CRRT
concetti di base 2

Nomenclatura: descrizione delle varie componenti del circuito, membrane, filtri, parti delle apparecchiature e sensori

IX edizione CRRT nursing

Mauro Neri
PhD in Mechatronic Engineering,
Materials Engineer,
International Renal Research Institute of Vicenza (IRRIV),
San Bortolo Hospital,
Vicenza

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The terminology used to describe the CRRT is often confusing and continuously evolving

Different Forms of Continuous Extracorporeal Treatment: Technical Aspects

Sieberth HG, Stummvoll HK, Kierdorf H (eds): Continuous Extracorporeal Treatment in Multiple Organ Dysfunction Syndrome. Contrib Nephrol. Basel, Karger, 1995, vol 116, pp 28–33

Continuous Renal Replacement Therapies: The Need for a Standard Nomenclature

Claudio Ronc…

Several forms of renal replacement therapy have been used for the treatment of acute renal failure in the critically ill patient in the last decade. The evolution of basic concepts into a more complex clinical approach and applied technology, now requires a detailed analysis of the various techniques with the aim of establishing a common nomenclature.

TECHNIQUE OF CONTINUOUS RENAL R…

Nomenclature for Continuous Renal …

Rinaldo Bellomo, MD, FRACP, Claudio Ronco, MD, a…

● Continuous renal replacement therapies (CRRTs) have evolved o… terminology for the different methods in use. At an International C… November 9-10, 1995, an international panel of experts developed a… The nomenclature was developed to define common terms and to … the field of CRRT are reviewed and published. This article describes … that these definitions will be used as a framework for subsequent de…

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INDEX WORDS: Continuous hemofiltration; acute kidney failure; … sepsis.

CONTINUOUS renal replacement therapy (CRRT) has now been applied to the management of critically ill patients for more than 15 years.[1] Although initially used in the form of a simple arteriovenous circuit to avoid the complexity associated with hemodialysis … evolved a great deal …

…ants in Continuous Renal …cement Therapy

…Turk, †Micha… Gao

…dianapolis, IN;

…prescription and delivery are discussed, with the focus on continuous venovenous hemofiltration (CVVH). Specifically, differences between postdilution and predilution CVVH will be highlighted, and the importance of blood flow rate in dose delivery for these therapies will be discussed. **Key Words:** Hemodialysis—…ous renal replacement

…py review
…ure

…and current nomenclat…

CLAUDIO RONCO and RINALDO BELL…

Department of Nephrology, St. Bortolo Hospital, Vicenza, Italy, and Intensive Care Un… Heidelberg, Victoria, Australia

Continuous renal replacement therapy: Evolution in technology and current nomenclature. The evolution of technology and biomaterials has permitted a parallel development of renal replacement therapies in the acute, critically ill patient. From the original description of continuous arteriovenous hemofiltration (CAVH), new techniques such as continuous venous venous hemofiltration (CVVH), hemodiafiltration (HDF) and high flux dialysis (HFD) have been developed and clinically utilized. A parallel improvement in efficiency has been achieved with daily clearances of urea as high as 50 liters or more. The use of special highly permeable dialyzers has also permitted increases in the clearances of larger solutes, thus leading to significant removals of chemical substances involved the …

Department of Pediatrics; Vanderbilt University Medical Center; Nashville, TN USA

Key words: dialysis, peritoneal dialysis, hemodialysis, renal replacement therapy, artificial kidney

Introduction

Support of renal function in modern times encompasses a wide array of methods and clinical scenarios, from the ambulatory patient to the critically ill. The ability to safely and routinely deliver ongoing organ support in the outpatient setting has, until recently, separated renal replacement therapy from other organ support. Renal replacement therapy (RRT) can be applied intermittently or continuously using extracorporeal (hemodialysis) or paracorporeal (peritoneal dialysis) methods. The purpose of …

modern dialysis today is performed using the work of Dr. Nils Alwall. The Alwall dialyzer compressed blood-filled cellophane tubing between an inner and outer cylinder. Dialysate was passed in the countercurrent direction to blood between the cylinders.[4] The authors describe dialysis in eight patients, including changes in levels of non-protein nitrogen (N.P.N.), using countercurrent exchange between blood and dialysis fluid that is still in use today in RRT.

The peritoneum was noted to be a "living dialyzer" by Dr. Tracey J. Putnam in 1923 in a series of experiments with

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Nomenclature in CRRT: the 4° generation of CRRT machines

Why is it important to have a consensus of terminology and nomenclature in CRRT?

