CRRT nursing

X Edizione

Corso Teorico Pratico

CRRT

Concetti di base 3

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CRRT:* *concetti di base 1: come funzionano le CRRT. Come funziona il circuito extracorporeo? Quali sono i meccanismi di trasporto soluti e acqua nei filtri? | *Z. Ricci*

***CRRT:* *concetti di base 2*:** Nomenclatura: descrizione delle varie componenti del circuito, membrane, filtri, parti delle apparecchiature e sensori | *M. Neri*

Agenda

- **<u>Tecniche</u>:**
  - **descrizione delle varie tecniche e delle loro caratteristiche sulla base di:**
    - **Efficienza**
    - **Peculiarità**
    - **Impiego clinico**
    - **Modalità applicative**

Continuous Renal Replacement Therapy

Who, When, Why, and How

CHEST

Modalities of RRT

Multiple modalities of renal support may be used in the management of the **critically ill patient** with kidney failure.

CRRT

Continuous Renal Replacement Therapies

IHD

Intermittent Hemo Dialysis

PIRRTs

Prolonged Intermittent Renal Replacement Therapies

Tandukar S & Palewsky PM. CHEST 2019;155:626-638

CRRT

Continuous Renal Replacement Therapies

IHD

Intermittent Hemo Dialysis

PIRRTs

Prolonged Intermittent Renal Replacement Therapies

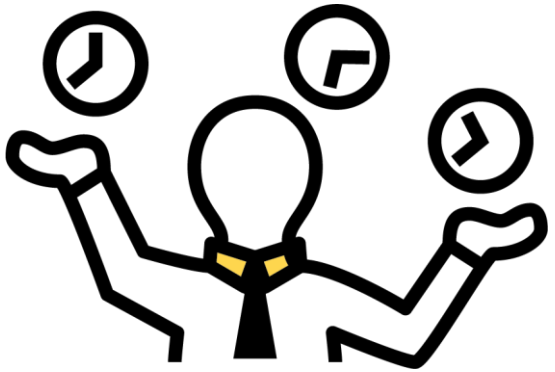
All of these use relatively similar extracorporeal blood circuits and differ primarily with regard to **duration of therapy** and, consequently, the **rapidity of net ultrafiltration and solute clearance**.

Tandukar S & Palewsky PM. CHEST 2019;155:626-638

Hybrid therapies - PIRRT

- With respect to frequency and duration, the term "**hybrid therapies**" relates to the blending or characteristics from both intermittent and continuous modalities.

- These therapies attempt to optimize the advantages and minimize the disadvantages of both modalities:
  - ✓ Efficient solute removal
  - ✓ Slower ultrafiltration rates for **hemodynamic stability**
  - ✓ Less **anticoagulant** exposure
  - ✓ Shorter **duration**
  - ✓ Lower **costs**
  - ✓ Decreased nurse workload



Villa et al. Critical Care (2016) 20:283

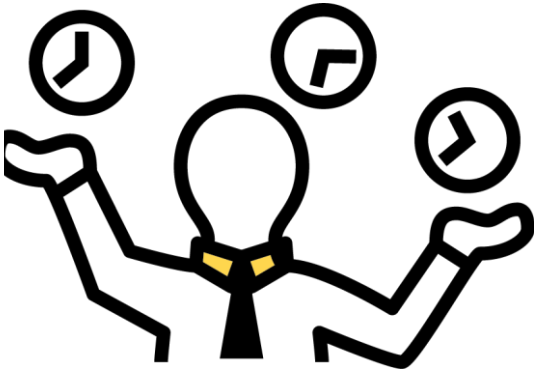
Nomenclature for renal replacement therapy and blood purification techniques in critically ill patients: practical applications

Hybrid therapies - PIRRT

Hybrid therapies encompass various specific “discontinuous” RRT modalities: :

- ✓ Sustained low-efficiency dialysis (SLED),
- ✓ Slow low-efficiency extended daily dialysis (SLEDD),
- ✓ Extended daily dialysis (EDD),
- ✓ Extended daily dialysis with filtration (EDDf),
- ✓ Extended dialysis (ED),
- ✓ “go slow dialysis”,
- ✓ Accelerated veno-venous hemofiltration (AVVH).

Hybrid therapies are **usually performed with standard intermittent hemodialysis equipment** (machines, filters, extracorporeal blood circuits).
Solute removal is largely **diffusive** but variants with a convective component, such as EDDf and AVVH, are possible.



Villa et al. Critical Care (2016) 20:283 (modified)

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

Prolonged Intermittent Renal Replacement Therapy

	INTERMITTENT	CONTINUOUS	HYBRID
	IHD	**CRRT**	***PIRRT***
Solute clearance	Diffusion	Diffusion / Convection / Both	Diffusion / Convection / Both (Most PIRRT trials have reported a **diffusive** modality)
Type of machine	Standard IHD machine	Standard CRRT machine	Either IHD or CRRT machine (Most PIRRT trials have used an IHD machine).
Qb (ml/min)	**400-500**	**100-200**	**150-400**
Qd (ml/min)	600-800	. . . (CVVHD – CVVH – CVVHDF)	100-200
Duration (h)	3-4	24	6-12

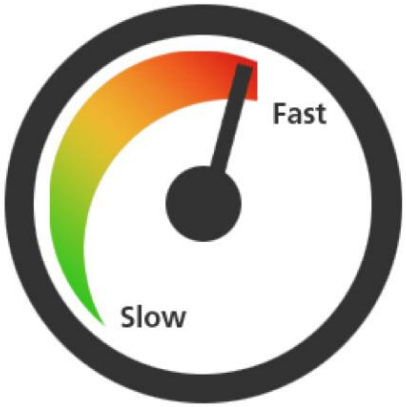
Edrees F et al. Advances in Chronic Kidney Disease; 23;3, 2016:195-202(modified)

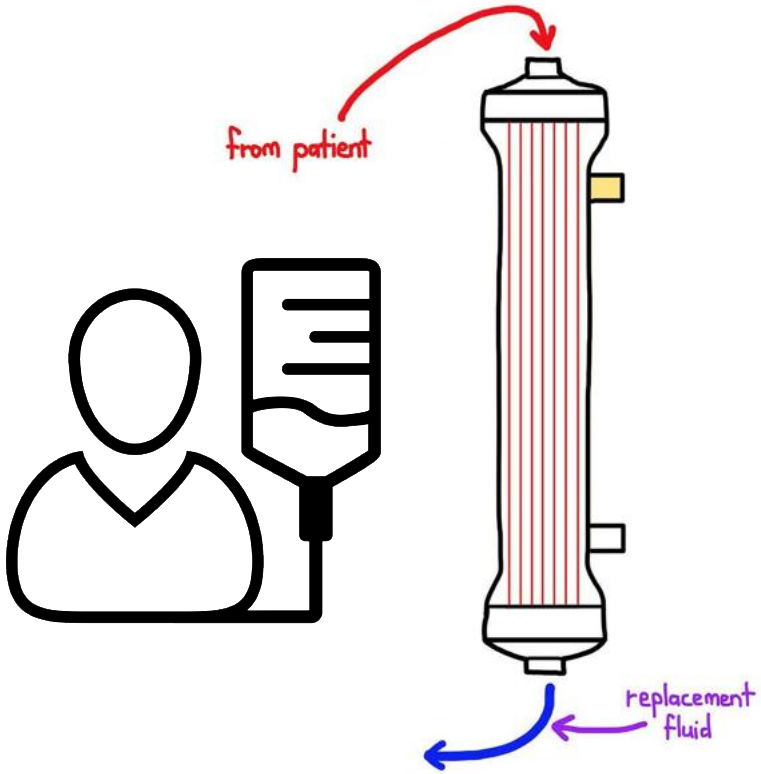
Prolonged Intermittent Renal Replacement Therapy

	INTERMITTENT	CONTINUOUS	HYBRID
	IHD	**CRRT**	***PIRRT***
Frequency	2-3 d/wk	Continuous	3-7 d/wk
Timing	Day	Day + night	Day or night
Anticoagulation	Can be performed without anticoagulation	Usually yes	Can be performed without anticoagulation
Vascular access	AVF – AVG - CVC	CVC	CVC
Usual UF rate	1-5 L/3-4 h	1800-2500 ml/h	1-4 L/6-12 h
Patient location	ICU, step down unit, ward	ICU, step down unit	ICU, step down unit, ward

Edrees F et al. Advances in Chronic Kidney Disease; 23;3, 2016:195-202(modified)


Fast
Slow


Fast
Slow


from patient
replacement fluid

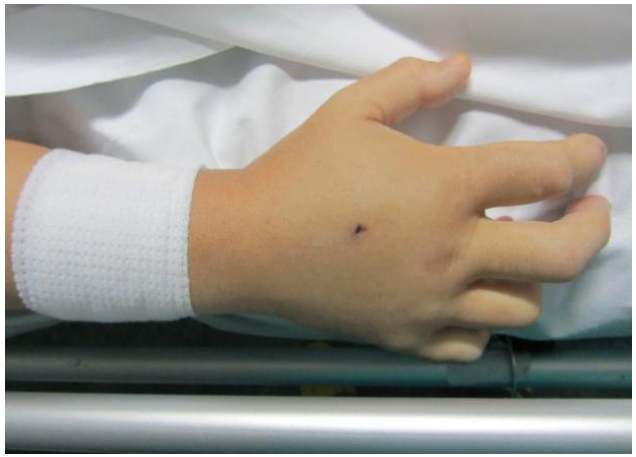
IHD

IHD provides **rapid** solute **clearance** and **ultrafiltration** during relatively brief (3- to 5-h) treatments

Tandukar S & Palewsky PM. CHEST 2019;155:626-638

WHAT IS THE OPTIMAL RRT MODALITY FOR PATIENTS WITH AKI?

