APCN x TSN 2025

23rd Asian Pacific Congress of Nephrology

Gene, Immunology, Vast, MEtabolism at its Finest!

Enhancing AKI Recovery in Dialysis-Dependent Cases
: Customizing Fluid Management and De-escalation Techniques

December 6(Sat), 2025

15:40-15:55

Harin Rhee, MD., PhD.

Pusan National University

Declare

- I have nothing to declare.

Degree of fluid overload at RRT initiation and mortality

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

Multi center prospective study (N=618)
Inclusion: AKI patients in ICU from 1999-2001
Definition of fluid overload (FO): Cumulative FO 10% > baseline BW
Outcome: In-hospital mortality

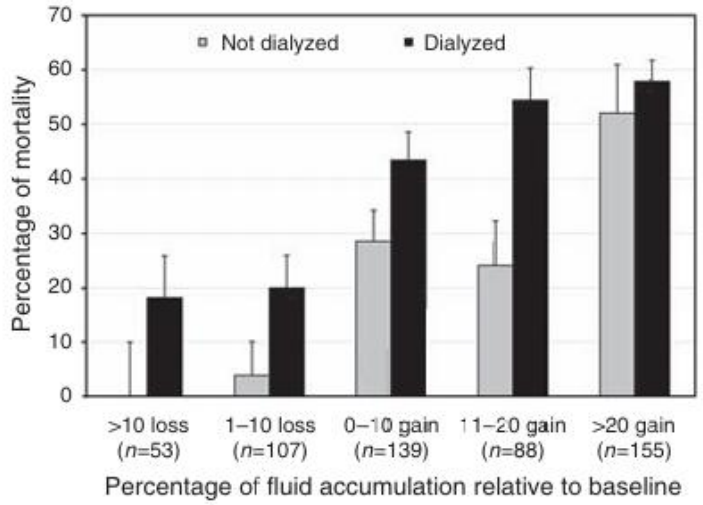

Figure 2 | Mortality rate by final fluid accumulation relative to baseline weight and stratified by dialysis status.

- ✓ Calculation of cumulative fluid balance

%FO = [Σ daily (fluid intake (L)– total output (L)]/ body weight (in kilograms) X100

- ✓ **% FO >10 at dialysis initiation was associated with 2.07 folds higher risk of death**

Degree of fluid overload at RRT initiation and mortality

Associations of fluid overload with mortality and kidney recovery in patients with acute kidney injury: A systematic review and meta-analysis

Ling Zhang, MD [1], Zhiwen Chen, RN [1], Yongshu Diao, RN, MD [*], Yingying Yang, MD, Ping Fu, MD, PhD

Division of Nephrology, West China Hospital of Sichuan University, Sichuan, Chengdu, China

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Bellomo 2012	1.1442	0.1522	23.6%	3.14 [2.33, 4.23]
Bouchard 2009	0.7275	0.2493	16.9%	2.07 [1.27, 3.37]
Fülöp 2010	0.9708	0.4656	7.9%	2.64 [1.06, 6.58]
Grams 2011	0.4762	0.1131	26.3%	1.61 [1.29, 2.01]
Silversides 2014	0.708	0.3034	13.9%	2.03 [1.12, 3.68]
Vaara 2012	0.9655	0.3583	11.4%	2.63 [1.30, 5.30]
Total (95% CI)			**100.0%**	**2.23 [1.66, 3.01]**

Heterogeneity: $Tau^2 = 0.08$; $Chi^2 = 13.14$, df = 5 (P = 0.02); $I^2 = 62\%$

Test for overall effect: Z = 5.27 (P < 0.00001)

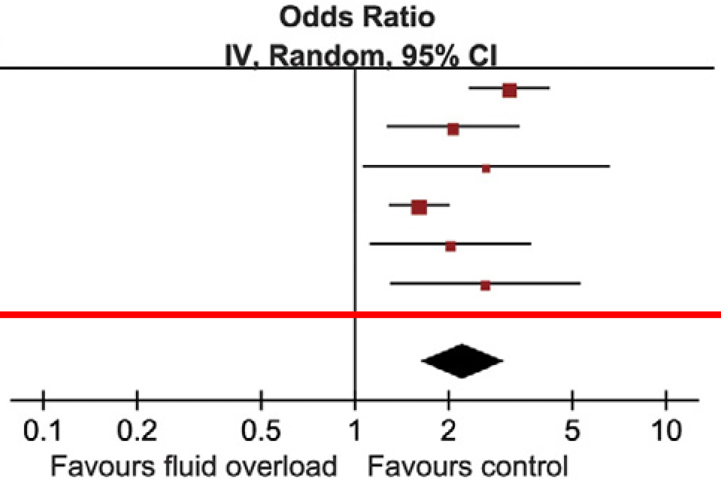

Fig. 3. Forest plot of association between fluid overload (dichotomous variables) and mortality.

Degree of fluid overload at RRT initiation and kidney recovery

Associations of fluid overload with mortality and kidney recovery in patients with acute kidney injury: A systematic review and meta-analysis

CrossMark

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Associations of fluid overload with kidney recovery

Source	Kidney recovery, fluid overload vs control	Unadjusted OR or HR (95% CI)	Adjusted OR or HR (95% CI)
Bouchard et al [12]	40% vs 47%	0.76 (0.54-1.07)	NR
Heung et al [11]	26.4% vs 42.9%	0.48 (0.25-0.92)	0.66 (0.37-1.15)
Xu et al [23]	30.2% vs 56.6%	0.33 (0.18-0.62)	NR
Zhang et al [21]	80% vs 86.3%[a]	0.64 (0.18-2.25)	NR

[a] Kidney recovery rate in survivors.

Definition	Kidney outcome assessment time
CR: serum cr <20% above baseline PR: dialysis independence	At hospital discharge
Discontinue dialysis for >2 weeks	1yr after the initiation of AKI-RRT
- (not found in Pubmed)	
- (found in Pubmed but Chinese)	28 day kidney recovery rate

L. Zhang et al. / Journal of Critical Care 30 (2015) 860.e7–860.e13

Degree of fluid overload at RRT initiation and kidney recovery

A single-center, retrospective analysis of 170 hospitalized adult patients with **AKI requiring dialysis**

- ✓ Renal recovery within 1 year of RRT initiation in 35.9% (61/170)
- ✓ Patients that recovered renal function had significantly less fluid overload at the time of RRT initiation compared to non-recovering patients (3.5 versus 9.3%, P = 0.004)

Cox regression model of risk for renal recovery within 1 year of dialysis initiation (n = 170)

Predictor	Hazard Ratio	95% CI	p-value
% FO at initiation (per 1%)	0.97	(0.95–1.00)	0.024
≥1 comorbidity	0.51	(0.30–0.89)	0.018
Baseline serum creatinine (per 1 mg/dL)	0.56	(0.37–0.87)	0.009
Use of vasopressors	0.49	(0.28–0.85)	0.011
Time between consult and initiation (per day)	0.84	(0.72–0.98)	0.025

The degree of FO at dialysis initiation was and independent predictor of non-recovery
Each 1% of FO was associated with 3% higher risk non-kidney recovery.

Heung et. Al., NDT 2012

RESEARCH **Open Access**

Influence of fluid accumulation on major adverse kidney events in critically ill patients – an observational cohort study

Debora M. Hofer[1*], Livio Ruzzante[1], Jan Waskowski[1], Anna S. Messmer[1] and Carmen A. Pfortmueller[1]

Single center retrospective study (N=13,326)
Inclusion: All ICU admitted patients, 2014-2018
Definition of fluid accumulation (FA): Cumulative FA 5% > baseline BW
Outcome: MAKE 30 (Death, need for new RRT, persistent renal dysfunction)

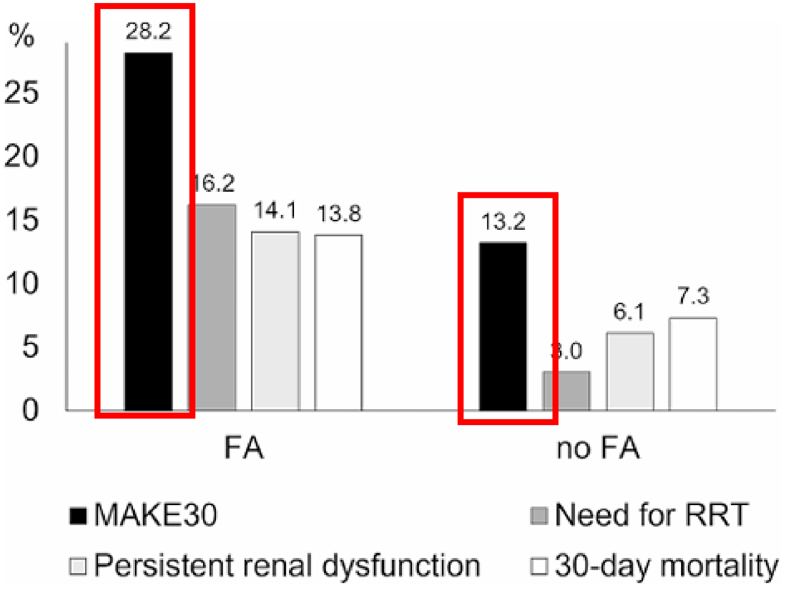

Table 2 Primary and secondary outcomes

	Univariable model (unadjusted)		Multivariable model (adjusted *)	
	OR (95%-CI) / Regression-Co-efficient B (95%-CI)	p-value	OR (95%-CI) / Regression-Co-efficient B (95%-CI)	p-value
Primary endpoint				
MAKE30	2.59 (2.25–2.99)	**< 0.001**	1.96 (1.67–2.30)	**< 0.001**

Hofer *et al. Annals of Intensive Care* (2024) 14:52

Contents

How to handle fluid overload in critically ill patients?

