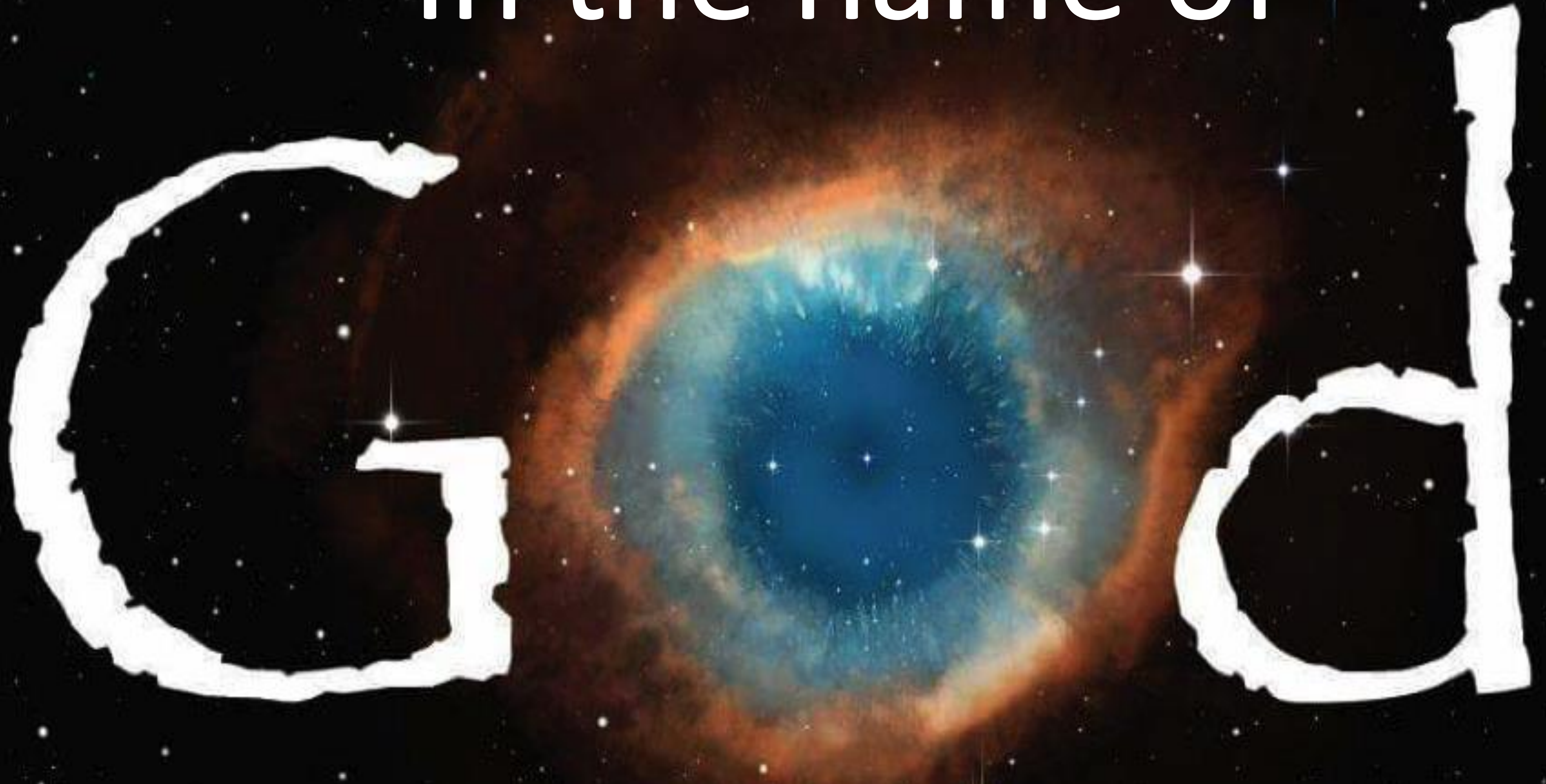
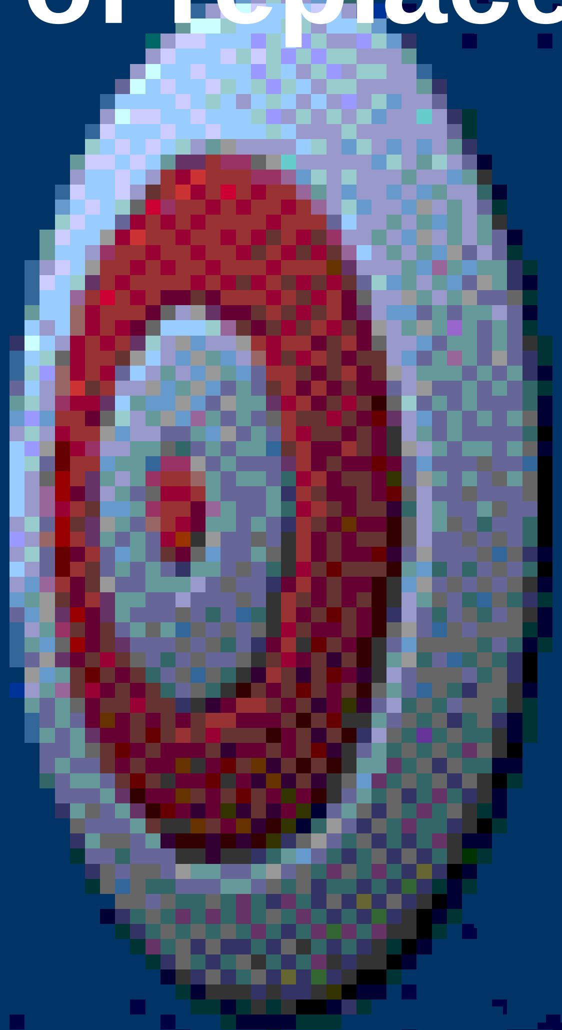
In the name of



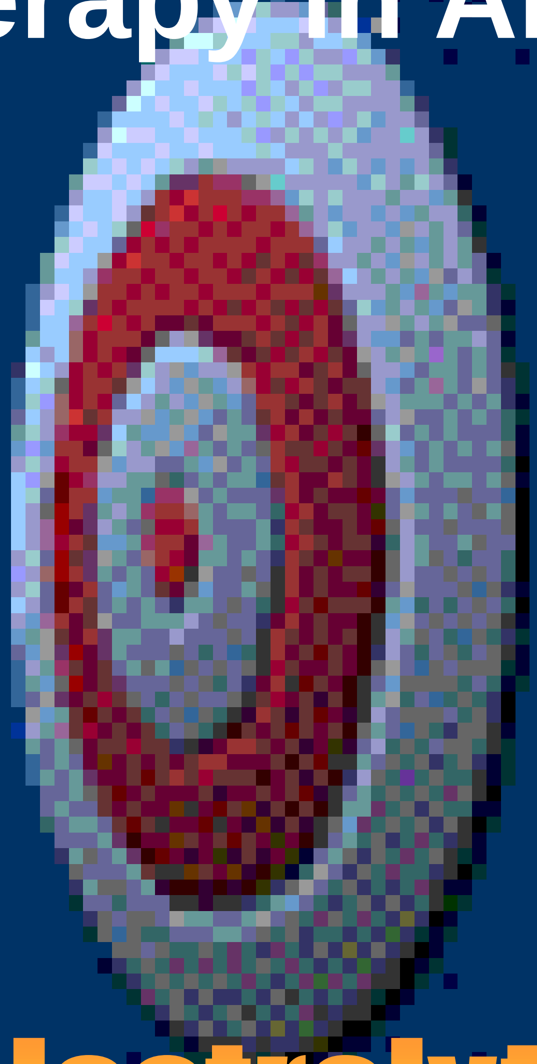
Fluid Replacement Therapy in the ICU Patients with AKI

Hassan Argani Professor of Nephrology

The goals of replacement fluid therapy in AKI



correct Volume status abnormalities



correct electrolyte abnormalities

The incidence of AKI in patients admitted to the ICU is high, ranging from 18 to 78%.

The successful resuscitation of six cholera patients with a NaCl- and sodium bicarbonate-based solution for the first time

Lewins R. Lancet 1832; 18: 243– 244.

Does the patient with AKI **need** fluid?

The **amount** and **time** of fluid utilized?

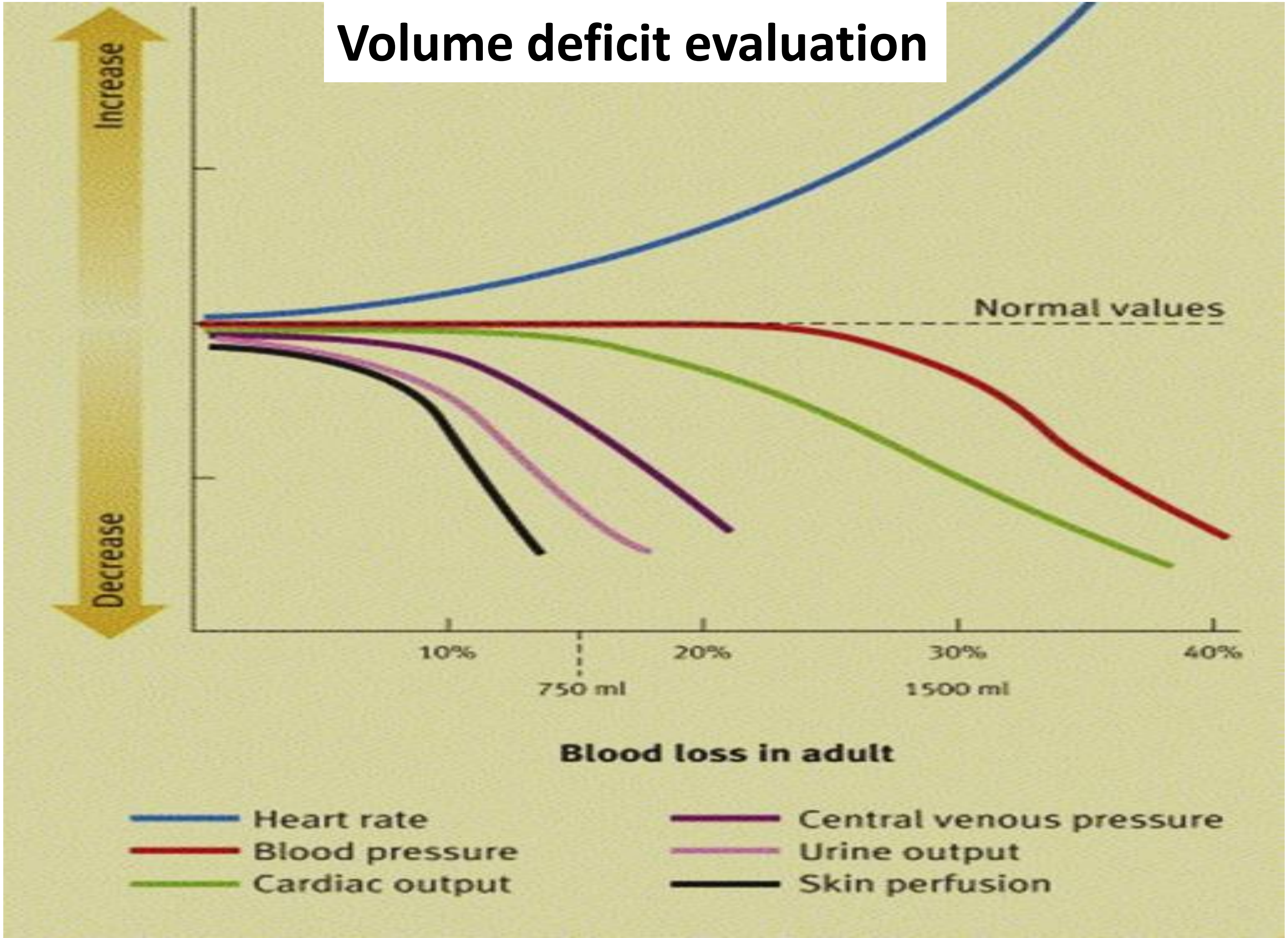
The **type** of fluid?

Does the patient with AKI **need** fluid?

The **amount** and time of fluid utilized?

The **type** of fluid?

Volume deficit evaluation



Parameters to guide fluid therapy

Clinical

- Mean arterial pressure
- Urine output
- Capillary refill

Minimally invasive

- IVC collapsibility index
- Passive leg raising test
- USG chest
  - B lines
  - Stroke volume variation
- Mixed venous oxygen saturation
- Central venous pressure

Invasive

- Intra-arterial pressure
  - Pulse pressure variation
  - Systolic pressure variation

Acute Dialysis Quality Initiative (ADQI XII):

Treatment tool

Fluid bolus injection:

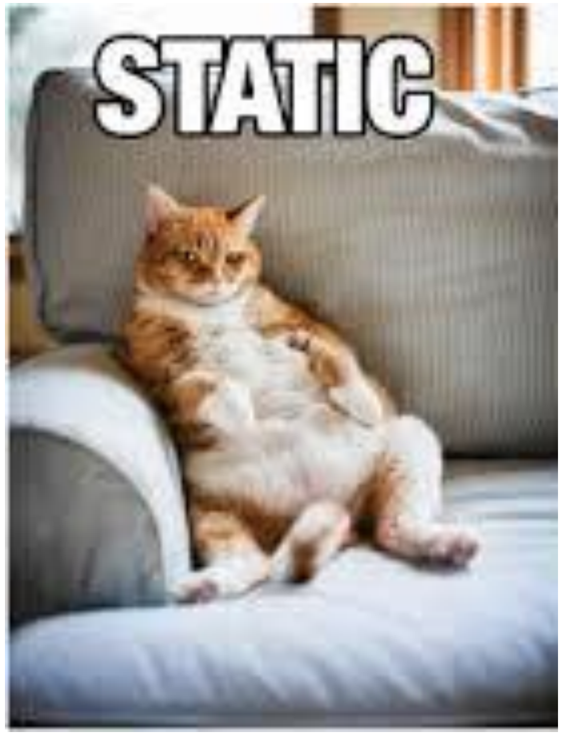
Rapid infusion of at least 500 ml over a maximum of **15 min** to correct hypotensive shock.

Fluid challenge:

Infusion of 500–1,000 ml of crystalloids or 300– 500 ml of colloids over **30 min** to provide information regarding the impact of fluids in the optimization of tissue perfusion or increased stroke volume >10%

Diagnostic tool

Fluid responsiveness



Assesses Preload

- ❖ CVP➔RVEDV.
- ❖ Pulmonary artery occlusion pressure (cardiac filling pressures)➔ LVEDP (preload).