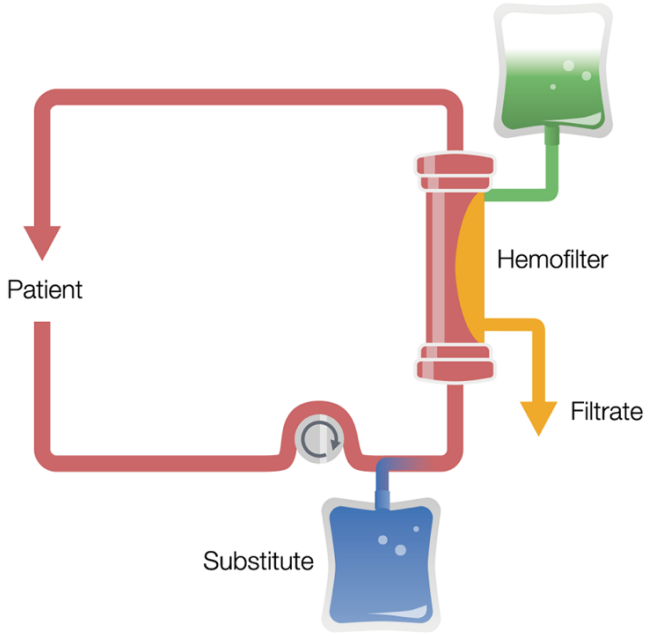
- The most problematic of these is intradialytic hypotension, which results from **fluid removal** on dialysis **at a rate that exceeds vascular refilling** from the intracellular and interstitial compartments.
- **Intradialytic hypotension** is a common complication in critically ill patients who often have the vexing combination of fluid overload and hemodynamic instability.



Rachoin JB & Weisberg LS. CCM 2019 Feb 13

WHAT IS THE OPTIMAL RRT MODALITY FOR PATIENTS WITH AKI?

- CRRT seems like an **ideal modality** for dialysis of **critically ill patients**, as it would be predicted to cause—by virtue of its **slow**, **continuous** nature—less hypotension and less radical electrolyte and pH perturbation than IHD.



Guérin C et al. Intensive Care Med 2002; 28:1411–1418
Bellomo R et al. Nephron 1995; 71:59–64

Rachoin JB & Weisberg LS. CCM 2019 Feb 13

CRRT

- CVVHD
- CVVH
- CVVHDF

The continuous therapies provide **more gradual fluid removal** and **solute clearance** over prolonged treatment times (optimally, 24 h per day but often interrupted due to system clotting or diagnostic or therapeutic procedures)

Tandukar S & Palewsky PM. CHEST 2019;155:626-638

CRRT

- CVVHD
- CVVH
- CVVHDF

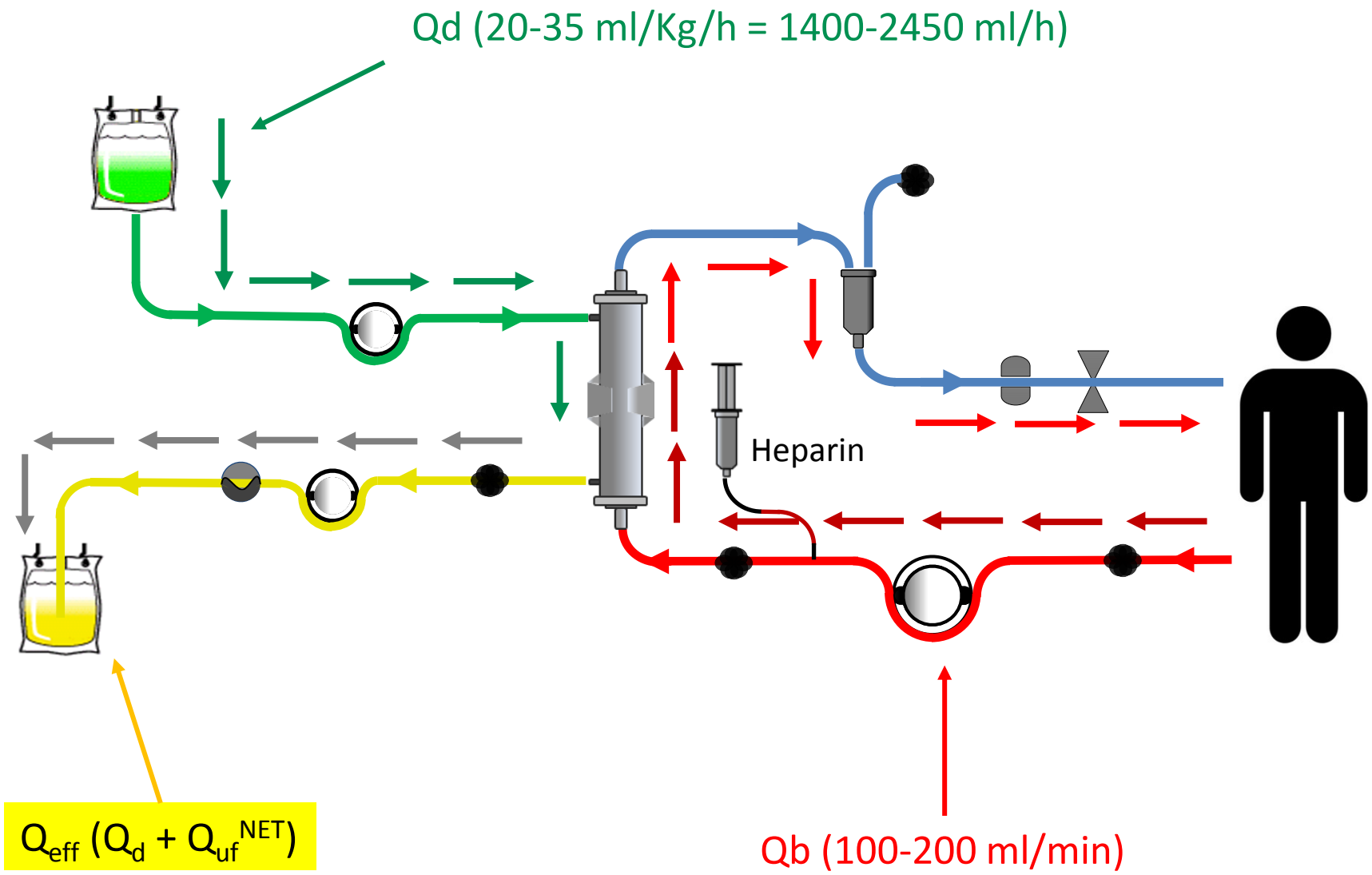
- IHD

- PIRRTs

In addition, dialytic therapies rely predominantly on **diffusive** solute clearance, whereas solute removal during hemofiltration occurs by **convection**.

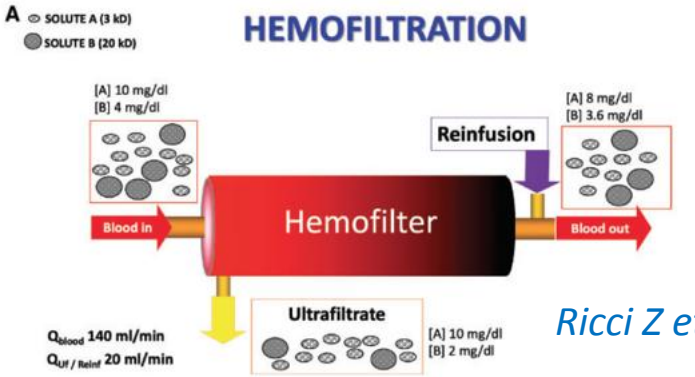
Tandukar S & Palewsky PM. CHEST 2019;155:626-638

CVVHD heparin



CVVH

Solute transport occurs by convection. Solutes are entrained in the bulk flow of water across the membrane, a process often referred to as "solvent drag."



