Les solutés de remplissage

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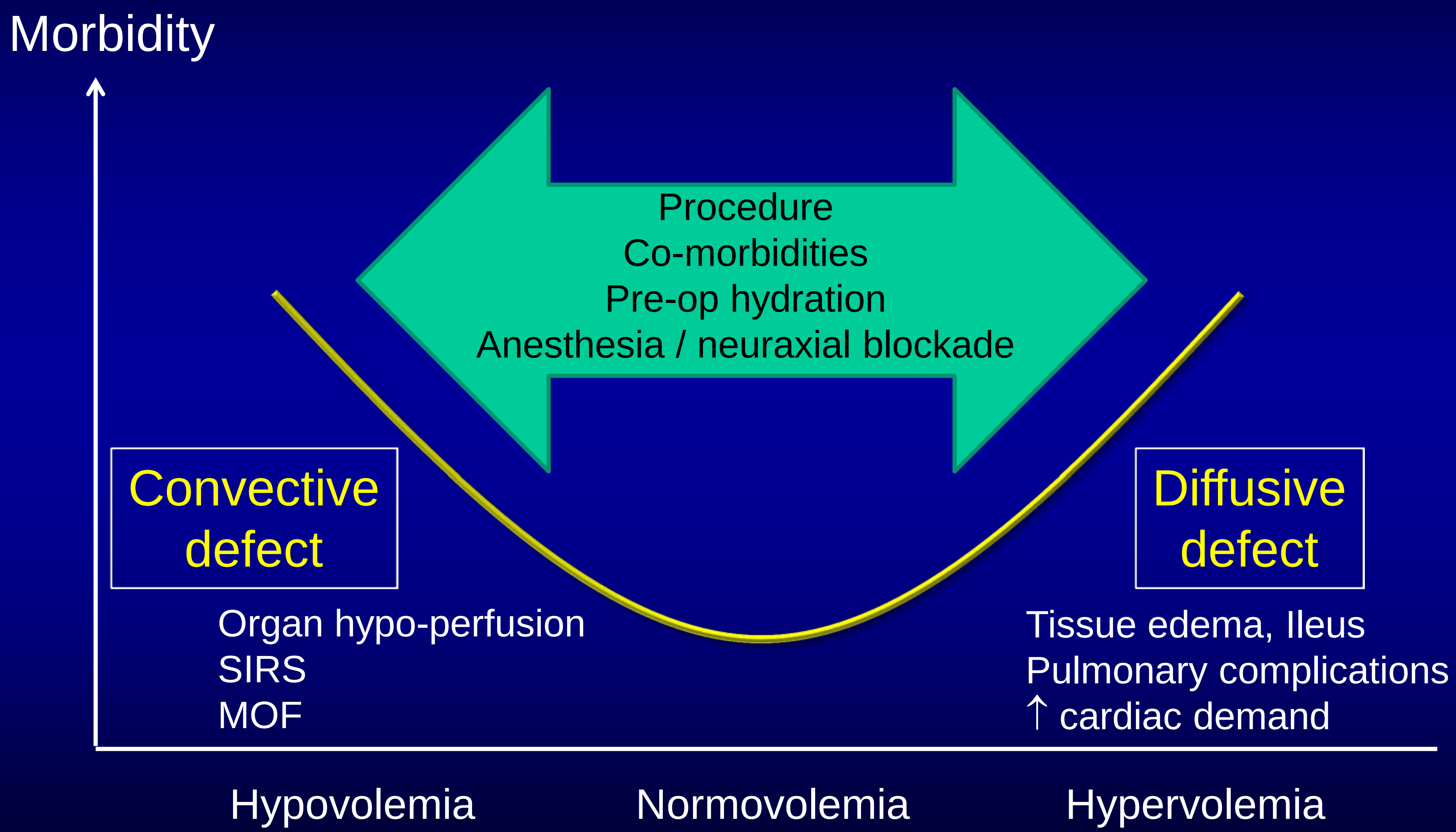
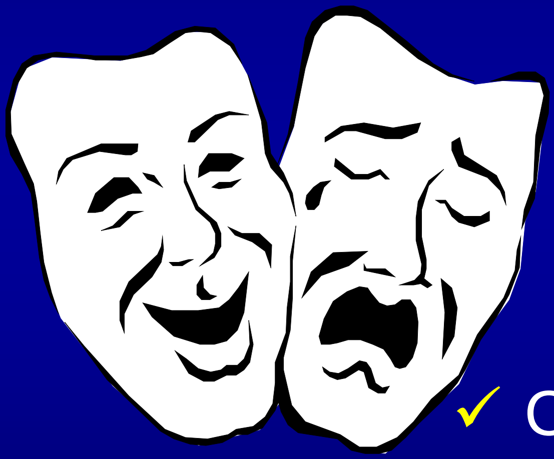
Fluid Resuscitation



Adapted from Belamy MC et al. Br J Anaesth 97:755-7, 2006.

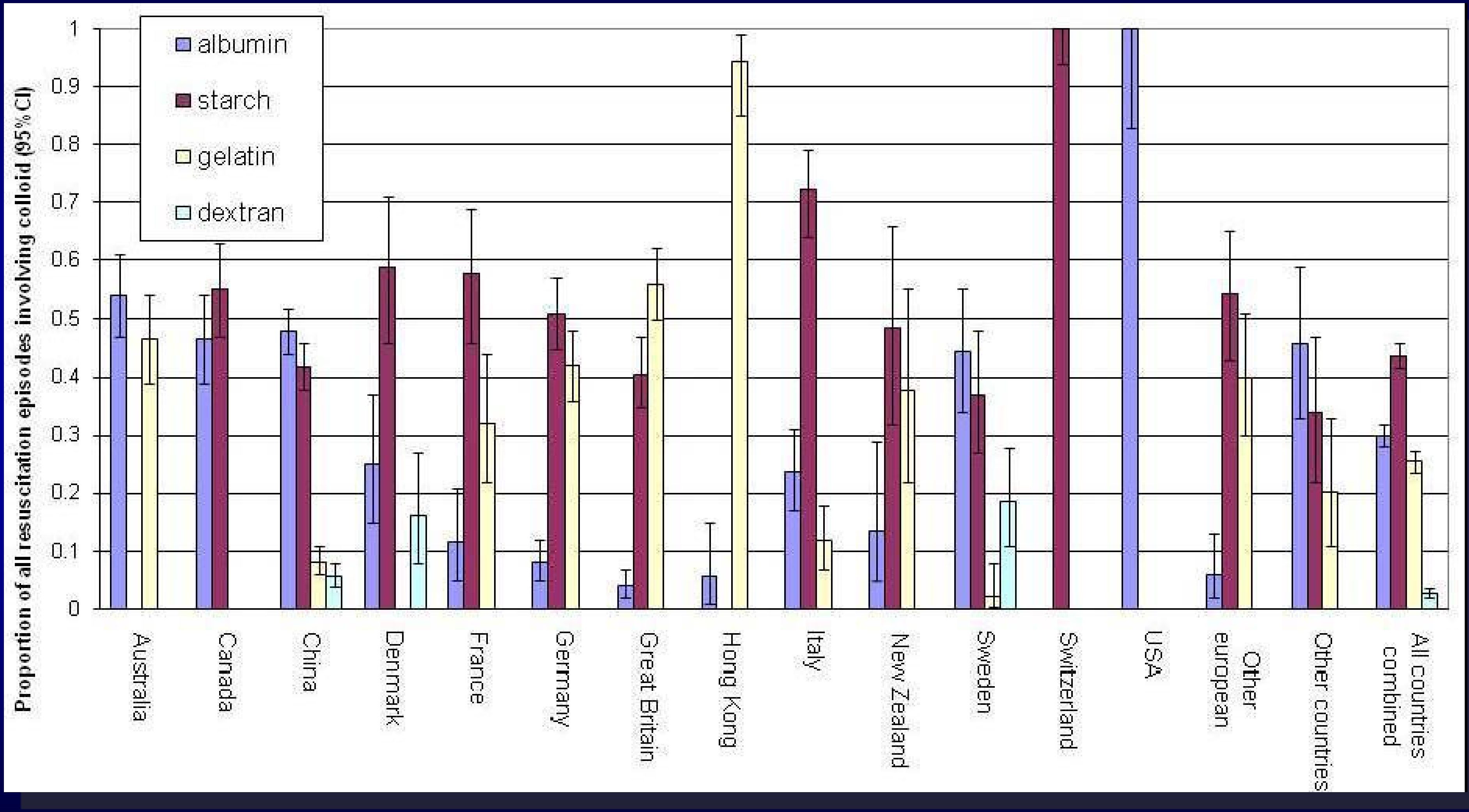
The Crystalloid / Colloid Controversy

✓ CRYSTALLOIDS
- Pro
  - ✧ Safe
  - ✧ Low cost
- Con
  - ✧ Interstitial edema
  - ✧ Hyperchloremic acidosis ?