Assesses Preload ***<u>Dependency</u>***

- ❖ Stroke Volume Variation (SVV)
- ❖ Pulse Pressure Variation (PPV)

Neth Heart J (2013) 21:530–536

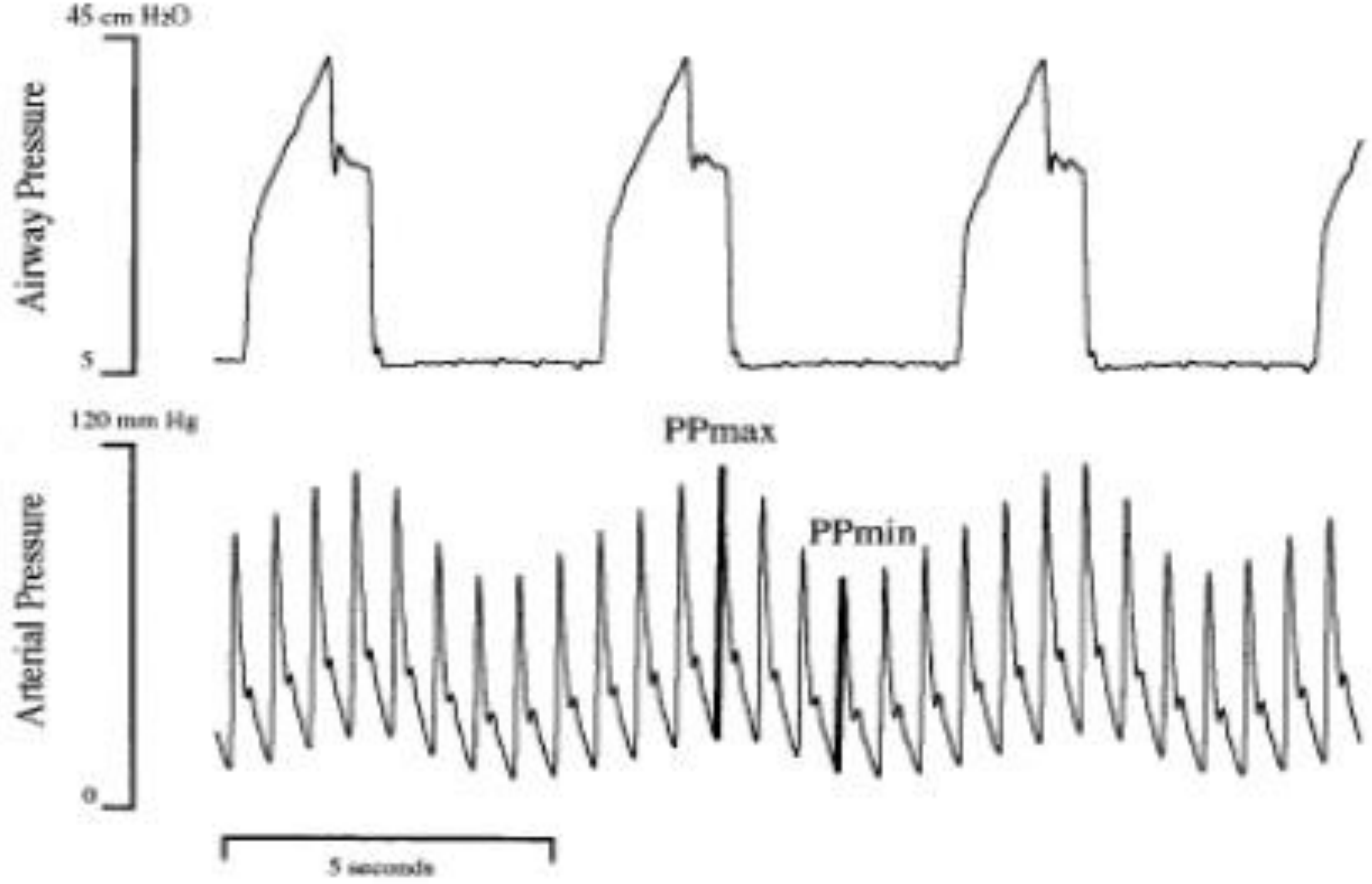
Neth Heart J (2013) 21:530–536

Predictive value of techniques used to determine fluid responsiveness

Method	Technology	AUC*
Pulse pressure variation (PPV)	Arterial waveform	0.94 (0.93-0.95)
Systolic pressure variation (SPV)	Arterial waveform	0.86 (0.82-0.90)
Stroke volume variation (SVV)	Pulse contour analysis	0.84 (0.78-0.88)
Left ventricular end-diastolic area (LVEDA)	Echocardiography	0.64 (0.53-0.74)
Global end-diastolic volume (GEDV)	Transpulmonary thermodilution	0.56 (0.37-0.67)
Central venous pressure (CVP)	Central venous catheter	0.55 (0.48-0.62)

IAP

Watch out for Systolic pressure variation



SURVIVING SEPSIS CAMPAIGN BUNDLES

TO BE COMPLETED WITHIN 3 HOURS:

1) Measure lactate level
2) Obtain blood cultures prior to administration of antibiotics
3) Administer broad spectrum antibiotics
4) Administer 30 mL/kg crystalloid for hypotension or lactate > 4mmol/L.

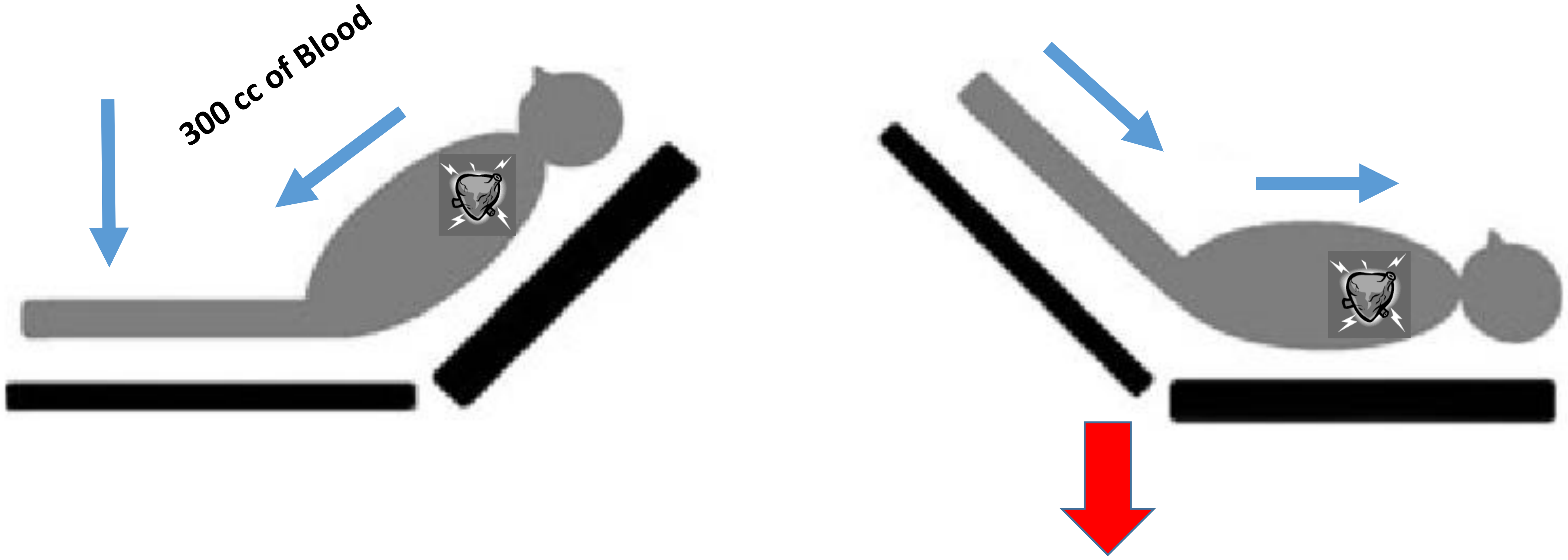
TO BE COMPLETED WITHIN 6 HOURS:

5) Apply vasopressors (for hypotension that does not respond to initial fluid resuscitation) to maintain a mean arterial pressure (MAP) ≥ 65 mm Hg
6) In the event of persistent arterial hypotension despite volume resuscitation (septic shock) or initial lactate 4 mmol/L (36 mg/dL): - Measure central venous pressure (CVP)* - Measure central venous oxygen saturation (ScvO2)*
7) Remeasure lactate if initial lactate was elevated*

***Targets for quantitative resuscitation included in the guidelines are CVP of ≥8 mm Hg, ScvO2 of 70%, and normalization of lactate.**

Crit Care Med 2013; 41:580–637

Passive leg raising(PLR) test



Increased PP, SV, BP

Neth Heart J (2013) 21:530–536

Possible passive leg raising false negative tests

Conditions of high intra-abdominal pressure

…should be noted that intra-abdominal hypertension (intra-abdominal pressure > 16 mm Hg) impairs venous return and reduces the ability of PLR to detect fluid responsiveness [54]…

Marik et al. Annals of Intensive Care 2011, 1:1

States of severe dehydration

…the blood volume mobilized by leg raising is dependent on total blood volume and so could be small in severely hypovolemic patients [39]…

Pinsky et al. Critical Care 2005, 9:566-572

Untimely measure of SV

…Because the maximal hemodynamic effects of PLR occur within the first minute of leg elevation [43], it is important to assess these effects with a method that is able to track changes in cardiac output or stroke volume on a real-time basis.

Marik et al. Annals of Intensive Care 2011, 1:1

Maneuver technique

…Jabot et al. [16] found significant differences in hemodynamic response to PLR performed by starting from supine versus semi recumbent position but in our analysis the reliability of PLR-cCO was proven to be independent from how the PLR maneuver was performed.…

Cavallaro F et a. Intensive Care Med (2010) 36:1475–1483

Does the patient with AKI **need** fluid?

The **amount** and time of fluid utilized?

The **type** of fluid?

Fluid therapy has 2 components for volume deficit

Replacement therapy

corrects any pre-existing water and electrolyte deficits

Maintenance therapy

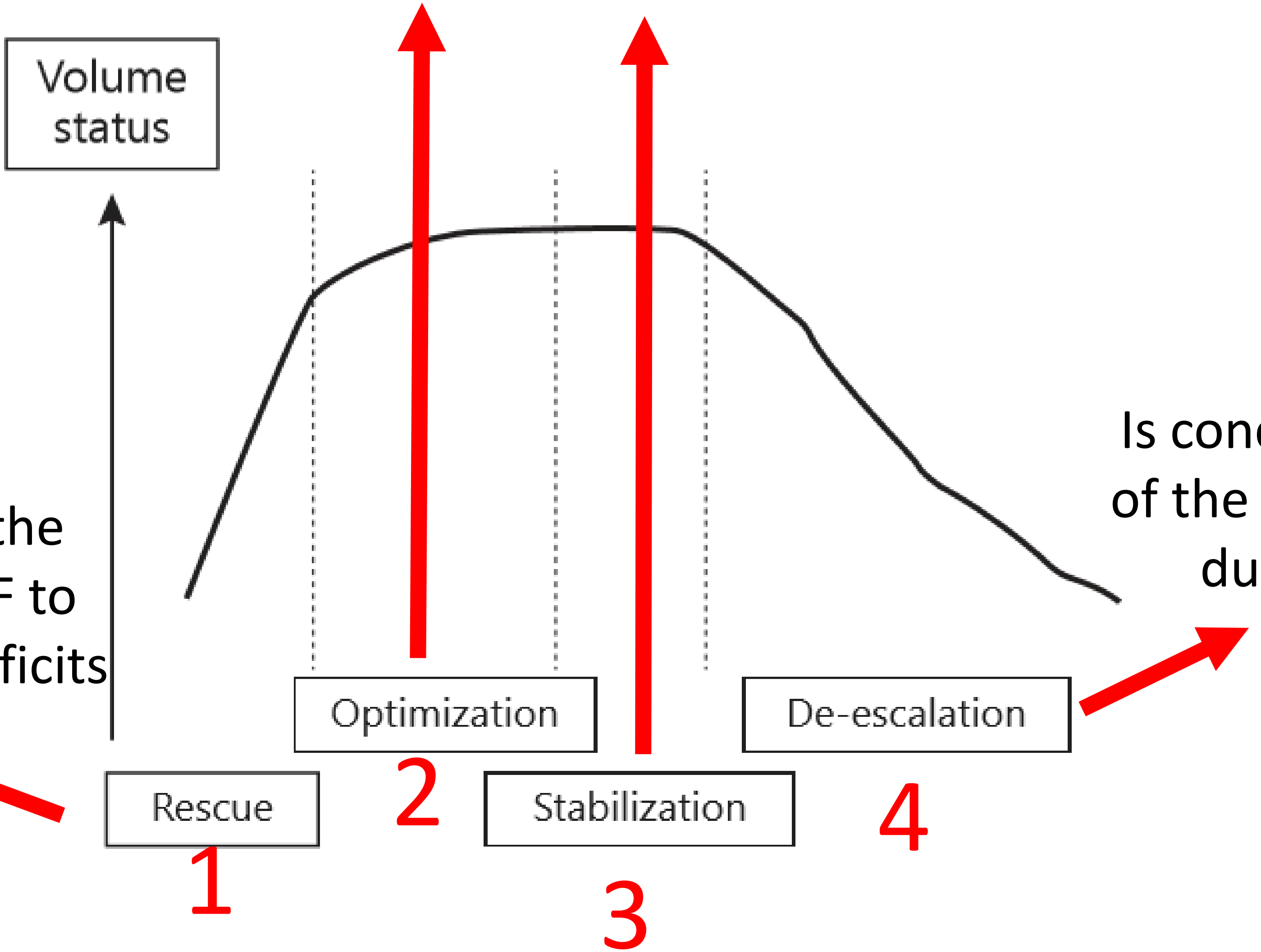
Replaces the ongoing losses

Patients expected to have inadequate energy or fluid intake for more than one to two weeks should be considered for parenteral or enteral nutrition

The four stages of volume resuscitation therapy

The main focus is on maintaining appropriate perfusion while avoiding further volume overload **(1.5 ml/kg/hour)**

The main focus is on the appropriate use of IVF to improve perfusion deficits



Is concentrated on removal of the fluids that were used during resuscitation

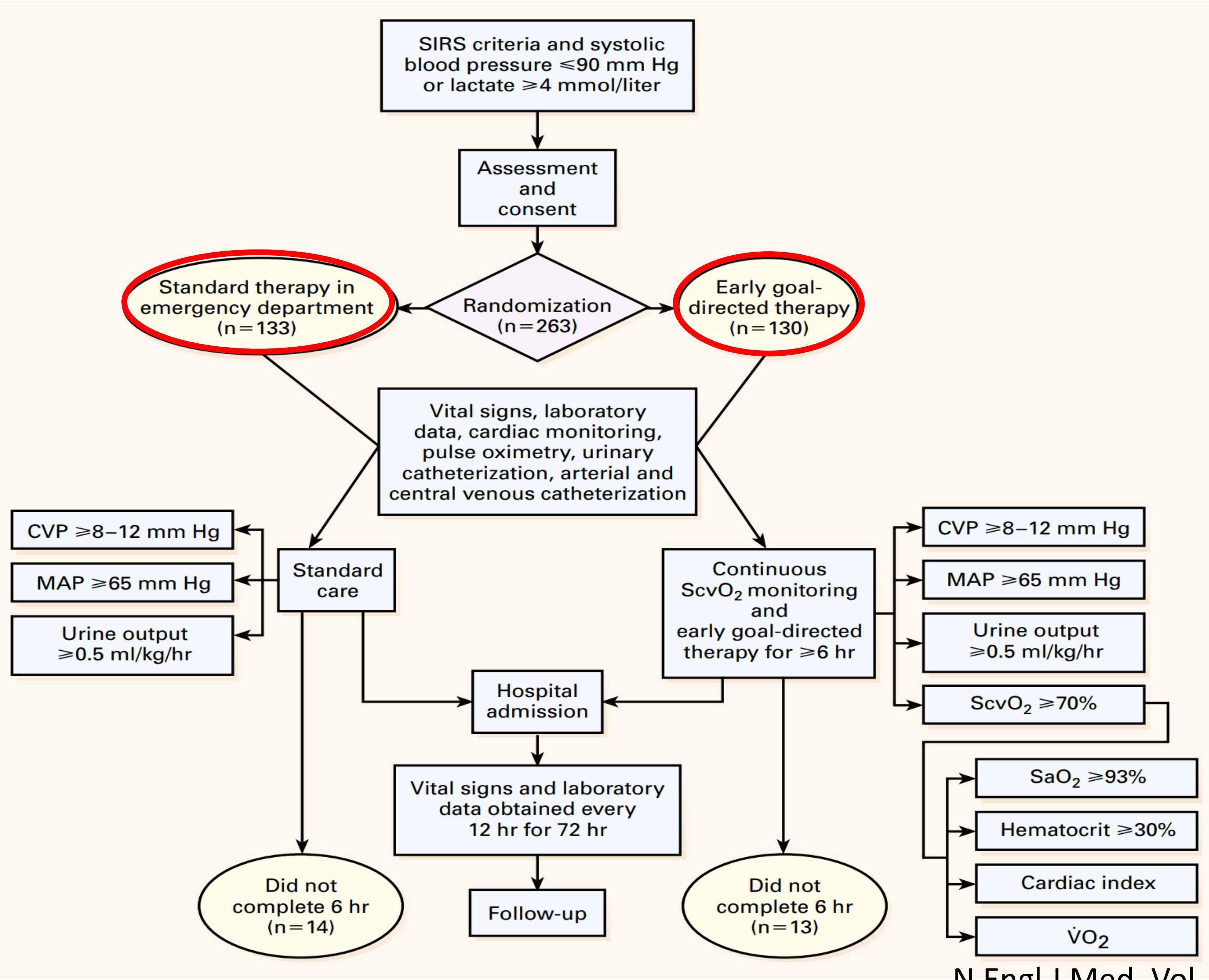
Kidney Dis 2016;2:64–71

The New England Journal of Medicine

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 Engl J Med, Vol. 345, No. 19 · November 8, 2001 ·