Ricci Z et al. NDT 2019 1-3

High ultrafiltration rates are needed to achieve sufficient solute clearance, and the ultrafiltrate volume beyond what is required to achieve desired net fluid removal is replaced with balanced IV crystalloid solutions.

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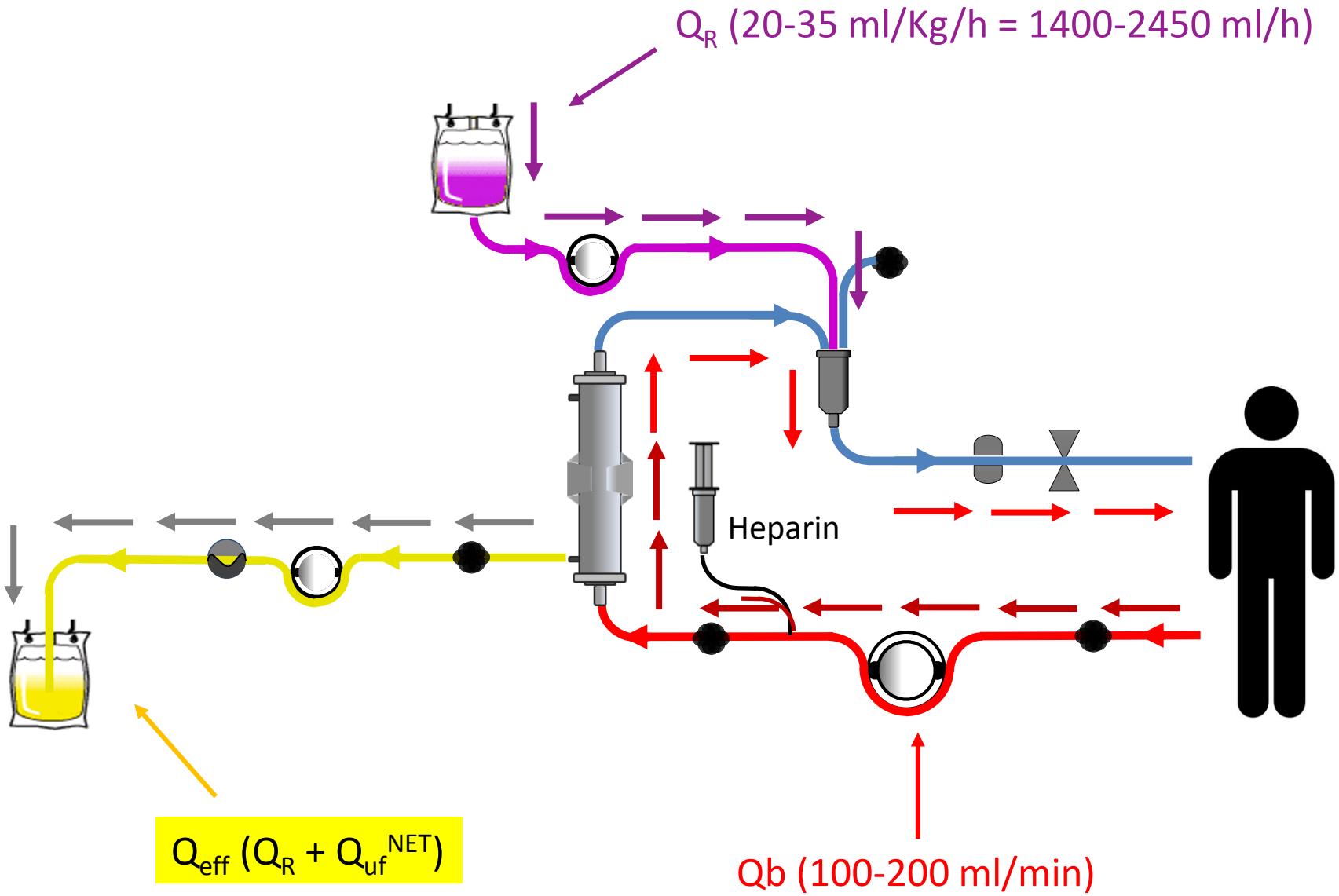
CVVH (100% post) heparin



CVVH (Continous Veno-Venous Hemofiltration)

- Continuous veno-venous hemofiltration (CVVH) uses **convection** to remove solutes through large volume fluid ultrafiltration.

- Small solute molecules, such as urea, and middle-sized molecules, such as inflammatory **cytokines**, are cleared.

- With the large volume of fluid removed, intravascular volume must be maintained using a **replacement fluid**.

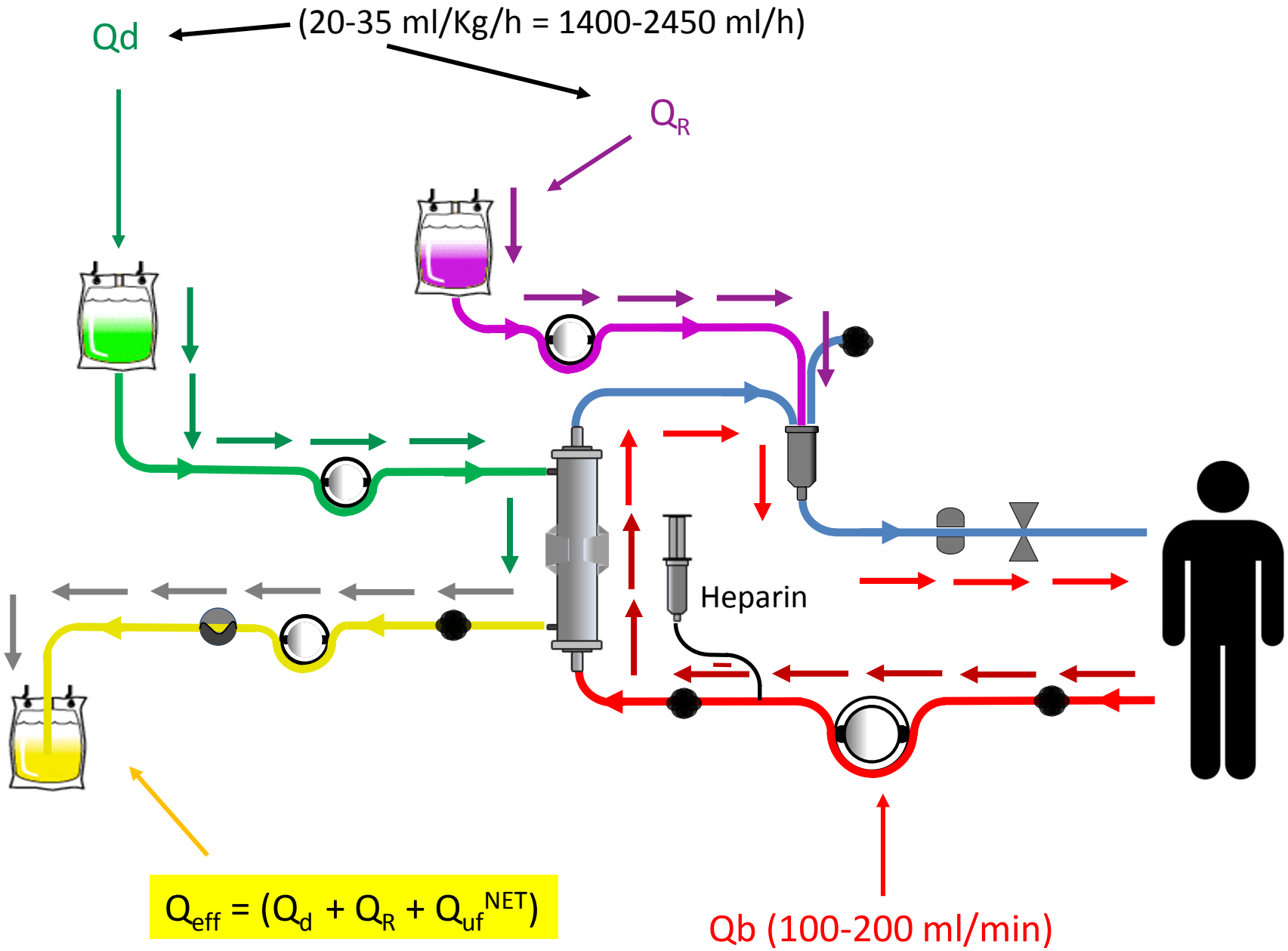
Alvarez G et al. Can J Anesth 2019 Feb 6.

