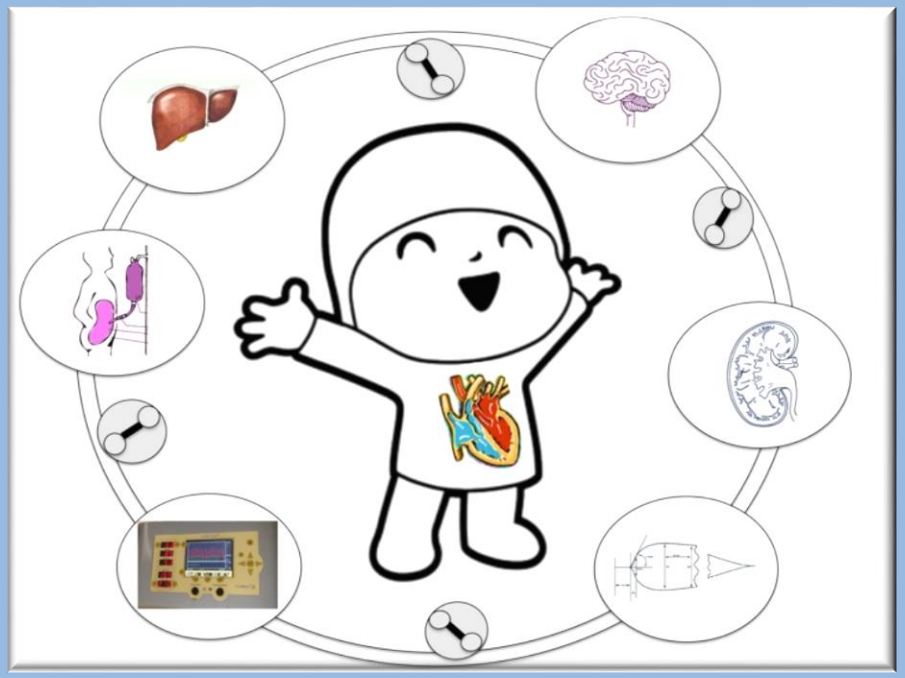
10 false beliefs in CCN



37th Vicenza Course on AKI & CRRT

May 28-30, 2019

Zaccaria Ricci

Dipartimento Medico Chirurgico
di Cardiologia Pediatrica

Bambino Gesù
OSPEDALE PEDIATRICO

Health-e-Child

Comune di Roma

Information Society Technologies

S. Bortolamius Vicenza Pietas et Cura

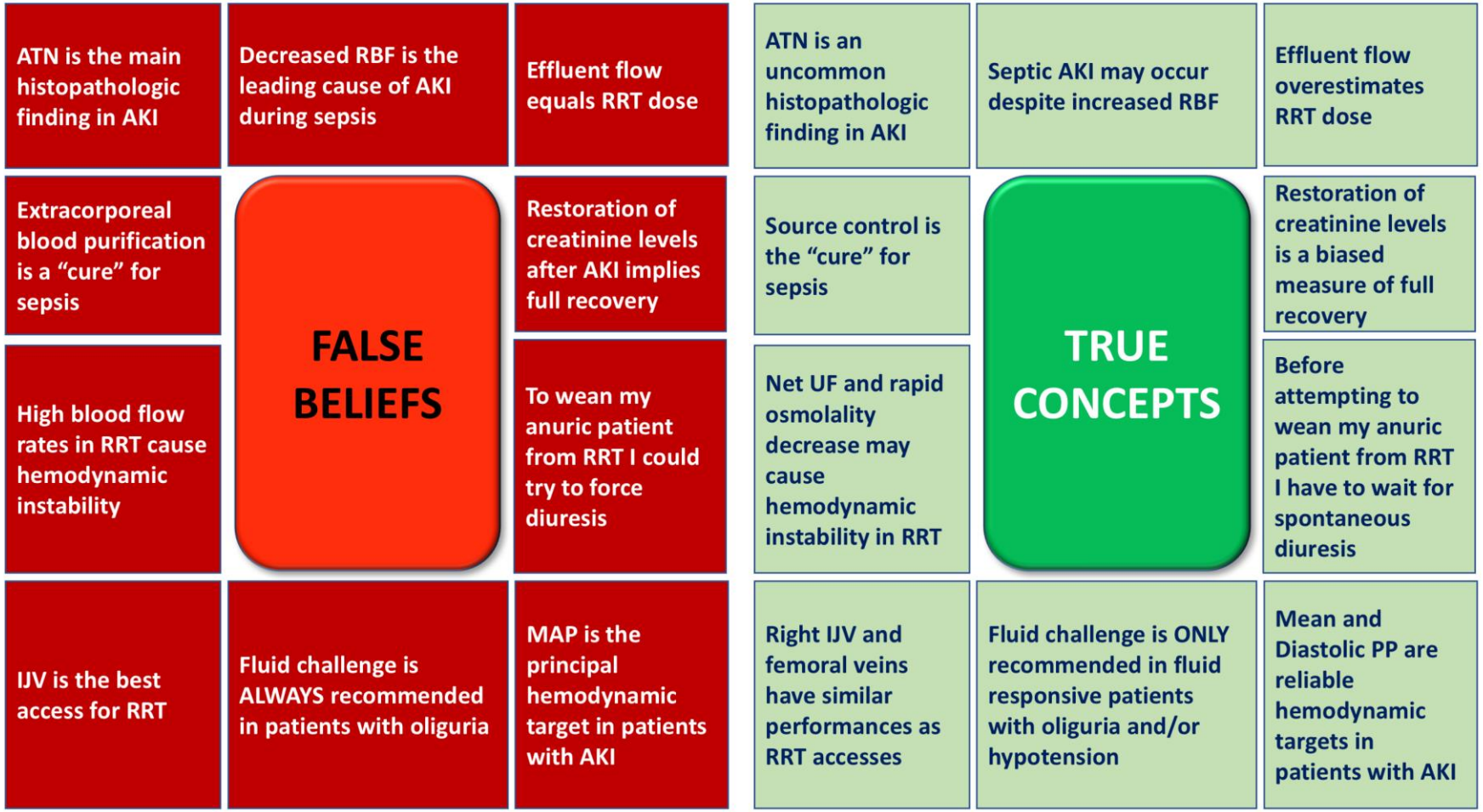
IRRIV International Renal Research Institute Vicenza

Nefrologia Dialisi e Trapianto Renale

The 10 false beliefs in adult critical care nephrology

Zaccaria Ricci[1*], Stefano Romagnoli[2] and Claudio Ronco[3,4]

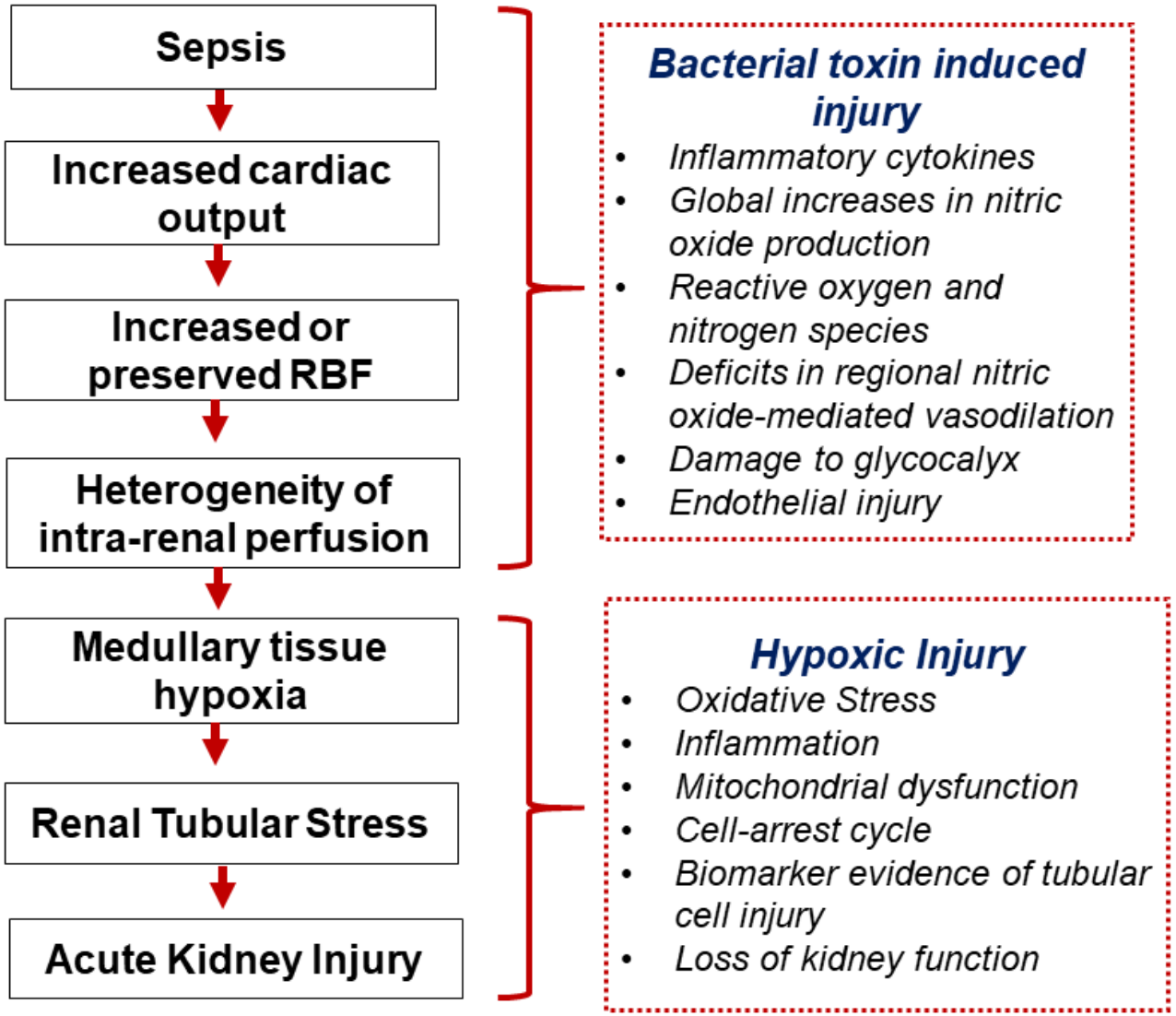
Intensive Care Med 2017



FALSE BELIEFS….

1. Decreased RBF is the leading cause of septic AKI
2. Colloids are useful to restore intravascular oncotic pressure
3. Diuretics cause AKI
4. Pre-renal AKI can be always treated by fluid loading
5. Antibiotic dosing should be always reduced during CRRT
6. Anticoagulation of CRRT circuit is not needed during ECMO
7. CRRT Blood flow rate causes hypotension
8. Negative RCTs are not useful
9. Studies on children are NOT useful… on adult patients
10. We like the idea of removing «renal» from all CCN acronyms

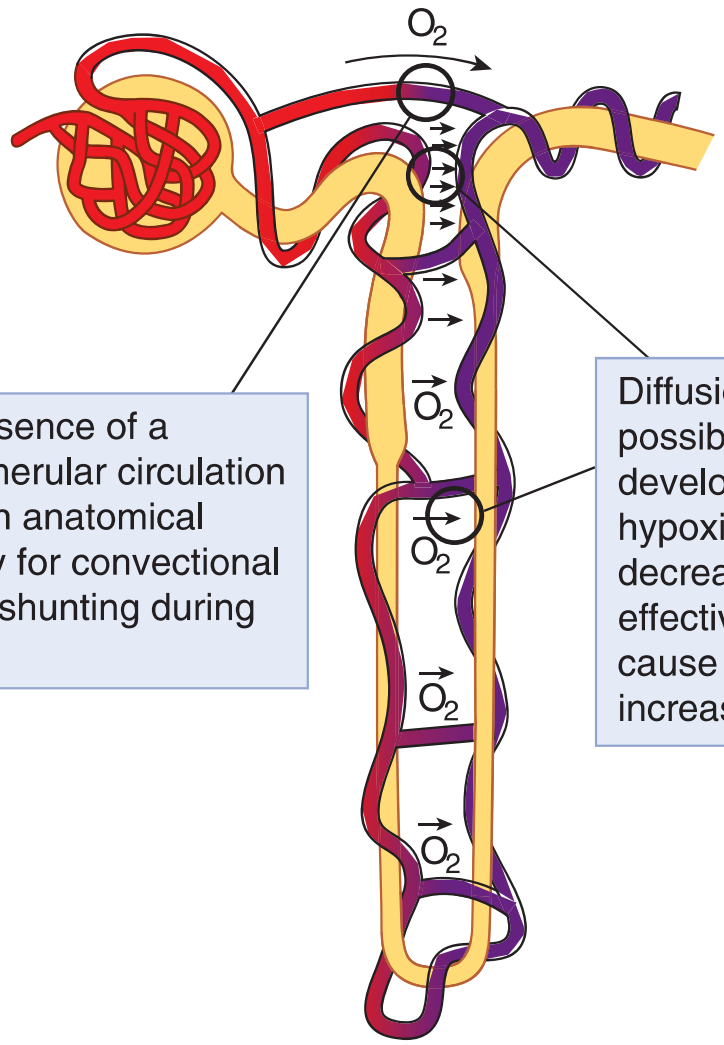
1. A decreased RBF is the leading cause of septic AKI



Sepsis-induced acute kidney injury: A disease of the microcirculation. Ma et al. MICROCIRC 2019

SEPTIC AKI

- Sepsis
- Increased cardiac output
- Increased or preserved RBF
- Heterogeneity of intra-renal perfusion
- Medullary tissue hypoxia
- Renal Tubular Stress
- Acute Kidney Injury



The presence of a periglomerular circulation offers an anatomical pathway for convectional oxygen shunting during sepsis.

