Service
de médecine
intensive adulte

The Role of CRRT

in the Management of Fluid Overload

Dr Antoine G. Schneider MD PhD

28 of January 2016

Colors of Sepsis Symposium

Disclosures

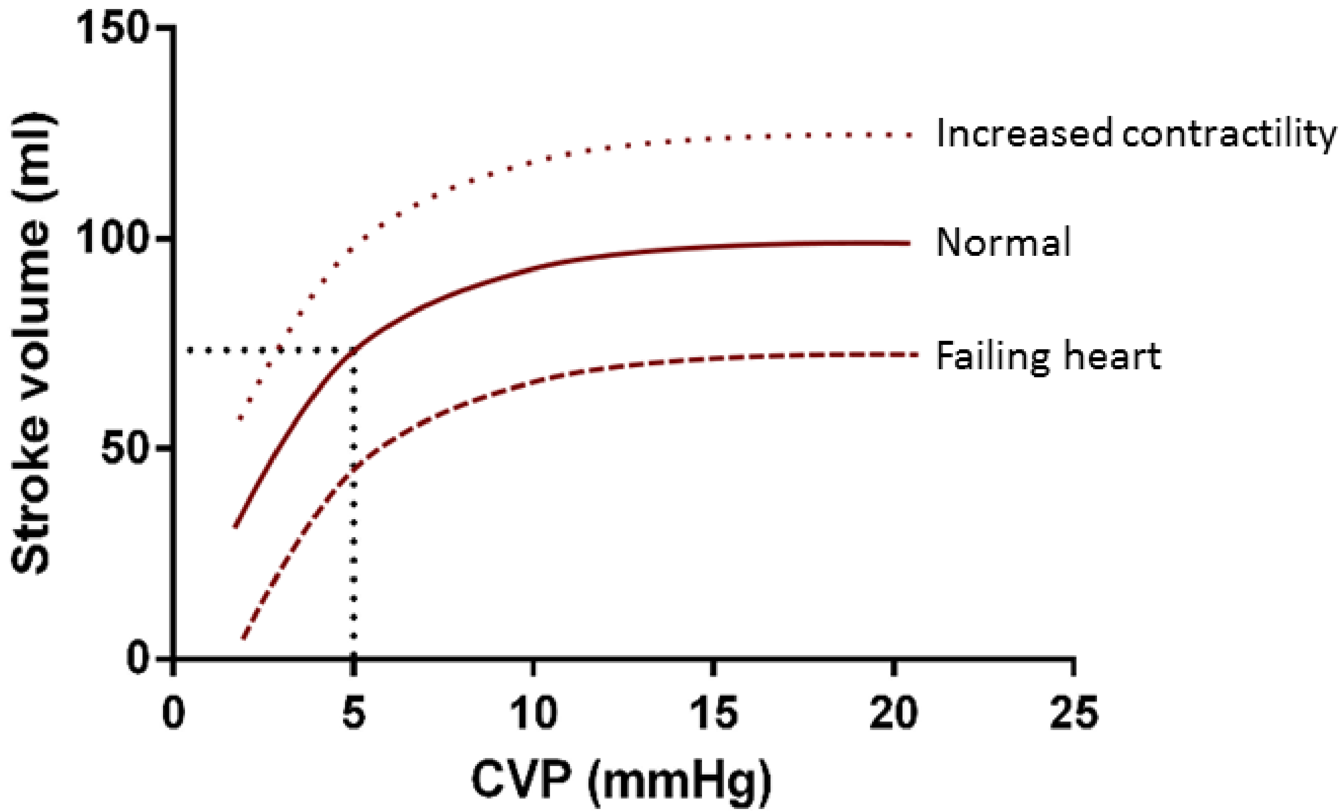
- Salary support by Canton de Vaud
- Grant support from the Leenaards Foundation, Switzerland
- Speaking / consulting / Travel support from
  - Baxter Healthcare Corp
  - Fresenius Medical Care
  - BBraun Avitum

Fluids in ICU

Fluids in ICU

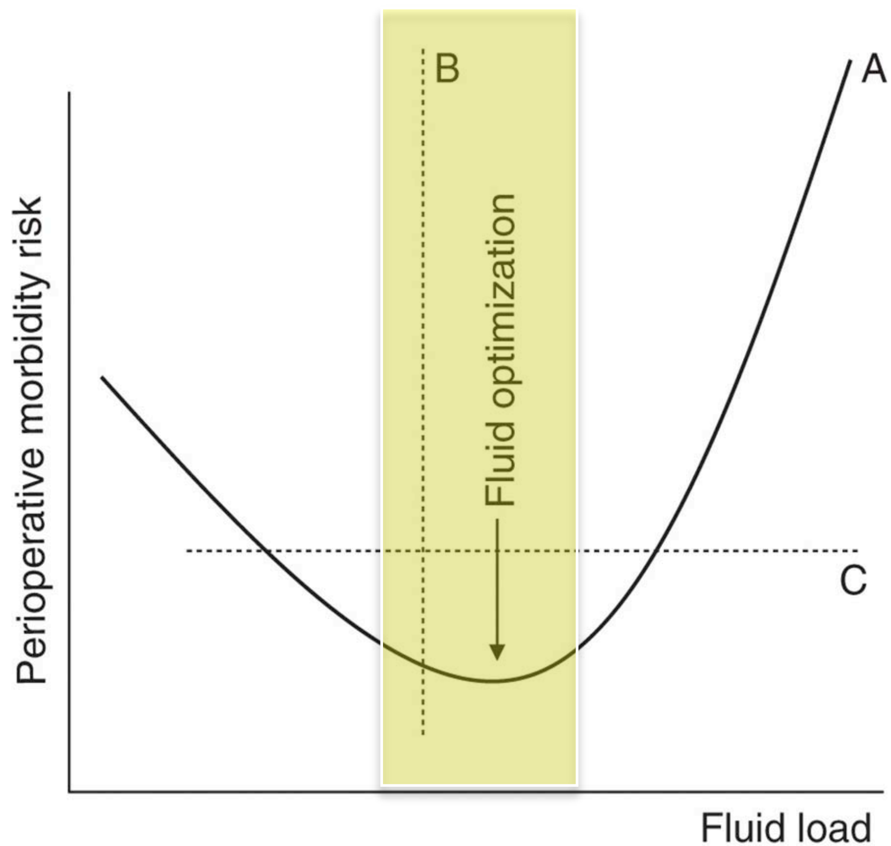
- Fluid administration is one of the most common intervention in ICU
- Fluid administration aims at:
  - Maintaining physiological homeostasis
  - Enable other drugs administration
  - Correcting perceived haemodynamic instability.