✓ COLLOIDS
- Pro
  - ✧ Volume effect
  - ✧ Rheological / anti-inflammatory properties?
- Con
  - ✧ Side effects
  - ✧ Costs

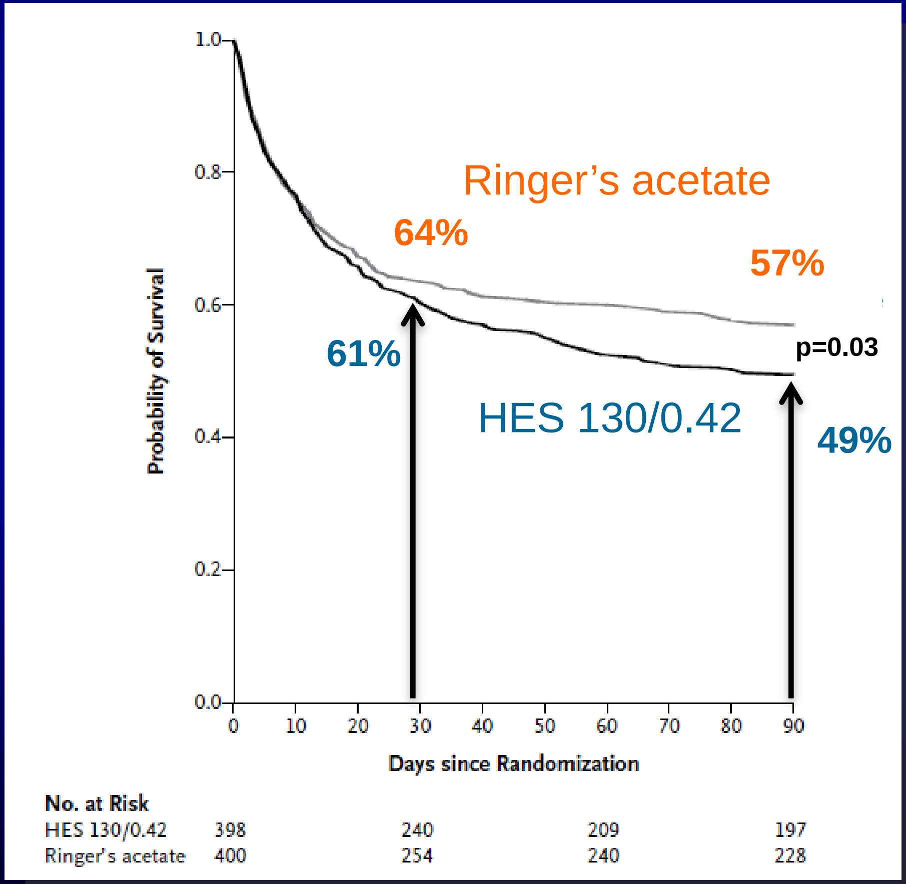
Resuscitation Fluid Use In Critically Ill Adults



From Finfer S et al. Crit Care 14 R185, 2010.

ORIGINAL ARTICLE

Hydroxyethyl Starch 130/0.42 versus Ringer's Acetate in Severe Sepsis

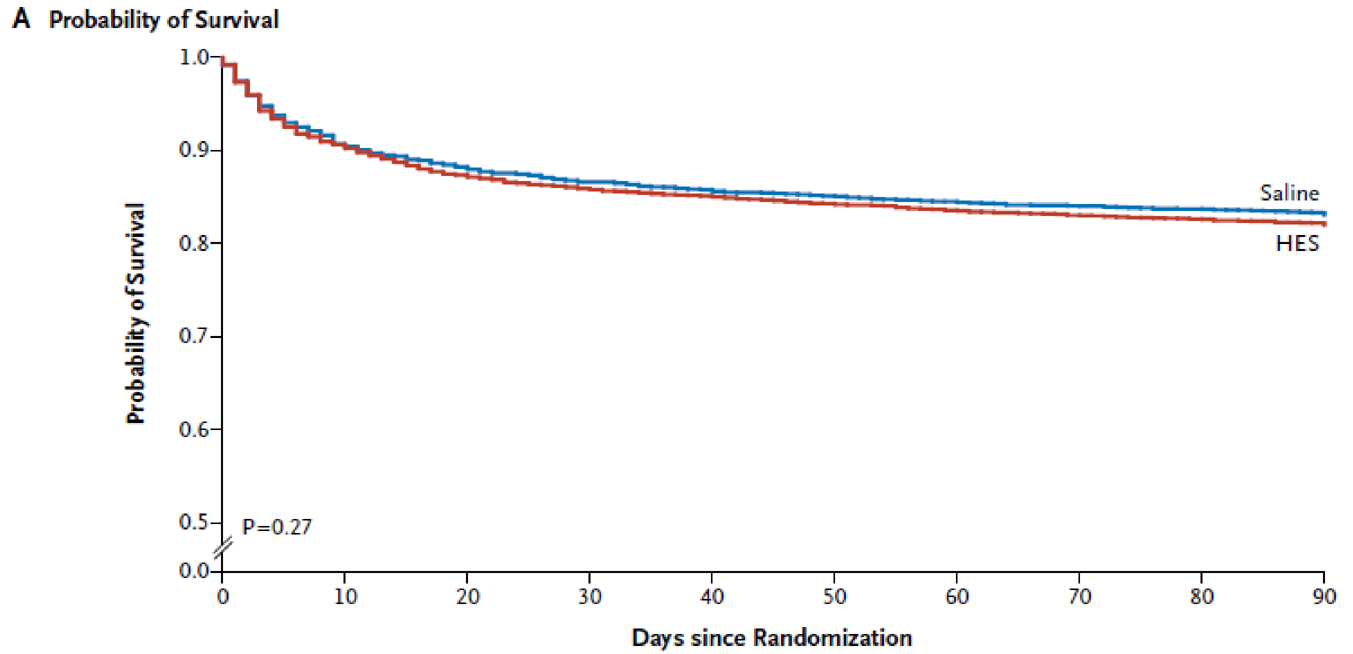


90-day dependence on dialysis: 1 in each group

From Perner A et al. N Engl J Med 367:124-34, 2012.

ORIGINAL ARTICLE

Hydroxyethyl Starch or Saline for Fluid Resuscitation in Intensive Care



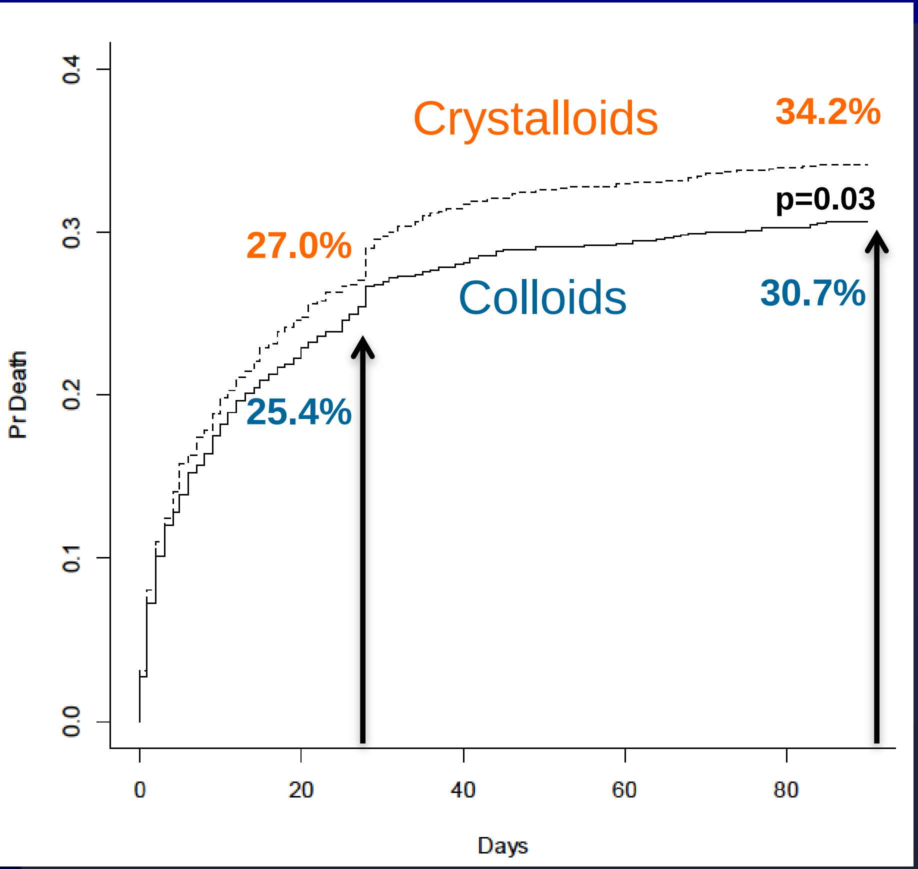
No. at Risk										
Saline	3336	3024	2943	2889	2860	2837	2816	2801	2788	2752
HES	3315	3004	2895	2846	2819	2791	2766	2747	2731	2695

From Myburgh JA et al. N Engl J Med 367:1901-11, 2012.

Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

Effects of Fluid Resuscitation With Colloids vs Crystalloids on Mortality in Critically Ill Patients Presenting With Hypovolemic Shock

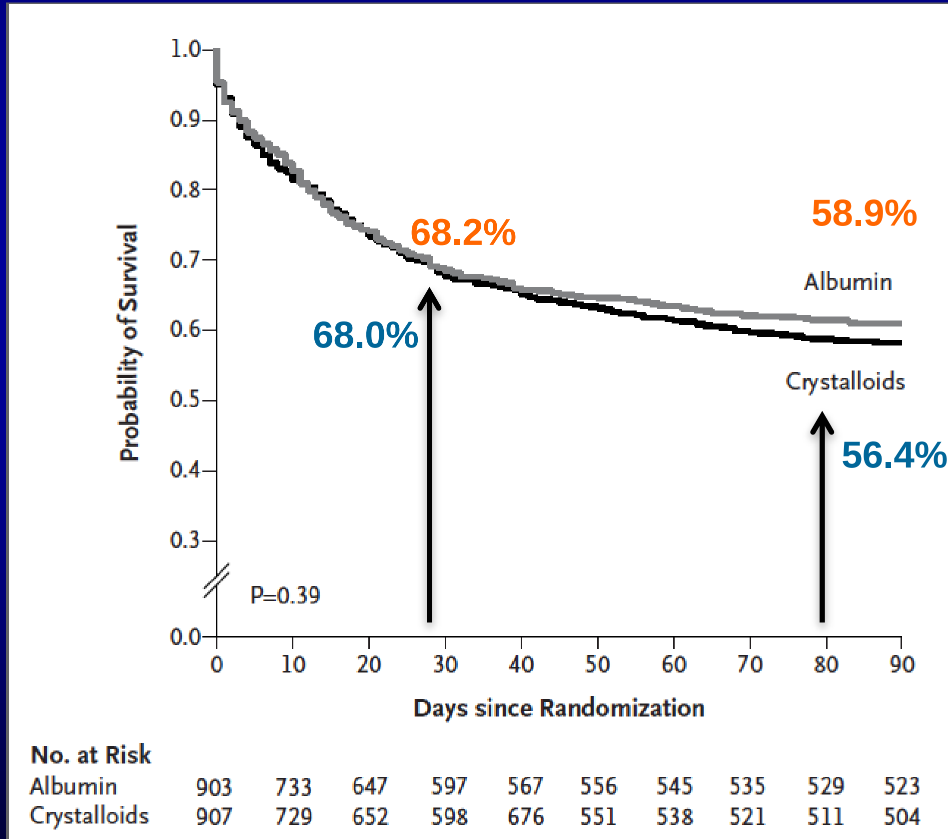
The CRISTAL Randomized Trial



From Annane J et al. JAMA 310:1809-17, 2013.

ORIGINAL ARTICLE

Albumin Replacement in Patients with Severe Sepsis or Septic Shock

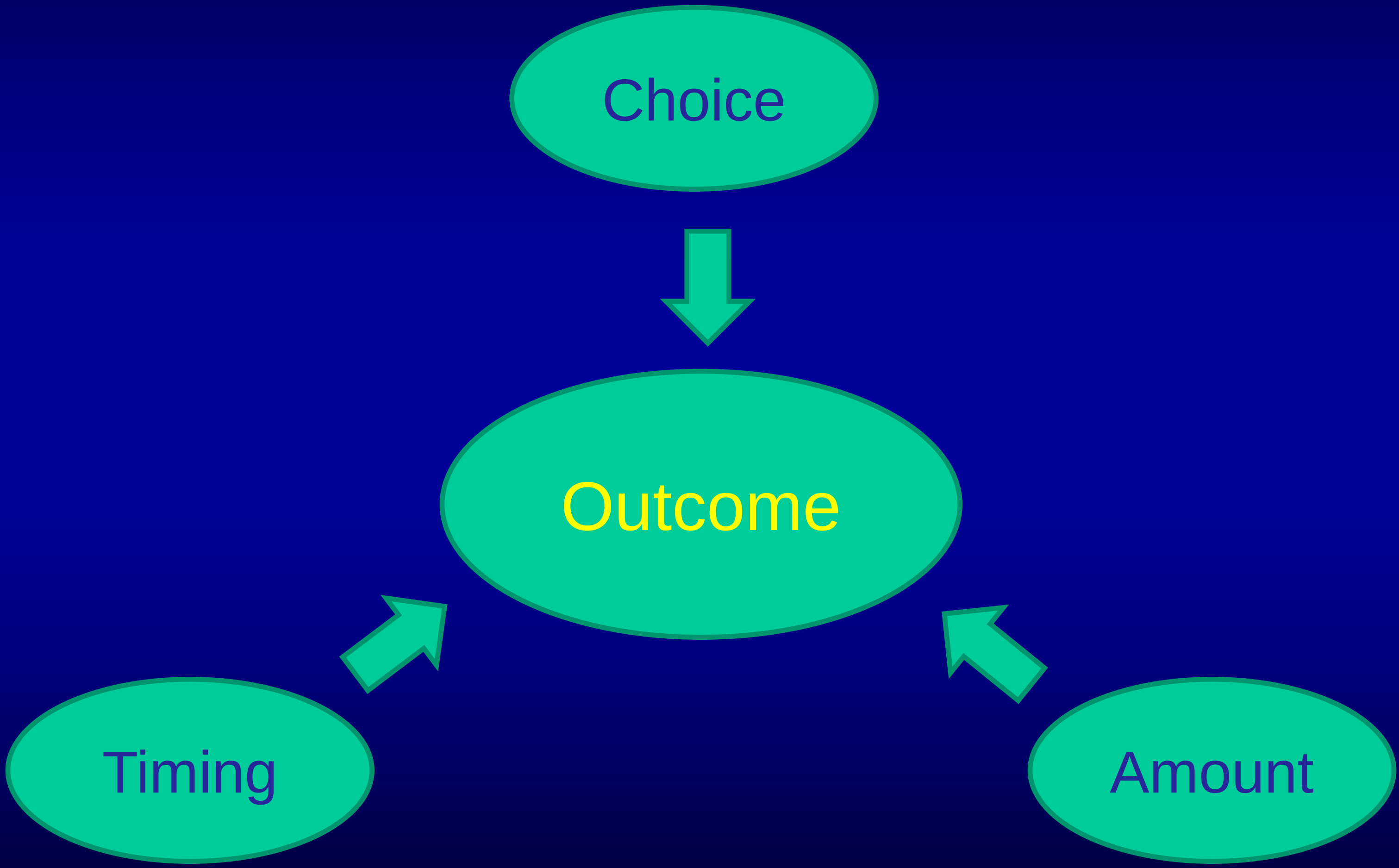


From Caironi P et al. N Engl J Med 2014, March 18 (Epub ahead of print)

Colloids Vs. Crystalloids For Fluid Resuscitation in ICU Septic Patients

	Perner et al.	**Myburgh et al.**	**Annane et al.**	**Caironi et al**
Study	Double-blind	Double-blind	Single-blind	Single-blind
Colloids Crystalloids	HES 130/0.4 (N=398) Ringer acetate (N=400)	HES 130/0.4 (N=976) NaCl 0.9% (N=945)	Miscellaneous (N=774) Miscellaneous (N=779)	20% alb +cryst (N=903) Cryst (N=907)
Indication	Clinical judgment	≥1 criterion of hypovolemia	3 criterions of hypovolemia	Clinical judgment
Fluids before randomization	Yes	Yes	No	Yes
Monitoring	?	?	?	?
Objectives	?	?	?	Goal-directed

The Influence of Fluid Resuscitation On Outcome



From Bagshaw SM & Bellomo R. Curr Opin Crit Care 13:541-8, 2007.

The Ideal Resuscitation Fluid

- ✓ Produces a predictable and sustainable increase in intravascular volume
- ✓ Has a chemical composition as close as possible to that of extracellular fluid
- ✓ Is metabolized and completely excreted without accumulation in tissues
- ✓ Does not produce adverse metabolic or systemic effects
- ✓ Is cost effective in terms of improving patient outcome

From Myburgh GA & Mythen MG. N Engl J Med 369:1243-51, 2013.

Fluid Electrolyte Compositions

Variable	Human Plasma	Colloids									Crystalloids		
		4% Albumin	Hydroxyethyl Starch						4% Succinylated Modified Fluid Gelatin	3.5% Urea-Linked Gelatin	0.9% Saline	Compounded Sodium Lactate	Balanced Salt Solution
			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
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											

From Myburgh GA & Mythen MG. N Engl J Med 369:1243-51, 2013.

Choice of a Plasma Substitute

- ✓ Volume expansion
- ✓ Micro-circulatory effects
  - Hemo-rheological properties
  - Anti-inflammatory properties
- ✓ Side effects
  - Anaphylaxis
  - Hemostasis
  - Renal function
  - Miscellaneous
- ✓ Costs

Tolerance to Anemia & The Microcirculation

- ✓ Tissue perfusion, a consequence of functional capillary density (FCD) is a function of perfusion pressure, vascular resistance and blood viscosity

- ✓ Below a Hct of 20% acute normovolemic hemodilution can be associated with a decrease in FCD

- ✓ Increasing plasma viscosity through the use of "viscogenic" plasma expanders can be associated with an improvement in FCD, improving tolerance to acute anemia

From Villeda NR et al. Curr Opin Anesthesiol 22:163-167, 2009.

British Journal of Anaesthesia **112** (1): 25–34 (2014)
Advance Access publication 17 September 2013 · doi:10.1093/bja/aet303

REVIEW ARTICLES

Incidence of postoperative death and acute kidney injury associated with i.v. 6% hydroxyethyl starch use: systematic review and meta-analysis

✓ Systematic review and meta-analysis of trials in which patients were randomly allocated to 6% HES solutions or alternative fluids in surgical patients (19 studies, N=1,567)

✓ Hospital mortality: risk difference = 0.00 (-0.02, 0.02)
✓ Acute kidney injury: risk difference = 0.02 (-0.02, 0.06)
✓ RRT: risk difference = -0.01 (-0.04, 0.02)

✓ Small studies with low event rates – low risk of heterogeneity

From Gillies MA et al. Br J Anaesth 112:25-34, 2014.