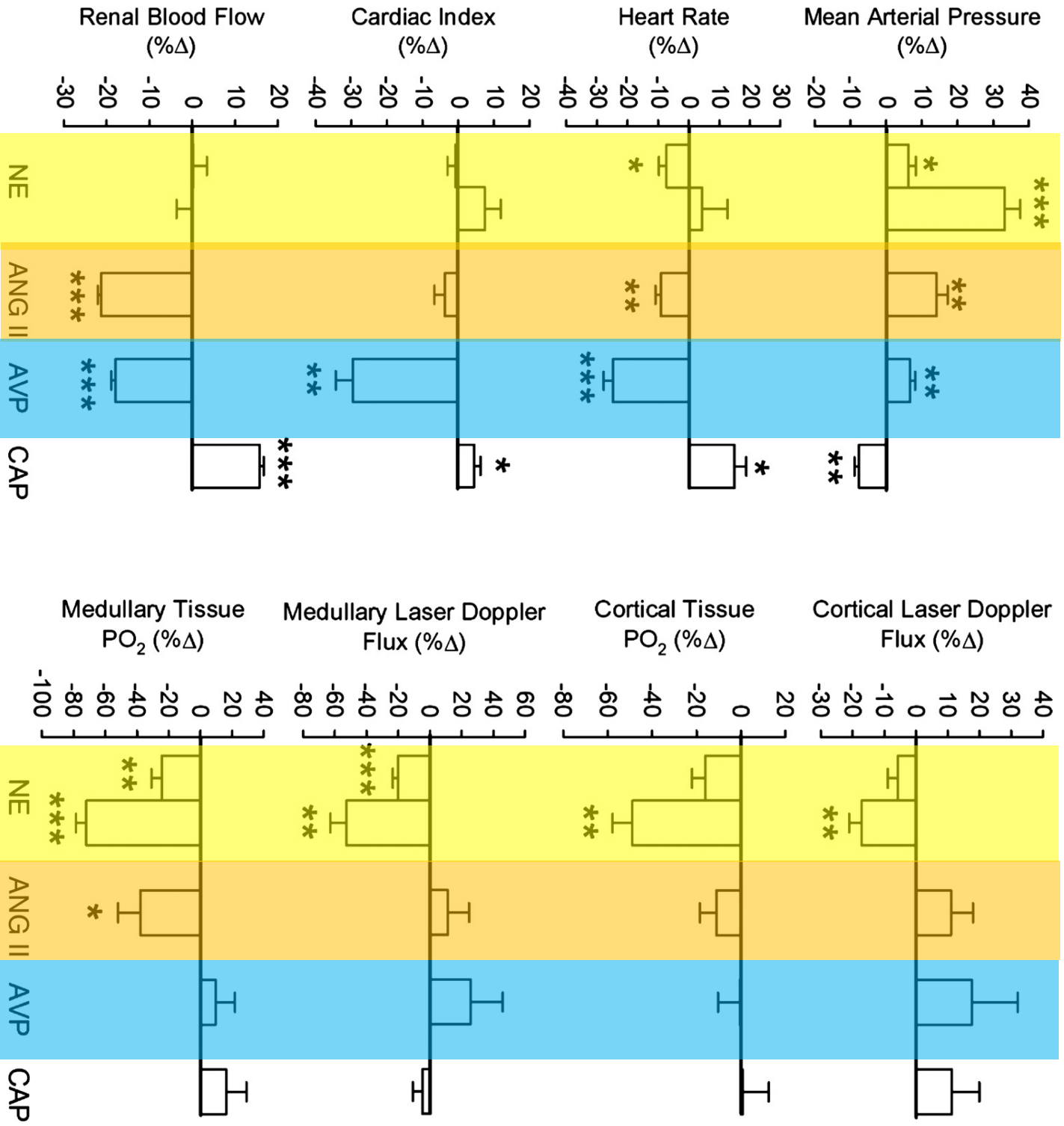
Diffusional shunting possibly adds to the development of medullary hypoxia in sepsis. Alternatively, decreased shunting effectiveness may also cause tubular injury through increased ROS production.

Post, KI 2017

Sepsis-induced acute kidney injury: A disease of the microcirculation. Ma et al. MICROCIRC 2019

Am J Physiol Regul Integr Comp Physiol 309: R1226–R1233, 2015.
First published September 9, 2015; doi:10.1152/ajpregu.00228.2015.

Variable responses of regional renal oxygenation and perfusion to vasoactive agents in awake sheep



2. Colloids are useful to restore intravascular oncotic pressure

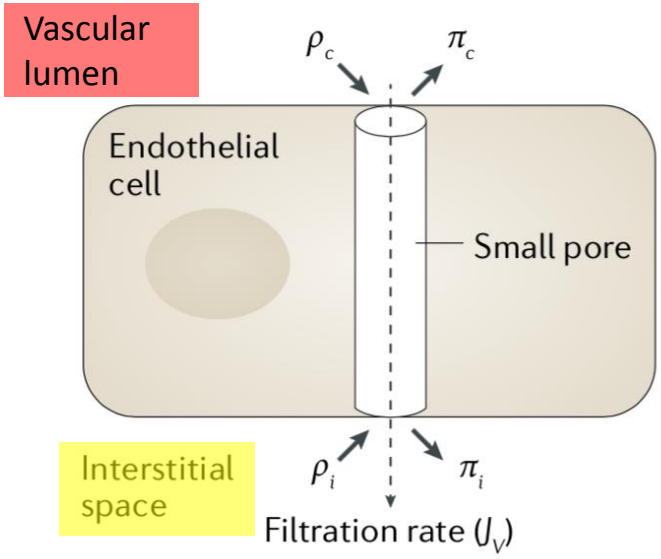
- Intravenous fluid administration is one of the most common interventions in acute and critical care medicine, but much of the physiological theory on which practice has been based is flawed.
- Intravenous fluids were established in clinical practice and licensed for use without robust investigation of their efficacy or safety, although large, high-quality, investigator-initiated trials have now provided such data.
- **Crystalloid fluids should be used for first-line therapy; in most patients, buffered salt solutions seem to offer benefits over normal saline.**
- **Albumin administration might be beneficial in patients with sepsis, cirrhosis or infections, but is contraindicated in patients with acute traumatic brain injury.**
- **Synthetic colloids, notably hydroxyethyl starch and gelatins, should not be used owing to their unacceptable safety profiles and lack of proven benefits over crystalloids.**

Finfer, Myburgh, Bellomo, Nat Rev Neph 2018

Finfer, Myburgh, Bellomo, Nat Rev Neph 2018

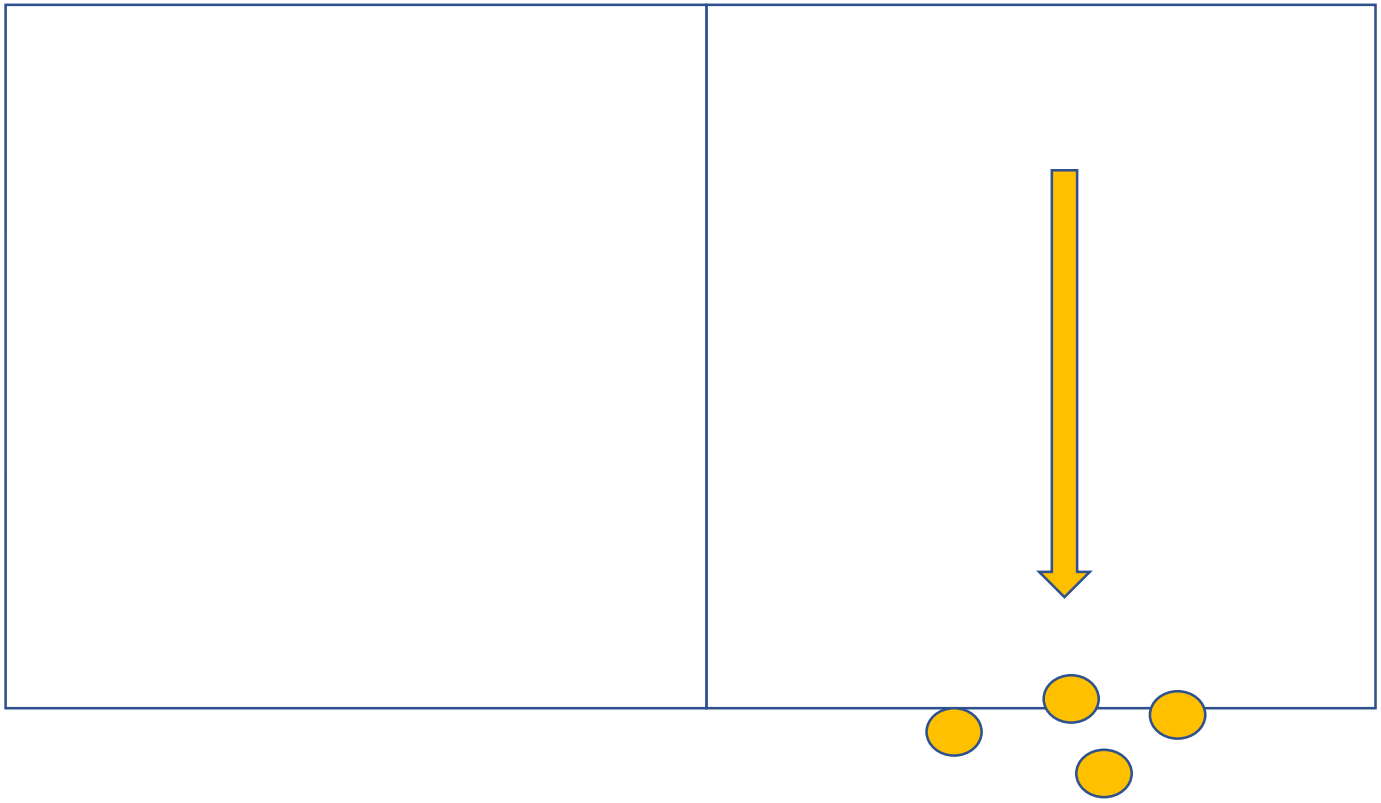
a Classic Starling principle

$$J_V = K[(\rho_c - \rho_i) - \sigma(\pi_c - \pi_i)]$$



b Revised Starling principle

$$J_V = (\rho_c - \rho_g) - \sigma(\pi_c - \pi_g)$$



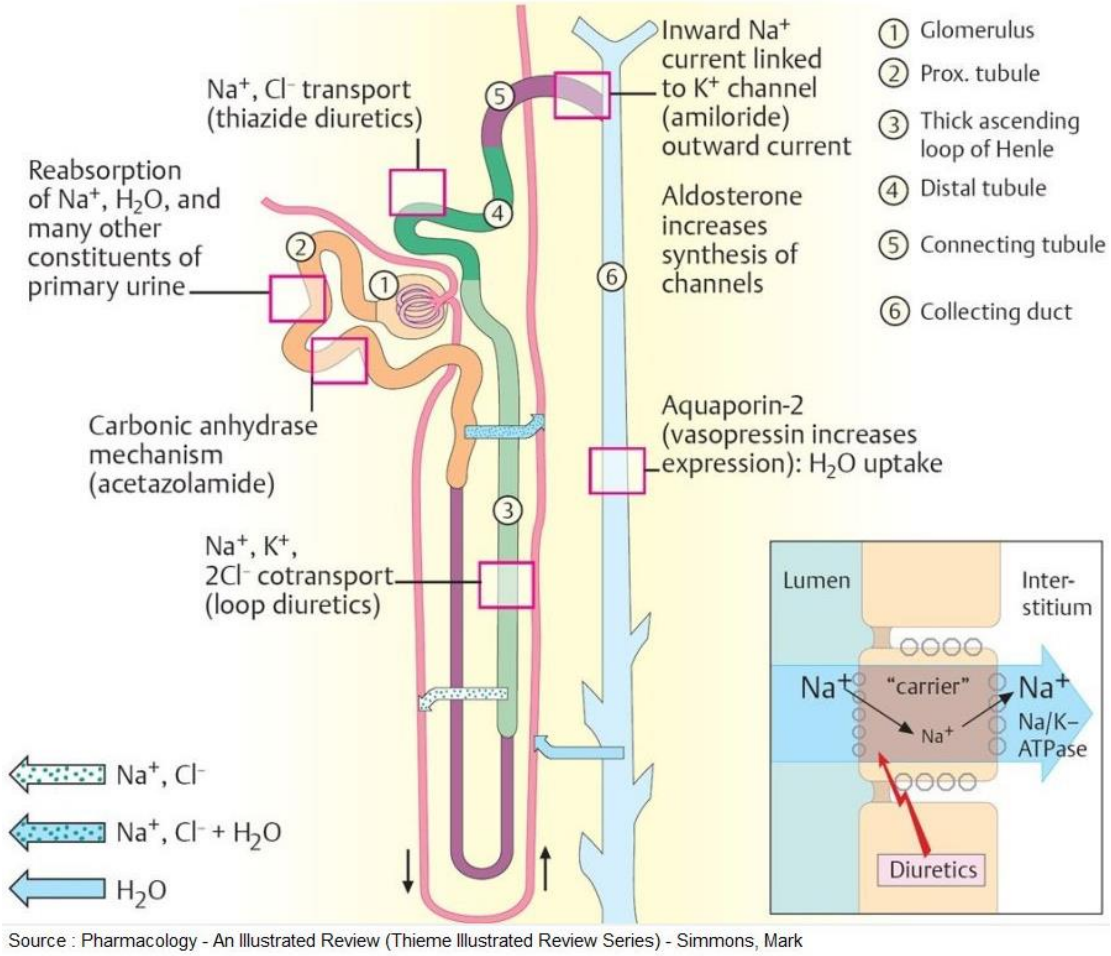
INTRAVASCULAR EXPANSION RATIO
colloids versus crystalloids
3:1

INTRAVASCULAR EXPANSION RATIO
colloids versus crystalloids
1.4:1

The use of plasma or plasma substitutes to achieve a sustained supranormal plasma volume or to reduce tissue oedema is not rational.