Fluids in ICU



Hall JE In Guyton and Hall Textbook of Medical Physiology, **2011:229 241.**
Shoemaker WC. Am J Surg **1965, 110:337 341.**

Fluids optimization in ICU



Line of risk

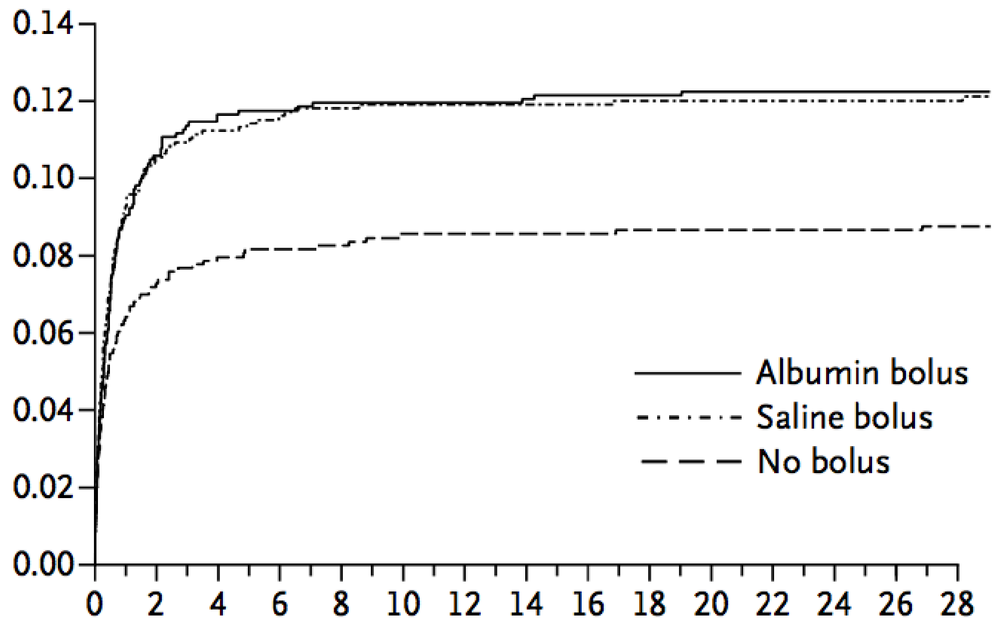
M. C. Bellamy Br. J. Anaesth. 2006;97:755-757

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., Charles Engoru, M.B., Ch.B., M.Med., Peter Olupot-Olupot, M.B., Ch.B., Samuel O. Akech, M.B., Ch.B., Richard Nyeko, M.B., Ch.B., M.Med., George Mtove, M.D., Hugh Reyburn, M.B., B.S., Trudie Lang, Ph.D., Bernadette Brent, M.B., B.S., Jennifer A. Evans, M.B., B.S., James K. Tibenderana, M.B., Ch.B., Ph.D., Jane Crawley, M.B., B.S., M.D., Elizabeth C. Russell, M.Sc., Michael Levin, F.Med.Sci., Ph.D., Abdel G. Babiker, Ph.D., and Diana M. Gibb, M.B., Ch.B., M.D., for the FEAST Trial Group*



Fluids in ICU: Controversies

- Type of fluids:
  - Colloids vs crystalloids
  - Balanced solutions vs Normal saline
  - Albumin
- Volume of fluids and optimal target endpoints for fluid therapy during resuscitation
  - CVP
  - Lactate clearance
- Fluid challenge: Definition / target endpoints

Finfer S et al. *Crit Care* 2010; **14**: R185

Fluid Overload

Fluid Overload: Evidence of Harm

Mc Dermid et al, W J of Crit Care Med 2014

Harm in Bowel Surgery

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

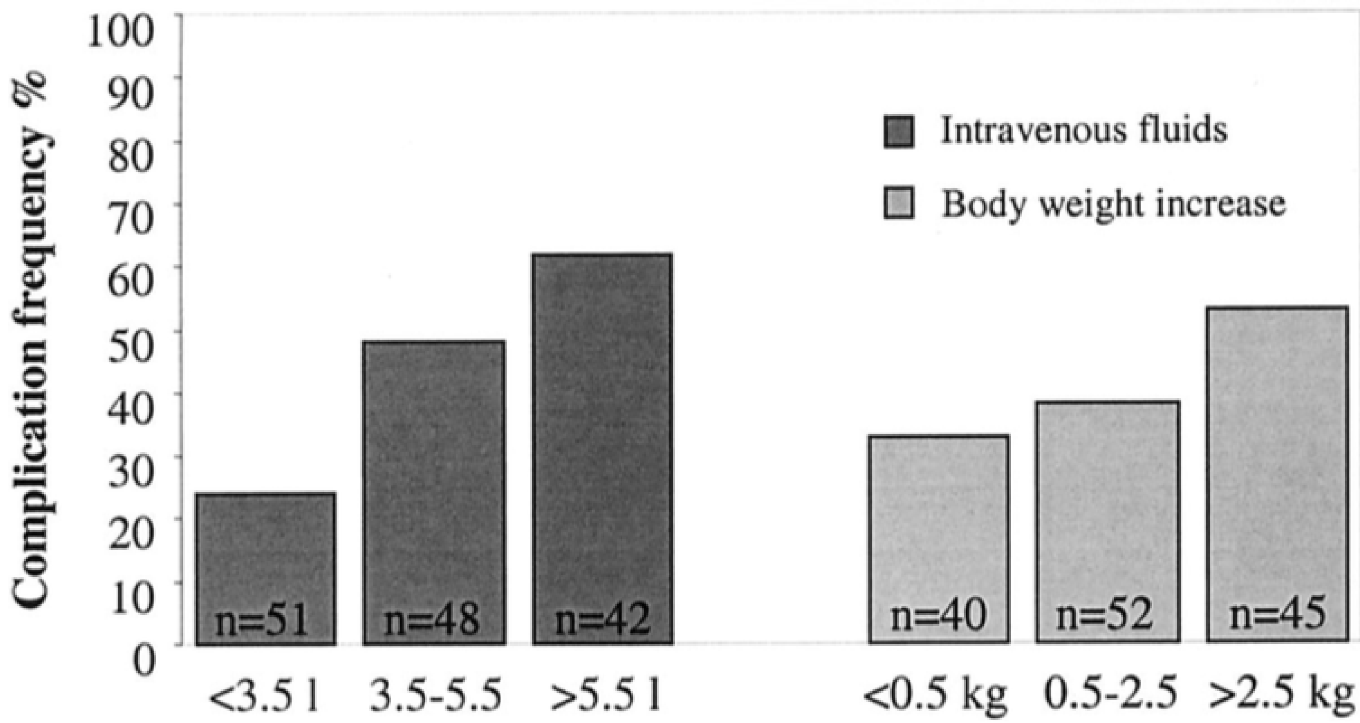
A Randomized Assessor-Blinded Multicenter Trial

	Blinded Assessment		
	Restricted Group	**Standard Group**	***P* value**
Overall complications	21	40	0.003
Major complications†	8	18	0.040
Minor complications†	15	36	0.000
Tissue-healing complications†	11	22	0.040
Cardiopulmonary complications†	5	17	0.007

n = 69 in restricted group and n = 72 in standard group.