CVVH (Continous Veno-Venous Hemofiltration)

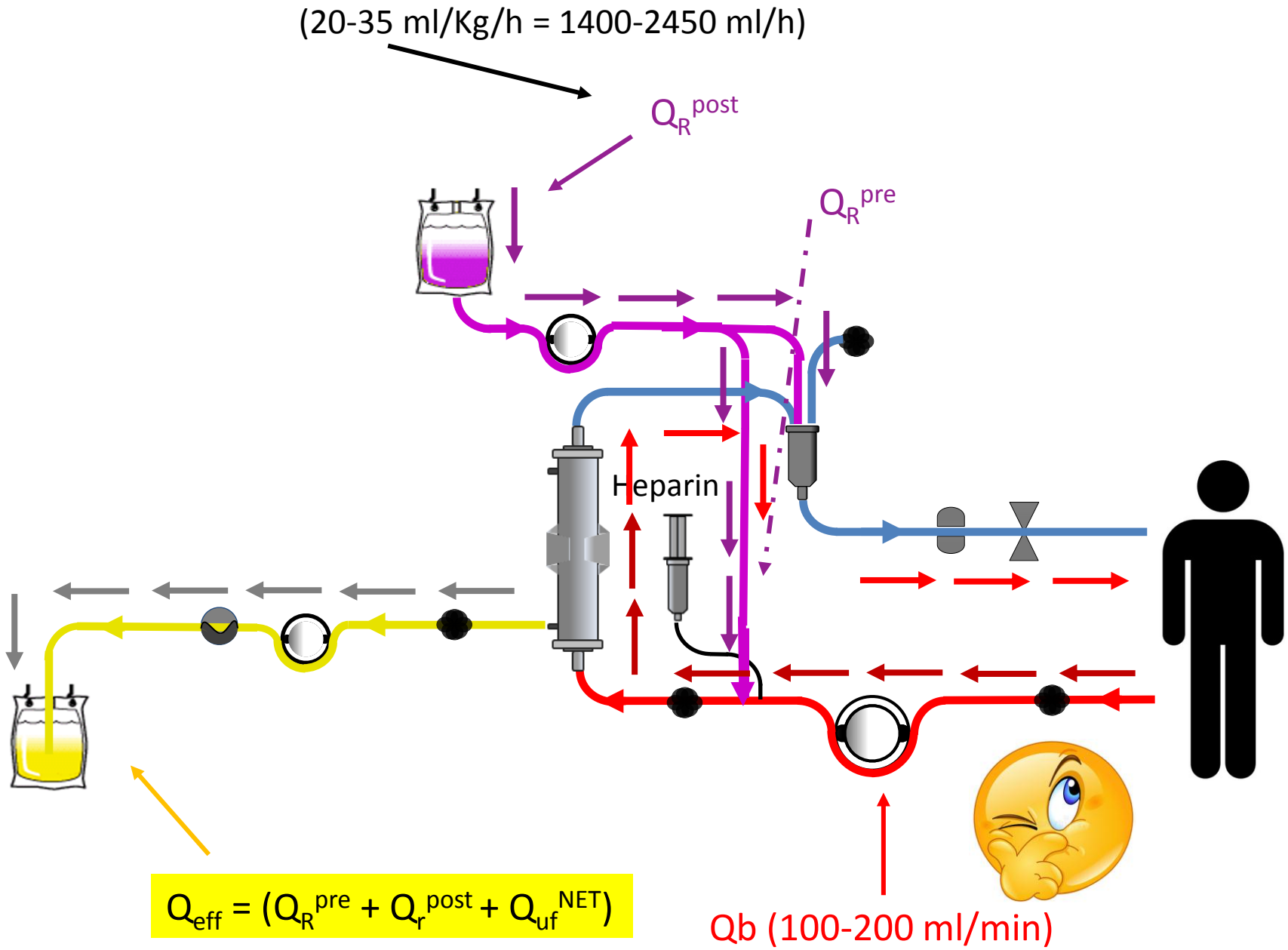
- The replacement fluid can be infused either before the hemofilter (**predilution**) or after the hemofilter (**post-dilution**).
- **Postdilution** results in more concentrated blood in the filter and higher solute clearance.
- Nevertheless, more concentrated blood can lead to a shorter filter lifespan.
- While **pre-dilution** means lower solute concentrations and clearance, this is offset by a higher ultrafiltration rate and **longer filter life**.

Alvarez G et al. Can J Anesth 2019 Feb 6.

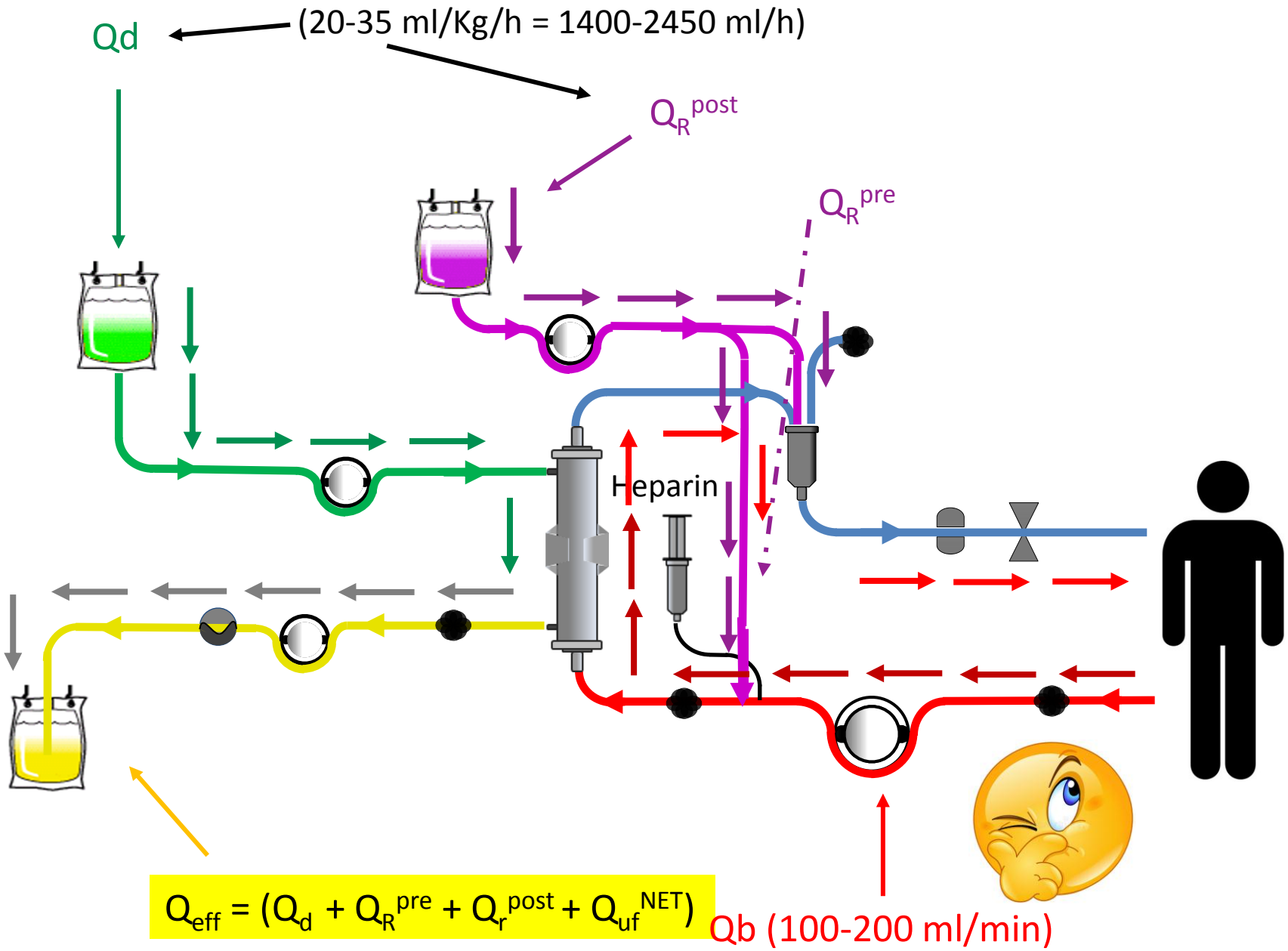
CVVHDF (100% post) heparin



CVVH (50% pre-post) heparin



CVVHDF (50% pre-post) heparin



Acute kidney injury: to dialyse or to filter?

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

ndt digest

As a practical approach, in order to achieve advantages from both techniques (Diffusion & Convection):

- Set: CVVHDF
- Prescription 20 - 35mL/kg/h of dialytic dose:

  - **Split** the flows between **haemofiltration** and **dialysis** in order to balance prolonged circuit life and efficiency of blood purification.