- <u>Prevent</u> fluid overload, if possible
- <u>Effective de-escalation</u>

Contents

How to handle fluid overload in critically ill patients?

- Prevent fluid overload, if possible

 - Restrictive fluid management

- Effective de-escalation

Four phases of intravenous fluid therapy: a conceptual model†

E. A. Hoste[1,2], K. Maitland[3,4], C. S. Brudney[5], R. Mehta[6], J.-L. Vincent[7], D. Yates[8], J. A. Kellum[9], M. G. Mythen[10] and A. D. Shaw[11] for the ADQI XII Investigators Group

Table 1 Characteristics of different stages of resuscitation: 'Fit for purpose fluid therapy'. GDT, goal directed therapy; DKA, diabetic keto acidosis; NPO, nil per os; ATN, acute tubular necrosis; SSC, surviving sepsis campaign

	Rescue	Optimization	Stabilization	De-escalation
Principles	Lifesaving	Organ rescue	Organ support	Organ recovery
Goals	Correct shock	Optimize and maintain tissue perfusion	Aim for zero or negative fluid balance	Mobilize fluid accumulated
Time (usual)	Minutes	Hours	Days	Days to weeks
Phenotype	Severe shock	Unstable	Stable	Recovering
Fluid therapy	Rapid boluses	Titrate fluid infusion conservative use of fluid challenges	Minimal maintenance infusion only if oral intake inadequate	Oral intake if possible Avoid unnecessary i.v. fluids
Typical clinical scenario	- Septic shock - Major trauma	- Intraoperative GDT - Burns - DKA	- NPO postoperative patient - 'Drip and suck' management of pancreatitis	- Patient on full enteral feed in recovery phase of critical illness - Recovering ATN
Amount	Guidelines, for example, SSC, pre-hospital resuscitation, trauma, burns, etc.			

Rescue Phase

Table 1 Characteristics of different stages of resuscitation: 'Fit for purpose fluid therapy'. GDT, goal directed therapy; DKA, diabetic keto acidosis; NPO, nil per os; ATN, acute tubular necrosis; SSC, surviving sepsis campaign

	Rescue		De-escalation
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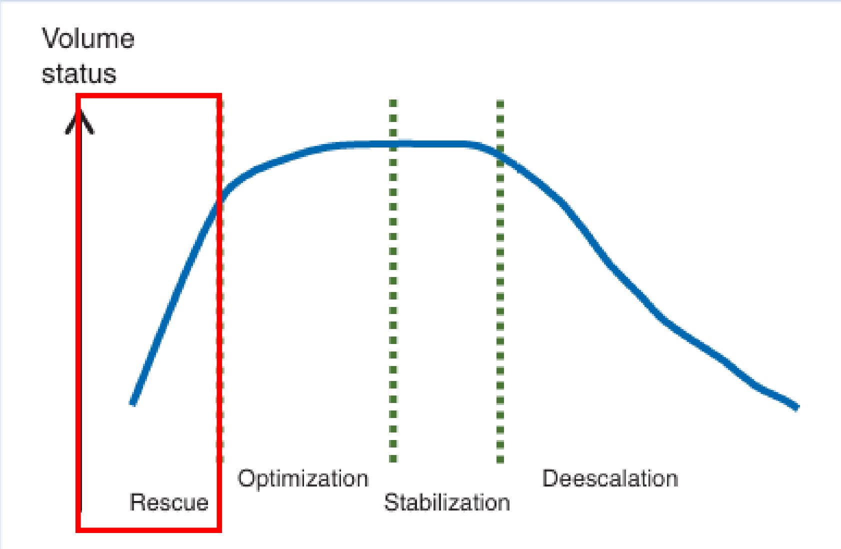

Fig 2 Patients' volume status at different stages of resuscitation. Reproduced with permission from ADQI (www.ADQI.org).

Optimization Phase

Table 1 Characteristics of different stages of resuscitation: 'Fit for purpose fluid therapy'. GDT, goal directed therapy; DKA, diabetic keto acidosis; NPO, nil per os; ATN, acute tubular necrosis; SSC, surviving sepsis campaign

	Rescue	Optimization
Principles	Lifesaving	Organ rescue
Goals	Correct shock	Optimize and maintain tissue perfusion
Time (usual)	Minutes	Hours
Phenotype	Severe shock	Unstable
Fluid therapy	Rapid boluses	Titrate fluid infusion conservative use of fluid challenges
Typical clinical scenario	- Septic shock - Major trauma	- Intraoperative GDT - Burns - DKA
Amount		Guidelines, for example, S

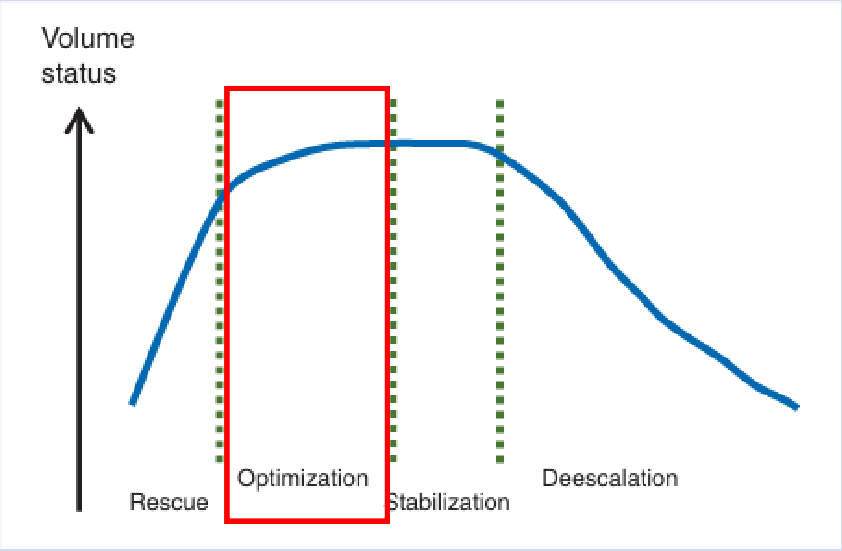

Fig 2 Patients' volume status at different stages of resuscitation. Reproduced with permission from ADQI (www.ADQI.org).

Titration of fluid : Fluid challenge test

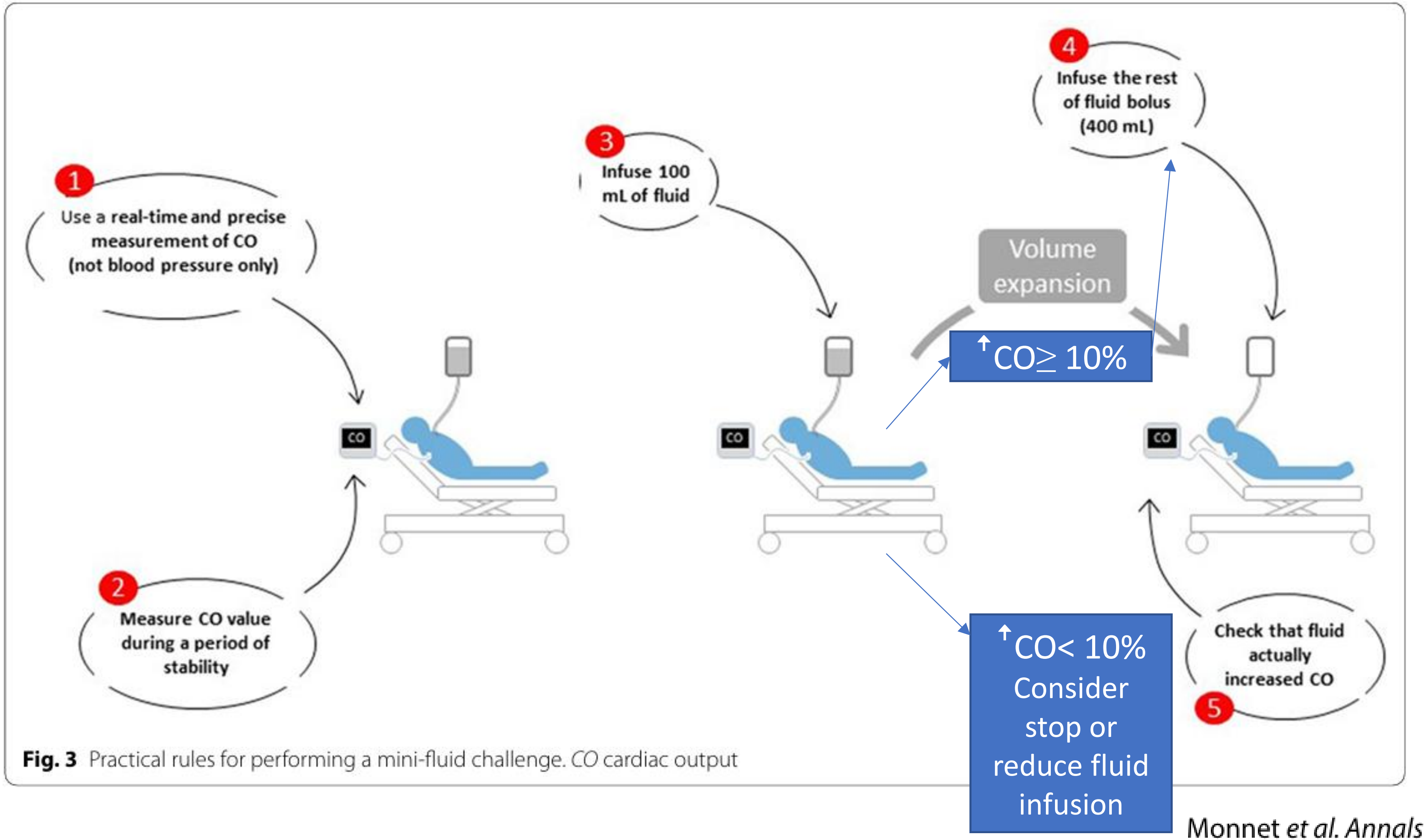

Fig. 3 Practical rules for performing a mini-fluid challenge. *CO* cardiac output