Brandstrup et al 2003 Ann surg 238:641-648

Harm in bowel surgery



Brandstrup et al ann surg 238:641-648 2003

Harm in Acute Lung Injury

ORIGINAL ARTICLE

Comparison of Two Fluid-Management Strategies in Acute Lung Injury

1000 patients with ALI were randomized to conservative or liberal fluid management strategy.

The conservative strategy had no effect on mortality (primary outcome, 25.5 vs 28.4%) but:

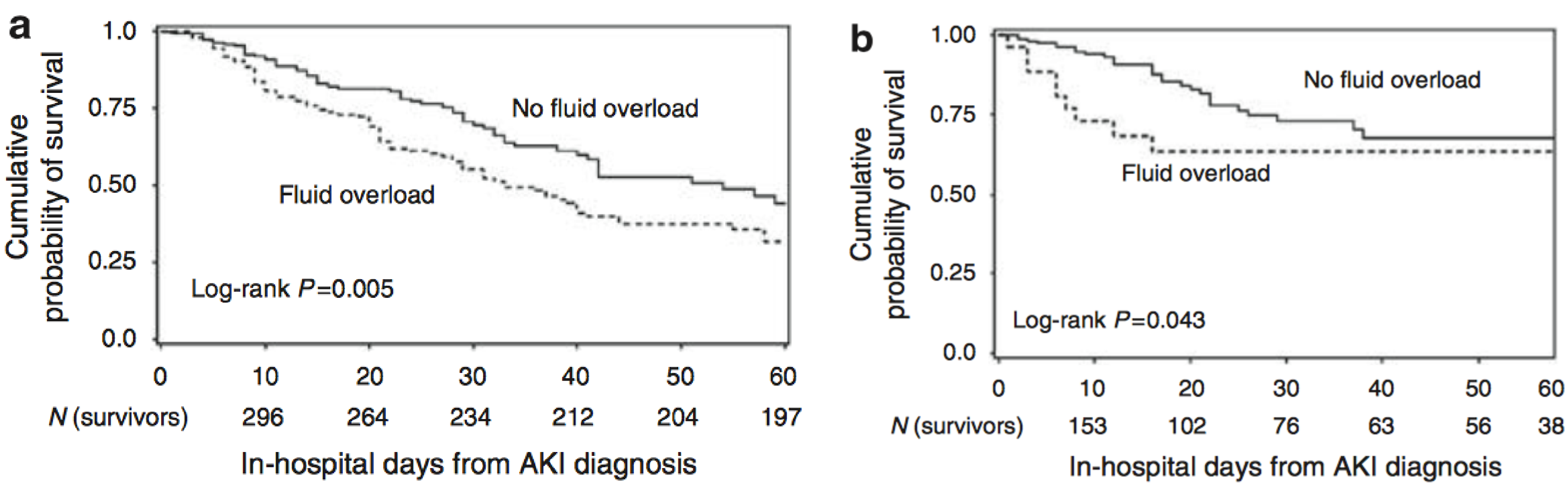
- Improved oxygenation index and the lung injury score
- Increased the number of ventilation and ICU free days

Wiedemann et al N Engl J Med 2006;354:2564-75


Yes! But fluids protect the Kidney!

Fluid accumulation, survival and recovery of kidney function in critically ill patients with acute kidney injury

Josée Bouchard[1], Sharon B. Soroko[1], Glenn M. Chertow[2], Jonathan Himmelfarb[3], T. Alp Ikizler[4], Emil P. Paganini[5] and Ravindra L. Mehta[1], Program to Improve Care in Acute Renal Disease (PICARD) Study Group



On Dialysis initiation

Non dialyzed patients

Bouchard et al Kidney International (2009) 76, 422–427

Research

Open Access

A positive fluid balance is associated with a worse outcome in patients with acute renal failure

Didier Payen[1], Anne Cornélie de Pont[2], Yasser Sakr[3], Claudia Spies[4], Konrad Reinhart[3], Jean Louis Vincent[5] for the Sepsis Occurrence in Acutely Ill Patients (SOAP) Investigators

Hazard ratios: results of multivariate Cox regression analysis for 60-day mortality in critically ill patients with acute renal failure

Characteristic	Hazard ratio	95% CI	*P* value
Age	1.02	1.01–1.03	<0.001
SAPS II (per point)	1.03	1.02–1.04	<0.001
Heart failure	1.38	1.05–1.81	0.02
Medical admission	1.68	1.35–2.08	<0.001
Mean fluid balance, L/24 hours	1.21	1.13–1.28	<0.001
Mechanical ventilation	1.55	1.14–2.11	<0.001
Liver cirrhosis	2.73	1.88–3.95	<0.001

CI, confidence interval; SAPS II, Simplified Acute Physiology Score II.

