I PER-CORSI
IN
NEFROLOGIA
E DIALISI

III PER-CORSO
LA PRESCRIZIONE
DEL TRATTAMENTO
DIALITICO

19 maggio 2023
NH Hotel Pontevecchio
Lecco

Vecchie e Nuove Membrane per Emodialisi

Sergio Bove
U.O. Nefrologia e Dialisi – P.O. Montichiari
ASST Spedali Civili Brescia

Membrane: pubblicazioni

membranes

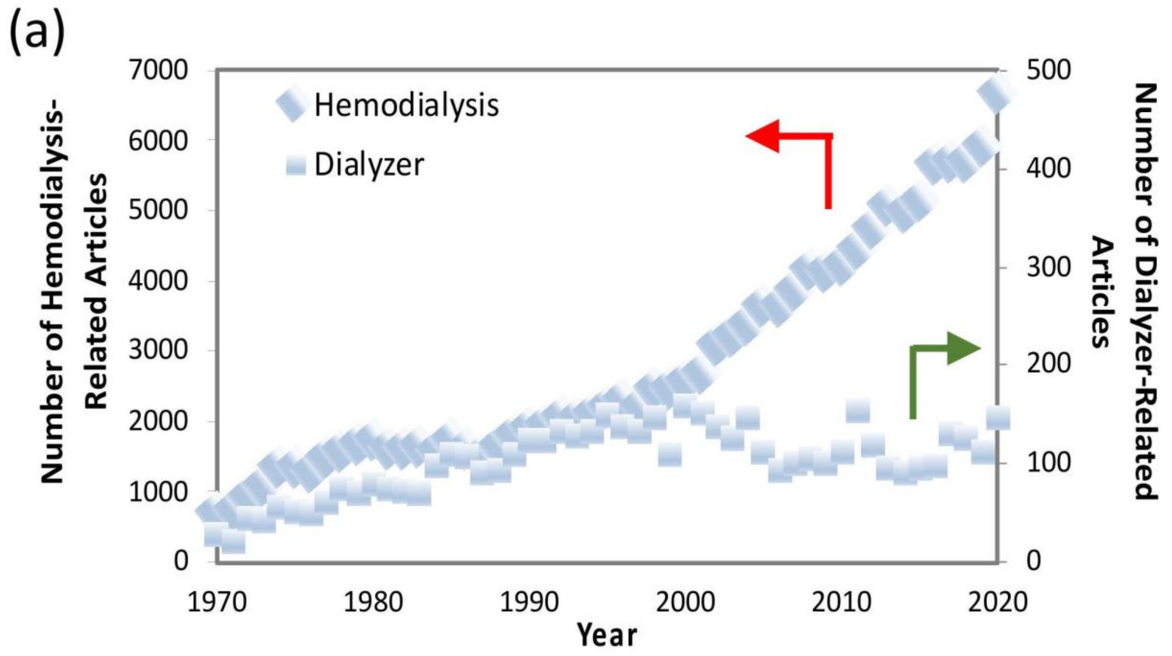
MDPI

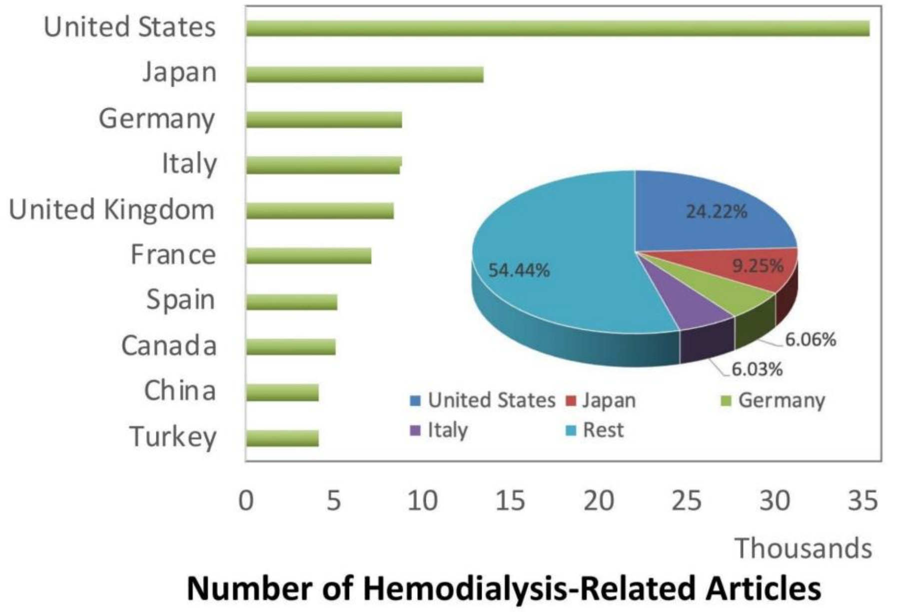
Review

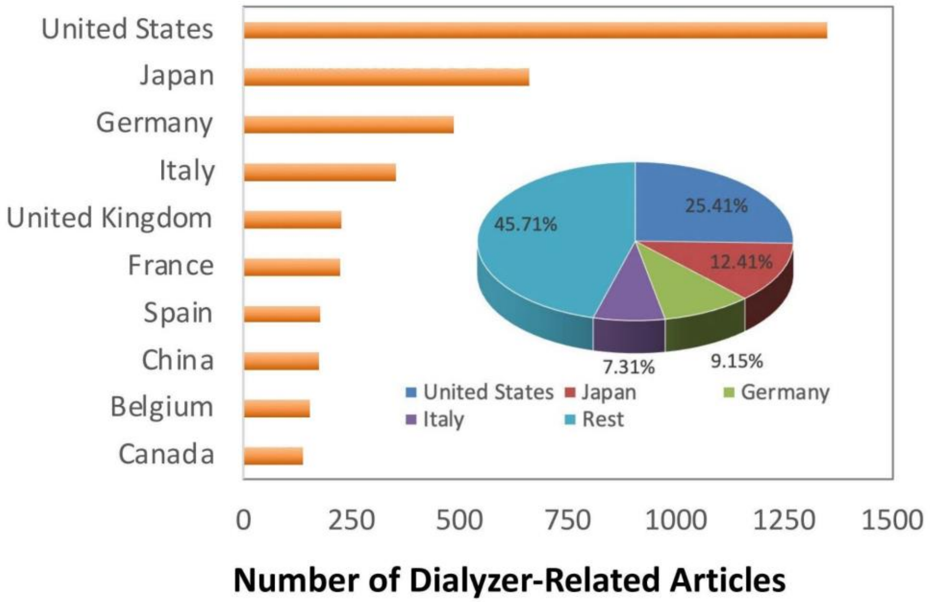
A Review of Commercial Developments and Recent Laboratory Research of Dialyzers and Membranes for Hemodialysis Application

Noresah Said [1], Woei Jye Lau [1,*], Yeek-Chia Ho [2], Soo Kun Lim [3], Muhammad Nidzhom Zainol Abidin [1] and Ahmad Fauzi Ismail [1]

Membranes **2021**, *11*, 767. https://doi.org/10.3390/membranes11100767 https://www.mdpi.com/journal/membranes







Membrane artificiali: definizione

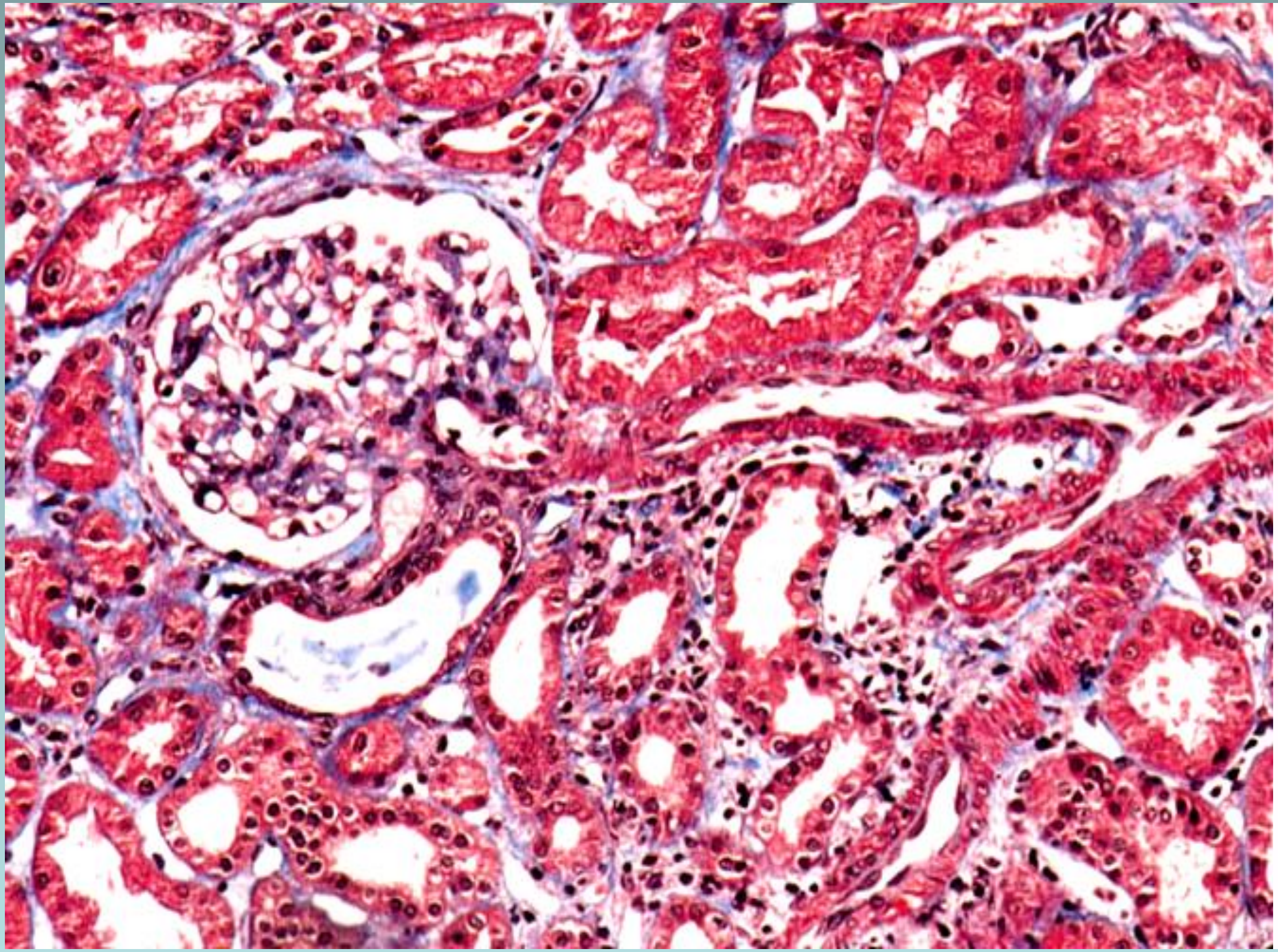
- *Alberti G, Drioli E*
- **Le membrane**
- *La Nuova Italia Scientifica (NIS) Editore, Roma 1995 (ISBN 88-430-0363-1)*

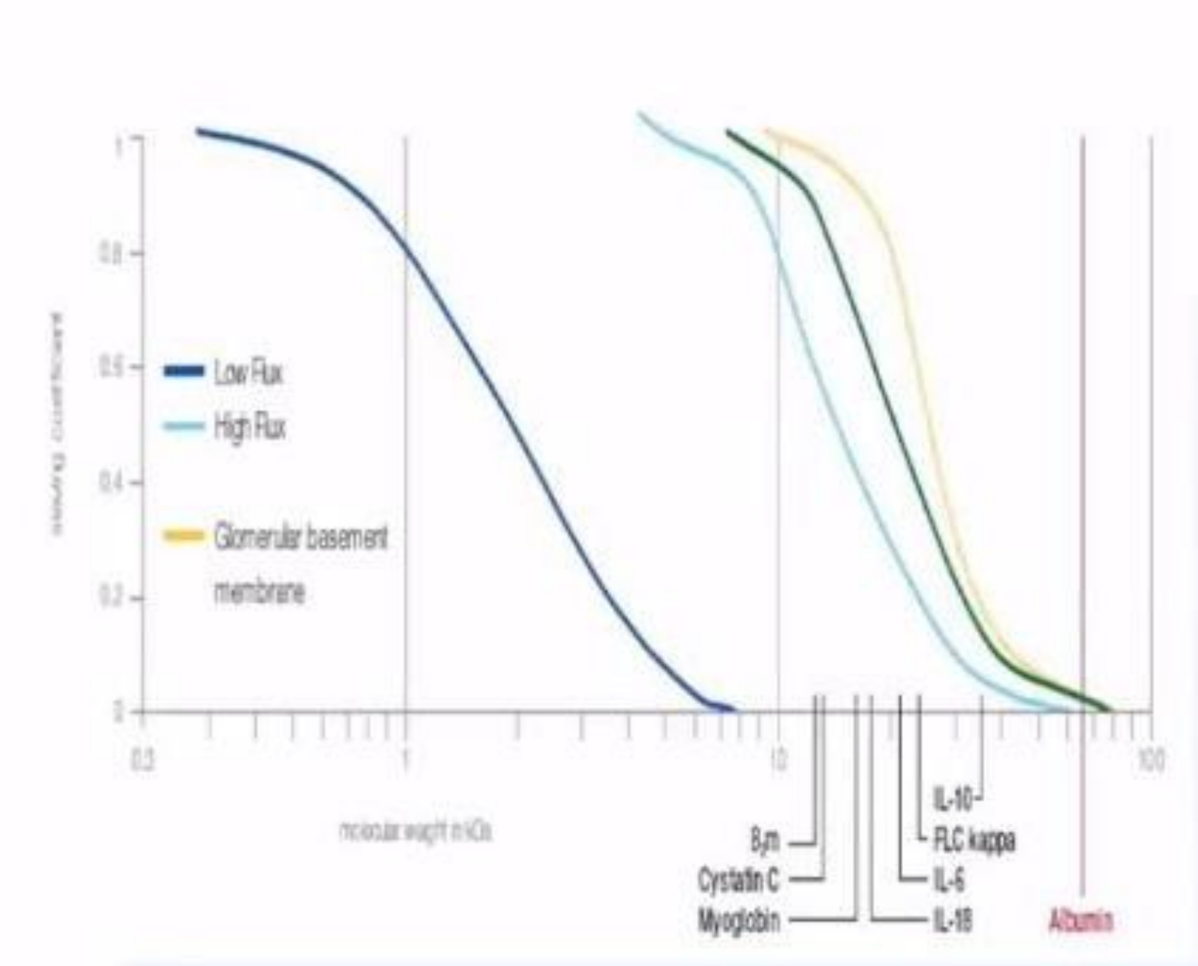
… Una fase - solida, liquida o gassosa - caratterizzata in genere da un elevatissimo rapporto superficie/spessore, capace di lasciarsi attraversare selettivamente, sotto adatte forze spingenti, da materia o energia…

La dialisi si basa su processi di scambio fra due compartimenti, il sangue e la soluzione dializzante, governati da gradienti di concentrazione *(diffusione)* o di pressione idrostatica *(convezione)*, singolarmente o in associazione tra di loro: il ruolo della membrana come elemento di separazione e di trasporto selettivo di soluti risulta quindi determinante

La definizione di un trattamento dialitico non può prescindere dalla scelta della membrana che andrà motivata sulle caratteristiche del trattamento da effettuare e del paziente che vogliamo trattare

La membrana dialitica ideale





Caratteristiche della membrana ideale

- Rapida diffusione dei soluti a basso *MW*
- Alta clearance di soluti di *MW* medio-alto
- Nessuna perdita di proteine *(ridotta perdita di proteine!!)*
- Resistenza al *transfer* di endotossine dal dialisato
- Permeabilità idraulica stabile e facilmente modulabile (agevole controllo del *Quf*)
- Superficie di contatto con il sangue: *inerte, senza bioreattività (ridotta trombogenicità, basso impatto su s.infiammatoria etc)*
- Caratteristiche e prestazioni: costanti e riproducibili
- Facile sterilizzabilità senza alterazione delle caratteristiche

Costo ragionevole

Tossine Uremiche e correlazioni cliniche

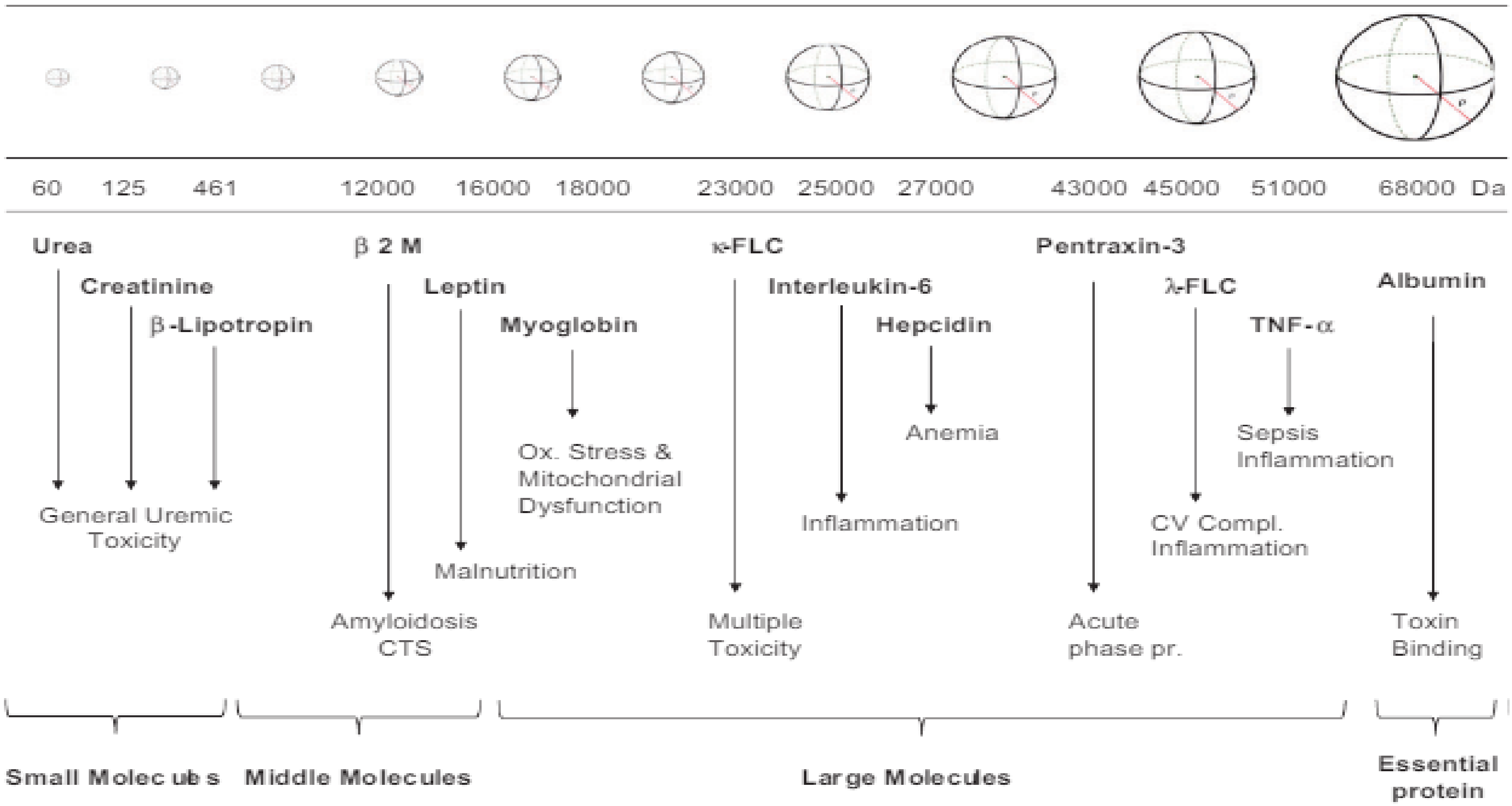


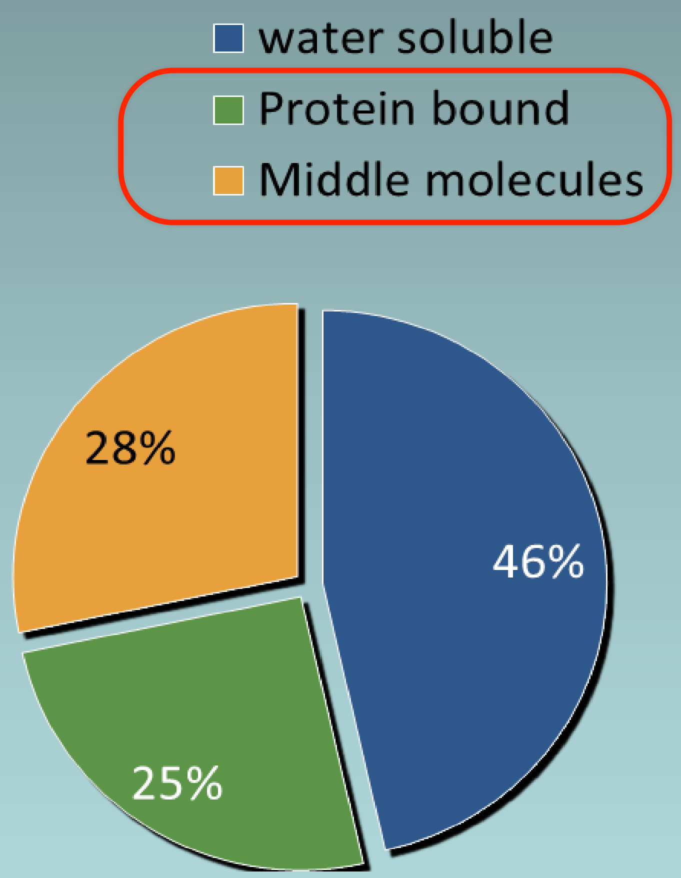
FIGURE 1: Schematic representation of different classes of uraemic toxins with their molecular size and relevant clinical effects.

Adapted from C Ronco, Blood Purif. 2017; 44:I-VII

Rimozione e Distribuzione Tossine Uremiche

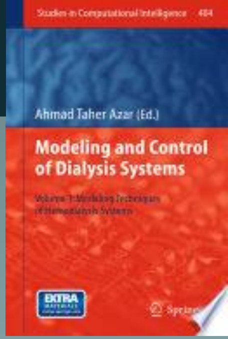
Table 1. Summary of middle molecules (n=59)

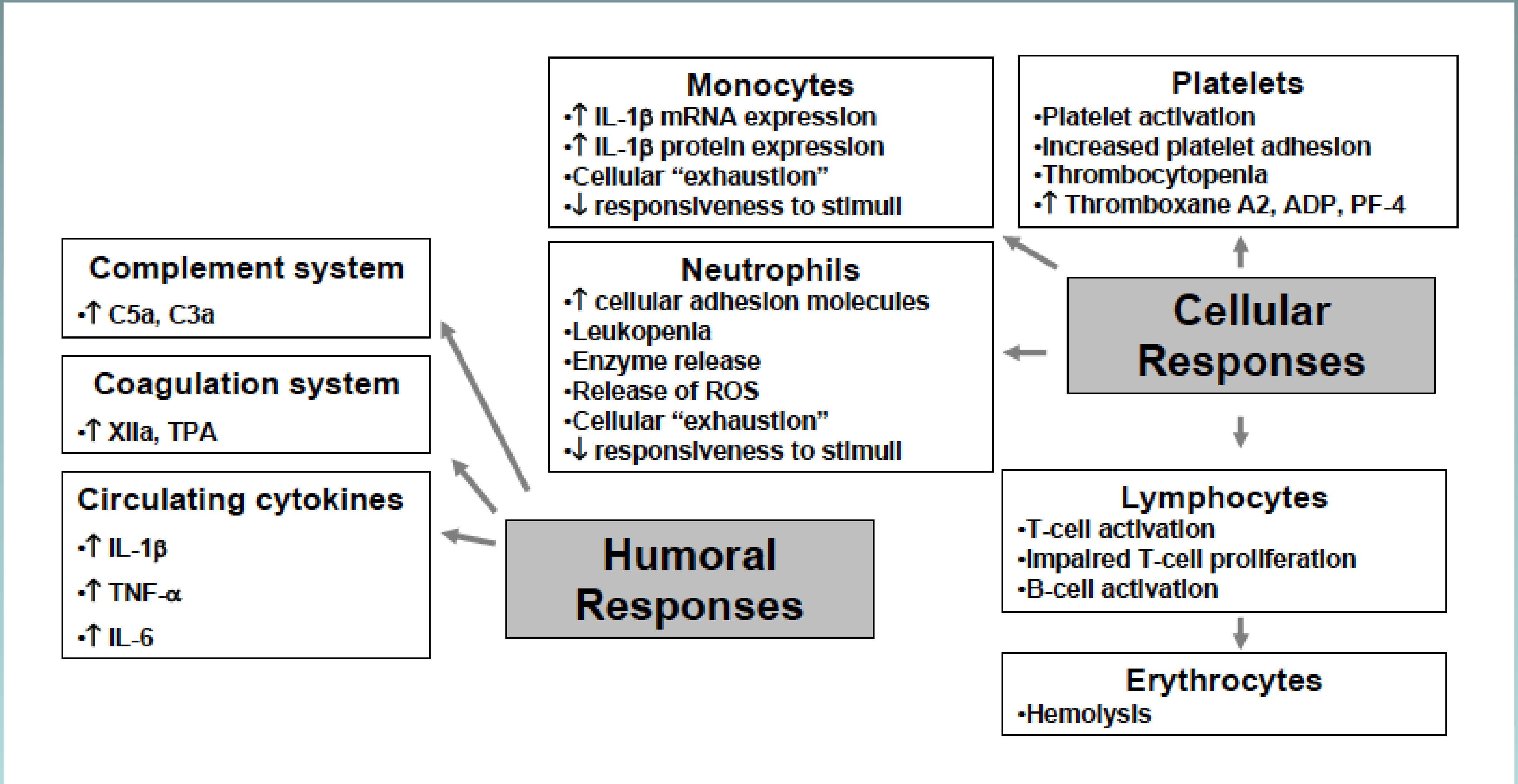
Removed by High Flux (<15 kD)	Molecular Mass, kD	Removed by HDF (15–24.9 kD)	Molecular Mass, kD	Not Currently Removed (>25 kD)	Molecular Mass, kD
Methionine-enkephalin	0.5	Clara cell protein	15.8	Hyaluronic acid	25
Glutathione	0.6	Leptin	16	β-Trace protein	26
Angiotensin A	0.8	Myoglobin	17	Soluble TNF receptor-1	27
δ-Sleep-inducing peptide	0.8	TNF-α	17	Adiponectin	30
Dinucleoside polyphosphates	1	Soluble TNF receptor-2	17	FGF-23	32
Substance P	1.3	IL-1β	17.5	α1-Microglobulin	33
Motilin	2.7	FGF-2	18	VEGF	34.2
Orexin B	2.9	IL-10	18	YKL-40	40
Atrial natriuretic peptide	3	Retinol binding protein	21.2	Pentraxin-3	40.2
Desacylgherlin	3.2	Prolactin	22	α1-Acid glycoprotein	43
Vasoactive interstinal peptide	3.3	κ-Ig light chain	22.5	AGEs	45
Calcitonin	3.4	Complement factor D	23.75	λ-Ig light chain	45
Gherlin	3.4	IL-18	24	Visfatin	55
β-Endorphin	3.4	IL-6	24.5	AOPPs	>60
Orexin A	3.5				
Calcitonin gene–related peptide	3.7				
Cholecystokinin	3.8				
Endothelin	4.2				
Neuropeptide Y	4.2				
SIAM-1	4.2				
Adrenomedullin	5.7				
Osteocalcin	5.8				
IGF-1	7.6				
IL-8	8				
Parathyroid hormone	9.5				
Guanylin	10.3				
β2-Microglobulin	11.8				
Uroguanylin	12				
Resistin	12.5				
Cystatin C	13.3				
Degranulation inhibiting protein[a]	14.1				