Monnet *et al. Annals of Intensive Care* (2022) 12:46

Continuous measurement of cardiac output

Table 1: Recommended indices to direct goal-directed therapy with the use of various minimally invasive cardiac output devices

MICO device	Indices used for GDT	Variation recommended	Intervention recommended
Esophageal Doppler	FTc	FTc <0.35 s	200 ml fluid challenge over 10 min
	SV	SV increase >10%	
Vigileo-FloTrac system (In OR, PPV tidal volume >8 ml/kg)	PPV	PPV/SVV >13%	200 ml fluid challenge over 15 min
	SVV	SV increase >10%	
Pulse oximeter pleth variability	PVI	PVI >15% for >5 min	
Vigileo-FloTrac system (GDT group)	SVV	SVV >12%	
	CO	Monitor CO change	
NICE protocol by the National Health Service in the UK	SV	SV >10% by 200-250 fluid over 5-10 min	
	BP		
		SV<10% by 200-250 fluid over 5–10 min	
Central venous saturation ($ScvO_2$) monitoring protocol	$ScvO_2$	$ScvO_2$ <70%	
	SaO_2	SaO_2 >95%	
	Hb	Hb >10 g %	
	P(v-a) CO_2	P (v-a) CO_2 >6 mmHg	
	SVV		

CO: Cardiac output, MICO: Minimally invasive cardiac output, GDT: Goal-directed therapy, FT
PPV: Pulse pressure variation, SVV: SV variation, PVI: Pleth variability index, BP: Blood pressur
for Health and Clinical Excellence, Hb: Hemoglobin

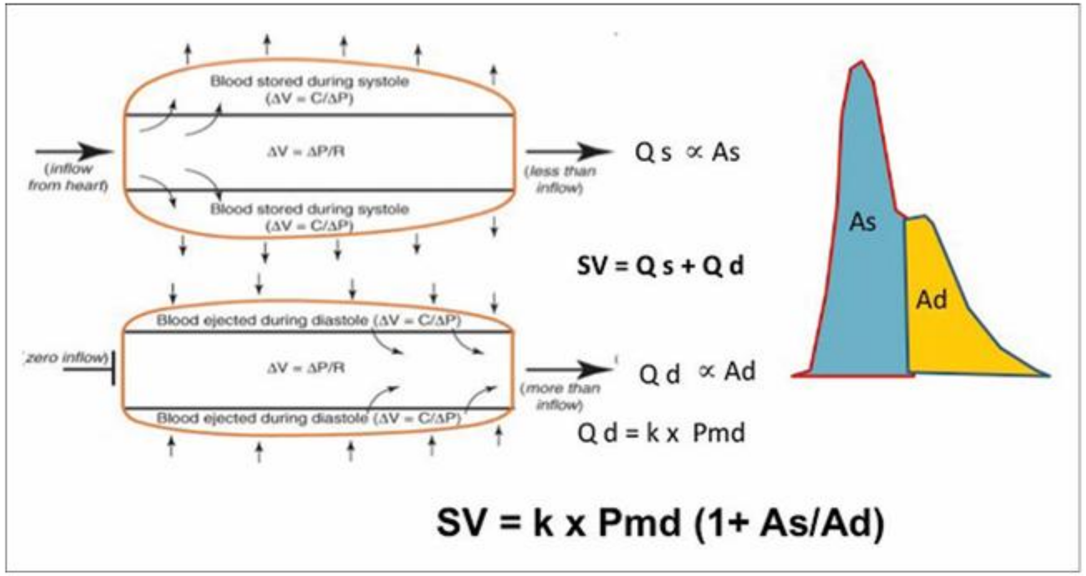

Figure 5: Pulse pressure analysis model to calculate the stroke volume using the arterial waveform

Optimization Phase : Fluid challenge test in PNUH

Baseline CO

100 mL of normal saline infusion
CO increased by 13%

Optimization Phase : Fluid challenge test

Major advantages of fluid challenge test

- Personalized quantification of the cardiovascular response during volume infusion
- Prompt correction of fluid infusion
- Minimizing the risk of fluid overload and its potential adverse effect, especially on the lungs

Crit Care Med 2006 Vol. 34, No. 5

Stabilization Phase

Table 1 Characteristics of different stages of resuscitation: 'Fit for purpose fluid therapy'. GDT, goal directed therapy; DKA, diabetic keto acidosis; NPO, nil per os; ATN, acute tubular necrosis; SSC, surviving sepsis campaign

	Rescue	Optimization	Stabilization
Principles	Lifesaving	Organ rescue	Organ support
Goals	Correct shock	Optimize and maintain tissue perfusion	Aim for zero or negative fluid balance
Time (usual)	Minutes	Hours	Days
Phenotype	Severe shock	Unstable	Stable
Fluid therapy	Rapid boluses	Titrate fluid infusion conservative use of fluid challenges	Minimal maintenance infusion only if oral intake inadequate
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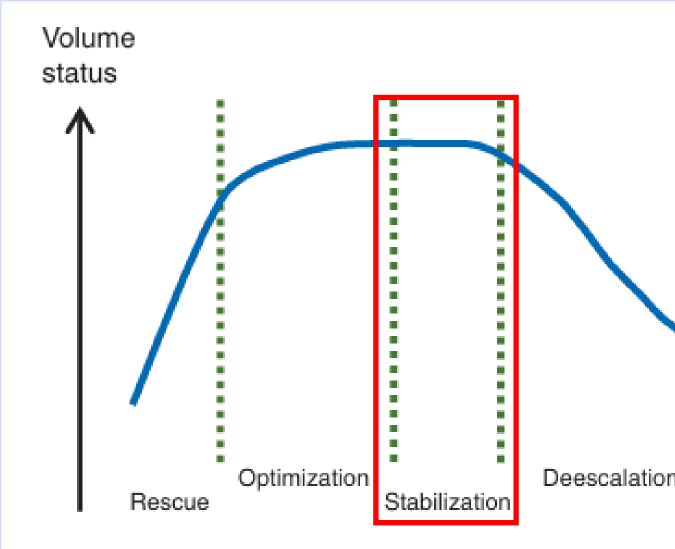

Fig 2 Patients' volume status at different stages of r
Reproduced with permission from ADQI (www.ADQI.

De-escalation Phase

Table 1 Characteristics of different stages of resuscitation: 'Fit for purpose fluid therapy'. GDT, goal directed therapy; DKA, diabetic keto acidosis; NPO, nil per os; ATN, acute tubular necrosis; SSC, surviving sepsis campaign

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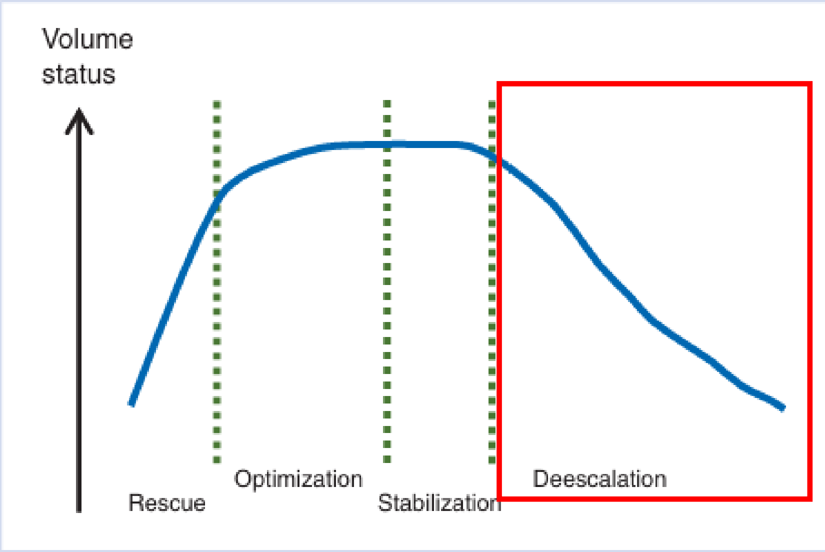

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Contents

How to handle fluid overload in critically ill patients?