Payen et al Critical Care 2008, 12:R74

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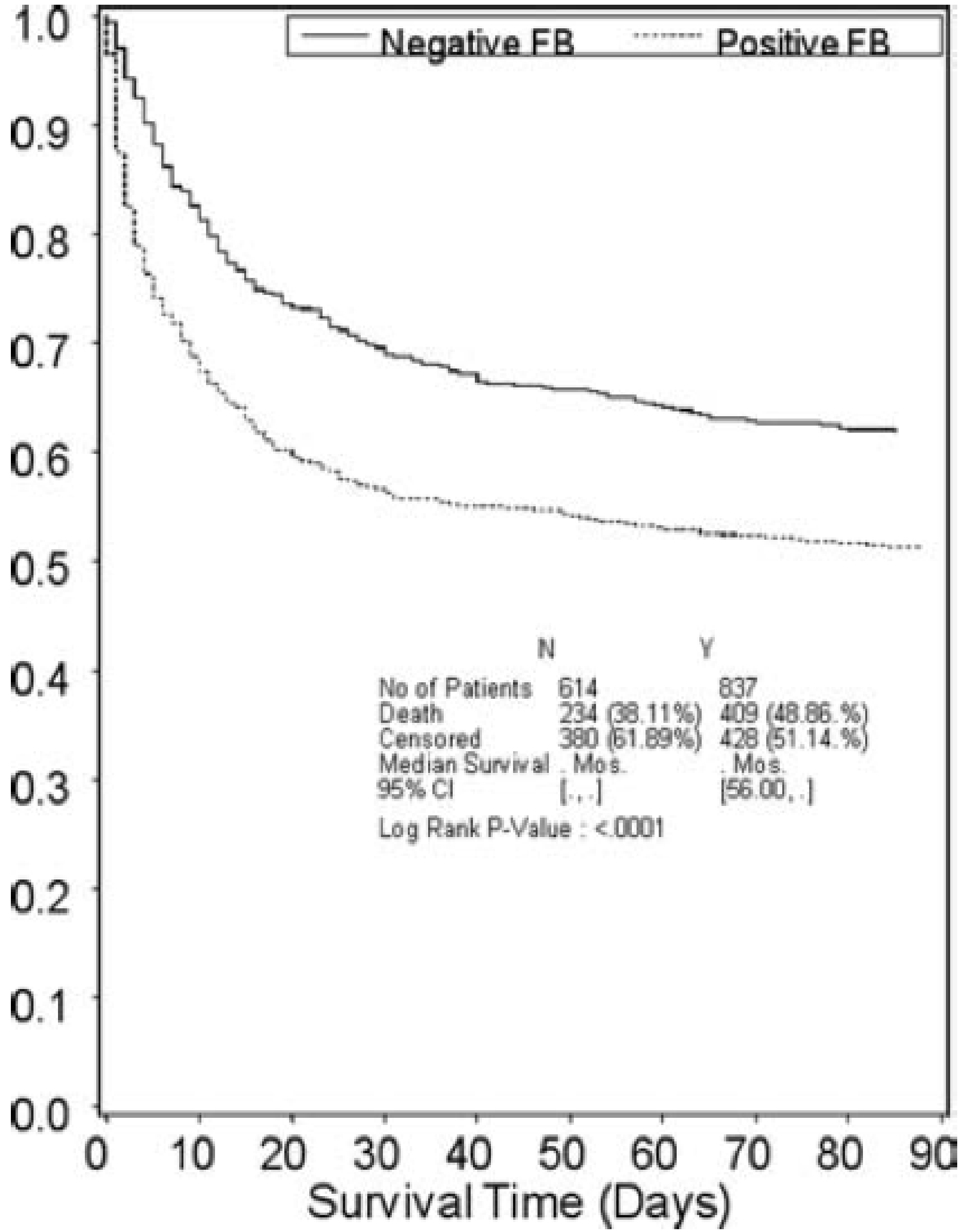

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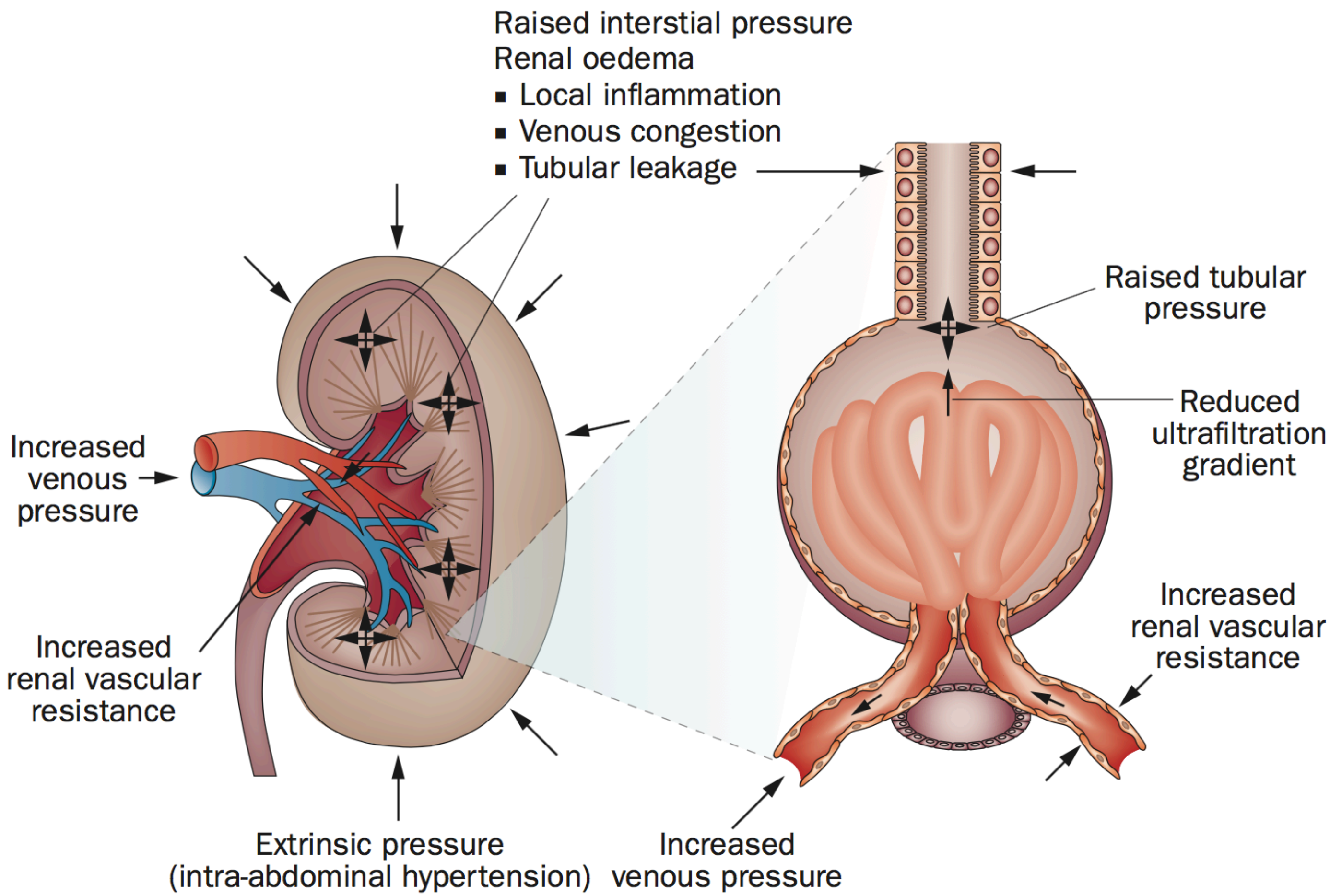
Non-surviv...
Survivors :

Fluid management for the prevention and attenuation of acute kidney injury

REVIEWS

John R. Prowle, Christopher J. Kirwan and Rinaldo Bellomo



Prowle et al Nat Rev Nephrol 2014

Fluid management for the prevention and attenuation of acute kidney injury

REVIEWS

John R. Prowle, Christopher J. Kirwan and Rinaldo Bellomo

Potential additional toxicity due to

- Excess chloride toxicity (afferent arterioles constriction)
- Starch Intratubular deposition

Prowle et al Nat Rev Nephrol 2014

What can we do about it?

