ANTE
Associazione Nazionale Tecnici Emodialisi

«Paziente con accesso vascolare non performante: come ottimizzare il trattamento?»

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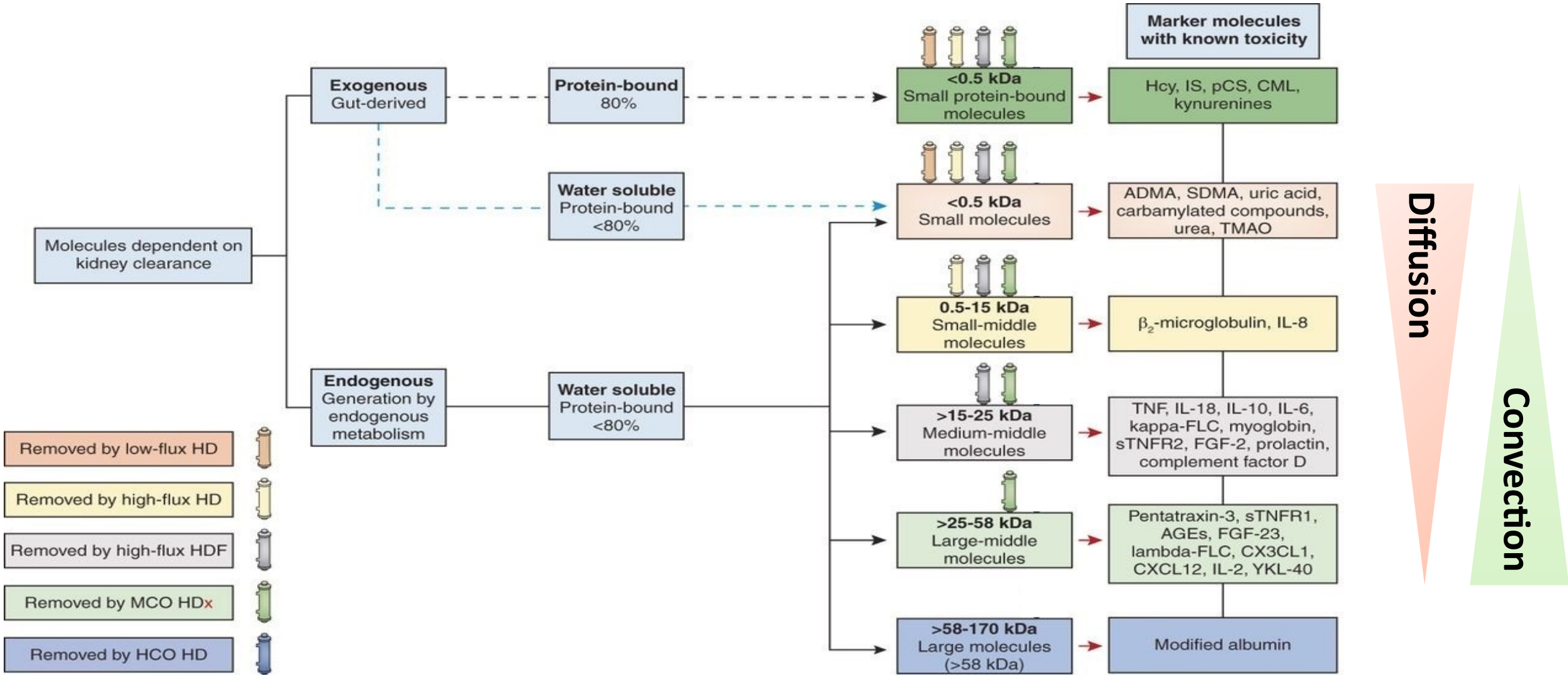
Unmet Medical Needs with Conventional Hemodialysis

In the 1980s the standard of care was low-flux hemodialysis…

- **Significant intradialytic morbidity** (i.e. symptomatic hypotensive episodes, cramps, and nausea)
- **High incidence of dialysis related disease** (i.e. ß2M-amyloidosis, atherosclerosis, cardiac disease, and aging)
- **Poor long-term outcomes** (i.e., mortality and poor quality of life)

Classification of Uremic Toxins



Rosner CJASN 2021

Clinical Benefits of Online HDF

- **Superior removal capacity** per unit time of online HDF across a large MWt spectrum

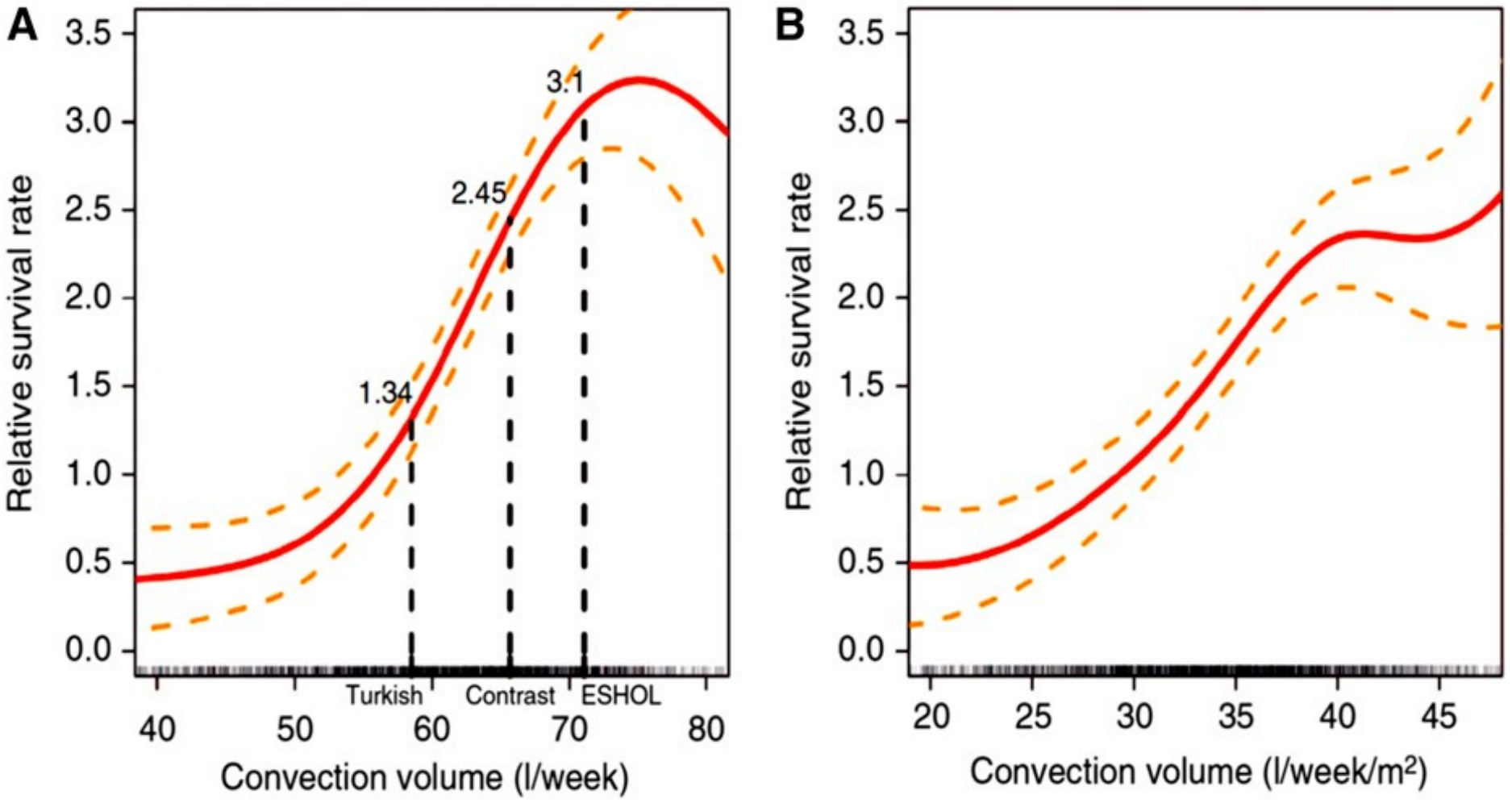
- **Greater hemodynamic stability and improved dialysis tolerance** (removal of negative inotropic compounds,
or vasodilating substances, negative thermal balance)

- **Reduction in chronic subclinical inflammation** Sensitive biomarkers of inflammation (CRP, IL1, IL6, and TNF-α) are significantly reduced with online HDF

- **Cost-efficiency of online HDF production.** Large volumes of substitution fluid can be produced and adjusted to individual patient needs at the cost of ultrapure dialysis fluid

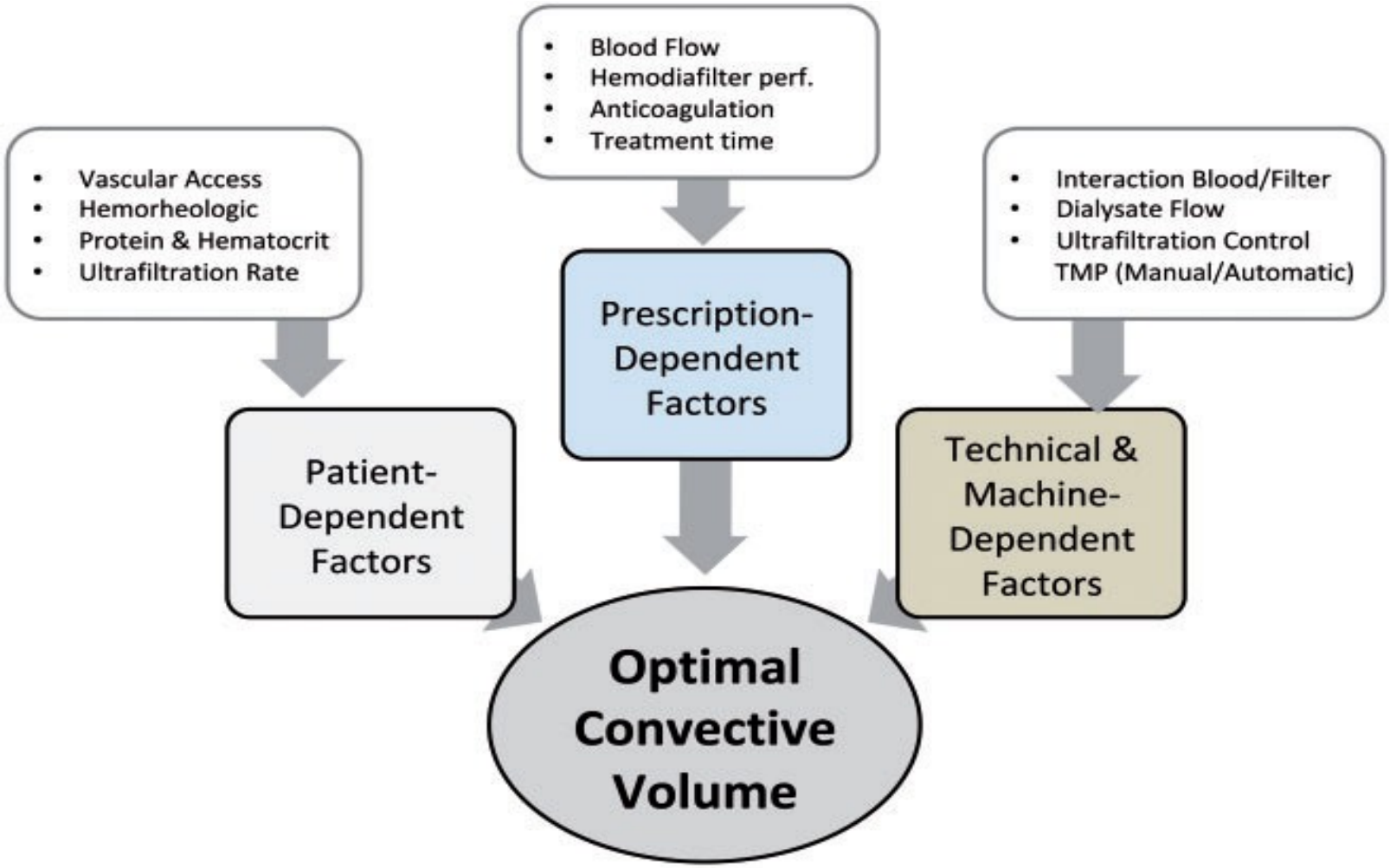
- **Long-term clinical outcomes** suggest that relative risk of all-cause and cardiovascular mortality is reduced in patients achieving high-volume online HDF.