- Effective de-escalation
  : maximum decongestion without ischemic injury

Dialysis modality and Kidney recovery : Evidences from Observational studies

IHD VS CKRT
: Better in CKRT

Table 1. Influence initial dialysis modality on the long-term outcomes in critically ill patients with AKI

Study	Setting	Population	Inclusion	Outcome	Results	
					Incidence	Risk estimation
Koyner et al. (2024) [22]	Retrospective, U.S. claim data	3,804	-	KRT dependence at discharge and 90 days	At discharge: CKRT, 26.5%; IHD, 29.8% At 90 days: CKRT, 4.9%; IHD, 7.4%	Lower in CKRT (OR, 0.68; 95% CI, 0.47–0.97)
Wald et al. (2023) [23]	Multicenter (168), muti-nations (15)	CKRT, 1,590; IHD, 606	Secondary analysis of STARRT-AKI	Death or KRT dependence at 90 days	CKRT, 51.8%; IHD, 54.3%	Lower in CKRT (OR, 0.84; 95% CI, 0.66–0.99)
Bonnassieux et al. (2018) [24]	Retrospective cohort study in 291 ICUs in France	24,750	-	Kidney recovery (dialysis free) at discharge	-	Lower in IHD (OR, 0.910; 95% CI, 0.834–0.992)
Truche et al. (2016) [25]	Prospective multicenter study in France	1,360	OUTCOMERE database	30-Day mortality and KRT dependence	-	No difference (HR, 1.00; 95% CI, 0.77–1.29) KRT dependence alone Lower in CKRT (HR, 0.54; 95% CI, 0.29–0.99)
Wald et al. (2014) [26]	Retrospective cohort study in Canada	CKRT, 2004; IHD, 2004	-	KRT dependence (median FU 3 years)	-	Lower in CKRT (HR, 0.75; 95% CI, 0.65–0.87)

AKI: acute kidney injury; KRT: kidney replacement therapy; CKRT: continuous kidney replacement therapy; IHD: intermittent hemodialysis; OR: odds ratio; STARRT-AKI: STandard versus Accelerated initiation of Renal Replacement Therapy in Acute Kidney Injury; ICU: intensive care unit; HR: hazard ratio.

Dialysis modality and Kidney recovery : Evidences from RCTs

Table 1. Main characteristics of randomized controlled trials comparing KRT techniques

Study	Time Frame	No. of Patients	Initiation Criteria for KRT	Survival (Intermittent HD versus CKRT)	Hemodynamic Status (Intermittent HD versus CKRT)	Kidney Function Recovery (Intermittent HD versus CKRT)
Mehta *et al.*[13]	1991–1995	166	At least one of the three following criteria: BUN >40 mg/dl; SCr >2.0 mg/dl; Rise in SCr >1 mg/dl from baseline values; And judgment of the treating nephrologist	ICU mortality 41.5% versus 59.5% (P<0.02); Hospital mortality 47.6% versus 65.5% (P<0.02)	NA	Complete recovery 33% versus 35% (ns); KRT dependency at hospital discharge 7% versus 14% (ns)
Augustine *et al.*[15]	1995–1999	80	Determined by the consulting nephrologist on the clinical service (no clear criteria)	Hospital mortality 70% versus 67.5% (ns)	The groups were not compared: Intermittent HD: decrease in MAP from baseline during the initial treatment (77.6 versus 75.0 mm Hg, P=0.04); CKRT: MAP remained unchanged from baseline (76.8 versus 77.4 mm Hg, P=ns)	KRT dependency at hospital discharge 20% versus 20% (ns)
Misset *et al.*[31]	1993–1996	39	At least one of the two following criteria: BUN >84 mg/dl; SCr >4.5 mg/dl; And mechanical ventilation for more than 48 h	NA	Mean value of MAP 81 versus 83 mm Hg (P=0.72); Greatest change of MAP (highest-lowest MAP) 48 versus 46 mm Hg (P=0.73); Frequency of MAP decrease >10 mm Hg 25% versus 26% (P=0.72)	NA
Uehlingrer *et al.*[14]	1998–2000	125	At least one of the two following criteria: SCr >4.0 mg/dl; UO <20 ml/h	ICU mortality 38% versus 34% (P=0.71); Hospital mortality 50.9% versus 47.1% (P=0.72)	Incidence of circulatory failure (average daily MAP <65 mm Hg) 15% versus 21% (P=0.36); Hemodynamic instability (average variability between maximum and minimum daily MAP) 40% versus 29% (P=0.13)	Complete recovery 42% versus 50% (P=0.61)
Vinsonneau *et al.*[12 a]	1999–2003	360	At least one of the three following criteria: SCr >3.5 mg/dl; BUN >100 mg/dl; UO <320 ml for 16 h[b]; And need for KRT determined by practitioner judgment; And multiple organ dysfunction	Day 60 mortality (primary end point) 31.5% versus 32.6% (P=0.98)	Hypotension (systolic arterial pressure ≤80 mm Hg or a fall >50 mm Hg from the baseline value) 39% versus 35% (P=0.47)	NA
Gasparović *et al.*[32]	2001–2003	104	At least two of the three following criteria: Three-fold increase in SCr; Hyperkalemia >5.5 mmol/L; Base excess >−6; And multiple organ dysfunction	Mortality (time not defined) 59.6% versus 71.1% (ns)	Blood pressure instability[c] (>10 mm Hg) (ns [values not given])	NA
John *et al.*[17]	Unclear but the article was published in 2001	33	At least one of the two following criteria: SCr >3 mg/dl; UO <10 ml/h; And severe septic shock; And need for MV; And APACHE II between 20 and 45; And pulmonary capillary wedge pressure ≥12 and <18 mm Hg	ICU mortality 70% in both groups (no more precision given)	Evolution of systolic arterial pressure after 2 h: 5 versus +12 mm Hg (P<0.05); Decline of cardiac output: 0.25 versus −1.54 L/min (P<0.01)	NA
Lins *et al.*[33] (SHARF)	2001–2004	316	Decision of the attending physician	Hospital mortality 62.5% versus 58.1% (P=0.43)	NA	eGFR <15 ml/min at hospital discharge 25% versus 17% (ns)

IHD VS CKRT
: no difference

CJASN 18: 661–667, 2023.

Dialysis modality and Kidney recovery : Evidences from Observational studies

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: Better in CKRT

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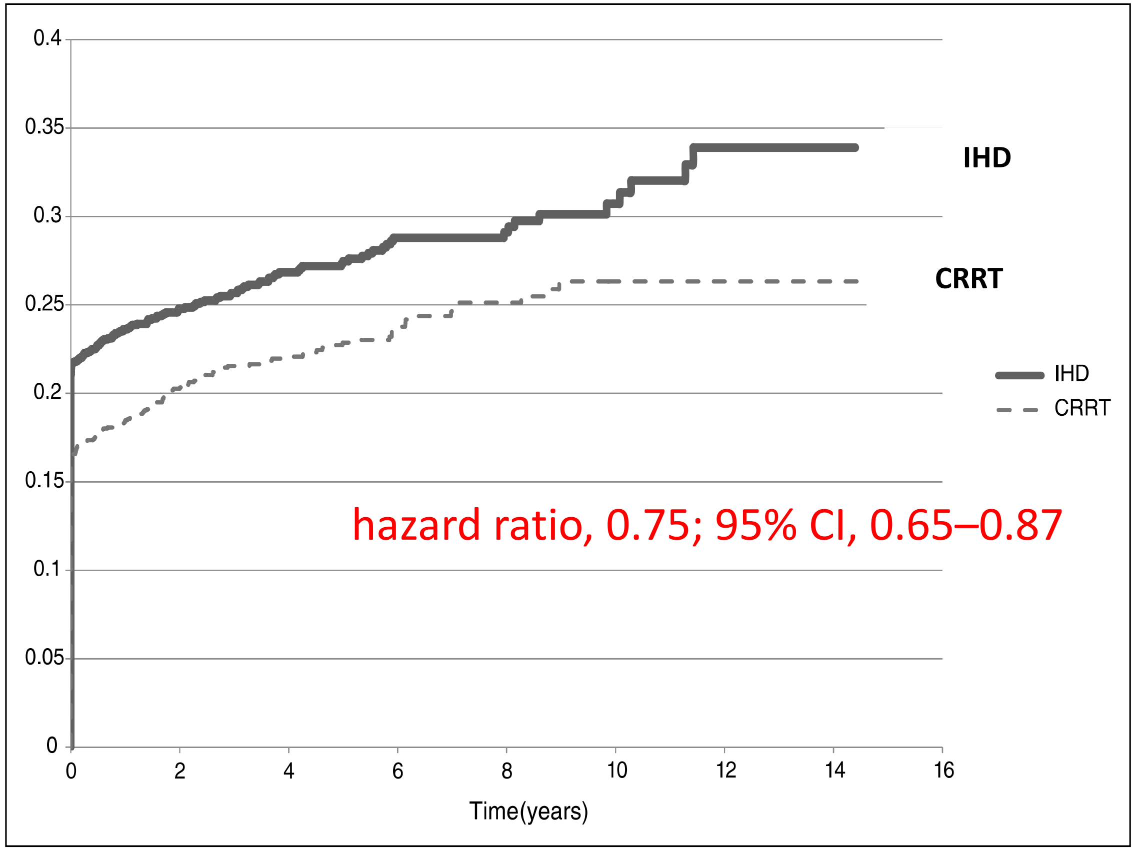
Modality and Long-term Renal Recovery

Cumulative risk of chronic dialysis among critically ill patients with AKI surviving to day 90 after RRT initiation



retrospective cohort study

2,315 CRRT recipients and 2,004 (87%) propensity matched to IHD based on:

- ✓ history of chronic kidney disease
- ✓ mechanical ventilation
- ✓ propensity score for the likelihood of receiving CRRT

- followed over a median of 3 years

Compared with iHD, initiation of CRRT in was associated with 25% lower likelihood of chronic dialysis