Fluid Management: a Practical Approach

- Limit the intensity and the duration of the initial resuscitation phase to the minimum
- Monitor fluid balance (daily and cumulative) and/or body weight
- Target neutral cumulative fluid balance after the initial phase of resuscitation
- This second stage usually involves **FLUID REMOVAL**
- Such aim, particularly in the setting of AKI, might involve RRT

Volume Management with RRT

- RRT techniques are designed to remove fluid from the **intravascular** compartment.
- Hemodynamic tolerance is dependent on refilling of the intravascular volume from the interstitial compartment, the PLASMA REFILL RATE (PRR)
- Matching fluid removal to the PRR might be easier with continuous modalities (CRRT)

Volume Management with CRRT

Goals:

- Remove excess fluids without compromising cardiac output and effective circulating volume (easier with continuous monitoring)
- Compensate for increased fluids given to provide adequate nutrition and drugs (Fluid balance monitoring)
- Attempts to maintain urinary output

Potential Errors

- User:
  - Inadequate prescription
  - Inadequate application of prescription
  - UF rates not optimized to PRR with resulting HD instability (Absence of prompt recognition of signs of hypovolemia)
- Machine:
  - Imprecise Fluid balance management (errors)
  - Override by operators of safety alarms intended to limit UF when the gravimetric scale being adjusted

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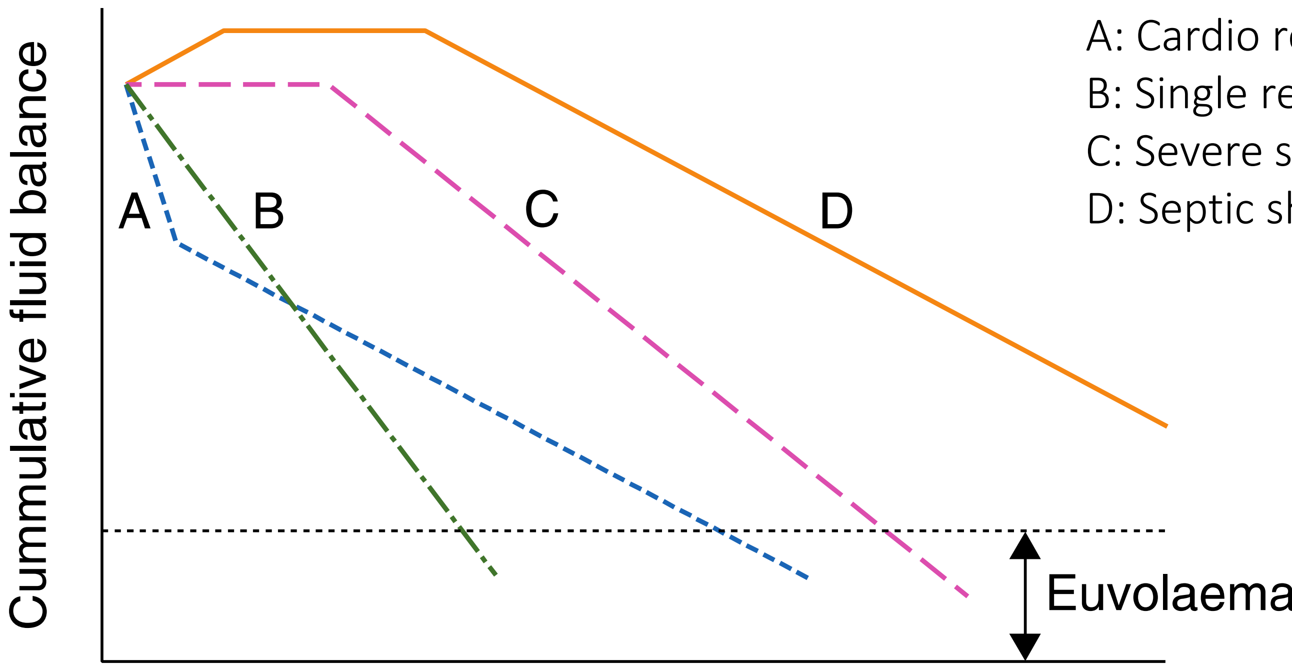
Indications and management of mechanical fluid removal in critical illness

M. H. Rosner[1†], M. Ostermann[2†*], R. Murugan[3], J. R. Prowle[4], C. Ronco[5], J. A. Kellum[3], M. G. Mythen[6] and A. D. Shaw[7] for the ADQI XII Investigators Group

BJA 2014

THE IMPORTANCE OF NET UF TRAJECTORY



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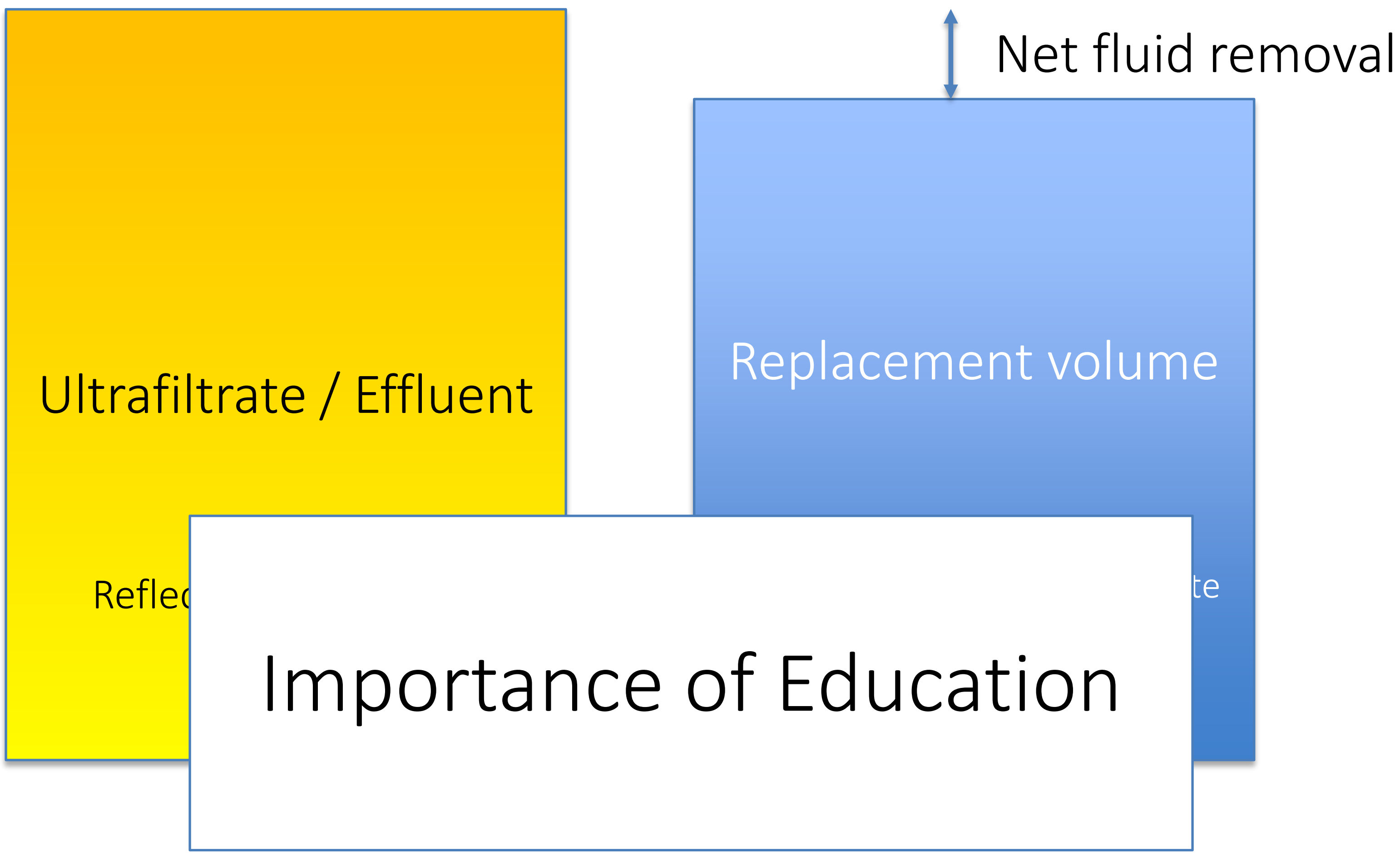
Definitions