- **Safety**
- **Accuracy** and **efficiency**
- **Communication** among all parties involved (physicians, nurses, technicians)
- To **uniform clinical research**
- To facilitate **comprehension** and **technological progress**

Nomenclature in CRRT: Index

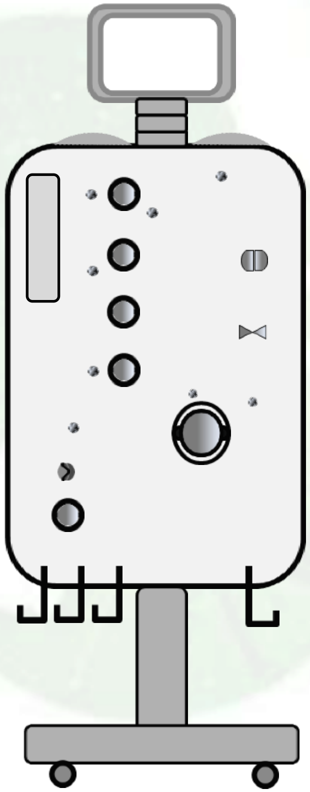
- **Main components of extracorporeal CRRT**
- Parameters of the filter/dialyzer
- Volumes and flows
- Time in CRRT
- Treatment evaluation methods: the “Dose”

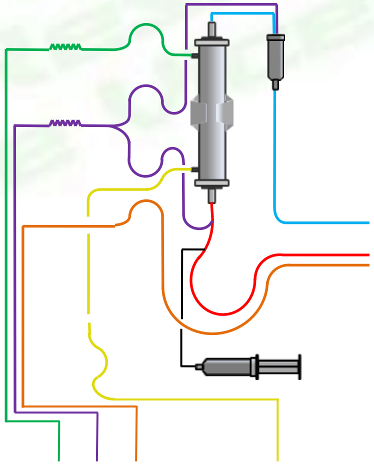
Main components of extracorporeal CRRT

«Non-disposable Hardware” of the machine

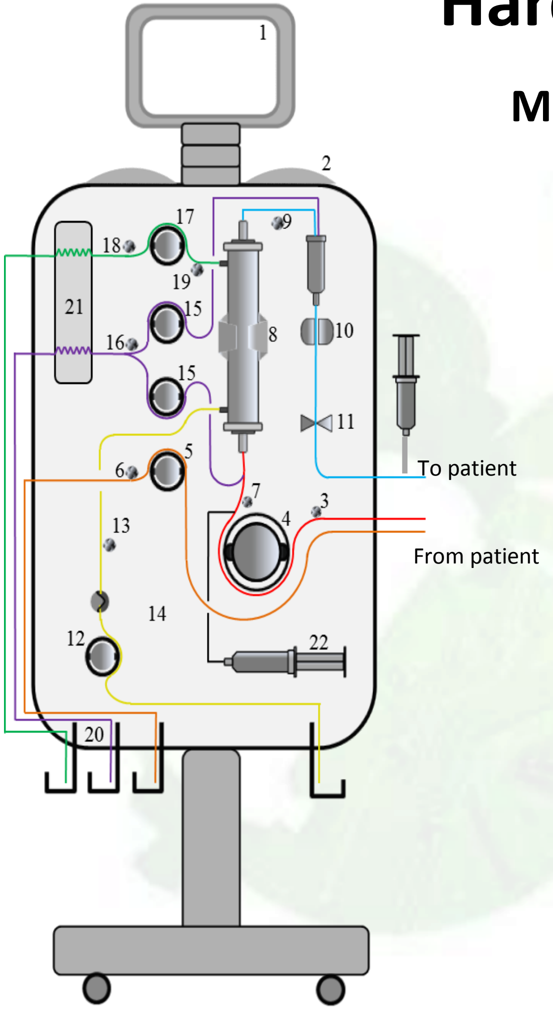
CRRT extracorporeal circuit

Disposables and filter





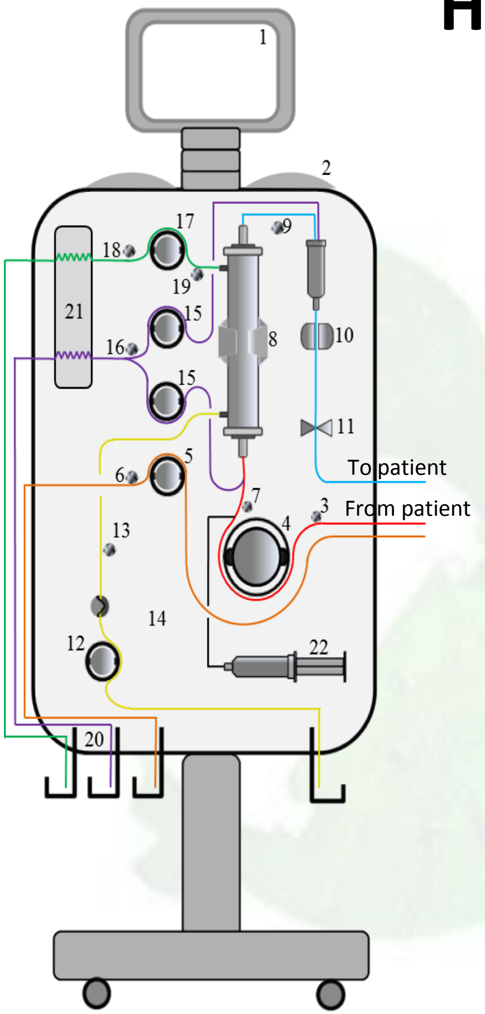
Hardware of the machine (1)