Woodcock, BJA 2012

3. Diuretics cause AKI

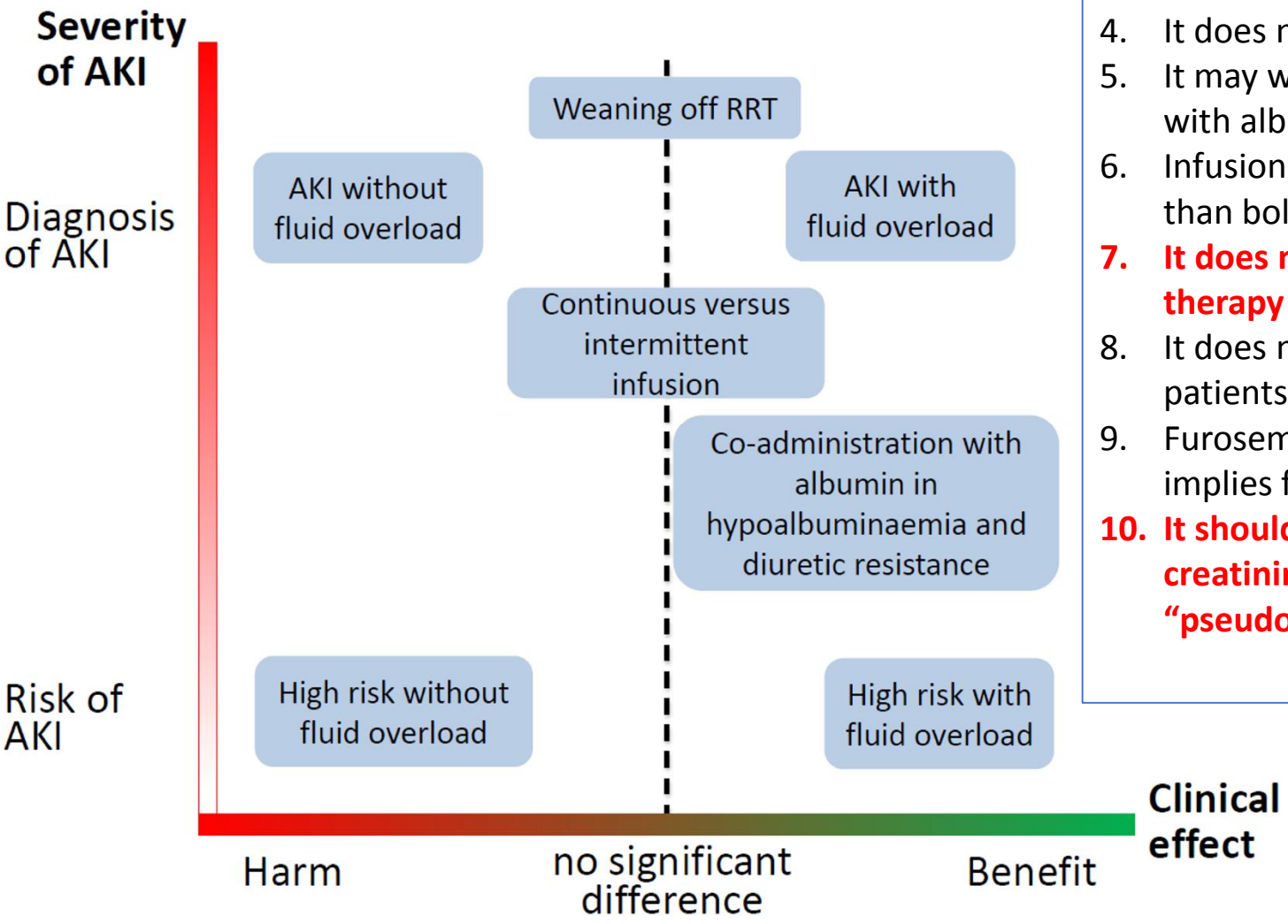


Source : Pharmacology - An Illustrated Review (Thieme Illustrated Review Series) - Simmons, Mark

DRUG	RBF (%CO)	GFR	TUBULAR Na REABS	Urine flow	DO2	O2Ex
furosemide	=	⬇	⬇	⬆	=	⬇

10 myths about frusemide

Michael Joannidis[1*], Sebastian J. Klein[1] and Marlies Ostermann[2]



1. **It does not cause AKI**
2. Furosemide and fluids together do not prevent AKI in high-risk patients
3. **It is not contraindicated in AKI**
4. It does not kick-start kidney function
5. It may work better if given together with albumin
6. Infusion is probably not more effective than boluses
7. **It does not prevent renal replacement therapy**
8. It does not help to wean anuric patients from RRT
9. Furosemide-induced diuresis after AKI implies full renal recovery.
10. **It should not be stopped if serum creatinine is increasing: consider "pseudo worsening renal function"**

4. Pre-renal AKI can be always treated by fluid loading

- The concept of «pre-renal» AKI is unfortunately very diffused
- It generally implies some renal dysfunction due to reduced renal perfusion
- It portends a form of somehow mild and transient oliguria
- Such implication frequently induces to associate «pre-renal» AKI with the need for volemia optimization (fluids)

4. Pre-renal AKI canNOT be always treated by fluid loading

Hence included into pre-renal AKI are:

-Cholera

-Bleeding

-Renal artery cla

va

insuff

-Vasoplegia

-Sepsis

A FLUID THERAPY IS VERY RARELY REQUIRED DURING THESE FORMS OF RENAL HYPOPERFUSION

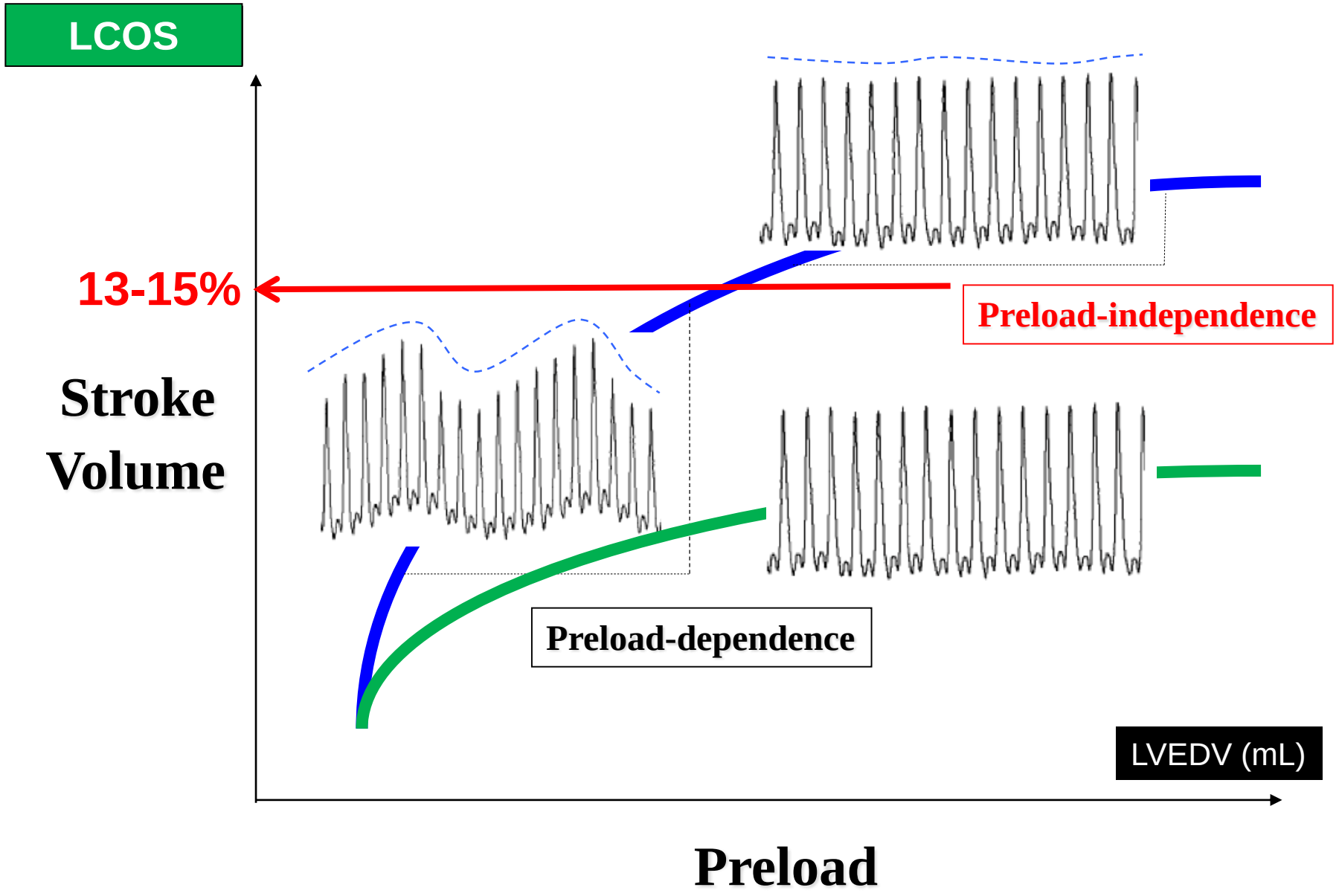
ion with Right Ventr failure

.....