N Engl J Med, Vol. 345, No. 19 · November 8, 2001 ·

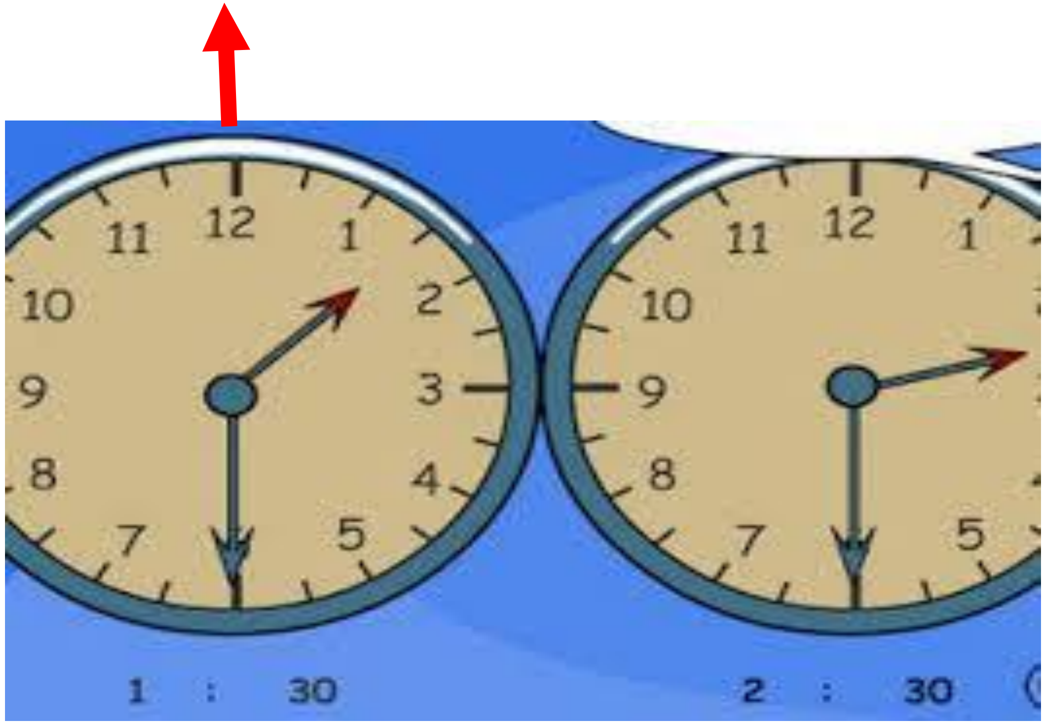
TABLE 3. KAPLAN–MEIER ESTIMATES OF MORTALITY AND CAUSES OF IN-HOSPITAL DEATH.*

VARIABLE	STANDARD THERAPY (N=133)	EARLY GOAL-DIRECTED THERAPY (N=130)	RELATIVE RISK (95% CI)	P VALUE
	no. (%)			
In-hospital mortality†				
All patients	59 (46.5)	38 (30.5)	0.58 (0.38–0.87)	0.009
Patients with severe sepsis	19 (30.0)	9 (14.9)	0.46 (0.21–1.03)	0.06
Patients with septic shock	40 (56.8)	29 (42.3)	0.60 (0.36–0.98)	0.04
Patients with sepsis syndrome	44 (45.4)	35 (35.1)	0.66 (0.42–1.04)	0.07
28-Day mortality†	61 (49.2)	40 (33.3)	0.58 (0.39–0.87)	0.01
60-Day mortality†	70 (56.9)	50 (44.3)	0.67 (0.46–0.96)	0.03
Causes of in-hospital death‡				
Sudden cardiovascular collapse	25/119 (21.0)	12/117 (10.3)	—	0.02
Multiorgan failure	26/119 (21.8)	19/117 (16.2)	—	0.27

N Engl J Med, Vol. 345, No. 19 · November 8, 2001 ·

Conclusion

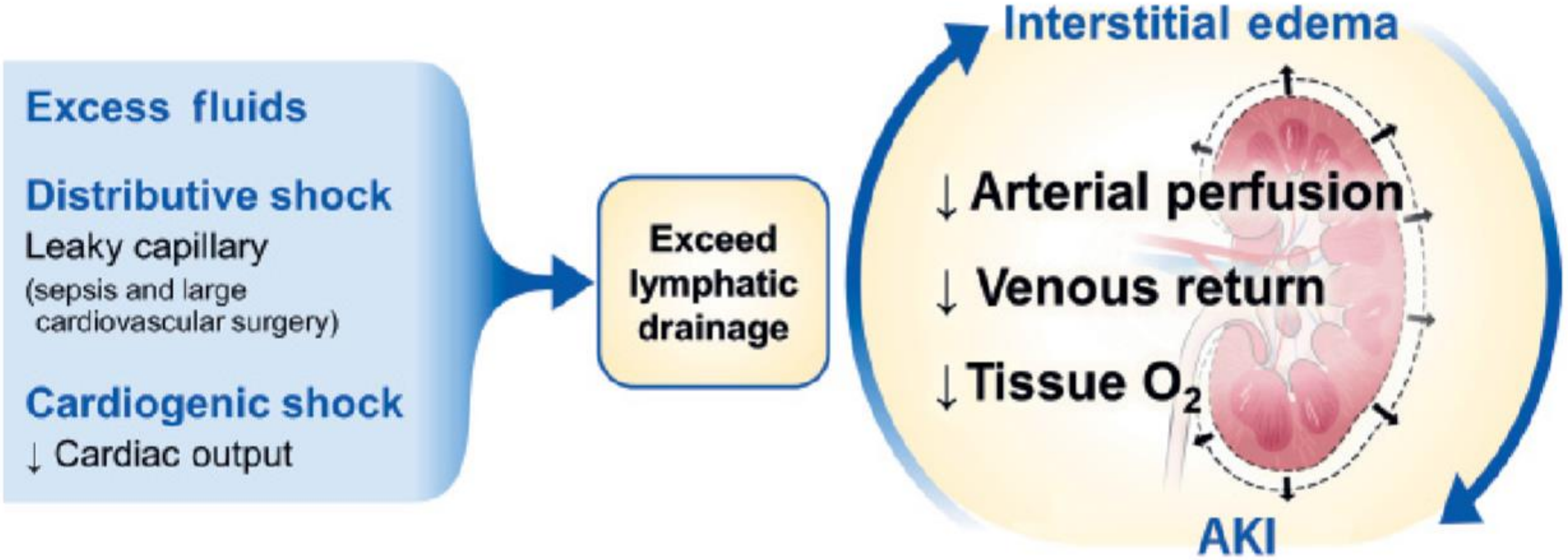
Earlier fluid resuscitation is better



In practice, critically ill patients typically receive large amounts of fluids during transit, in the ED, and prior to the ICU admission

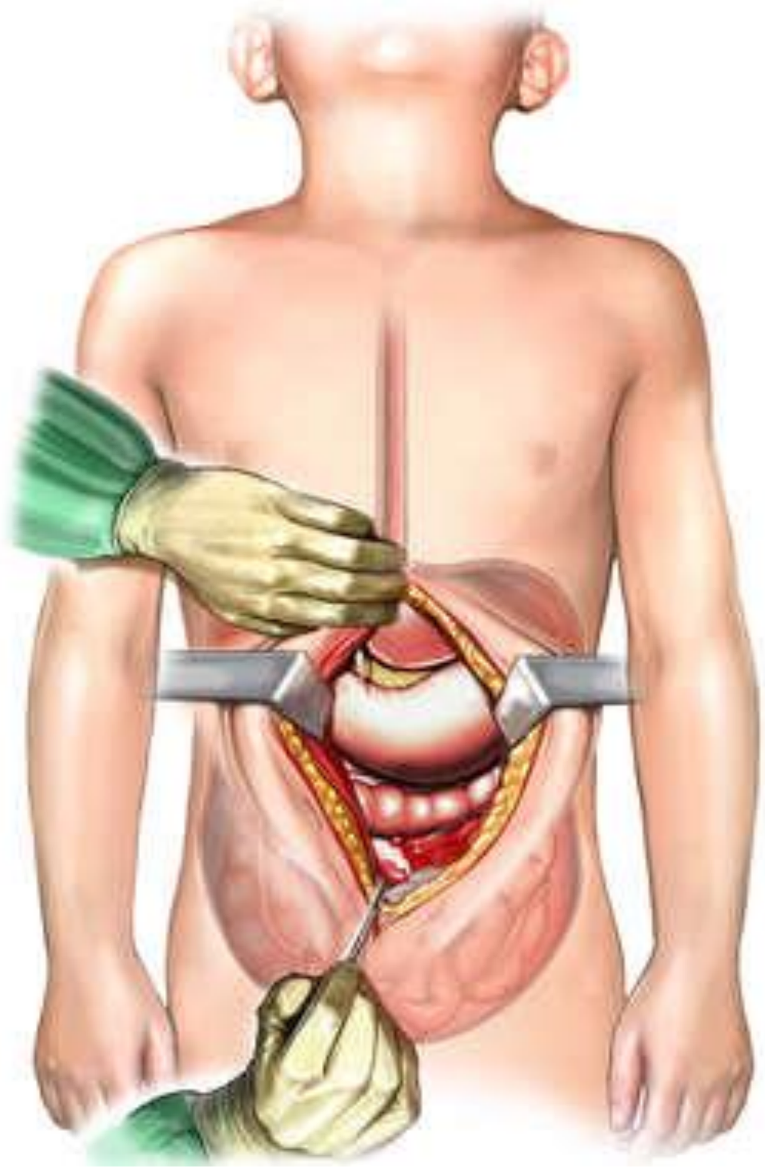
Sub/Super optimal fluid therapy can cause AKI or worsen existing AKI

Excess fluids and AK



Blood Purif 2017;43:163–172

Patients undergoing any major surgery typically gain 3– 6kg due to fluid administration which has been associated with worse cardiopulmonary and surgical wound healing outcomes and overall outcomes



Hemodynamically stable patients are NPO for <8 h for an elective procedure, no maintenance fluids are required

↓

No maintenance fluids are required

Patients with septic shock

↓

Fluids+ Vasopressors

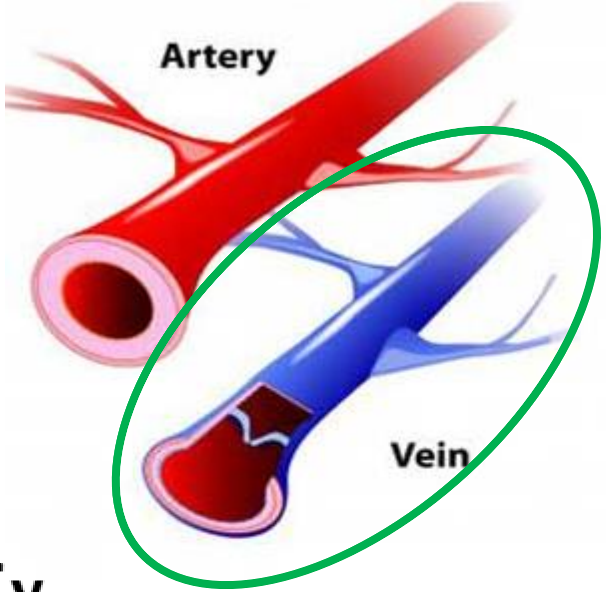
Cardiovascular surgery such as aortic aneurysms repair and cardiac valve replacement, postoperative vasoplegia is common.

↓

Isotonic fluids + vasoactive agents

American Journal of Physiology - Renal Physiology
American Physiological Society

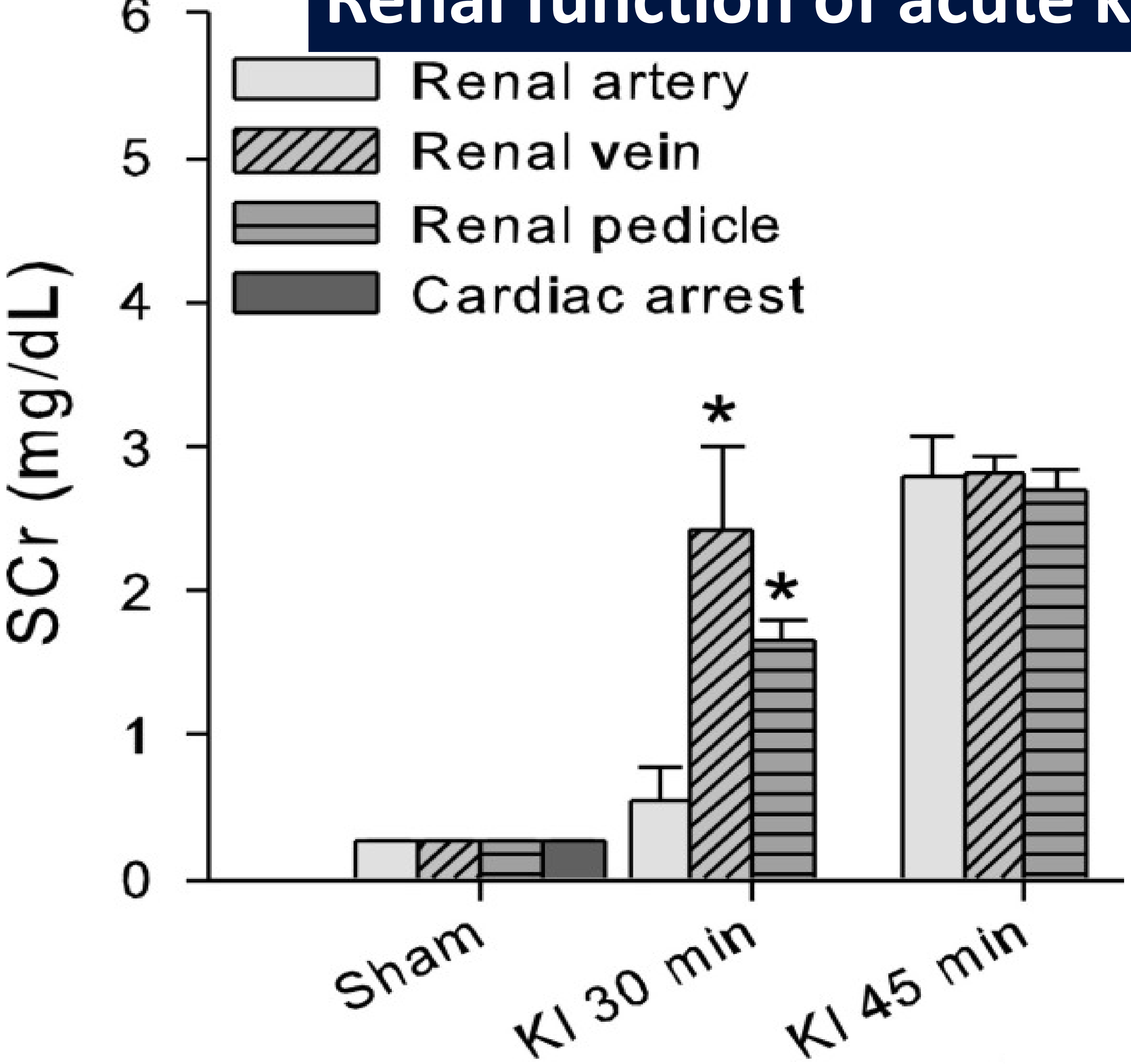
Acute renal venous obstruction is more detrimental to the kidney than arterial occlusion: implication for murine models of acute kidney injury



Xiang Li, Manchang Liu, [...], and Hamid Rabb

Am J Physiol Renal Physiol. 2012 Mar 1;302(5):F519-25

Renal function of acute kidney injury (AKI) mice.