Patient Survival Depends on High Convection Volume



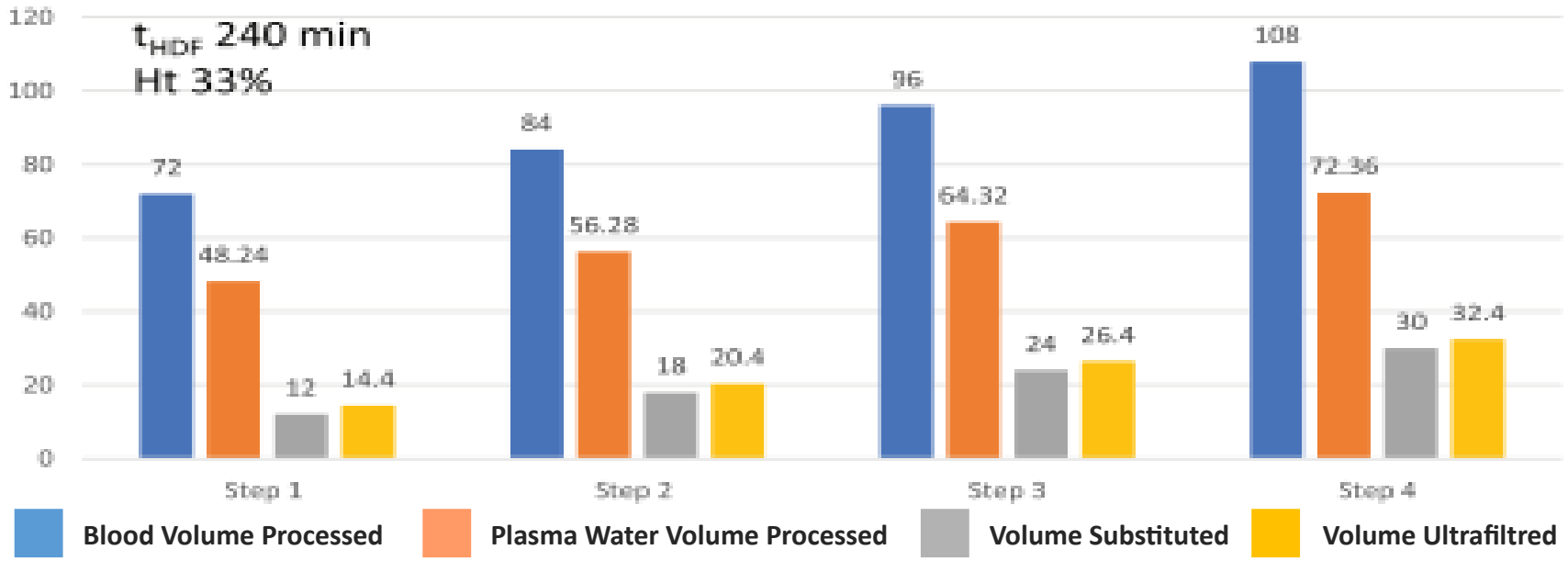
Canaud CJASN 2018

Practice Pattern Associated with Achievement of Optimal Convective Volume



Canaud NDT 2020

Stepwise implementation of HDF in clinical setting

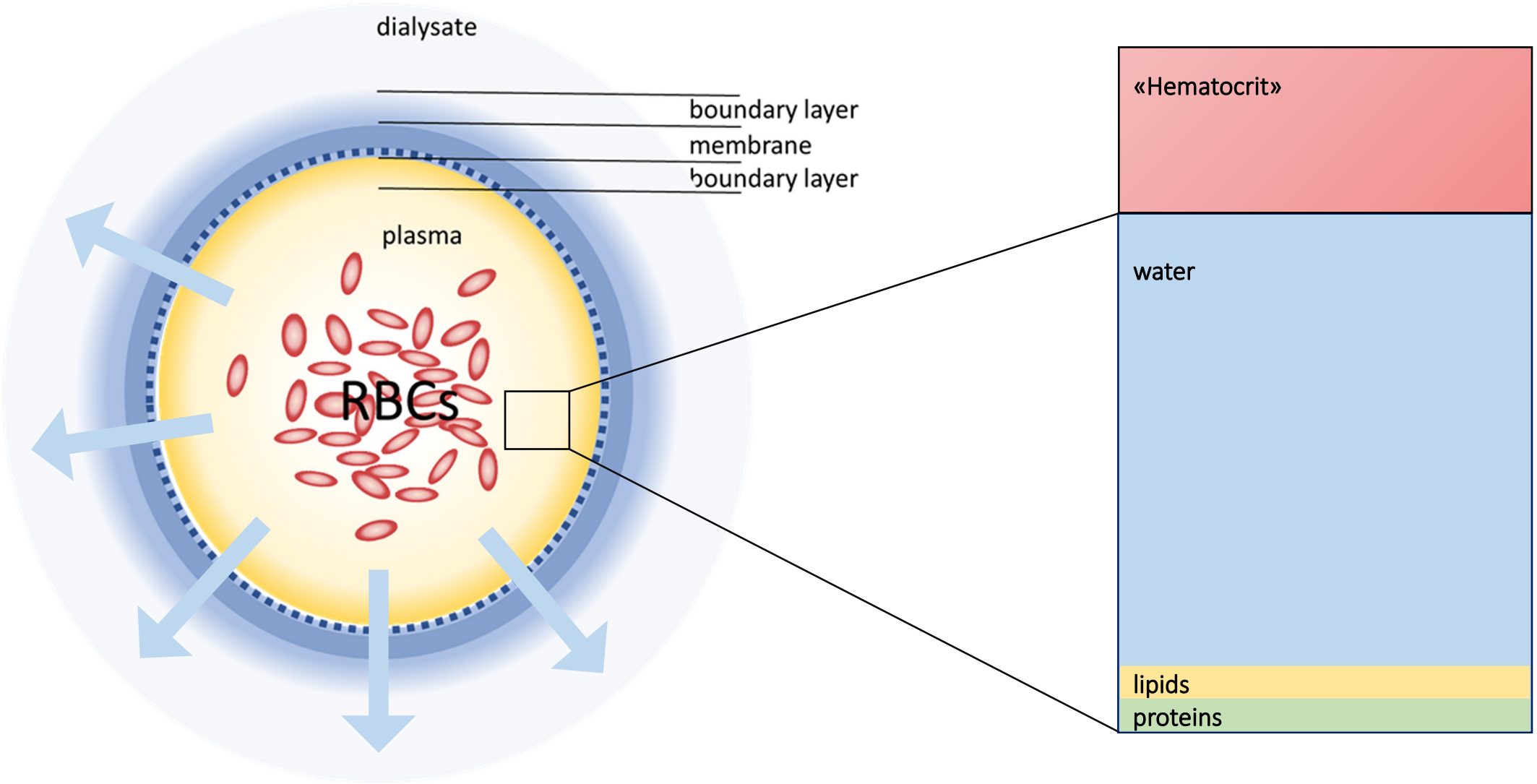


		Step 1	Step 2	Step 3	Step 4
Blood Flow Rate	QB, ml/min	300	350	400	450
Substitution Flow Rate	QSUB, ml/min	50	75	100	125
Ultrafiltration Flow Rate	QUF, ml/min	60	85	110	135
Dialyzer Surface Area	DSA, m^2	1,6	1,8	2,2	2,4
	Needle size, G	16	15	15	14

Canaud and Davenport *Sem Dial* 2022

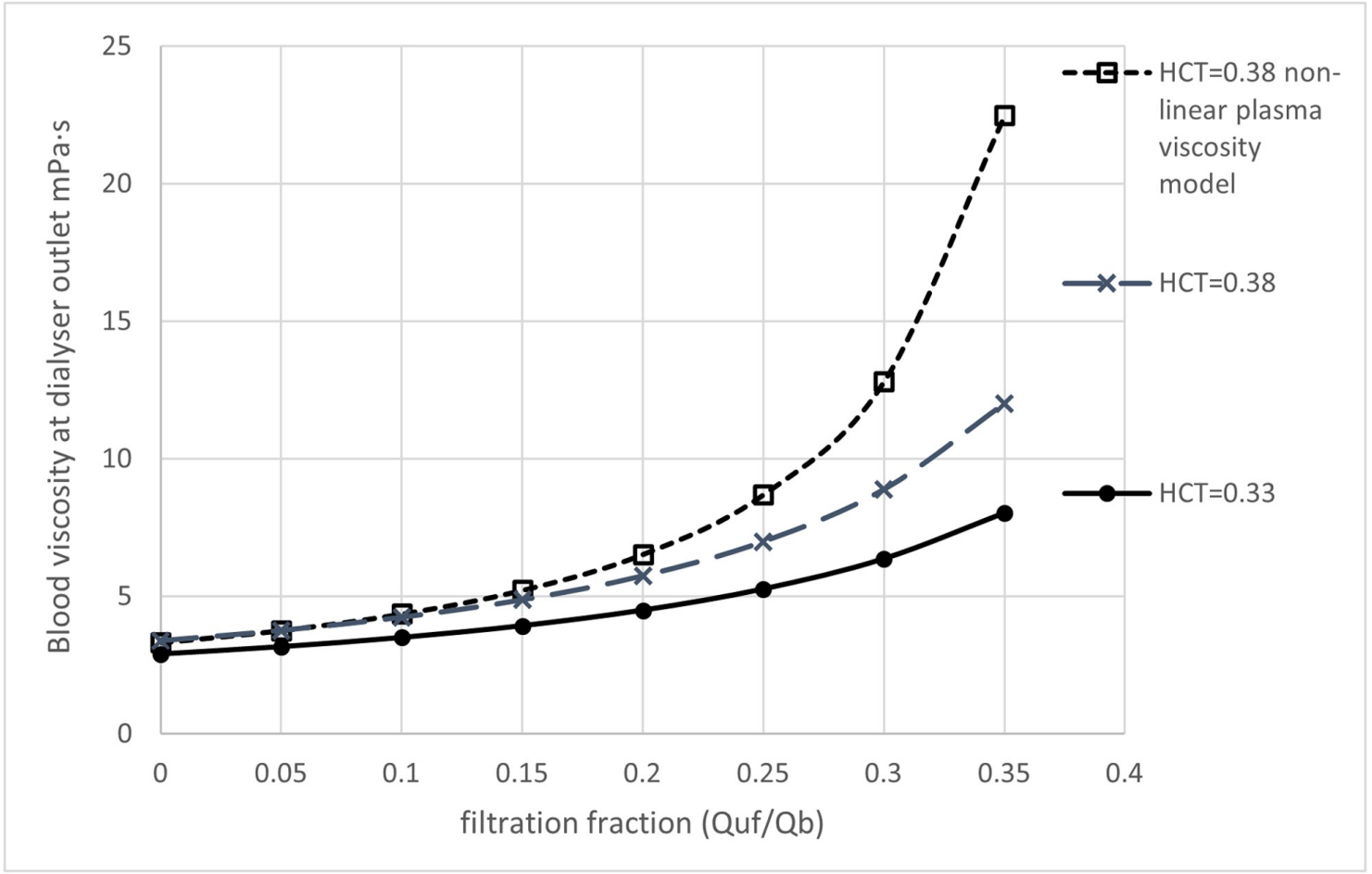
Filtration Fraction (FF)

$$FF = \frac{Q_{uf}}{Q_b}$$



FILTRATION FRACTION: do not exceed 30% !!!