Main components:

- Monitor
- Pumps
    - Blood pump
    - Dialysate pump
    - Replacement (pre and/or post)
    - Ultrafiltrate/effluent pump
    - Systemic anticoagulation pump (e.g. heparin)
    - Regional anticoagulation pump (e.g. citrate)
    - Reversal anticoagulation pump (e.g. calcium)
- Return safety automatic clamp (and access safety automatic clamp)
- Components for fluid balance system monitoring: scales
- Heater

Hardware of the machine (2)



Main Sensors:

- Pressure sensors
  - Access pressure sensor (before blood pump): $\mathbf{P_{ACC}}$
  - Pre filter pressure sensor (after blood pump / before filter) $\mathbf{P_{PRE}}$
  - Return pressure sensor line: $\mathbf{P_{RET}}$
  - Effluent/ultrafiltrate line: $\mathbf{P_{EFF}}$
  - Transmembrane pressure**: TMP**
  - Pressure drop**:** $\mathbf{P_{DROP}}$
- Return air bubbles detector (vs. access air bubbles detector)
- Blood leak detector (BLD) in the effluent/ultrafiltrate line

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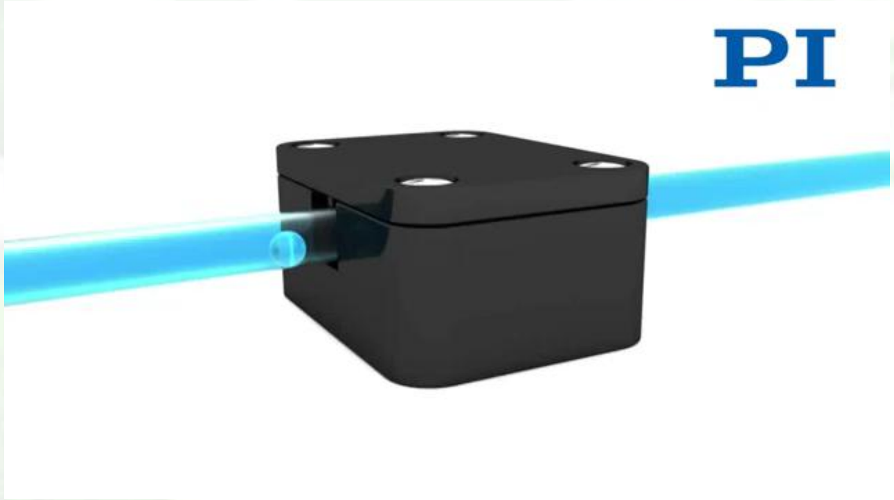
Hardware of the machine: sensors

