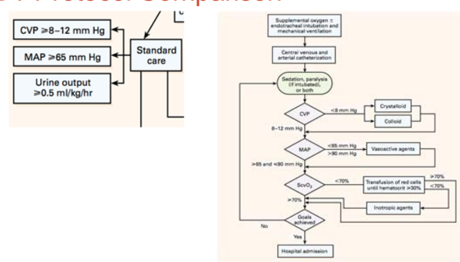
EARLY GOAL-DIRECTED THERAPY IN THE TREATMENT OF SEVERE SEPSIS AND SEPTIC SHOCK

EMANUEL RIVERS, M.D., M.P.H., BRYANT NGUYEN, M.D., SUZANNE HAVSTAD, M.A., JULIE RESSLER, B.S., ALEXANDRIA MUZZIN, B.S., BERNHARD KNOBLICH, M.D., EDWARD PETERSON, PH.D., AND MICHAEL TOMLANOVICH, M.D., FOR THE EARLY GOAL-DIRECTED THERAPY COLLABORATIVE GROUP*

- N=263
- Detroit, MI
- Pts with severe sepsis (lactate >4) or septic shock (SBP<90) enrolled
- First 6h of therapy in the ED
- Average ScVO2 49% on admission!

E. Rivers et al., N Engl J Med 345, 1368–1377 (2001).

EGDT Protocol Comparison



5L crystalloid in 6h
Mortality 46.5%

3.5L crystalloid in 6h
Mortality 30.5%

So what fluid to use?

Table 1. Types and Compositions of Resuscitation Fluids.*

Variable	Human Plasma	Colloids: 4% Albumin	Hydroxyethyl Starch: 10% (200/0.5)	Hydroxyethyl Starch: 6% (450/0.7)	Hydroxyethyl Starch: 6% (130/0.4)		Hydroxyethyl Starch: 6% (130/0.42)		4% Succinylated Modified Fluid Gelatin	3.5% Urea-Linked Gelatin	Crystalloids: 0.9% Saline	Compounded Sodium Lactate	Balanced Salt Solution
Trade name		Albumex	Hemohes	Hextend	Voluven	Volulyte	Venofundin	Tetraspan	Gelofusine	Haemaccel	Normal saline	Hartmann's or Ringer's lactate	PlasmaLyte
Colloid source		Human donor	Potato starch	Maize starch	Maize starch	Maize starch	Potato starch	Potato starch	Bovine gelatin	Bovine gelatin			
Osmolarity (mOsm/liter)	291	250	308	304	308	286	308	296	274	301	308	280.6	294
Sodium (mmol/liter)	135–145	148	154	143	154	137	154	140	154	145	154	131	140
Potassium (mmol/liter)	4.5–5.0			3.0		4.0		4.0		5.1		5.4	5.0
Calcium (mmol/liter)	2.2–2.6			5.0				2.5		6.25		2.0	
Magnesium (mmol/liter)	0.8–1.0			0.9		1.5		1.0					3.0
Chloride (mmol/liter)	94–111	128	154	124	154	110	154	118	120	145	154	111	98
Acetate (mmol/liter)						34		24					27
Lactate (mmol/liter)	1–2			28								29	
Malate (mmol/liter)								5					
Gluconate (mmol/liter)													23
Bicarbonate (mmol/liter)	23–27												
Octanoate (mmol/liter)		6.4											

Crystalloids vs. Colloids

- A mythical debate
- Albumin:~$50/dose
- 1L crystaloid: ~$1/dose (or less)
- Voluven (hydroxyethyl starch): ~$10/dose
- Many, many patients involved in many, many studies

ORIGINAL ARTICLE

A Comparison of Albumin and Saline for Fluid Resuscitation in the Intensive Care Unit

The SAFE Study Investigators*

- 6997 patients in Australia and NZ
- 28 days of resuscitation
- 4% Albumin vs. normal saline

SAFE

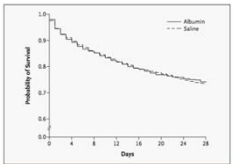


Figure 1. Kaplan–Meier Estimates of the Probability of Survival.
P=0.96 for the comparison between patients assigned to receive albumin and those assigned to receive saline.

- CVP increased more in the albumin group
- More RBCs given in the albumin group
- Volume ratio of albumin to saline: 1:1.4 (not 1:3)

…hydroxyethyl starch?