$$FF = \frac{Q_{uf}}{Q_b}$$



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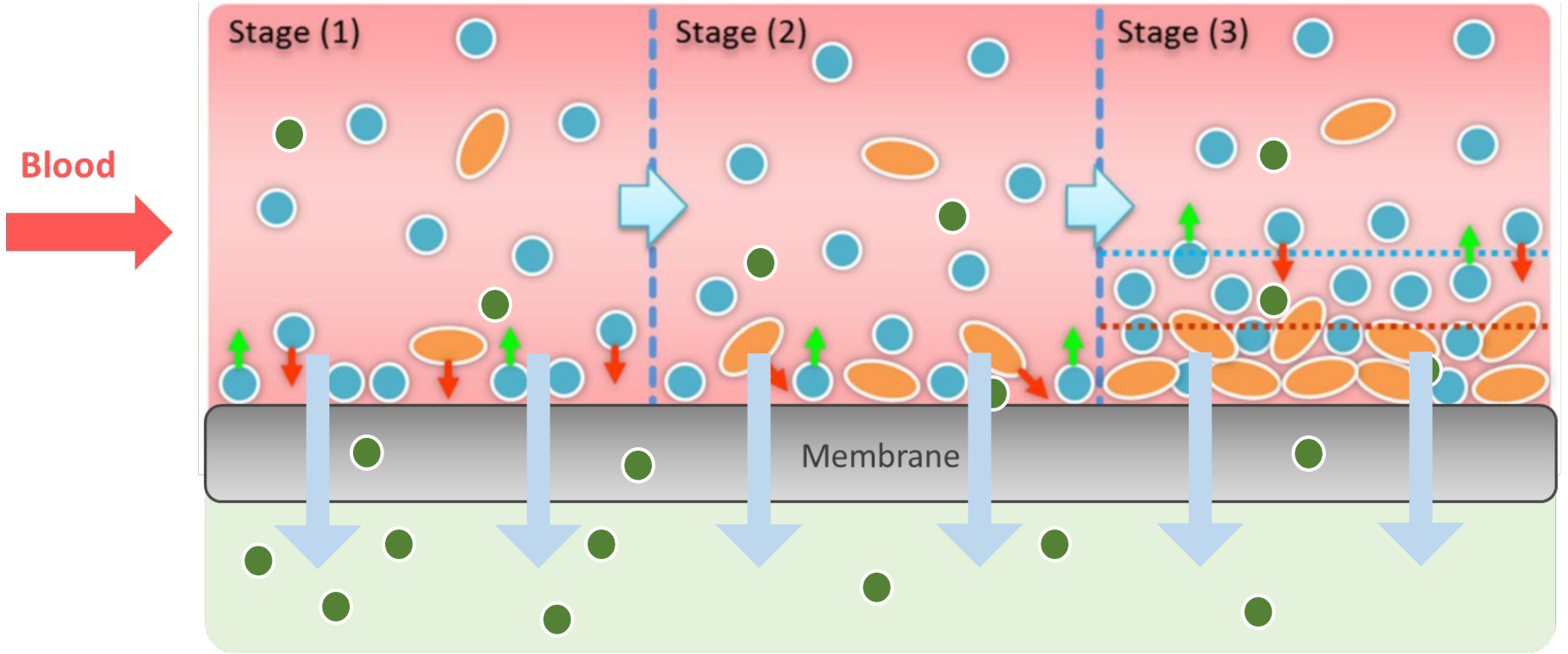
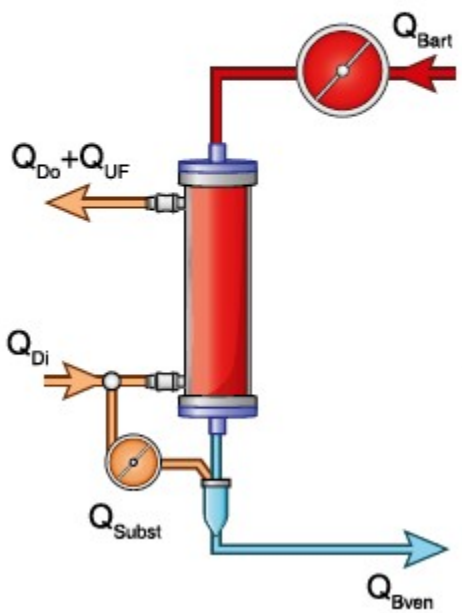
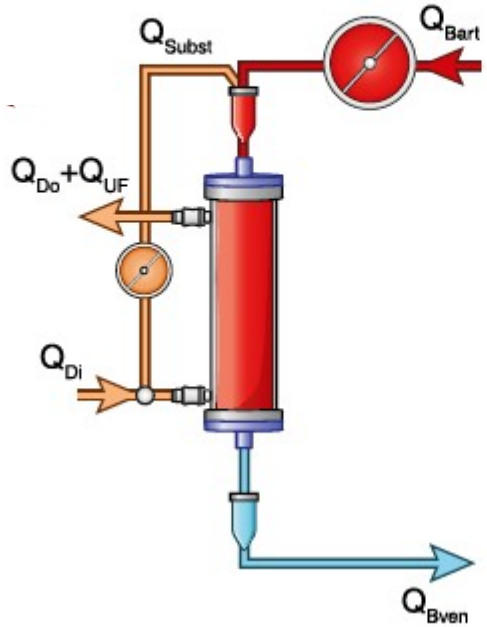


- Concentration polarizzation
- Secondary membrane
- Blockage of membrane pores

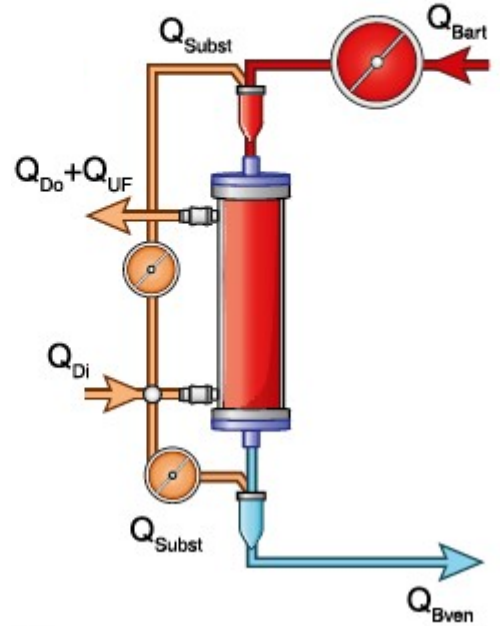
Post-dilution HDF

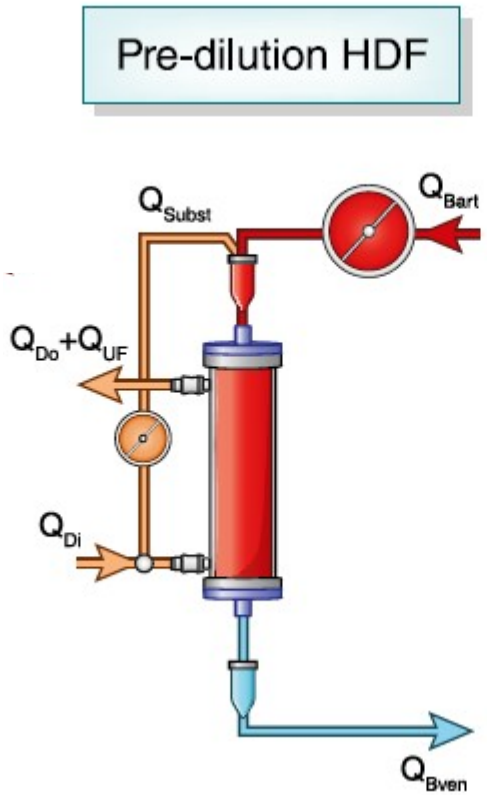


Pre-dilution HDF



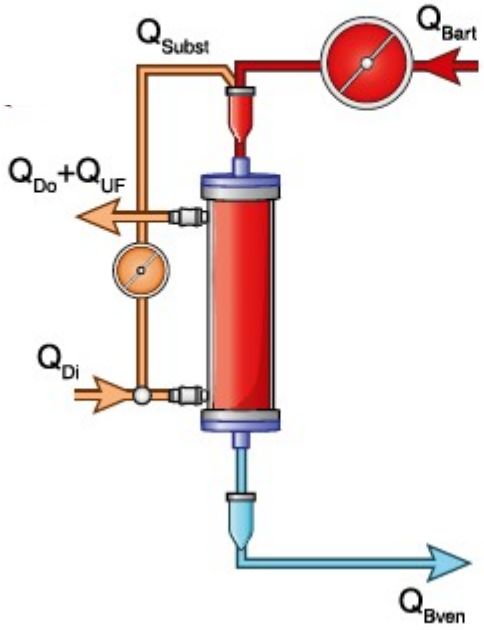
Mixed-dilution HDF





By infusing the substitution fluid upstream of the dialyzer, the problems caused by the substantial intradialyzer increase in blood and plasma viscosity are avoided. However, the concentration of uremic toxins in the blood compartment of the dialyzer is reduced by the predilution. This reduces the concentration gradients which drive diffusion and reduces concentrations in the ultrafiltrate, thus reducing clearance by convection. Therefore, in order to provide equivalent clearance to postdilution HDF, predilution substitution and ultrafiltration rates must be much higher