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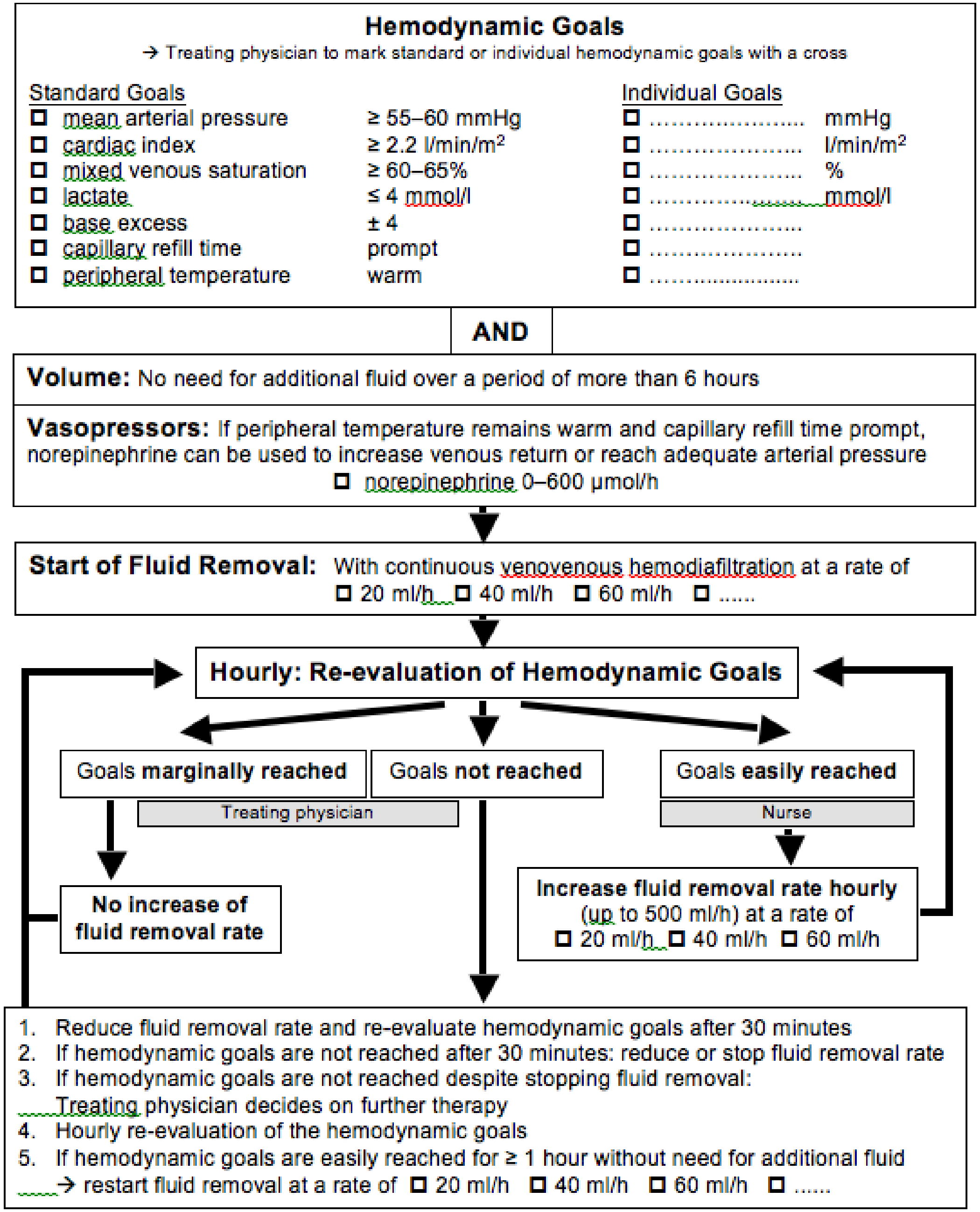
Forced fluic ... vith acute kidney inju