Pre-Renal Azotemia: A Flawed Paradigm in Critically Ill Septic Patients? 2007

Rinaldo Bellomo[a], *Sean Bagshaw*[a], *Christoph Langenberg*[a], *Claudio Ronco*[b]

Starling Curve: fluid responsiveness



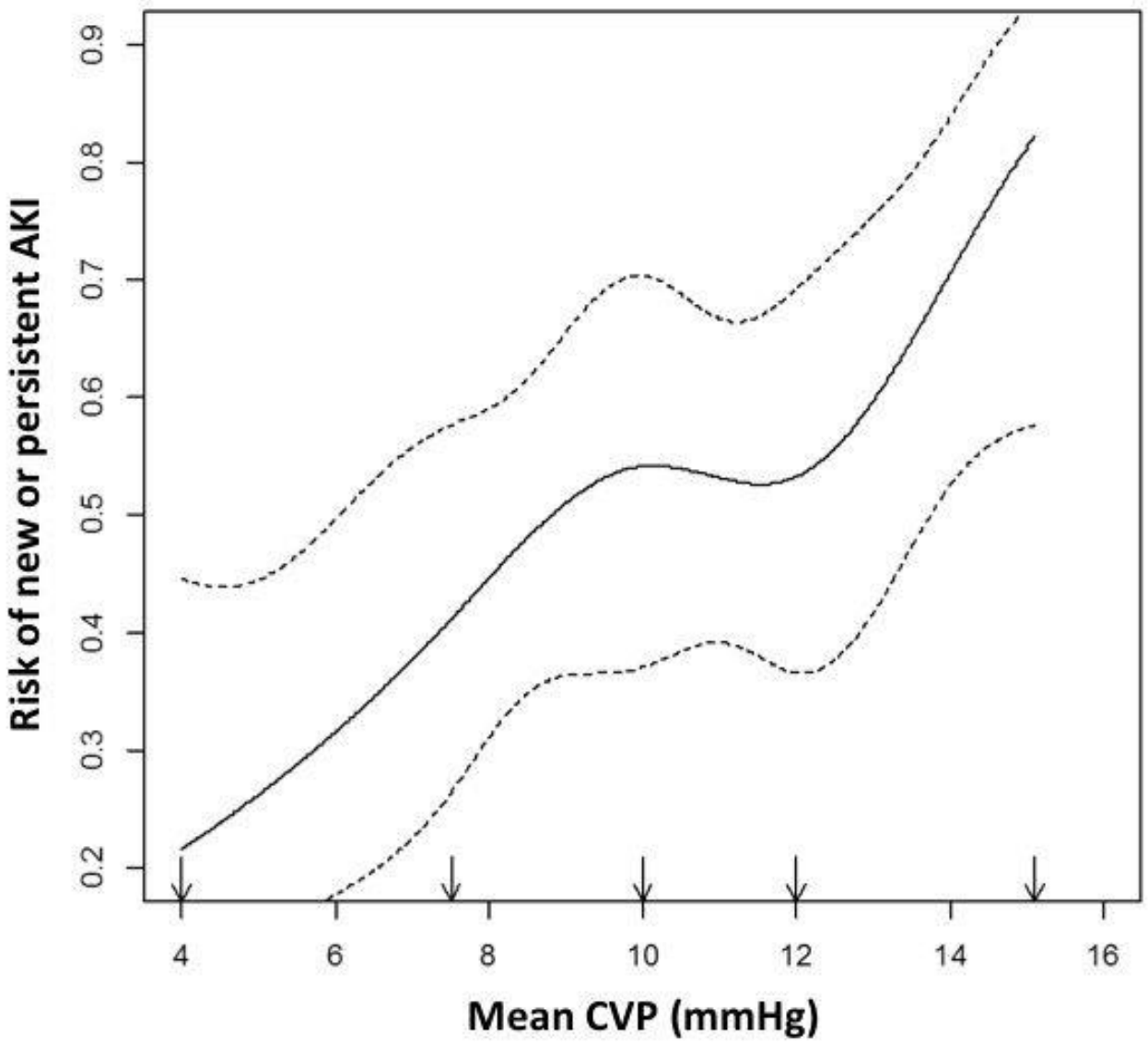
Courtesy of prof S. Scolletta

RESEARCH Open Access

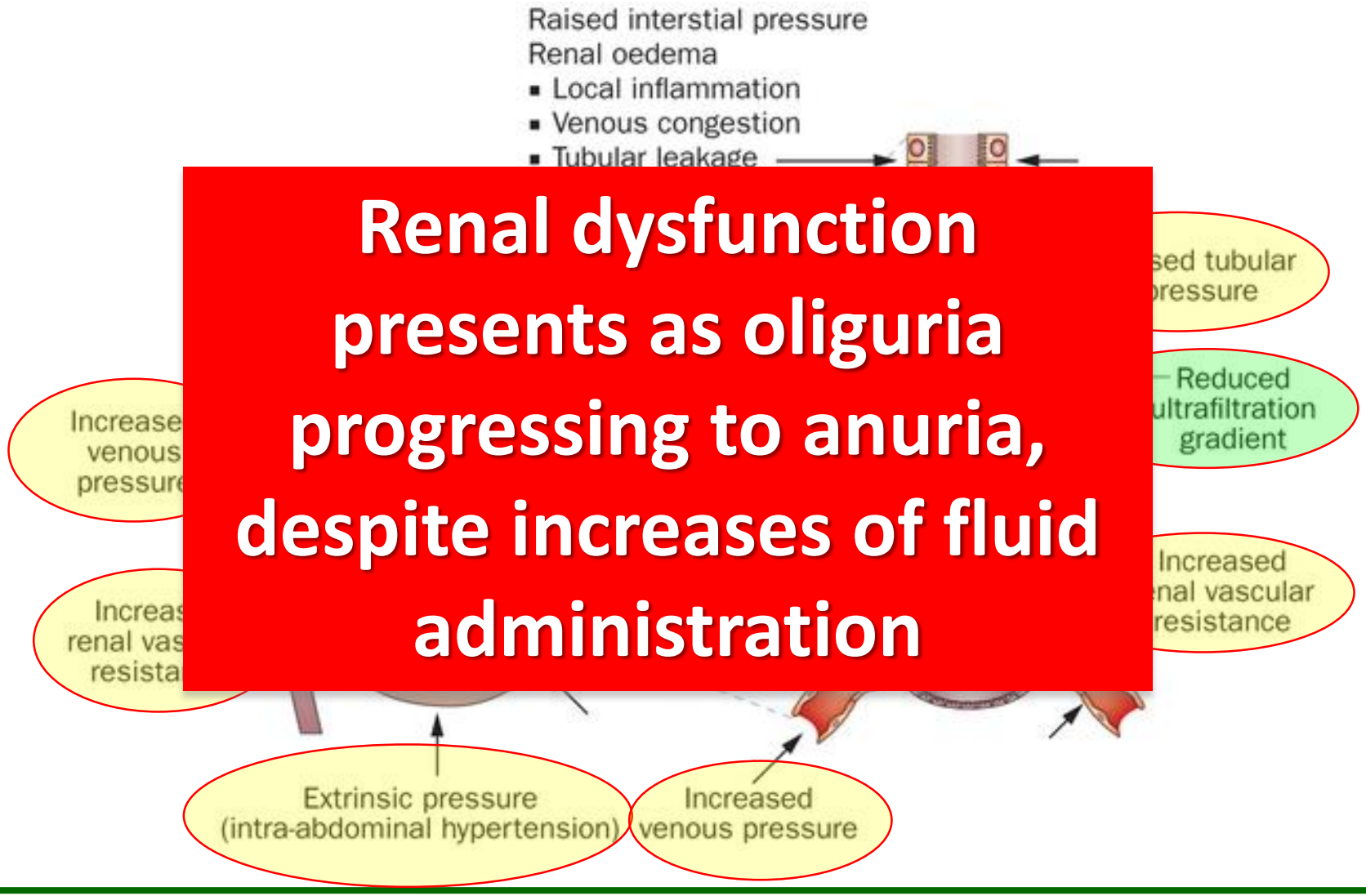
Association between systemic hemodynamics and septic acute kidney injury in critically ill patients: a retrospective observational study

Matthieu Legrand[1,2*], Claire Dupuis[1], Christelle Simon[1], Etienne Gayat[1,3], Joaquim Mateo[1], Anne-Claire Lukaszewicz[1,2,4] and Didier Payen[1,2,4]

CRITICAL CARE



Renal Compartment Syndrome (post-renal AKI)



Renal dysfunction presents as oliguria progressing to anuria, despite increases of fluid administration

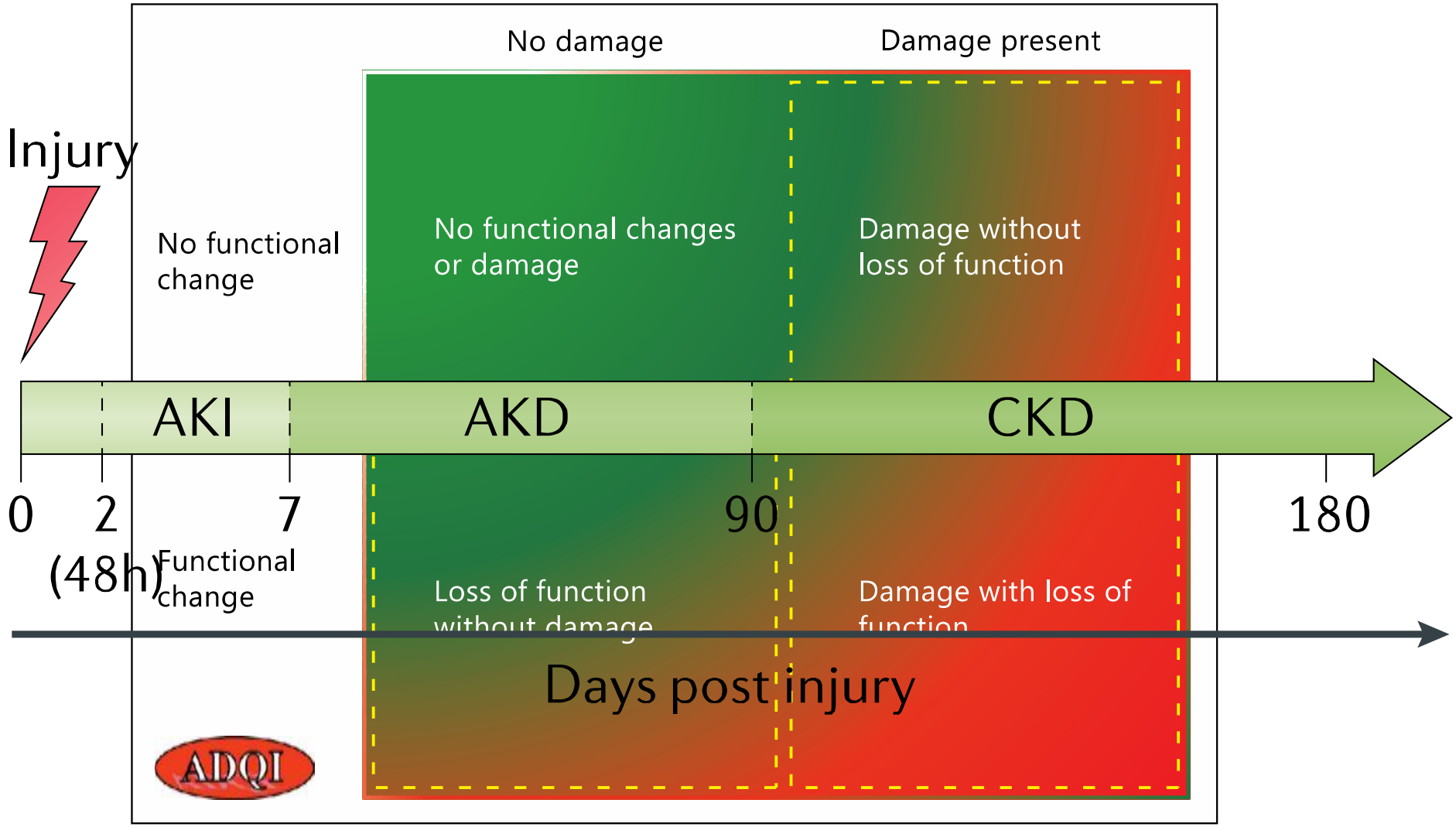
Balogh Z et al. Lancet 2014; 384: 1466–75

TRANSIENT AKI (it does not exclude harm)

PERSISTENT AKI

-FUNCTIONAL AKI

-DAMAGE AKI



5. Antibiotic dosing should be always reduced during CRRT

ELSEVIER

Contents lists available at ScienceDirect

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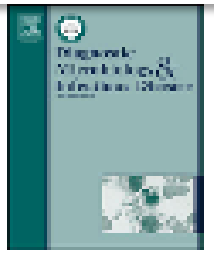


How can we ensure el ients

receiving different typ

Janattul-Ain Jamal [a], Bruce A n A. Roberts [a,d,*]

[a] Burns Trauma and Critical Care Research Centr
[b] Department of Clinical Social and Administrath
[c] Department of Anaesthesia and Intensive Care,
[d] Royal Brisbane and Women's Hospital, Herston