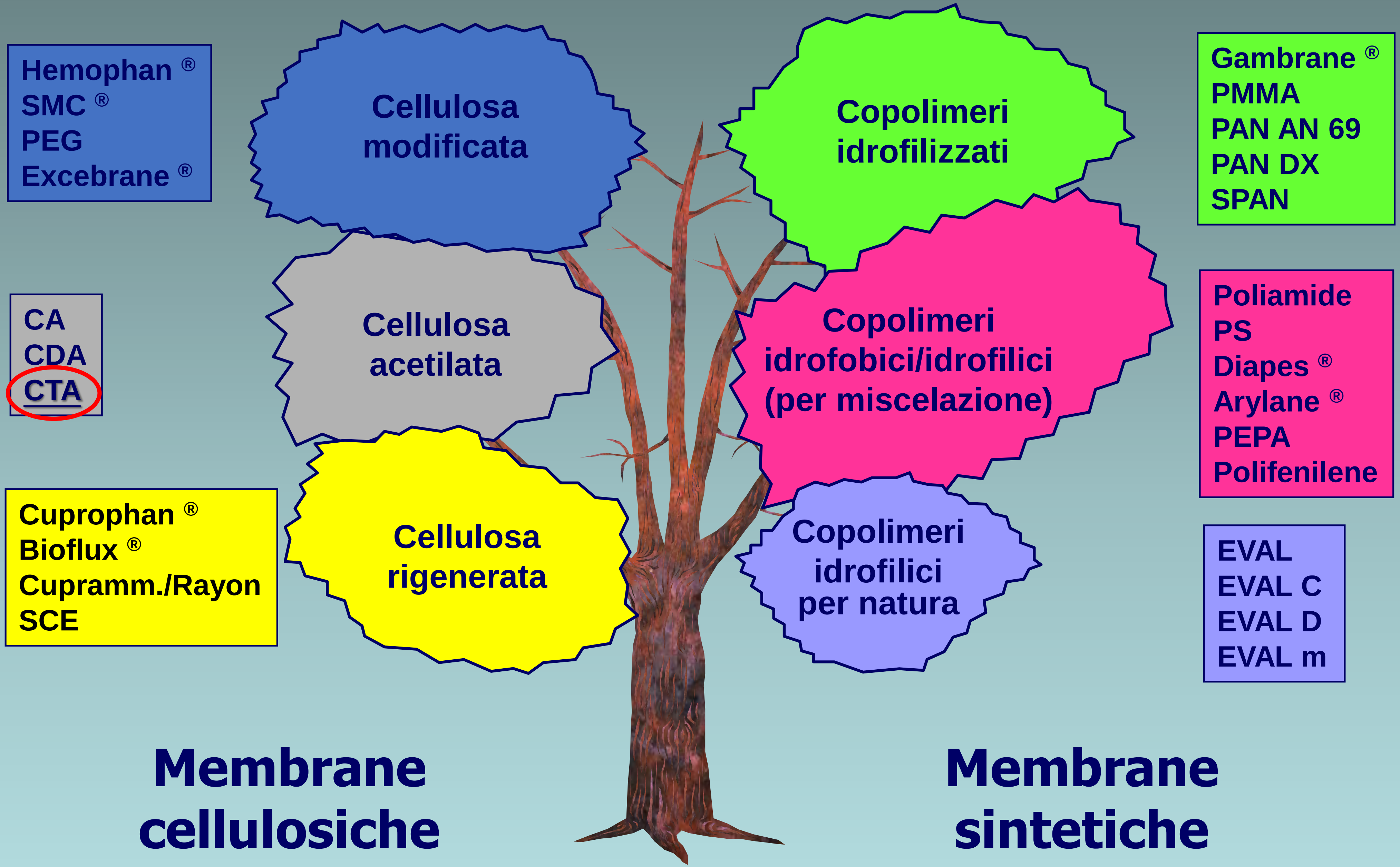
Duranton F et al. J Am Soc Nephrol 23: 1258–1270, 2012

Membrane e Biocompatibilità





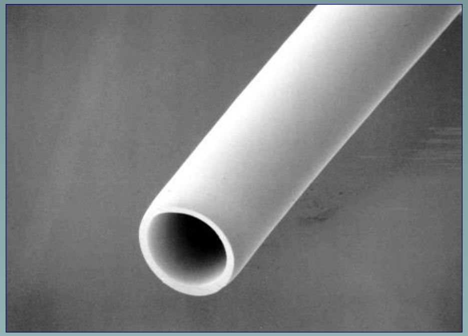
O. Liangos and B.L. Jaber Mod. and Cont.of Dial. Syst. Chapter 9,2013

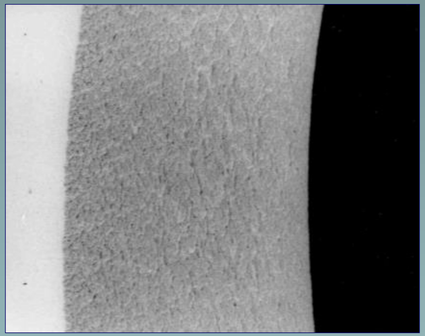

Hemophan ®
SMC ®
PEG
Excebrane ®
Cellulosa modificata
CA
CDA
CTA
Cellulosa acetilata
Cuprophan ®
Bioflux ®
Cupramm./Rayon
SCE
Cellulosa rigenerata
Copolimeri idrofilizzati
Gambrane ®
PMMA
PAN AN 69
PAN DX
SPAN
Copolimeri idrofobici/idrofilici (per miscelazione)
Poliamide
PS
Diapes ®
Arylane ®
PEPA
Polifenilene
Copolimeri idrofilici per natura
EVAL
EVAL C
EVAL D
EVAL m
Membrane cellulosiche
Membrane sintetiche

Membrane per emodialisi
Caratteristiche fisico-chimiche

Simmetria e omogeneità

- Membrana simmetrica = *skin layers* simili (cellulosica)
- Membrana asimmetrica = *skin layers* diversi (sintetica)
- Membrana omogenea = struttura uniforme
- Membrana disomogenea = struttura non uniforme





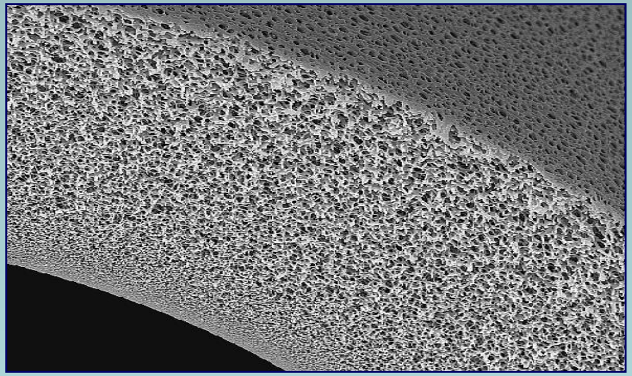
membrana cellulosica simmetrica

Spessore

- Spessore complessivo della membrana (comprende tutta la struttura sia in caso di omogeneità che disomogeneità)
- Spessore differenziato (struttura per struttura)

34 µm support structure

1 µm = 1000 nm Skin layer



membrana sintetica asimmetrica

Origine del polimero

- Naturale (cellulosica) o sintetica

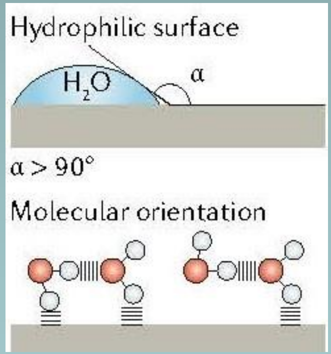
Membrane: idrofilicità e idrofobicità

- **Idrofilicità = capacità di attrarre acqua**
- **Idrofobicità = capacità di respingere acqua**

Membrane idrofiliche vs. idrofobiche

☺ **"Vantaggi"**

- **Alta diffusibilità *(Ko)***
- **Basso adsorbimento proteico**
- ***sc ↔ - Performances ↔***
- **Scarsa adesione piastrinica**
- **Bassa trombogenicità**



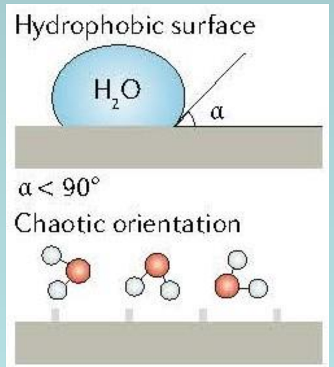
☹ **"Svantaggi"**

- **Bassa convettività *(Kuf)***
- **Alta interazione con le cellule**
- **Alta attivazione complementare**
- **Bassa emocompatibilità**

Membrane idrofobiche vs. idrofiliche

☺ **"Vantaggi"**

- **Alta convettività *(Kuf)***
- **Bassa interazione con le cellule**
- **Bassa attivazione complementare**
- **Elevata emocompatibilità**



☹ **"Svantaggi"**

- **Bassa diffusibilità *(Ko)***
- **Alto adsorbimento proteico**
- ***sc ↓ - Performances ↓***
- **Alta adesione piastrinica**
- **Alta trombogenicità**

Membrane: idrofilicità

membranes

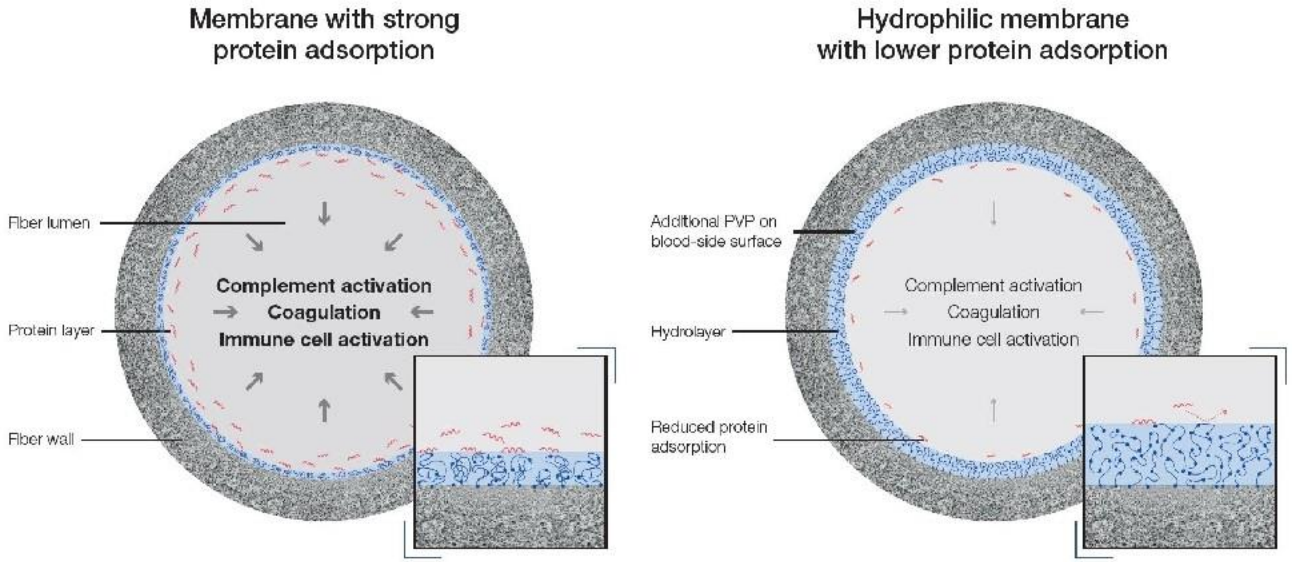
MDPI

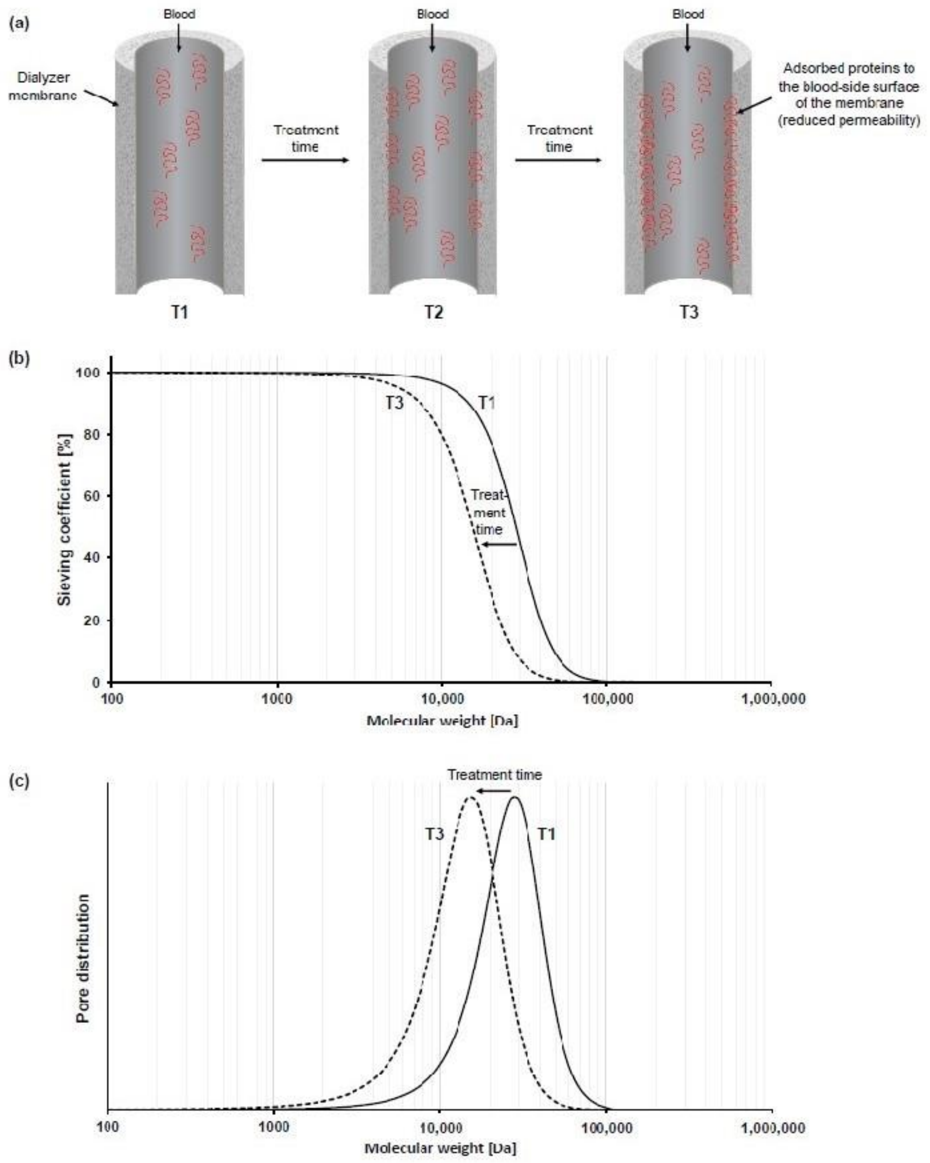
Review

Impact of Hydrophilic Modification of Synthetic Dialysis Membranes on Hemocompatibility and Performance

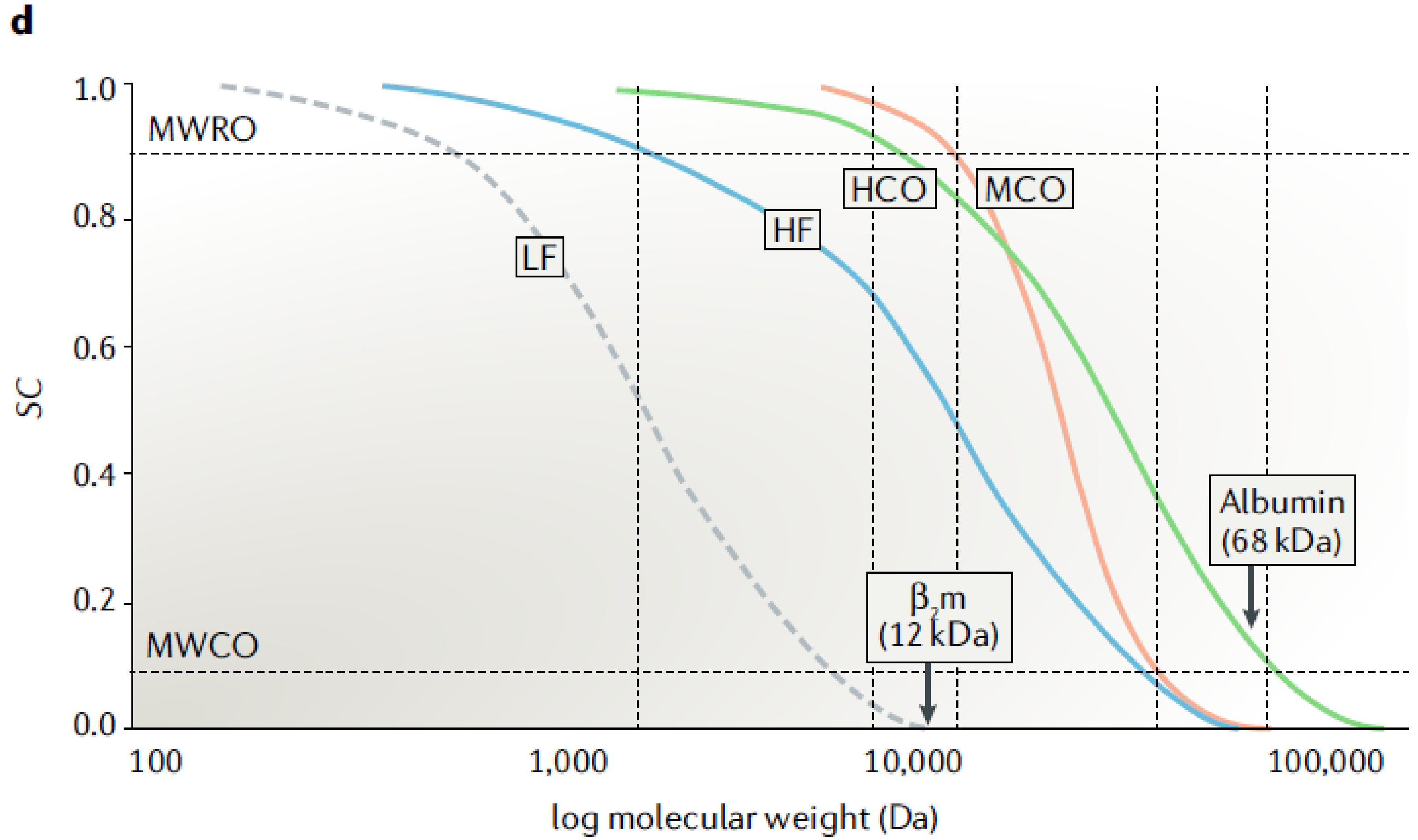
Adam M. Zawada [1,*], Thomas Lang [2], Bertram Ottillinger [3], Fatih Kircelli [4], Manuela Stauss-Grabo [2] and James P. Kennedy [1]

Membranes **2022**, *12*, 932. https://doi.org/10.3390/membranes12100932





Nuova Classificazione delle Membrane (panoramica curve di sieving)



SIEVING COEFFICIENT:*S*

Probabilità che una sostanza attraversi quella determinata membrana, è un dato statistico:

S=Cd/Cp

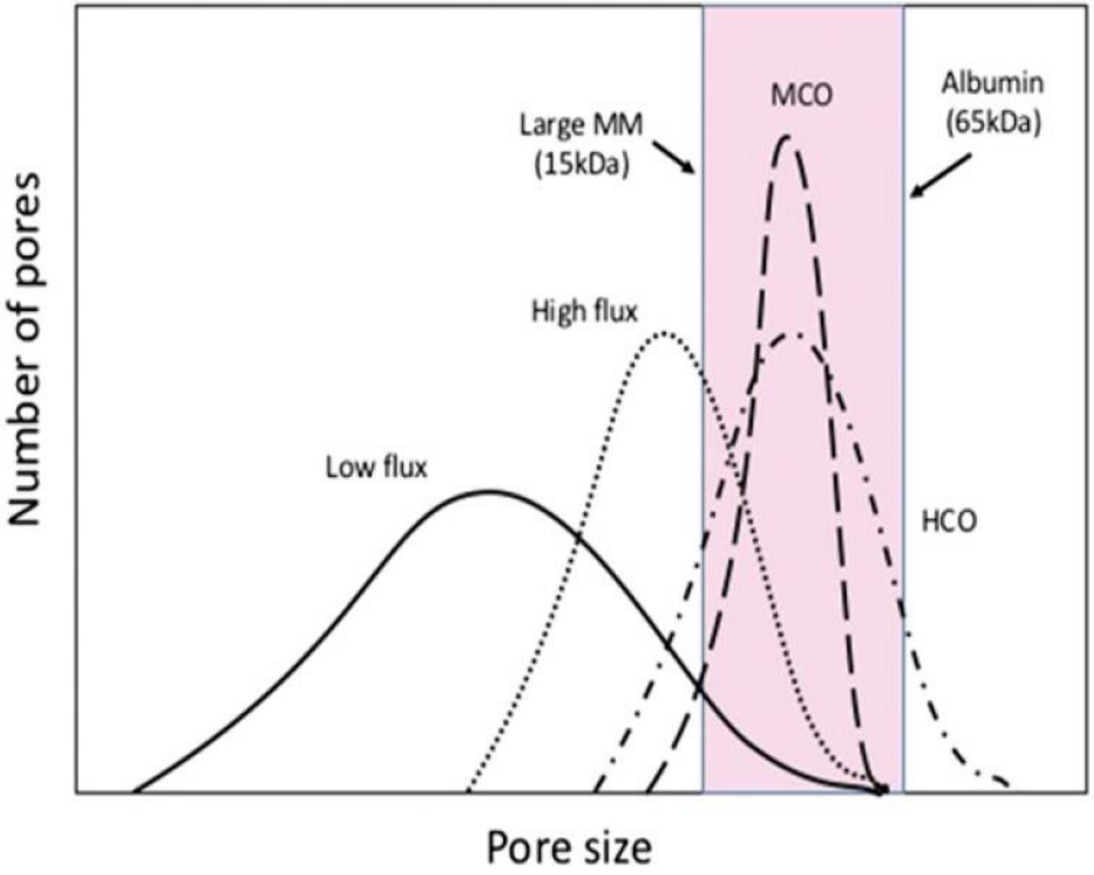
S=1 il 100% delle volte che la molecola incontra la membrana la attraversa