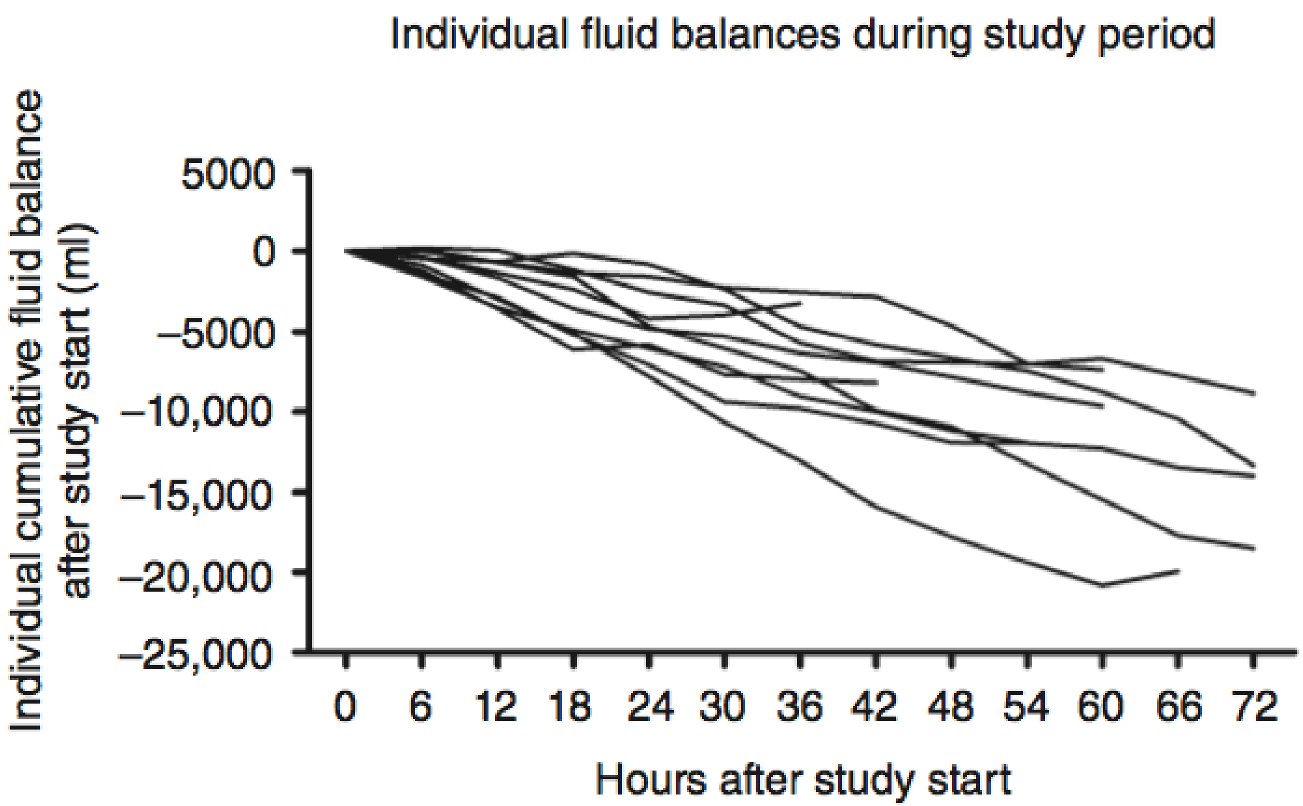
C. C. Ganter[1], R. Hoc ... M. Jakob[1]
[1]Department of Intensive Ca ... witzerland and [2]Department of Nephrology and Hyperten:



Ganter et al Acta Anesth Scandin 2012

Forced fluid removal in critically ill patients with acute kidney injury

C. C. Ganter[1], R. Hochuli[1], M. Bossard[1], R. Etter[1], J. Takala[1], D. E. Uehlinger[2] and S. M. Jakob[1]
[1]*Department of Intensive Care Medicine, Bern University Hospital (Inselspital) and University of Bern, Bern, Switzerland and* [2]*Department of Nephrology and Hypertension, Bern University Hospital (Inselspital) and University of Bern, Bern, Switzerland*



Ganter et al **Acta Anesth Scandin 2012**

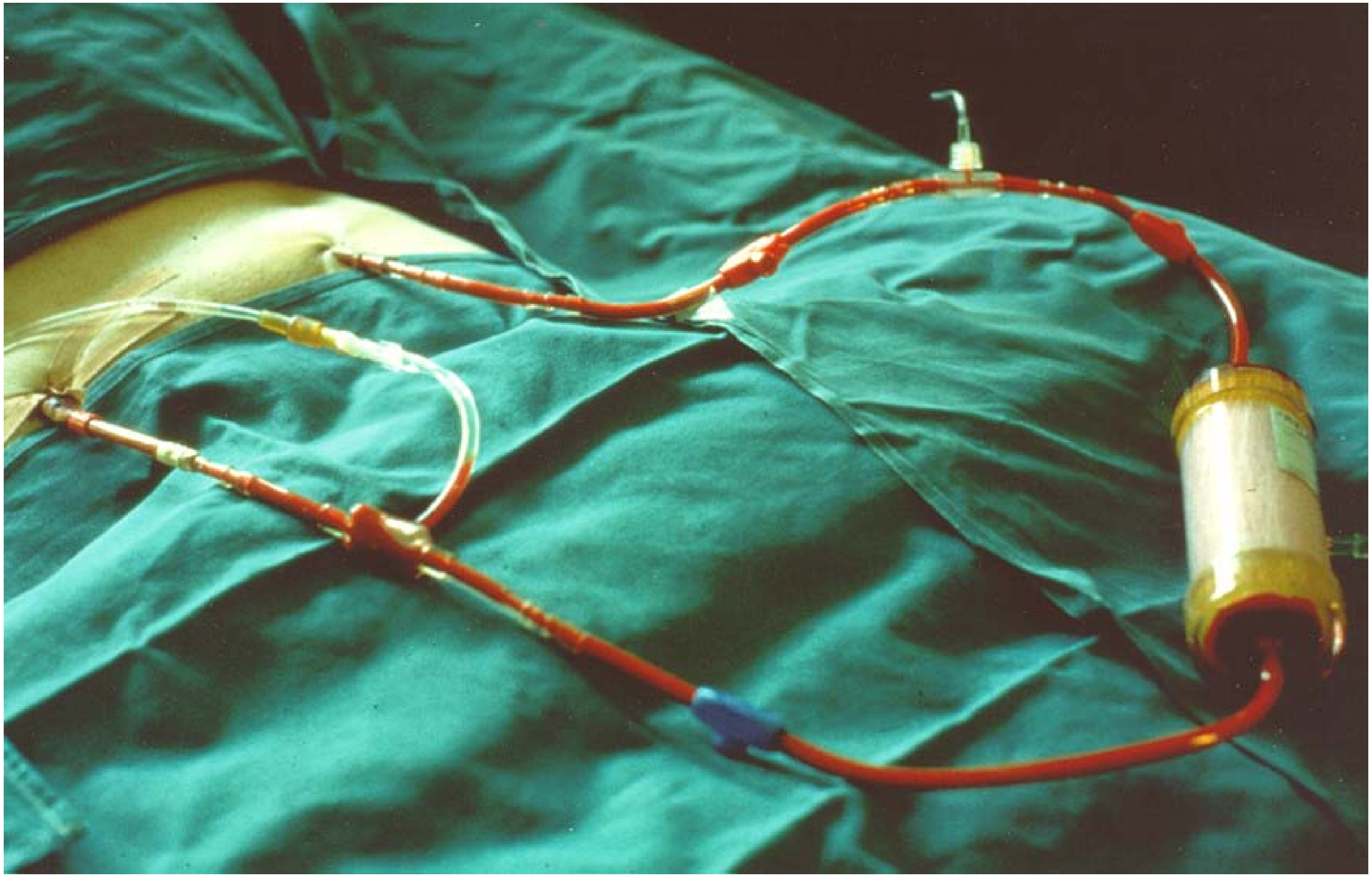
Potential Errors

- User:
  - Inadequate prescription
  - Inadequate application of prescription
  - UF rates not optimized to PRR with resulting HD instability(Absence of prompt recognition of signs of hypovolemia)
- **Machine**:
  - **Imprecise fluid balance management** (errors)
  - Override by operators of safety alarms intended to limit UF when the gravimetric scale being adjusted

Potential Errors

- A typical prescription involves 2 to 4 litres exchanges per hour
- A 1% error would lead to 0.5 to 1 liter a loss /gain per day
- Very high precision required!