30 or 45 min of kidney ischemia (KI) by clamping the bilateral renal artery, vein, or pedicle followed by cardiopulmonary resuscitation or reperfusion.

Am J Physiol Renal Physiol. 2012 Mar 1;302(5):F519-25

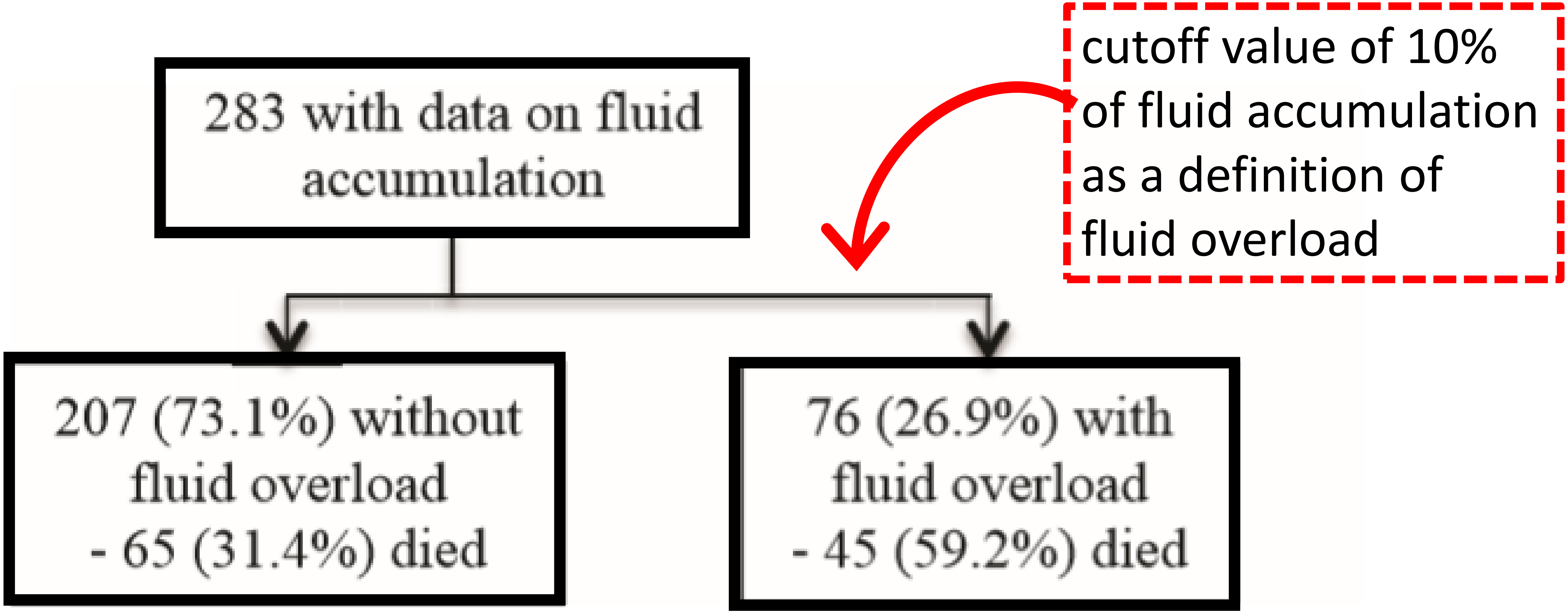
Vaara *et al. Critical Care* 2012, **16**:R197
http://ccforum.com/content/16/5/R197

CRITICAL CARE

RESEARCH Open Access

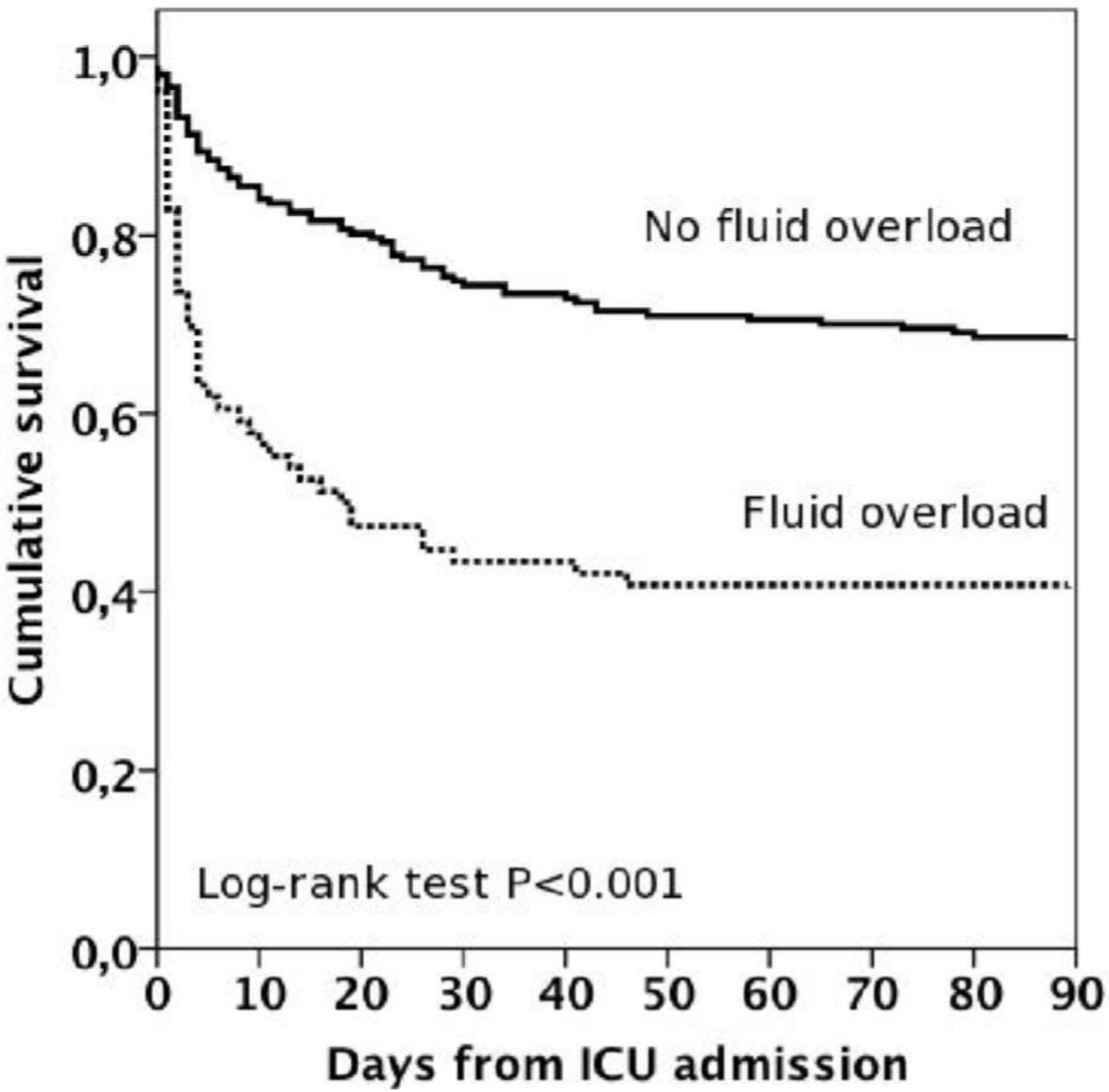
Fluid overload is associated with an increased risk for 90-day mortality in critically ill patients with renal replacement therapy: data from the prospective FINNAKI study

Suvi T Vaara[1*], Anna-Maija Korhonen[1], Kirsi-Maija Kaukonen[1], Sara Nisula[1], Outi Inkinen[2], Sanna Hoppu[3], Jouko J Laurila[4], Leena Mildh[1], Matti Reinikainen[5], Vesa Lund[6], Ilkka Parviainen[7] and Ville Pettilä[1,8], for The FINNAKI study group



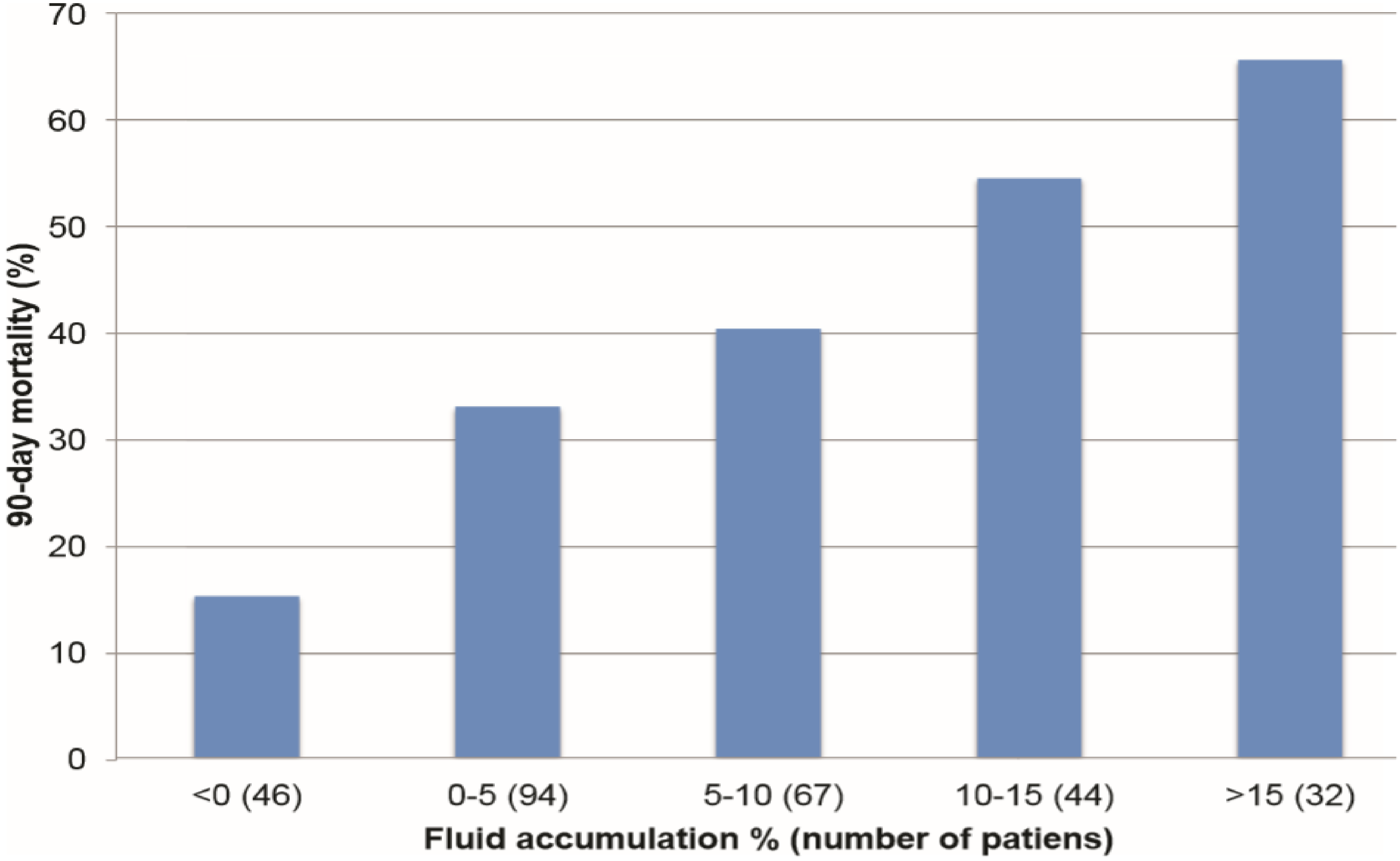
Vaara et al. Critical Care 2012, 16:R197

Kaplan-Meier unadjusted survival curves for 90-day survival in patients with or without fluid overload.



Vaara et al. Critical Care 2012, 16:R197

Ninety-day mortality according to the percentage of fluid accumulation prior to renal replacement therapy initiation



Vaara et al. Critical Care 2012, 16:R197

Conclusion

The 90-day mortality of critically ill patients treated with RRT was 39%.

Patients with fluid overload had twice as high 90-day mortality compared to those without.

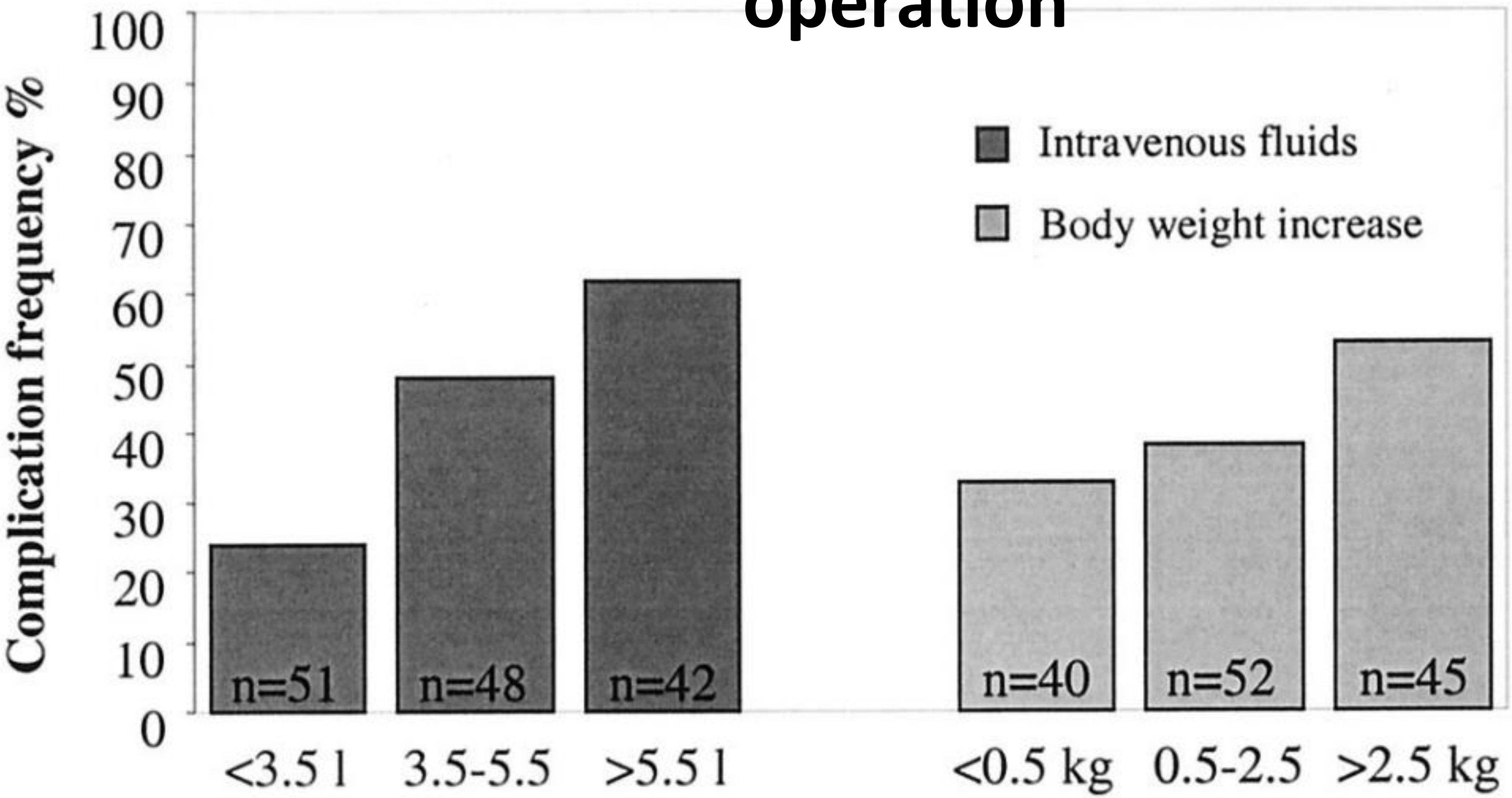
Vaara et al. Critical Care 2012, 16:R197

Effects of Intravenous Fluid Restriction on Postoperative Complications: Comparison of Two Perioperative Fluid Regimens

A Randomized Assessor-Blinded Multicenter Trial

Annals of Surgery • Volume 238, Number 5, November 2003

Complication frequency related to intravenous fluid administration and body weight increase on the day of operation



Annals of Surgery • Volume 238, Number 5, November 2003

Conclusion

Perioperative intravenous fluid therapy aiming at unchanged body weight reduces complications after elective colorectal surgery.