2015

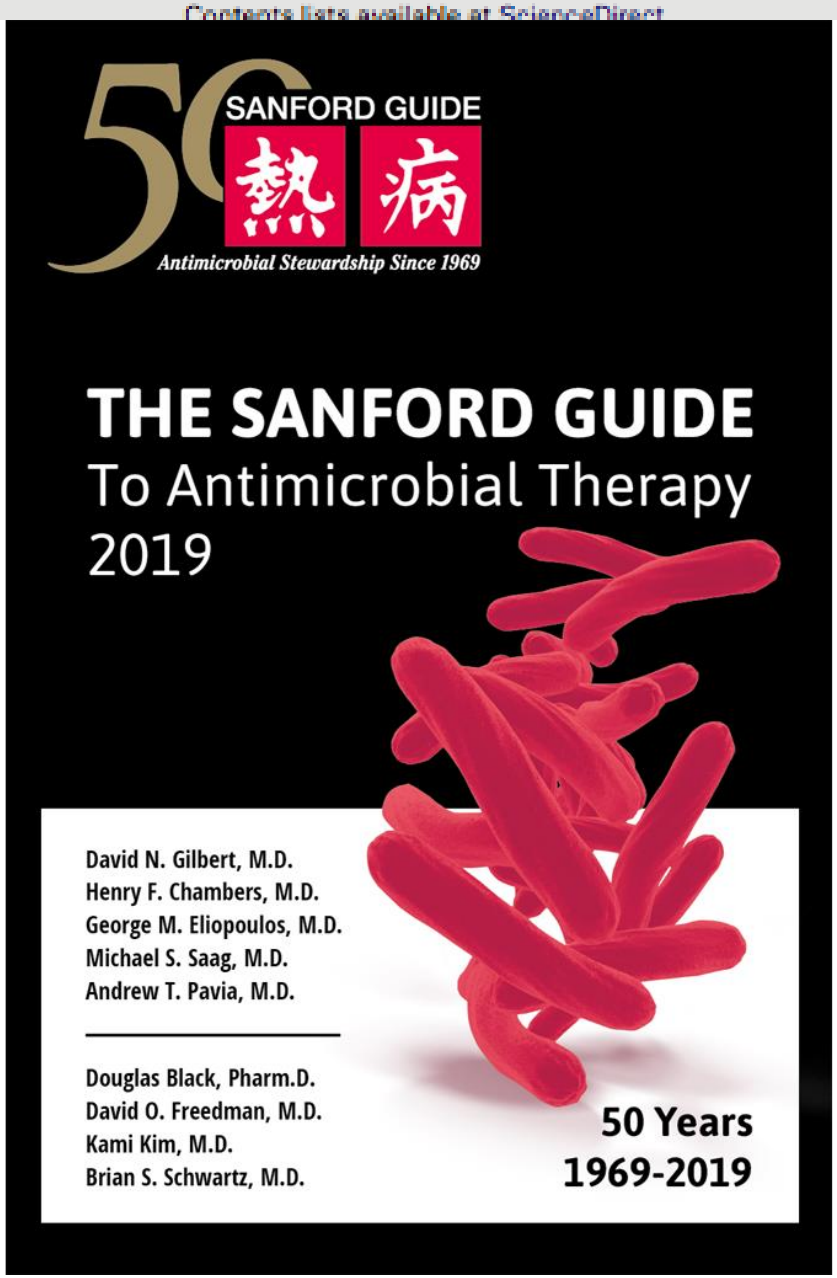


Table 1
Pharmacokinetic parameters of different classes of antibiotics in

Drug/(Reference)	Type of RRT/No. of patients (n)	RRT settings Qb (mL/min)	AUC_{0-T} (mg.h/L)	Cl_{total} (mL/min)	Cl_{RRT} (mL/min)	S_c
Aminoglycosides						
Amikacin* (Akers et al., 2011)	CVVH (n = 12)	NA	214.8 ± 113.8[b]	146.7 ± 148.3	NA	NA
Amikacin (Taccone et al., 2011)	CVVHDF (n = 13)	150.0	NA	88.2[b,f] (7.0–231.0)	NA	NA
Amikacin (D'Arcy et al., 2012)	CVVHDF (n = 5)	200.0	NA	58.0 ± 12.3	47.7 ± 6.8	0.8 ± 0.1
Gentamicin (Petejova et al., 2012a)	CVVH (n = 7)	200.0	NA	61.2[b] (44.1–107.1)	28.8[b] (27.9–30.6)	0.8

PK, SC and drug removal during CRRT

DRUG	Renal excret	Free fract (%)	Vd (L Kg^{-1})	MW (Da)	SC	RRT Removal
Amikacine	95%	>95%	0.22	586	0.95	S
Amphotericin B	5-10%	10%	4	926	0.35	N
Cefepime	85%	84%	0.3	481	0.72	S
Ceftazidime	60-85%	83%	0.28-0.40	547	0.90	S
Ceftriaxone	30-65%	10%	0.12-0.18	553	0.20	<< other beta-lactams
Ciprofloxacine	50-70%	60-80%	2.5	331	0.70	S
Fluconazole	70%	88%	0.70	306	0.88	↑
Gentamicin	95%	>95%	0.23	478	0.81	S
Imipenem/Cilast	20-70 / 60%	79-87% / 56%	0.22 / 0.24	317/380	0.90/0.75	S
Meropenem	65%	98%	0.35	437	1.0	S
Piperacillin/ Tazobactam	75-90 / 65%	70% / 78%	0.25 / 0.21	540/322	0.82	S (Piperacillina > Tazob.)
Teicoplanin	40-60%	10-40%	0.5-1.2	1885	0.05	low
Vancomicin	90-100%	50-90%	0.47-1.1	1448	0.70-0.80	S

Variability of antibiotic concentrations in critically ill patients receiving continuous renal replacement therapy: A multicentre pharmacokinetic study*

Darren M. Roberts, PhD; Jason A. Roberts, PhD; Michael S. Roberts, PhD; Xin Liu, PhD; Priya Nair, FCICM; Louise Cole, PhD; Jeffrey Lipman, MD; Rinaldo Bellomo, MD; on behalf of the RENAL Replacement Therapy Study Investigators

CCM 2012

- Wide variability in trough concentrations: 6.7-fold for meropenem, 3.8-fold for piperacillin, 10.5-fold for tazobactam, 1.9-fold for vancomycin, and 3.9-fold for ciprofloxacin.

- Overall, **15% of dosing intervals did not meet predetermined minimum therapeutic target concentrations**, 40% did not achieve the higher target concentration, and, during **10% of dosing intervals, antibiotic concentrations were excessive**.

Optimizing ceftolozane-tazobactam dosage in critically ill patients during continuous venovenous hemodiafiltration

Gerardo Aguilar[1,2*], Rafael Ferriols[2,3], Sara Martínez-Castro[1,2], Carlos Ezquer[2,3], Ernesto Pastor[1,2], José A. Carbonell[1,2], Manuel Alós[2,3] and David Navarro[2,4,5]

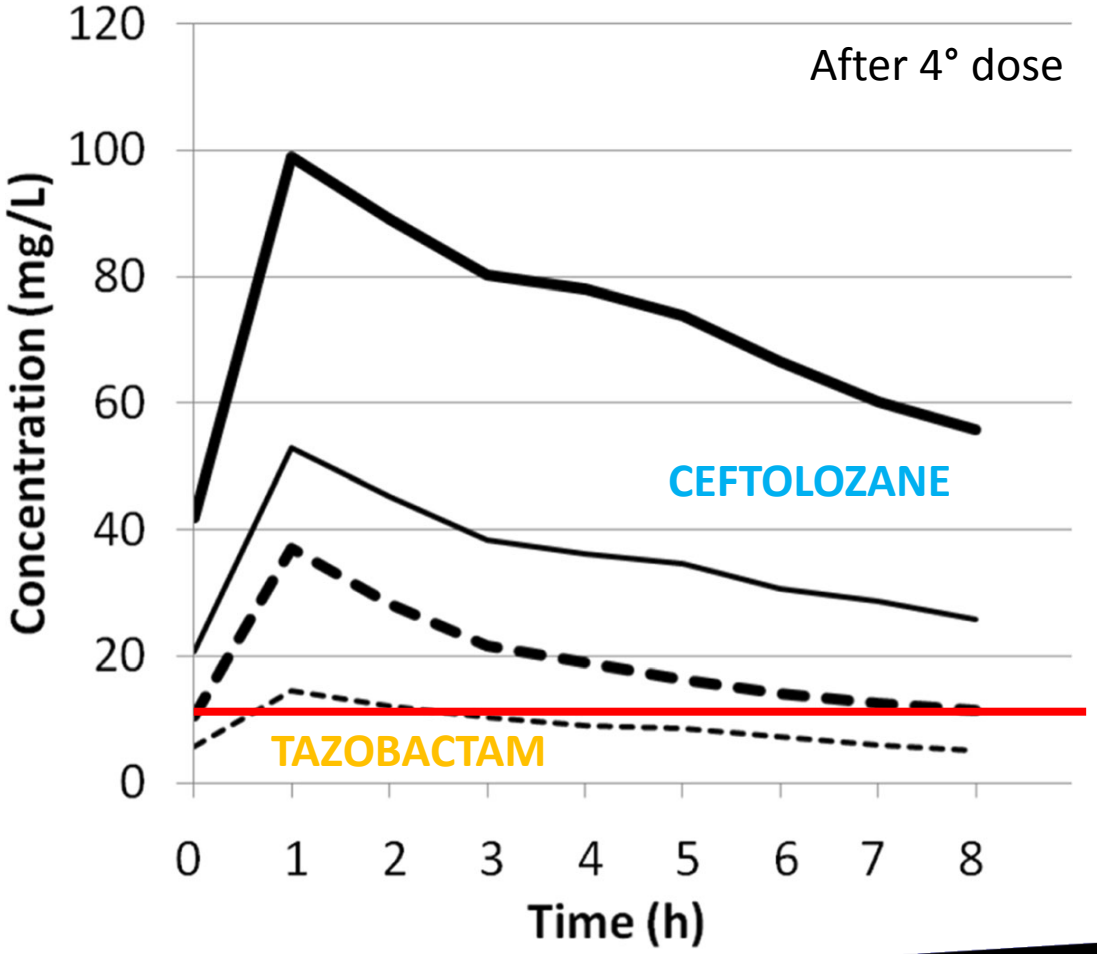


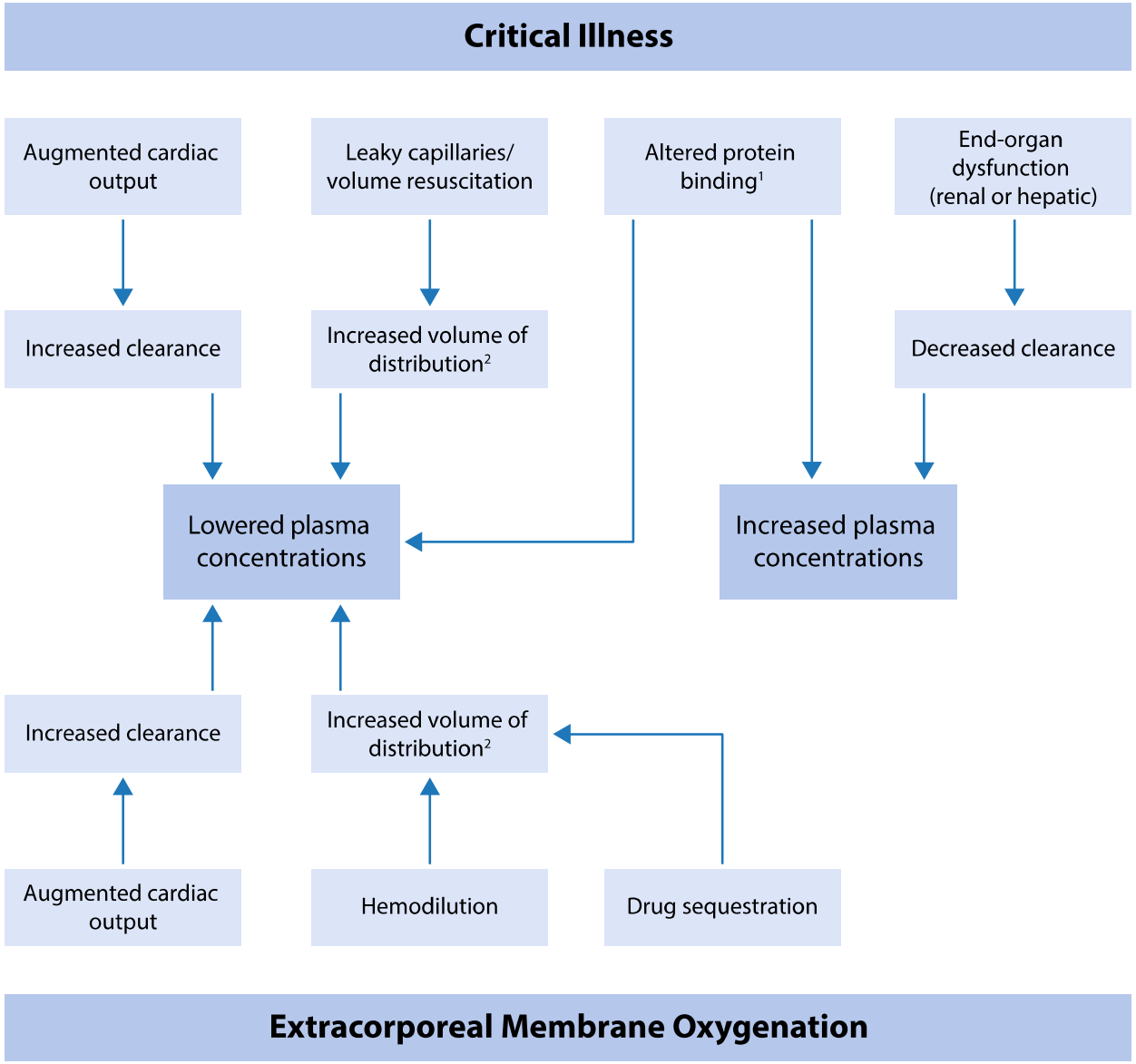
Table 2 Pharmacokinetic parameters of ceftolozane and tazobactam

Parameter	Ceftolozane		Tazobactam	
	Pre-filter	Post-filter	Pre-filter	Post-filter
Clearance (L/h)	2.1	5.4	6.4	17.4
Volume of distribution (L)	53.9	97.5	108.9	194.2
Half-life (h)	17.9	12.6	11.9	7.8
AUC (h mg/L)	960	373	157	57.6
Maximum concentration (mg/L)	99	53	37	14.5
Minimum concentration (mg/L)	55.9	25.8	11.4	5.1