Potential Errors



Potential Errors

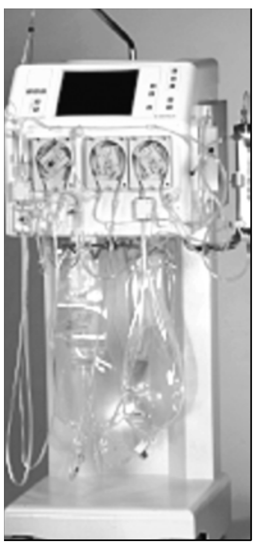
- User:
  - Inadequate prescription
  - Inadequate application of prescription
  - UF rates not optimized to PRR with resulting HD instability (Absence of prompt recognition of signs of hypovolemia)
- Machine:
  - Imprecise Fluid balance management (errors)
  - **Override by operators of safety alarms**

The International Journal of Artificial Organs / Vol. 28 / no. 8, 2005 / pp. 765-776

Technical Overview

Management of fluid balance in CRRT: A technical approach

C. RONCO[1], Z. RICCI[2], R. BELLOMO[3], I. BALDWIN[3], J. KELLUM[4]



In vitro FB errors on 2nd generation machines:

- ✓ Prisma/Prismaflex
- ✓ Multifiltrate
- ✓ Diapact
- ✓ Aquarius

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Technical Overview

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TABLE VI - REPLACEMENT AT: 2400 ml/h (2.4 l/h)

Number of alarms	Blood 200 ml/min	Dialysate 2400 ml/h 40 ml/min	Alarm intervention m/s	Fluid balance pulled from container, displayed	Fluid balance step error	Theoretical dialysate flow within the alarm intervention
1	OK	OK	0.27	10	**20**	18.0
2	OK	OK	0.23	30	**20**	15.3
3	OK	OK	0.23	50	**20**	15.3
4	OK	OK	0.25	70	**20**	16.7
5	OK	OK	0.25	90	**20**	16.7
6	OK	OK	0.24	100	**10**	16.0
7	OK	OK	0.25	120	**20**	16.7
8	OK	OK	0.25	140	**20**	16.7
9	OK	OK	0.25	160	**20**	16.7
10	OK	OK	0.25	170	**10**	16.7
11	OK	OK	0.25	**190**	**20**	16.7

The International Journal of Artificial Organs / Vol. 28 / no. 8, 2005 / pp. 765-776

Technical Overview

Management of fluid balance in CRRT: A technical approach

C. RONCO[1], Z. RICCI[2], R. BELLOMO[3], I. BALDWIN[3], J. KELLUM[4]

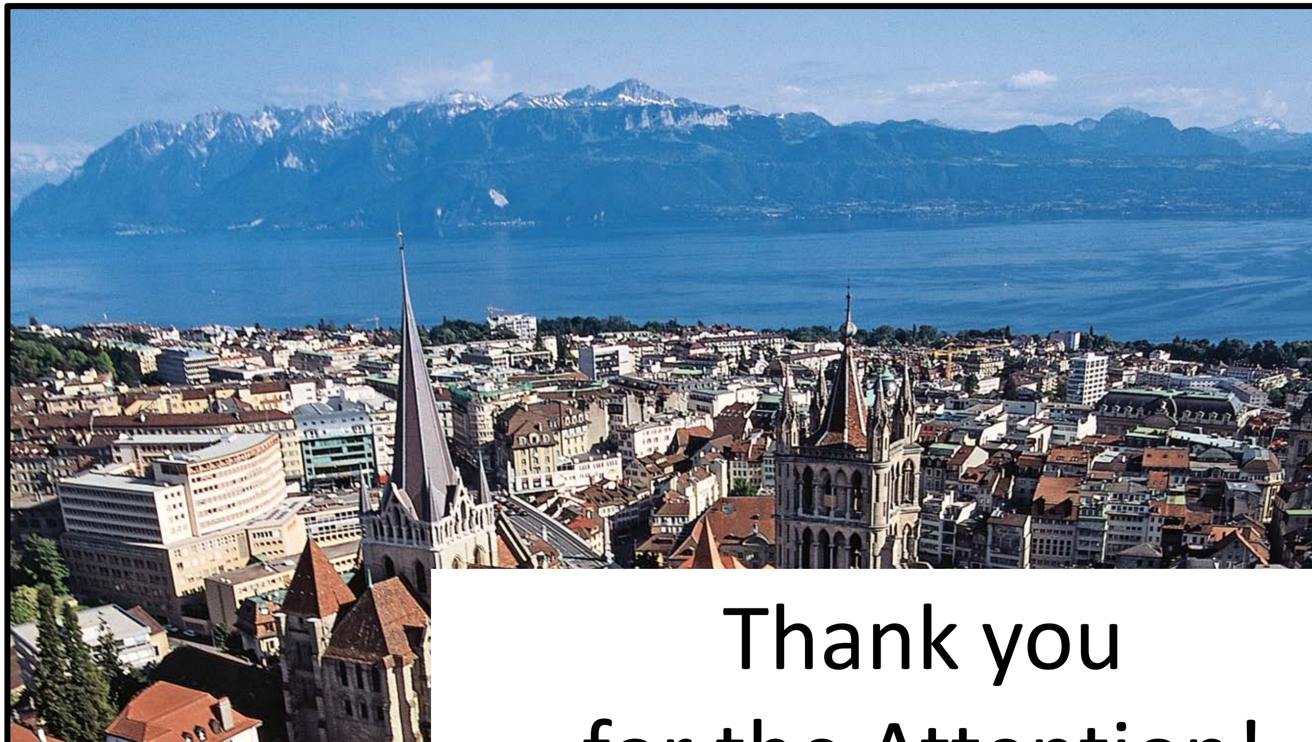
- Most machines do not stop the treatment after multiple overrides of the "fluid balance error" alarm.
- Each alarms requires a 20-50 g difference to be triggered
- Hence overriding an alarm 10 x can generate 200 to 500 ml error in fluid balance

Conclusions

- Fluid overload an important issue in critical illness associated with harm in numerous settings
- Fluid administration should be restricted to the minimum
- Fluid restriction has NOT been associated with renal damage

Conclusions

- Fluid removal is often required after the initial resuscitation phase and need to follow different trajectories.
- CRRT is often required in such context
  - Fluid removal is a key aspect of the CRRT prescription
  - Fluid removal has to be fully delivered and monitored (it is part of the dose)
  - Correct fluid balance trajectories have to be set



Lausanne

Thank you
for the Attention!

CHUV