Annals of Surgery • Volume 238, Number 5, November 2003

Nephrol Dial Transplant (2012) 27: 956–961
doi: 10.1093/ndt/gfr470
Advance Access publication 19 August 2011

Fluid overload at initiation of renal replacement therapy is associated with lack of renal recovery in patients with acute kidney injury

Michael Heung[1,*], Dawn F. Wolfgram[2,*], Mallika Kommareddi[1], Youna Hu[3], Peter X. Song[3] and Akinlolu O. Ojo[1]

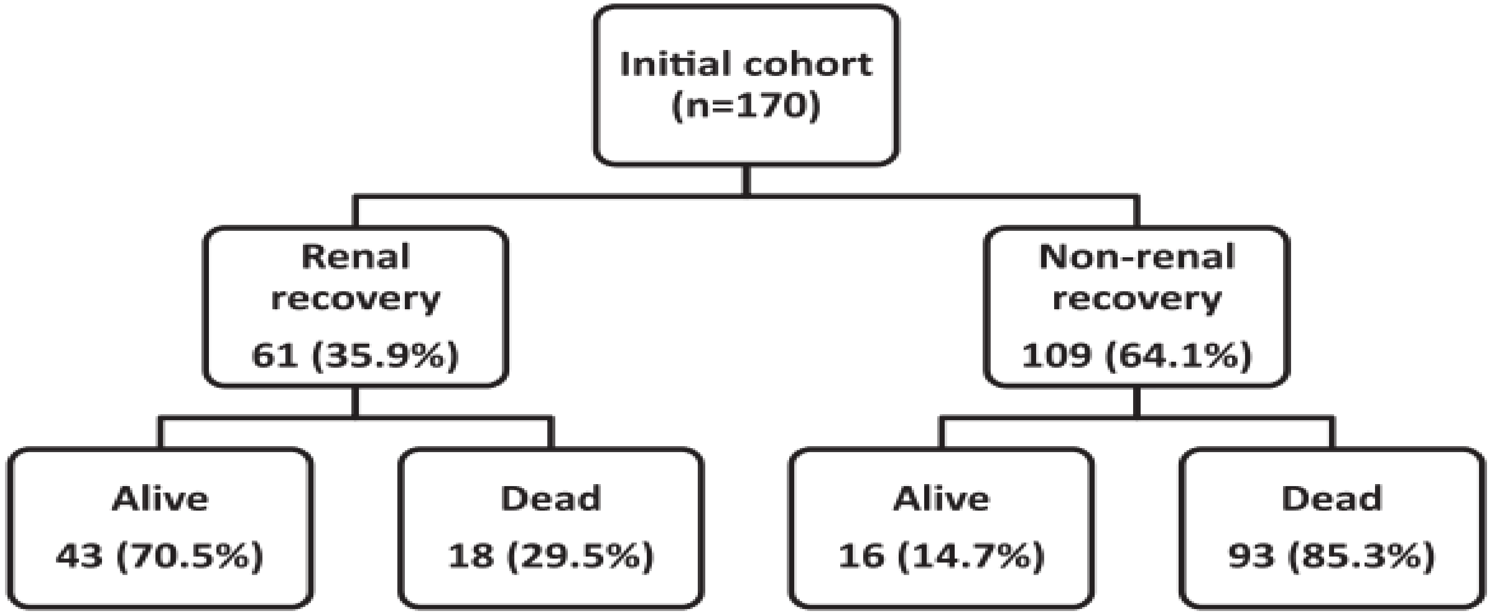
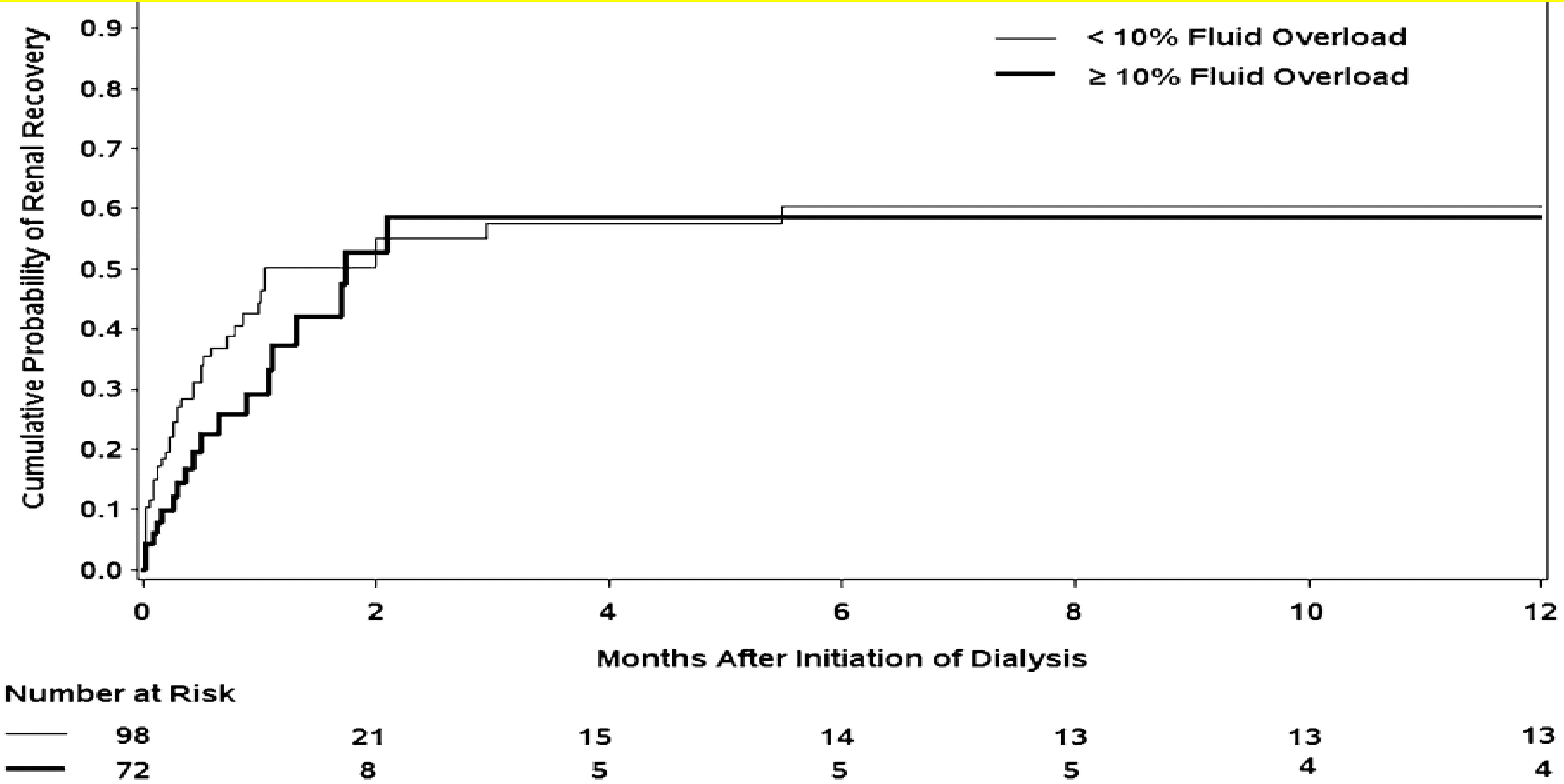


Fig. 1. One year outcomes among patients with AKI requiring RRT.

weight-based assessment of fluid overload can provide important prognostic information for recover of AKI during 1 year



Studies examining the effects of diuretics in AKI.

Reference	Study type	Population	n	Effect of diuretics
Mehta et al. (2002) [27]	Retrospective cohort	Patients in 4 teaching hospital ICUs affiliated with the University of California with nephrology consultations, medical and surgical ICU patients	552	Increased risk of death or nonrecovery of renal function (OR 1.77), magnified when patients who died within the first week after consultation were excluded (OR 3.12)
Uchino et al. (2004) [28]	Prospective multicenter, epidemiological study	ICU patients with the following etiologies of AKI: severe sepsis/septic shock (43.8%), major surgery (39.1%), low cardiac output 29.7%), hypovolemia (28.2%)	1734	No statistically significant difference in groups with or without diuretic use
Shiliday et al. (1997) [29]	Prospective, randomized, double-blind placebo-controlled trial	ICU patients at a single center	92	Increase in urine output with diuretics Improvement in mortality for those who became nonoliguric but had lower APACHE II scores at baseline. No difference in mortality between those who became nonoliguric with placebo versus diuretics
Cantarovich et al. (2004) [30]	Prospective, randomized, double-blind, placebo-controlled trial	Multicenter trial, 13 ICUs, 10 nephrology wards	338	Increase in urine output with diuretics No improvement in survival, renal recovery, number of dialysis sessions, or duration of need for dialysis between the two groups
Van der Voort et al. (2009) [31]	Prospective, randomized, double-blind, placebo-controlled trial	ICU patients at a single center treated with CVVH	72	Increase in urine output with diuretics. No improvement in duration of renal failure or rate of renal recovery
Wu et al. (2012) [32]	Prospective, multicenter, observational study	Postsurgical ICU patients receiving hemodialysis	572	Higher doses of diuretics were associated with hypotension and increased mortality

Indication of diuretics in critically ill patients with AKI

- ❑ **Volume overload**
- ❑ **Hyperkalemia**

} when the patient is making urine

Annals of Surgery • Volume 238, Number 5, November 2003

Does the patient with AKI **need** fluid?

The **amount** and **time** of fluid utilized?

The **type** of fluid?

the type of fluid that has been lost

Choice of replacement fluid

any concurrent electrolyte disorders

Types of intravenous fluids

- Colloids
- Albumin
- Dextran
- HES

- Crystalloids
- Isotonic
  - Normal saline
  - Balanced salt solution
    - Ringer lactate
    - Ringer acetate
- Hypotonic
  - 0.45 % saline
  - 5% dextrose
- Hypertonic

Fluid Therapy: Choice of Fluid

- Crystalloids have a much larger volume of distribution compared to Colloids.

- Crystalloid resuscitation requires more fluid to achieve the same endpoints as Colloids.

- Crystalloids result in more edema.

Dellinger etal. Crit Care Med 2004,32:858-873

If the IV fluids are deemed necessary in the ICU

Acute hemorrhagic shock

blood products are preferred to maintain volume status and tissue perfusion

Cirrhosis and advanced hepatic failure

Albumin-containing fluids and, recently, albumin dialysis can be beneficial

Acute brain trauma

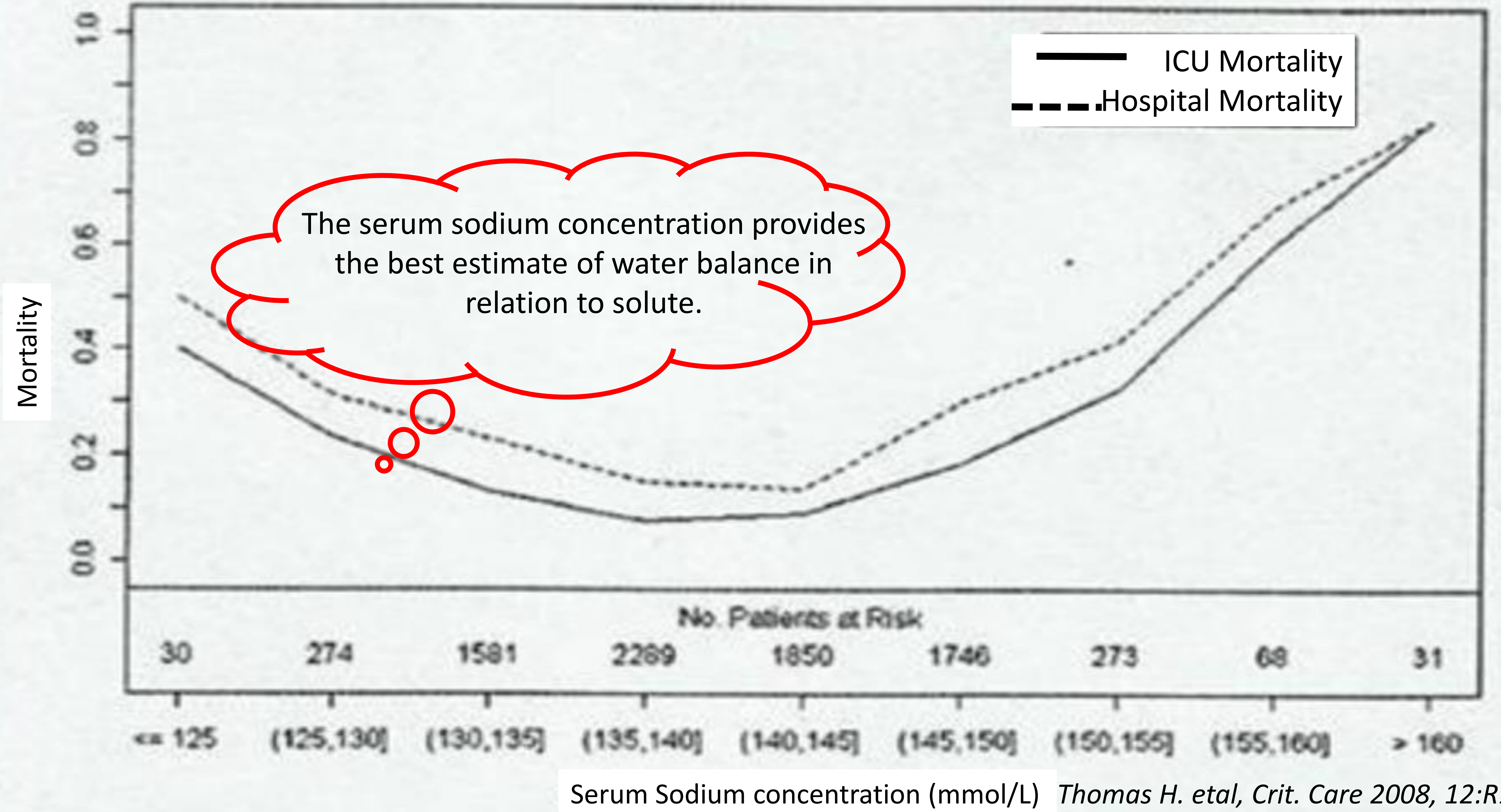
Only crystalloid fluids

albumin containing fluids have been shown to increase complications, including mortality