Pre-dilution HDF



Pre Blood Pump

Red blood cells

Water

Lipids

Proteins

Blood in

Red blood cells

Water

Lipids

Proteins

Blood out

Red blood cells

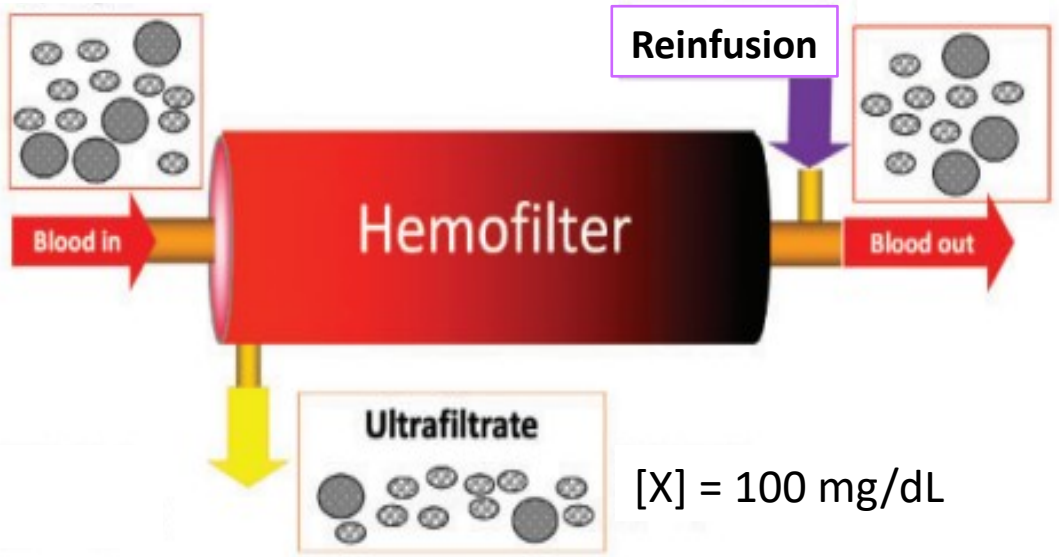
water

lipids

proteins

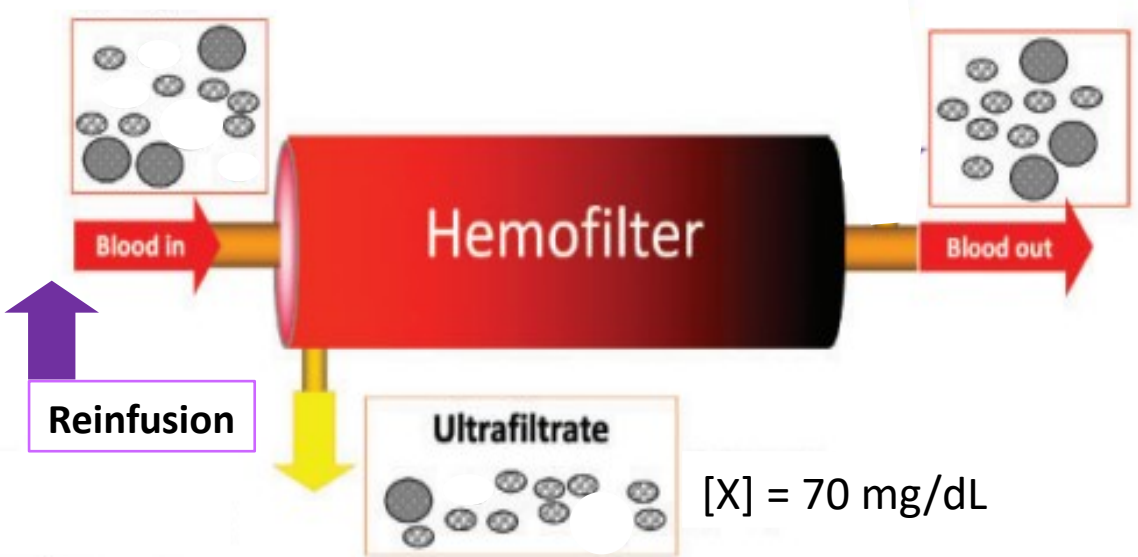
Post - dilution *vs* Pre - dilution

[X] = 100 mg/dL



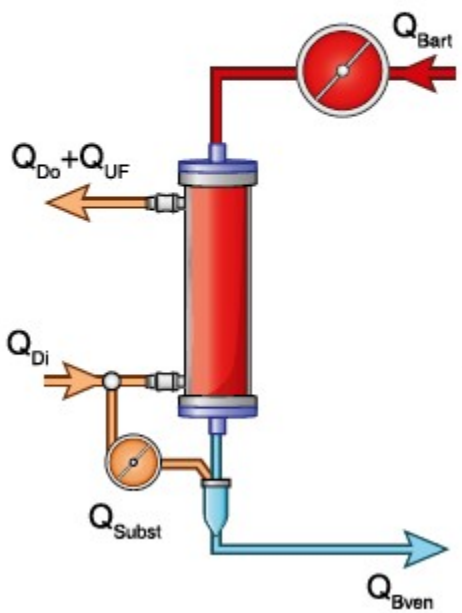
[X] = 100 mg/dL

[X] = 70 mg/dL