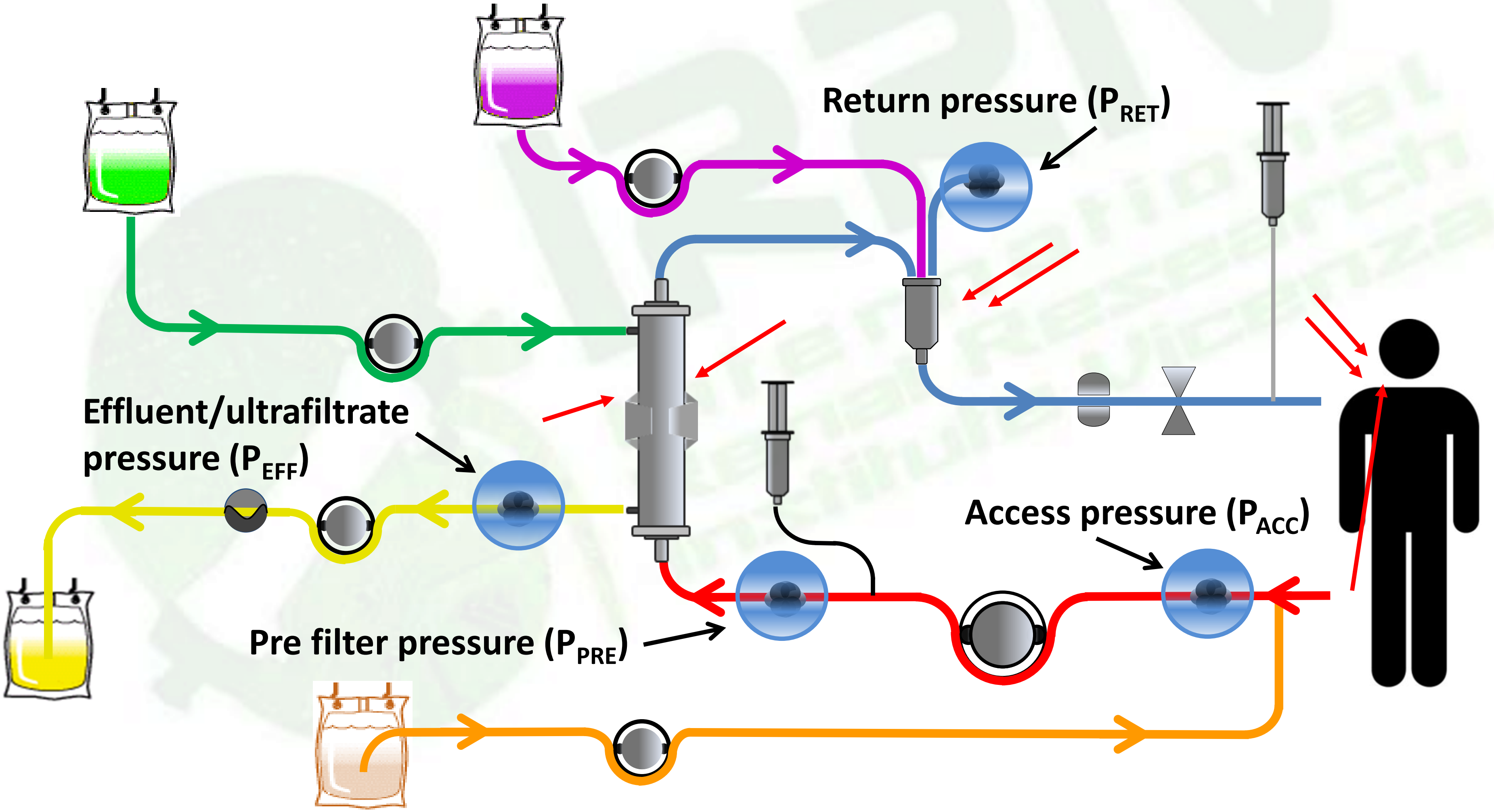
Return air bubbles detector: to detect air bubbles in the return line



Hardware of the machine: sensors

Blood leak detector (BLD) in the effluent/ultrafiltrate line: to detect rupture of fibers in the filter

The extracorporeal circuit for CRRT: pressures (1)



The extracorporeal circuit for CRRT: pressures (2)

TMP: pressure gradient across the membrane

$$TMP^* = (P_{PRE} + P_{OUT}) / 2 - P_{EFF}$$

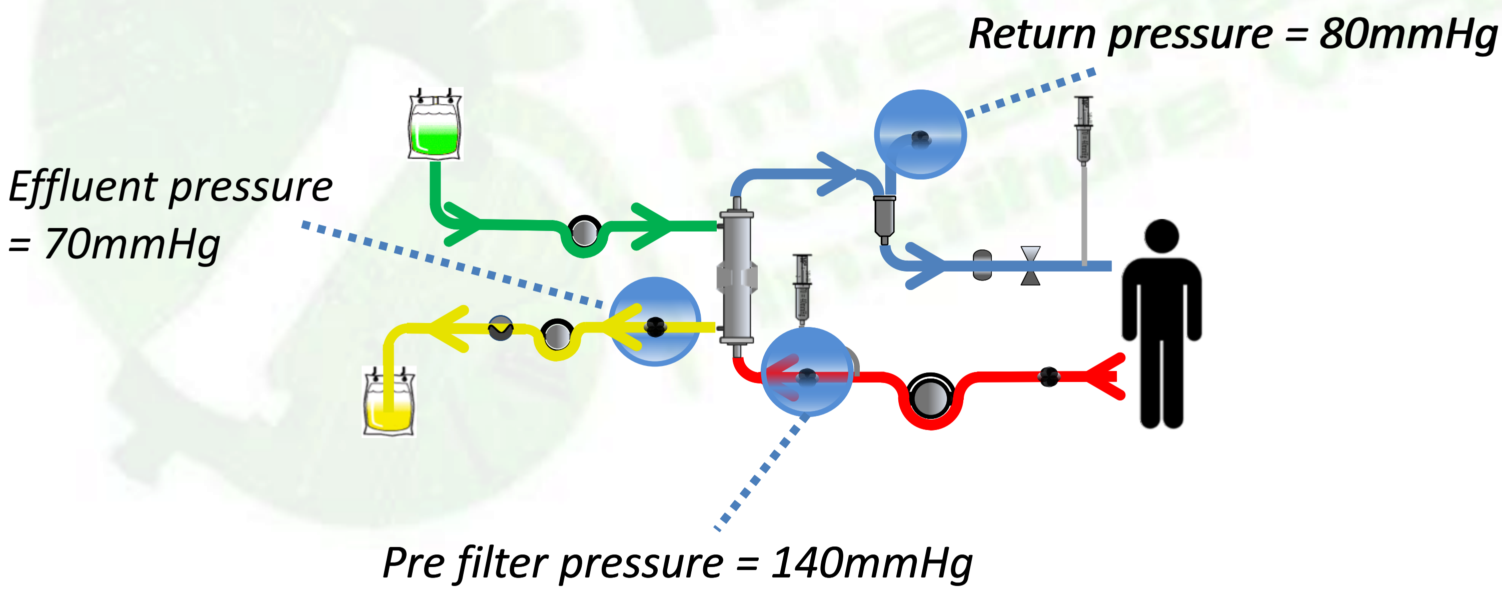
P_{DROP}: pressure difference pre and post filter