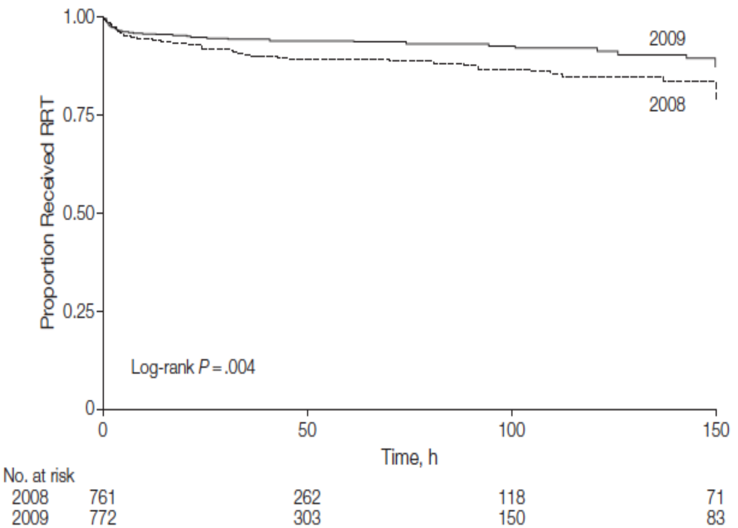
Association Between a Chloride-Liberal vs Chloride-Restrictive Intravenous Fluid Administration Strategy and Kidney Injury in Critically Ill Adults

- ✓ Prospective open-label sequential period pilot study
  - ICU patients 02-08/2008: standard IV fluids (N=760)
  - ICU patients 02-08/2009: chloride restrictive IV fluids (N=773)
- ✓ Primary objectives: peak creat level and AKI (RIFLE)

Table 3. Incidence of Acute Kidney Injury Stratified by Risk, Injury, Failure, Loss, and End-Stage (RIFLE) Serum Creatinine Criteria

	No. (%) [95% CI] of Patients[a]		
	Control Period (n = 760)	Intervention Period (n = 773)	*P* Value
RIFLE class			
Risk	71 (9.0) [7.2-11.0]	57 (7.4) [5.5-9.0]	.16
Injury	48 (6.3) [4.5-8.1]	23 (3.0) [1.8-4.2]	.002
Failure	57 (7.5) [5.6-9.0]	42 (5.4) [3.8-7.1]	.10
Injury and failure	105 (14) [11-16]	65 (8.4) [6.4-10.0]	<.001

Figure 2. Renal Replacement Therapy (RRT) in the Intensive Care Unit (ICU)



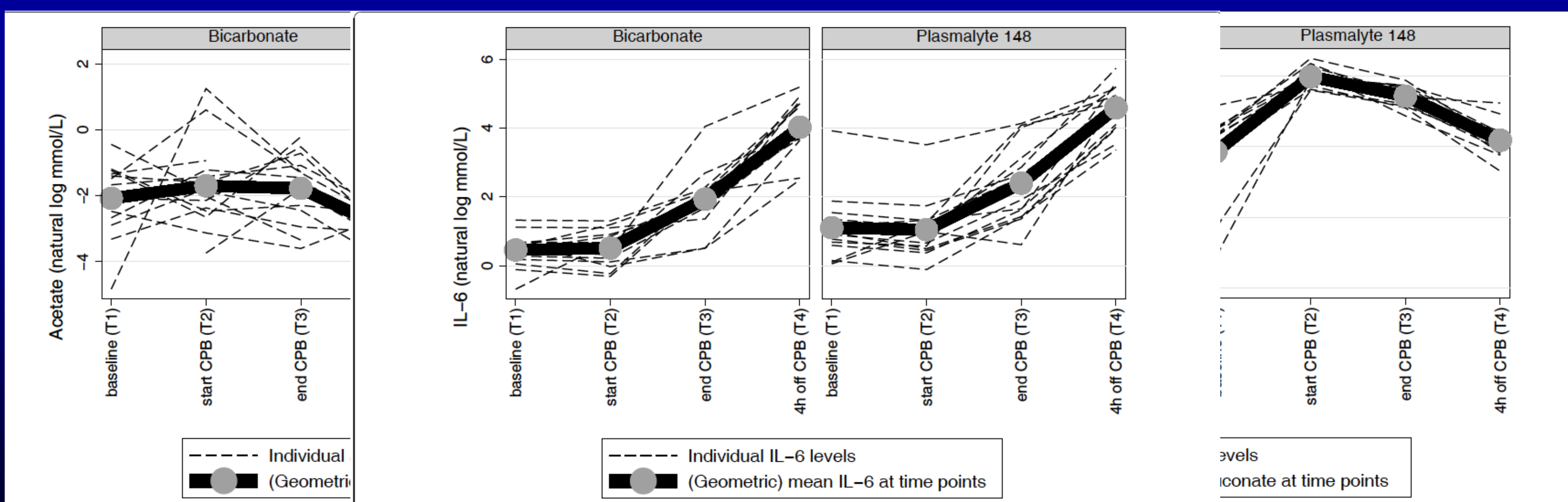
From Yunos NM et al. JAMA 308:1566-72, 2012.

RESEARCH Open Access

Plasma acetate, gluconate and interleukin-6 profiles during and after cardiopulmonary bypass: a comparison of Plasma-Lyte 148 with a bicarbonate-balanced solution

CRITICAL CARE

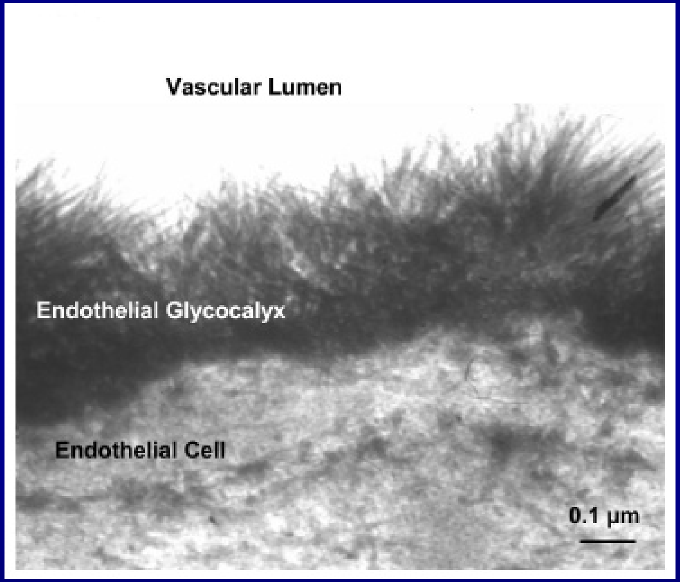
- ✓ Acetate in plasma: proinflammatory and cardiotoxic effects
- ✓ Prospective quasi-randomized study CPB prime (2 L) with either HCO3-balanced fluid (N=15) or Plasmalyte148® (N=15)



From Davies PG et al. Crit Care 15:R21, 2011.

The Endothelial Glycocalyx: the Double-barrier Concept of Vascular Permeability

✓Healthy endothelium is coated by the endothelial glycolalyx, a layer of membrane-bound proteoglycans and glycoproteins



Endothelial glycocalyx binds plasma proteins and fluids with a functional thickness of more than 1 µm. The amount of plasma not participating to the normal blood circulation is about 700-1000 mL in humans

✓By exerting a vital role on the physiologic endothelial permeability barrier, and preventing leucocyte and platelet adhesion, it mitigates inflammation and tissue edema

From Chappell D et al. Anesthesiology 109:724-740, 2008.

Fluid Resuscitation in ICU Patients

- ✓ Iatrogenic acute hypervolemia triggers atrial natriuretic peptide release, which has the power to degrade the endothelial glycocalyx

Kamp-Jensen M et al. Br J Anaesth 64:606-610, 1990.
Bruegger D et al. Am J Physiol Heart Circ Physiol 289:H1993-9, 2005.

- ✓ Degradation of the endothelial glycocalyx leads to platelet aggregation, leukocyte adhesion, and tissue oedema through increased endothelial permeability

Vink H et al. Circulation 101:1500-2, 2000.
Michel CC. Exp Physiol 82:1-30, 1997.
Chappell D et al. Anesthesiology 107-776-84, 2007.

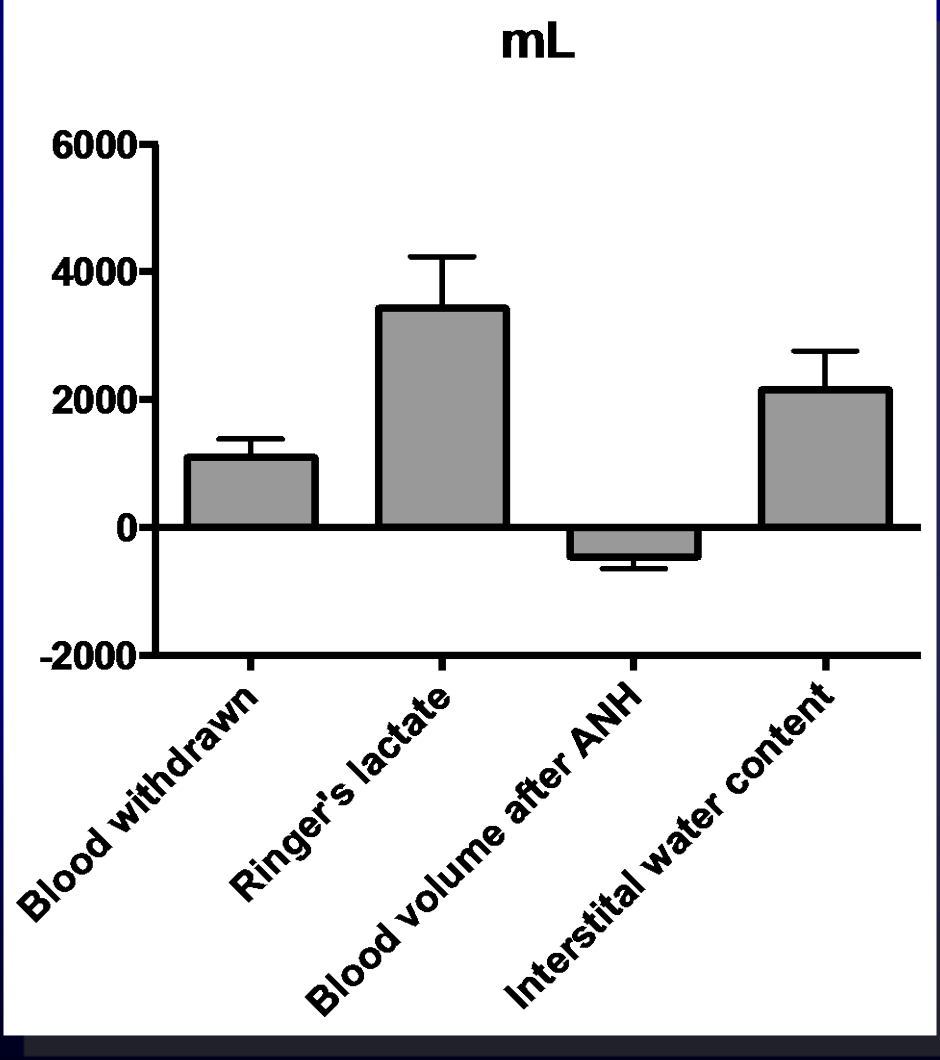
Fluid Resuscitation in ICU Patients

✓ Hypervolemia may result from inadequate monitoring of fluid resuscitation.