Any other condition

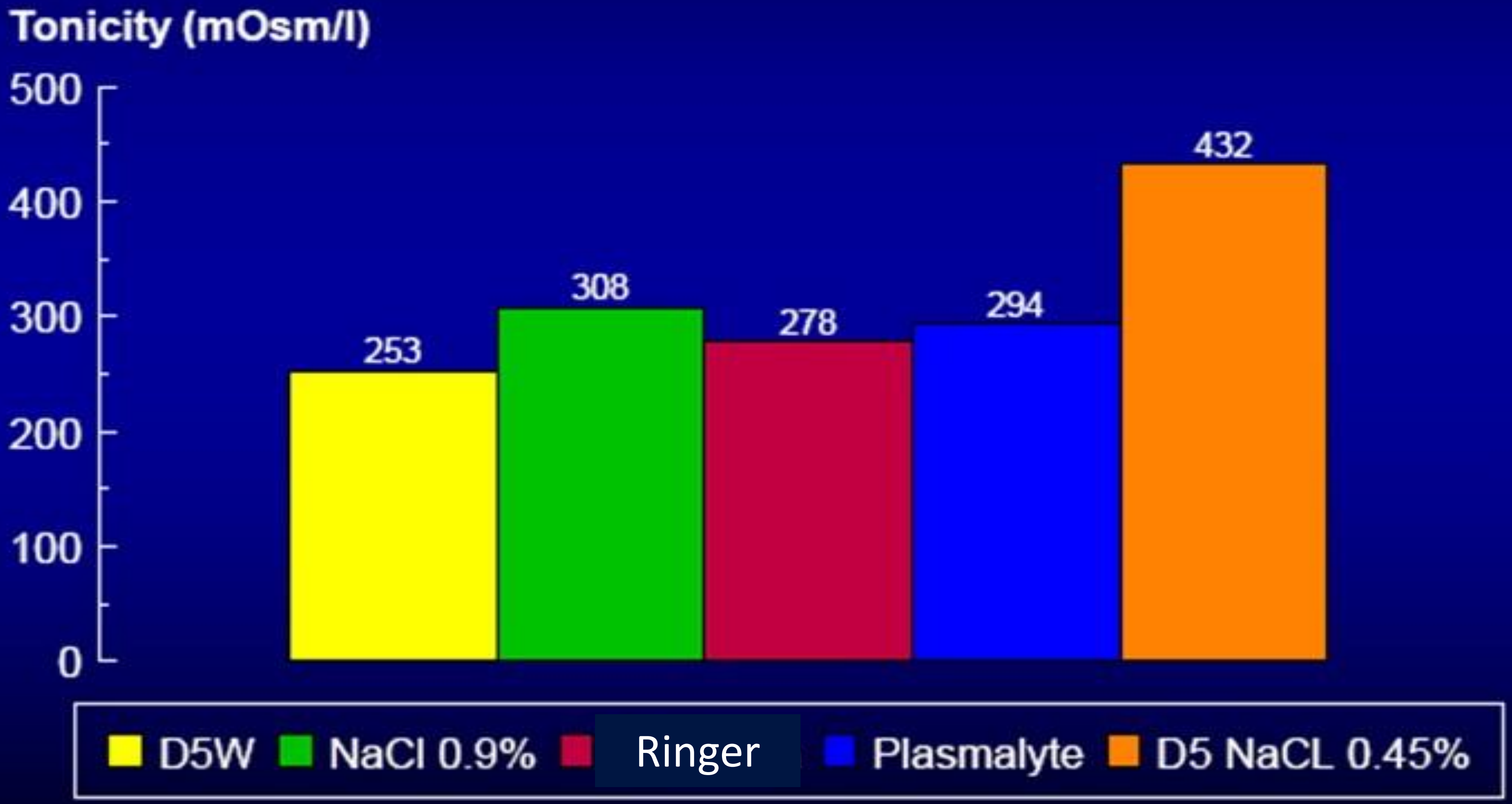
Crystalloid fluids > Colloid fluids

The Epidemiology of ICU sodium concentration



Thomas H. etal, Crit. Care 2008, 12:R162

Fluid Electrolytes Composition



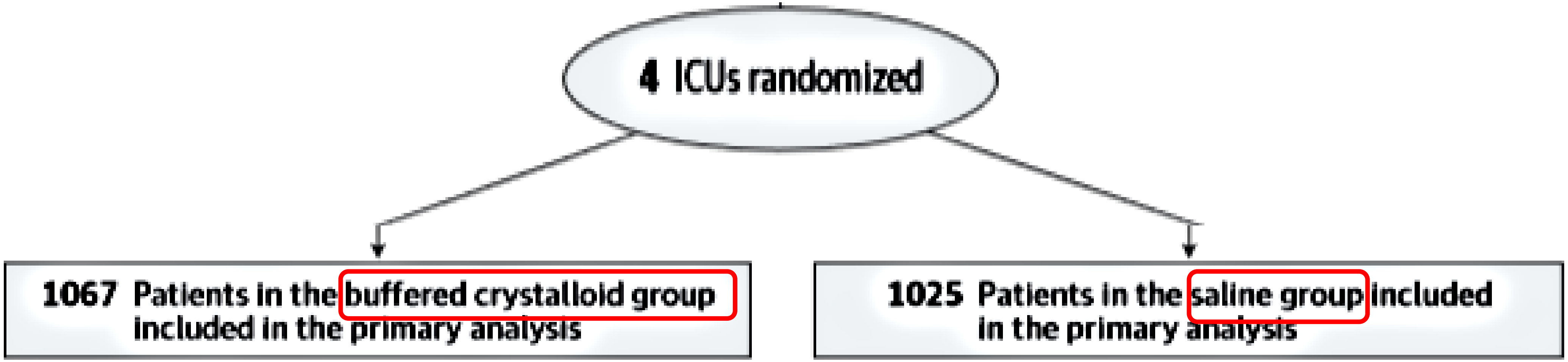
Research

JAMA.2015;314(16):1701-1710

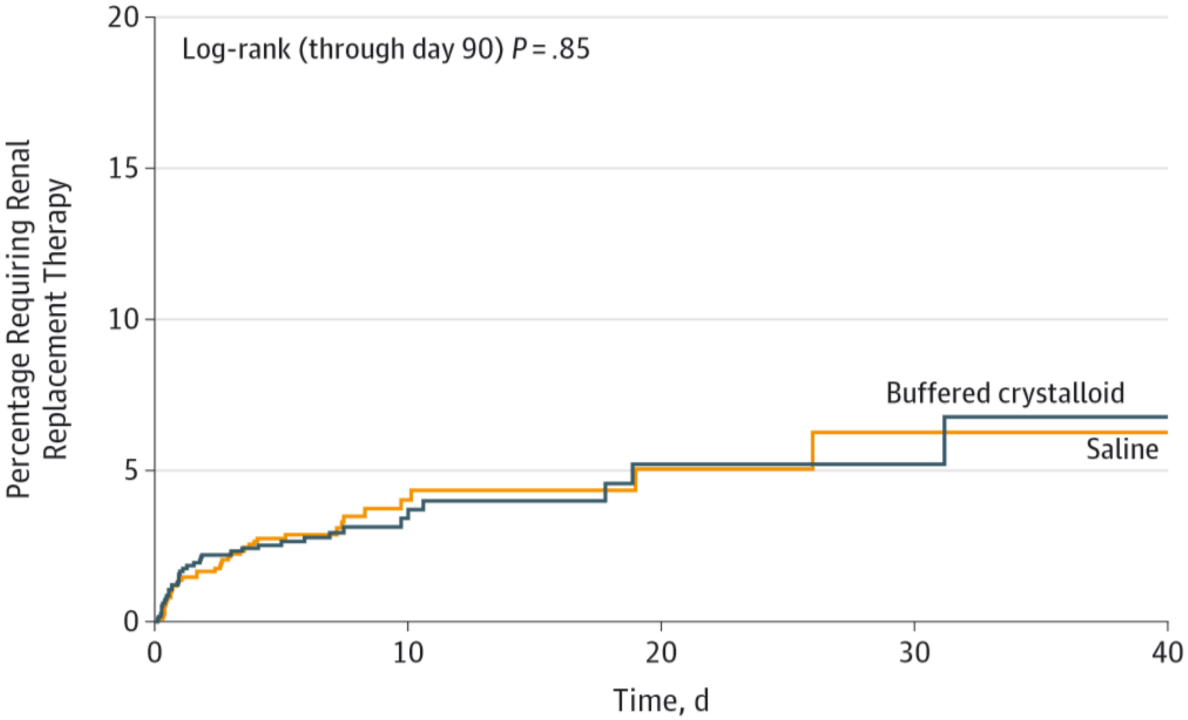
Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

Effect of a Buffered Crystalloid Solution vs Saline on Acute Kidney Injury Among Patients in the Intensive Care Unit
The SPLIT Randomized Clinical Trial

Paul Young, FCICM; Michael Bailey, PhD; Richard Beasley, DSc; Seton Henderson, FCICM; Diane Mackle, MN; Colin McArthur, FCICM; Shay McGuinness, FANZCA; Jan Mehrtens, RN; John Myburgh, PhD; Alex Psirides, FCICM; Sumeet Reddy, MBChB; Rinaldo Bellomo, FCICM; for the SPLIT Investigators and the ANZICS CTG



Cumulative Incidence of Patients Requiring Renal Replacement Therapy Until Day 90 After enrollment in the SPLIT Trial



BUT

- heterogeneous population.
- The severity of disease was low.
- The total amount of serum injection was low.

October27,2015 Volume314,Number16 , 1701-1710

Feature Articles

Crit Care Med 2014; 42:1585–1591

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

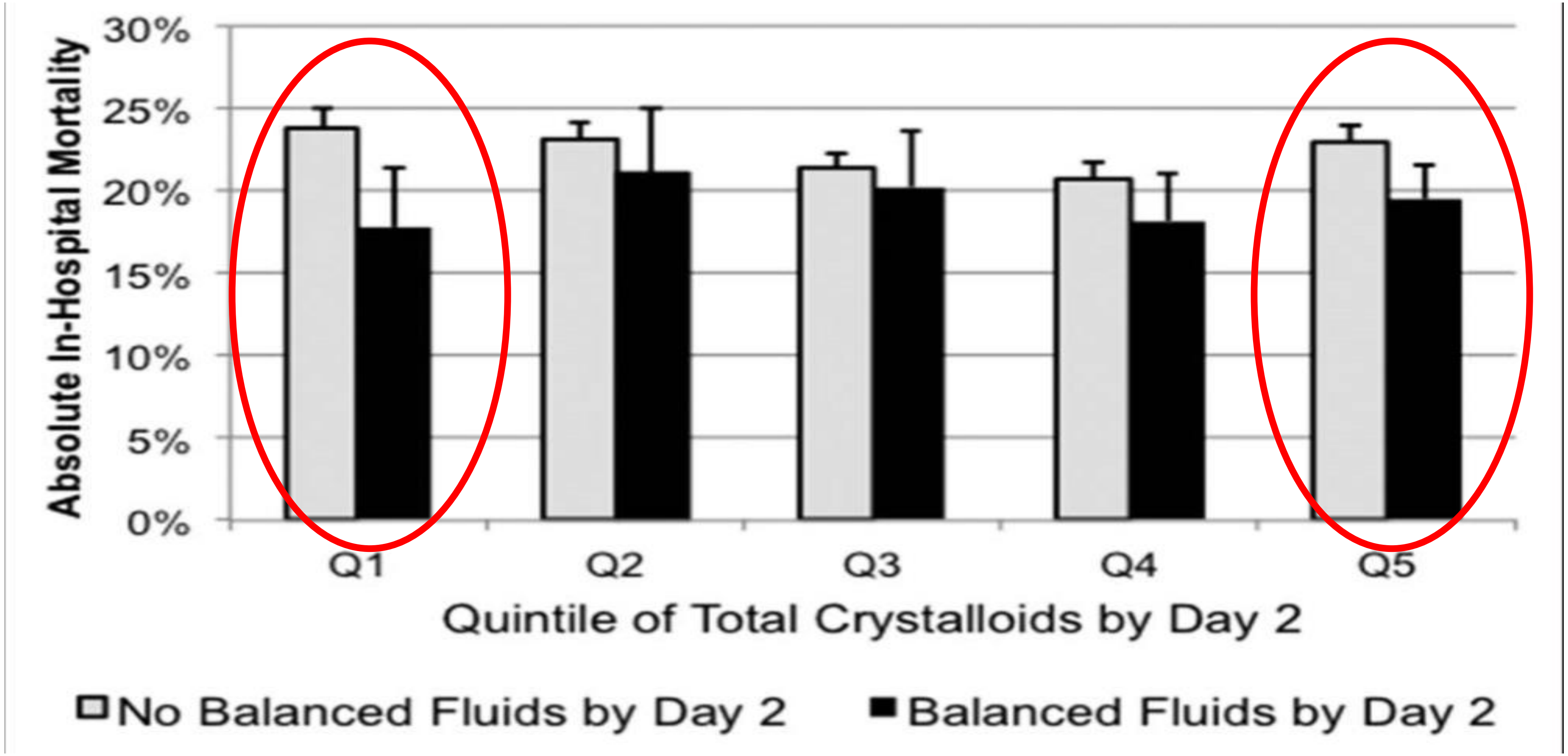
Karthik Raghunathan, MD, MPH[1,2]; Andrew Shaw, MB, FRCA, FFICM, FCCM[1]; Brian Nathanson, PhD[3]; Til Stürmer, MD, PhD[4]; Alan Brookhart, PhD[4]; Mihaela S. Stefan, MD[5]; Soko Setoguchi, MD, DrPH[6]; Chris Beadles, MD, PhD[2]; Peter K. Lindenauer, MD, MSc[7]

53,448 patient admitted to ICU

Received Balanced Fluids (n=3,396)

Received Non-Balanced Fluids (n=50,052)

Mortality rate was higher in the non –balanced fluid compared with balanced fluid specially while high serum volumes or low serum volumes were needed.



Q1 = 2.5 L,
Q2 = 4 L,
Q3 = 5.5 L,
Q4 = 7 L,
Q5 = 10.5 L

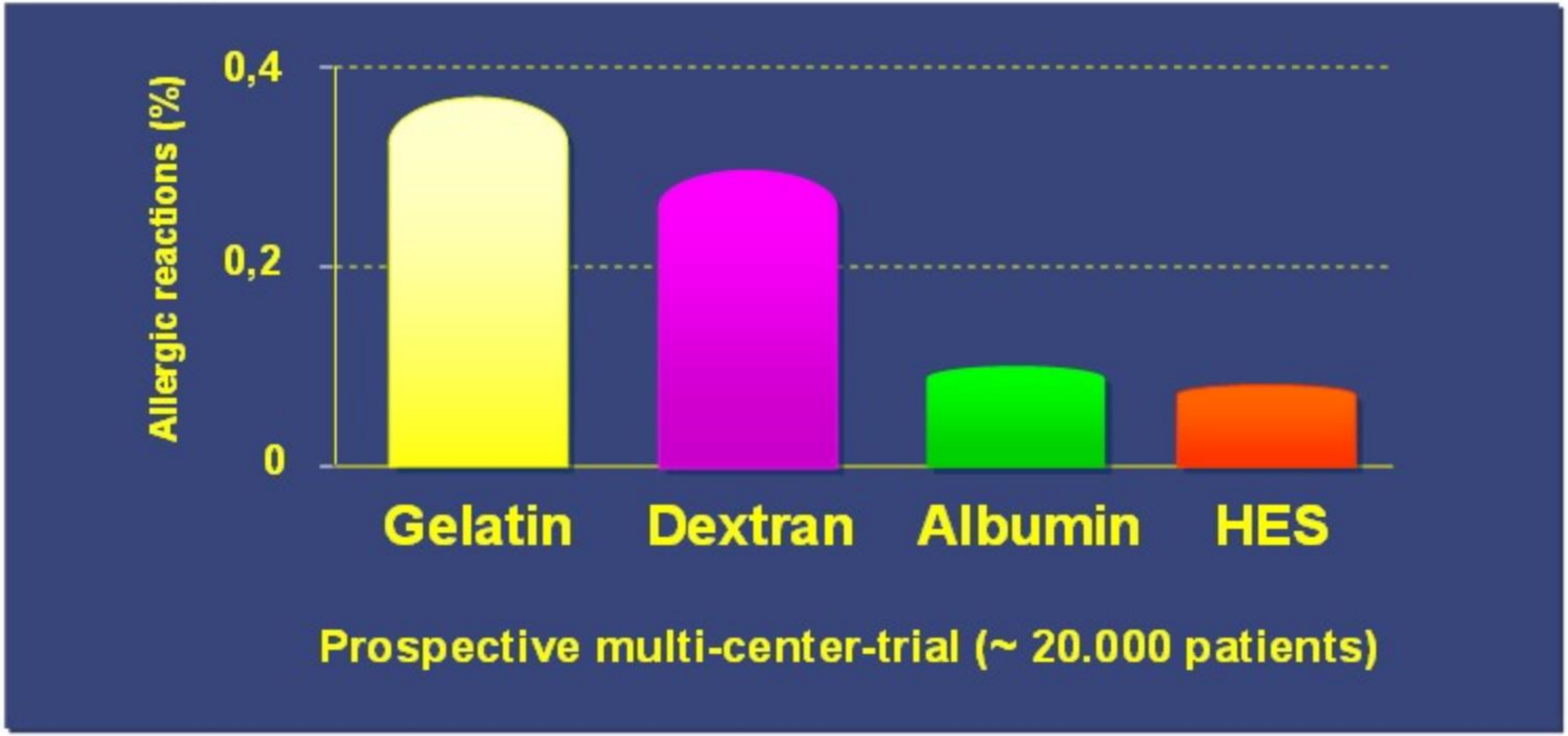
Crit Care Med 2014; 42:1585–1591

Conclusion

Balanced Fluids Have lower mortality than non-balanced fluids

Crit Care Med 2014; 42:1585–1591

Allergic Reaction with Colloid Solution



Laxenaire et al., Ann Fr Anes Réanim 1994

Crystalloid solution	Components (mEq in 1,000 ml)	pH	Osmolarity (mOsmol/l)	Cost ($/1,000 ml)
Lactated Ringer's / Hartmann's solution	Sodium 130, chlorine 109, potassium 4, calcium 3, lactate 28	6 to 7.5	273	0.94
Ringer's acetate	Sodium 130, chlorine 112, potassium 5.4, calcium 0.9, magnesium 1, acetate 27	5.1 to 5.9	276	[a]
Normal saline	Sodium 154, chlorine 154	4.5 to 7	308	1.03
NormoSol-R, Plasma-Lyte A	Sodium 140, chlorine 98, potassium 5, magnesium 3, acetate 27, gluconate 23	7.4 (other pH formulations available)	295	2.21
Dextrose 5%, (variable concentrations available)	H_2O, dextrose	3.2 to 6.5	252	0.96