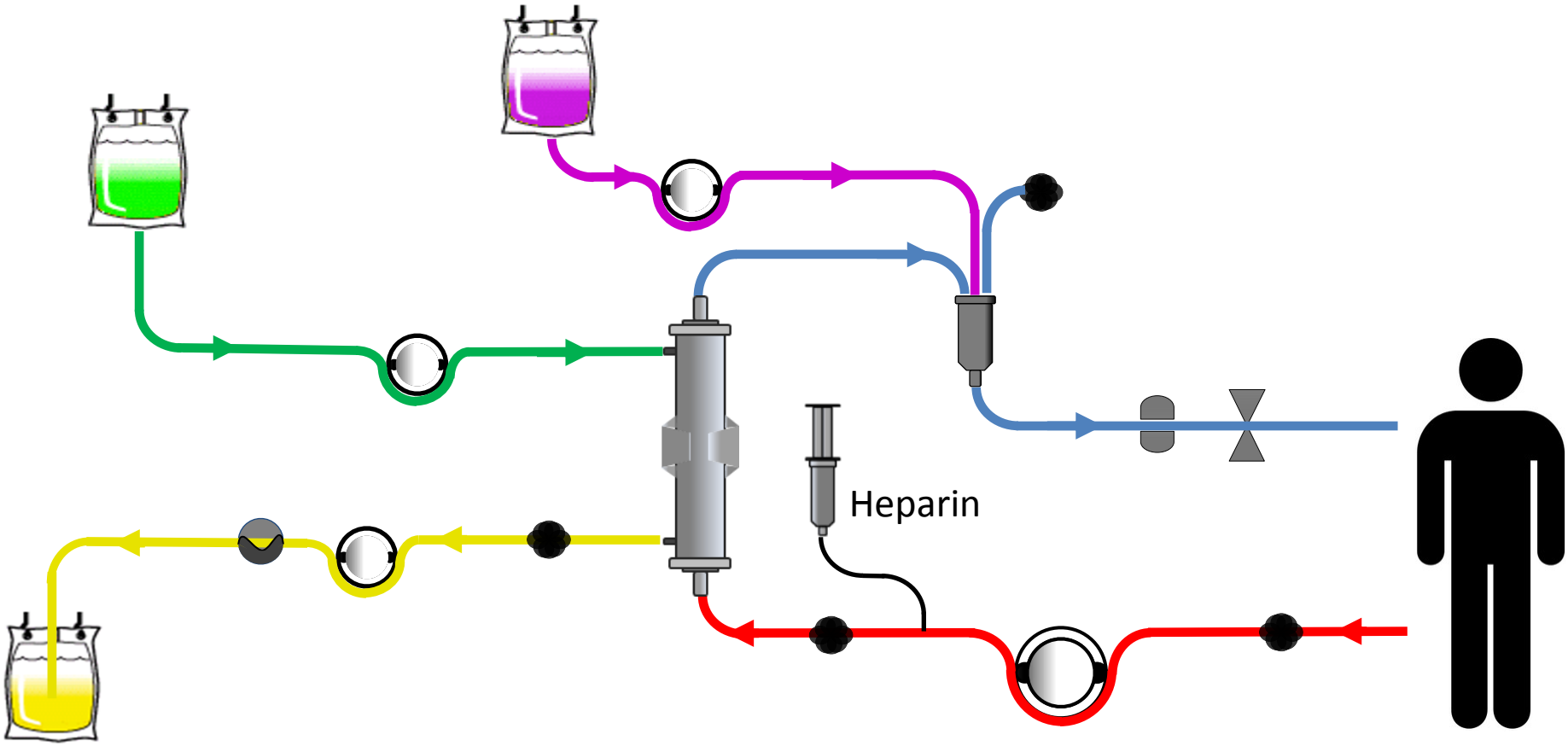
However, during haemodiafiltration, the **highest possible convective dose should always be delivered by setting the haemofiltration rate to 20% of plasma flow**, with the remaining prescription set as diffusion, just to reach the desired intensity target.

Ricci Z et al. Nephrol Dial Transplant (2019) 1–3

CVVHDF (post-Hep)

70 Kg – 30 ml/Kg/h →
Q_{eff}= 2100 ml/h

$Q_{uf}^{NET} = 0$



CVVHDF (post-Hep)

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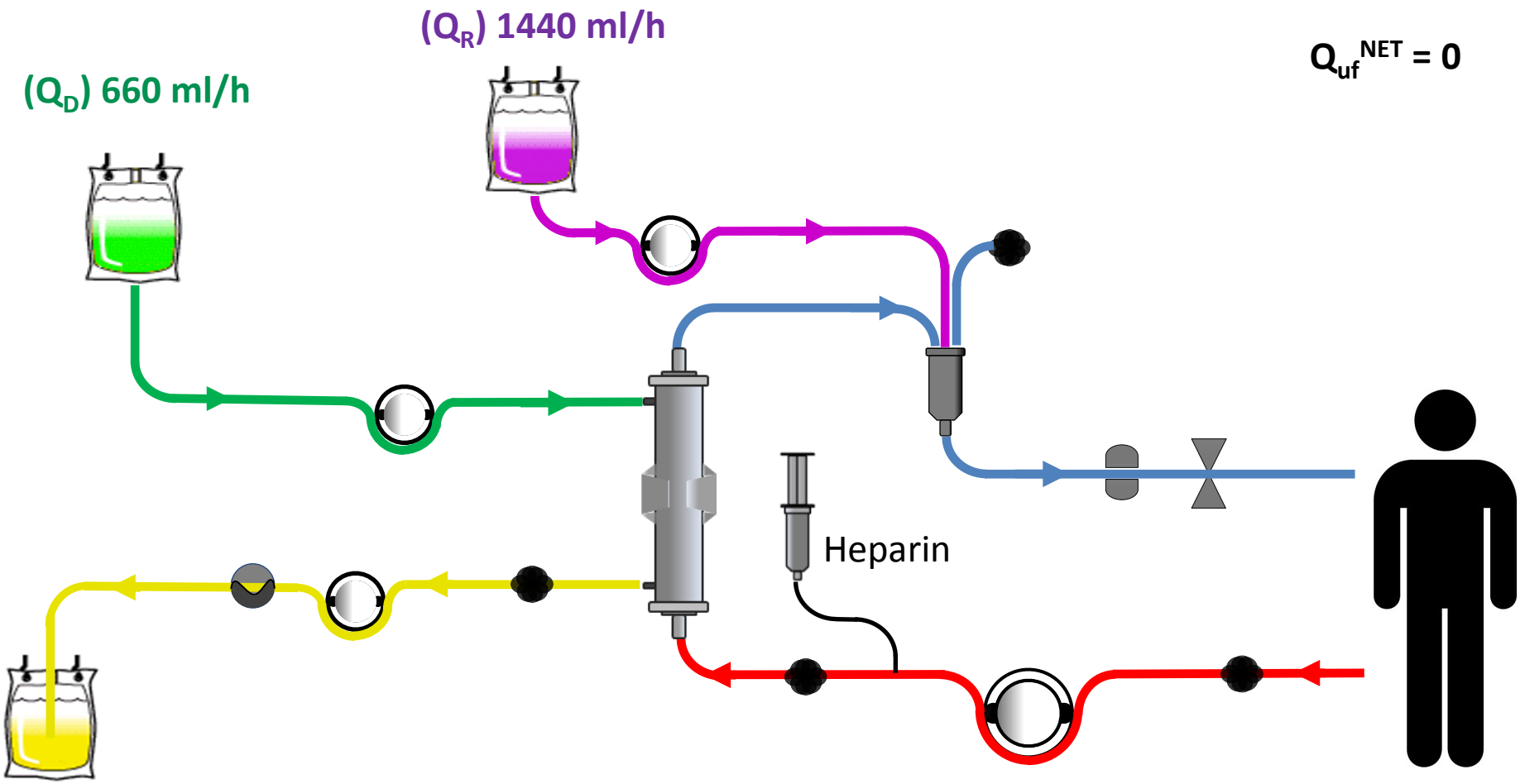


Q_b = 200 ml/min → Qp = 120 ml/min → 7.200 ml/h → (20%) → Quf = 1440 ml/h

PIRRTs

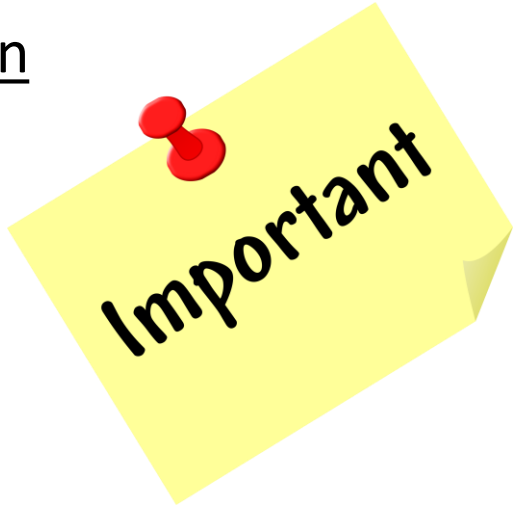
The multiple forms of PIRRT are characterized by treatments that are generally **between 8 and 16 h in duration**, with **slower** rates of solute clearance and ultrafiltration than IHD but more rapid than CRRT.