✓In these conditions, hypervolemia might be more easily achieved with colloids than with crystalloids…

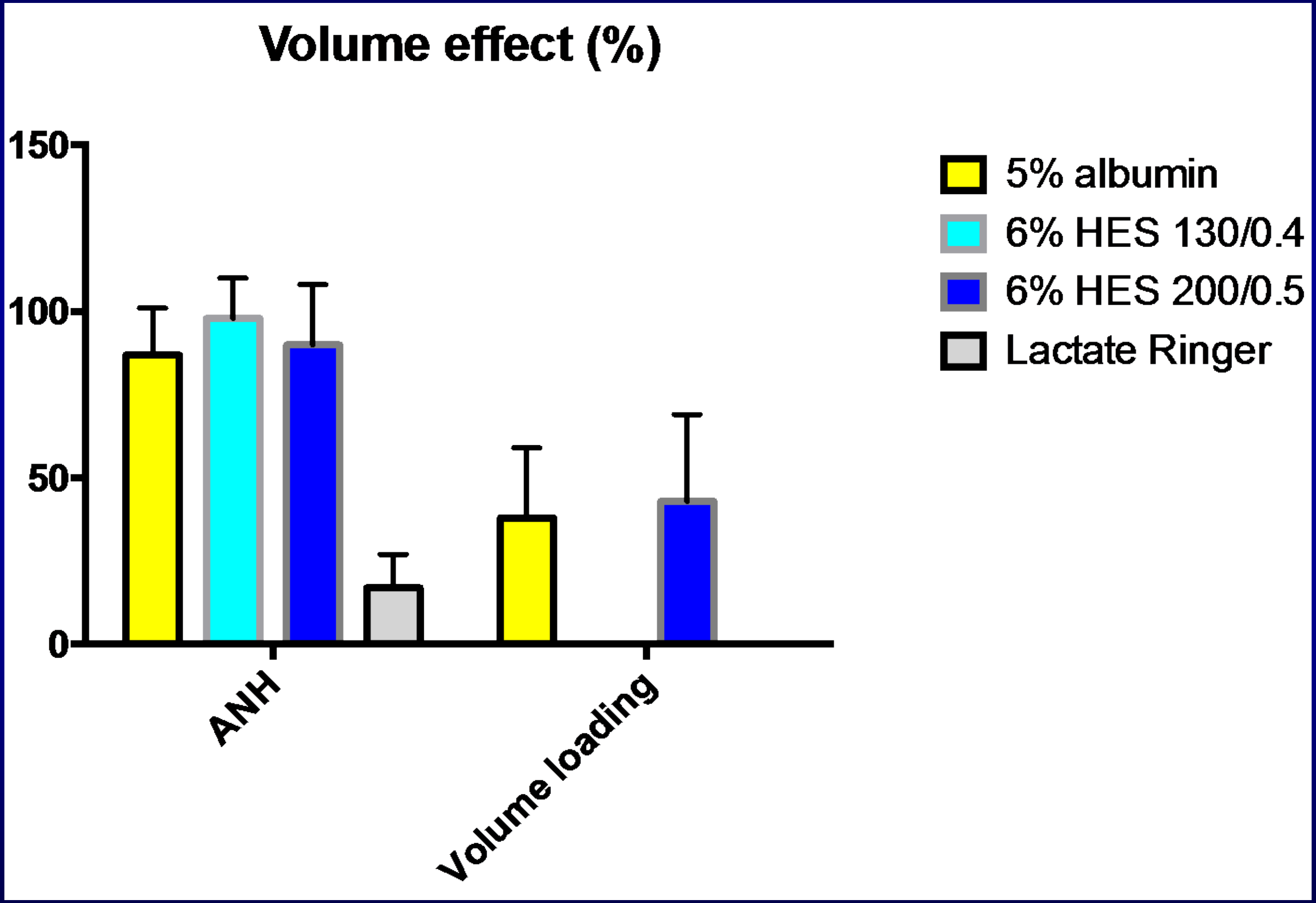
Intravascular Volume Effect of Ringer's Lactate

- ✓ Intended normovolemic hemodilution in 10 female adults
- ✓ Double-tracer volume measurement
- ✓ Ringer's lactate: three-fold amount of withdrawn blood



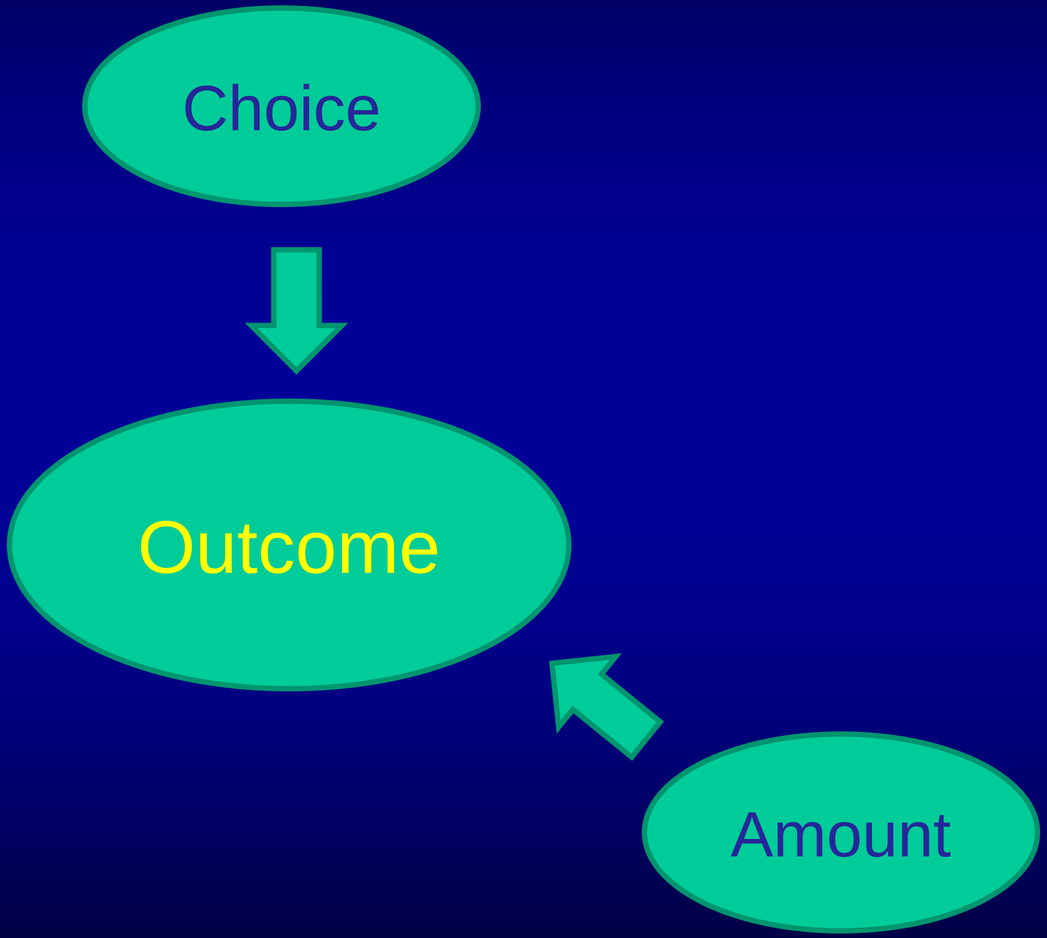
From Jacob M et al. Crit Care 16:R86, 2012.

Volume Effects of Fluids Are Context-sensitive



From Jacob M & Chappell D. Curr Opin Crit Care 19:282-9, 2013.

The Influence of Volume Management On Outcome



From Bagshaw SM & Bellomo R. Curr Opin Crit Care 13:541-8, 2007.

Perioperative Fluid Administration

- ✓Preoperative fasting does not normally cause intravascular hypovolemia

  Rehm M et al. Anesthesiology 95:849-56, 2002.

- ✓ The evidence supporting the concept that hemorrhage or operation is associated with the development of a « third space » is weak

  Brandstrup B et al. Surgery 139:419-432, 2006.

- ✓The measured basal evaporative water loss is only about 0.5 ml/kg.h, increasing to a maximum of 1.0 ml/kg.h during major surgery

  Lamke LO et al. Acta Chir Scand 143:279-84,1977.