ORIGINAL ARTICLE

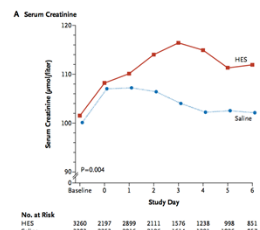
Hydroxyethyl Starch or Saline for Fluid Resuscitation in Intensive Care

John A. Myburgh, M.D., Ph.D., Simon Finfer, M.D., Rinaldo Bellomo, M.D., Laurent Billot, M.Sc., Alan Cass, M.D., Ph.D., David Gattas, M.D., Parisa Glass, Ph.D., Jeffrey Lipman, M.D., Bette Liu, Ph.D., Colin McArthur, M.D., Shay McGuinness, M.D., Dorrilyn Rajbhandari, R.N., Colman B. Taylor, M.N.D., and Steven A.R. Webb, M.D., Ph.D., for the CHEST Investigators and the Australian and New Zealand Intensive Care Society Clinical Trials Group*

- Same group as SAFE
- 7000 patients, diverse ICU patients
- Primary outcome 90 day mortality
  - No difference in primary outcome

J. A. Myburgh et al., N Engl J Med 367, 1901–1911 (2012).

HES vs. Saline



- Risk of AKI was 34.6 vs 38% (higher in HES, p=0.007)
- Risk of RRT was 5.8% vs 7% (higher in HES group, p=0.04)

LR vs NS?

- What about the chloride?

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			10% (200/0.5)	6% (450/0.7)	6% (130/0.4)		6% (130/0.42)						
Trade name		Albumex	Hemohes	Hextend	Voluven	Volulyte	Venofundin	Tetraspan	Gelofusine	Haemaccel	Normal saline	Hartmann's or Ringer's lactate	PlasmaLyte
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Sodium (mmol/liter)	135–145	148	154	143	154	137	154	140	154	145	154	131	140
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Calcium (mmol/liter)	2.2–2.6			5.0				2.5		6.25		2.0	
Magnesium (mmol/liter)	0.8–1.0			0.9		1.5		1.0					3.0
Chloride (mmol/liter)	94–111	128	154	124	154	110	154	118	120	145	154	111	98
Acetate (mmol/liter)						34		24					27
Lactate (mmol/liter)	1–2			28								29	
Malate (mmol/liter)								5					
Gluconate (mmol/liter)													23
Bicarbonate (mmol/liter)	23–27												
Octanoate (mmol/liter)		6.4											

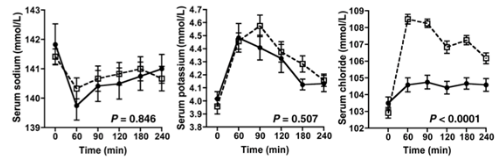
A Randomized, Controlled, Double-Blind Crossover Study on the Effects of 2-L Infusions of 0.9% Saline and Plasma-Lyte® 148 on Renal Blood Flow Velocity and Renal Cortical Tissue Perfusion in Healthy Volunteers

Abeed H. Chowdhury, BSc, MRCS, Eleanor F. Cox, PhD,† Susan T. Francis, PhD,† and Dileep N. Lobo, DM, FRCS, FACS**

- 20 healthy male volunteers given 2L NS
- Many, many variables observed and recorded

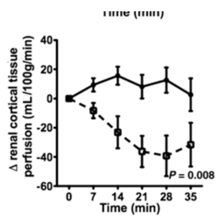
A. H. Chowdhury, E. F. Cox, S. T. Francis, D. N. Lobo, Annals of Surgery 256, 18–24 (2012).

Electrolyte Effects of NS



A. H. Chowdhury, E. F. Cox, S. T. Francis, D. N. Lobo, Annals of Surgery 256, 18–24 (2012).

Renal Effects of NS



A. H. Chowdhury, E. F. Cox, S. T. Francis, D. N. Lobo, Annals of Surgery 256, 18–24 (2012).

Does this clinically affect things?

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

Nor'azim Mohd Yunos, MD
Rinaldo Bellomo, MD, FCICM
Colin Hegarty, BSc

Context Administration of traditional chloride-liberal intravenous fluids may precipitate acute kidney injury (AKI).