Tandukar S & Palewsky PM. CHEST 2019;155:626-638

PIRRT is most commonly provided by using **equipment similar to that for IHD** but with lower blood and dialysate flow rates.

PIRRTs

It can also be performed by using **equipment designed for CRRT** but with **augmented dialysate and/or ultrafiltration rates** to achieve similar delivered therapy over a shorter duration



Tandukar S & Palewsky PM. CHEST 2019;155:626-638

WHAT IS THE OPTIMAL RRT MODALITY FOR PATIENTS WITH AKI?

PIRRT

- There are no convincing data that demonstrate a difference in important clinical outcomes with PIRRT, compared with other RRT modalities

Edrees F et al. Adv Chronic Kidney Dis. 2016;23(3):195-202.

Rachoin JB & Weisberg LS. CCM 2019 Feb 13

Selection of RRT Modality

Although **CRRT** and **PIRRT** are most commonly used in **hemodynamically unstable patients**, there is marked variation in practice

Some centers use CRRT (or PIRRT) in all ICU patients with renal failure regardless of hemodynamic status, whereas **others** use IHD, albeit with adjustments in prescription, even in vasopressor dependent patients.

Tandukar S & Palewsky PM. CHEST 2019;155:626-638

Although the benefit of a slow, continuous modality of renal support in hemodynamically unstable patients may seem **self-evident**, **randomized trials have failed to show differences with regard to either mortality or recovery of kidney function** comparing CRRT with either IHD or PIRRT

Mehta RL et al. Kidney Int. 2001;60(3):1154-1163.
Augustine JJ, et al. Am J Kidney Dis. 2004;44(6):1000-1007.
Uehlinger DE, et al. Nephrol Dial Transplant. 2005;20(8):1630-1637.
Vinsonneau C et al. Lancet. 2006;368(9533):379-385.
Lins RL et al. Nephrol Dial Transplant. 2009;24(2):512-518.
Schefold JC et al. Crit Care. 2014;18(1):R11.
Bagshaw SM et al. Crit Care Med. 2008;36(2):610-617.
Pannu N et al. JAMA. 2008;299(7):793-805.
Friedrich JO et al. Critical Care. 2012;16(4): R146.
Zhang L et al. Am J Kidney Dis. 2015;66(2):322-330.
Kielstein JT, et al. Am J Kidney Dis. 2004;43(2):342-349.
Schwenger V et al. Crit Care. 2012;16(4):R140.
KDIGO. Kidney Int. 2012;2012(suppl):1-138.

It must be recognized, however, that to provide **IHD** in hemodynamically unstable patients, the standard prescription may require modification, such as prolongation of treatment time to allow for more gradual ultrafiltration, use of higher dialysate sodium concentrations, and reduced dialysate temperatures

Tandukar S & Palewsky PM. CHEST 2019;155:626-638

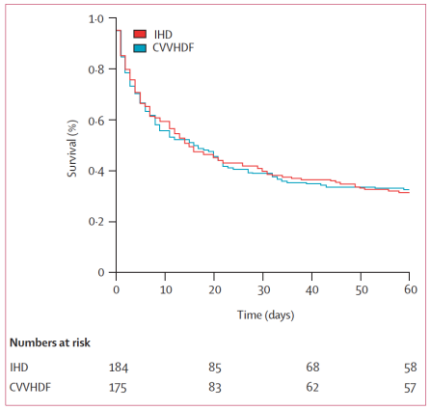
WHAT IS THE OPTIMAL RRT MODALITY FOR PATIENTS WITH AKI?

- In order to minimize hemodynamic perturbation in critically ill patients on IHD, the prescription may need to be modified.

- Exacerbation of hemodynamic instability may be mitigated by extending treatment time

[Hemodiafe trial: average lenght = 5.2 hr per session]

Vissonneau C et al. Lancet. 2006 29; 368(9533): 379-85



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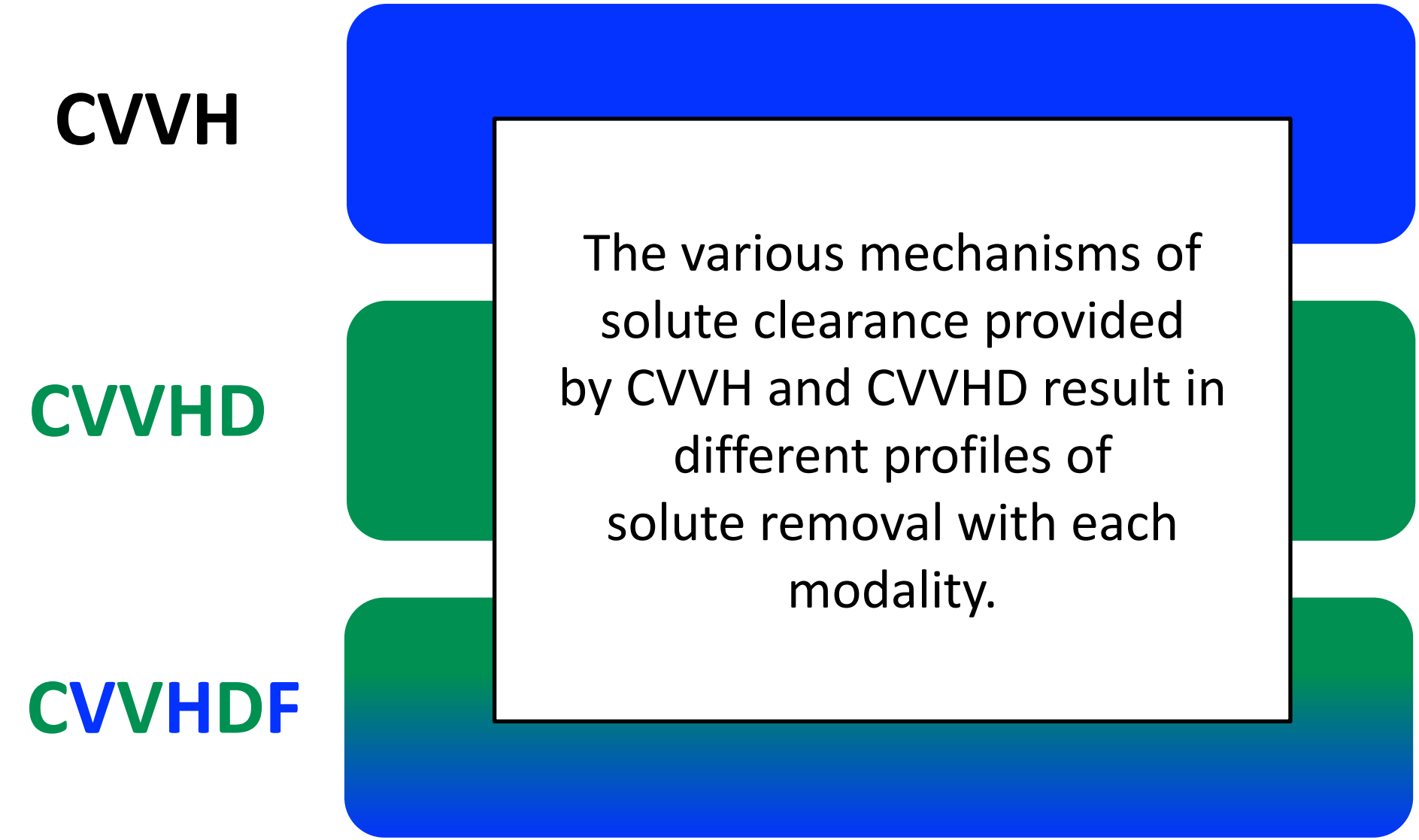
Although the **Kidney Disease: Improving Global Outcomes (KDIGO)** Clinical Practice Guideline for AKI recommends the use of CRRT for patients who are **hemodynamically unstable**, the strength of this recommendation is **low**.

Observational data, however, do suggest that CRRT is more effective in **achieving net negative fluid balance** than IHD.