Perioperative Fluid Administration

- ✓ Principal goal: optimization of cardiac preload: this requires optimization of circulating blood volume which cannot be directly assessed routinely

- ✓ Measure of volume responsiveness referred to as a "goal-directed" approach may represent a interesting alternative

Hemodynamic Parameters to Guide Fluid Therapy

Method	**Technology**	**Area under the curve (95% CI)**
Pulse pressure variation	Arterial wave form	0.94 (0.93-0.95)
Systolic pressure variation	Arterial wave form	0.86 (0.82-0.90)
Stroke volume variation	Pulse contour analysis	0.88 (0.78-0.88)
LV end-diastolic area	Echocardiography	0.64 (0.53-0.74)
Global end-diastolic volume	Transpulmonary hemodilution	0.56 (0.37-0.67)
Central venous pressure	Central venous catheter	0.55 (0.18-0.62)

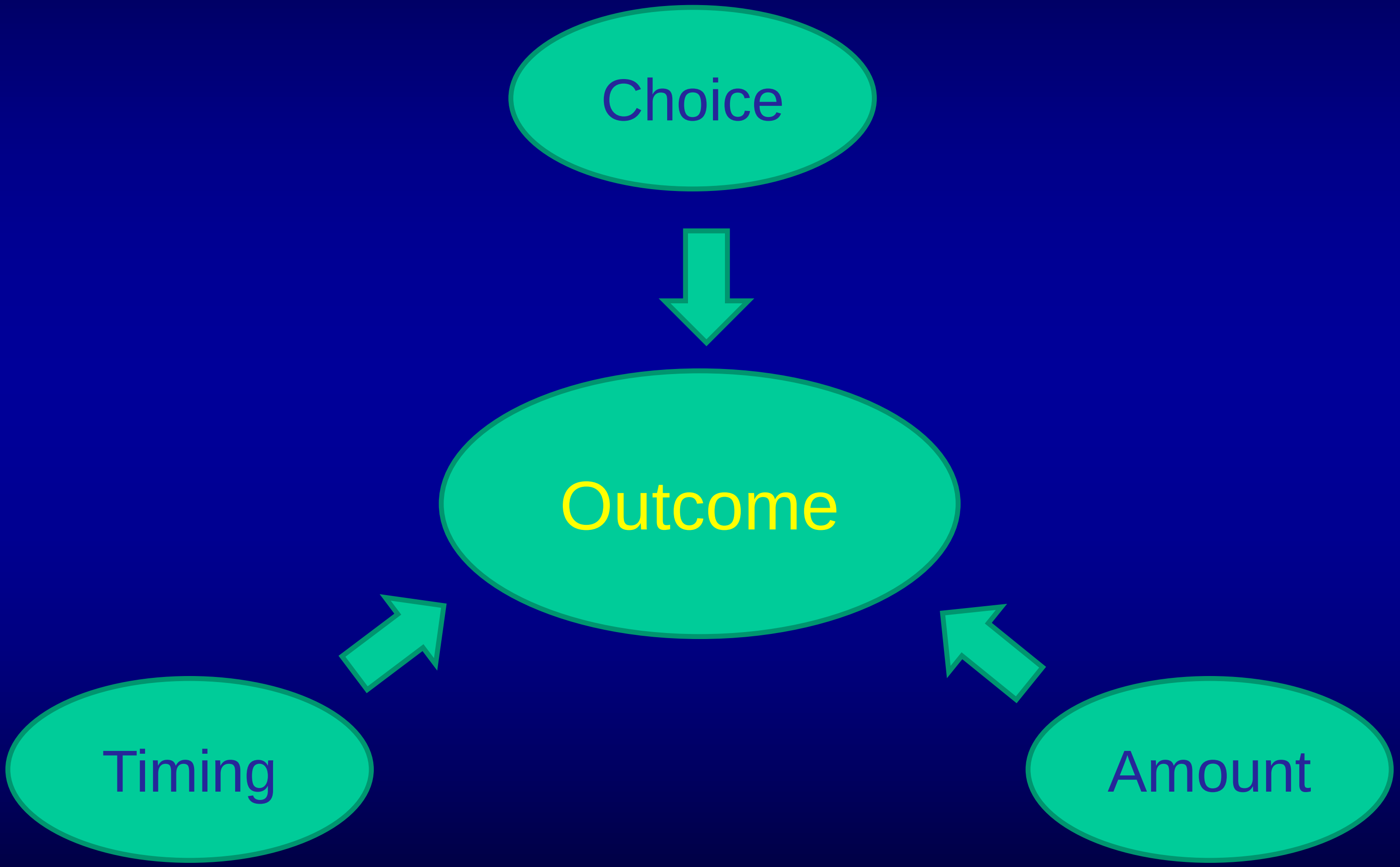
From Marik PE et al. Crit Care Med 37:2642-7, 2009.

Fluid Administration Strategies

- ✓ The « recipe » book approach
- ✓ Intravascular pressure measurement
- ✓ Systolic and pulse pressure variation
- ✓ « Fluid » challenge
  - Intravascular pressure measurement
  - Blood flow measurement
- Measurement of tissue perfusion

From Grocott MPW et al. Anesth Analg 100:1093-106, 2005.

The Influence of Volume Management On Outcome



From Bagshaw SM & Bellomo R. Curr Opin Crit Care 13:541-8, 2007.

Doppler-Optimized Fluid Management During Elective Colorectal Resection

✓ - Control (n=52): routine management

- Protocol (N=51): maximized stroke volume with colloid boluses based on oesophageal Doppler