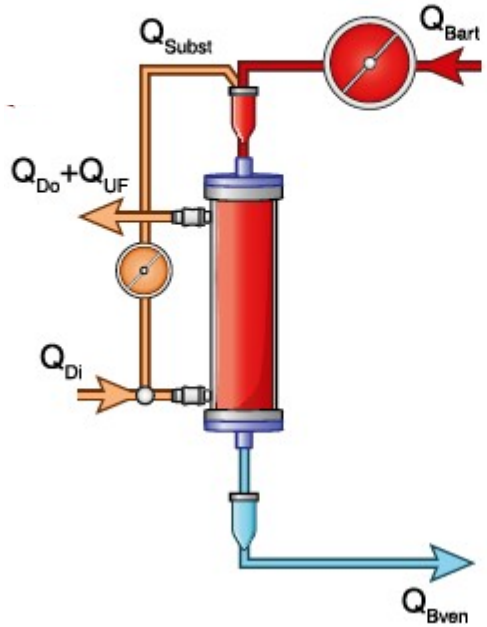


[X] = 70 mg/dL

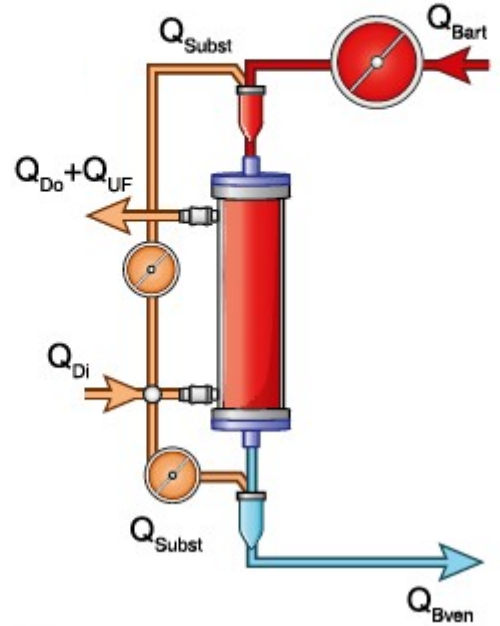
Post-dilution HDF



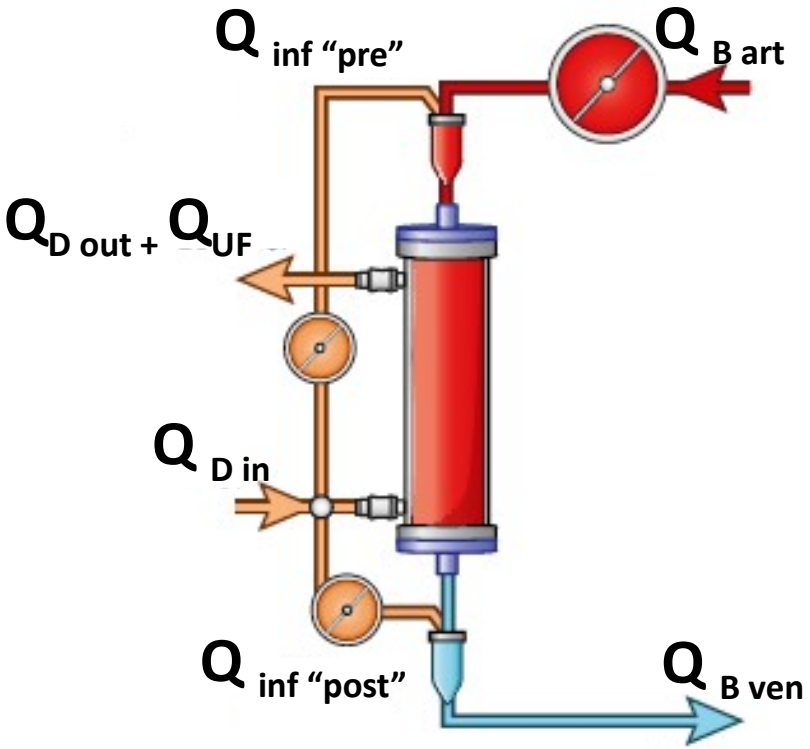
Pre-dilution HDF

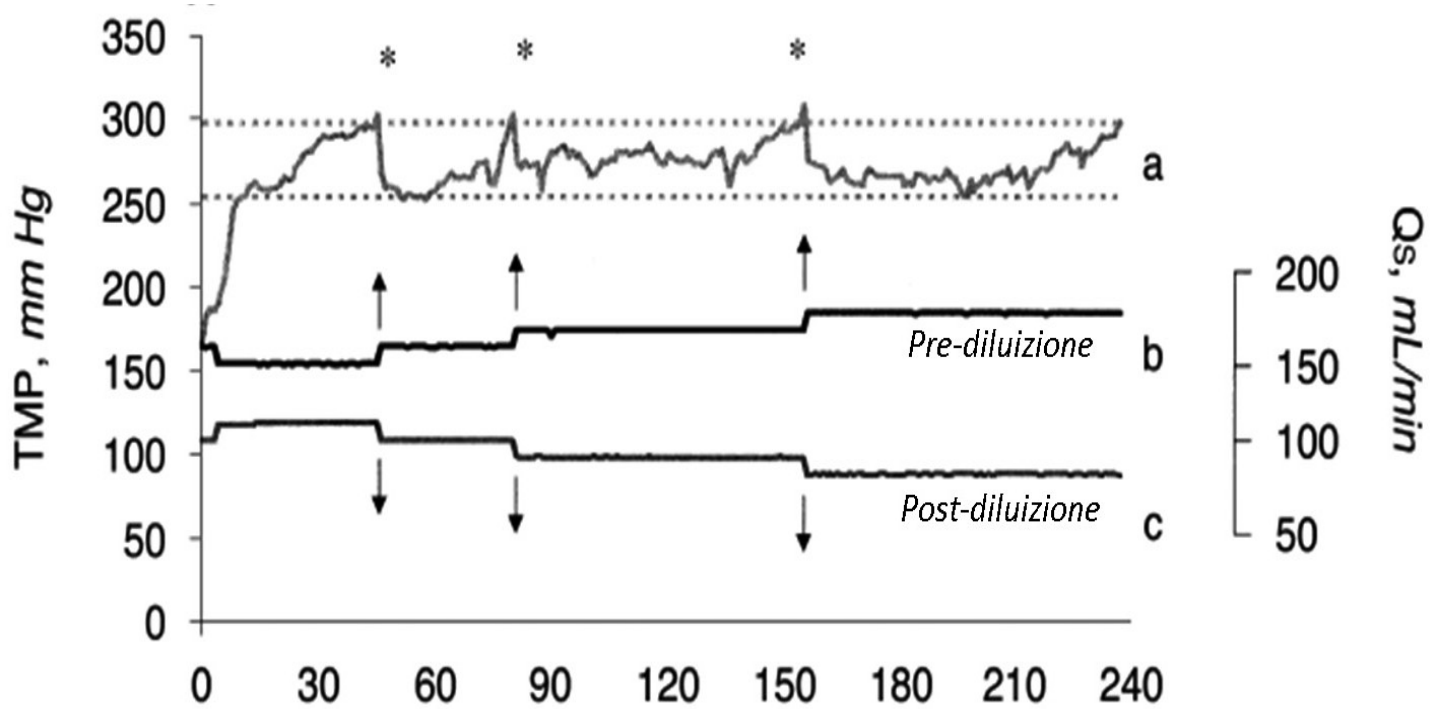


Mixed-dilution HDF



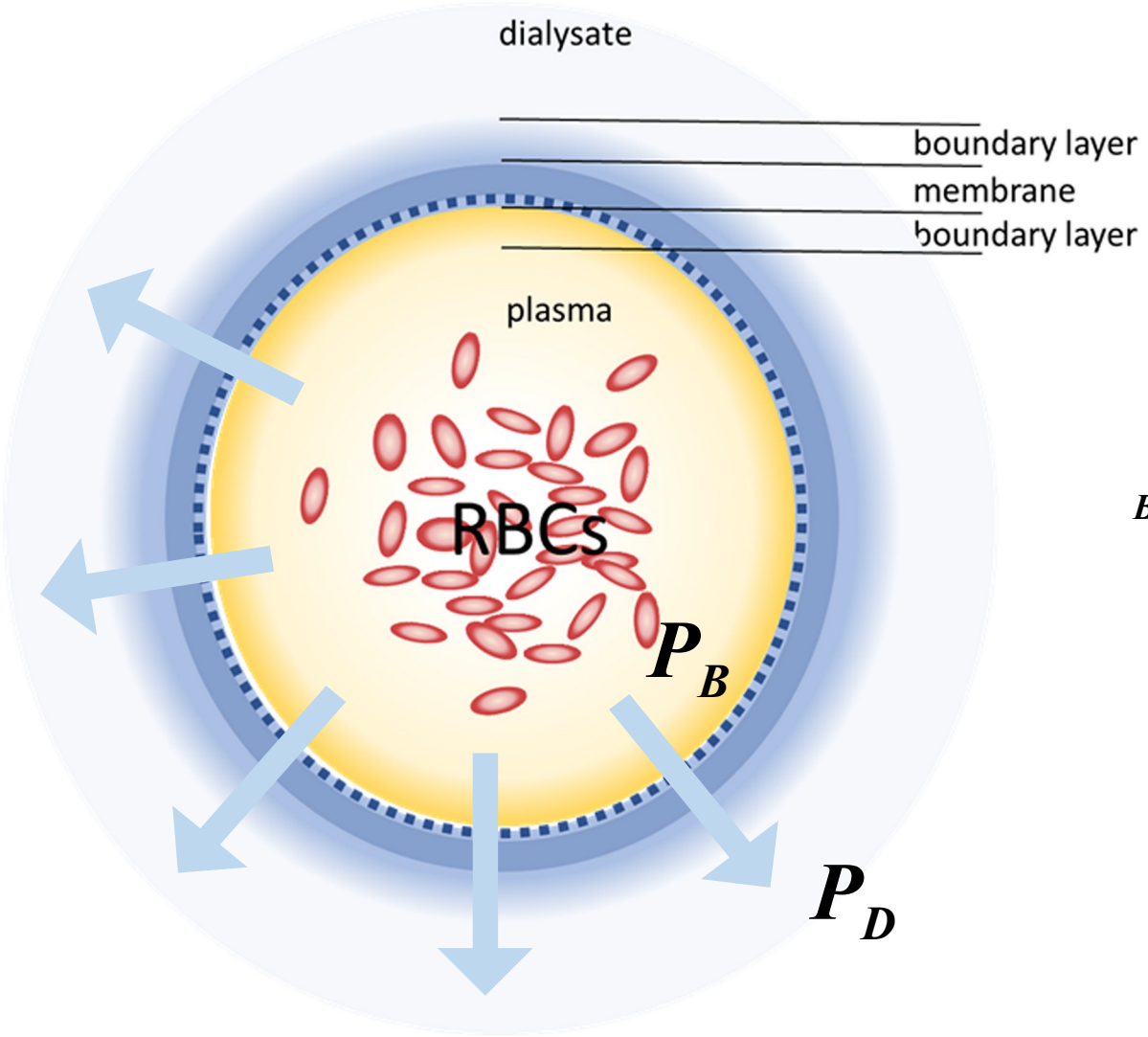
Mixed – dilution HDF

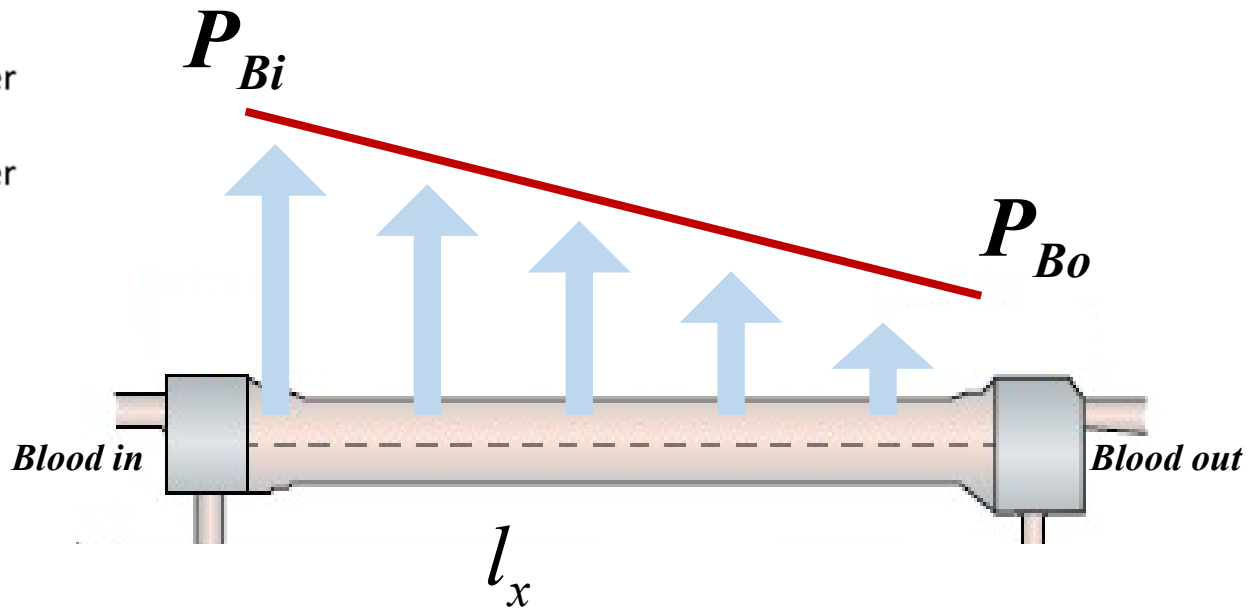




Zerbi and Pedrini GIN 2012

Tran membrane Pressure (TMP)