Tandukar S & Palewsky PM. CHEST 2019;155:626-638



Tandukar S & Palewsky PM. CHEST 2019;155:626-638

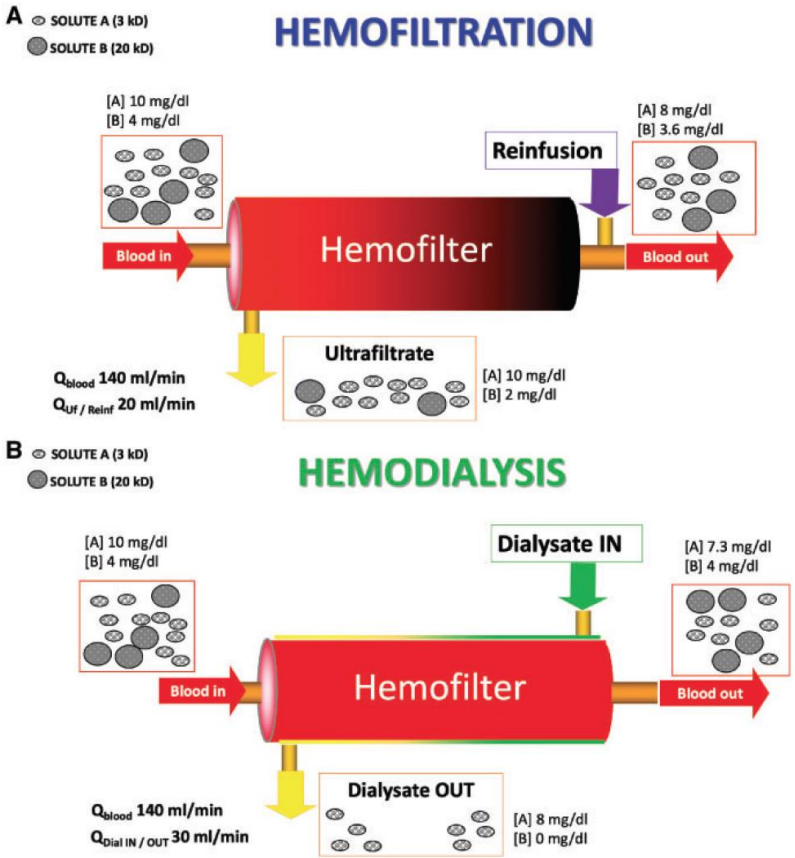
Nephrol Dial Transplant (2019) 1–3
doi: 10.1093/ndt/gfz022

ndt digest

Acute kidney injury: to dialyse or to filter?

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

- Extraction of medium-sized and large molecules from the blood is greater with convective rather than diffusive methods.



Ricci Z, Romagnoli S, Ronco C. NDT 2019 1-3

CVVHD
IHD

Diffusion provides efficient clearance of low-molecular-weight solutes (< 500-1,500 Daltons)

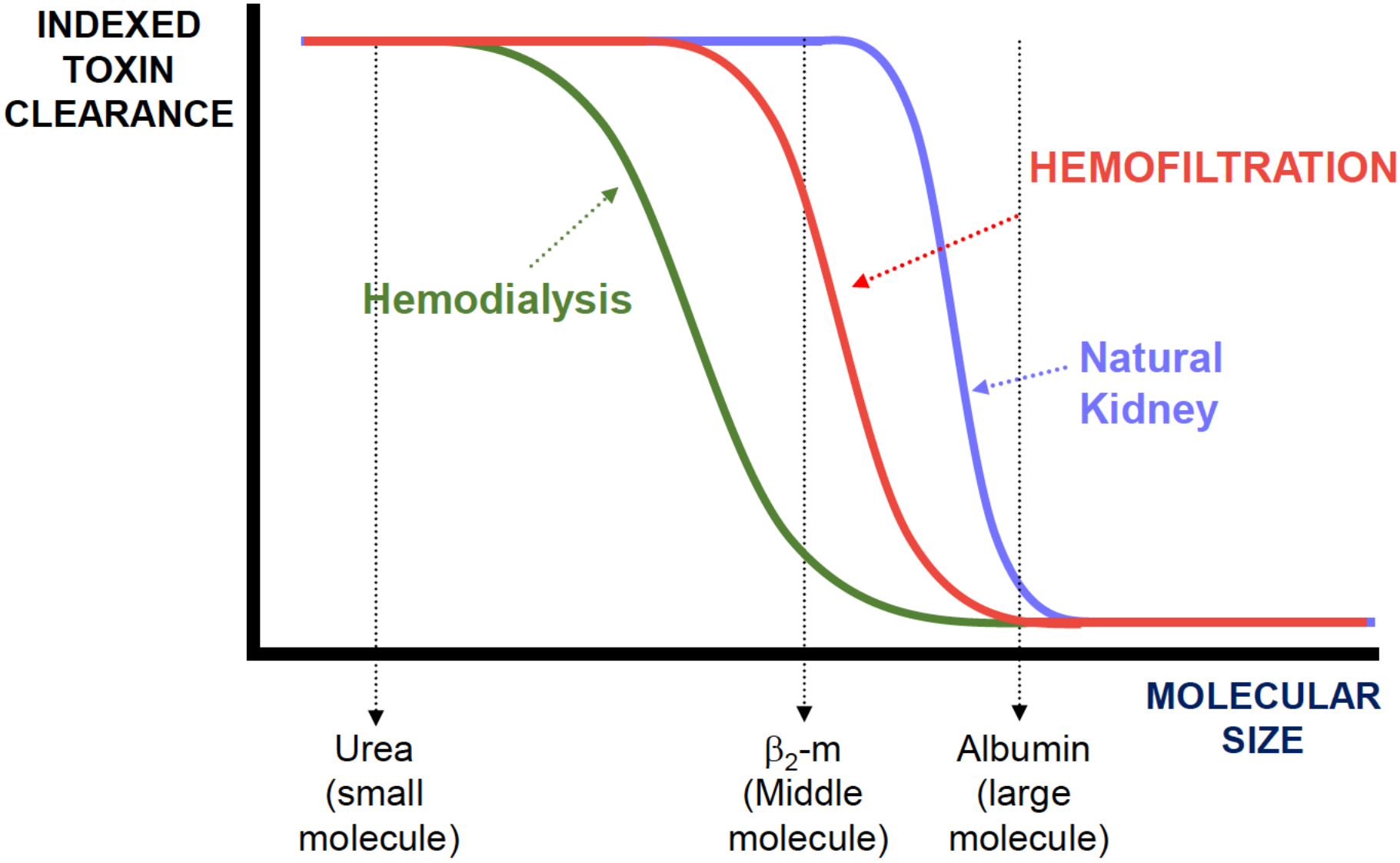
Tandukar S & Palewsky PM. CHEST 2019;155:626-638

CVVH

Solute movement in convection is limited primarily by the size of the **pores** in the hemofilter membrane.

CVVHDF

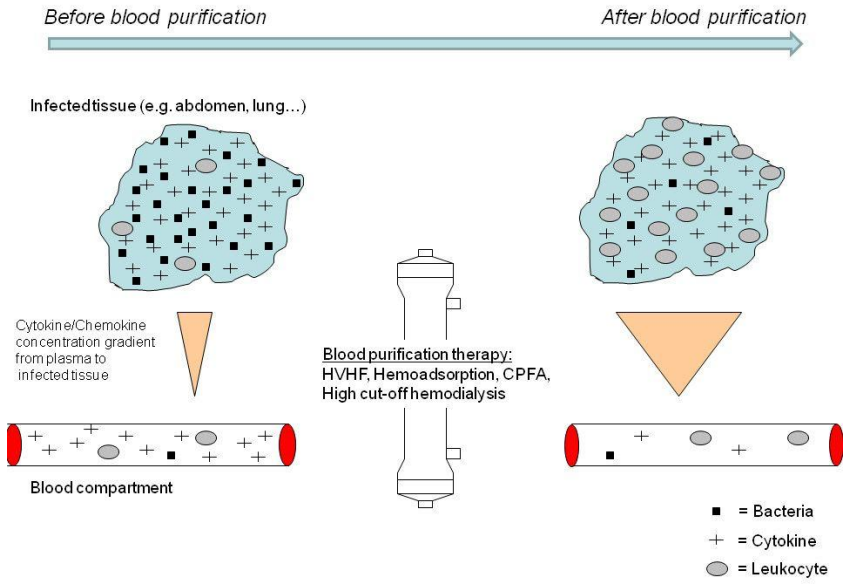
Tandukar S & Palewsky PM. CHEST 2019;155:626-638


INDEXED
TOXIN
CLEARANCE
HEMOFILTRATION
Hemodialysis
Natural
Kidney
MOLECULAR
SIZE
Urea
(small
molecule)
β2-m
(Middle
molecule)
Albumin
(large
molecule)

WHAT IS THE OPTIMAL RRT MODALITY FOR PATIENTS WITH AKI?