Crystalloids

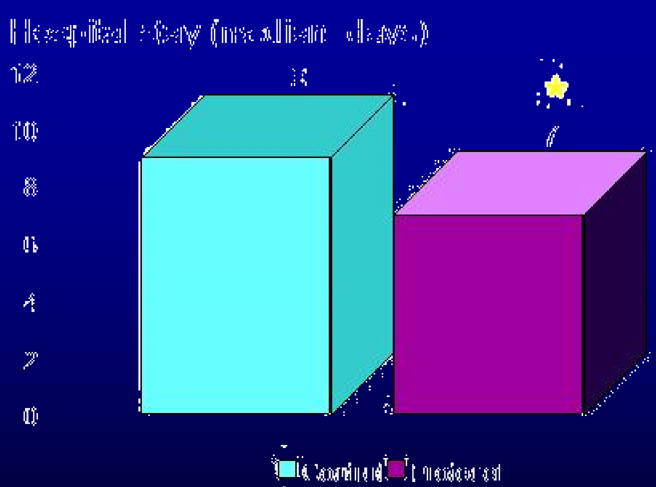
✓ - Control: 2625 ± 1004 ml

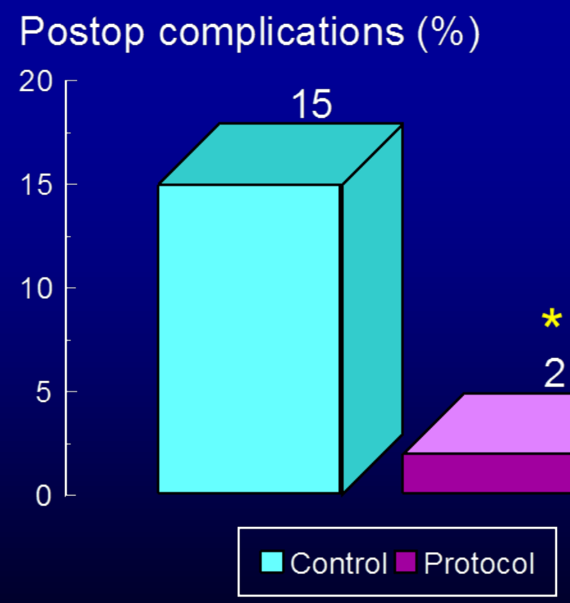
- Protocol: 2298 ± 863 ml

Colloids

- Control: 1209 ± 824 ml

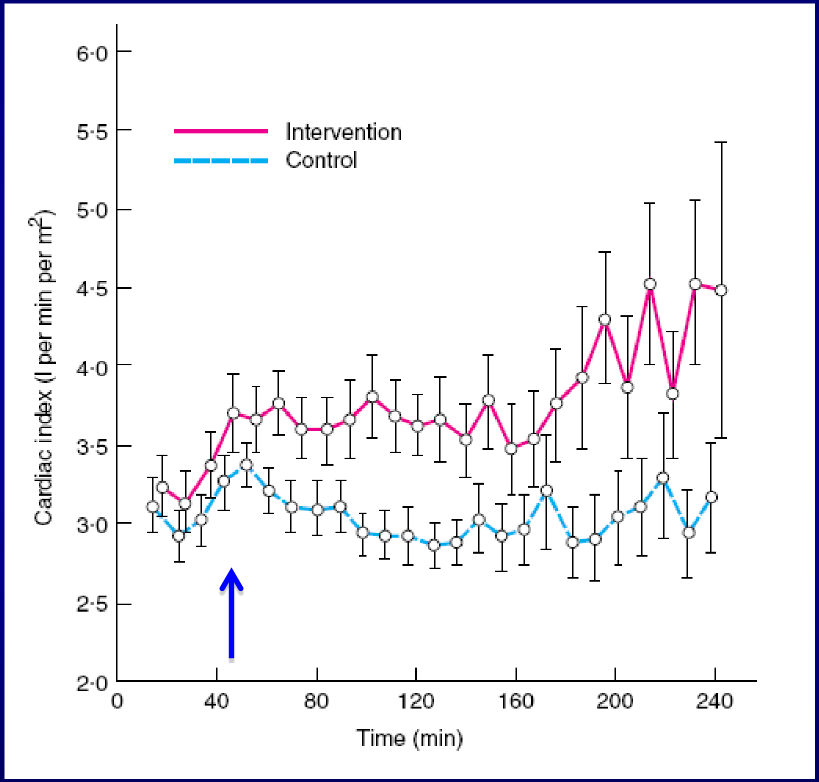
- Protocol: 1340 ± 838 ml

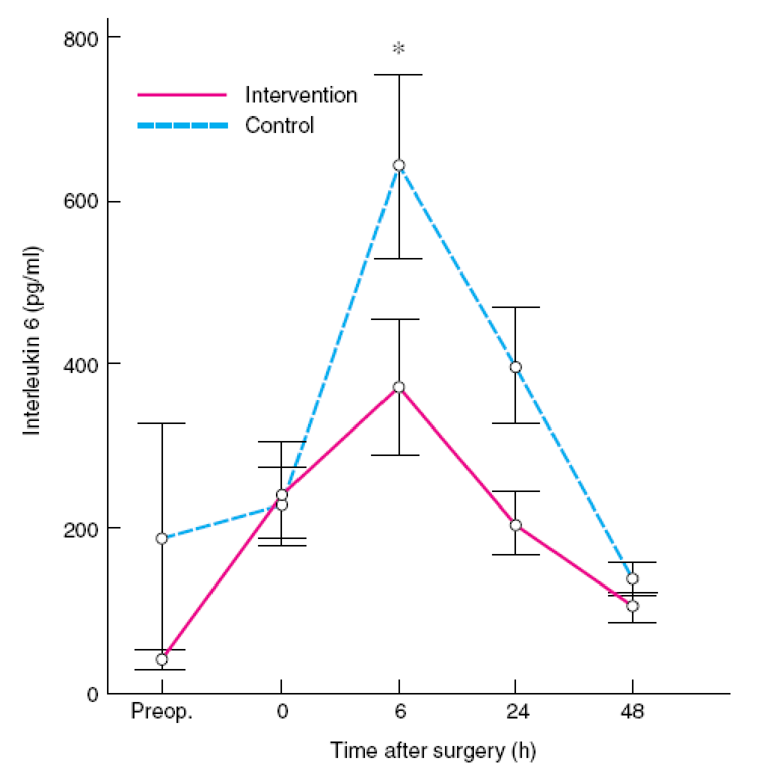




From Noblett SE et al.Br J Surg 93:1069-1076, 2006.

Doppler-Optimized Fluid Management During Elective Colorectal Resection





From Noblett SE et al.Br J Surg 93:1069-1076, 2006.

REVIEW ARTICLE

CRITICAL CARE MEDICINE

Simon R. Finfer, M.D., and Jean-Louis Vincent, M.D., Ph.D., *Editors*

Resuscitation Fluids

John A. Myburgh, M.B., B.Ch., Ph.D., and Michael G. Mythen, M.D., M.B., B.S.

✓ Fluids should be administered with the same caution that is used for any intravenous drug

✓ Fluid resuscitation is a component of a complex physiological process

✓ Fluid requirements change over time in critically ill patients

✓ Specific considerations apply to different categories of patients

N Engl J Med 2013;369:1243-51.

Perioperative Fluid Administration

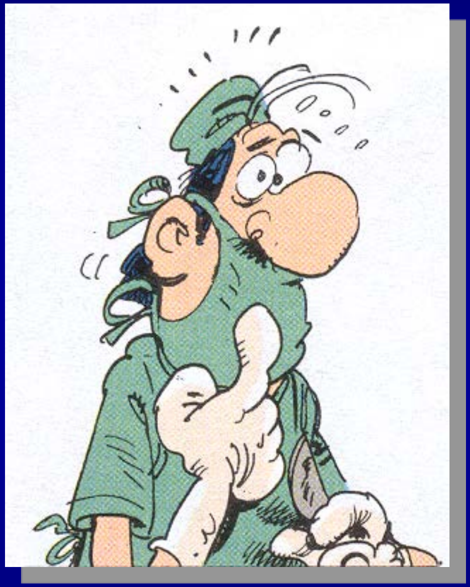
✓ Replacement of "physiologic" losses (urine production, insensible perspiration…)

→ crystalloids in a 'balanced" form

✓ Replacement of "non physiologic" losses (mainly blood losses…)

→ colloids, blood products

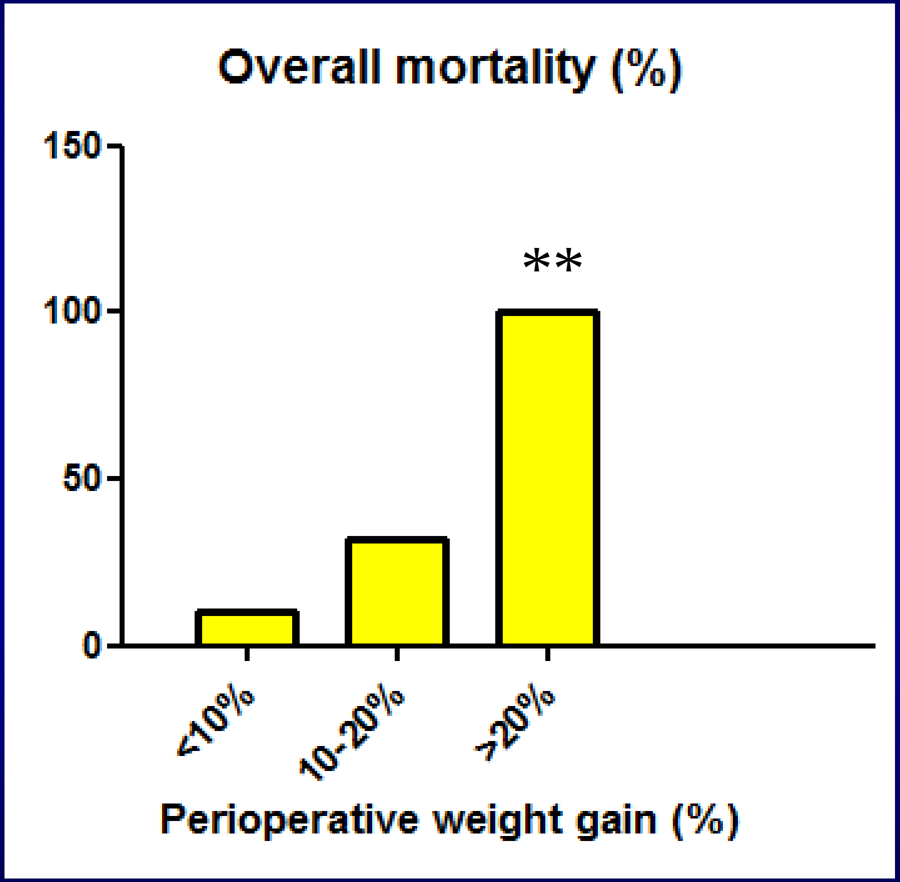
We know more…



…But do we know better ?

Thank you very much for your attention

Perioperative Weight Gain & Mortality

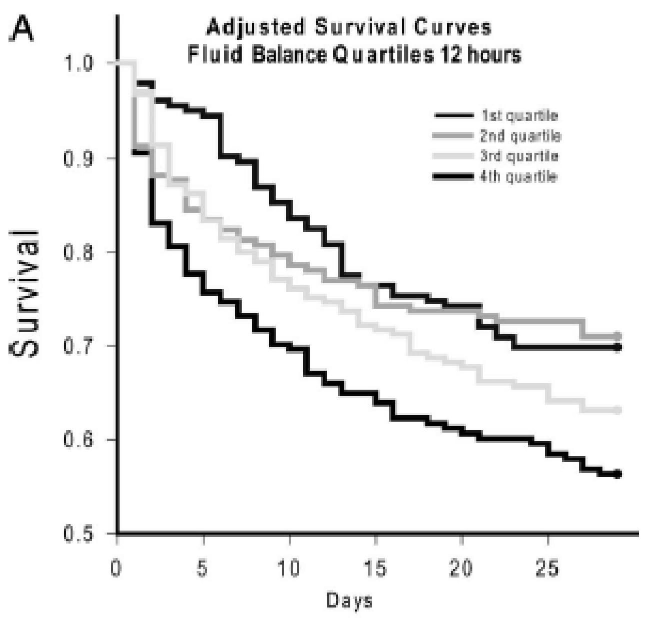


From Lowell JA et al. Crit Care Med 18:728-33, 1990.

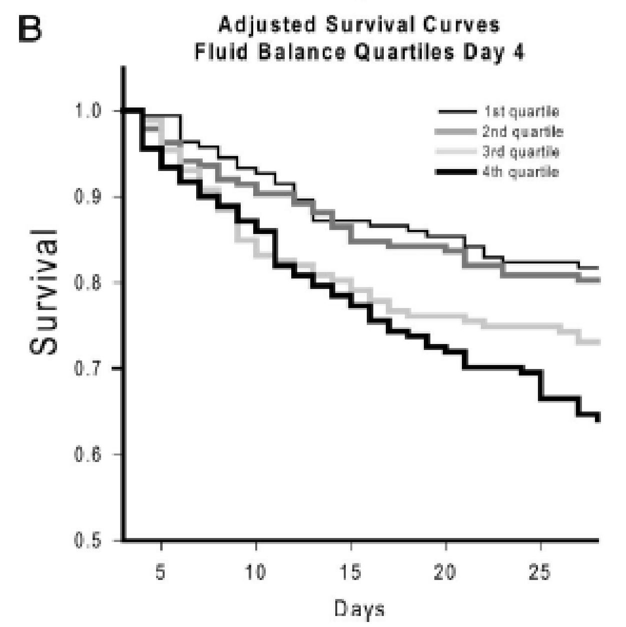
Fluid Resuscitation in Septic Shock: Fluid Balance & Mortality

- ✓ Retrospective review of the use of IV fluids during the first 4 days of care

	Quartile 1 (Dry)	Quartile 2	Quartile 3	Quartile 4 (Wet)
12 hrs				
Intake, mL	2900 (2050–3900)	4520 (3700–5450)	6110 (5330–7360)	10,100 (8430–12,100)
Output, mL	2200 (1100–3920)	1590 (960–2560)	1180 (600–2070)	1260 (600–2400)
Balance, mL	710 (−132–1480)	2880 (2510–3300)	4900 (4290–5530)	8150 (7110–10,100)
Day 4				
Intake, mL	16,100 (12,800–19700)	18,500 (15,700–22,500)	22,800 (19,700–26,700)	30,600 (26,200–36,000)
Output, mL	14,600 (11,500–20100)	11,000 (8210–14,500)	9960 (6940–12,900)	8350 (5100–12,300)
Balance, mL	1560 (−723–3210)	8120 (6210–9090)	13,000 (11,800–14,700)	20,500 (17,700–24,500)



From Boyd JH et al. Crit Care Med 39:259-65, 2011.