$$P_{DROP} = P_{PRE} - P_{OUT}$$

$$TMP^* = \frac{140+80}{2} - 70 = 40\text{mmHg}$$

$$P_{DROP} = 140 - 80 = 60\text{mmHg}$$

Example



Disposable components of the circuit

Disposables are single-use components of the extracorporeal circuit; they are specific for every machine and are usually designed for a specific treatment modality.

Line	Color	Color code
Blood inflow line	Red	
Blood outflow line	Blue	
Dialysate line	Green	
Effluent/ultrafiltrate line	Yellow	
Replacement line	Purple	
Regional anticoagulation line (e.g. citrate)	Orange	
Systemic anticoagulation line (e.g. Heparin)	White	
Reversal antagonist line (e.g. calcium)	Grey	

Filters

The **filter** is the key disposable where blood is effectively purified.
Filter identifies all the disposables that purify blood by ultrafiltration, convection, diffusion.

Filters		
	Ultrafilter →	Ultrafiltration modality
	Hemofilter →	Hemofiltration modality
	Hemodialyzer →	Hemodialysis modality
	Hemodiafilter →	Hemodiafiltration modality
	Plasmafilter →	Plasmapheresis modality
	Cartridge or sorbent or adsorber →	Hemoperfusion or plasmaperfusion modality

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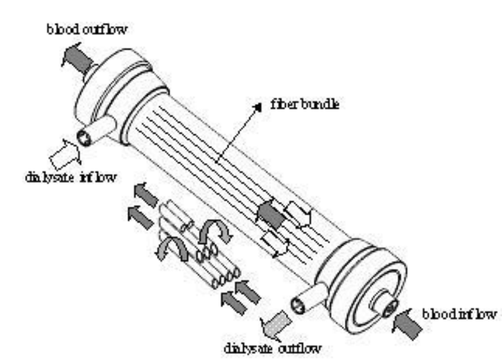
Parameters of the membranes (1)

The geometrical characteristics → Performance characteristics



Surface area

The surface area (A) represents the total area of membranes directly in contact with blood

Parameters of the membranes (1)

The performance characteristics → Potential applications

Ultrafiltration coefficient of the membrane (K_{UF})
K_{UF} represents the water permeability of a filter's membrane per unit of pressure and surface [ml/h/mmHg/m²].

K_{UF} < 10 ml/h/mmHg/m^2	→	**LOW FLUX** membranes
10 ml/h/mmHg/m^2 < K_{UF} < 25 ml/h/mmHg/m^2	→	**MIDDLE FLUX** membranes
K_{UF} > 25 ml/h/mmHg/m^2	→	**HIGH FLUX** membranes

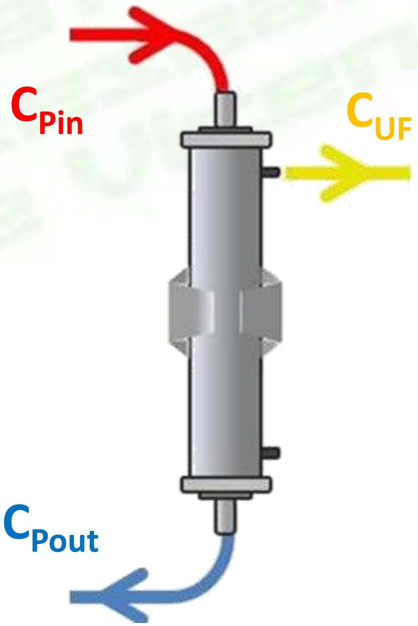
Performance parameters of the membranes (2)