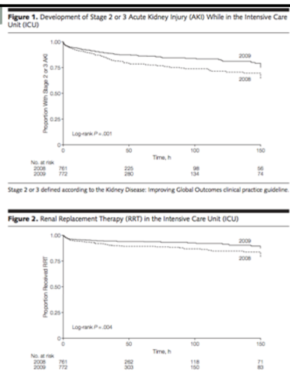
Objective To assess the association of a chloride-restrictive (vs chloride-liberal) intravenous fluid strategy with AKI in critically ill patients.

- Before/after study in Australia (2008/2009)
- 760pts vs 773pts
- Before: chloride-rich fluids allows
- After: (6 months later) no chloride-rich fluids
- Primary Outcome: Cr rise and AKI risk

N. M. Yunos et al., JAMA: The Journal of the American Medical Association 308, 1566–1572 (2012).

Results

- Total Chloride decreased by 144,504mmol.
- After covariate adjustment, OR of AKI was 0.52 (14% vs. 8.4%) after chloride-rich fluids
- No differences in mortality, hospital length of stay, or ICU length of stay, or long term RRT need.



What about fluid boluses at all?

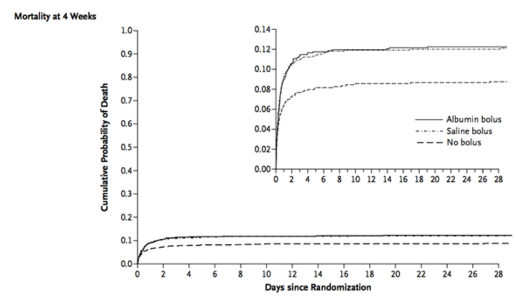
The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JUNE 30, 2011 VOL. 364 NO. 26

Mortality after Fluid Bolus in African Children with Severe Infection

Kathryn Maitland, M.B., B.S., Ph.D., Sarah Kiguli, M.B., Ch.B., M.Med., Robert O. Opoka, M.B., Ch.B., M.Med.,

- Children with febrile illness in Sub-Saharan Africa
- 2 strata (1 with hypotension, 1 without),
- 3 groups (20-40mL/kg albumin bolus, crystalloid bolus, 0.9% saline maintenance only)
- rates of death 10.6%, 10.5%, 7.3%, OR 1.44 (1.09-1.9)



Historical Perioperative Fluid Fundamentals

1. Fasted patients are hypovolemic
2. Insensible perspiration increases dramatically during surgery
3. Third space losses require generous substitution
4. Hypervolemia is harmless because the kidneys regulate the overload

Rational Perioperative Fluid Management

- Should we maximize preload to maximize stroke volume?
- What is restrictive vs. liberal?
- "In practice, adequate volume is usually defined by hemodynamic stability, because there is no routine clinical method for evaluating tissue perfusion."
- Even in healthy volunteers it takes 2 days to completely excrete a saline infusion of 22mL/kg

D. Chappell, M. Jacob, K. Hofmann-Kiefer, P. Conzen, M. Rehm, Anesthesiology 109, 723–740 (2008).

ORIGINAL ARTICLE

Comparison of Two Fluid-Management Strategies in Acute Lung Injury

The National Heart, Lung, and Blood Institute Acute Respiratory Distress Syndrome (ARDS) Clinical Trials Network*

- 2x2 factorial trial with PAC vs. CVP
- 1000 patients with ARDS
- Fluid balance during 7 days was +7L vs. 0L

National Heart, Lung, and Blood Institute Acute Respiratory Distress Syndrome (ARDS) Clinical Trials Network et al., N Engl J Med 354, 2564–2575 (2006).