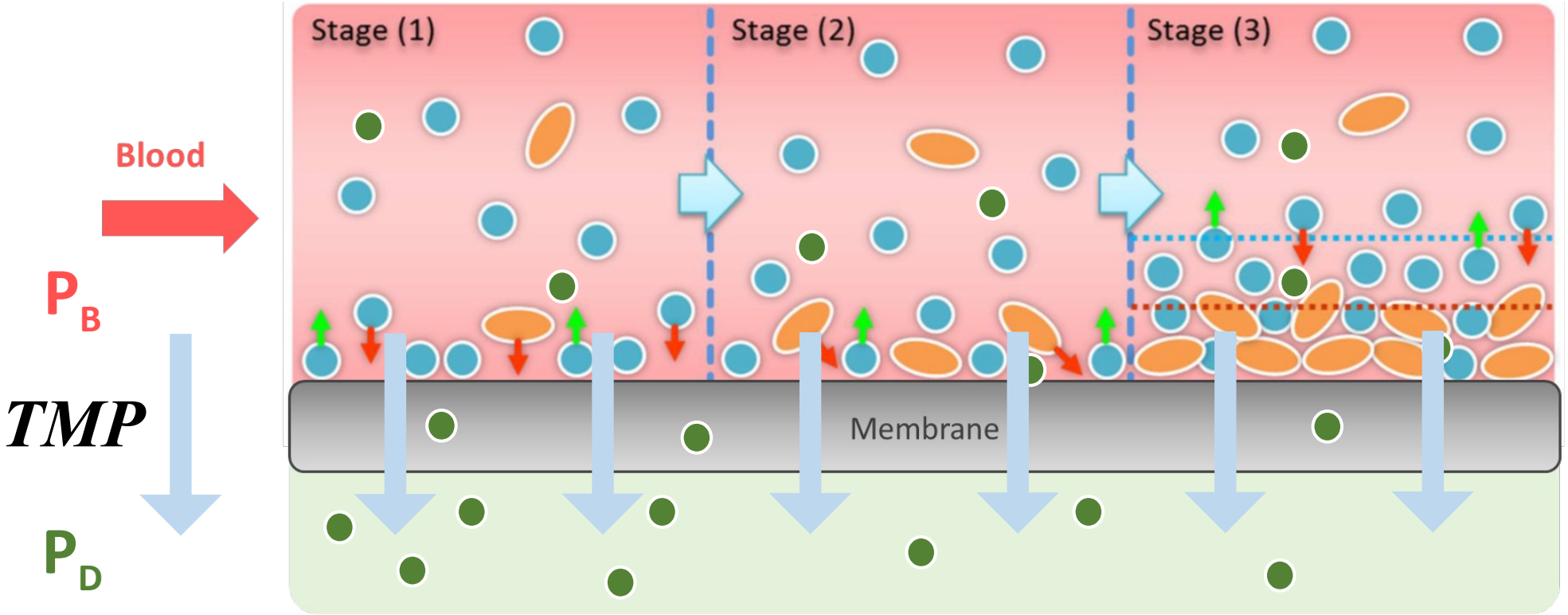




$$TMP\ l_x = P_B\ l_x - P_D\ l_x$$

Tran membrane Pressure (TMP) during hemodialysis session

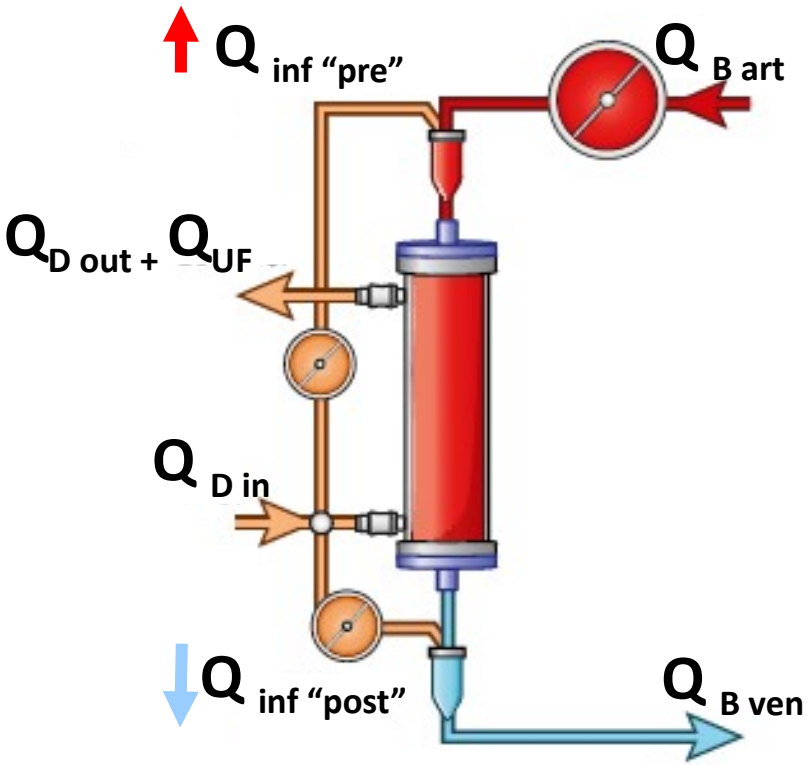
$$TMP = P_B - P_D - \pi_B$$

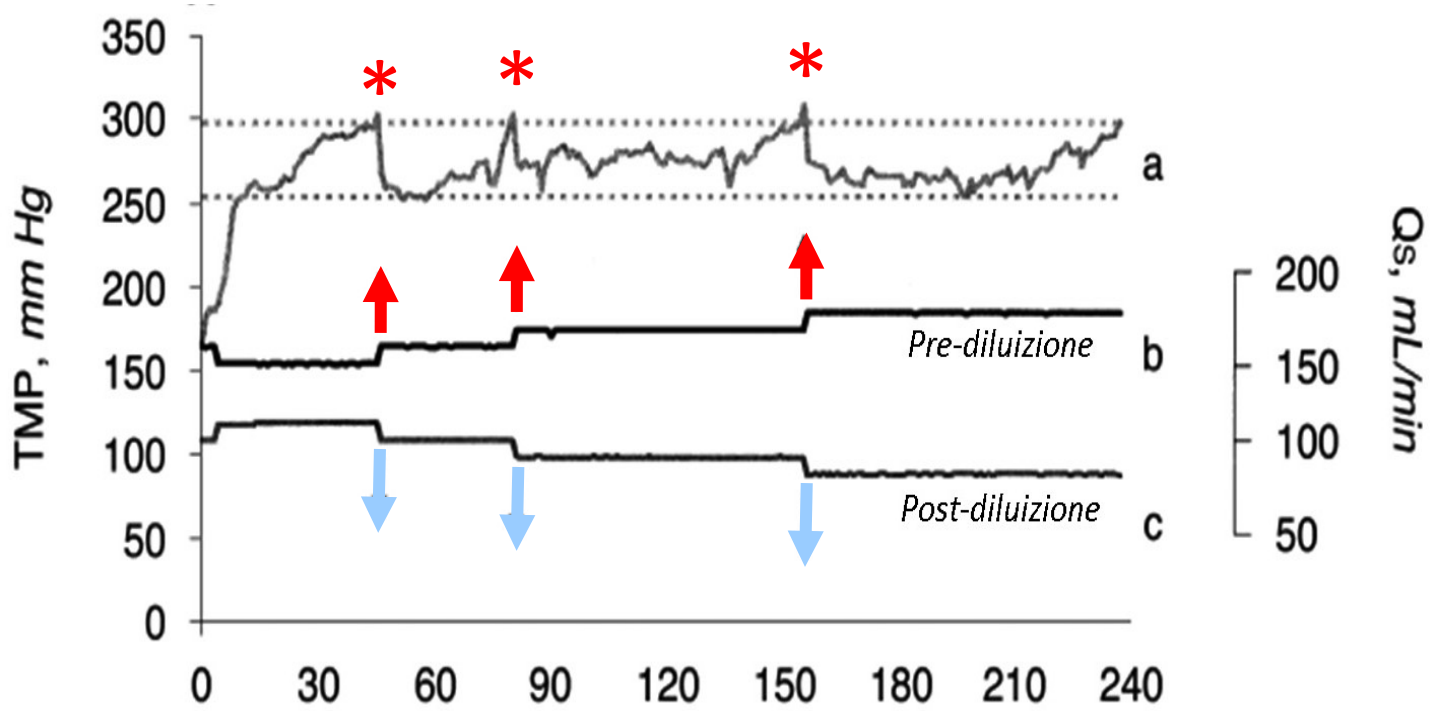


- Concentration polarizzation
- Secondary membrane
- Blockage of pores

Dialisate

Mixed – dilution HDF





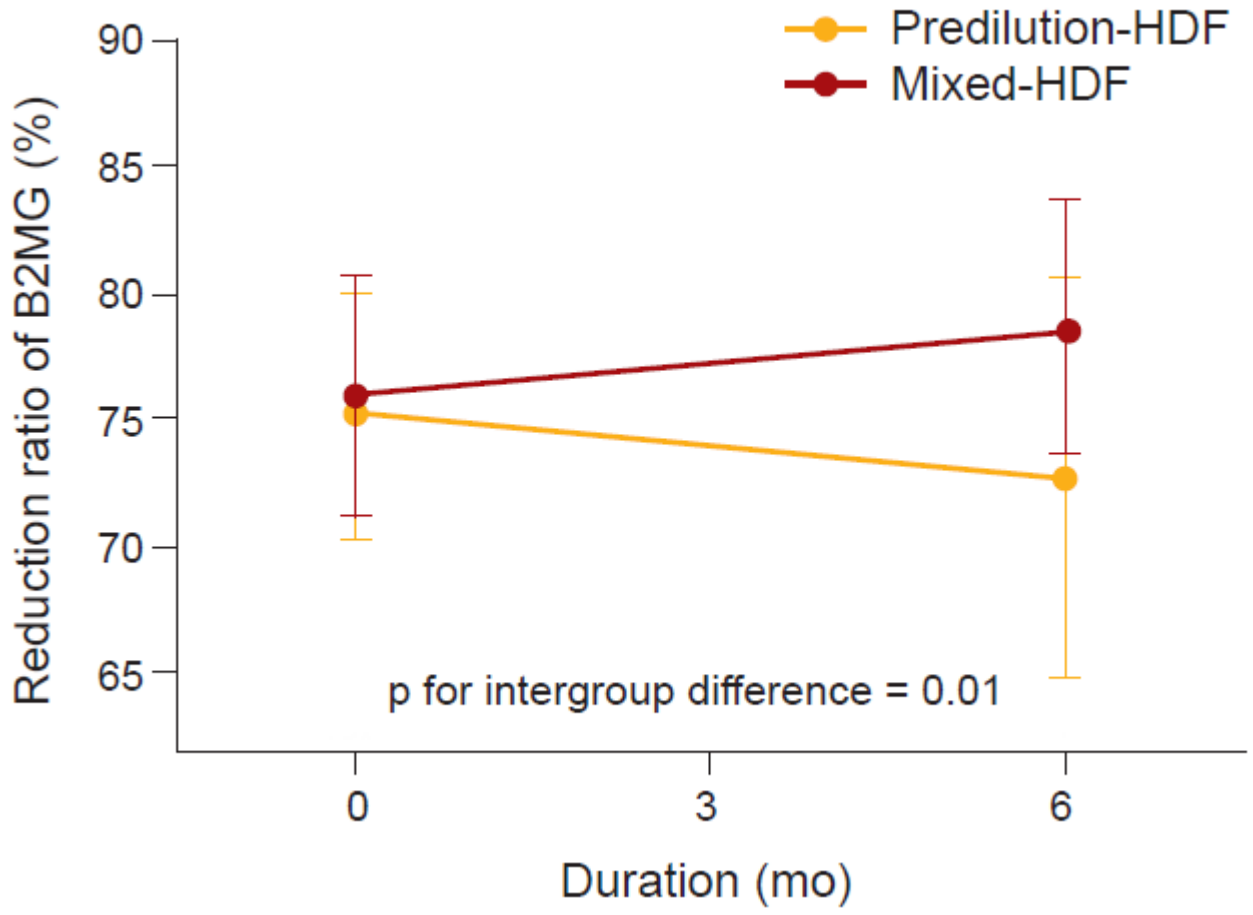
Zerbi and Pedrini GIN 2012

Differences in Convection Volume between Predilution HDF and Mixed-HDF

Variable	Treatment	Observed data				p-value	
		Mean value during 6 mo	Baseline	Month 3	Month 6	Between-group	Within-group
Convection volume (L/session)							
Absolute	Predilution	41.0 ± 10.3	40.4 ± 8.0	39.1 ± 8.7	44.0 ± 13.1		0.17
	Mixed	35.0 ± 5.7	32.6 ± 7.8	36.3 ± 4.2	36.1 ± 3.7	<0.001	0.01
Convection volumes adjusted for body surface area (L/m^2 per session)							
Absolute	Predilution	24.5 ± 3.8	24.4 ± 5.1	23.1 ± 5.5	25.8 ± 7.8		0.27
	Mixed	20.6 ± 5.5	18.0 ± 5.1	20.0 ± 4.1	23.8 ± 10.5	0.004	0.004

Park *Kidney Res Clin Pract* 2021

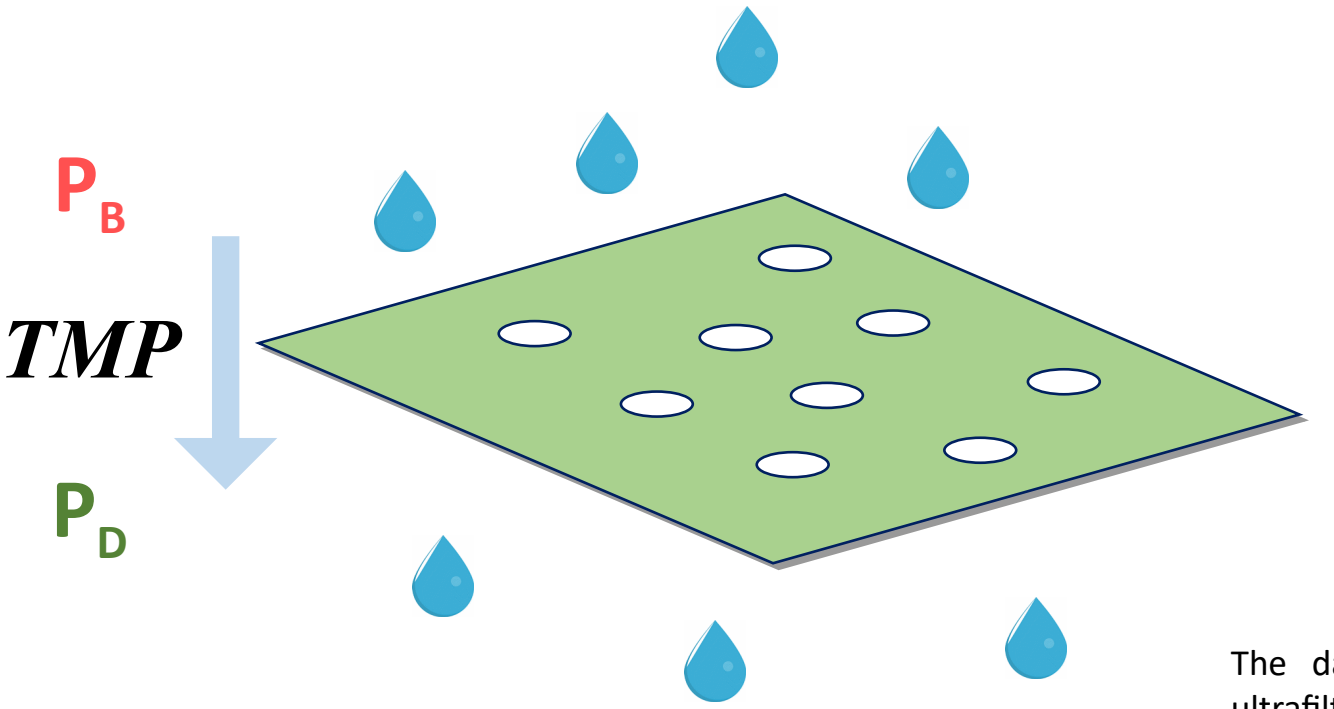
Changes in reduction ratios of B2MG

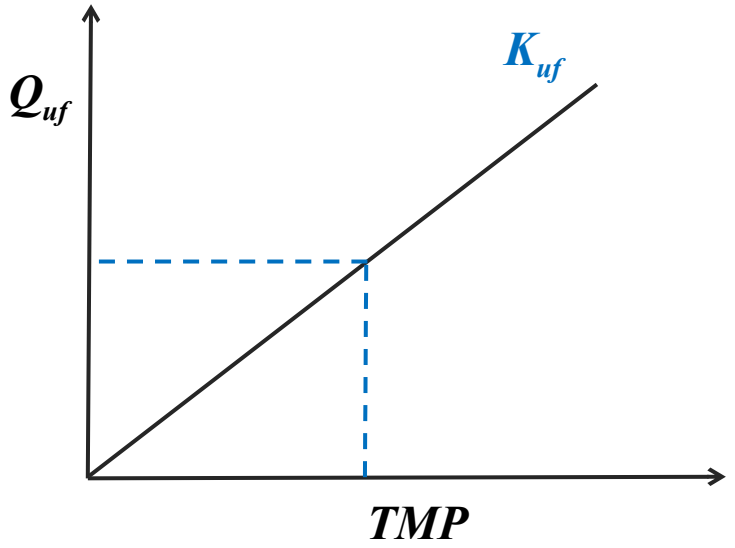


Park *Kidney Res Clin Pract* 2021

Ultrafiltration Coefficient (K_{uf})