Sieving coefficient (SC)

Sieving coefficient is the ratio of a specific solute concentration in the ultrafiltrate over the mean solute concentration in the plasma before and after the filter.

$$SC = \frac{C_{UF}}{C_{Pi}}$$

$0 \leq SC \leq 1$



Performance parameters of the membranes (3)

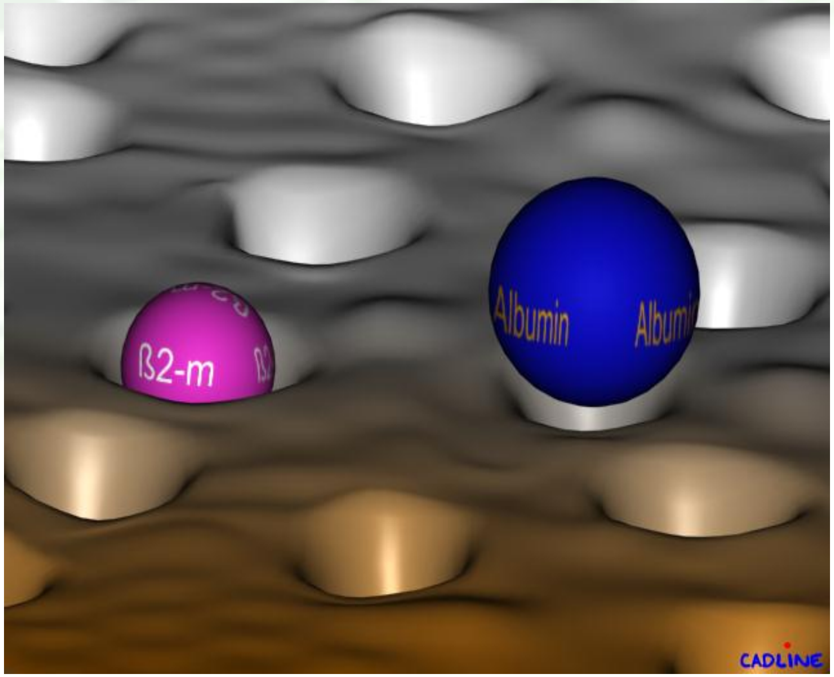
Cut-Off

For a specific membrane, the cut-off value represents the molecular weight of the smallest solute that doesn't pass through the membrane.

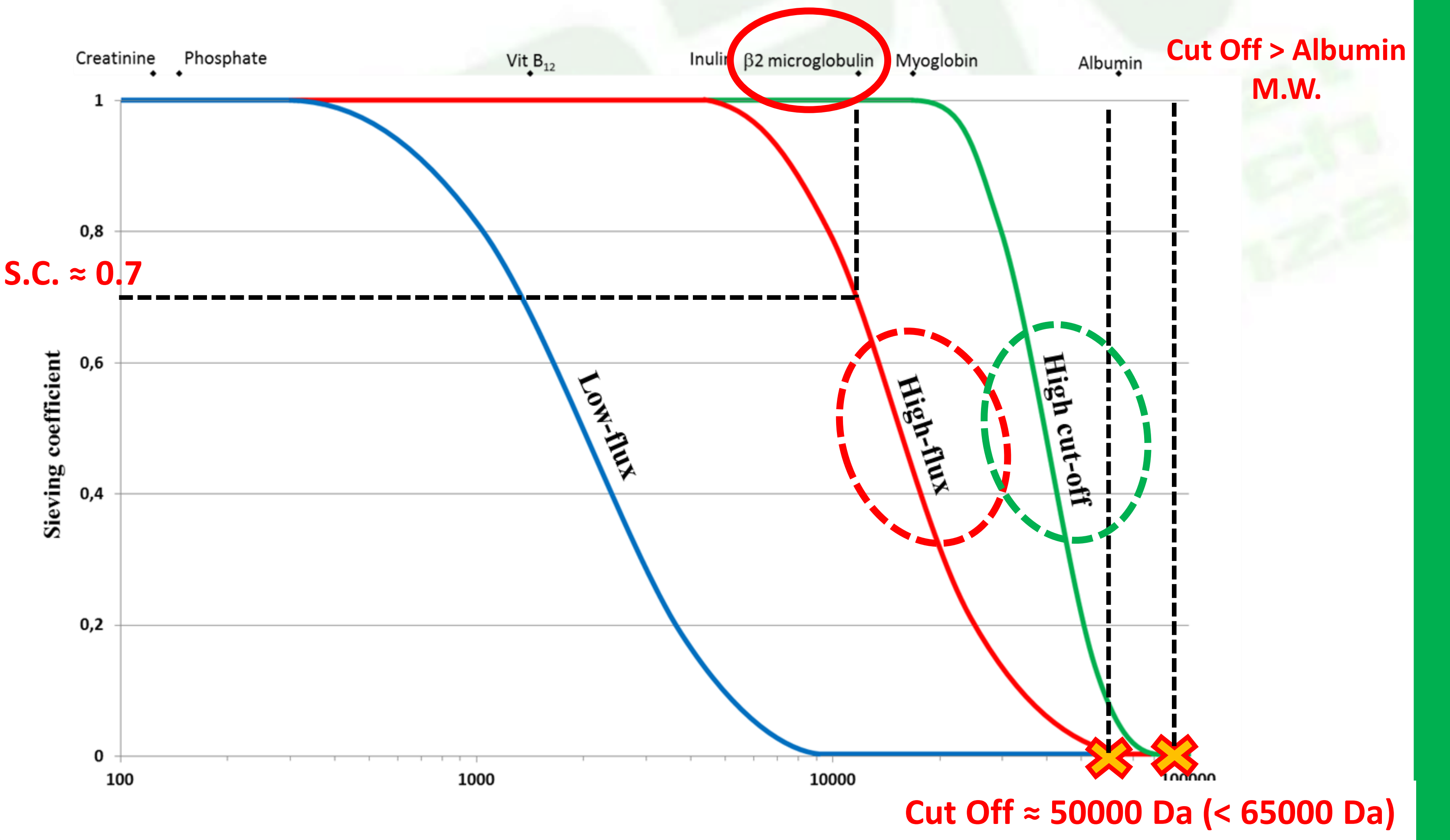
"High Cut-Off Membranes"