Wald et al., Crit Care Med. 2014 Apr;42(4):868-77

Initial renal replacement therapy (RRT) modality associates with 90-day postdischarge RRT dependence in critically ill AKI survivors

Jay L. Koyner [a,1], Rachel H. Mackey [b,c,1,*], Jorge Echeverri [d], Ning A. Rosenthal [b], Leslie A. Carabuena [b], Daniel Bronson-Lowe [d], Kai Harenski [e], Javier A. Neyra [f]

- ✓ Retrospective cohort: large US hospital discharge database (Premier PINC AI) linked to commercial claims data.
- ✓ Adult ICU patients receiving first RRT (CRRT or IHD) for AKI, **between January 1, 2018, and June 30, 2021,**
- ✓ **N =** 3804 patients (CRRT n = 1064; IHD n = 2740)

3804 patients (CRRT n = 1064; IHD n = 2740) survivors 90-day post-discharge

- Compared % of RRT dependence

4.9% of CRRT-treated
7.4% of IHD-treated → were younger; lower prevalence of comorbidities, but higher severity of illness

RRT dependence at 90 days post-discharge for patients with CRRT vs. IHD

Weighted OR (95% CI); p-value	Adjusted Weighted OR (95% CI); p-value*
0.69 (0.48–0.98); 0.04	**0.68 (0.48–0.98); 0.04**

After adjusting for patient, hospital, and illness severity factors using inverse probability of treatment weighting (IPTW)

✓ CRRT-treated patients had a 30% lower odds of being RRT-dependent at 90 days post-discharge

Journal of Critical Care Volume 82, August 2024, 154764

Kidney recovery and dialysis modality

- Multiple observational studies showed better kidney recovery rate with CKRT than with IHD.

  : KRT dependence at 30 or 90 day after hospital discharge

- These were not consistently shown in RCTs : no differences in KRT dependence or complete kidney recovery rate at hospital discharge

- Based on the longer follow-up and the larger population based retrospective data, **slower, more continuous fluid/solute removal with CRRT may support a higher rate of independence from dialysis.**

Contents

How to handle fluid overload in critically ill patients?

- Effective de-escalation

 - Avoid unnecessary fluid

 - Use diuretics

 - Dialysis

  : Mode of dialysis

  Rate of fluid removal

What would be the most tolerated UF rate during CKRT?

Lessons from the previous studies

Original Investigation | Critical Care Medicine

Association of Net Ultrafiltration Rate With Mortality Among Critically Ill Adults With Acute Kidney Injury Receiving Continuous Venovenous Hemodiafiltration

A Secondary Analysis of the Randomized Evaluation of Normal vs Augmented Level (RENAL) of Renal Replacement Therapy Trial

Raghavan Murugan, MD, MS, FRCP; Samantha J. Kerti, MS; Chung-Chou H. Chang, PhD; Martin Gallagher, MD, PhD; Gilles Clermont, MD, MSc; Paul M. Palevsky, MD; John A. Kellum, MD, MCCM; Rinaldo Bellomo, MD, PhD

Table 3. Association of NUF With Survival From Gray Model

NUF Rate	Model	Hazard Ratio (95% CI)[a] 0-2 d	3-6 d	7-12 d	13-26 d	27-90 d	P Value
No. of patients at risk		1390	1216	1085	976	862	
>1.75 mL/kg/h vs <1.01 mL/kg/h	Unadjusted	0.62 (0.47-0.82)	0.86 (0.67-1.10)	1.31 (1.02-1.68)	1.46 (1.11-1.91)	1.70 (1.23-2.34)	<.001
	Adjusted[b]	1.13 (0.81-1.57)	1.24 (0.93-1.66)	1.51 (1.13-2.02)	1.52 (1.11-2.07)	1.66 (1.16-2.39)	.01
>1.75 mL/kg/h vs 1.01-1.75 mL/kg/h	Unadjusted	0.97 (0.72-1.30)	1.16 (0.89-1.49)	1.49 (1.16-1.91)	1.40 (1.07-1.82)	1.66 (1.21-2.28)	.002
	Adjusted[b]	1.12 (0.81-1.56)	1.18 (0.89-1.57)	1.44 (1.10-1.90)	1.42 (1.07-1.89)	1.77 (1.26-2.49)	.004
1.01-1.75 mL/kg/h vs <1.01 mL/kg/h	Unadjusted	0.64 (0.48-0.85)	0.74 (0.57-0.96)	0.84 (0.64-1.09)	1.14 (0.86-1.52)	0.97 (0.69-1.37)	.006
	Adjusted[b]	1.01 (0.74-1.39)	1.09 (0.82-1.46)	1.00 (0.74-1.34)	1.15 (0.84-1.52)	0.85 (0.58-1.25)	.59
NUF per 0.50-mL/kg/h increase	Unadjusted	0.90 (0.85-0.97)	0.97 (0.92-1.03)	1.06 (1.00-1.12)	1.09 (1.03-1.16)	1.11 (1.04-1.19)	<.001
	Adjusted[b]	1.03 (0.97-1.09)	1.05 (1.00-1.11)	1.08 (1.02-1.15)	1.11 (1.04-1.18)	1.13 (1.05-1.22)	.003

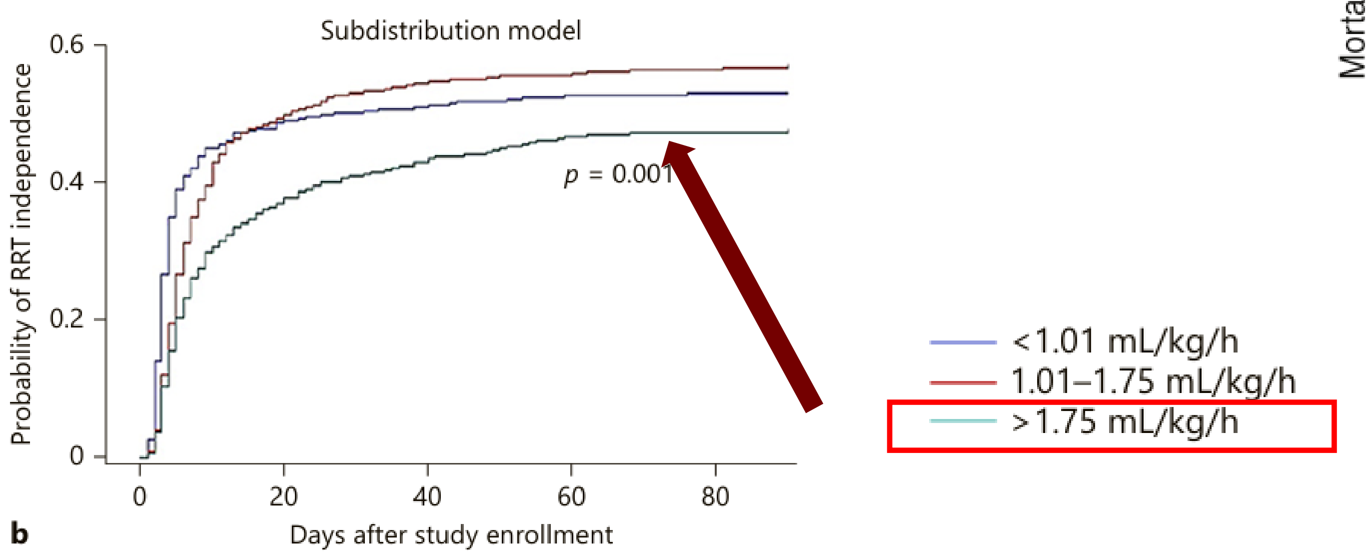
JAMA Netw Open. 2019;2(6):e195418

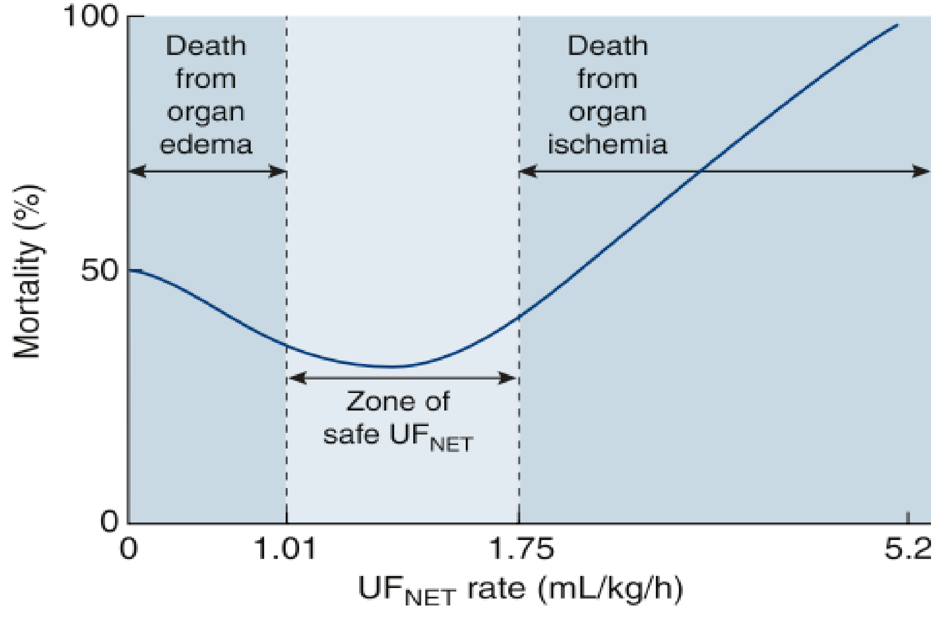
What would be the most tolerated UF rate during CKRT?