CVP-based conservative vs. liberal fluid strategy improves outcomes

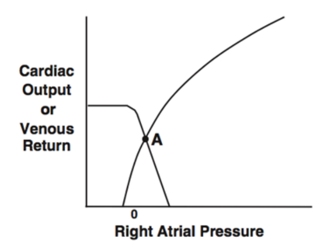
Measured intravascular pressure (mm Hg)				MAP <60 mm Hg or a need for any vasopressor (except dopamine ≤5 μg/kg/min); consider correctable causes of shock first	MAP ≥60 mm Hg without vasopressors (except dopamine ≤5 μg/kg/min)			
CVP		PAOP[G]			Average urinary output <0.5 ml/kg/hr		Average urinary output ≥0.5 ml/kg/hr	
Conservative strategy	Liberal strategy	Conservative strategy	Liberal strategy		**Ineffective Circulation** Cardiac index <2.5 liters/min/m² or cold, mottled skin with capillary-refilling time >2 sec	**Effective Circulation** Cardiac index ≥2.5 liters/min/m² or absence of criteria for ineffective circulation	**Ineffective Circulation** Cardiac index <2.5 liters/min/m² or cold, mottled skin with capillary-refilling time >2 sec	**Effective Circulation** Cardiac index ≥2.5 liters/min/m² or absence of criteria for ineffective circulation
Range 1				1 Vasopressor[F] Fluid bolus[E]	3 KVO IV Dobutamine[A] Furosemide[B,1,2,4]	7 KVO IV Furosemide[B,1,2,4]	11 KVO IV Dobutamine[A] Furosemide[B,1,3,4]	15 KVO IV Furosemide[B,1,3,4]
>13	>18	>18	>24					
Range 2					4 KVO IV Dobutamine[A]	8 KVO IV Furosemide[B,1,2,4]	12 KVO IV Dobutamine[A]	16 KVO IV Furosemide[B,1,3,4]
9–13	15–18	13–18	19–24					
Range 3				2 Fluid bolus[E] Vasopressor[F]	5 Fluid bolus[C]	9 Fluid bolus[C]	13 Fluid bolus[C]	17 Liberal KVO IV
4–8	10–14	8–12	14–18					18 Conservative Furosemide[B,1,3,4]
Range 4					6 Fluid bolus[C]	10 Fluid bolus[C]	14 Fluid bolus[C]	19 Liberal fluid bolus
<4	<10	<8	<14					20 Conservative KVO IV

Table 3. Main Outcome Variables.*

Outcome	Conservative Strategy	Liberal Strategy	P Value
Death at 60 days (%)	25.5	28.4	0.30
Ventilator-free days from day 1 to day 28†	14.6±0.5	12.1±0.5	<0.001
ICU-free days†			
Days 1 to 7	0.9±0.1	0.6±0.1	<0.001
Days 1 to 28	13.4±0.4	11.2±0.4	<0.001
Organ-failure–free days†‡			
Days 1 to 7			
Cardiovascular failure	3.9±0.1	4.2±0.1	0.04
CNS failure	3.4±0.2	2.9±0.2	0.02
Renal failure	5.5±0.1	5.6±0.1	0.45
Hepatic failure	5.7±0.1	5.5±0.1	0.12
Coagulation abnormalities	5.6±0.1	5.4±0.1	0.23
Days 1 to 28			
Cardiovascular failure	19.0±0.5	19.1±0.4	0.85
CNS failure	18.8±0.5	17.2±0.5	0.03
Renal failure	21.5±0.5	21.2±0.5	0.59
Hepatic failure	22.0±0.4	21.2±0.5	0.18
Coagulation abnormalities	22.0±0.4	21.5±0.4	0.37
Dialysis to day 60			
Patients (%)	10	14	0.06
Days	11.0±1.7	10.9±1.4	0.96

Not Significant

Physiologic Basis for IVF



Conclusions of a Recent Review:

- Fluids should be administered with the same caution as any other IV drug
- Consider cumulative fluid balance and actual body weight when selecting the dose of resuscitation fluid
- Consider vasoactive agents early in the treatment of shock
- Fluid requirements change over time in critically ill patient
- Oliguria is a normal response to hypovolemic and should not be used SOLEY as a trigger or end point for fluid resuscitation, especially in the post-resuscitaiton period (>24h)
- The role of hypotonic maintenance fluids is questionable once dehydration has been corrected
- Isotonic, balanced salt solutions are pragmatic initial resuscitation fluid for the majority of acutely ill patients

J. A. Myburgh, M. G. Mythen, N Engl J Med 369, 1243–1251 (2013).

Case Revisited

She is now HD5 and was extubated HD4. Her vital signs have been normal for the last 48h, save for still requiring O2 by NC at 3L/min with SpO2=95%. You're on call and receive a call from the ICU RN because her UOP has been 20mL/hr for the last 4hrs. She has mild diffuse edema.

What would you do?

THANK YOU!

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