↓

SC for albumin > 0



Performance parameters of the membranes (2)



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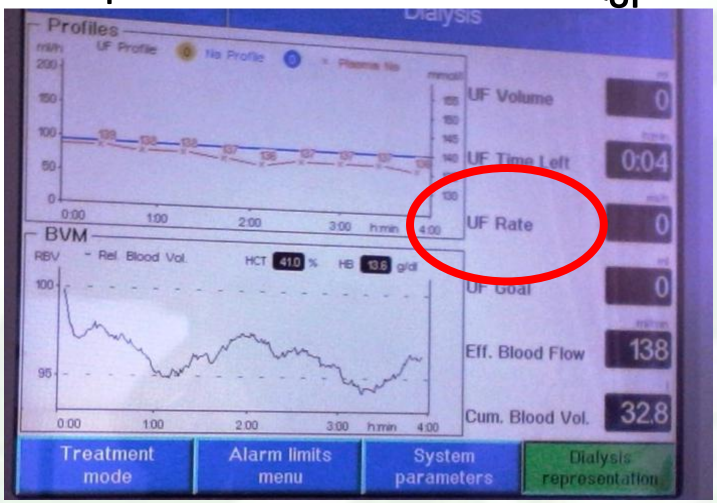
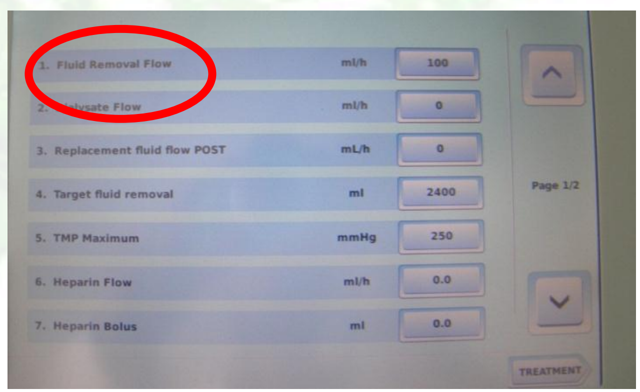
Volumes and fluids

Example of NO consensus: Q_{UF}^{NET}





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Fluids in CRRT

FLOW RATE	SYMBOL	UNIT OF MEASURE
Blood flow rate	Q_B	ml/min
Plasma flow rate	Q_P	ml/min
Replacement flow rate (Substitution flow rate) (Infusion flow rate)	Q_R^{PRE} Q_R^{POST} $Q_R^{PRE/POST}$	ml/h
Net ultrafiltration flow rate	Q_{UF}^{NET}	ml/h
Ultrafiltration flow rate	Q_{UF}	ml/h
Dialysate flow rate	Q_D	ml/h
Effluent flow rate	Q_{EFF}	ml/h

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TIME in CRRT

- ***Effective treatment time*** is defined as the cumulative time while the purification of blood is ongoing. Practically it means that the pumps of dialysate, replacement and effluent are working.