Lessons from the previous studies

Association between Net Ultrafiltration Rate and Renal Recovery among Critically Ill Adults with Acute Kidney Injury Receiving Continuous Renal Replacement Therapy: An Observational Cohort Study

Raghavan Murugan[a, b] Samantha J. Kerti[b] Chung-Chou H. Chang[b, c, d] Martin Gallagher[e] Ary Serpa Neto[f, g] Gilles Clermont[b] Claudio Ronco[h] Paul M. Palevsky[a, c, i] John A. Kellum[a, b] Rinaldo Bellomo[j]





Blood Purif 2022;51:397–409

Nat Rev *Nephrol* **17**, 262–276 (2021)

What would be the most tolerated UF rate during CKRT?

Challenges…

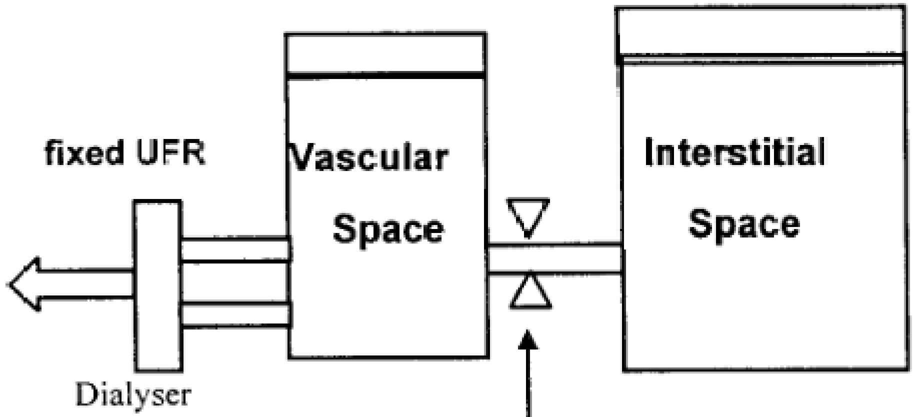
1. Fluid balance VS Machine balance

NUF volume (mL) = Ultrafiltrate volume − [replacement fluid + dialysate volume]
NUF rate (mL/kg/hr) = cumulative NUF volume (mL) / (weight at study enrollment [in kilograms] × treatment duration [in hours])

=> Fluid directly infused into patients was not considered

2. Special considerations for individual capillary refill rate

Principles of mechanical fluid removal



Capillary refill

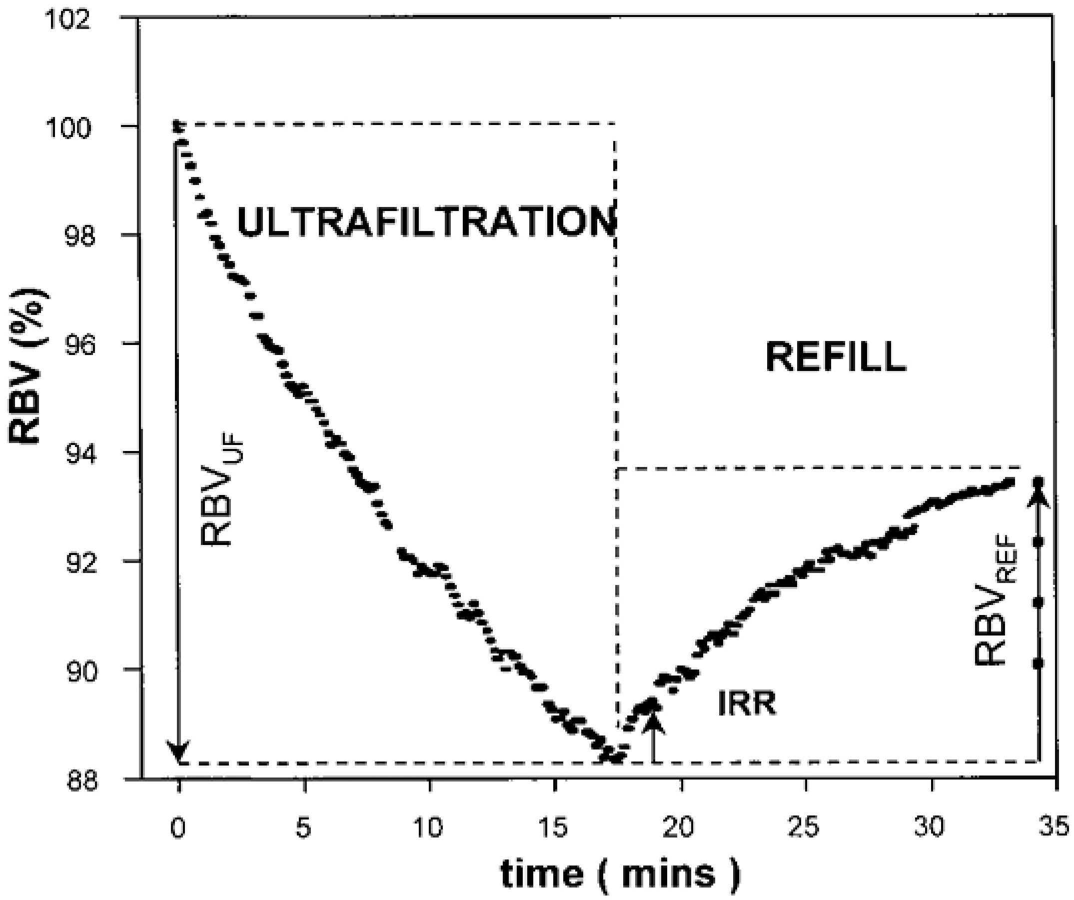


Fig 1. A typical RBV profile obtained in response to a UF pulse showing decay, subsequent refill phase, and measured parameters. Values for ΔRBV in percentage, and for IRR, in percentage per minute. Abbreviation: ΔRBV_{ref}, the magnitude of RBV change during the refill phase, in percentage.

✓ Ultrafiltration rate exceeding capillary refill rate results in circulatory shock and organ ischemia

MITRA ET AL *American Journal of Kidney Diseases*, Vol 40, No 3 (September), 2002: pp 556-565

What would be the most tolerated UF rate during CKRT?

Determinants of plasma refill rate – Maintenance HD patients

Journal of the Medical Research Institute
JMRI, 2008; Vol. 29 No.1: (17-27)

Journal of the Medical Research Institute

Role of Plasma Refill Rate, Its Determinants and Some Other Variables in Pathogenesis of Intradialytic Hypotension

[1] **Salah S. Naga,** [2] **Mohammad N. Mowafy,** [2] **Yaser A. Ammar,** [2] **Abd ElAziz A. Elkak,** [3] **Hisham S. El-Banawy and** [2] **Nissreen S. Elfadawy**

Table (6): Correlations between Plasma refill Rate and Study Parameters in the 40 Study Subjects.

Parameter Correlated with Plasma Refill Rate	r	P
Age	- 0.074	0.651
Duration of Dialysis	- 0.092	0.573
Serum Sodium	0.115	0.479
Mean Plasma Albumin	0.330	0.037*
Plasma Prealbumin	0.184	0.255
Haematocrit (Pre-Dialysis)	0.021	0.897
Haematocrit (Post-Dialysis)	0.099	0.541
Ultrafiltration Volume	0.993	0.000**
Ultrafiltration Rate	0.993	0.000**

*: Significant Correlation (P < 0.05), **: Highly Significant Correlation (P < 0.01).

What would be the most tolerated UF rate during CKRT?

Special considerations in Septic patients

REVIEW **Open Access**

Vascular leak in sepsis: physiological basis and potential therapeutic advances

Ross R. McMullan[1*], Daniel F. McAuley[1,2], Cecilia M. O'Kane[1] and Jonathan A. Silversides[1,2]

Hypoalbuminemia

Disruption of cell-cell junction

Degradation of glycocalyx

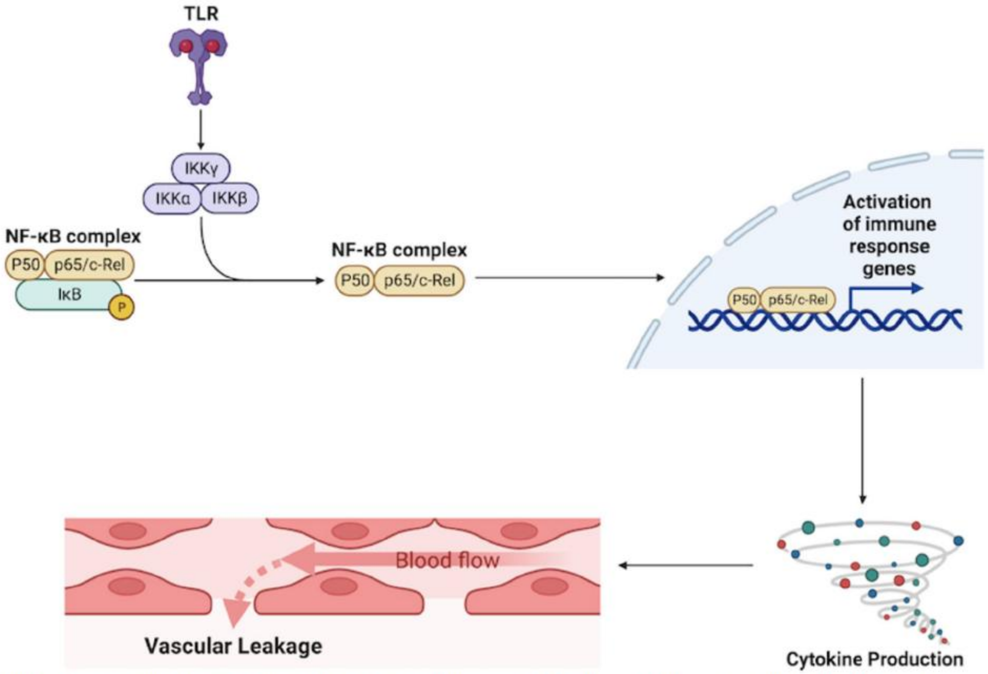


Fig. 2 An array of microbial components stimulate the innate immune response by activating Toll-like receptors which results in the nuclear translocation of the transcription factor NF-κB. NF-κB then promotes the expression of pro-inflammatory cytokines such as TNF- *a* which induces endothelial cell dysfunction