Colloid solution	Components (per liter)	Source	Cost ($)
Albumin 25%	12.5 g/50 ml human albumin	Human	46.42/50 ml
Plasma protein fraction 5%	50 g/l selected plasma proteins (88% albumin, 12% α-globulins and β-globulins, 1% γ-globulins), sodium 154 mEq, potassium 0.25 mEq, chlorine 100 mEq	Human	39.31/250 ml
Hydroxyethylstarch 130/0.4	Hydroxyethylstarch 130/0.4, 6% in 500 ml normal saline (other base solutions available)	Synthesized from amylopectin	47.13/500 ml
Hydroxyethylstarch 600/0.75	Hydroxyethylstarch 600/0.75, 6% in 500 ml normal saline (other base solutions are available)	Synthesized from amylopectin	15.55/500 ml
Gelatin 4%	40 g gelatinpolysuccinate	Bovine collagen	[a]
Dextran 40	10 g dextran 40, 5g dextrose	Biosynthesized from sucrose by *Leuconostoc* bacteria	20.55/500 ml

Research | JAMA.2013;310(17):1809-1817

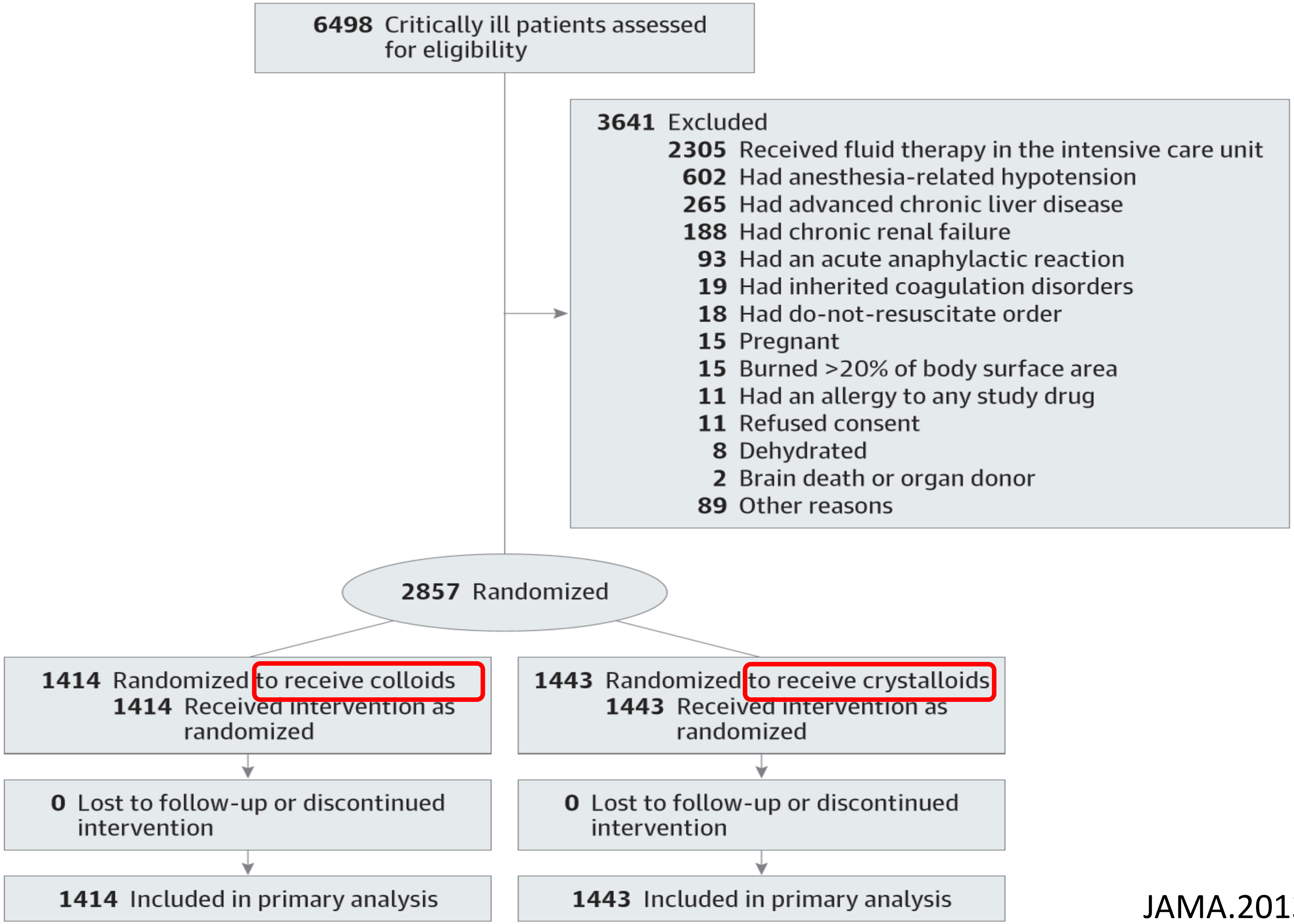
Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

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

The CRISTAL Randomized Trial

Djillali Annane, MD, PhD; Shidasp Siami, MD; Samir Jaber, MD, PhD; Claude Martin, MD, PhD; Souheil Elatrous, MD; Adrien Descorps Declère, MD; Jean Charles Preiser, MD; Hervé Outin, MD; Gilles Troché, MD; Claire Charpentier, MD; Jean Louis Trouillet, MD; Antoine Kimmoun, MD; Xavier Forceville, MD, PhD; Michael Darmon, MD; Olivier Lesur, MD, PhD; Jean Reignier, MD; Fékri Abroug, MD; Philippe Berger, MD; Christophe Clec'h, MD, PhD; Joël Cousson, MD; Laure Thibault, MD; Sylvie Chevret, MD, PhD; for the CRISTAL Investigators

Figure 1. Patient Enrollment in the Colloids Versus Crystalloids for the Resuscitation of the Critically Ill (CRISTAL) Trial



JAMA.2013;310 (17):1809-1817

Table 3. Mortality Outcomes in Patients Who Received Only 1 Type of Fluid

	Colloids Group, No.		Crystalloids Group, No.		
	Patients	Deaths	Patients	Deaths	HR (95% CI)
28-d Mortality					
Entire population	1414	359	1443	390	0.92 (0.80-1.07)
HES vs isotonic saline	645	149	1035	275	0.83 (0.68-1.01)
Gelatins vs isotonic saline	281	69	1035	275	0.90 (0.69-1.17)
HES vs Ringer solution	645	149	72	22	0.71 (0.45-1.11)
Gelatins vs Ringer solution	281	69	72	22	0.78 (0.48-1.26)
Albumin vs isotonic saline	80	24	1035	275	1.10 (0.72-1.68)
90-d Mortality					
Entire population	1414	434	1443	493	0.88 (0.77-0.99)
HES vs isotonic saline	645	181	1035	346	0.79 (0.66-0.95)
Gelatins vs isotonic saline	281	84	1035	346	0.87 (0.68-1.10)
HES vs Ringer solution	645	181	72	26	0.72 (0.48-1.09)
Gelatins vs Ringer solution	281	84	72	26	0.80 (0.51-1.24)
Albumin vs isotonic saline	80	28	1035	346	1.02 (0.69-1.50)

Abbreviations: HES, hydroxyethyl starches; HR, hazard ratio.

JAMA.2013;310 (17):1809-1817

Conclusions

- Among ICU patients with hypovolemia, the use of colloids compared with crystalloids did not result in a significant difference in 28-day mortality.

JAMA.2013;310 (17):1809-1817

Guidet *et al. Critical Care* 2012, **16**:R94
http://ccforum.com/content/16/3/R94

CRITICAL CARE

RESEARCH | Open Access

Assessment of hemodynamic efficacy and safety of 6% hydroxyethylstarch 130/0.4 vs. 0.9% NaCl fluid replacement in patients with severe sepsis: The CRYSTMAS study

Bertrand Guidet[1,2,3*], Olivier Martinet[4], Thierry Boulain[5], Francois Philippart[6,7], Jean François Poussel[8], Julien Maizel[9], Xavier Forceville[10], Marc Feissel[11], Michel Hasselmann[4], Alexandra Heininger[12] and Hugo Van Aken[13]

Guidet et al. Critical Care 2012, 16:R94 , 1-10

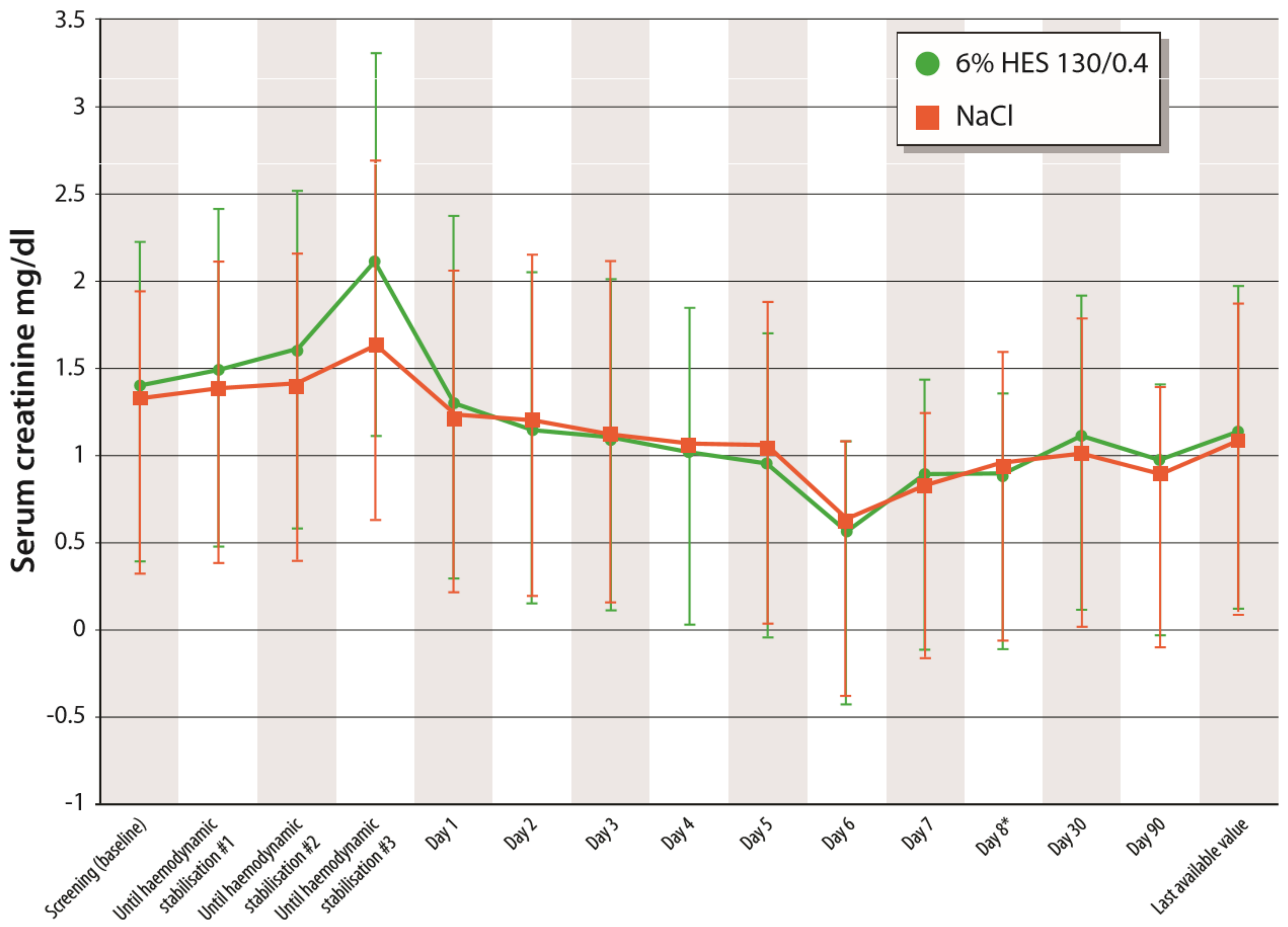


Figure 2 Evolution of mean serum creatinine (SCr) levels over time.

Guidet et al. Critical Care 2012, 16:R94 , 1-10

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

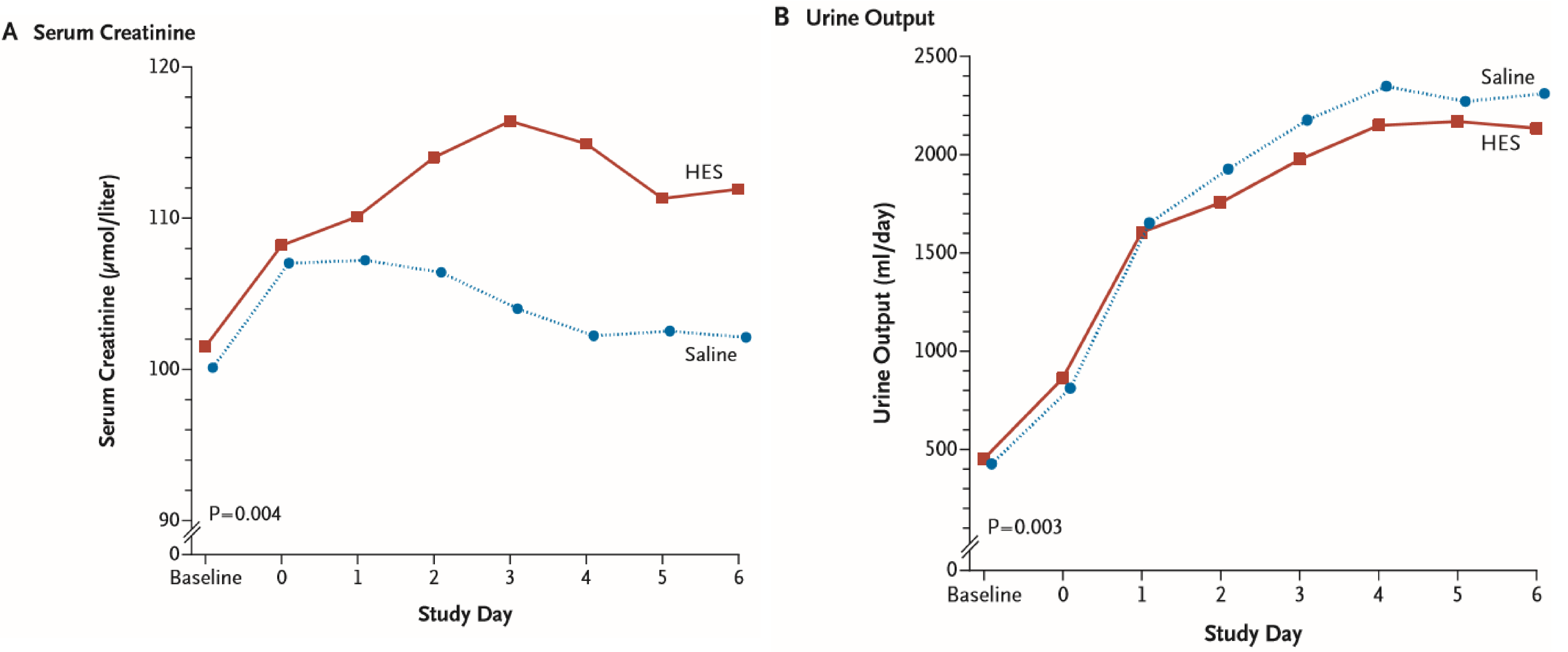
CHEST TRIAL

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*

N Engl J Med 2012;367:1901-11.