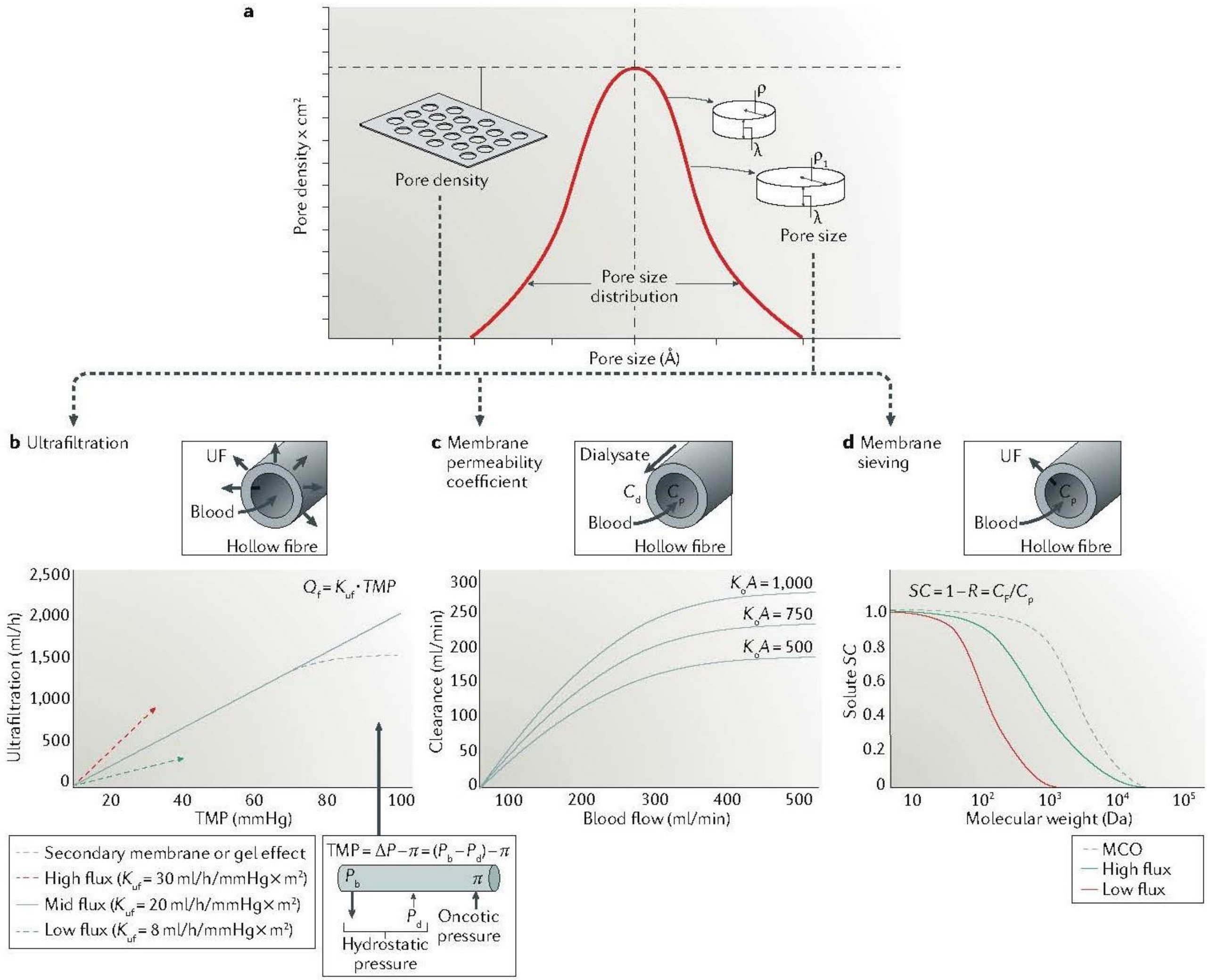
S=0 in nessun caso la molecola attraversa la membrana

MWRO (molecular weight retention onset): il peso molecolare di una sostanza che presenta un **S=0.9** nei confronti di una determinata membrana

MWCO (molecular weight cut off): il peso molecolare di una sostanza che presenta un **S=0.1** nei confronti di una determinata membrana

Filtri MCO





Claudio Ronco and William R. Clark Nat Rev Nephrol. 2018 Jun;14(6):394-410

Filtri MCO

Editorial

Blood Purification

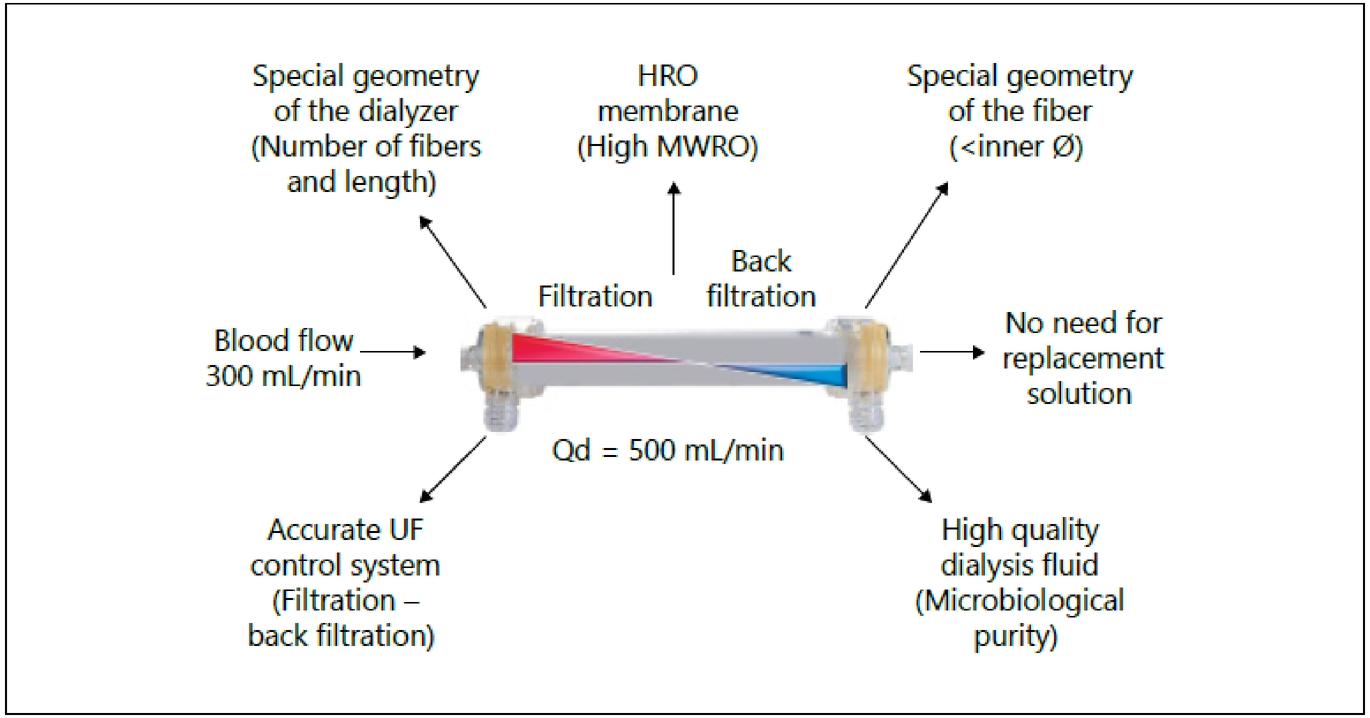
Blood Purif 2017;44:I–VIII
DOI: 10.1159/000476012

Published online: May 10, 2017

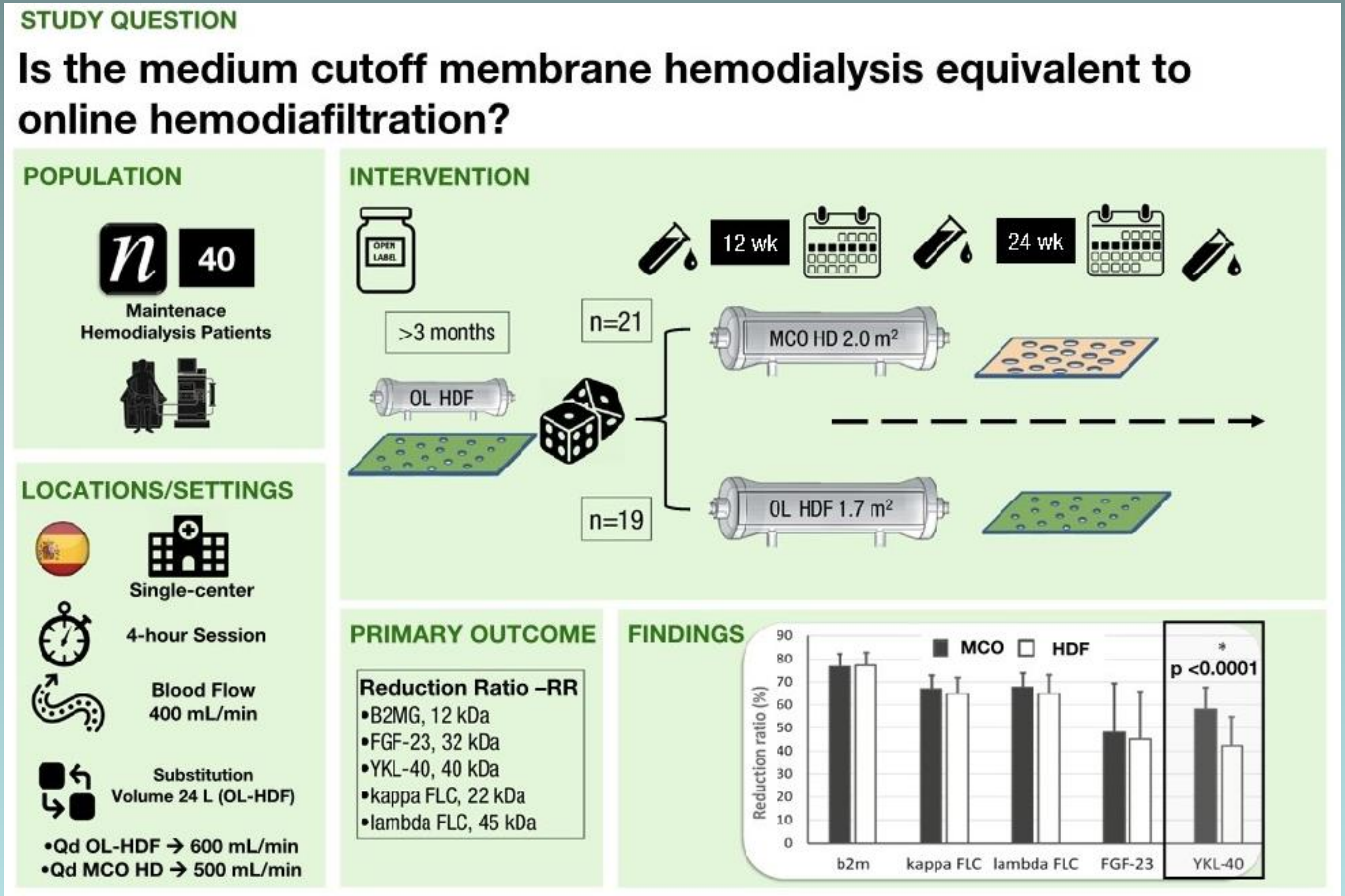
The Rise of Expanded Hemodialysis

Claudio Ronco[a, b]

[a]Department of Nephrology Dialysis and Transplantation, St. Bortolo Hospital, and [b]International Renal Research Institute, Vicenza, Italy



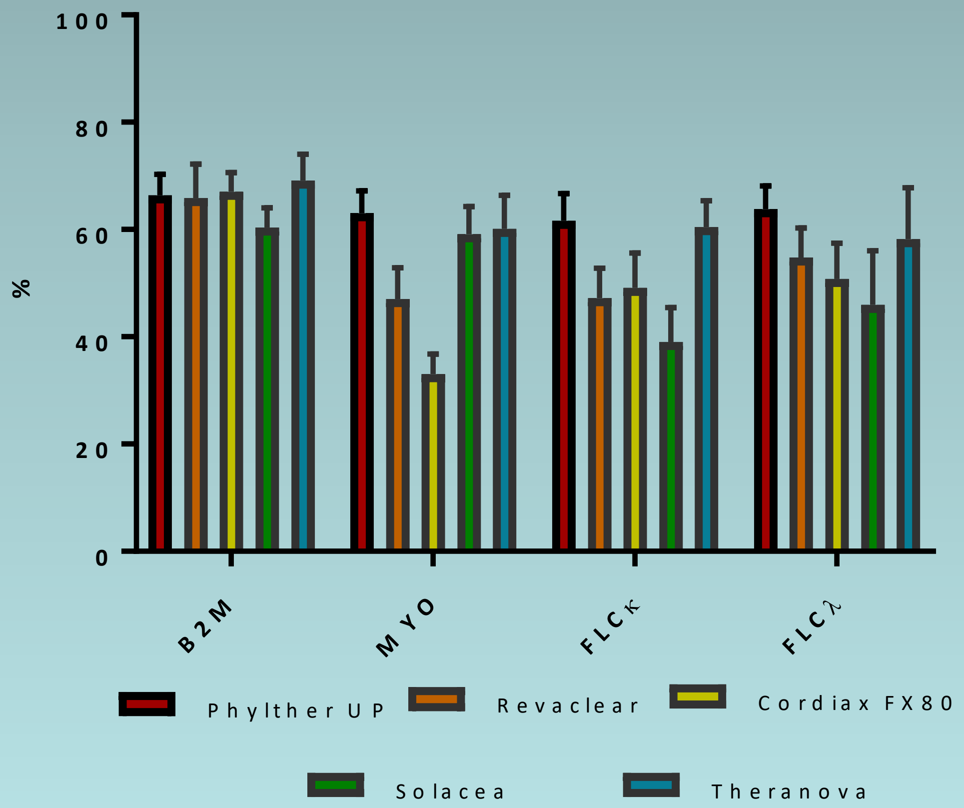
MCO vs HDF



Adapted from Hadad Arascue et al Ther Apher Dial. 2022;26:37–44

MCO vs HF

	β2M [a,b]	Myoglobin[c,d]	FLC κ [e,f]	FLC λ [g,h]
Phylther Up	66.38±3.89	63.0±4.21	61.65±5.04	63.75±4.40
Revaclear 400	65.88±3.60	47.00±5.88	47.19±5.63	54.75±5.54
Cordiax FX80	67.0±3.66	33.00±3.78	49.09±6.56	50.80±6.67
Solacea	60.38±3.62	59.13±5.19	39.00±6.43	45.97±10.03
Theranova 400	69.13±4.88	60.13±6.24	60.42±4.99	58.21±9.54



Toxins and albumin mass removal in spent dialysate per session

	β2M (mg)	Myoglobin (μg)	FLC κ (mg)	FLC λ (mg)	Albumin (g)
Phylther UP	136±23	1388±534	438±153	115±54	4.07±0.65
Revaclear	165±85	1196±617	604±363	68±35	1.53±0.41
FX 80	102±49	177±14	89±44	6.00±0.01	0.26±0.01
Cordiax	98±40	774±419	200±51	25±10	0.26±0.001
Solacea	140±52	1336±582	252±101	60±22	0.66±0.16
Theranova	166±56	1432±746	424±189	96±36	1.89±0.59

Bove S et al. Neph Dial Trans 2018 33 Supp.1- i190

Pazienti Target per membrane HRO

Nephrol Dial Transplant (2020) 35: 328–335
doi: 10.1093/ndt/gfz189
Advance Access publication 3 October 2019

Comparison of the removal of uraemic toxins with medium cut-off and high-flux dialysers: a randomized clinical trial

Mohamed Belmouaz[1], Marc Bauwens[1], Thierry Hauet[2,3], Valentin Bossard[2], Pierre Jamet[1], Florent Joly[1], Elise Chikhi[1], Sandrine Joffrion[2,3], Elise Gand[4] and Frank Bridoux[1]

Blood Purification
Research Article
Blood Purif
DOI: 10.1159/000508061
Received: March 6, 2020
Accepted: April 20, 2020
Published online: July 7, 2020

Comparison of Circulating Levels of Uremic Toxins in Hemodialysis Patients Treated with Medium Cut-Off Membranes and High-Flux
...a in Sisli Hamidiye Etfal
...l Control Study

Vuslat Yilmaz[c] Taner Basturk[d]
Nazif Ozcafer[a] Abdulkadir Unsal[d]

Article

Efficacy and Safety of ...
Theranova 400 Dialyze...
A Randomized Controlled Tri...

Daniel E. Weiner,[1] Luke Falzon,[2] Line Skoufos,[3]

Canadian Society of Nephrology/ Société canadienne de néphrologie CSN/SCN
CANADIAN JOURNAL OF KIDNEY HEALTH AND DISEASE
Journal canadien de la santé et de la maladie rénale
Original Basic Research

Effects of Medium Cut-Off Versus High-Flux Hemodialysis Membranes on Biomarkers: A Systematic Review and Meta-Analysis

Canadian Journal of Kidney Health and Disease
Volume 9: 1–15

DOI: 10.1177/20543581211067090
journals.sagepub.com/home/cjk
SAGE

Maryam Kandi[1], Romina Brignardello-Petersen[1], Rachel Couban[1], Celina Wu[2], and Gihad Nesrallah[2,3]

...modialysis – Research Article
...d Purif
...: 10.1159/000505567
Received: August 27, 2019
Accepted: December 19, 2019
Published online: January 22, 2020

OPEN

Randomized controlled trial of medium cut-off versus high-flux dialyzers on quality of life outcomes in maintenance hemodialysis patients

Jeong-Hoon Lim[1], Yeongwoo Park[2], Ju-Min Yook[1], Soon-Youn Choi[1], Hee-Yeon Jung[1], Ji-Young Choi[1], Sun-Hee Park[1], Chan-Duck Kim[1], Yong-Lim Kim[1] & Jang-Hee Cho[1]

A tRial Evaluating Mid Cut-Off Value Membrane Clearance of Albumin and Light Chains in HemoDialysis Patients: A Safety Device Study

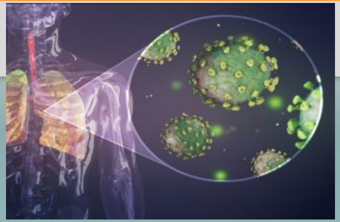
Rathika Krishnasamy[a–c] Carmel M. Hawley[b–d] Meg J. Jardine[c, e–g]
Matthew A. Roberts[c, h] Yeoungjee Cho[b–d] Muhgeot Wong[e, f] Anne Heath[f]
Craig L. Nelson[i–k] Shaundeep Sen[g] Peter F. Mount[l] Elaine M. Pascoe[b, c]
Liza A. Vergara[c] Peta-Anne Paul-Brent[c] Nigel D. Toussaint[m, n]
David W. Johnson[b–d] Colin A. Hutchison[c, o]

Studi confrontano MCO con HIGH FLUX
periodi di studio compresi tra 4 e 24 settimane

Pazienti Target per membrane HRO

COVID-19

in the course of sepsis from SARS CoV2



Restless leg syndrome

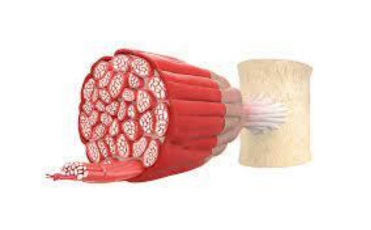
The molecules can directly cause symptoms, for example the retention of α-1 microglobulin is associated with restless leg syndrome (RLS)

Chronic Inflammation

Several of the 27 large middle-molecules had described pathways by which they can contribute to chronic inflammation, including the pro-inflammatory cytokines interleukins 1β, 6, 18, and TNF-α, Myoglobin and AGEs etc

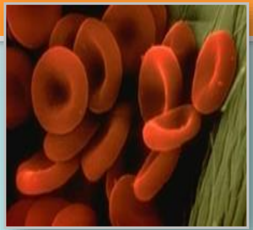
AKI

Rhabdomyolysis or others AKI that can be treated with SLED or Intermittent HD



Erythropoietin resistance

Potentially, if increased removal of large middle-molecules reduces chronic inflammation, then erythropoietin resistance in turn could be improved.



Haemorragic Pts with atrial flutter , CVC, Incident Pts

Balance between anticoagulant therapy, calcification risk and stenosis.Single or biweekly dialysis

Filtri MCO: *infiammazione*

PLOS | ONE

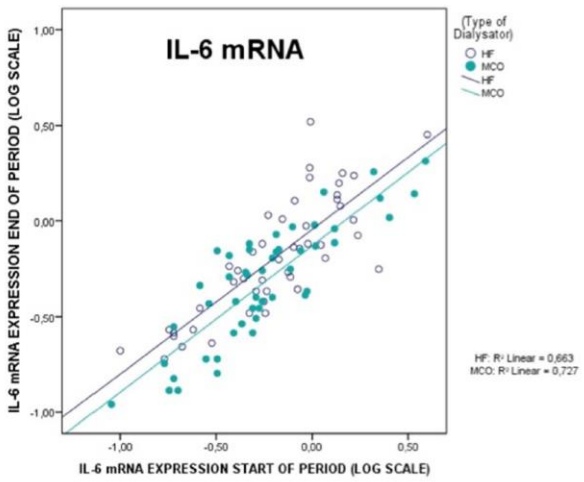
RESEARCH ARTICLE

Medium Cut-Off (MCO) Membranes Reduce Inflammation in Chronic Dialysis Patients—A Randomized Controlled Clinical Trial

Daniel Zickler[1]*, Ralf Schindler[1], Kevin Willy[1], Peter Martus[2], Michael Pawlak[3], Markus Storr[4], Michael Hulko[4], Torsten Boehler[4], Marcus A. Glomb[5], Kristin Liehr[5], Christian Henning[5], Markus Templin[3], Bogusz Trojanowicz[6], Christof Ulrich[6],

PLOS ONE | DOI:10.1371/journal.pone.0169024 January 13, 2017

Dialyzer	Mem-brane polymer	Membrane type	Fiber length (mm)	Fiber inner diameter (μm)	Membrane area (m^2)	Membranewall thickness (μm)	UF coefficient (ml/h/ mm_{Hg})	Sterilization
MCO-Ci 400	PAES/PVP	medium cut-off (MCO 4)	236	180	1.8	35	50	Steam
Revaclear 400	PAES/PVP	high-flux (Poracton[TM])	236	190	1.8	35	54	Steam



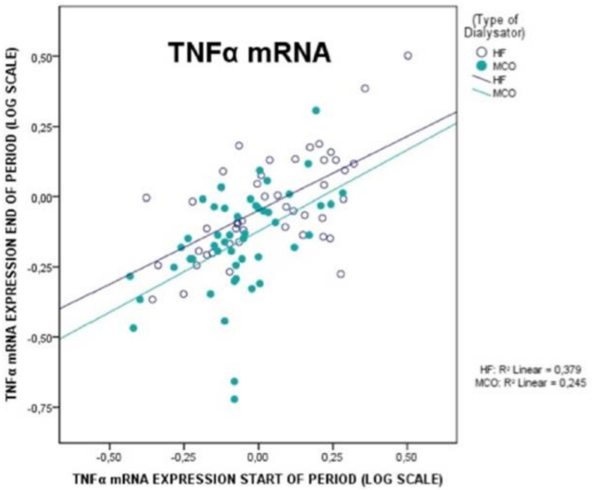


Table 3. Primary endpoints (TNF- α mRNA / IL-6 mRNA) and long-term plasma levels before and after 4 weeks treatment with High-flux / MCO. Shown are only parameters with a significant change after the MCO-period.