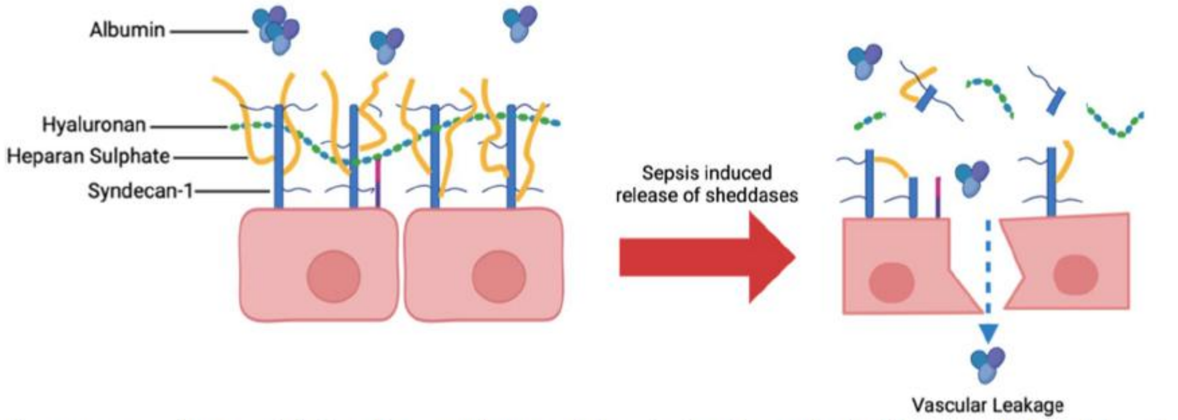


Fig. 3 The sepsis state results in vascular leakage due to a combination of glycocalyx degradation and cell–cell disruption. The loss of glycocalyx and endothelial integrity results in the transvascular loss of albumin which favours vascular leakage

McMullan *et al. Critical Care* (2024) 28:97

Difficulties in CRRT-fluid removal in patients with low serum albumin

Worsening or improving hypoalbuminemia during continuous renal replacement therapy is predictive of patient outcome: a single-center retrospective study

Harin Rhee[1,2*], Gum Sook Jang[1], Sungmi Kim[1,2], Wanhee Lee[1,2], Hakeong Jeon[1,2], Da Woon Kim[1,2], Byung-min Ye[3,4], Hyo Jin Kim[1,2], Min Jeong Kim[3,4], Seo Rin Kim[3,4], Il Young Kim[3,4], Sang Heon Song[1,2], Eun Young Seong[1,2], Dong Won Lee[3,4] and Soo Bong Lee[3,4]

Single center retrospective study (N=793)
Inclusion: Critically ill patients with AKI required CRRT
Comparisons : Changes in serum albumin within 48hrs
Outcome: In-hospital mortality

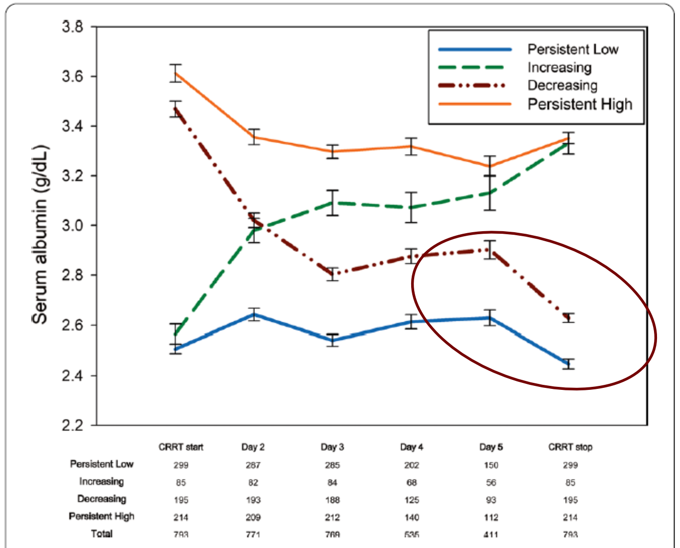
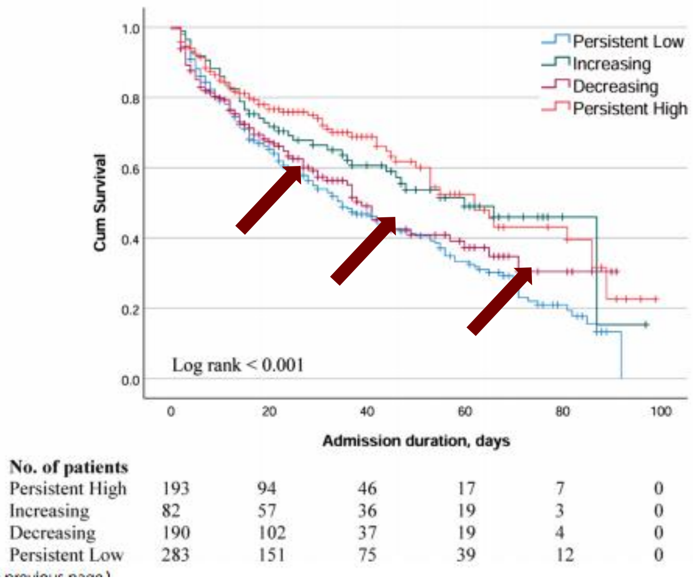
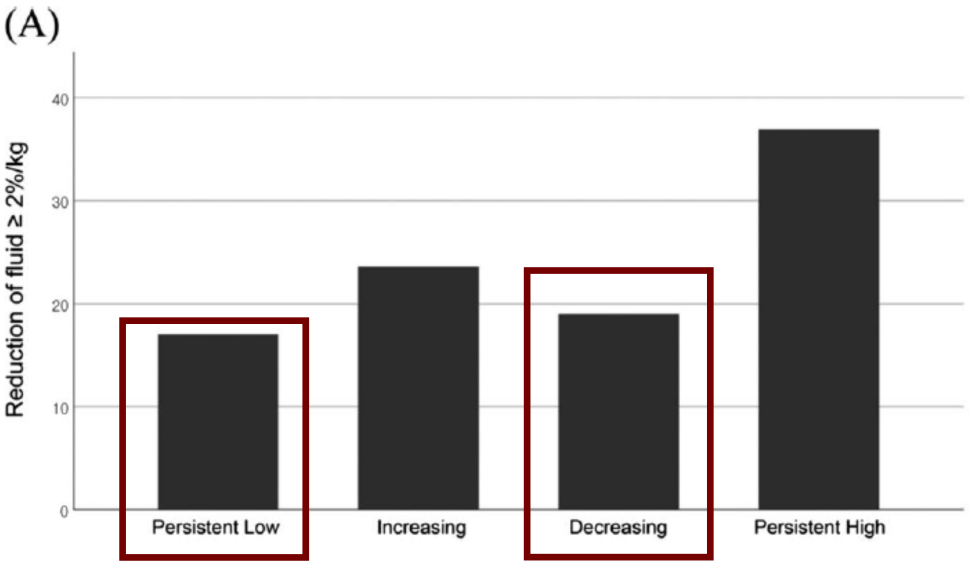


Fig. 2 Changes in serum albumin level during continuous renal

Inhospital Mortality



Total fluid removal during CRRT



Contents

How to handle fluid overload in critically ill patients?