AUC area under the concentration-time curve

….in ECMO the condition is even worse

- Criticall… …ickly changin… inflamm…
- In patie… …e that **volume**… …nts undergo… …equently high init…
- On the … …ed with CRRT ar… …doses had to b…



- Antibiotic, S…
- Shekar, CC 2… …study investigators meropenem… …ment therapy on
- Goncales-Pe…

5. Antibiotic dosing might be adjusted during CRRT

1. Therapeutic drug dosing is a mandatory requirement for the future
2. ABT adjustments should consider the renal dose, the utilized membrane, Vd of the patient
3. Side effects should be included in this process
4. Probably ABT dose should be rarely reduced, sometimes increased, tendentially left unchanged

6. Anticoagulation of CRRT circuit is not needed during ECMO

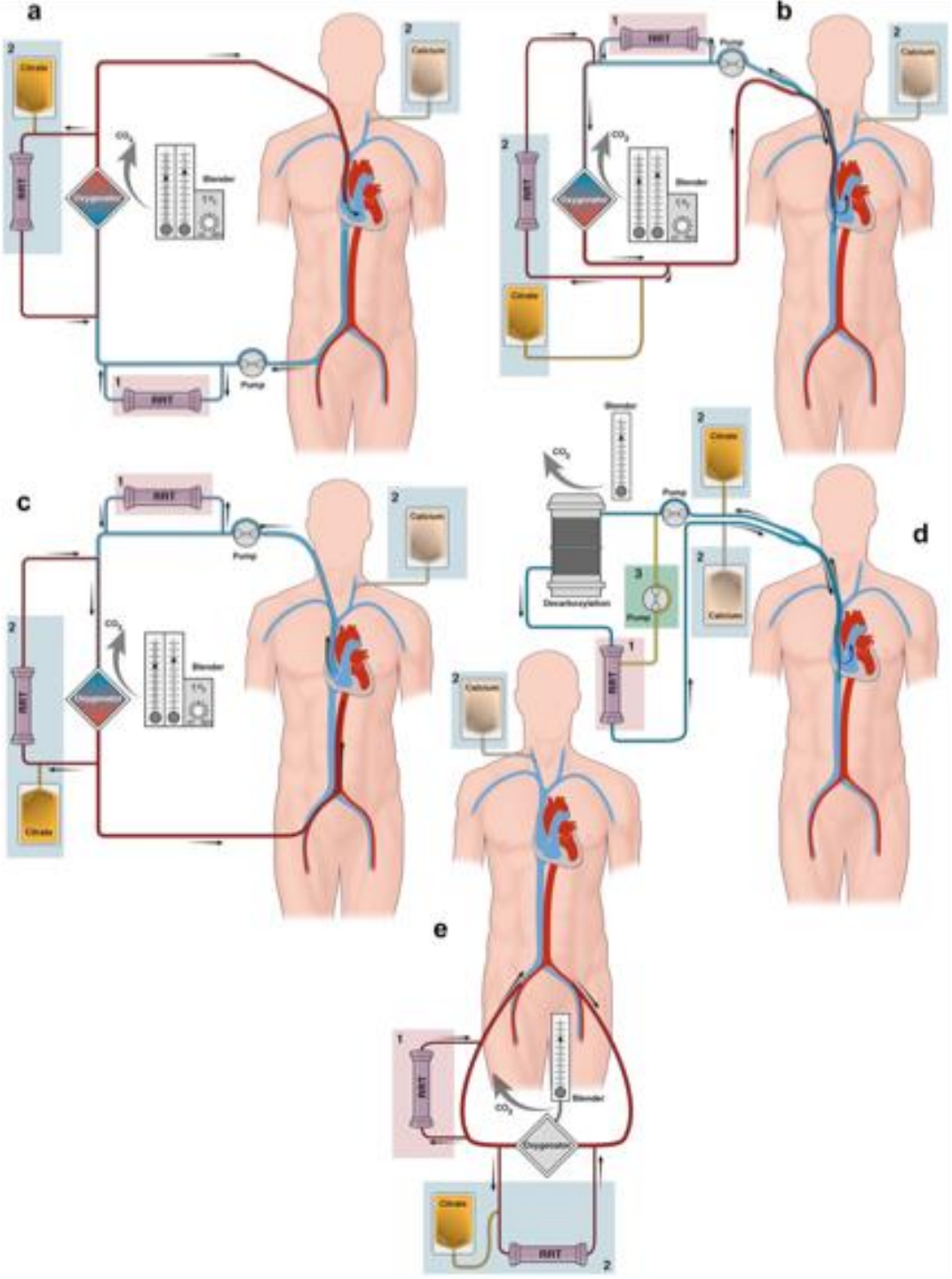
LETTER Open Access

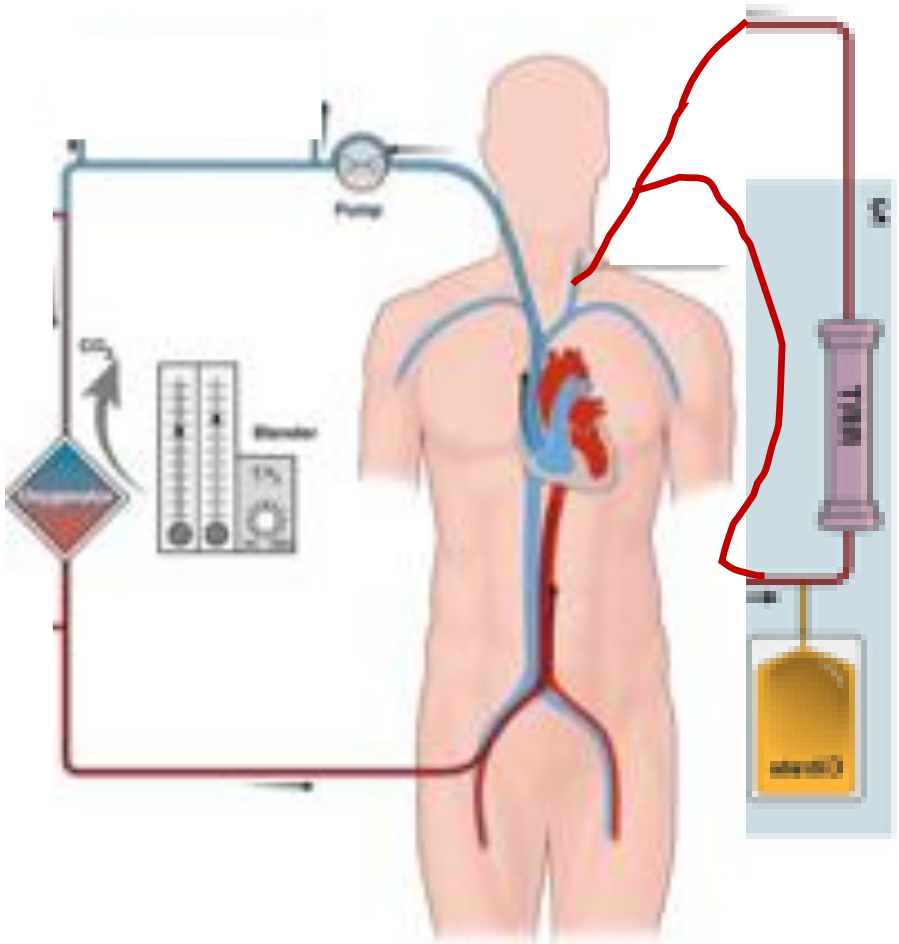
Intertwining extracorporeal membrane oxygenation and continuous renal replacement therapy: sense or nonsense?

Rita Jacobs, Patrick M Honore* and Herbert D Spapen

See related research by Chen *et al.*, http://ccforum.com/content/18/6/675

…." we **strongly argue against the combined use of ECMO and CRRT** within a sing circuit. … A separate CRRT device can perfectly run under a proper dedicated anticoagulation therapy (for example, regional citrate).
This permits avoidance of ECMO-induced" effects such as " anticoagulant dilution, resulting in less thrombotic events," and "shear stress, activation of the clotting cascade and release noxious cytokines, which exposes patients to the potential life-threatening effects of hemolysis, disseminated intravascular coagulation and enhanced systemic inflammation"





Husain-Syed, ICM 2018

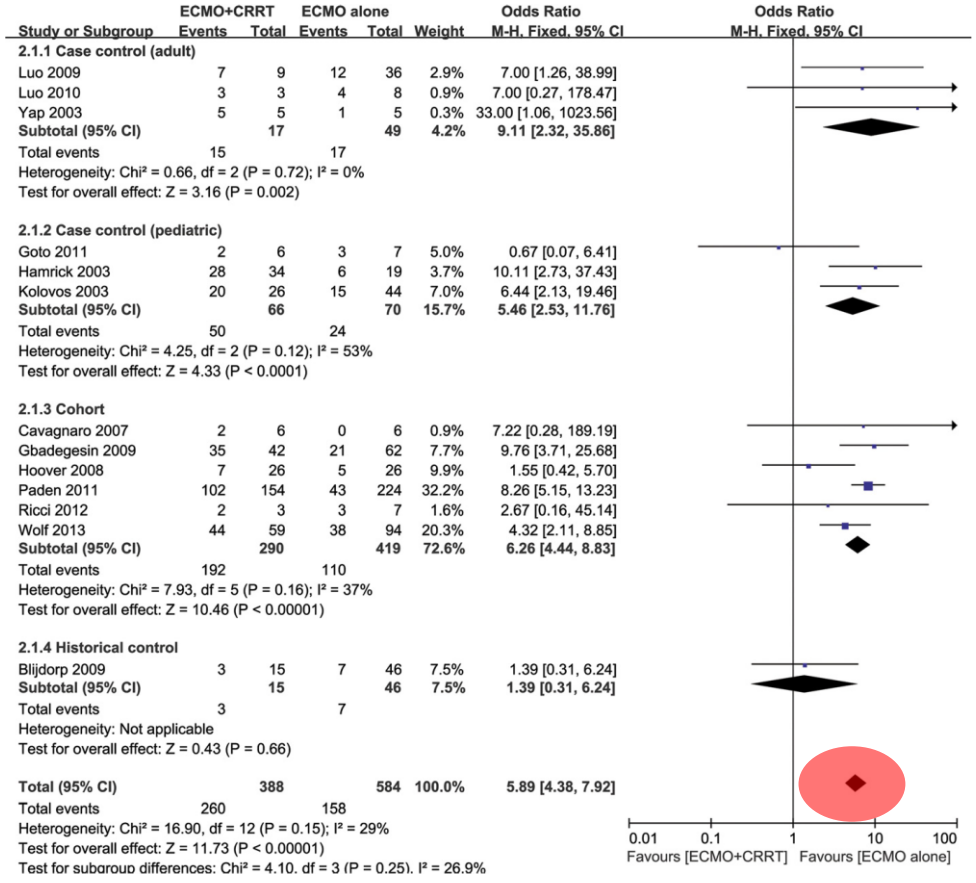
Chen et al. Critical Care 2014, 18:675
http://ccforum.com/content/18/6/675