- ***Downtime*** is the time when the machine treatment is stopped. Practically it means that the pumps of dialysate, replacement and effluent are NOT working. Downtime can be due to:
  - Machine alarms (membranes clotting, vascular access malfunctions)
  - Change bag procedure
  - Other clinical procedures

- ***Total treatment time*** is defined as the sum of the effective time of treatment and downtime.

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Dose in CRRT

Dose: "amount of blood cleared of toxins by the extracorporeal circuit"

«K»: [ml/(Kg h)]

Examples

Patient Weight = 75 Kg

Dialysate flow rate = 1500 ml/h
Replacement flow rate = 1000 ml/h
NET ultrafiltration flow rate = 100 ml/h

⇩

Effluent flow rate= 2600 ml/h

$$DOSE= \frac{Effluent\ flow}{Weight} = \frac{2600}{75} = 35\ ml/(Kg\ h)$$

Patient Weight = 75 Kg

Dose = 35 ml/(Kg h)

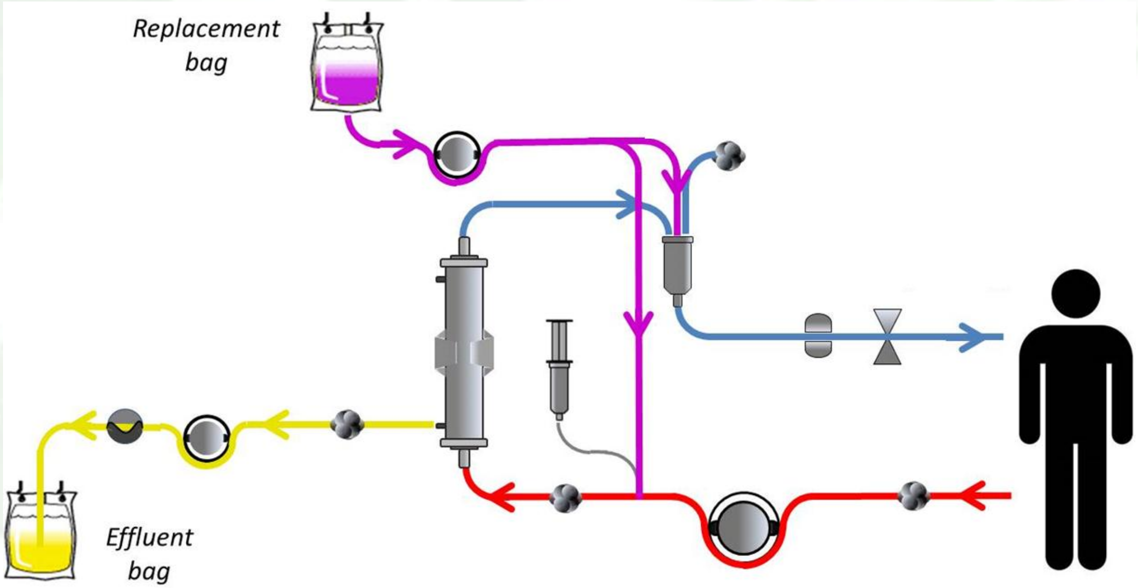
⇩

Effluent flow= $Dose \cdot Weight = 35 \cdot 75$= *2600 ml/h*

High Volume Hemo Filtration

- *High-Volume Hemofiltration (HVHF):* hemofiltration with
  35 ml/Kg/h < prescribed dose < 45ml/Kg/h

- *Very High-Volume Hemofiltration (VHVHF):* hemofiltration with
  prescribed dose > 45ml/Kg/h



Dose in CRRT

Prescribed dose	**=**	***Delivered dose***

Reduction of the downtime

- Time organization (early preparation of the machine, early preparation of the bags for the exchange procedures,…)
- To perform operations quickly and efficiently
- Continuous monitoring of the treatment parameters (Pressures)
- Fast communication and reciprocal interactions with the physicians
- Good knowledge of the machine and terminology

Conclusions

- Understanding the Terminology and Nomenclature explaining the CRRT is essential to **implement adequate treatment choices to the individual patient.**

- When intensivists, nephrologists, nurses and technicians gather at the bedside to decide on **CRRT management strategies** and to implement treatment, they make a series of decisions. The **apparent simplicity** of this **process** belies an enormous degree of complexity: a standard terminology allows immediate comprehension.

- To **facilitate comprehension and future progress**, we expect that not only the **hospital staff**, but even the **field of industry** will also adopt a **standard terminology**, in order to apply the technology at the bedside as well as possible.

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