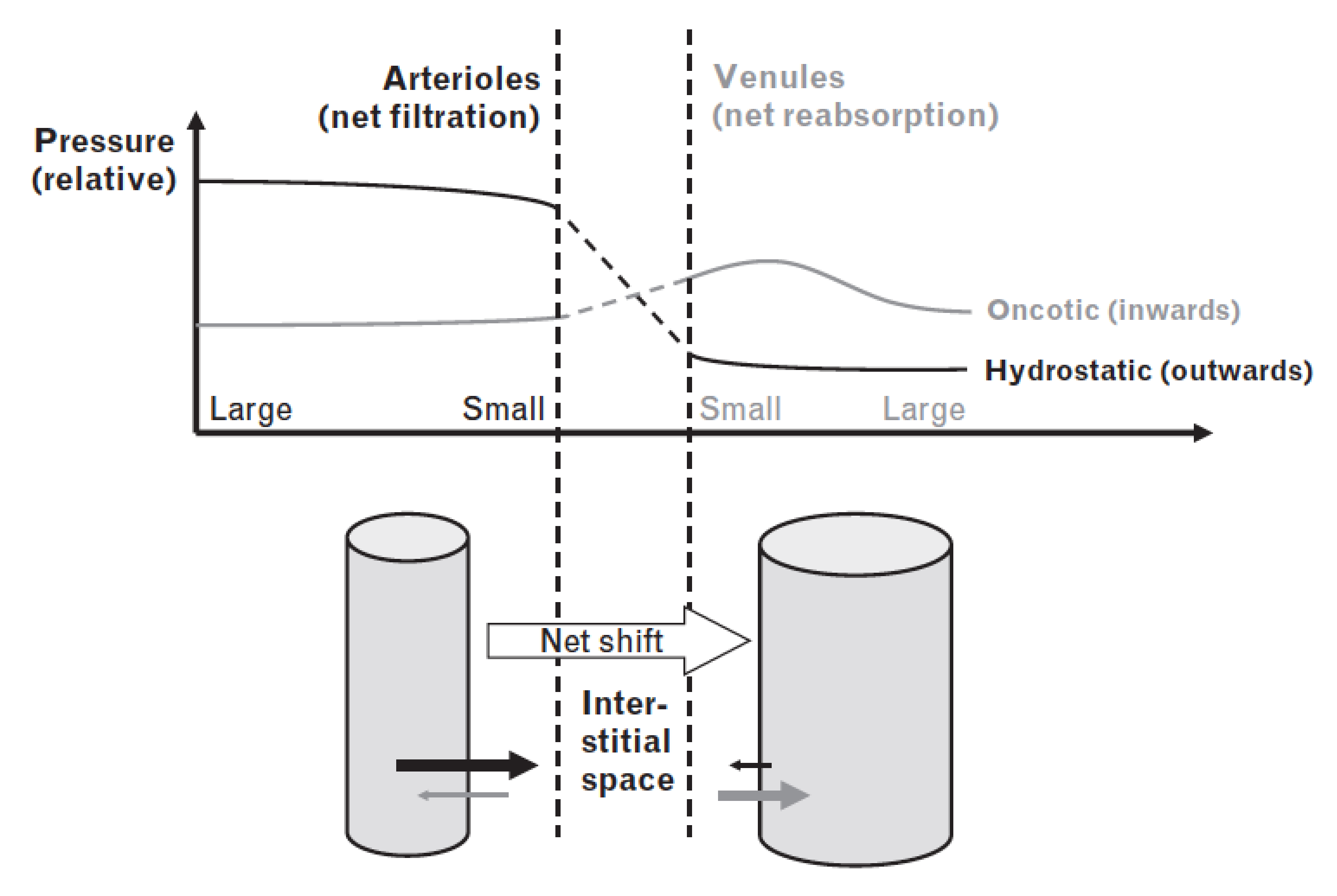
Goal-Directed Fluid Therapy in Major Surgery

- ✓ Meta-analysis of RCTs: 23 trials - 3861 patients
- ✓ Goal-directed therapy:16 studies
  - ↓ risk of pneumonia - RR: 0.7 (95% CI:0.6-0.9)
  - ↓ risk of renal complications - RR: 0.7 (95% CI:0.5-0.9)
  - ↓ length of hospital stay - MD 2 days (95% CI:1-3)
  - ↓ time to resumption of normal diet – MD 1.4 day (95% CI:0.8-1.7)
  - No change in mortality RR: 0.88 (95% CI:0.70-1.12)

Effects of Goal-Directed Fluid Therapy on Renal Complication not influenced by the applied hemodynamic goals

From Corcoran T et al. Anesth Analg 114:640-51, 2012.

The Filtration Behaviour According to Starling



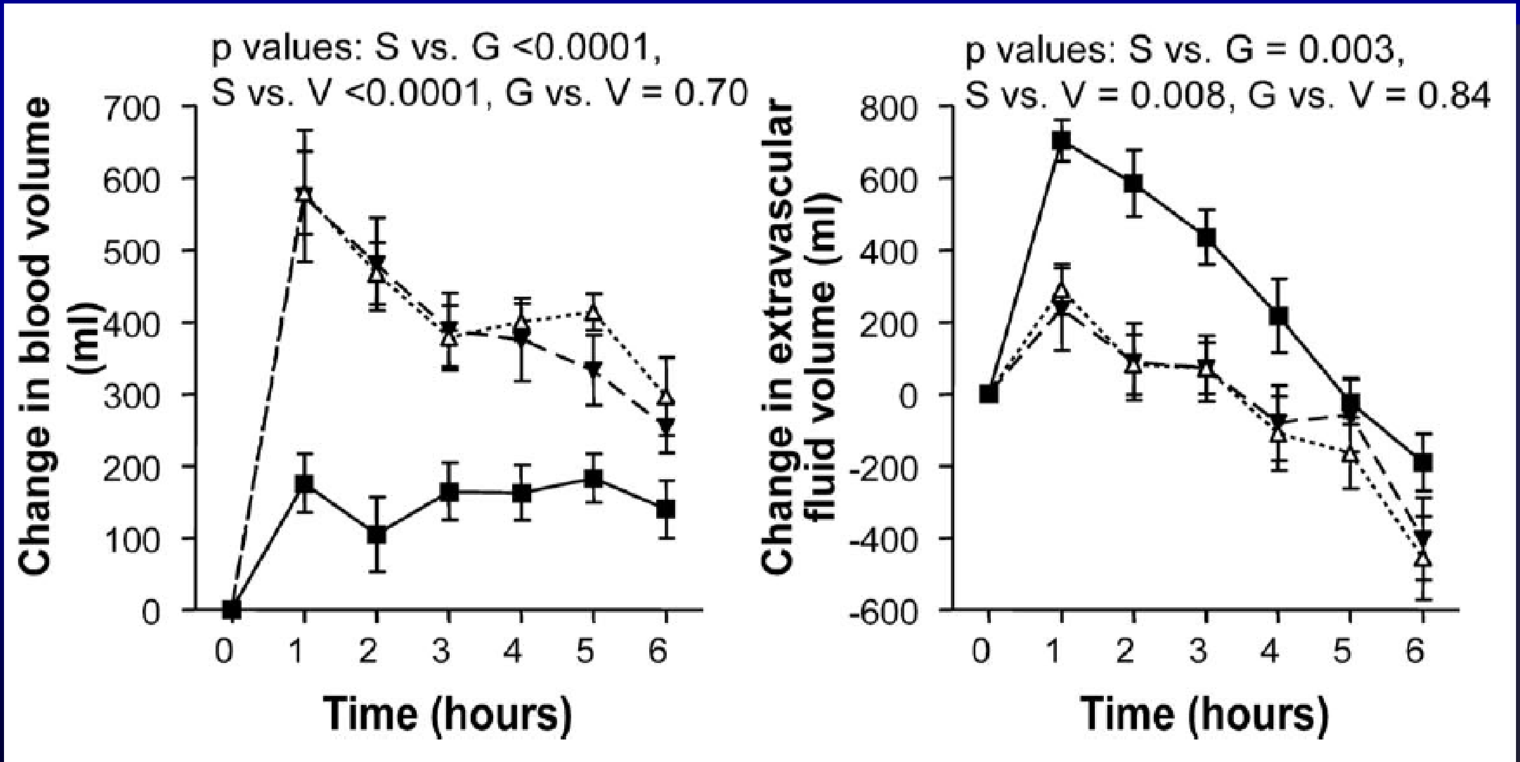
From Jacob M & Chappell D. Curr Opin Crit Care 19:282-9, 2013.

Fluid Compartment Physiology

70 kg - healthy volunteers

✓ Randomized three-way crossover study: 1l infusion over 1h

- NaCl 0.9%
- 4% modified fluid gelatin
- 6% HES 130/0.4



From Lobo DN et al. Crit Care Med 38:464-70, 2010.