CRITICAL CARE

RESEARCH Open Access

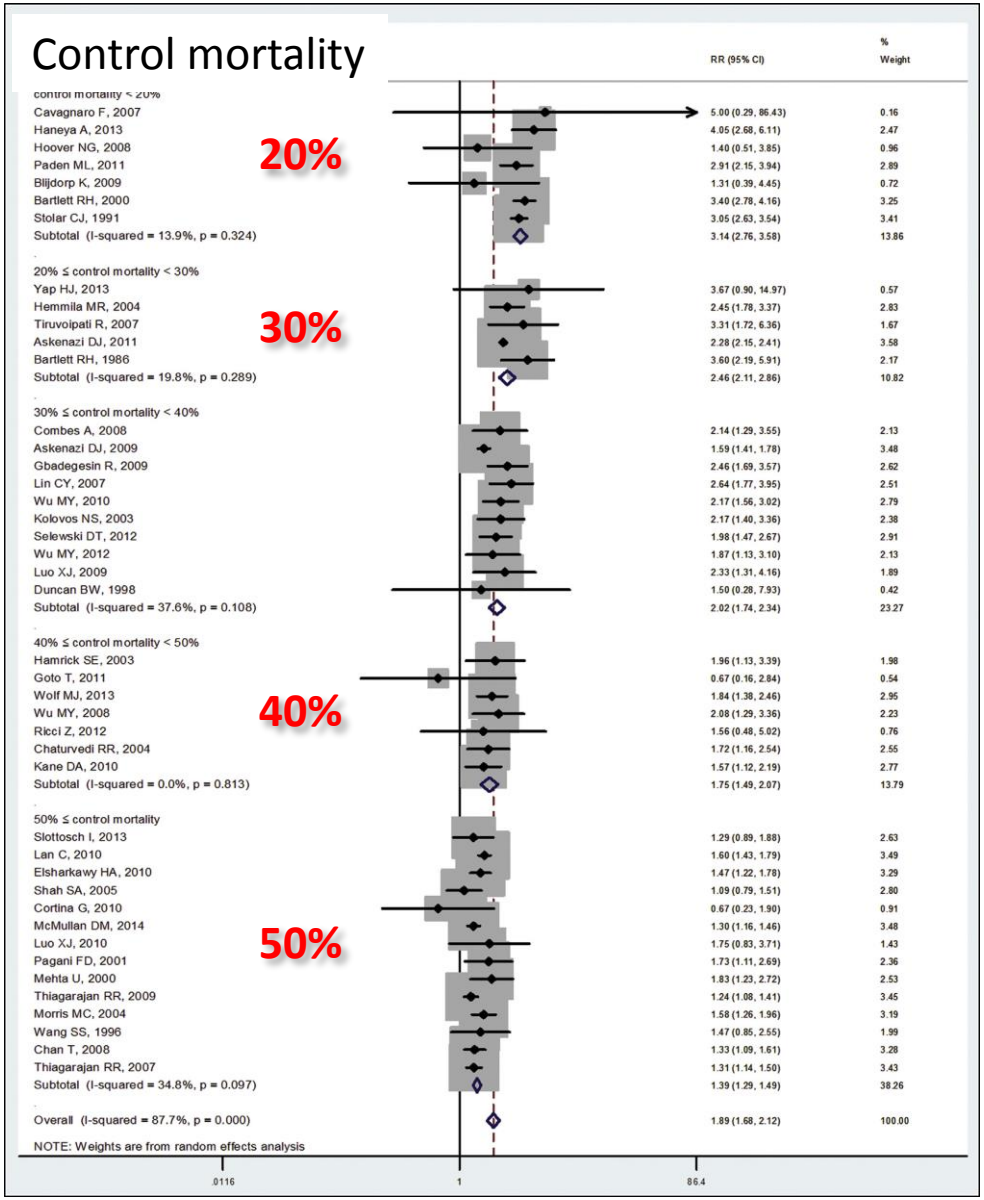
Combination of extracorporeal membrane oxygenation and continuous renal replacement therapy in critically ill patients: a systematic review

Han Chen[1], Rong-Guo Yu[2], Ning-Ning Yin[1] and Jian-Xin Zhou[1*]



Effects of Renal Replacement Therapy in Patients Receiving Extracorporeal Membrane Oxygenation: A Meta-Analysis

Ann Thor Surg 2015

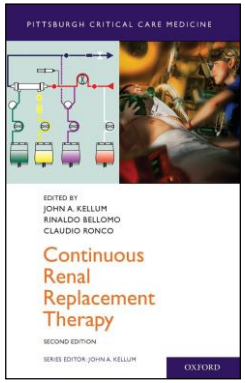


Continuous renal replacement therapy during extracorporeal membrane oxygenation: why, when and how?

Marlies Ostermann[a], Michael Connor Jr[b,c], and Kianoush Kashani[d]

Table 2. Methods of combining continuous renal replacement therapy with extracorporeal membrane oxygenation

Combination of CRRT and ECMO	Specific type	Advantages	Disadvantages/risks
Integrated approach	In-line haemofilter	Relatively easy to set up Low cost Ability to generate large volumes of ultrafiltrate No need for separate anticoagulation	No pressure monitoring Requires external pump to control ultrafiltration Less precise ultrafiltration Risk of excessive ultrafiltration Limited solute clearance Flow turbulences and risk of haemolysis
	Integration of CRRT device in ECMO circuit	Provision of ultrafiltration and solute clearance Mode of solute clearance not restricted Control of ultrafiltration No need for separate vascular access No need for separate anticoagulation	exposure of CRRT machine to pressures outside the safety range Risk of air entrapment Flow turbulences and risk of haemolysis Risk of thrombus formation on the additional connectors Generation of shunt within ECMO circuit
	Connection of CRRT device to oxygenator	Control of ultrafiltration Pressures maintained within safety range of CRRT device	Potential risk of interfering with oxygenator
Parallel systems	Separate CRRT and ECMO circuits	Provision of ultrafiltration and solute clearance Mode of solute clearance not restricted Precise fluid removal Ability to provide CRRT independent of ECMO No need for separate anticoagulation Option of using separate anticoagulation method to keep CRRT circuit patent No need to involve ECMO team when changing CRRT circuit	Need for separate vascular access Increased difficulty caring for patient with two separate extracorporeal circuits Higher extracorporeal blood volume



NO ANTICOAGULATION IS REASONABLE IN SELECTED CASES

It is not necessary to use full heparin anticoagulation every time the clinicians are concerned about the bleeding risks

- After major surgery and/or epidural cath → no anticoagulation for the first 24-48 hours (or citrate) maybe a safer option
- When another extracorporeal treatment is running (i.e. ECMO) → no additional anticoagulation should be considered
- **Patients already receiving "full" anticoagulation for other reasons** (i.e warfarin or LMWH for mechanical prosthetic valves)

- A filter life 20-24 hours can be considered a benchmark of adequate patency: if such average duration of a circuit is possible without the administration of any anticoagulation, then the treatment duration can be considered adequate

---

Kellum JA, Bellomo R, Ronco C - 2015

LESS…. ANTICOAGULATION

HEPARIN DOSING GUIDE			
Heparin infusion rate	INR	aPTT	Platelets
10 IU/Kg/h	< 1.5	< 40 s	> 150,000 / mL
5 IU/Kg/h	>1.5 but < 2.5	> 40 s but < 60 s	< 150,000 / mL > 75,000 / mL
No anticoagulation	> 2.5	> 60 s	< 75,000 mL

Kellum JA, Bellomo R, Ronco C - 2015

Continuous Renal Replacement Therapy in Venovenous Extracorporeal Membrane Oxygenation: A Retrospective Study on Regional Citrate Anticoagulation

ASAIO 2019

Marco Giani,* Vittorio Scaravilli,† Flavia Stefanini,‡ Gabriele Valsecchi,‡ Roberto Rona,* Giacomo Grasselli,†§ Giacomo Bellani,*‡ Antonio M. Pesenti,†§ and Giuseppe Foti*‡

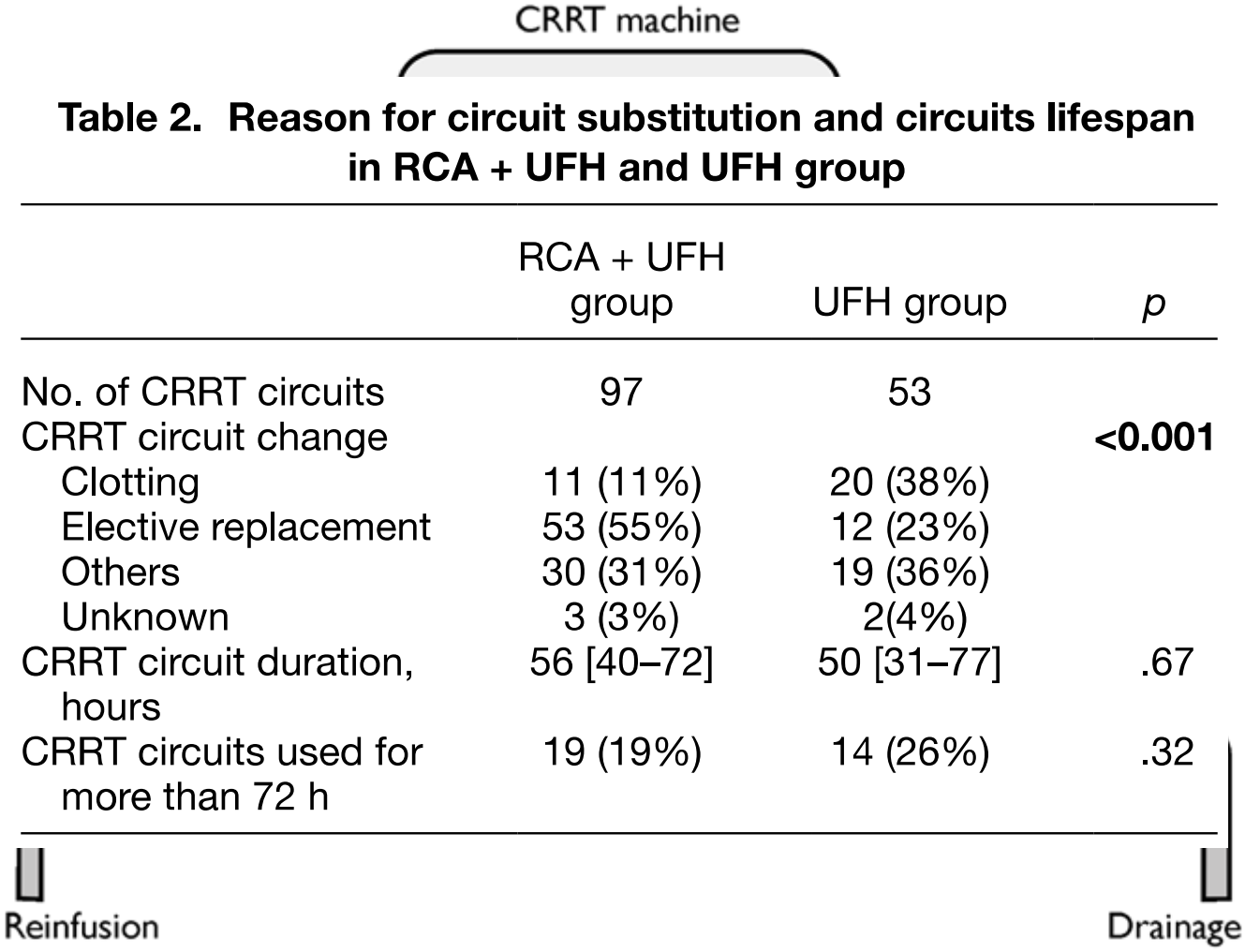


Table 2. Reason for circuit substitution and circuits lifespan in RCA + UFH and UFH group

	RCA + UFH group	UFH group	*p*
No. of CRRT circuits	97	53	
CRRT circuit change			**<0.001**
Clotting	11 (11%)	20 (38%)	
Elective replacement	53 (55%)	12 (23%)	
Others	30 (31%)	19 (36%)	
Unknown	3 (3%)	2(4%)	
CRRT circuit duration, hours	56 [40–72]	50 [31–77]	.67
CRRT circuits used for more than 72 h	19 (19%)	14 (26%)	.32

-Clotting: increase of pressure across the filter (*e.g.* pressure drop > 150 mmHg) or presence of visible clots that required circuit replacement to continue CRRT treatment
-Unscheduled change: before 72 hours uninterrupted CRRT

- 48 patients CRRT during vv-ECMO in the study period.
- CRRT circuit clotting was 11% in the 22 RCA + UFH group *vs.* 38% in the 15 UFH group ($p < 0.001$). -11 received both and were exclud-
- No complication with citrate anticoagulation

7. Blood flow rates cause hypotension

- FALSE!
- WHEN THE TREATMENT IS STARTED THE SAME AMOUNT OF BLOOW THAT IS WITHDRAWN FROM THE VEIN IS ALSO REINFUSED (IN THE SAME VEIN)
- VENOUS RETURN IS NOT AFFECTED AT STEADY STATE
- (OTHERWISE V-V ECMO WOULD ALWAYS IMPLY A CATASTROPHIC HEMODYNAMIC INSTABILITY)

7. Blood flow rates cause hypotension

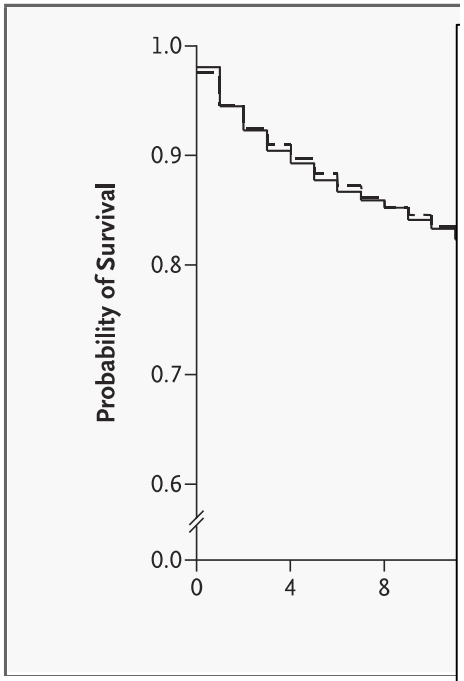
- Priming the extracorporeal circuit with patient's blood without reinfusing the priming solution causes a relative hypovolemia.
- Net ultrafiltration rate exceeding the rate of intravascular refilling leads to hypovolemia
- Vasoactive drugs dilution/removal during ET may decrease serum concentration and therapeutic effect.
- Sudden decrease in blood osmolality during intermittent hemodialysis (disequilibrium syndrome) has been shown to be a risk factor for hemodynamic worsening.