	High-flux		MCO		p MCO vs HF
	T = 0	T = 4 weeks	T = 0	T = 4 weeks	
Primary endpoint					
TNF-α mRNA	1.19 ± 0.57	1.02 ± 0.49*	0.92 ± 0.34	0.75 ± 0.31**	< 0.001
IL-6 mRNA	0.86 ± 0.68	0.83 ± 0.67	0.78 ± 0.80	0.60 ± 0.43**	0.001
Clinical chemistry					
Albumin g/l	36.6 ± 3.2	37.5 ± 2.7	37.0 ± 3.6	35.3 ± 3.7**	< 0.001
CRP mg/l	13.4 ± 25.5	9.6 ± 15.7	15.3 ± 30.0	9.3 ± 14.5	n.s.
Urea mg/dl	131± 38	129 ± 35	128 ± 34	115 ± 29**	0.012
Beta2M mg/l	27.0 ± 9.1	26.1 ± 8.6	26.9 ± 8.4	25.7 ± 8.1**	n.s.
Other					
FLC kappa mg/l	134 ± 65	140 ± 77	137 ± 65	120 ± 54**	0.003
FLC lambda mg/l	91 ± 42	91 ± 44	95 ± 46	79 ± 36**	< 0.001
Fetuin A μg/ml	569 ± 124	543 ± 122	560 ± 131	519 ± 112*	n.s.
Lp-PLA2 ng/ml	180 ± 90	185 ± 108	156 ± 76	189 ± 101**	0.026

* = p<0.05 vs. T = 0

** = p<0.01 vs. T = 0.

Filtri MCO: *rischio cardio-vascolare*

scientific reports

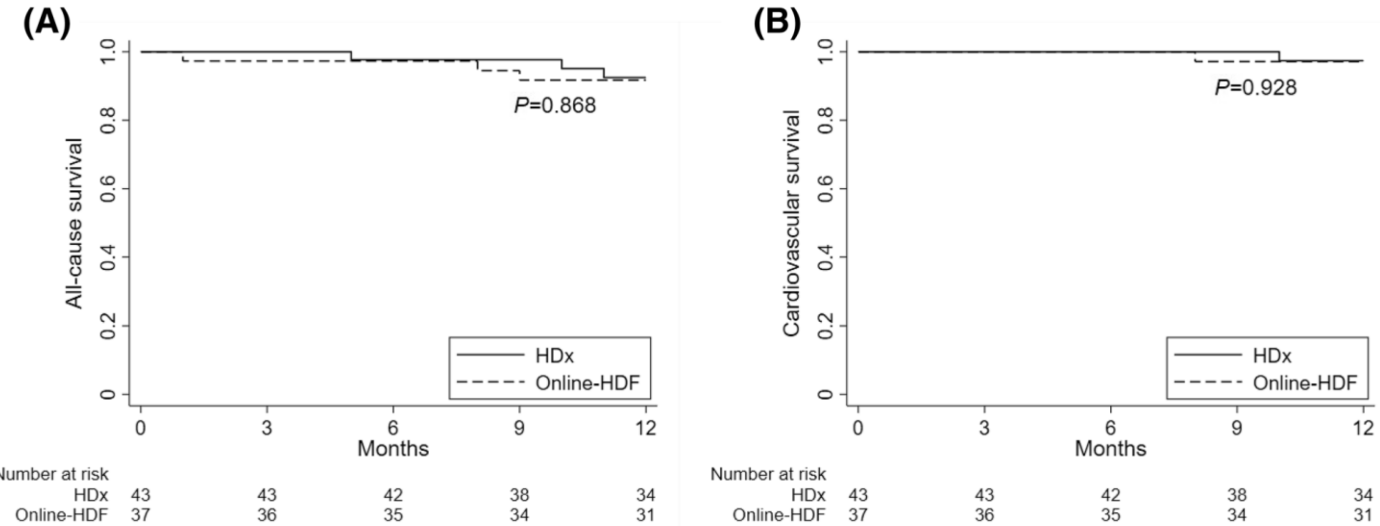
OPEN

Cardiovascular Risk Comparison between Expanded Hemodialysis Using Theranova and Online Hemodiafiltration (CARTOON): A Multicenter Randomized Controlled Trial

Yeonhee Lee[1], Myoung-jin Jang[2], Junseok Jeon[3], Jung Eun Lee[3], Wooseong Huh[3], Bum Soon Choi[4], Cheol Whee Park[4], Ho Jun Chin[1,5], Chae Lin Kang[6], Dong Ki Kim[1], Seung Seok Han[1] & Kwon Wook Joo[1]

Scientific Reports | (2021) 11:10807 | https://doi.org/10.1038/s41598-021-90311-6

Variables	Baseline values	Change from the baseline (mean and 95% confidence intervals)			
		6 months	*P* value	12 months	*P* value
baPWV (m/s)					
HDx	1.8±0.7	0.1 (0 to 0.2)	0.176	0 (−0.1 to 0.2)	0.518
Online-HDF	1.9±0.7	−0.1 (−0.2 to 0)	0.221	0.1 (0 to 0.3)	0.046
Between-group difference		0.2 (0 to 0.3)	0.066	−0.1 (−0.3 to 0.1)	0.317
LVEF (%)					
HDx	63.0 (57.0–69.0)	−0.2 (−2.5 to 2.1)	0.860	−0.7 (−3.1 to 1.7)	0.561
Online-HDF	63.0 (56.0–66.0)	0.6 (−1.8 to 3.0)	0.622	−0.6 (−3.1 to 1.9)	0.660
Between-group difference		−0.8 (−4.1 to 2.6)	0.648	−0.1 (−3.5 to 3.4)	0.966
LVMI (g/m²)					
HDx	111.3 (88.7–138.9)	−36.1 (−79.9 to 7.6)	0.106	−39.2 (−84.0 to 5.5)	0.086
Online-HDF	114.7 (102.2–142.9)	−22.5 (−69.8 to 24.8)	0.351	−54.7 (−103.2 to −6.1)	0.027
Between-group difference		−13.4 (−77.7 to 50.8)	0.682	14.5 (−51.4 to 80.4)	0.666
E/e'					
HDx	12.0 (10.0–16.0)	0.3 (−1.0 to 1.7)	0.628	0.4 (−1.0 to 1.8)	0.536
Online-HDF	12.8 (10.0–14.8)	−0.8 (−2.3 to 0.6)	0.274	−0.2 (−1.7 to 1.3)	0.815
Between-group difference		1.2 (−0.8 to 3.2)	0.240	0.7 (−1.4 to 2.7)	0.516
Coronary artery calcium score*					
HDx	295 (19–799)	64.6 (0.7 to 128.5)	0.048	154.9 (91.0 to 218.8)	<0.001
Online-HDF	268 (16–678)	23.0 (−43.1 to 89.1)	0.496	36.6 (−29.5 to 102.7)	0.277
Between-group difference		41.6 (−50.3 to 133.6)	0.375	118.3 (26.3 to 210.2)	0.012



Variables	Baseline values	Change from the baseline (mean and 95% confidence intervals)			
		6 months	*P* value	12 months	*P* value
BNP (pg/mL)					
HDx	369.1 (185.0–910.0)	51.4 (−267.9 to 370.7)	0.752	127.4 (−206.1 to 460.9)	0.454
Online-HDF	287.2 (139.5–907.0)	−140.7 (−487.4 to 205.9)	0.426	−111.7 (−470.0 to 246.7)	0.541
Between-group difference		192.2 (−279.2 to 663.5)	0.424	239.1 (−250.4 to 728.6)	0.338
NT-proBNP (ng/mL)					
HDx	3.95 (2.16–6.83)	−0.31 (−4.19 to 3.56)	0.874	1.42 (−2.64 to 5.48)	0.493
Online-HDF	4.27 (2.19–16.82)	−3.24 (−7.40 to 0.92)	0.127	−3.32 (−7.61 to 0.98)	0.130
Between-group difference		2.96 (−2.72 to 8.64)	0.307	4.66 (−1.25 to 10.57)	0.122
Troponin-I (ng/mL)					
HDx	0.06 (0.04–0.09)	0 (0 to 0.01)	0.538	0 (−0.01 to 0.01)	0.550
Online-HDF	0.06 (0.03–0.07)	0 (−0.01 to 0.01)	0.901	0 (0 to 0.01)	0.189
Between-group difference		0 (−0.03 to 0.01)	0.224	0 (−0.02 to 0.02)	0.926
Troponin-T (ng/mL)					
HDx	0.06 (0.04–0.09)	0 (−0.01 to 0)	0.362	0 (−0.01 to 0.01)	0.437
Online-HDF	0.06 (0.03–0.07)	−0.01 (−0.02 to 0)	0.130	−0.01 (−0.02 to 0)	0.139
Between-group difference		0 (−0.01 to 0.02)	0.595	0 (−0.01 to 0.02)	0.526
C-reactive protein (mg/dL)					
HDx	0.07 (0.04–0.23)	0.21 (−0.30 to 0.72)	0.421	0.10 (−0.43 to 0.62)	0.722
Online-HDF	0.09 (0.04–0.23)	0.47 (−0.08 to 1.01)	0.095	−0.02 (−0.54 to 0.58)	0.951
Between-group difference		−0.25 (−1.00 to 0.50)	0.511	0.08 (−0.69 to 0.74)	0.835
Interleukin-6					
HDx	9.55 (7.78–11.48)	4.09 (−2.28 to 10.47)	0.208	1.85 (−4.76 to 8.47)	0.582
Online-HDF	8.40 (7.02–11.94)	0.55 (−6.17 to 7.27)	0.872	−1.88 (−8.77 to 5.00)	0.592
Between-group difference		3.54 (−5.72 to 12.80)	0.453	3.74 (−5.81 to 13.28)	0.443

Membrane e COVID-19

KI REPORTS
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REVIEW

Management of Patients on Dialysis and With Kidney Transplantation During the SARS-CoV-2 (COVID-19) Pandemic in Brescia, Italy

Check for updates

Federico Alberici[1,2], Elisa Delbarba[2], Chiara Manenti[2], Laura Econimo[2], Francesca Valerio[2], Alessandra Pola[2], Camilla Maffei[2], Stefano Possenti[2], Simone Piva[1,3], Nicola Latronico[1,3], Emanuele Focà[4,5], Francesco Castelli[4,5], Paola Gaggia[2], Ezio Movilli[2], Sergio Bove[6], Fabio Malberti[7], Marco Farina[8], Martina Bracchi[9], Ester Maria Costantino[10], Nicola Bossini[2], Mario Gaggiotti[2] and Francesco Scolari[1,2]; on behalf of the Brescia Renal COVID Task Force[11]

Nephron

Clinical Practice: Review Article

Nephron
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Published online: August 4, 2020

Rationale for Medium Cutoff Membranes in COVID-19 Patients Requiring Renal Replacement Therapy

Claudio Ronco[a, b] Thiago Reis[b, c] Mario Cozzolino[d, e]

Blood Purification

Research Article

Blood Purif
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Published online: January 14, 2021

Medium Cut-Off Dialysis Membranes: Can They Have Impact on Outcome of COVID-19 Hemodialysis Patients?

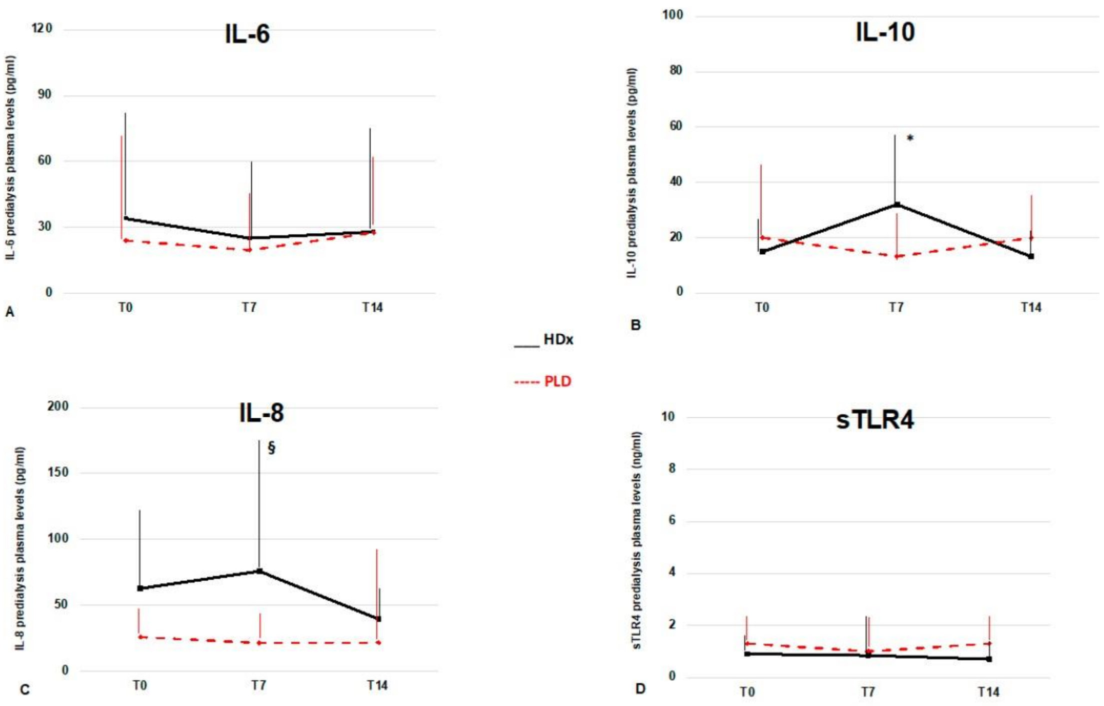
Serkan Feyyaz Yalın[a] Mehmet Rıza Altıparmak[b] Mevlut Tamer Dincer[b]
Serap Yadigar[a] Ahmet Murt[b] Ergun Parmaksiz[a] Claudio Ronco[c, d]

Journal of Clinical Medicine
MDPI

Article

Effects of Different Dialysis Strategies on Inflammatory Cytokine Profile in Maintenance Hemodialysis Patients with COVID-19: A Randomized Trial

Pasquale Esposito[1,2,*], Leda Cipriani[1], Daniela Verzola[1], Maria Antonietta Grignano[3], Mara De Amici[4], Giorgia Testa[5], Fabrizio Grosjean[3], Elisa Russo[1], Giacomo Garibotto[1], Teresa Rampino[3] and Francesca Viazzi[1,2]



Membrane adsorbenti: *PMMA, PEPA, AN69…..*

< 500 Da

Diffusion

Urea

500-15000 Da

Middle molecules

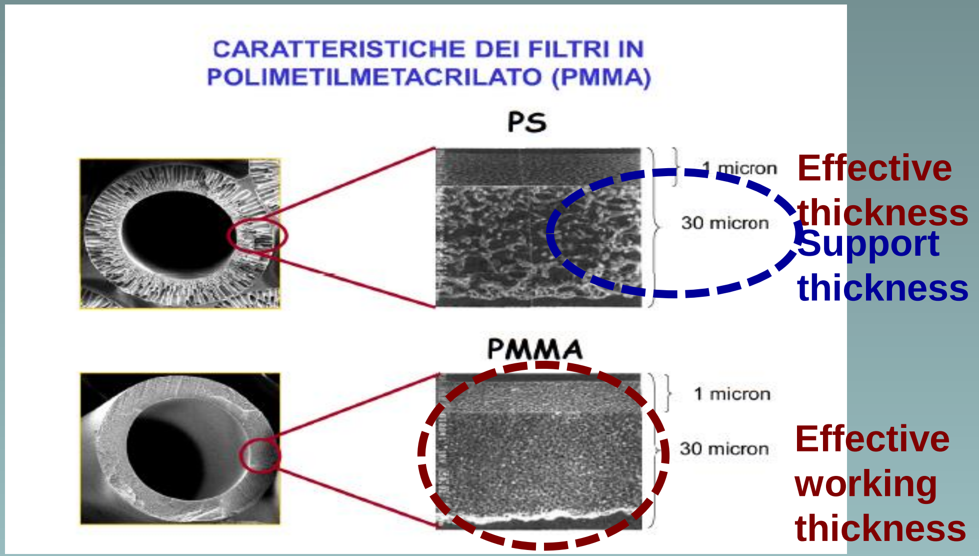
Convection

Middle and large molecules
protein-bound uremic toxin (PBUT)

Adsorption

> 50000 Da

Molecole cariche



ABSENCE OF OH GROUPS →	NO COMPLEMENT ACTIVATION
HYDROFOBICITY AND HIGH THICKNESS OF MEMBRANE →	ENDOTOXIN NOT PASSING FROM DIALYSATE SIDE TO BLOOD SIDE
ADSORPTION →	DETENTION OF CYTOKINES PRODUCED BY ACTIVATED MACROPHAGES

Infiammazione in uremia e CVD

Review Article

Biomarkers of Chronic Inflammatory State in Uremia and Cardiovascular Disease

Vincenzo Panichi, Alessia Scatena, Massimiliano Migliori,
Valentina Marchetti, Sabrina Paoletti, and Sara Beati

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Received 6 March 2012; Revised 5 April 2012; Accepted 17 April 2012

International Journal of Inflammation

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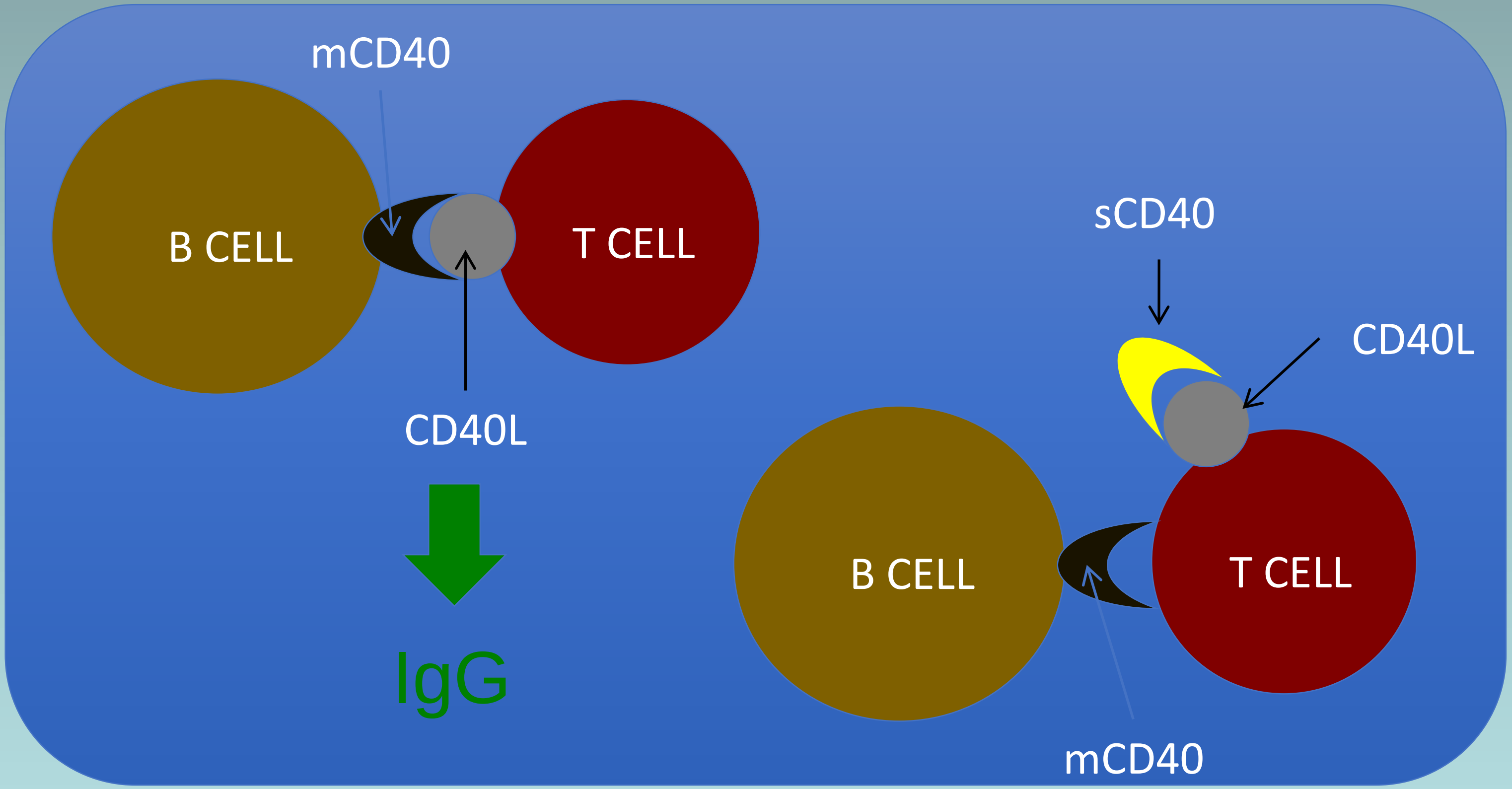
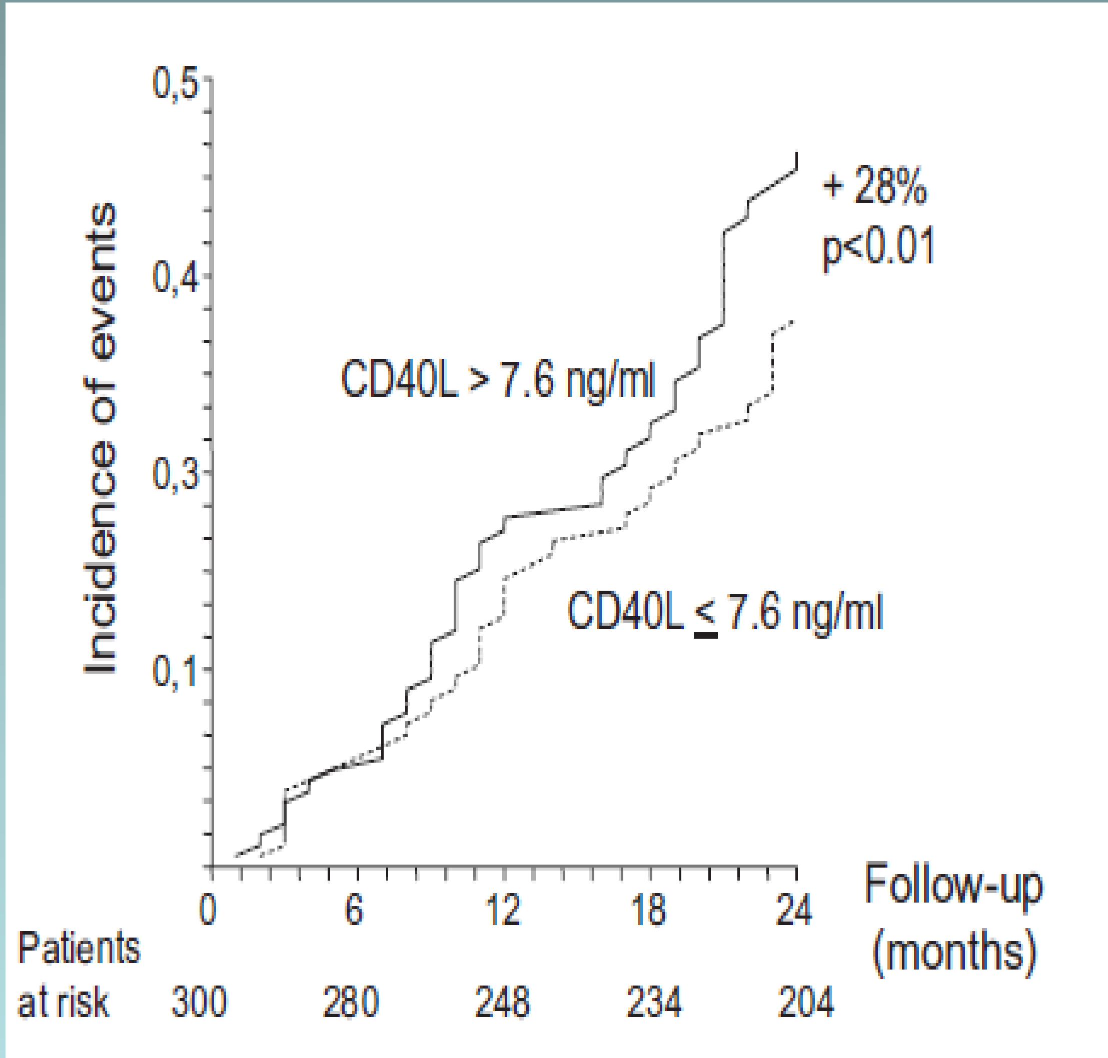
TRADITIONAL MARKERS	IL-6	CRP
NON TRADITIONAL MARKERS	CD40/CD40L complex	PTX-3



V Panichi et al. Intern J of Inflam Volume 2012, Article ID 360147

Il fattore Solubile CD40 Ligando predittivo di mortalità e morbidità cardio vascolare



the prognostic value of sCD40L as factor of cardiovascular Morbidity and Mortality is evident also in over 200 chronic HD patients from the RISCAVID population at 24-month follow-up

G. Desideri et al.Nephrol Dial Transplant (2011) 26: 2983–2988

HBV and sCD40

Immunology 2003 **110** 131–140

Potential role of soluble CD40 in the humoral immune response impairment of uraemic patients

CÉCILE CONTIN,* VINCENT PITARD,* YAHSOU DELMAS,† NADÈGE PELLETIER,‡ THIERRY DEFRANCE,‡ JEAN-FRANÇOIS MOREAU,* PIERRE MERVILLE*† & JULIE DÉCHANET-MERVILLE* **UMR-CNRS 5540, Université Bordeaux 2, Bordeaux, France, †Department of Nephrology and Hemodialysis, CHU Bordeaux, Bordeaux, France and ‡INSERM U404, Lyon, France*

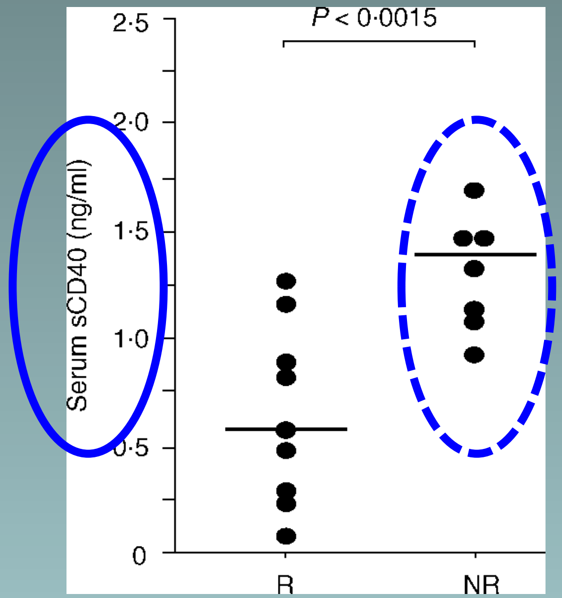


Figure 6. Serum sCD40 levels in chronic haemodialysed patients in the course of Hepatitis B vaccination and correlation to their vaccinal response status. Two groups of haemodialysed patients were set up according to their response to hepatitis B vaccination. Responsive patients (R, $n = 9$) presented >10 IU/l of anti-HBs IgG one month after last vaccine injection whereas Non-responsive patients (NR, $n = 8$) presented <10 IU/l. sCD40 values of each patients correspond to the mean of the four sCD40 values obtained during the vaccination. Lines represent the median values of sCD40 for all the patients of each group. *$P < 0{\cdot}0015$ determined using a Mann–Whitney test.

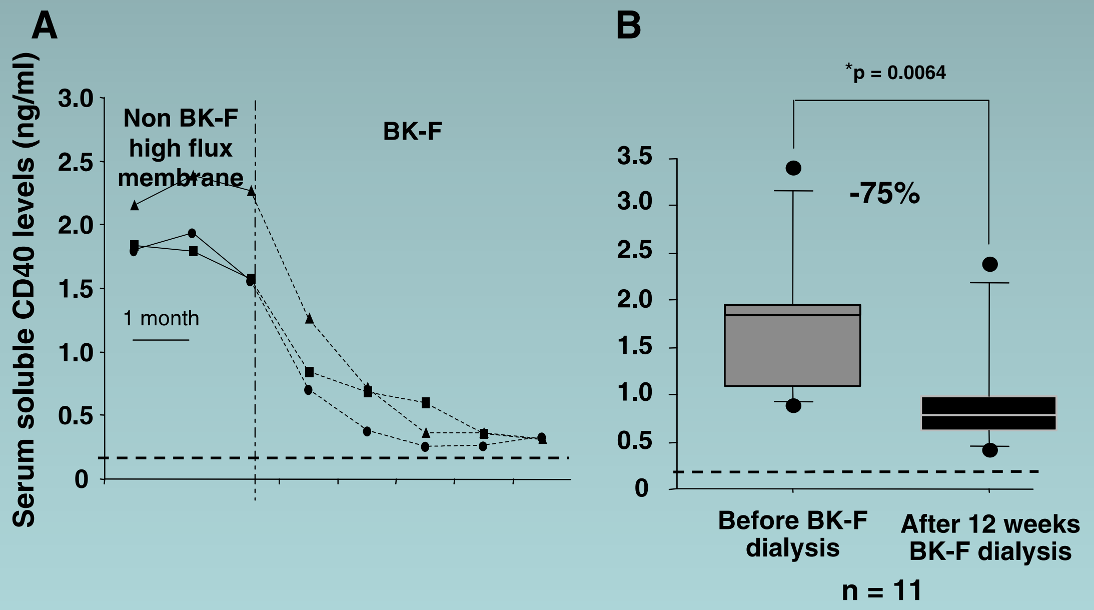


Fig. 3. Longitudinal follow-up of sCD40 levels in patients dialysed on non-PMMA high-flux membranes or BK-2.1F membranes. (**A**) Soluble CD40 concentrations were measured monthly by ELISA in the serum of three patients dialysed on non-PMMA high-flux membrane and who were then switched to BK-2.1F membrane. Blood samples were taken after the dialysis session. Dotted line represents mean level of sCD40 in healthy subjects. (**B**) Levels of sCD40 in the serum of 11 patients before and after 12 weeks of dialysis on BK-2.1F membrane. *Non-parametric Wilcoxon *U*-test.