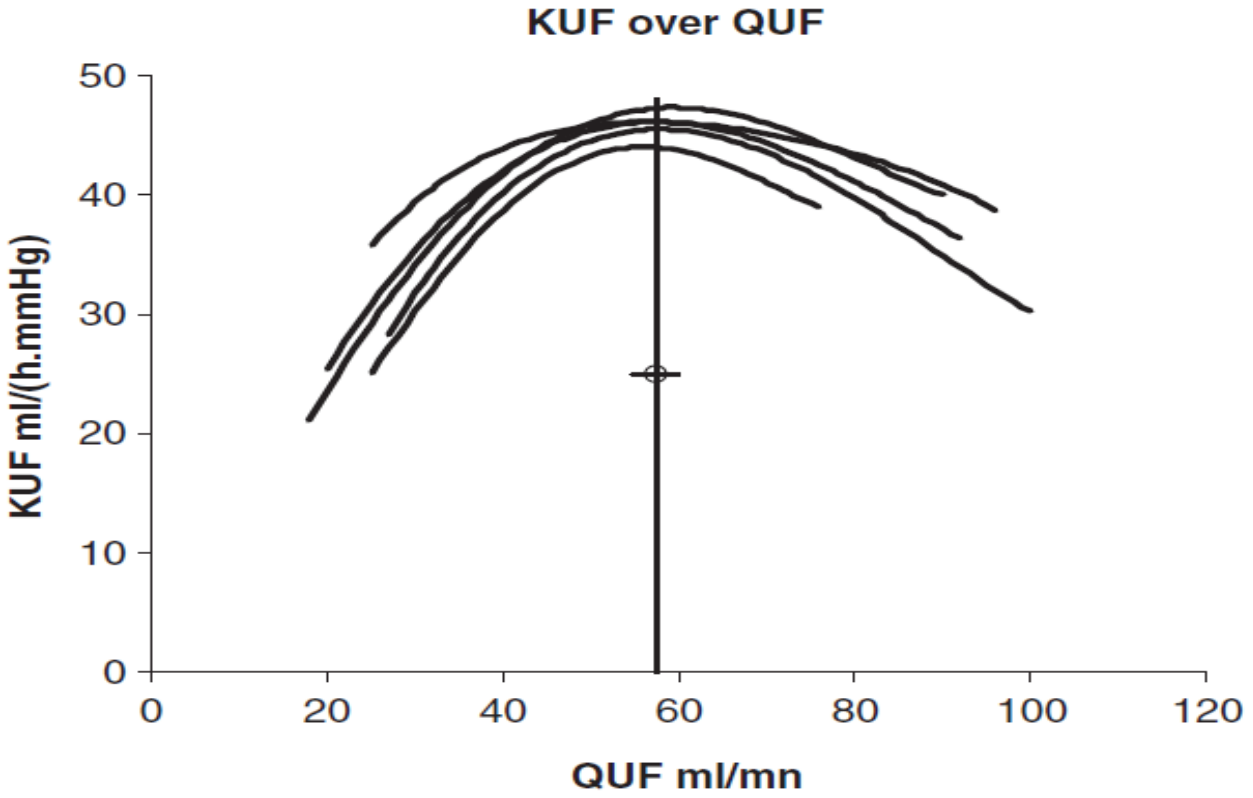
$$Q_{uf} = K_{uf} * TMP$$

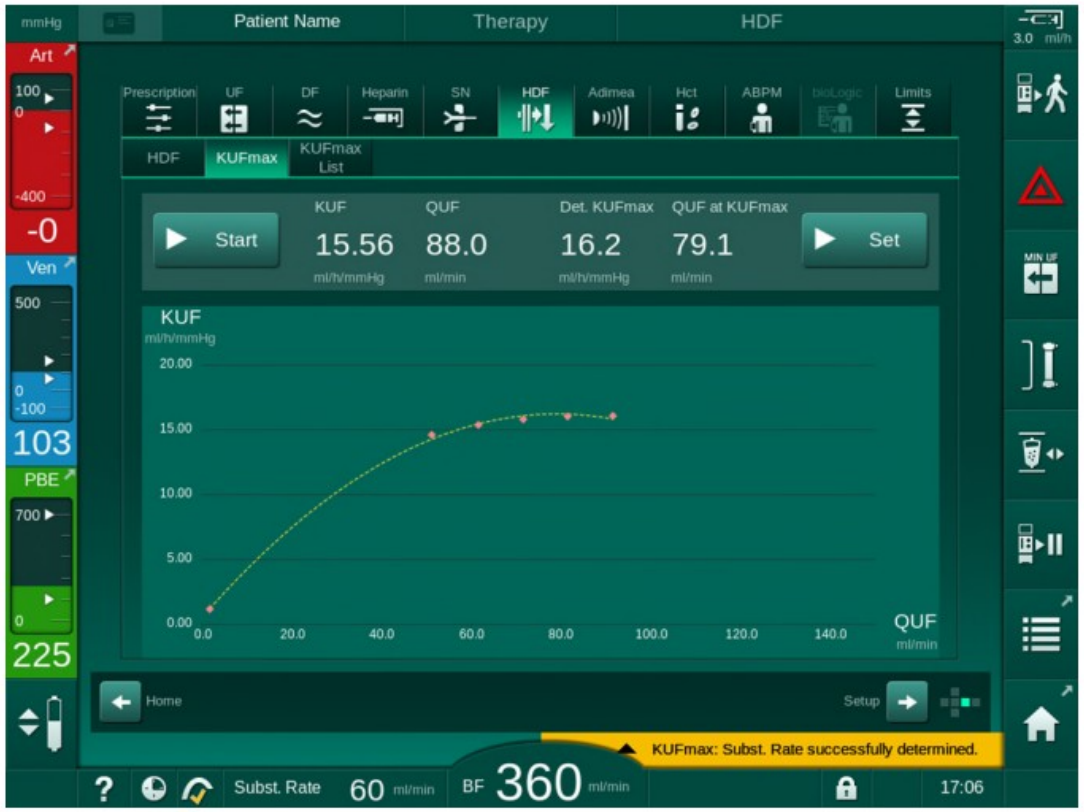




The datasheet provided by manufacturers for every dialyzer includes the ultrafiltration coefficient (Kuf). This is the ratio Quf/TMP measured in vitro. Typically, manufacturers determine Kuf using bovine or human blood. The required Hct and plasma protein concentration of the blood is standardized at 0.32 ± 0.02 and 60 ± 5 g/L (according to ISO 8637-1).

The Ultrafiltration Coefficient (K_{uf}) of a dialyser is not a fixed value





Ficheux ***Nephrol Dial Transplant*** **2011**

The Ultrafiltration Coefficient (K_{uf}) of a dialyser is not a fixed value

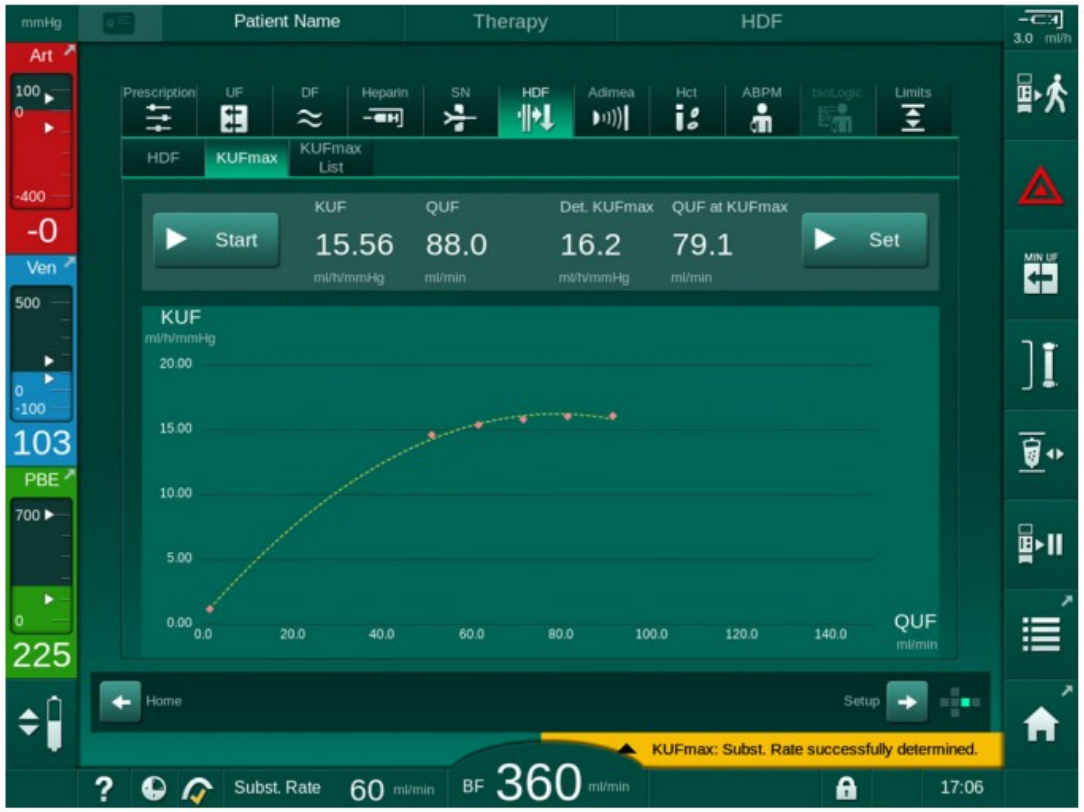
UTILIZZO DI K_{UF} MAX AUTOMATICO IN «HDF OL POST»

- Buoni volumi di convezione
- Riduzione dell'intervento dell'infermiere per esempio