8. Negative RCTs are not useful

ORIGINAL ARTICLE

A Comparison of Albu
Resuscitation in th

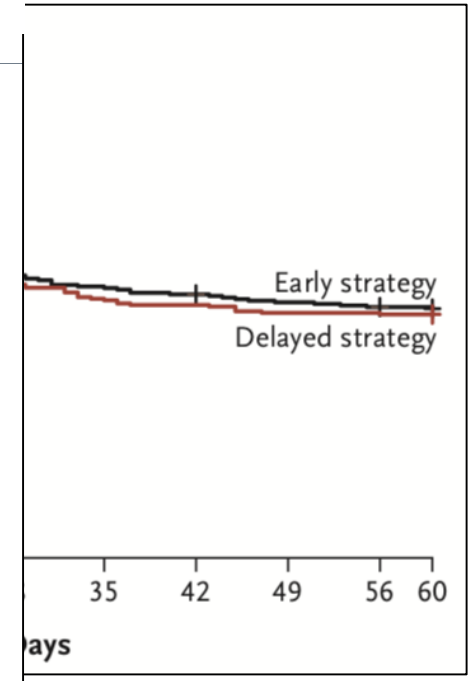
The SAFE Stu



ORIGINAL ARTICLE

Renal-Replacement
nsive Care Unit

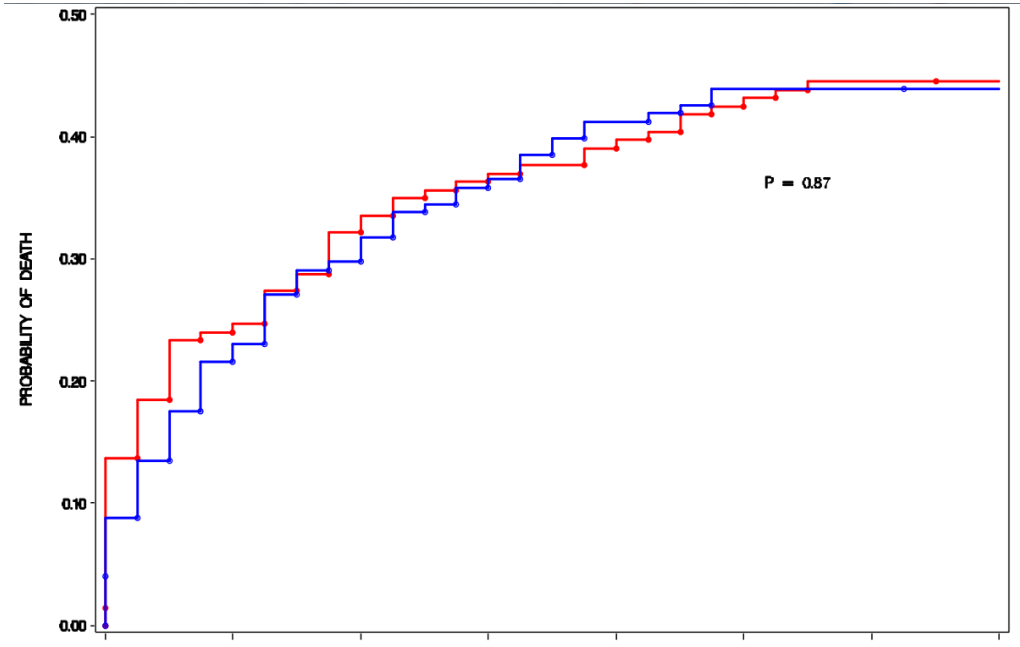
roup



JAMA | Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

Effect of Targeted Polymyxin B Hemoperfusion on 28-Day Mortality in Patients With Septic Shock and Elevated Endotoxin Level

The EUPHRATES Randomized Clinical Trial



8. Negative RCTs are fundamental

EDITORIAL

Improved survival in critically ill patients: are large RCTs more useful than personalized medicine? Yes

Rinaldo Bellomo[1,4*], Giovanni Landoni[2] and Paul Young[3]

EDITORIAL

Improved survival in critically ill patients: are large RCTs more useful than personalized medicine? No

Jean-Louis Vincent[*]

1. All clinicians are attracted by the belief that their actions are important or even life-saving.

easy to accept the idea that a plausible biological hypothesis (i.e. high

nbiased information to guide other

bvious, clinicians cannot really

- They a… endorsed
- Detractors of (negative) RCTs claim t… essentially wrong comparators: this might be true w…
- Also it is stated that most (positive) RCTs only provided evidence o… of a beneficial treatment
- **Precision medicine is delivered on the basis of the interpretation and integration of many forms of evidence**

1) RCT and precision medicine are complementary
2)Negative RCTs allow the possibility of writing EDITORIALS!

9. Studies on children are not useful on adult patients

Studies typically cited on adult meetings including children:

1) NGAL in pediatric cardiac surgery, Mishra J, the Lancet 2005
2) Children with MODS and CRRT, Goldstein S, KI 2005
3) FEAST trial, K Maitland, the NEJM 2011
4) AKI definition, KDIGO guidelines, KI 2012
5) Fluid overload and outcomes, Alobaidi R, pJAMA 2018

9. Studies on children are useful on adult patients

Other settings where «peds» are certainly going to contribute to the field

1) Renal Angina Index (Basu, Lancet Child Adolesc Health 2018)
2) ECMO and CRRT (Mallory, Selewsky, Profeta)
3) Follow-up of patients receveri

REMEMBER NOT TO OVERLOOK CLINICAL INSIGHTS DERIVING FROM PEDIATRIC SCIENCE!

10. We like the idea of removing the term «renal» from all CCN acronyms

End Stage Renal Disease = End Stage Kidney Disease
Chronic Renal Failure = Chronic Kidney Disease
Acute Renal Failure = Acute Kidney Injury

Renal Replacement Therapy = Extracorporeal Kidney Support
Continuous Renal Replacement Therapy = Continuous Kidney Replacement Therapy
Circuit Clotting = Artificial Kidney Failure

Noradrenaline = Norepinephrine
Renal Angina Index = Kidney Pain Score
RENAL Study = KIDNEY Trial

10. We do not like the idea of removing the term «renal» from all CCN acronyms

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Critical Care

REVIEW Open Access

Nomenclature for renal replacement therapy and blood purification techniques in critically ill patients: practical applications

Gianluca Villa[1,2], Mauro Neri[1,3], Rinaldo Bellomo[4], Jorge Cerda[5], A. Raffaele De Gaudio[2], Silvia De Rosa[1], Francesco Garzotto[1], Patrick M. Honore[6], John Kellum[7], Anna Lorenzin[1], Didier Payen[8], Zaccaria Ricci[9], Sara Samoni[10], Jean-Louis Vincent[11], Julia Wendon[12], Marta Zaccaria[1], Claudio Ronco[1*], on behalf of the Nomenclature Standardization Initiative (NSI) Alliance

Abstract

This article reports the conclusions of the second part of a consensus expert conference on the nomenclature of renal replacement therapy (RRT) techniques currently utilized to manage acute kidney injury and other organ dysfunction syndromes in critically ill patients. A multidisciplinary approach was taken to achieve harmonization of definitions, components, techniques, and operations of the extracorporeal therapies. The article describes the RRT techniques in detail with the relevant technology, procedures, and phases of treatment and key aspects of volume management/fluid balance in critically ill patients. In addition, the article describes recent developments in other extracorporeal therapies, including therapeutic plasma exchange, multiple organ support therapy, liver support, lung support, and blood purification in sepsis. This is a consensus report on nomenclature harmonization in extracorporeal blood purification therapies, such as hemofiltration, plasma exchange, multiple organ support therapies, and blood purification in sepsis.

Keywords: Terminology, Pump, Pressure sensor, CRRT machine, Continuous veno-venous hemodialysis, Continuous veno-venous hemofiltration, Continuous veno-venous hemodiafiltration, High volume hemofiltration, Continuous plasmafiltration coupled with adsorption, Hemoperfusion

Abbreviations: AKI, Acute kidney injury; AVVH, Accelerated veno-venous hemofiltration; CPE, Continuous plasma exchange; CPFA, Continuous plasmafiltration coupled with adsorption; CRRT, Continuous renal replacement therapy; CVVH, Continuous veno-venous hemofiltration; CVVHD, Continuous veno-venous hemodialysis; CVVHDF, Continuous veno-venous hemodiafiltration; CVVHFD, Continuous veno-venous high-flux dialysis; ECMO, Extracorporeal membrane oxygenation; ED, Extended dialysis; EDD, Extended daily dialysis; EDDf, Extended daily dialysis with filtration; FPSA, Fractionated plasma separation and adsorption; HVHF, High-volume hemofiltration; ICU, Intensive care unit; IHD, Intermittent hemodialysis; IHDF, Intermittent hemodiafiltration; IHF, Intermittent hemofiltration; IHFD, Intermittent high-flux dialysis; MARS, Molecular adsorbent recirculating system; MOST, Multiple organ support therapy; PIRRT, Prolonged intermittent renal replacement therapy; PMX, Polymyxin; RRT, Renal replacement therapy; SCUF, Slow continuous ultrafiltration; SLED, Sustained low-efficiency dialysis; SLEDD, Slow low-efficiency extended daily dialysis; SPAD, Single pass albumin dialysis; TMP, Transmembrane pressure; TPE, Therapeutic plasma exchange; VHVHF, Very high-volume hemofiltration

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Neri et al. Critical Care (2016) 20:318
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Critical Care

REVIEW Open Access

Nomenclature for renal replacement therapy in acute kidney injury: basic principles

Mauro Neri[1,2], Gianluca Villa[1,3], Francesco Garzotto[1], Sean Bagshaw[4], Rinaldo Bellomo[5], Jorge Cerda[6], Fiorenza Ferrari[1], Silvia Guggia[1], Michael Joannidis[7], John Kellum[8], Jeong Chul Kim[9], Ravindra L. Mehta[10], Zaccaria Ricci[11], Alberto Trevisani[2], Silvio Marafon[12], William R. Clark[13], Jean-Louis Vincent[14], Claudio Ronco[1*] and on behalf of the Nomenclature Standardization Initiative (NSI) alliance

Abstract

This article reports the conclusions of a consensus expert conference on the basic principles and nomenclature of renal replacement therapy (RRT) currently utilized to manage acute kidney injury (AKI). This multidisciplinary consensus conference discusses common definitions, components, techniques, and operations of the machines and platforms used to deliver extracorporeal therapies, utilizing a "machine-centric" rather than a "patient-centric" approach. We provide a detailed description of the performance characteristics of membranes, filters, transmembrane transport of solutes and fluid, flows, and methods of measurement of delivered treatment, focusing on continuous renal replacement therapies (CRRT) which are utilized in the management of critically ill patients with AKI. This is a consensus report on nomenclature harmonization for principles of extracorporeal renal replacement therapies. Devices and operations are classified and defined in detail to serve as guidelines for future use of terminology in papers and research.

Keywords: Terminology, Diffusion, Convection, Ultrafiltration, Transmembrane pressure, CRRT membranes, CRRT modalities, Dose, CRRT efficiency, Clearance

Background

The management of critically ill patients with acute kidney injury (AKI) requiring renal replacement therapy (RRT) demands a multidisciplinary approach. In spite of previous efforts at harmonization, the terminology used to describe the different aspects and modalities of RRT is often confusing. A consensus conference on RRT terminology was organized to develop common definitions for the components, techniques, and operation of the machines and platforms used for acute extracorporeal therapies.

In this article, we report the conclusions of the consensus group on the basic principles underlying RRT technologies and the application of those principles to patient care, using "machine-centric" rather than "patient-centric" terminology. We provide a detailed description of the performance characteristics of membranes and filters, solute and fluid transport mechanisms across membranes, flow rate parameters, and methods of treatment evaluation, focusing on the continuous RRT (CRRT) used in the treatment of critically ill patients.

Methodology

A conference was organized in Vicenza, Italy, to gather experts in CRRT and members of CRRT manufacturing companies to establish consensus on technical terminology and definitions relevant to basic principles of CRRT and related technology [1]. The conference provided the background for a modified Delphi consensus methodology as previously utilized for the Acute Disease Quality initiative consensus sessions [2]. Prior to the conference, participants screened the literature of the last 25 years and previous taxonomy efforts [3–5]. Keywords included "*continuous renal replacement therapy*", "*dialysis*", "*hemofiltration*", "*convection*", "*diffusion*", "*ultrafiltration*", "*dose*", "*blood purification*", "*renal support*", "*multiorgan dysfunction*", together with the

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…LESS FALSE BELIEFS

1. Alteration in intra-RBF may be on the reasons of septic AKI
2. Colloids do not restore intravascular oncotic pressure
3. Diuretics can be indicated in congestive AKI
4. Pre-renal AKI is a flawed paradigm
5. Antibiotic dosing should be adjusted (rarely reduced) during CRRT
6. Several options can be considered for anticoagulation of CRRT circuit during ECMO
7. CRRT Blood flow rates are not the causes of HIRRT
8. Negative RCTs are fundamental
9. Studies on children are VERY useful… for adult patients
10. We like the idea of leaving «renal» on all CCN acronyms