C.Contin et al. Immunology 2003 (110) 131-140

PMMA e vaccinazione HBV

Archives of Renal Diseases and Management
Peertechz

Ralli Chiara[1], Imperiali Patrizio[1], Gabbrilelli Claudio[2], Conti Paolo[2], Lombardi Marco[3], Sidoti Antonino[4], Capitanini Alessandro[5], Piluso Adriano[5], Tekle Kiros Seble[6], Duranti Diletta[7] and Duranti Ennio[1*]

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Keywords: Hemodialysis; Immune dysfunctions;

Research Article

Hemodialysis with Polymethylmethacrylate Restores the Response to Hepatitis B Vaccination in Chronic Dialysis Patients: Hypothesized Mechanism of Action

Abstract

Patients undergoing hemodialysis often present with a reduced response to anti-hepatitis B virus (anti-HBV) vaccination. The soluble form of CD40 (sCD40) is elevated in hemodialysis patients and this has been shown to correlate with lack of response to anti-HBV vaccination. Due to its high molecular weight, conventional dialyzers cannot clear sCD40. Previous studies have demonstrated, that dialysis membranes in polymethylmethacrylate (PMMA) can reduce the levels of sCD40. We have studied the effect of dialysis with PMMA membranes in patients who were non-responders to anti-HBV vaccination after a complete cycle of vaccinations. Interestingly, we found that significantly more patients in the PMMA group were able to mount a response to vaccination, compared to the control group (P = 0.04).

SciMedCentral
Journal of Chronic Diseases and Management

Short Notes

Adsorptive Hemodialysis by Polymethylmethacrylate (PMMA): an update on Hepatitis B Vaccination Immunoresponce

Ennio Duranti and Diletta Duranti*
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doi: 10.1093/ndtplus/sfq033
NDT PLUS Nephrology Dialysis Transplantation

Potential role of the soluble form of CD40 in deficient immunological function of dialysis patients: new findings of its amelioration using polymethylmethacrylate (PMMA) membrane

Cécile Contin-Bordes[1,2], Adeline Lacraz[3] and Valérie de Précigout[3]

	Total	Controls	PMMA
Patients	32	15	17
Average age	73 ± 12	78 ± 9	67 ± 15
Gender (M/F)	18/14	8/7	10/7
Dry weight (kg)	74 ± 21	75 ± 17	73 ± 26
Dialysis vintage (months)	75 ± 58	97 ± 67	54 ± 48
Type of dialysis	Bicarbonate	Bicarbonate	Bicarbonate
Membrane	Polysulfone-polyamide	Polysulfone-polyamide	PMMA series BK-F
HBsAb (UI/L)	< 10	< 10	< 10

	Controls	PMMA	X^2 test
Patients	15	17	
Patients with HBsAb > 10	2	8	
Percentage of responders	**13 %**	**47 %**	**0.04**

PMMA e Immuno protezione

Blood
Purification

Review

Blood Purif
DOI: 10.1159/000529971

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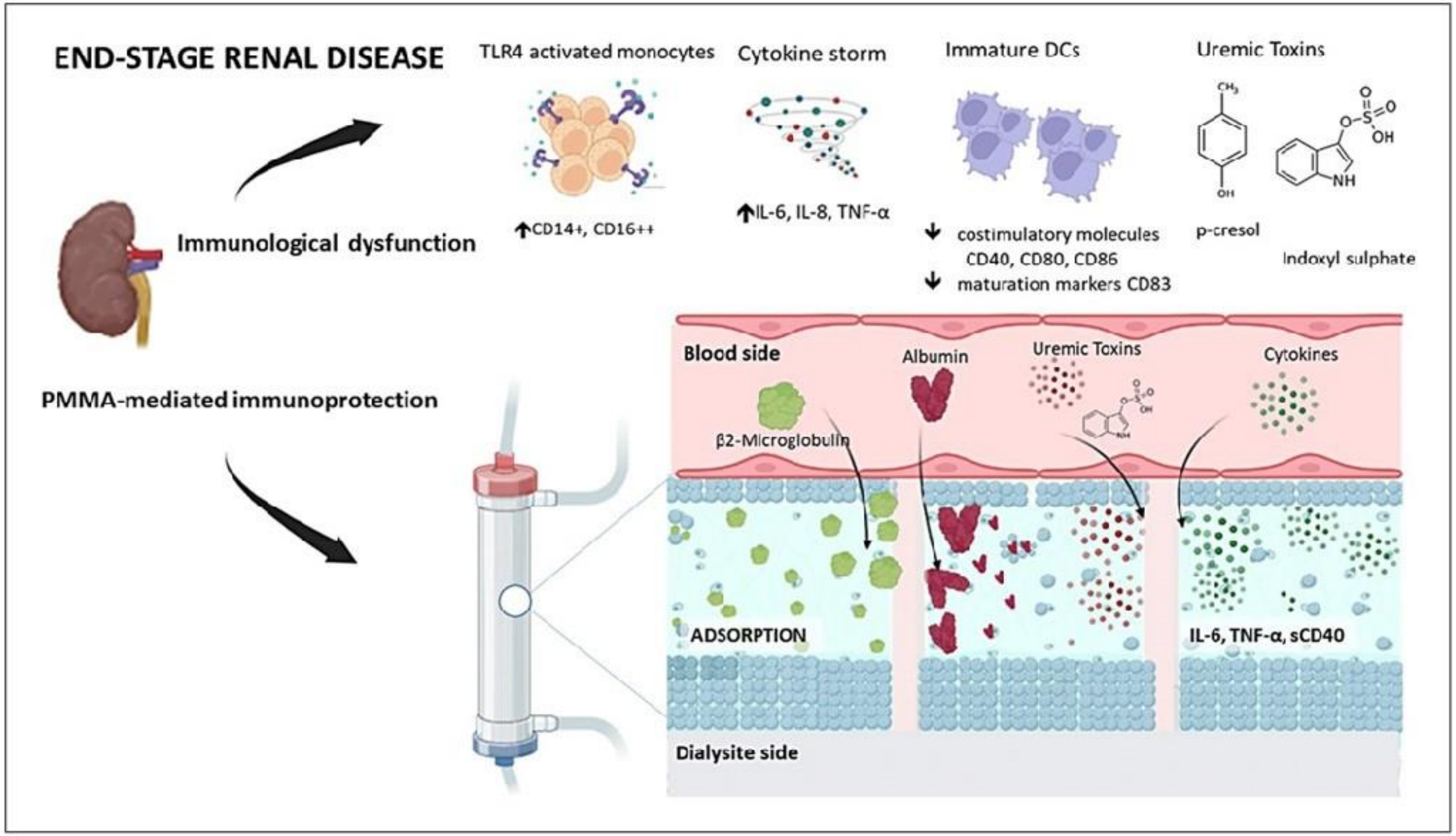
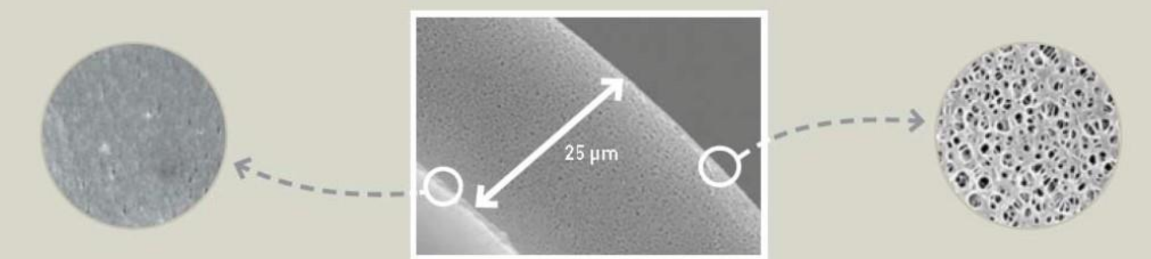
Accepted: February 7, 2023
Published online: April 19, 2023

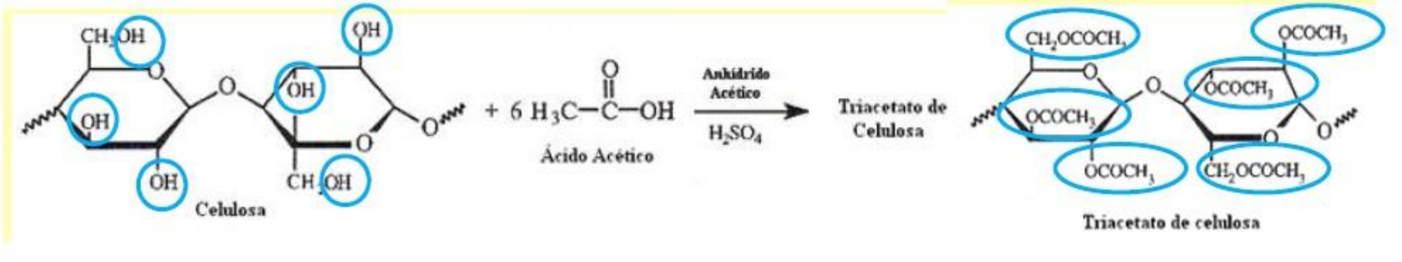
Enhancing Immune Protection in Hemodialysis Patients: Role of the Polymethyl Methacrylate Membrane

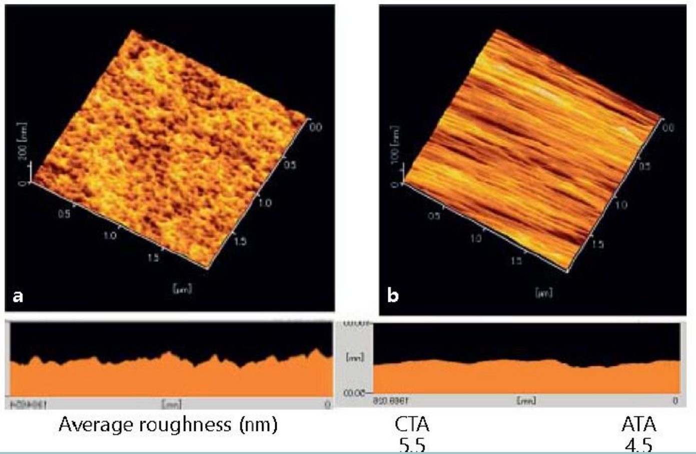
Rossana Franzin[a] Alessandra Stasi[a] Gianvito Caggiano[a]
Elena Squiccimarro[a] Vincenzo Losappio[b] Marco Fiorentino[a] Carlo Alfieri[c]
Giovanni Stallone[b] Loreto Gesualdo[a] Giuseppe Castellano[c]



Membrane e ipersensibilità: Triacetato di cellulose asimmetrico *ATA*







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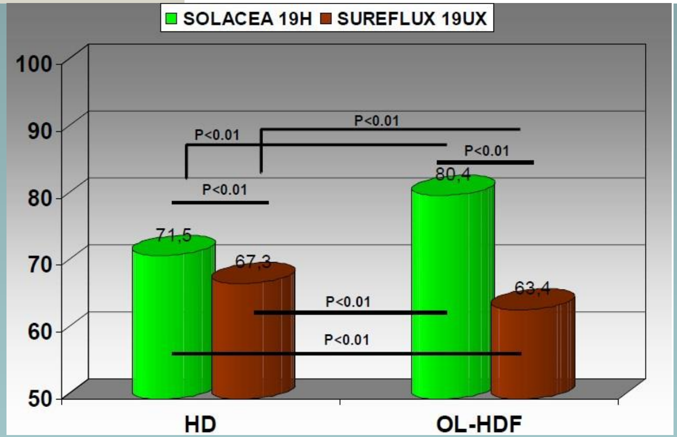

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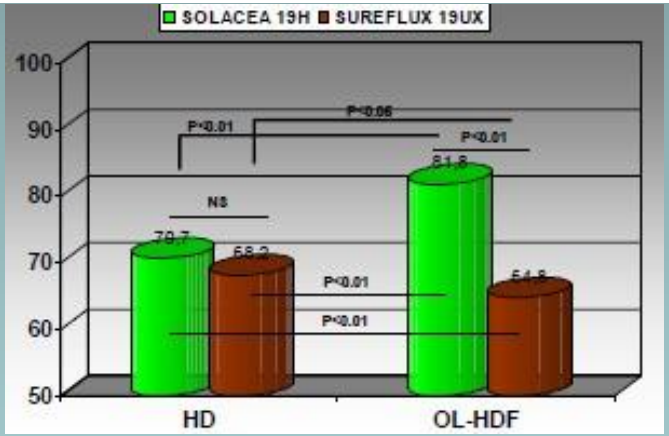

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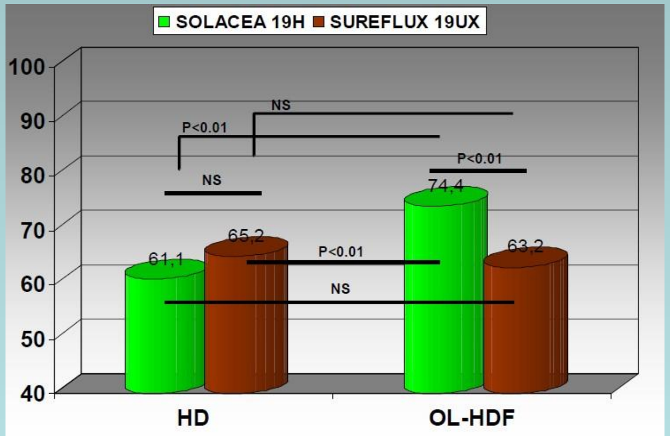

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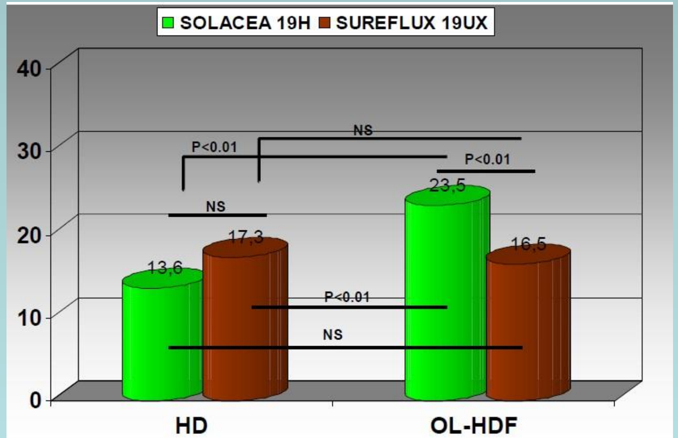

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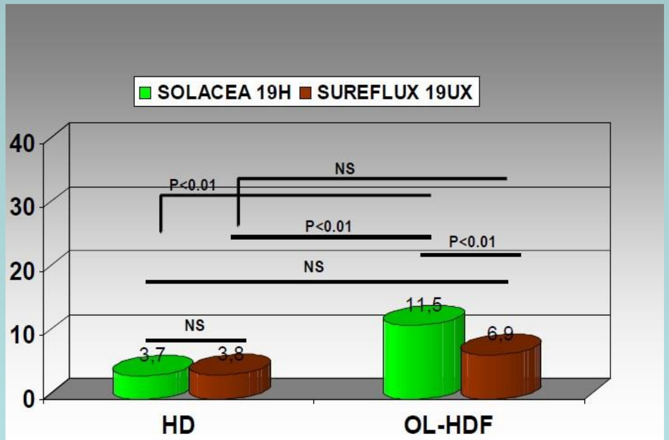


Maduell et al. Nefrologia 3, 2017

The Netherlands Journal of Medicine

REVIEW

Acute reactions to polysulfone/polyethersulfone dialysers: literature review and management

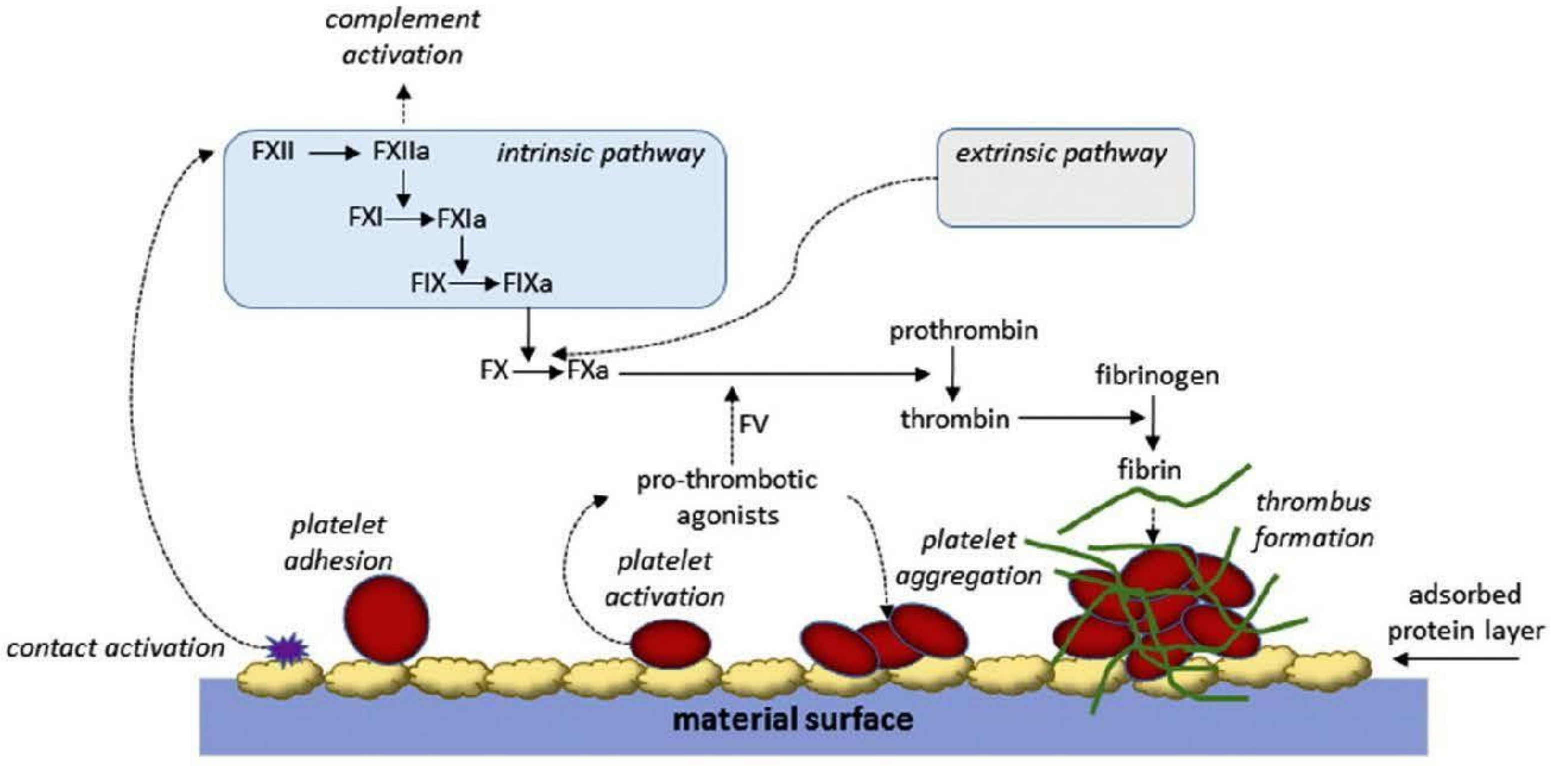
W.H. Boer[1*], Y. Liem[2], E. de Beus[1], A.C. Abrahams[1]

J ANUA R Y 2 0 17, V OL . 7 5 , N O. 1

Table 1. *Summary of cases of acute dialyser reactions reported in the literature between 2003 and 2016*

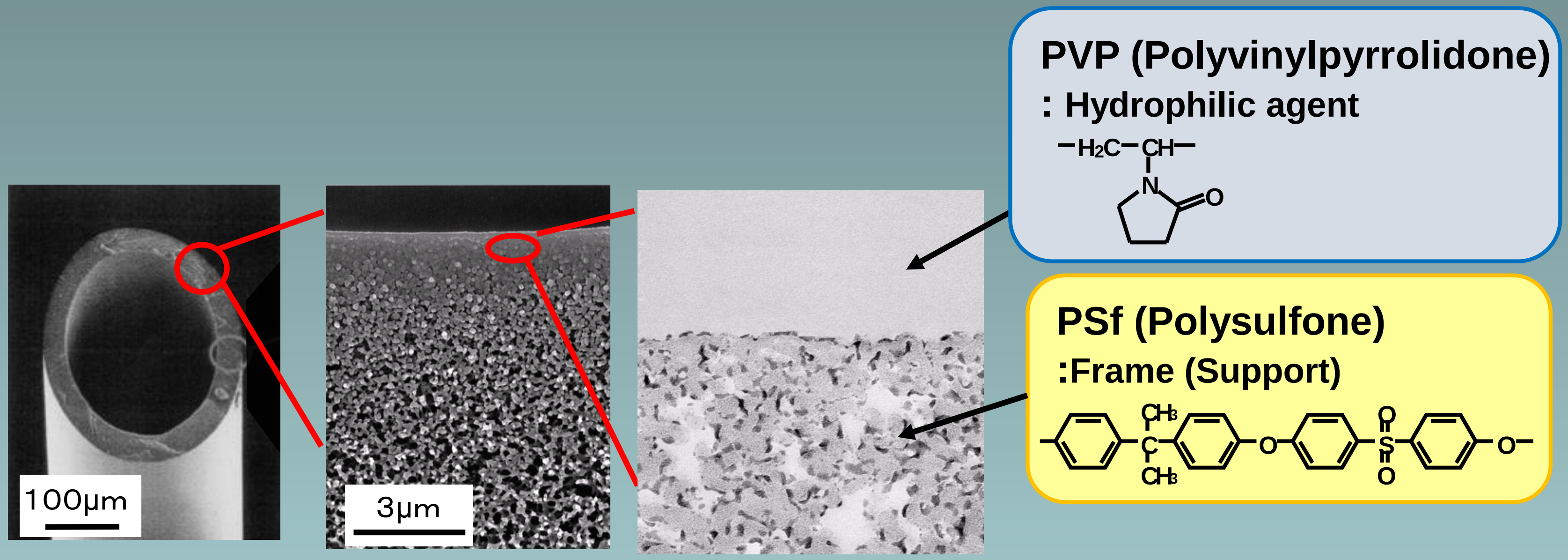
Case	Gender /age	Dialyser causing symptoms	Duration of exposure to dialyser	Alternative dialyser symptomatic	Alternative dialyser asymptomatic	Reference
1	F / 57	F8-HPS [a] (Fresenius) *polysulfone*	21 months	BS 1.8U (Toray) *polysulfone*/1st exposure	FB-170U (Nipro) *cellulose triacetate*	Ohashi (2003)[14]
2	F / 75	Optiflux F160Nre (Fresenius) *polysulfone*	1st exposure	Hemoflow F70Nre (Fresenius) *polysulfone*/1st exposure	Nephral ST400 [b] (Gambro) *PAN*	Yang (2005)[19]
3	M / 45	F10-HPS [c] (Fresenius) *polysulfone*	~3 years	-	Brand & type unspecified *Cellulose triacetate* [d]	Arenas (2006)[4]
4	M / 51	F8 [e] (Fresenius) *polysulfone*	1st exposure	F10-HPS (Fresenius) *polysulfone*/1st exposure 180 MHP (Idemsa) *polyethersulfone*/ 1st exposure	Brand & type unspecified *Cellulose triacetate* [f]	Arenas (2007)[5]
5	F / 67	F-10-HPS [g] (Fresenius) *polysulfone*	1st exposure	-	Dicea 170 (Baxter) *cellulose diacetate*	Huang (2007)[9]
6	F / 84	FX-80 (Fresenius) *polysulfone*	1st exposure, ongoing for 1 month	Polyflux 17L (Gambro) [h] *Poly(aryl)ethersulfone*/ 1st exposure BLS 512 (Bellco-Sorin) *polyethersulfone*/ 1st exposure FX-10 (Fresenius) *polysulfone*/1st exposure	Nephral ST 500 (Gambro) *PAN*	Coentrão (2010)[7]
7	M / 77	Diacap PS15-PVP (Bbraun) *polysulfone*	10th & 11th session	FX-80 (Fresenius) *polysulfone*/1st exposure	Dicea 110G (Baxter) *cellulose diacetate*	Bacelar Marques (2011)[6]
8	F / 51	Optiflux F180NR (Fresenius) *polysulfone*	~2 years	-	CT-190G (Baxter) *cellulose triacetate* AM-BIO-100 (Asahi) *alkyl ether polymer grafted cellulose*	Posadas (2011)[15]
9	F / 77	Toraylight CS-1.3U (Toray) *polysulfone*	2.3 months	-	FB-130Pβ (Nipro) *cellulose triacetate*	Konishi (2011)[10]
10	M / 79	PS-1.3UW (Fresenius) *polysulfone*	1 month	-	Filtryzer BG-1.3PQ (Toray) *PMMA*	
11	F / 75	Toraylight CS-1.3U (Toray) *polysulfone*	7.4 months	-	Filtryzer BG-1.3PQ (Toray) *PMMA*	
12	F / 64	PS-1.3UW (Fresenius) *polysulfone*	1st exposure	-	FB-130Pβ (Nipro) *cellulose triacetate*	
13	F / 63	Toraylight CS-1.3U (Toray) *polysulfone*	2-3 weeks	-	Filtryzer BG-1.3PQ (Toray) *PMMA*	
14	M / 65	PS-1.6UW (Fresenius) *polysulfone*	5 weeks	-	Filtryzer BG-1.6PQ (Toray) *PMMA*	
15	M / 76	PS-1.3UW (Fresenius) *polysulfone*	5 weeks	FDX-150GW (Nikkiso) [i] *PEPA*/1st exposure	Filtryzer BG-1.3PQ (Toray) *PMMA* FB-150Pβ (Nipro) *cellulose triacetate*	
16	F / 34	Pureflux Purema (Nipro) *polyethersulfone*	1st and 2nd exposure	-	Prismaflex (Gambro) *Poly(aryl)ethersulfone*	Heegard (2013)[8]
17	M / 86	Polyflux 21H (~210H?) (Gambro) *Poly(aryl)ethersulfone*	4-6 weeks	FX-80M (Fresenius) *polysulfone*/1st exposure BG 2.1U (Toray) *PMMA*/1st exposure	Nephral [j] (Gambro) *PAN* Sureflux 19UX (Nipro) *cellulose triacetate*	Martin-Navarro (2014)[11]
18	F / 75	FX-60 [k] (Fresenius) *polysulfone*	2nd exposure	-	F6-HPS (Fresenius) *polysulfon*[e]	Shu (2014)[17]
19	M / 70	Rexeed [l] (Asahi) *polysulfone*	1st exposure	-	Patient died	Tsang (2014)[18]
20	M / 58	Polyflux 210H [m] (Gambro) *Poly(aryl)ethersulfone*	1st exposure	Elisio 21H (Nipro) *polyethersulfone*/ 1st exposure	Sureflux 21UX (Nipro) *cellulose triacetate*	Sanchez-Villanueva (2014)[16]
21	F / 80	Helixone FX-80 (Fresenius) *polysulfone*	~4 months and 1 month later	Polyflux 210H (Gambro) *Poly(aryl)ethersulfone*/ 3rd exposure Elisio 21H (Nipro) *polyethersulfone*/after 8 months exposure	Sureflux 21UX (Nipro) *cellulose triacetate*	
22	M / 75	Helixone FX-100 Classix (Fresenius) *polysulfone*	1st exposure	FX-100 (Fresenius) *polysulfone*/1st exposure	Sureflux 21UX (Nipro) *cellulose triacetate*	
23	M / 48	Helixone FX-100 Classix (Fresenius) *polysulfone*	1st exposure	-	Lost to follow-up	
24	M / 70	Helixone FX-100 Classix (Fresenius) *polysulfone*	1st exposure [n]	-	Sureflux 21UX (Nipro) *cellulose triacetate*	
25	F / 83	Helixone FX-100 Classix (Fresenius) *polysulfone*	1st exposure	-	Sureflux 21UX *cellulose triacetate*	
26	M / 75	Polyflux H (Gambro) *Poly(aryl)thersulfone*	1st exposure [o]	-	Nephral ST (Gambro) *PAN*	Mazarakis (2014)[12]
27	M / 79	Optiflux F160 NR (Fresenius) *polysulfone*	2 years	-	Exceltra 150 (Baxter) *cellulose triacetate*	Mukaya (2015)[13]
28	M / 90	F8-HPS (Fresenius) *Polysulfone*	1st exposure	Polyflux 17L (Gambro) *Poly(aryl)ethersulfone*/ 1st exposure	Nephral ST 500 (Gambro) *PAN*	Cerqueira (2015)[2]
29	M / 69	Cordiax FX 600 [p] (Fresenius) *polysulfone*	32 months / 1st exposure	Polyflux 17L (Gambro) *Poly(aryl)ethersulfone*/ 1st exposure	Nephral ST 500 (Gambro) *PAN*	
30	F / 58	Optiflux F160Nre [q] (Fresenius) *polysulfon*	1st exposure	-	CT-110G (Baxter) *cellulose triacetate*	Sayeed (2015)[3]
31	M / 74	F8-HPS (Fresenius) *polysulfone*	7 months	-	Sureflux 150-L (Nipro) *cellulose triacetate*	Current paper
32	M / 69	F8-HPS (Fresenius) *polysulfone*	3rd exposure	-	Sureflux 150-L (Nipro) *cellulose triacetate*	