- Effective de-escalation

- Avoid unnecessary fluid

- Use diuretics

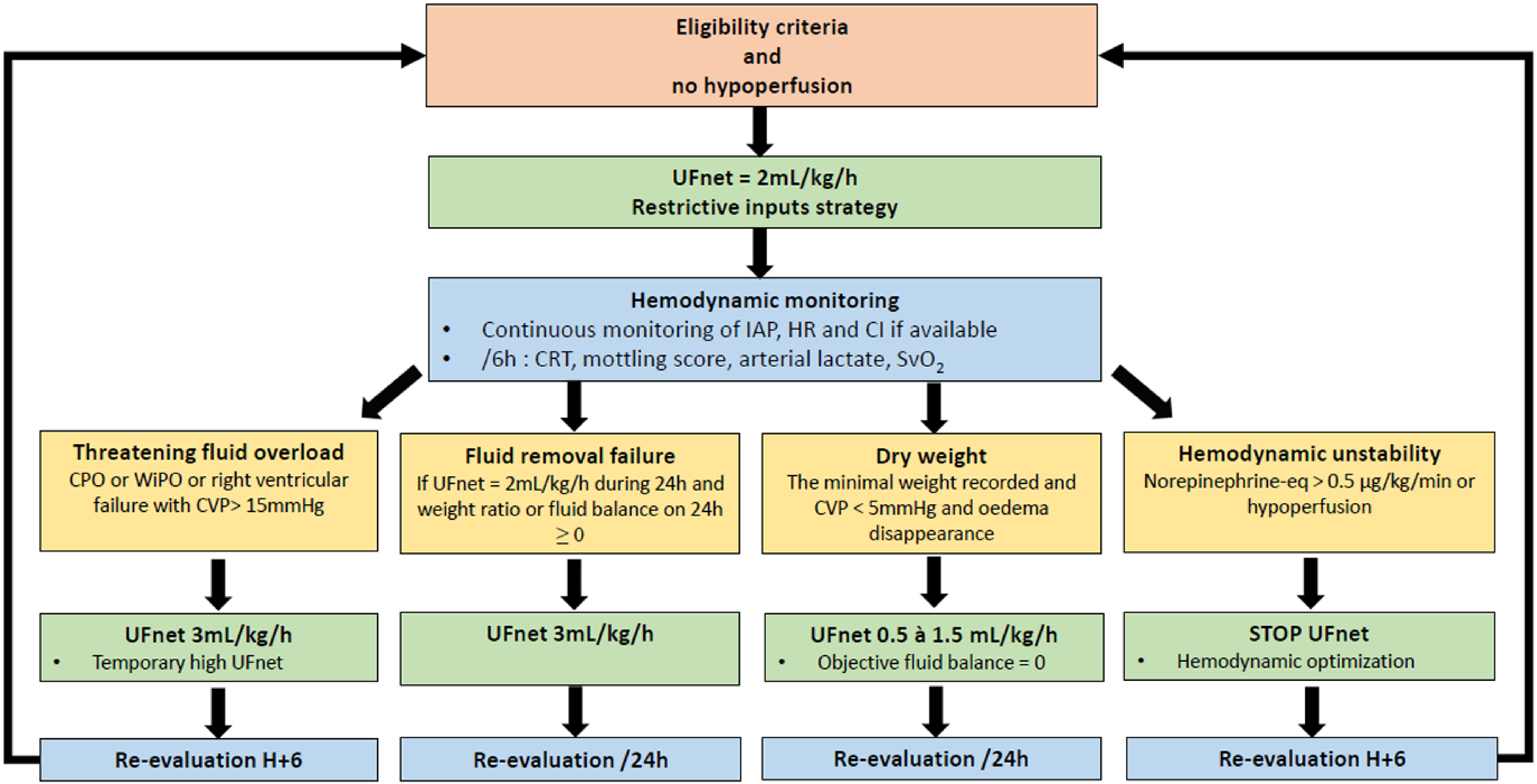
- Dialysis

: Mode of dialysis

Rate of fluid removal

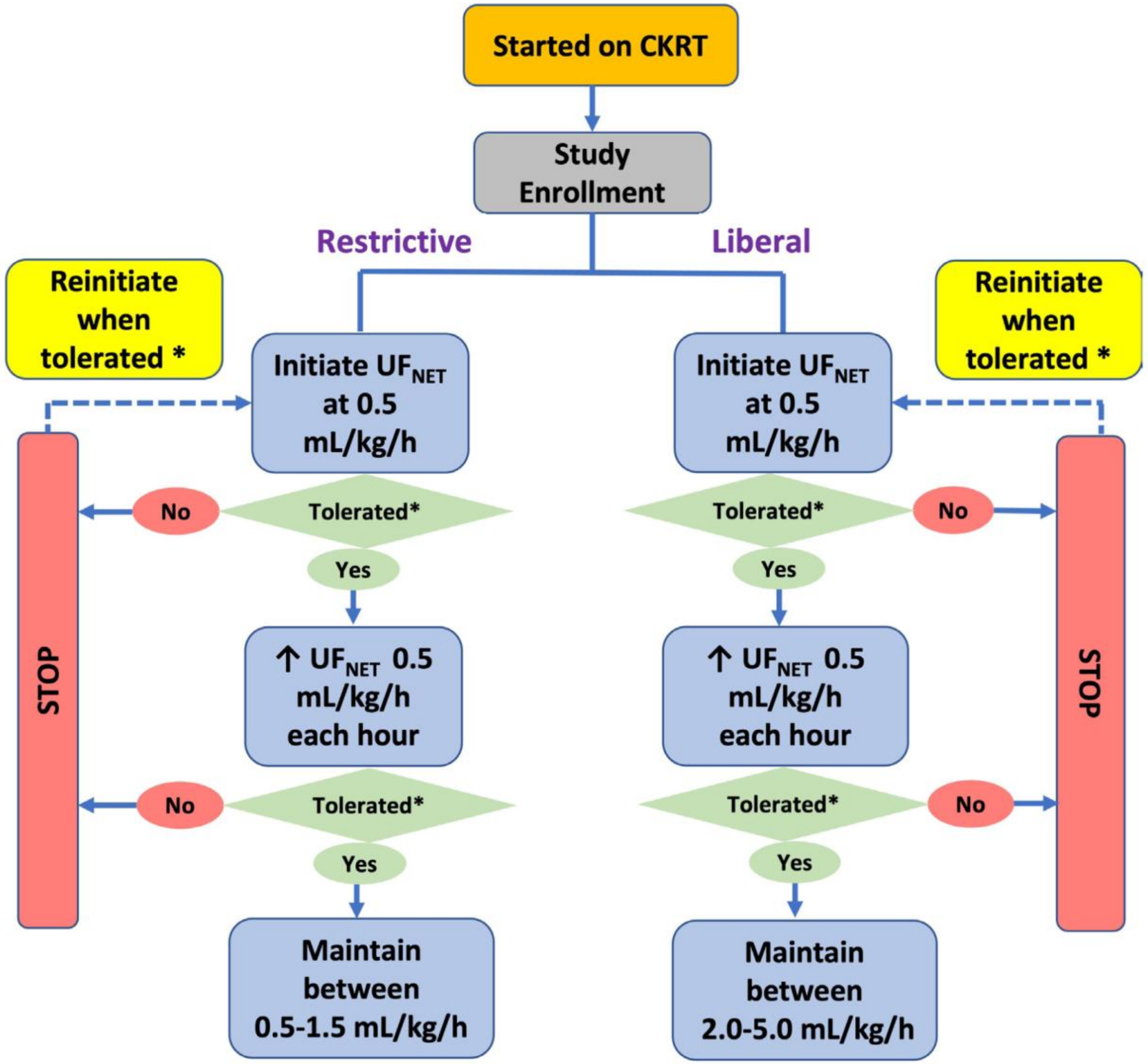
: needs to be personalized based on the patient responsiveness

Perfusion-based de-resuscitation strategy



Journal of Critical Care 72 (2022)

Restrictive versus Liberal Rate of Extracorporeal Volume Removal Evaluation in AKI (RELIEVE-AKI): a pilot clinical trial protocol



Multicenter study – 10 ICUs , 2 centers in the US

Evaluating UF Net – as patient balance and not machine balance

Liberal UF Net: 2-5ml/kg/h

Restrictive UF Net: 0.5-1.5ml/kg/h

A web-based net fluid removal rate calculator provides decision support for critical care clinicians to deliver the study intervention precisely.

Predicted body weight (PBW):

Females:

$$\mathrm{PBW\ (kilograms)} = 45.5 + 2.3\,[\mathrm{height\ (inches)} - 60]$$

Males:

$$\mathrm{PBW\ (kilograms)} = 50 + 2.3\,[\mathrm{height\ (inches)} - 60]$$

Murugan R, et al. BMJ Open 2023

Terminated

The trial was terminated due to insufficient funds.

Restrictive Versus Liberal Rate of Extracorporeal Volume Removal Evaluation in Acute Kidney Injury (RELIEVE-AKI)

ClinicalTrials.gov ID NCT05306964

Sponsor University of Pittsburgh

Information provided by Raghavan Murugan, University of Pittsburgh (Responsible Party)

Last Update Posted 2025-08-29

Active, not recruiting

Proactive Prescription-based Fluid Management vs Usual Care in Critically Ill Patients on Kidney Replacement Therapy (Probe-Fluid)

ClinicalTrials.gov ID NCT05473143

Sponsor Centre hospitalier de l'Université de Montréal (CHUM)

Information provided by Centre hospitalier de l'Université de Montréal (CHUM) (Responsible Party)

Last Update Posted 2025-10-01

The study is a pilot randomized clinical trial comparing a protocol-based fluid management strategy with usual care in critically ill patients receiving KRT. The fluid management protocol is intended to achieve neutral or negative daily fluid balance by both preventing and treating fluid accumulation. The protocol was designed to provide a standardized framework to prescribe fluid removal while allowing the attending care team to modify treatment targets according to their clinical evaluation.

Conclusion

How to handle fluid overload in critically ill patients?

- If possible, prevent fluid overload.

  After initial fluid resuscitation, fluid therapy needs to be titrated based on the fluid responsiveness.

  Fluid challenge test is helpful for the optimal infusion of intravenous fluid.

- Timing and intensity of fluid removal, as well as modality choice (CRRT vs. IHD), influence long-term dialysis independence and the degree of kidney recovery.
- Given the differences in patients' tolerances to fluid removal, a perfusion-based, dynamically adjusted UF strategy can optimize decongestion while minimizing hemodynamic instability.
- We need RCTs and new frameworks aim to optimize UF strategies that balance FO correction against the risk of hypoperfusion, aiming to improved kidney recover after AKI

Thank you for your attention

Questions?

rheeharin@pusan.ac.kr