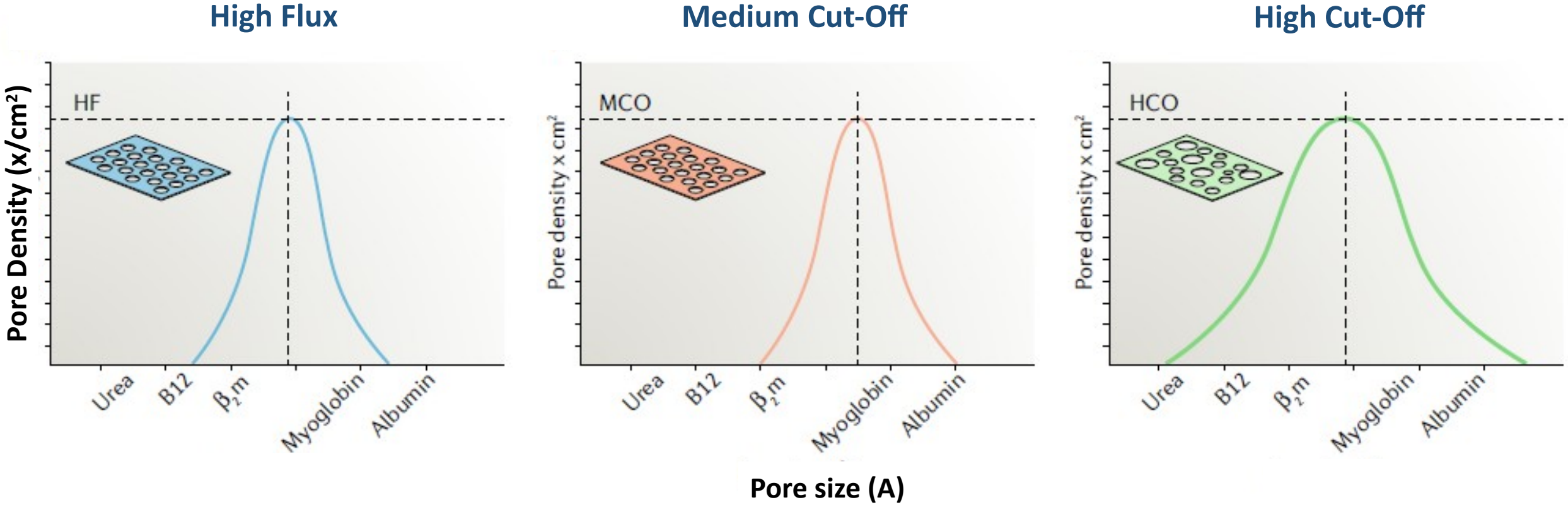
a causa di allarmi di TMP

- Alta Efficienza nella rimozione delle medie molecole

(β2m) con contenimento delle perdite di albumina

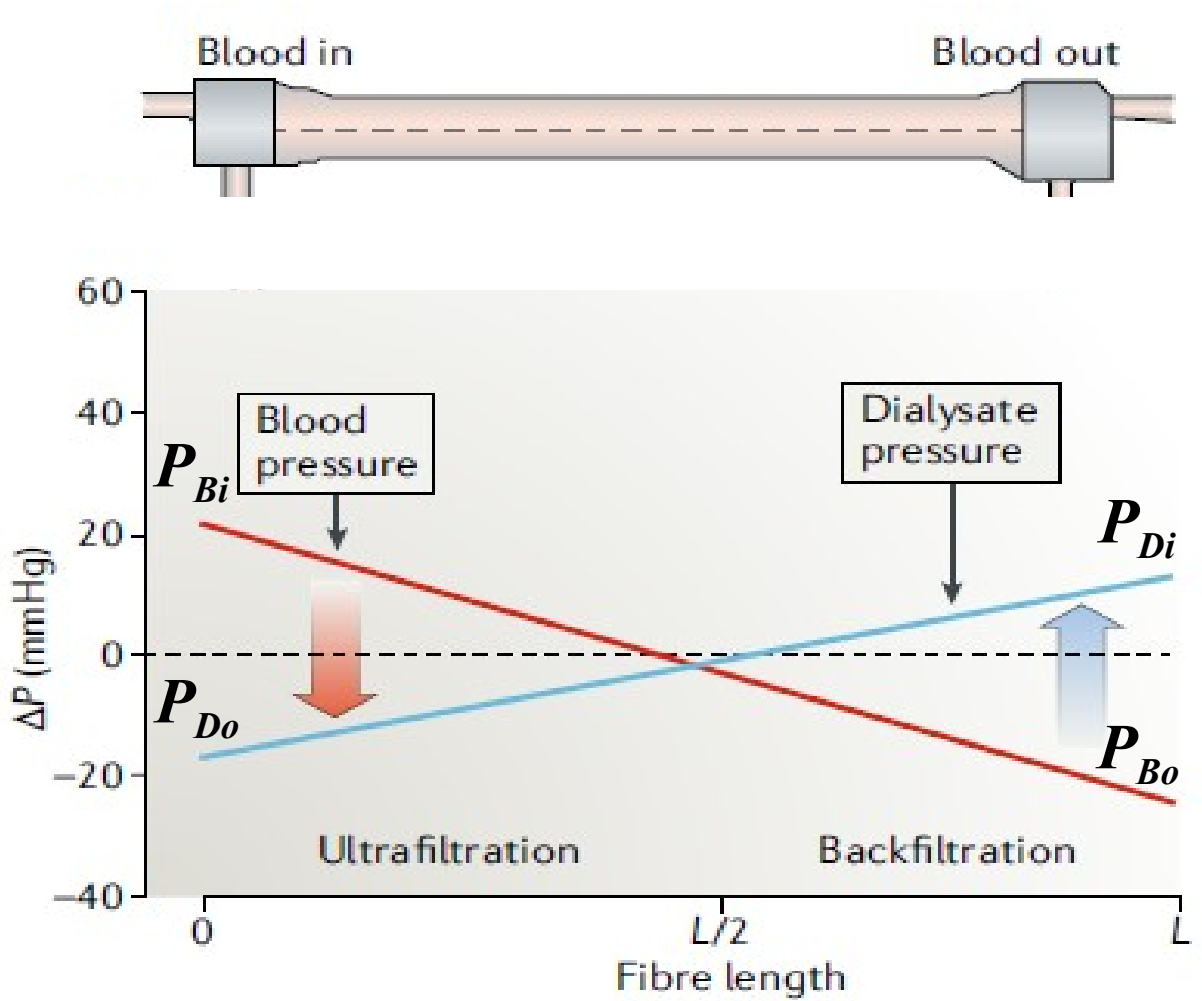


Pore size Distribution Curves for three classes of Membranes



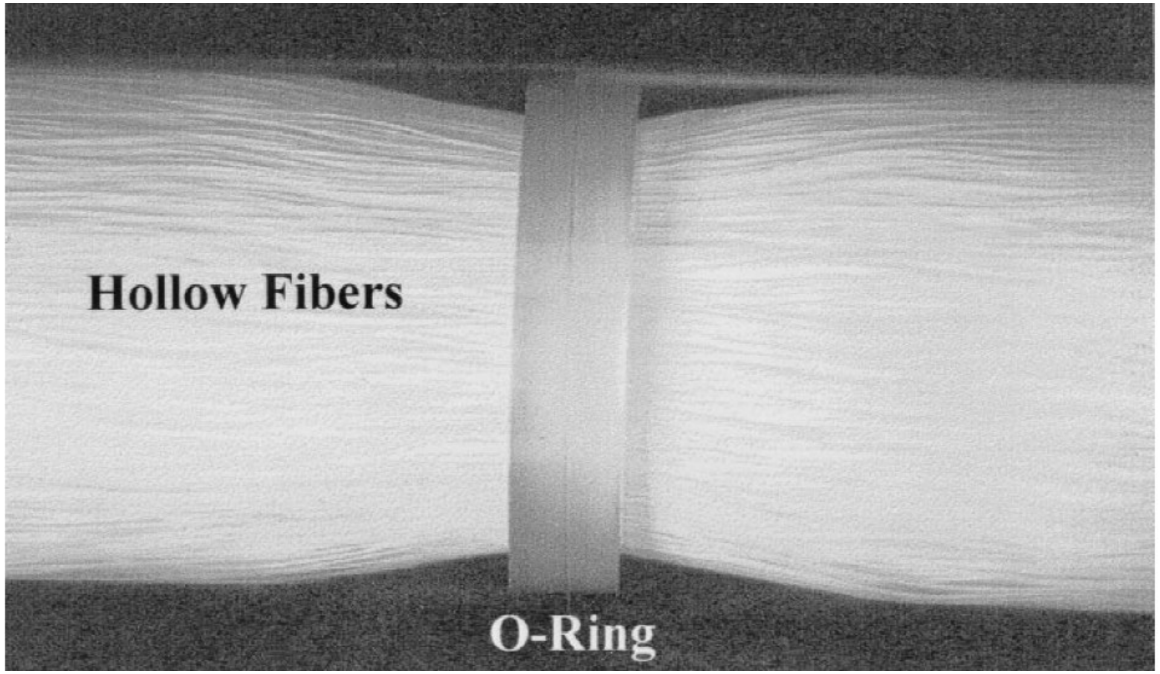
Pressure Profiles inside a Hollow-Fibre Haemodialyser

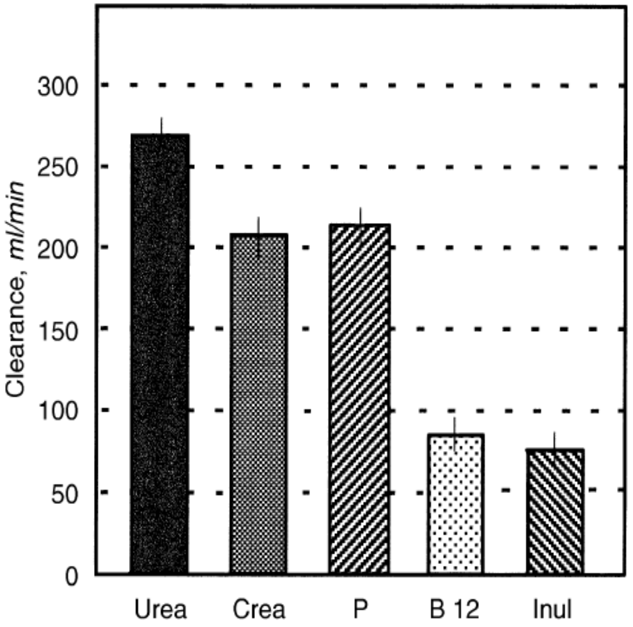
$$Q_B = \Delta P / (8\mu L / \pi r^4)$$

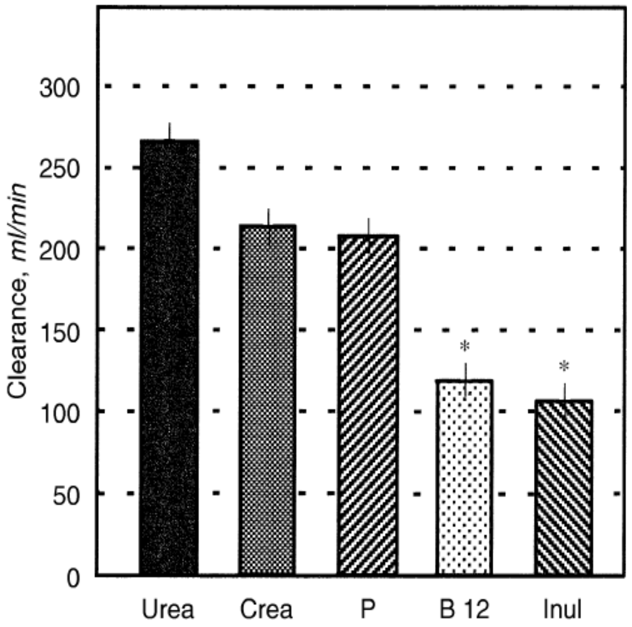


Enhancement of convective transport by internal filtration in a modified experimental hemodialyzer
Technical Note

CLAUDIO RONCO, GIANCARLO ORLANDINI, ALESSANDRA BRENDOLAN, ANDREA LUPI, and GIUSEPPE LA GRECA

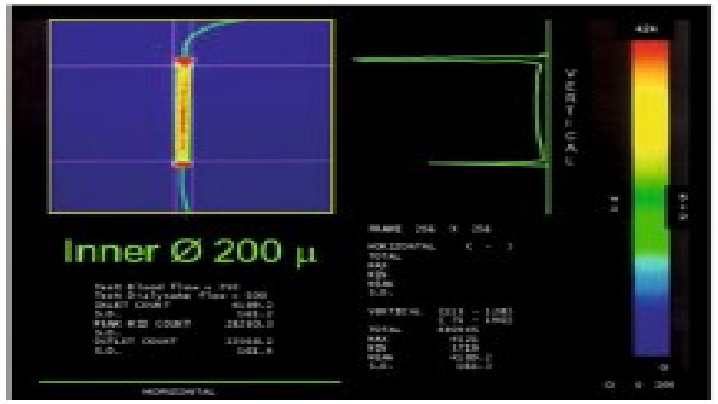


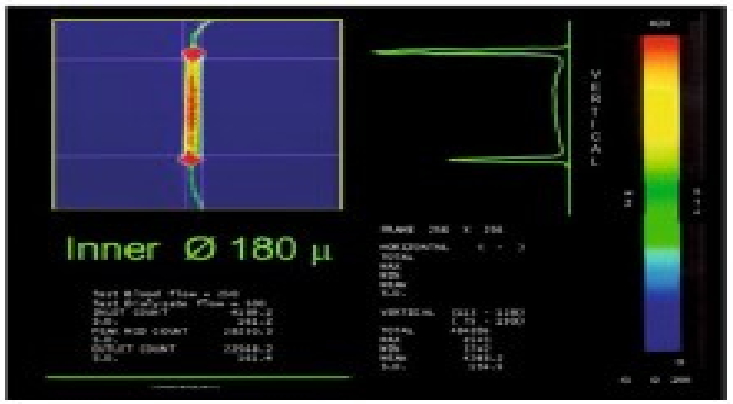


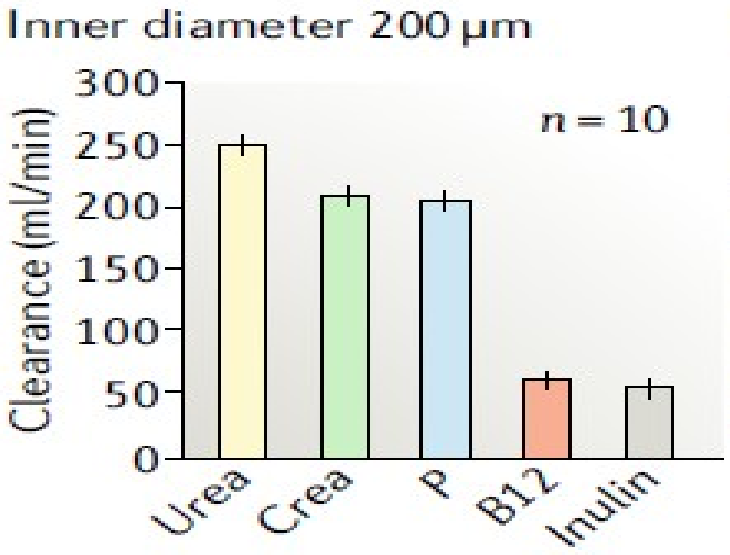


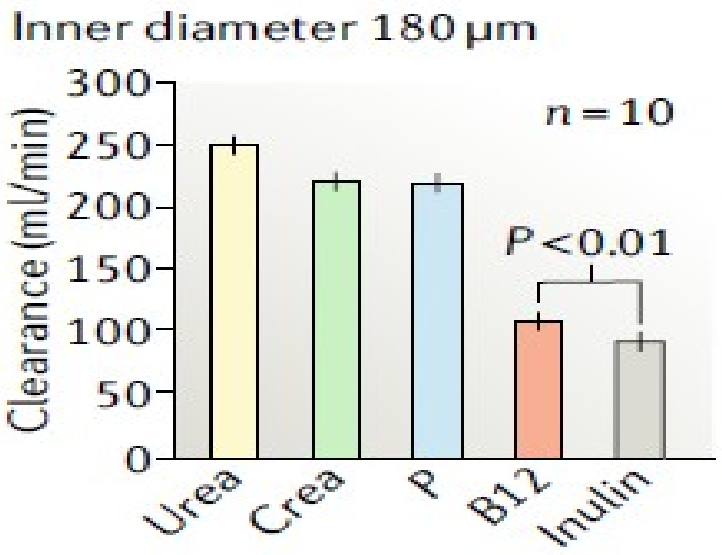
Kidney International, Vol. 54 (1998), pp. 979–985

Effect of a Reduced Inner Diameter of Hollow Fibers









Ronco *Kid Int* 2000

Conclusioni

- ✓ L'utilizzo sempre più diffuso dell'emodiafiltrazione on line ha il significato di ampliare il più possibile lo spettro depurativo e si propone l'ambizioso obbiettivo di migliorare quantità e qualità di vita del paziente emodializzato

- ✓ L'efficienza di un trattamento convettivo si «misura» in termini di volume di convezione ottenuto. La condizione imprescindibile per ottenere dei volumi di convezione elevati è quella di avere un flusso sangue elevato (FF; TMP; K_{uf})

- ✓ Lo sviluppo tecnologico ha cercato di offrire soluzioni per ottimizzare la depurazione delle «tossine uremiche» medio ed elevato peso molecolare anche nel paziente con accesso vascolare non performante regolando gli scambi convettivi attraverso sistemi di biofeedback oppure realizzando membrane sempre più capaci di sfruttare la cosiddetta «filtrazione interna»

- ✓ La sfida sembra essere dunque quella di utilizzare le conoscenze cliniche e tecnologiche per personalizzare e ottimizzare la terapia dialitica a partire dalle caratteristiche uniche del paziente e, in questo caso, del suo accesso vascolare.