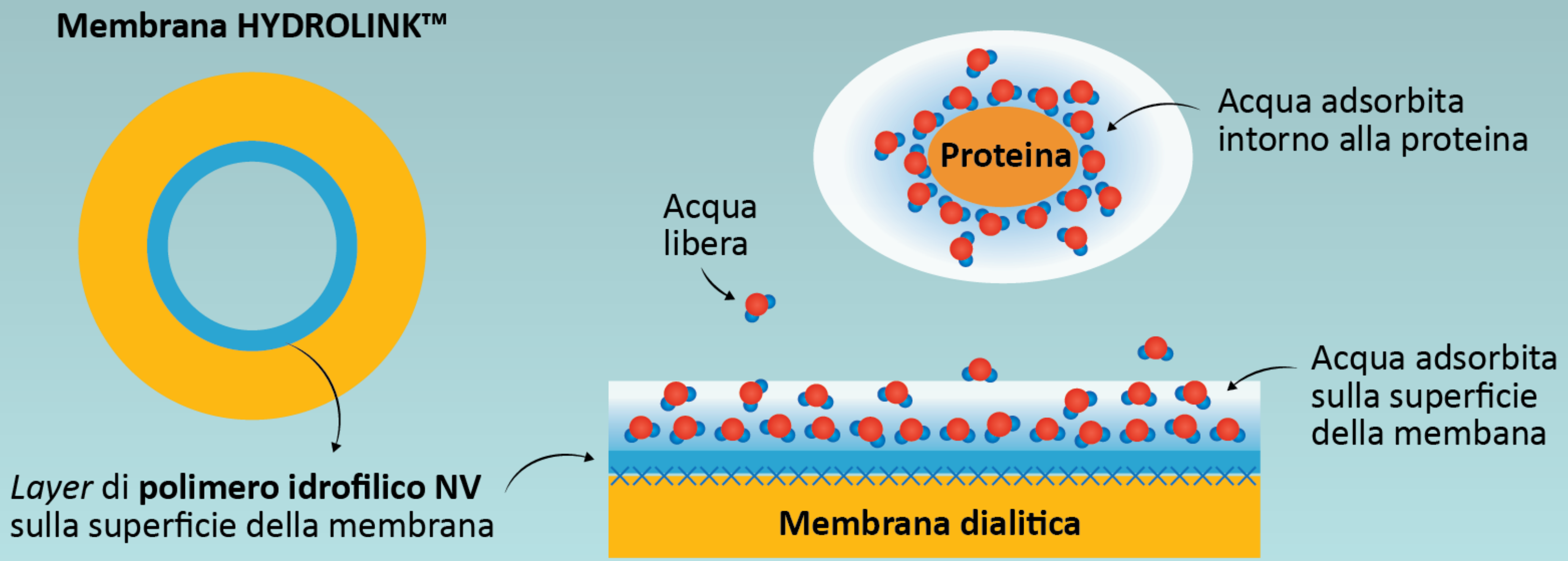
Membrane: Biocompatibilità



Membranes **2021**, 11, 239.

Membrane e anticoagulazione: *Hydrolink*





- La membrana HYDROLINK, propone una tecnologia innovativa che adotta **l'acqua adsorbita sulla superficie della membrana come unica interfaccia con il sangue**, evitando l'adesione delle proteine e la stimolazione delle piastrine.

- Questa membrana ha la caratteristica di promuovere l'afflusso di acqua dal comparto ematico sulla sua superficie, formando uno strato acquoso continuo che può migliorare l'emocompatibilità del contatto membrana/sangue.

Nuove membrane: Helyxone®*hydro*

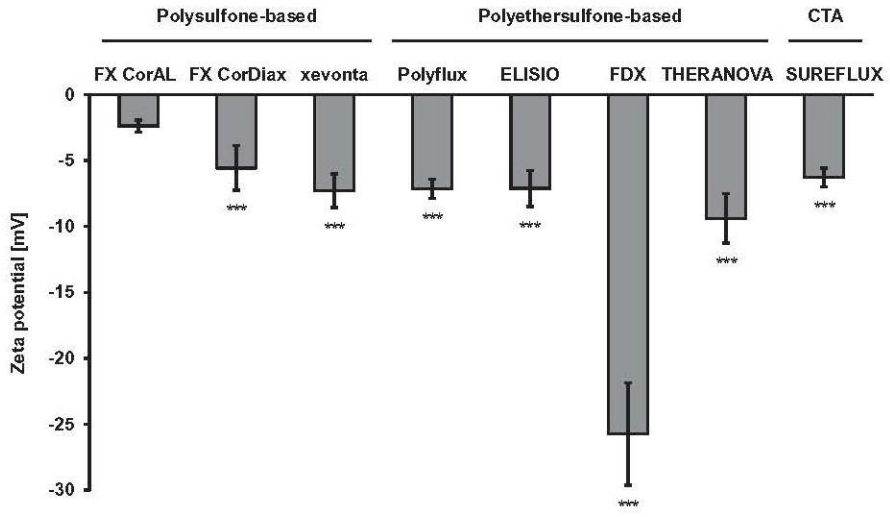
MAIN TEXT ARTICLE

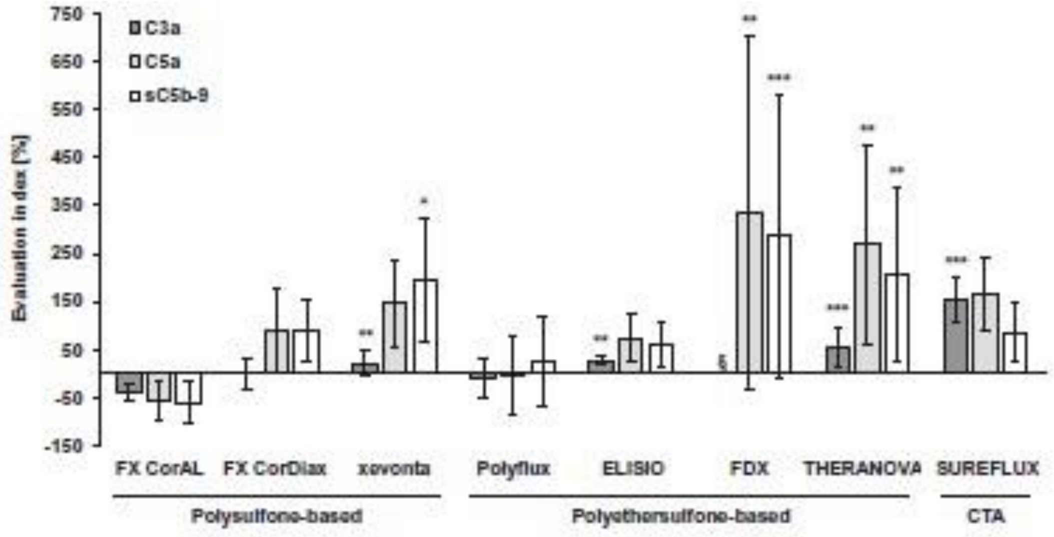
Artificial Organs | WILEY

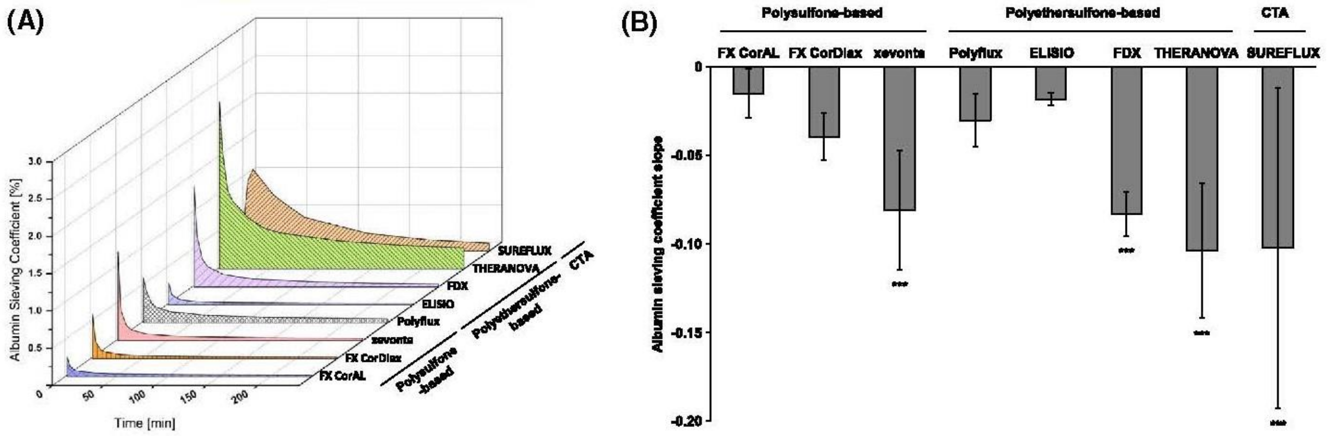
Complement activation by dialysis membranes and its association with secondary membrane formation and surface charge

Pascal Melchior[1] | Ansgar Erlenkötter[2] | Adam M. Zawada[1] | Dirk Delinski[1] | Christian Schall[3] | Manuela Stauss-Grabo[4] | James P. Kennedy[1]

Artificial Organs. 2021;45:770–778. DOI: 10.1111/aor.13887







Nuove membrane: Helyxone®*hydro*

Original Investigation

Kidney360

Performance and Hemocompatibility of a Novel Polysulfone Dialyzer: A Randomized Controlled Trial

Götz Ehlerding,[1] Ansgar Erlenkötter,[2] Adelheid Gauly,[3] Bettina Griesshaber,[3] James Kennedy,[2] Lena Rauber,[2] Wolfgang Ries,[4] Hans Schmidt-Gürtler,[1] Manuela Stauss-Grabo,[3] Stephan Wagner,[5] Adam M. Zawada,[2] Sebastian Zschätzsch,[5] and Manuela Kempkes-Koch[6]

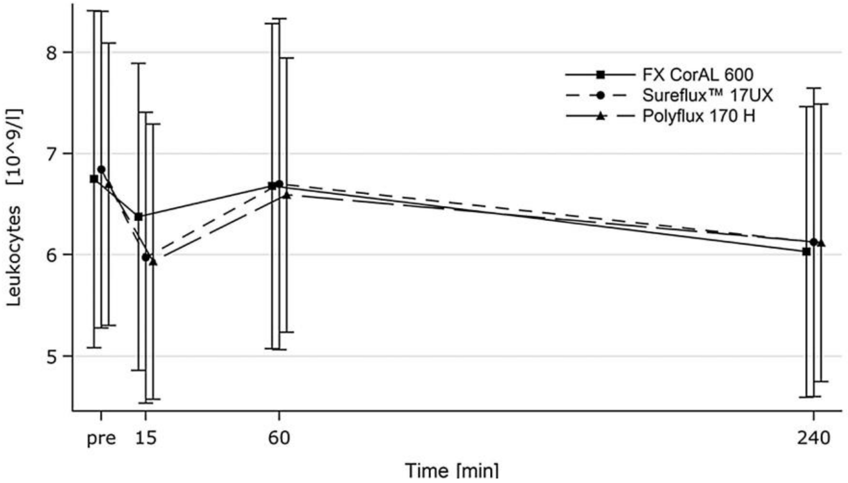
KIDNEY360 2: 937–947, 2021. doi: https://doi.org/10.34067/KID.0000302021

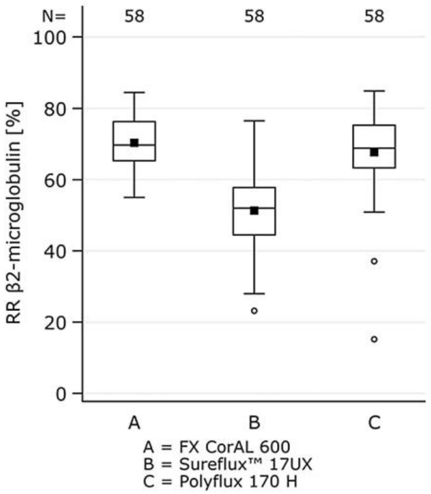
ORIGINAL ARTICLE

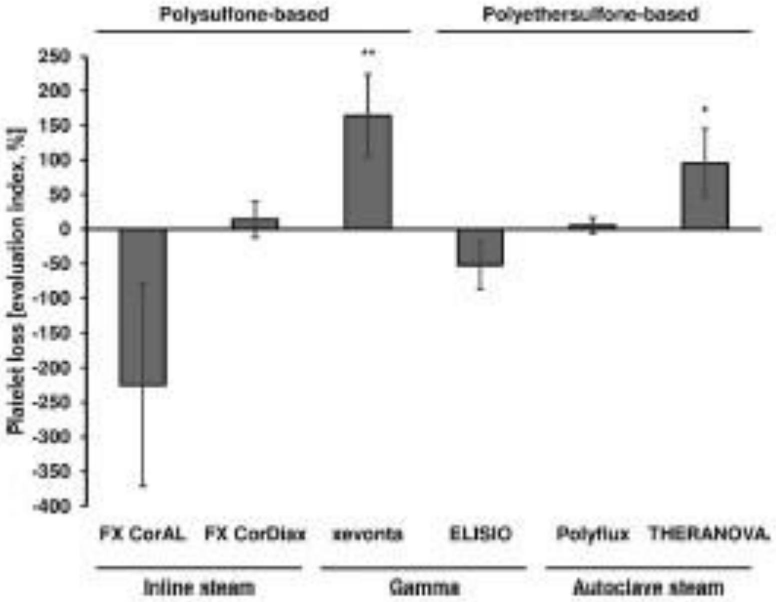
Polyvinylpyrrolidone in hemodialysis membranes: Impact on platelet loss during hemodialysis

Adam M. Zawada[1] | Pascal Melchior[1] | Ansgar Erlenkötter[2] | Dirk Delinski[1] | Manuela Stauss-Grabo[3] | James P. Kennedy[1]

Hemodialysis International. 2021;1–9. wileyonlinelibrary.com/journal/hdi



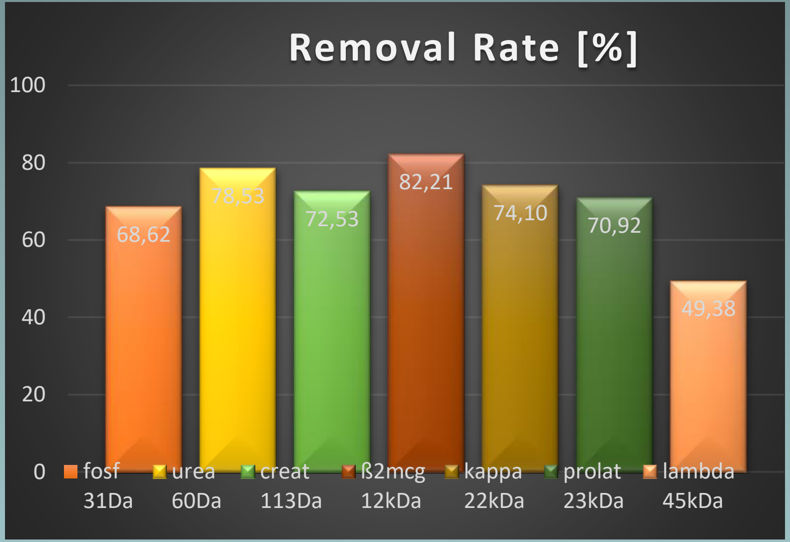


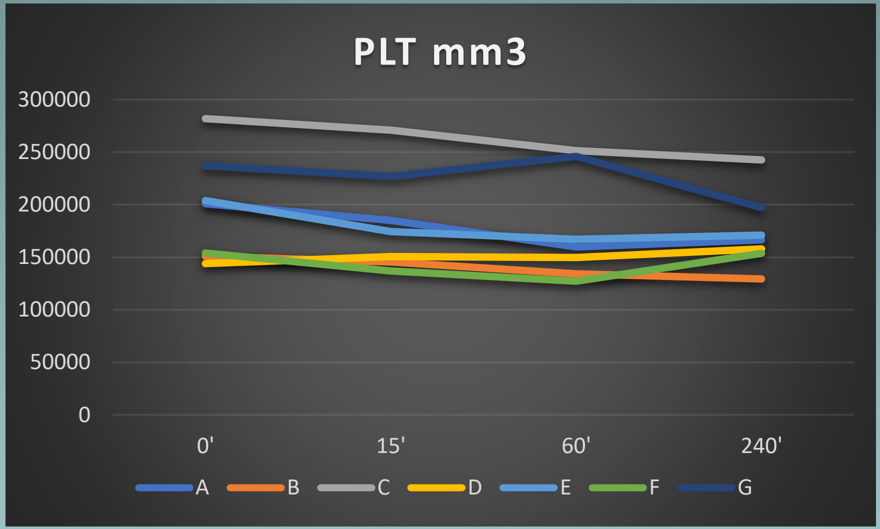


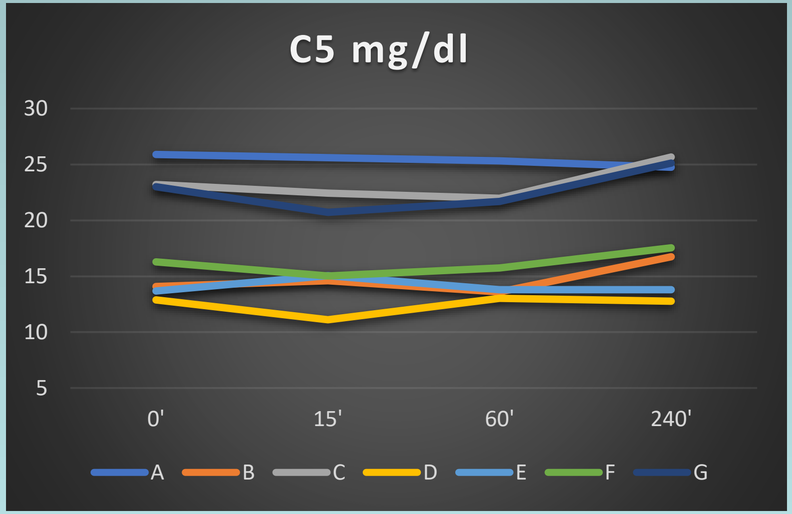
Nuove membrane: Helyxone®*hydro*

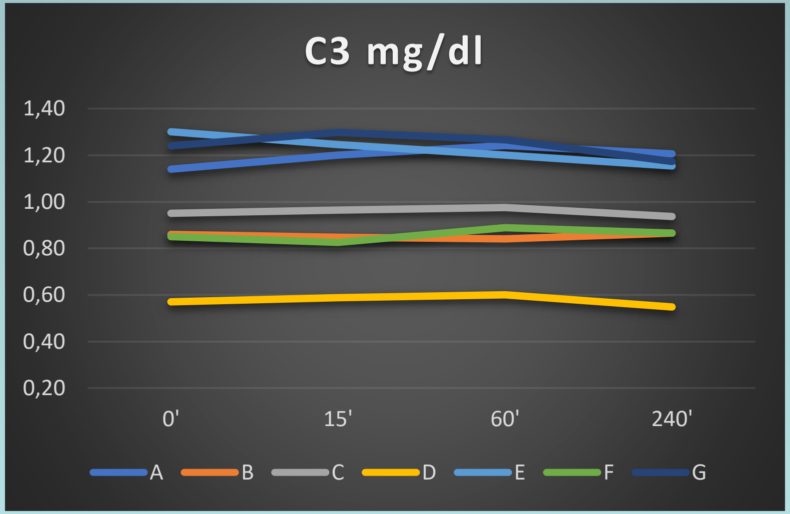
Data dialisi (aa)	6,57 ± 4,16
Età (aa)	66,57 ± 12,22
Sesso	6M 1F
Qb ml/m	325,71±25,07
Qd ml/m	500
Tecnica	HDF
Hb IN	11,27 ± 0,83
Hct IN	34,09 ± 2,58
Minuti dialisi	235,71±11,33
V conv (L)	23 ± 1,41
Uf (L)	3,06 ± 0,83
Accesso vascolare	F.A-V

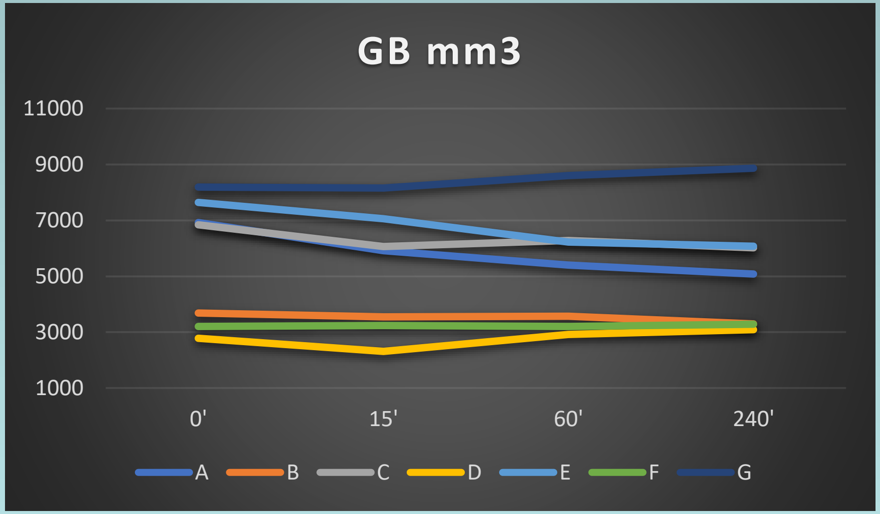
FXcoral 800: 2,0 m² polysulfone/polyvinylpyrrolidone











S. Bove, L. Bregoli: dati preliminari

Nuove membrane: Clearum™ :(*pes*)