Resuscitation with 6% HES , does not provide clinical benefit to the ICU patients , but results an increased rate of renal replacement therapy



N Engl J Med 2012;367:1901-11.

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

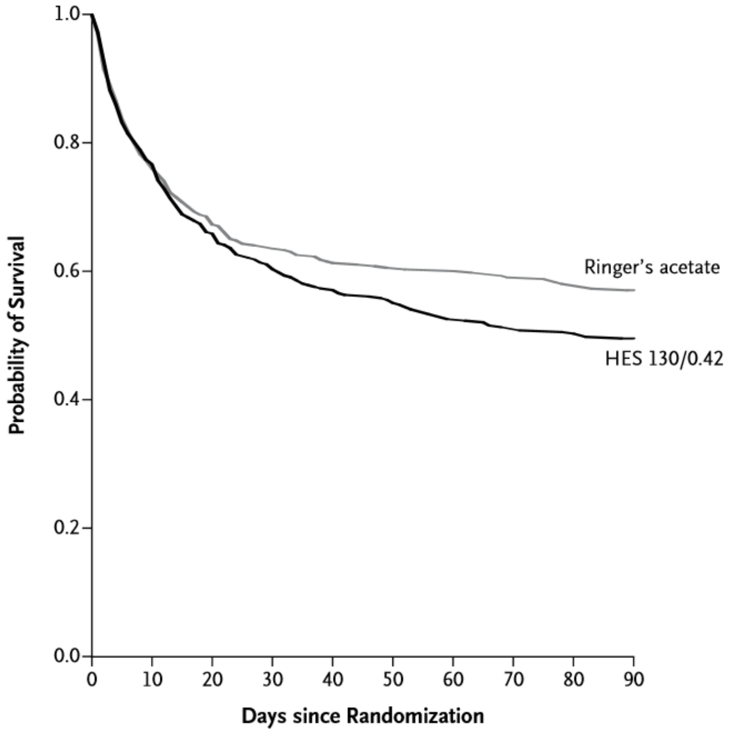
Scandinavian Starch for Severe Sepsis/Septic Shock (6S) trial

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

Anders Perner, M.D., Ph.D., Nicolai Haase, M.D.,
Anne B. Guttormsen, M.D., Ph.D., Jyrki Tenhunen, M.D., Ph.D.,
Gudmundur Klemenzson, M.D., Anders Åneman, M.D., Ph.D.,
Kristian R. Madsen, M.D., Morten H. Møller, M.D., Ph.D., Jeanie M. Elkjær, M.D.,
Lone M. Poulsen, M.D., Asger Bendtsen, M.D., M.P.H., Robert Winding, M.D.,
Morten Steensen, M.D., Pawel Berezowicz, M.D., Ph.D., Peter Søe-Jensen, M.D.,
Morten Bestle, M.D., Ph.D., Kristian Strand, M.D., Ph.D., Jørgen Wiis, M.D.,
Jonathan O. White, M.D., Klaus J. Thornberg, M.D., Lars Quist, M.D.,
Jonas Nielsen, M.D., Ph.D., Lasse H. Andersen, M.D., Lars B. Holst, M.D.,
Katrin Thormar, M.D., Anne-Lene Kjældgaard, M.D., Maria L. Fabritius, M.D.,
Frederik Mondrup, M.D., Frank C. Pott, M.D., D.M.Sci., Thea P. Møller, M.D.,
Per Winkel, M.D., D.M.Sci., and Jørn Wetterslev, M.D., Ph.D.,
for the 6S Trial Group and the Scandinavian Critical Care Trials Group*

N Engl J Med 2012;367:124-34.

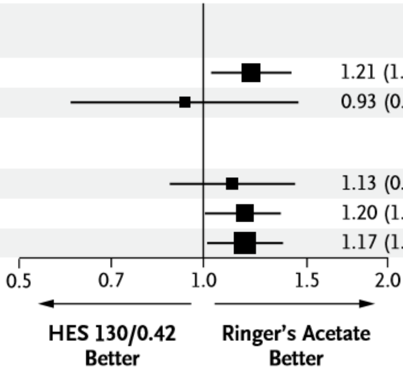
A Time to Death



No. at Risk				
HES 130/0.42	398	240	209	197
Ringer's acetate	400	254	240	228

B Relative Risk of the Primary Outcome

Subgroup	HES 130/0.42	Ringer's Acetate	Relative Risk (95% CI)	P Value for Heterogeneity
	no. of events/no. in subgroup			
Shock at the time of randomization				0.22
Yes	179/336	148/337	1.21 (1.04–1.42)	
No	23/62	25/63	0.93 (0.60–1.46)	
Acute kidney injury at the time of randomization				0.60
Yes	72/142	63/140	1.13 (0.88–1.44)	
No	130/256	110/260	1.20 (1.00–1.45)	
All patients	202/398	173/400	1.17 (1.01–1.36)	



N Engl J Med 2012;367:124-34.

Additional Beneficial Effects of Albumin

- ❖ Albumin favorably alters the antioxidant status in critically ill patients with sepsis.
- ❖ Albumin favorably alters systemic thiols and the antioxidant capacity of plasma.
- ❖ Patients with SBP treated with antibiotics and albumin vs antibiotics alone were less likely to have renal dysfunction develop and were less likely to die.

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

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

The SAFE Study Investigators*

Saline versus Albumin Fluid Evaluation (SAFE)

In 7000 acutely ill patients

N Engl J Med 2004;350:2247-56.

conclusion

There was no overall difference according to outcome between Albumin and Saline in the heterogeneous ICU patients

The subset of patients with septic shock was reported to have RR of dying of 0.87 if given albumin.

The subset of patients with traumatic brain injuries was reported to have RR of dying of 1.62 if given albumin.

N Engl J Med 2004;350:2247-56.

SAFE Trial
6S Trial
CHEST Trial
CRYSTMAS Trial
CRISTAL Trial

Conclusions

1. Crystalloids are the initial fluids of choice in the resuscitation of severe sepsis.
2. Against the use of hydroxyethyl starches for fluid resuscitation of severe sepsis.
3. Albumin is the ideal fluid resuscitation for septic shock when patients require substantial amounts of crystalloids.
4. Fluid administration should be continued as long as there is hemodynamic improvement either based on dynamic (eg, change in pulse pressure, stroke volume variation) or static (eg, arterial pressure, heart rate) variables.

PLOS ONE

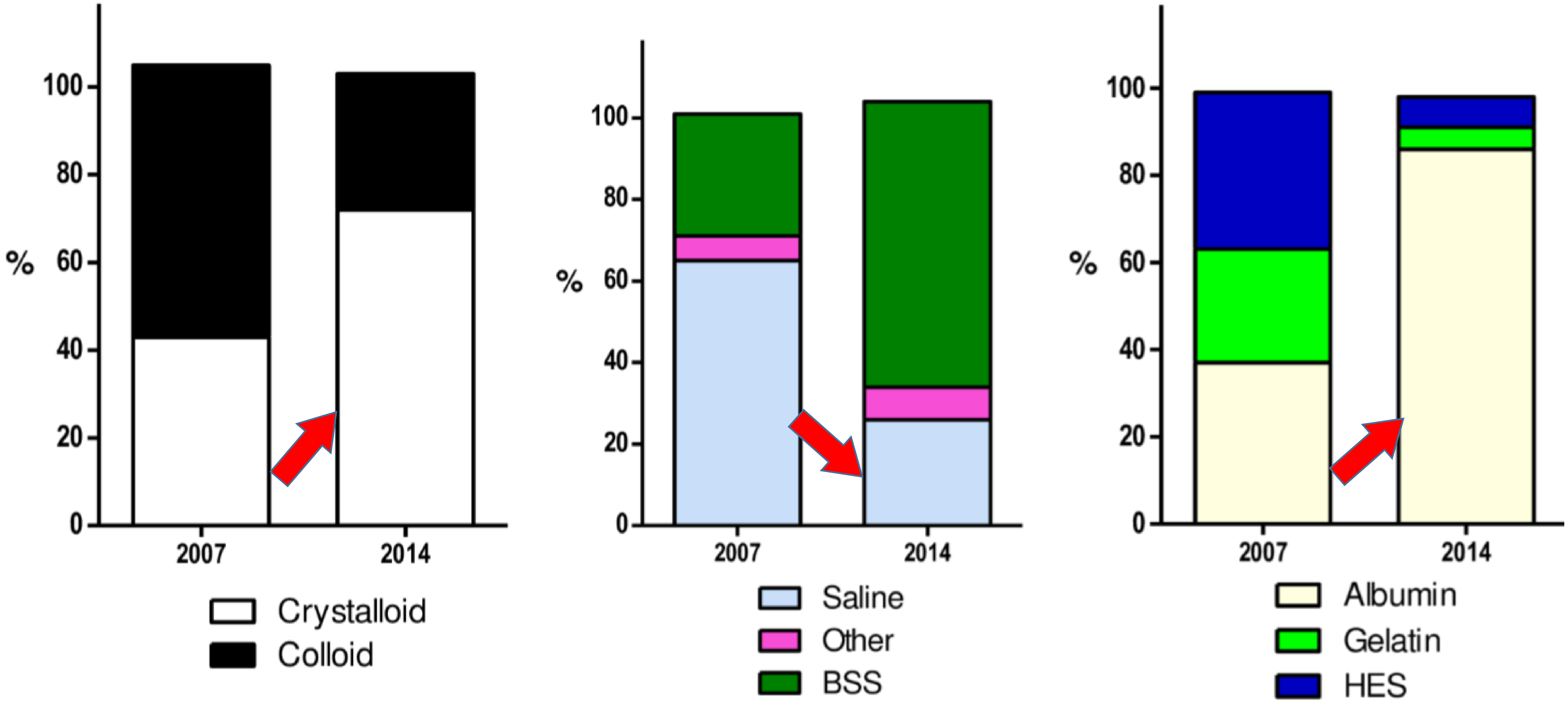
May 12, 2017 : 1-21

RESEARCH ARTICLE

Patterns of intravenous fluid resuscitation use in adult intensive care patients between 2007 and 2014: An international cross-sectional study

Naomi E. Hammond[1,2,3,4*], Colman Taylor[1,3], Simon Finfer[1,2,3], Flavia R. Machado[5], YouZhong An[6], Laurent Billot[3,7], Frank Bloos[8], Fernando Bozza[9], Alexandre Biasi Cavalcanti[10], Maryam Correa[1], Bin Du[11], Peter B. Hjortrup[12], Yang Li[1], Lauralyn McIntryre[13], Manoj Saxena[1,4,14], Frédérique Schortgen[15], Nicola R. Watts[1], John Myburgh[1,4,14], for the Fluid-TRIPS and Fluidos Investigators[¶], The George Institute for Global Health, The ANZICS Clinical Trials Group, BRICNet, and the REVA research Network

Proportion of all fluid resuscitation episodes given in 2007 and 2014 in 84 ICUs



PLOS ONE; May 12, 2017 : 1-21

The final Conclusion

- New modalities for assessment of dynamic indices offer non-invasive options to guide fluid therapy and assess the likely hemodynamic response to volume administration.
- Factors that may influence the choice of resuscitation fluid for a critically ill patient include the clinician's preference, the tolerability of the treatment, its safety, and its cost.
- The amount and composition of fluids used in the ICU can directly impact outcomes of patients.
- HES appears to cause harm and should be avoided in the septic population and in patients at risk for kidney injury.
- The timing of fluid administration is just as important as (if not more important than) the amount given.
- Goal-directed fluid therapy designed to optimize either stroke volume or preload is well established in high-risk patient groups and should be considered in all critically ill patients.
- Patients with significant fluid overload and unresponsive to diuretics should be considered for early initiation of RRT.

Thank you for your attention

Case 1

Blood Purif 2017;43:163–172

A 65-year-old man with severe ulcerative colitis and pulmonary fibrosis. He underwent a diverting loop ileostomy post total colectomy on June 28, 2016. Postoperatively, he received ketorolac both IV and oral for pain. Postoperative day 3, his serum creatinine (sCr) began to rise, from 1.1 on admission to 3.6 mg/dl on July 4, 2016. His urine output declined (to 5–15 ml/h) and, meanwhile, his ileostomy output increased from 5.5 liters on July 2 to >7 liters on July 3 and 10 and 12 liters on July 4 and 5. He was started on IV 0.9% saline initially. He developed hypernatremia, acidosis and hyperkalemia. Nephrology Service was emergently called. Saline was changed to lactated ringers overnight. Next morning, his BP was 110/74 mm Hg, HR 82/min, RR 18/min, temperature 36.5. He had basilar crackles in both lung fields (which was his baseline due to chronic lung disease). His heart and abdomen were benign. Ileostomy bag was full and liquidy. No skin rash and no dependent edema were observed. Laboratory studies revealed hemoglobin 12.1 g/dl, leukocytes 10.7 × 109/liters, platelets 2,757 × 109/liters, sodium 131 mmol/l, potassium 4.4 mmol/l, phosphorus 3.7 mg/dl, chloride 94 mmol/l, bicarbonate 20 mmol/l, BUN 37 mg/dl, creatinine 2.9 mg/dl. Urinalysis revealed granular casts and renal epithelial cells (4–10/hpf).

Blood Purif 2017;43:163–172

Questions:

Management of acute kidney failure and decreased urine output?

Management of fluid replacement and serum electrolytes?

Blood Purif 2017;43:163–172

Answer:

AKI likely due to: Hemodynamic instability during the operation+ postoperative NSAID exposure. He also had a large ileostomy output that has caused additional volume fluctuation. He initially received 0.9% saline, which contributed to his hyperkalemia and acidosis. IV fluids were changed to lactated ringers overnight (as per the nephrology recommendation). On examination next day, he was euvolemic. Nephrology Service recommended loop diuretics to promote urine output and replace the output of ileostomy and urine with 0.9% saline and lactated ringers alternating in 1:1 ratio and maintain his net fluid balance at around 0 to slightly negative (–0.5 to –1.0 l/day) as long as he was hemodynamically stable. His electrolytes gradually returned to reference range. His ileostomy output peaked at 16.9 liters on July 8 and subsequently reduced to <4 liters by July 11. His sCr reduced from a peak of 3.6 mg/dl to 0.9 mg/dl. He was discharged with oral sodium bicarbonate and sodium chloride tablets. This case illustrates the complexity of fluid management in the setting of AKI. In general, crystalloids should be given with specific attention to the patient's tonicity, fluid balance and acid-base status. Postoperatively, the patient should be kept in an euvolemic state. Kidneys have limited capacity to excrete Na, especially post operation. Overzealous fluid prescription can lead to volume overload, especially in patients who have developed AKI. Compared to normal serum, 0.9% saline has a slightly higher osmolality, and lactated ringers slightly lower osmolality. The alternate use would cancel out the potential alteration of osmolality with the exclusive 0.9% saline or exclusive lactate ringers. The patient's urine output should also be taken into consideration when prescribing fluids. As the patient's output reduces, the replacement fluids should be tapered down accordingly.

Blood Purif 2017;43:163–172