- Several studies have examined effects of convective modalities on **cytokines** in patients with sepsis and AKI

Bellomo R et al. Ren Fail 1995; 17:457–466
Kellum JA et al. Crit Care Med 1998;26:1995–2000
Lonnemann G et al. Kidney Int Suppl 1998; 66:S43–S46
van Bommel EF et al. Ren Fail 1997; 19:443–454



Rimmeleé T & Kellum JA. Critical Care201115:205

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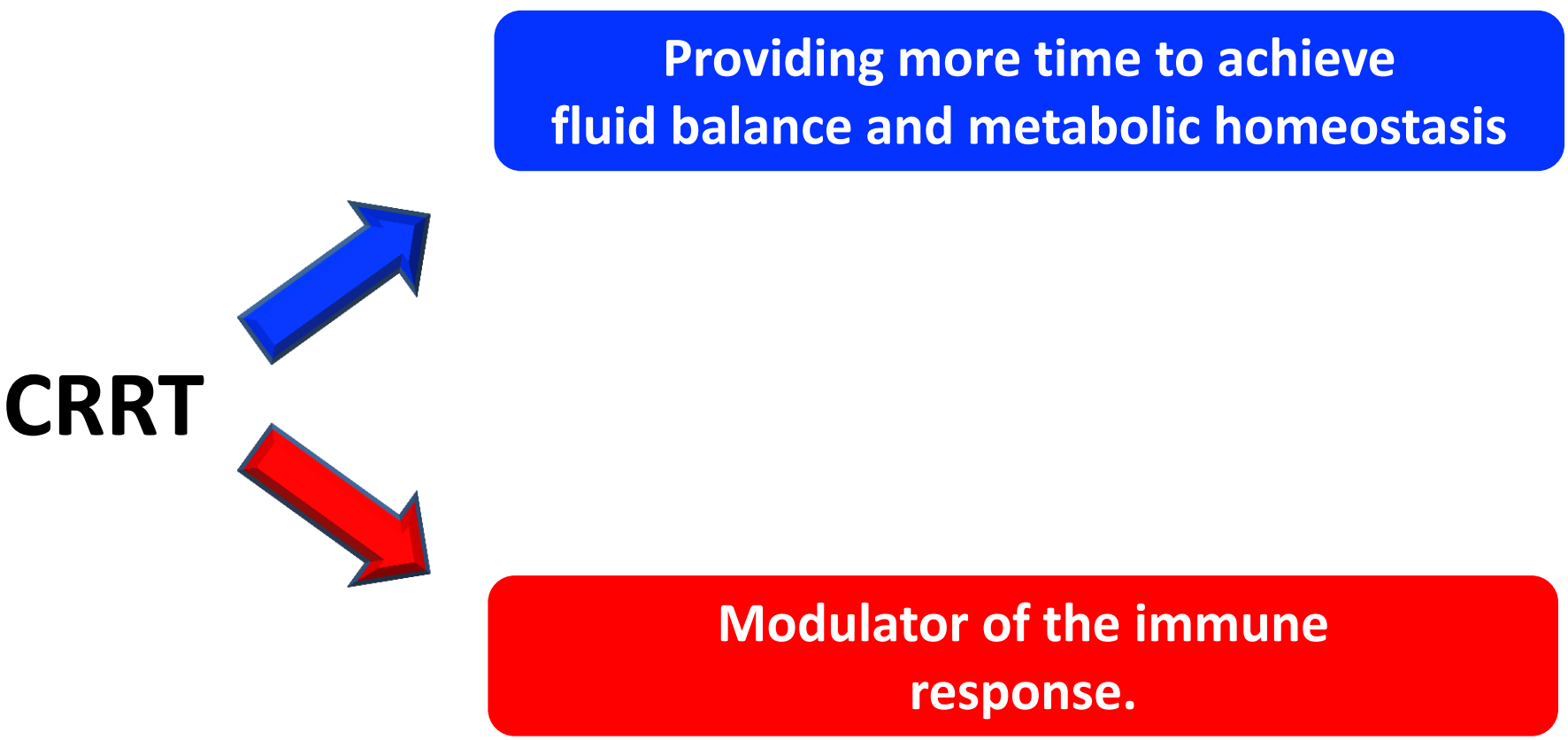
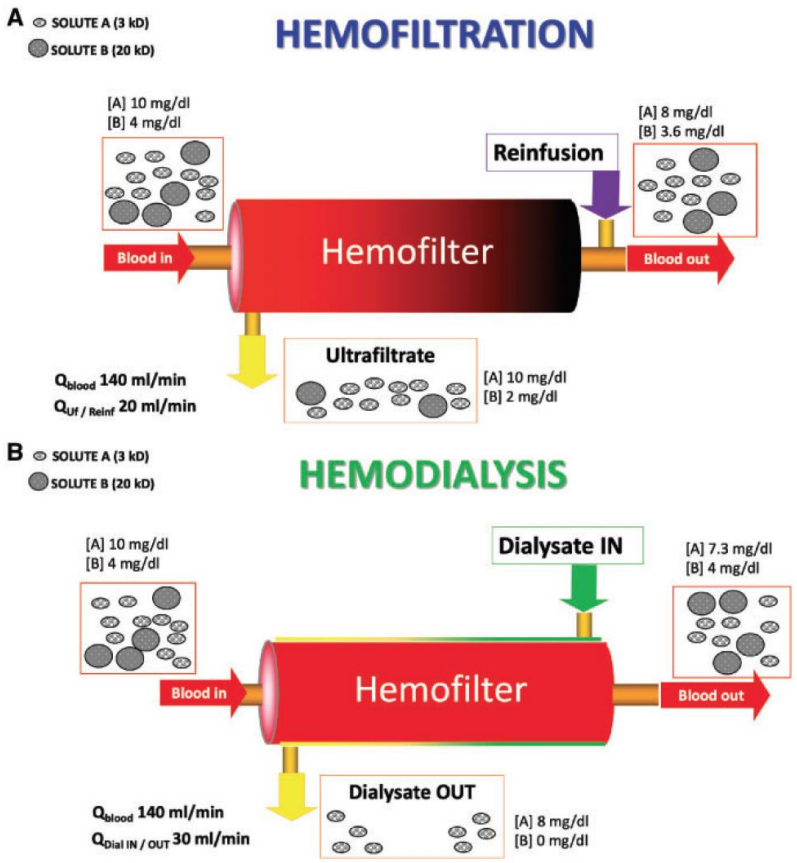
CRRT in Sepsis and Multisystem Organ Failure



- High-volume hemofiltration (HVHF)
- High-cutoff membranes
- Hybrid (filtration + adsorption) systems such as coupled plasma filtration absorption.

Macedo E et al. Am J Kidney Dis. 2016;68:645-65



Ricci Z, Romagnoli S, Ronco C. NDT 2019 1-3

Thus, current evidence does not provide a reason to choose a **convective modality over a diffusive** modality in the treatment of patients with AKI.

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CRRT is **strongly recommended over IHD** for the management of AKI in patients with acute brain injury, in whom acute perturbations in plasma solute concentration may **exacerbate intracranial hypertension** which, in combination with systemic hypotension, may lead to critical cerebral hypoperfusion.

Davenport A. Hemodial Int 2010; 14(Suppl 1):S27–S31

CRRT in Acute Brain Injury

Dialysis disequilibrium syndrome

Conventional IHD may exacerbate the reduction in cerebral perfusion and increase cerebral edema.

Rapid urea removal from the plasma and water shift to the intracellular compartment can worsen brain edema.

IHD

Intradialytic hypotension can cause a decrease in MAP and CPP
CPP=MAP-ICP

Increase ICP by compensatory cerebral vasodilation.

Macedo E et al. Am J Kidney Dis. 2016;68:645-65

CRRT in Acute Brain Injury

IHD should be avoided because it is associated with a more significant increase in ICP compared to CRRT.

"CRRT, rather than intermittent RRT, for AKI patients with acute brain injury or other causes of increased intracranial pressure or generalized brain edema. (2B)"

Kidney Disease Improving Global Outcomes: *Kidney Int Suppl* 2012, **2**.

Macedo E et al. Am J Kidney Dis. 2016;68:645-65

WHAT IS THE OPTIMAL RRT MODALITY FOR PATIENTS WITH AKI?

- Many patients **transition** from one modality to another during the course of their AKI, usually from CRRT to IHD as their hemodynamic instability resolves.
- Increasingly, hybrid modalities that provide RRT for **6–18 hours** per day, collectively referred to as **prolonged intermittent RRT (PIRRT)**, are used either as an initial modality or as a transition between CRRT and IHD

Edrees F et al. Adv Chronic Kidney Dis. 2016;23(3):195-202.

Rachoin JB & Weisberg LS. CCM 2019 Feb 13

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CORSO CRRT

CRRT: concetti di base 3

Grazie !

Stefano Romagnoli