Received: 20 March 2021 | Revised: 19 April 2021 | Accepted: 2 May 2021
DOI: 10.1111/aor.13993

MAIN TEXT ARTICLE

Artificial Organs WILEY

Efficacy and safety of the Clearum dialyzer

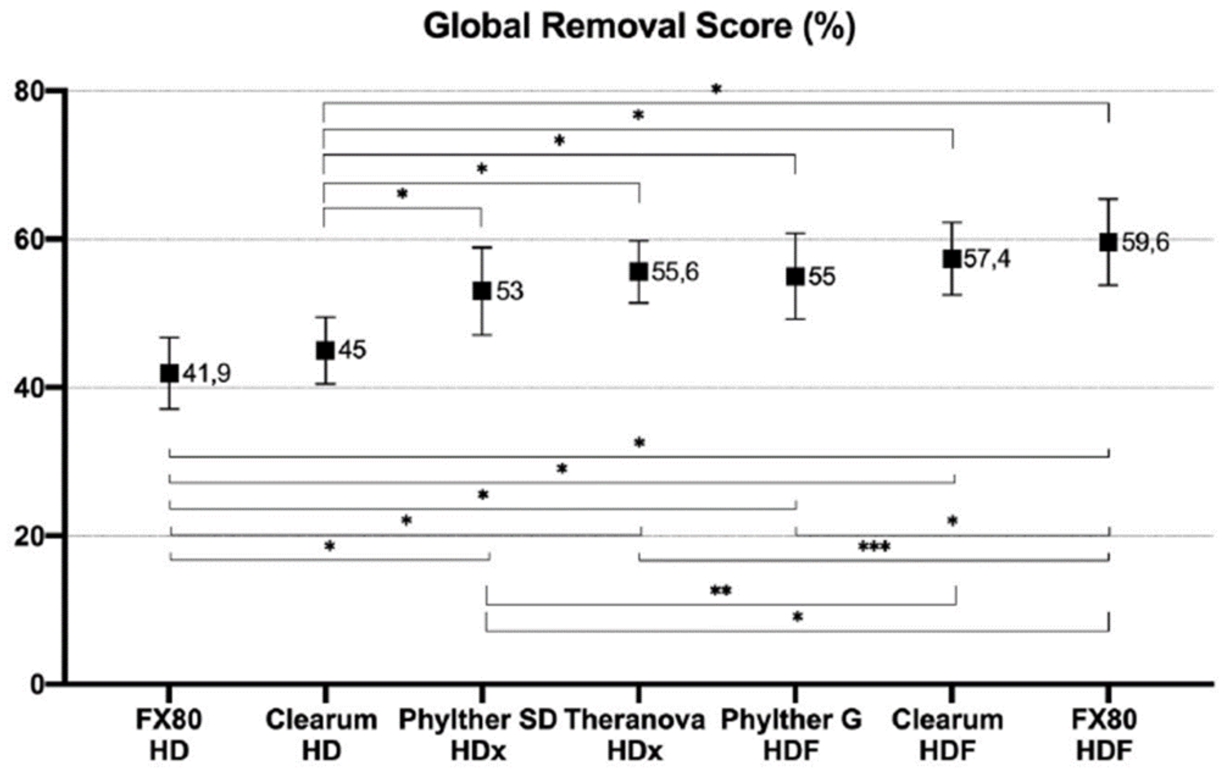
Francisco Maduell[1,2] | José Jesús Broseta[1] | Diana Rodríguez-Espinosa[1] | Evelyn Hermida-Lama[1] | Elena Cuadrado-Payán[1] | Lida María Rodas[1] | Miquel Gómez[1] | Marta Arias-Guillén[1] | Néstor Fontseré[1] | Manel Vera[1] | Nayra Rico[3]

Artificial Organs. 2021;45:1195–1201. wileyonlinelibrary.com/journal/aor

We used the global removal score (GRS) to evaluate the efficacy of a global removal dialyzer including molecules from 60 to 41 000 Da and considering albumin RR as negative values, calculated with the following formula[10]:

$$((\text{Urea}_{RR} + \beta_2 - m_{RR} + \text{myoglobin}_{RR} + \text{prolactin}_{RR} + \alpha_1 - \text{microglobulin}_{RR} + \alpha_1 - \text{acid glycoprotein}_{RR} - \text{albumin}_{RR})/6).$$

Small Toxin	Urea (60 Da)
	Creatinine (113 Da)
Medium Toxin	β2 - Microglobulin (11,800 Da)
	Myglobin (17,200 Da)
	Prolactin (23,000 Da)
Large Toxin	a1 - Microglobulin (33,000 Da)
	a1 - Acid Glycoprotein (41,000 Da)
	Albumin in serum (66,000 Da)



…Online hemodiafiltration does not significantly increase the clearance of protein-bound azotemic toxin, for example p-cresol sulfate and indoxyl sulfate. Protein-bound solutes have been shown to be toxic to endothelial cells, and have been associated with increased risk of mortality in hemodialysis patients…

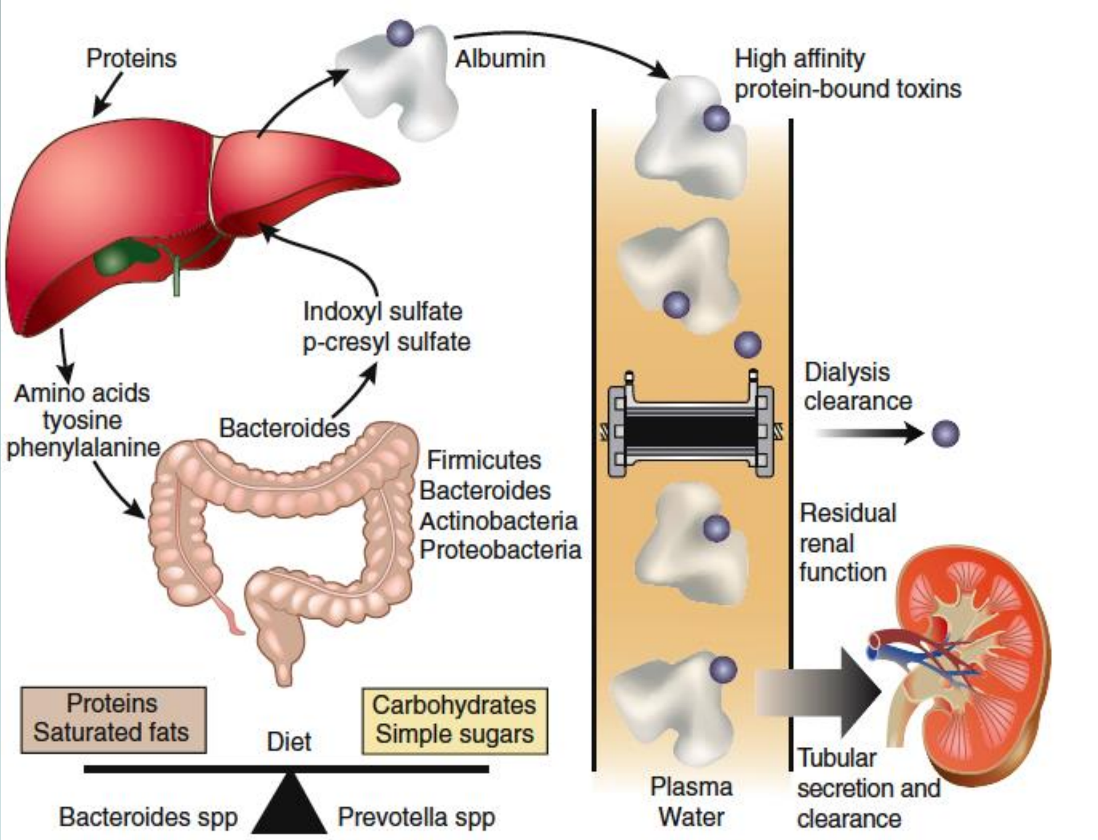


Figure 1 | Schematic diagram demonstrating the interrelationship between diet, gut microbiome, and the protein-bound azotemic solutes, indoxyl sulfate, and p-cresol sulfate. Although protein-bound solutes can be cleared with residual renal function, dialysis clearance is limited to the plasma-free solute.

Table 1 | Relative protein binding

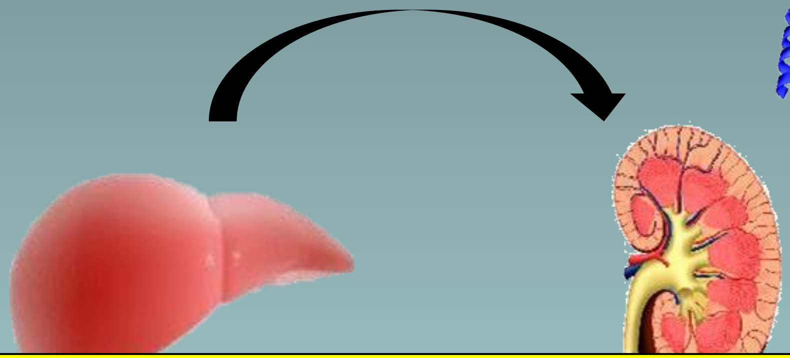
Azotemic compound	Relative protein binding (%)
p-Cresol glucuronide	< 40
Hippuric acid	40–50
Phenylacetylglutamine	40–50
Indoxyl glucuronide	50–60
Phenylacetic acid	60–70
Indole acetic acid	90–95
p-Cresol sulfate	90–95
Indoxyl sulfate	> 95
3-carboxy-4-methyl-5-propyl-2-furanpropanoic acid	> 95

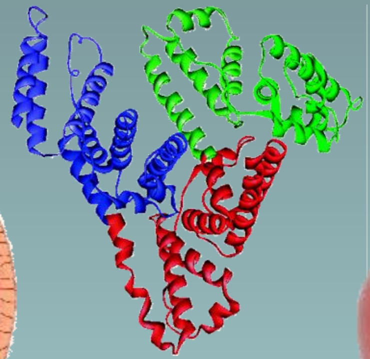
…This study emphasizes that current dialytic therapies can only clear freely available water-soluble solutes…

A. Davenport Kidney International (2017) 91, 1008–1010;

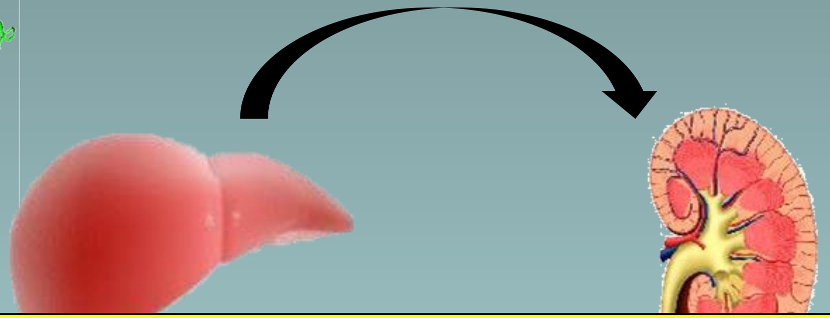
Ciclo dell'Albumina

Normal renal function





In CKD patients



In physiological conditions, the production of Albumin, equal to 9-12 g / day in adults, only commits 20-30% of the cells liver. The liver has, therefore, a large functional reserve that allows it to increase the synthesis of albumin of 3-4 times in case of need.

…..available data suggest a need for caution when use dialyzer containeng membranes that produces a loss > 20 gr/w of albumin whereas *<u>the use of dialyzers resulting in a weekley loss <12 gr/w appears to pose little risk to patient</u>* *(Ward et al. NDT 2018)*

bilirubin, fatty acids, Drugs, toxins…)

- Act as a free-radical scavenger

- to remove albumin without the antioxidant effect
- facilitate synthesis of new albumin with an antioxidant effect.

Krieter and Canaud-NDT (2003) 18:651-654
Terawaki et al. Th Aph Dia (2010) 14(5):465-471

Nuova classificazione membrane

Category	Ultrafiltration coefficient[a] (mL/h/mmHg/m^2)	β_2-microglobulin		Albumin		Reference
		Clearance[b] (mL/min)	Sieving coefficient[a]	Loss into dialysate[c] (g)	Sieving coefficient[a]	
Low flux	<12	<10	–	0	0	[9]
High flux	14–40	20–80	<0.7–0.8	<0.5	<0.01	[9]
Medium cut-off	40–60	>80	0.99	2–4	<0.01	[10]
Protein-leaking	>40	>80	0.9–1.0	2–6	0.01–0.03	[11]
High cut-off	40–60	–	1.0	9–23	<0.2	[12, 13]

[a] *In vitro.*
[b] For conventional haemodialysis with a blood flow rate of 300–400 mL/min. Includes contributions from diffusion, convection and adsorption.
[c] For 4 h of conventional haemodialysis.

M.Storr and R.Ward NDT (2018) 33:iii22 – iii27

Nuova Identificazione Membrane

THOUGHTS AND PROGRESS

Artificial Organs | WILEY

The Dialyzer Identification Code (DIC): A filter characteristics codification for dialyzer choice in renal replacement therapy

Federico Nalesso[1] | Leda Cattarin[1] | Lorenzo Arcangelo Calò[1] | Francesco Garzotto[2]

M Membrane Material/s
A Area (m^2)
K_O urea mass transfer coefficient*
K_{UF} (mL/h/mmHg)*
U_{CL} Urea Clearance (mL/min)*
$M{\cdot}MW_{CL}$ Middle MW Clearance** (mL/min)
$H{\cdot}MW_{CL}$ High MW Clearance*** (mL/min)
$\beta 2M_{SC}$ β2M Sieving Coefficient
$M{\cdot}MW_{SC}$ Middle MW Sieving Coefficient**
$H{\cdot}MW_{SC}$ High MW Sieving Coefficient***
MW·RO MW Retention Onset (Kda)
MW·CO MW Cut-Off (Kda)
$M{\cdot}MW_{RR}$ Middle MW Reduction Rate**
$H{\cdot}MW_{RR}$ High MW Reduction Rate***

$$RR(\%) = \left(1 - \frac{C_{Post}}{C_{Pre}}\right) \times 100$$

**SC QB=300 mL/min; QUF=0.2*QB (ISO8637); Kuf: HCT 32%, 37°C*
** KO ,Clearance (QB = 300 mL/min, QD = 500mL/min, QUF=0)*
***MW ≥ 17 KDa (the molecule used has to be specified for standardization)*
****MW ≥ 40 KDa (the molecule used has to be specified for standardization)*

Legend: SC Sieving Coefficient, RR Reduction Rate (%), MW Molecular Weight (KDa)

**MMW: Myoglobin (17.2 kDa)
***HMW : sFLC λ (50 kDa)

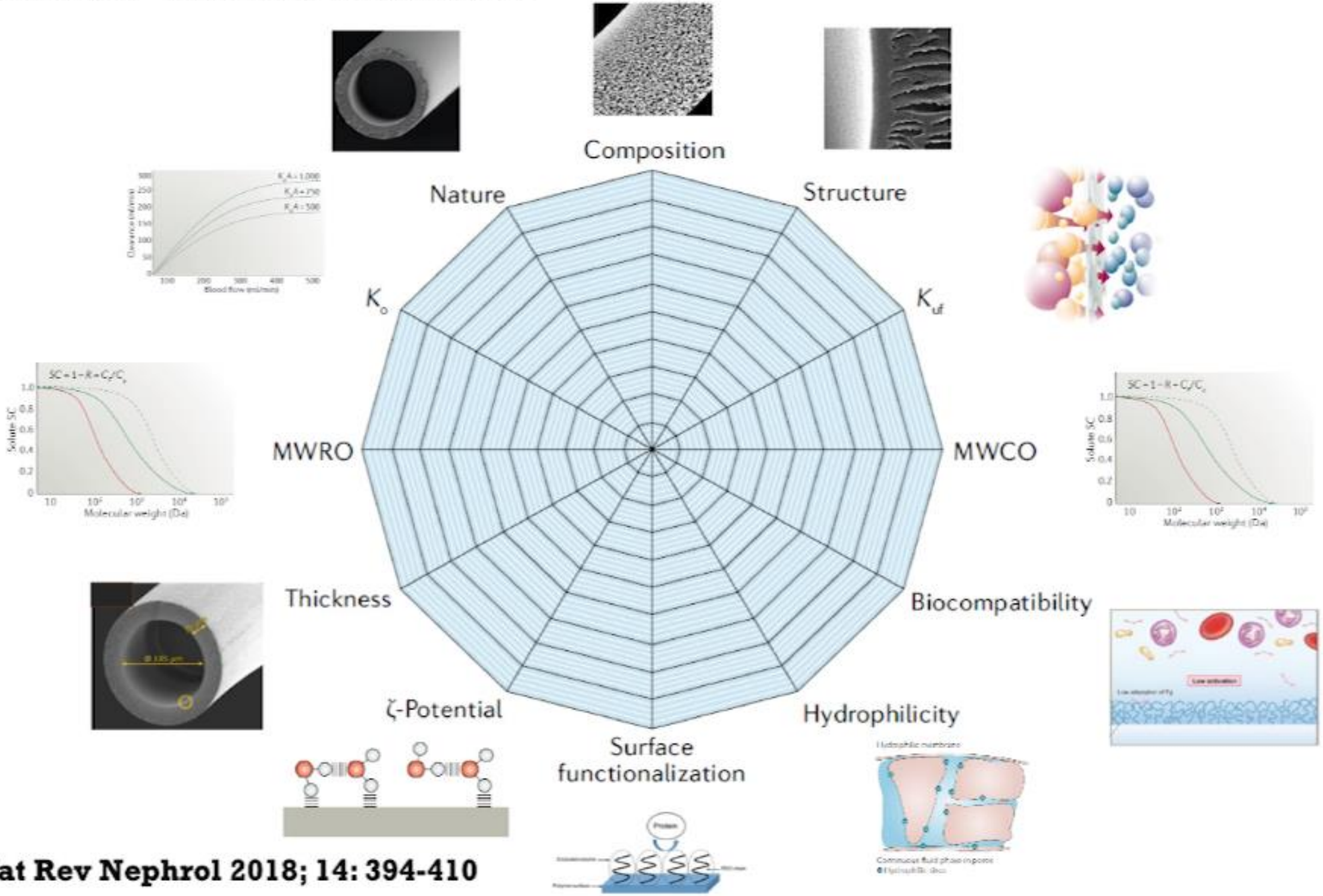
Membrane:
CTA cellulose triacetate
CUP Cuprophan
EVAL Ethylene-vinyl-alcohol copolymers
HYD Hydrolink
MCM modified cellulosic membranes
PA Polyamide
PAES Polyarylethersulfone
PAESp Polyarylethersulfone polyvinylpyrrolidone
PAN Polyacrylonitrile
PEPA Polyester polymer alloy (PES plus PAR poly-arylate)
PES Polyethersulfone
PMMA Polymethylm methacrylate
PSf Polysulfone

Therapy
HD Hemodyalisis
HDx Expanded HD
HFD HighFluxDialysis
HDF Hemodiafiltration
HF Hemofiltration
HFR HF with endogenous reinfusion
AFB Acetate Free Biofiltration

Main depuration process
DI Diffusion
CO Convection
AD Adsorption
IF Internal-Filtration
RO Replacement On-Line
RB Replacement Bag
RE Replacement Endogenous

Artificial Organs. 2020;44:1220–1223.

MULTIDIMENSIONAL CLASSIFICATION OF DIALYSIS MEMBRANES

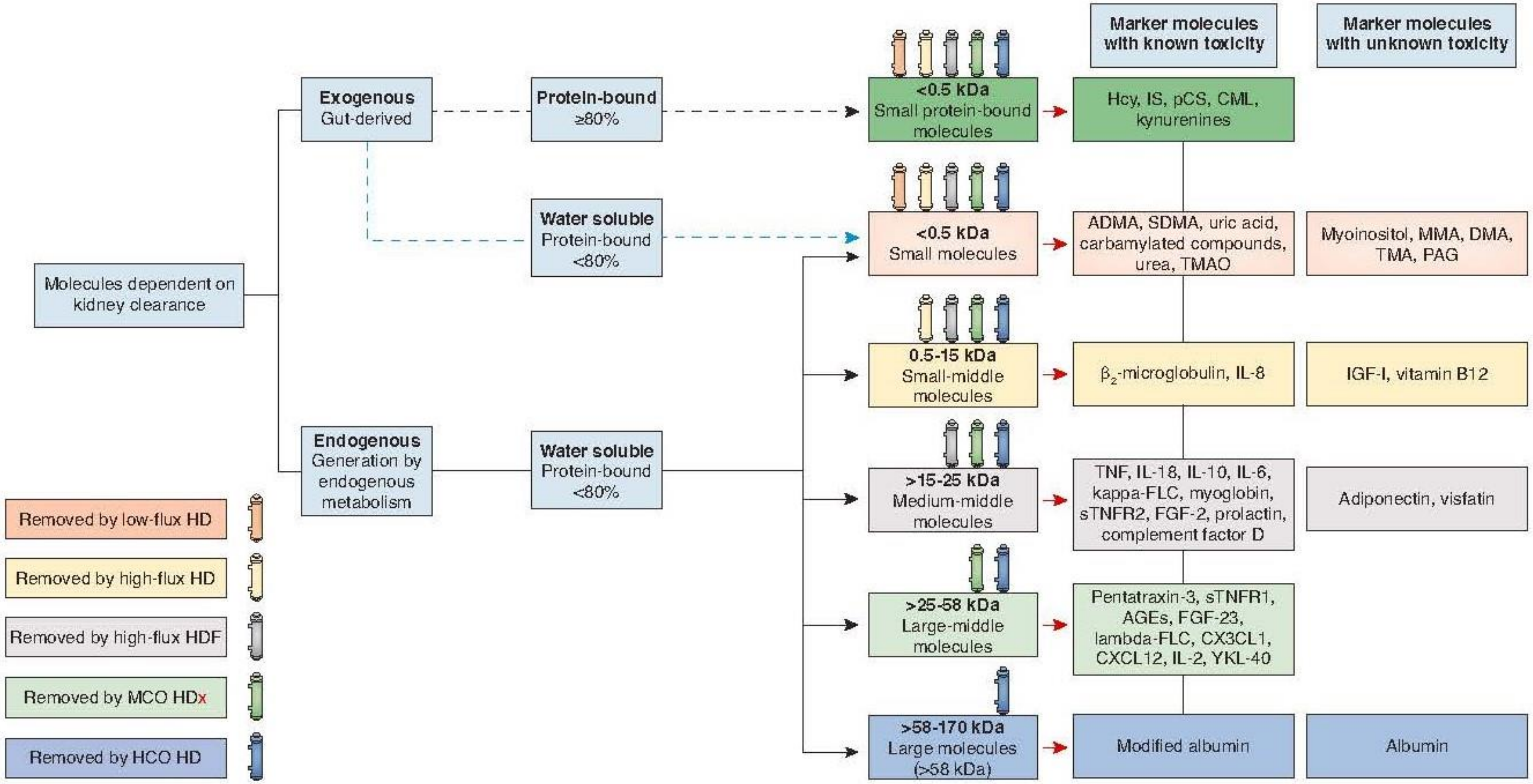


Ronco C, Clark WR. Nat Rev Nephrol 2018; 14: 394-410

REVIEW

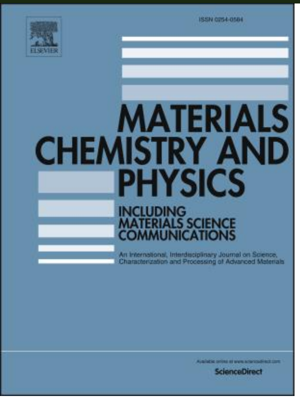
Classification of Uremic Toxins and Their Role in Kidney Failure

Mitchell H. Rosner,[1] Thiago Reis,[2,3] Faeq Husain-Syed,[4] Raymond Vanholder,[5] Colin Hutchison,[6,7] Peter Stenvinkel,[8] Peter J. Blankestijn,[9] Mario Cozzolino,[10] Laurent Juillard,[11,12] Kianoush Kashani,[13] Manish Kaushik,[14] Hideki Kawanishi,[15] Ziad Massy,[16,17] Tammy Lisa Sirich,[18,19] Li Zuo,[20] and Claudio Ronco,[21,22]



CJASN ePress. Published on October 4, 2021 as doi: 10.2215/CJN.02660221

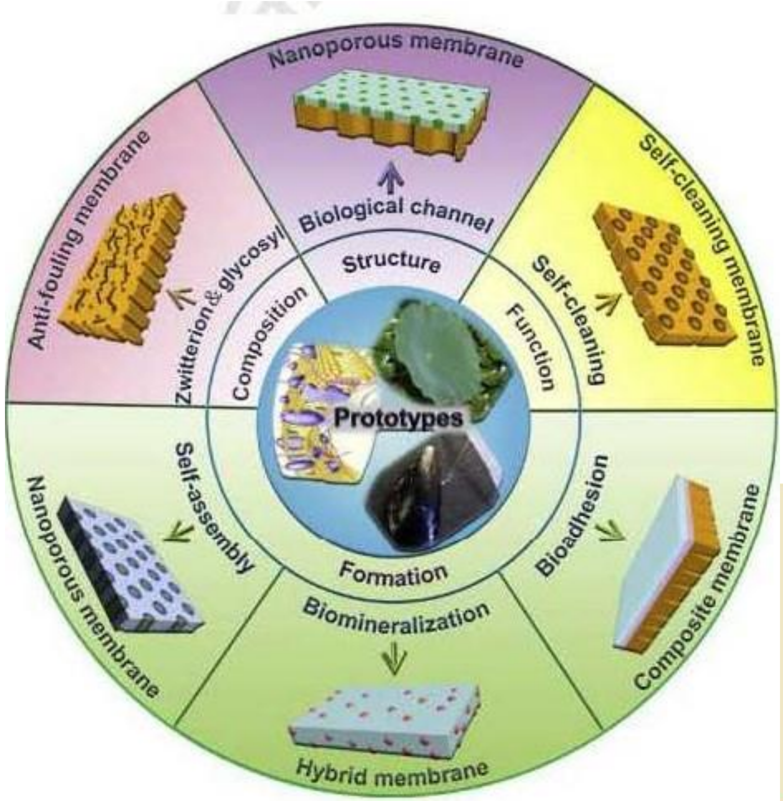
MEMBRANE IL FUTURO: *Bio-mimetiche e "Bio-ispirate"*

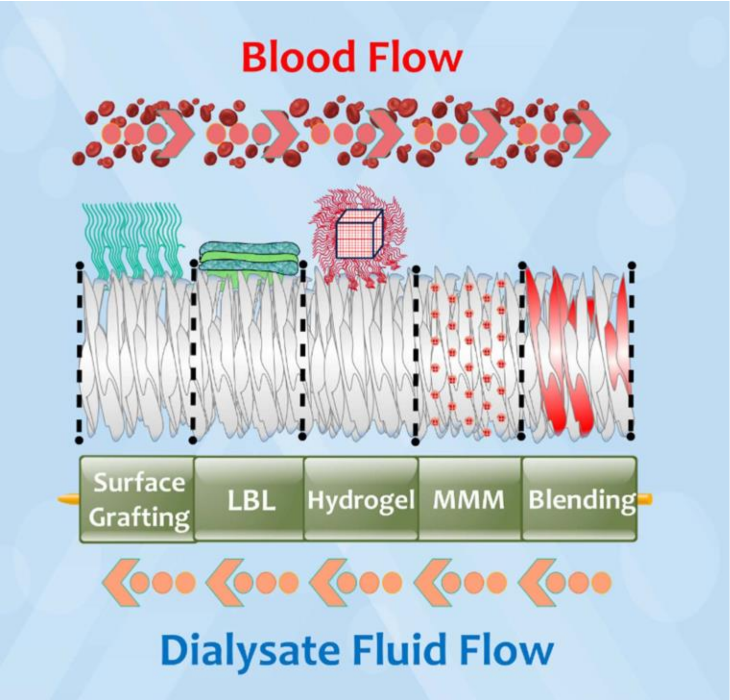


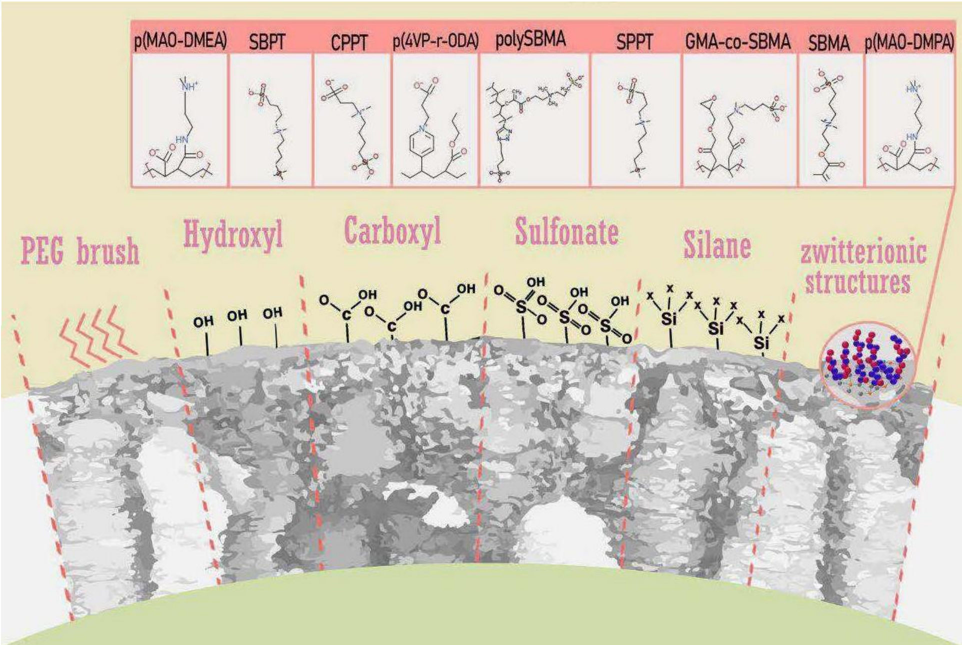
A critical review of recent advances in hemodialysis membranes hemocompatibility and guidelines for future development

Arash Mollahosseini, Amira Abdelrasoul, Ahmed Shoker

doi.org/10.1016/j.matchemphys.2020.122911







MEMBRANE IL FUTURO: *Mixed Matrix Membrane*

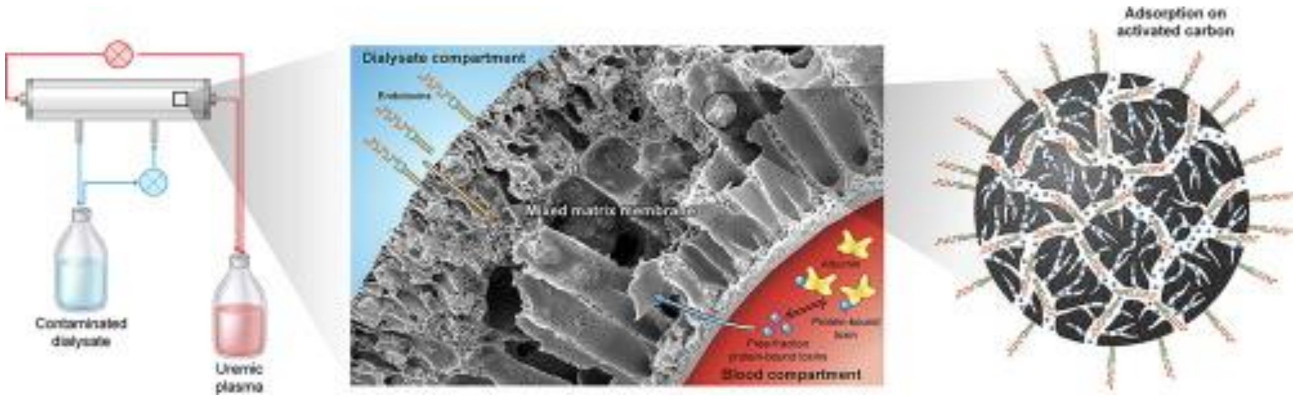
SCIENTIFIC REPORTS

OPEN

New low-flux mixed matrix membranes that offer superior removal of protein-bound toxins from human plasma

Received: 10 June 2016
Accepted: 07 September 2016
Published: 05 October 2016

Denys Pavlenko[1], Esmée van Geffen[1,2], Mies J. van Steenbergen[3], Griet Glorieux[4], Raymond Vanholder[4], Karin G. F. Gerritsen[2] & Dimitrios Stamatialis[1]



Acta Biomaterialia 90 (2019) 100–111

Contents lists available at ScienceDirect

Acta Biomaterialia

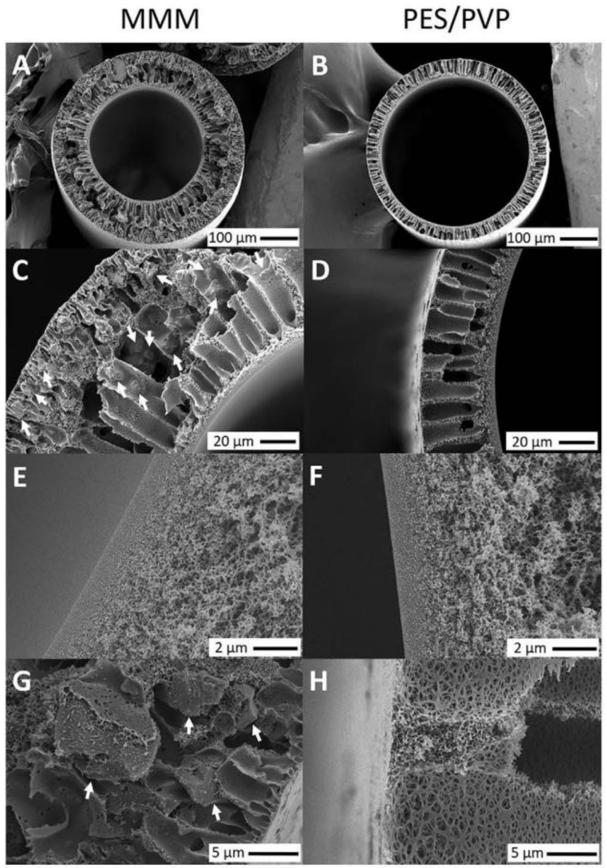
journal homepage: www.elsevier.com/locate/actabiomat

ELSEVIER

Full length article

In vitro assessment of mixed matrix hemodialysis membrane for achieving endotoxin-free dialysate combined with high removal of uremic toxins from human plasma

Ilaria Geremia [a], Ruchi Bansal [b], Dimitrios Stamatialis [a,*]



MEMBRANE IL FUTURO: *MMMs and Smart Hybrid Membrane*

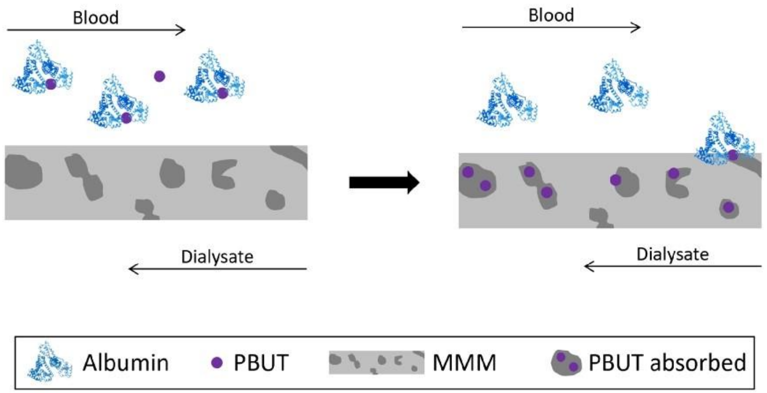
toxins MDPI

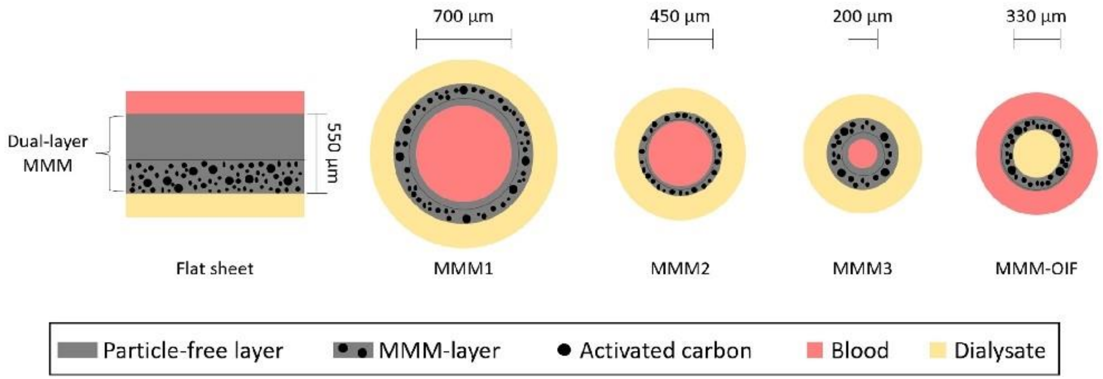
Review

Adsorption- and Displacement-Based Approaches for the Removal of Protein-Bound Uremic Toxins

Flávia S. C. Rodrigues [1] and Mónica Faria [1,2,*]

Toxins **2023**, *15*, 110. https://doi.org/10.3390/toxins15020110





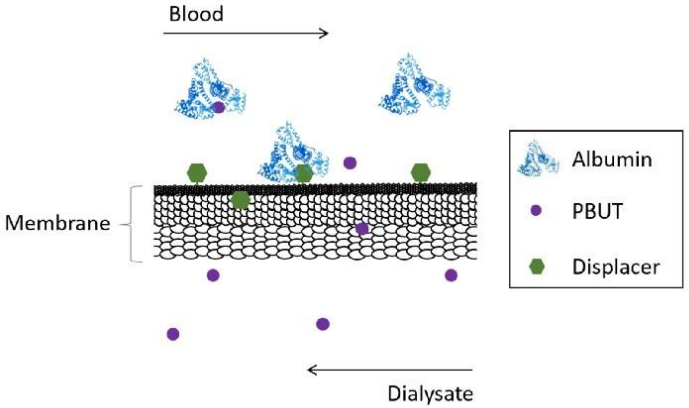
Journal of *Functional Biomaterials* MDPI

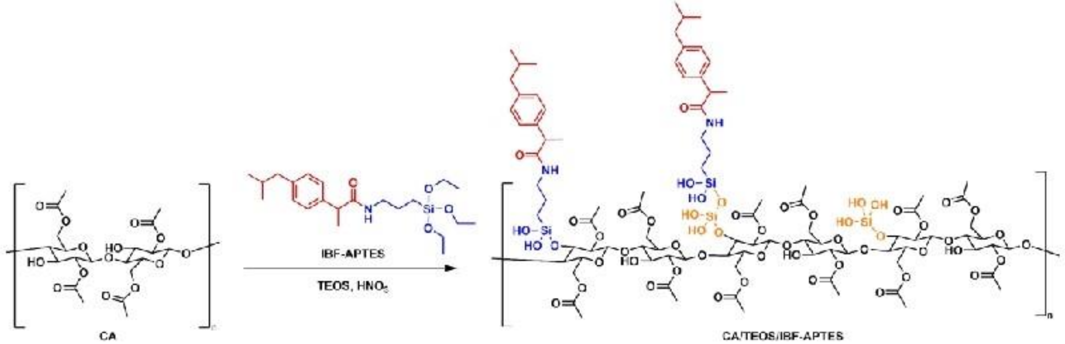
Communication

A Novel Strategy for Enhanced Sequestration of Protein-Bound Uremic Toxins Using Smart Hybrid Membranes

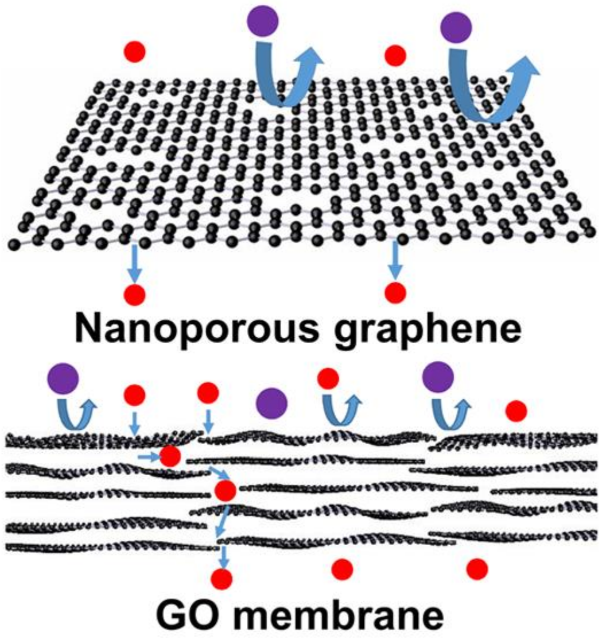
Madalena Lopes [1], Rita F. Pires [1], Mónica Faria [1,*] and Vasco D. B. Bonifácio [2,3,*]

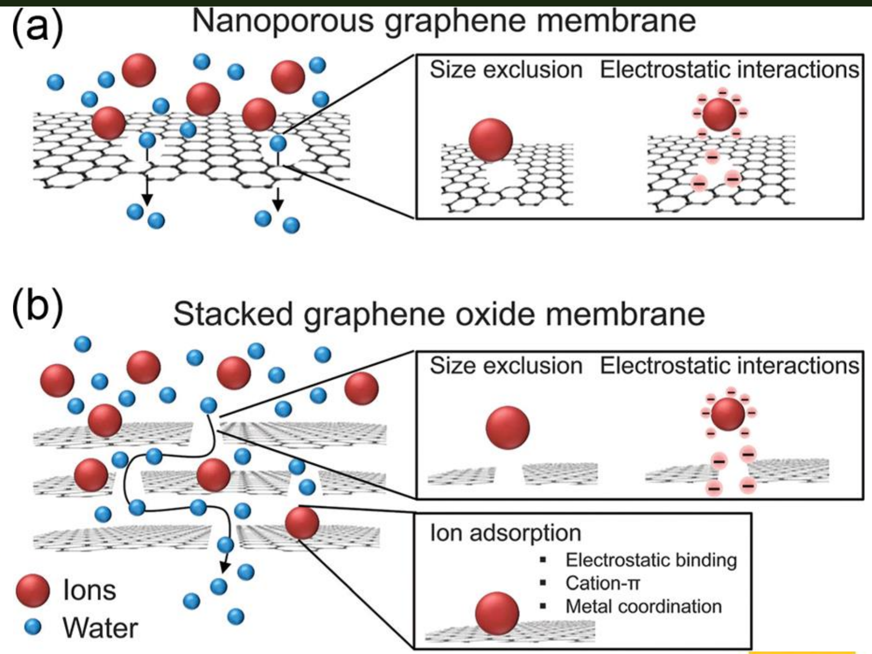
J. Funct. Biomater. **2023**, *14*, 138. https://doi.org/10.3390/jfb14030138

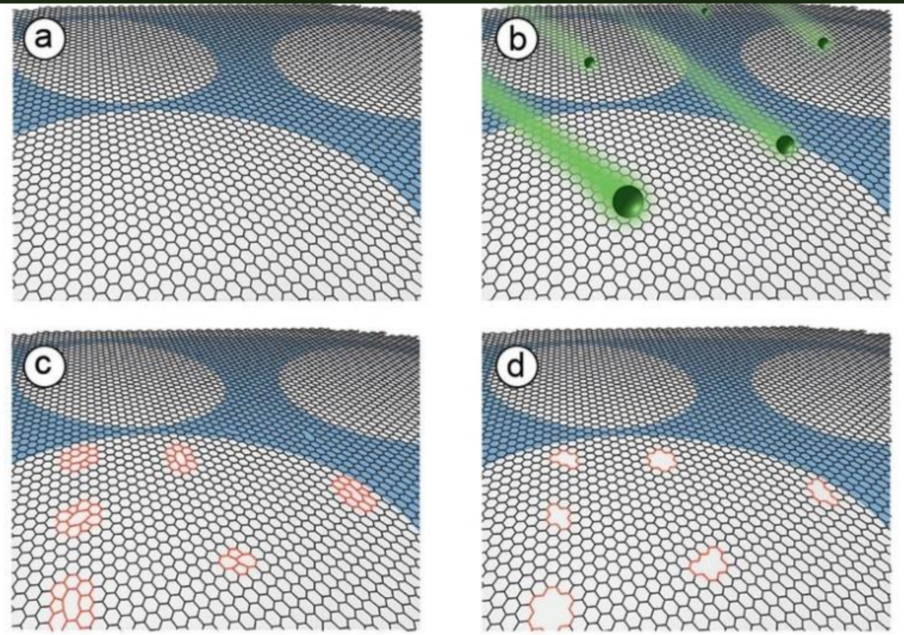




MEMBRANE IL FUTURO: *Graphene*







THE JOURNAL OF PHYSICAL CHEMISTRY Letters

Perspective

pubs.acs.org/JPCL

Graphene-Based Membranes for Molecular Separation

Liang Huang, Miao Zhang, Chun Li, and Gaoquan Shi*

Country Collaborative Innovation Center for Nanomaterial Science and Engineering, Department of Chemistry, Tsinghua University, Beijing 100084, People's Republic of China

MIT News
ON CAMPUS AND AROUND THE WORLD

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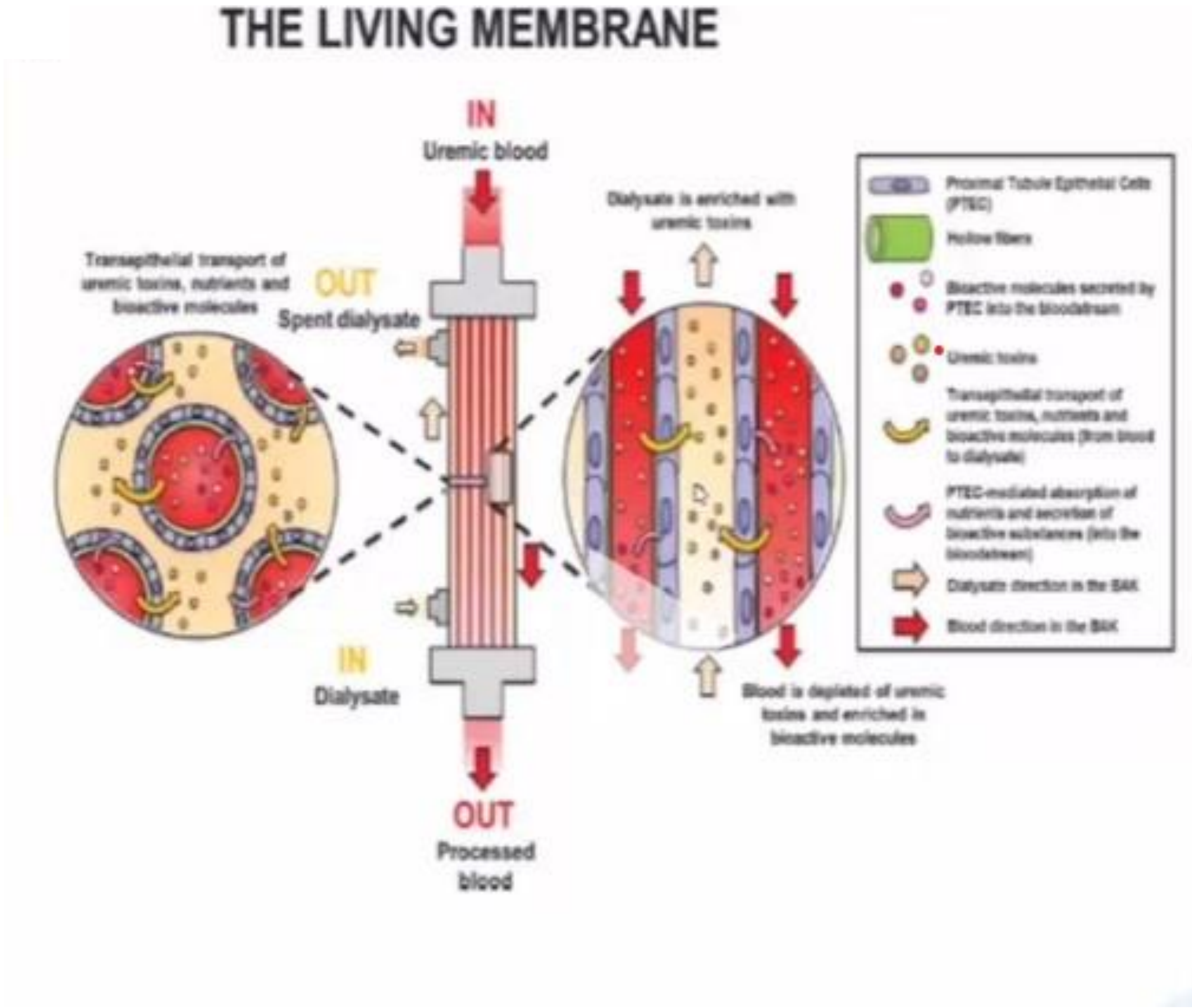
Scientists produce dialysis membrane made from graphene

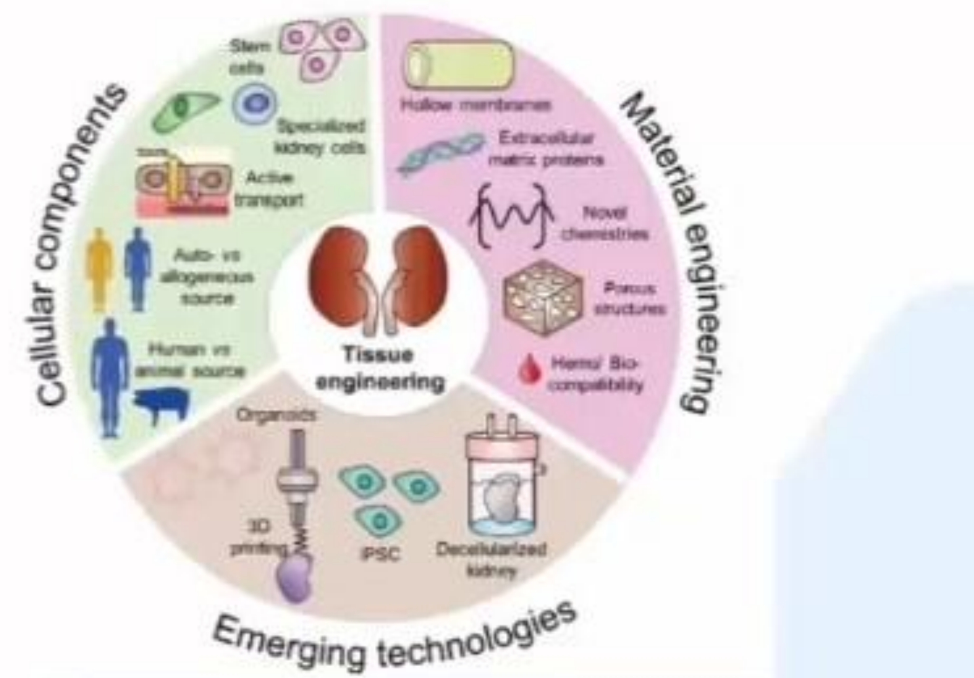
Material can filter nanometer-sized molecules at 10 to 100 times the rate of commercial membranes.

Jennifer Chu | MIT News Office
June 28, 2017

"Because graphene is so thin, diffusion across it will be extremely fast," Kidambi says. "A molecule doesn't have to do this tedious job of going through all these tortuous pores in a thick membrane before exiting the other side. Moving graphene into this regime of biological separation is very exciting."

MEMBRANE IL FUTURO: *The Living Membrane*

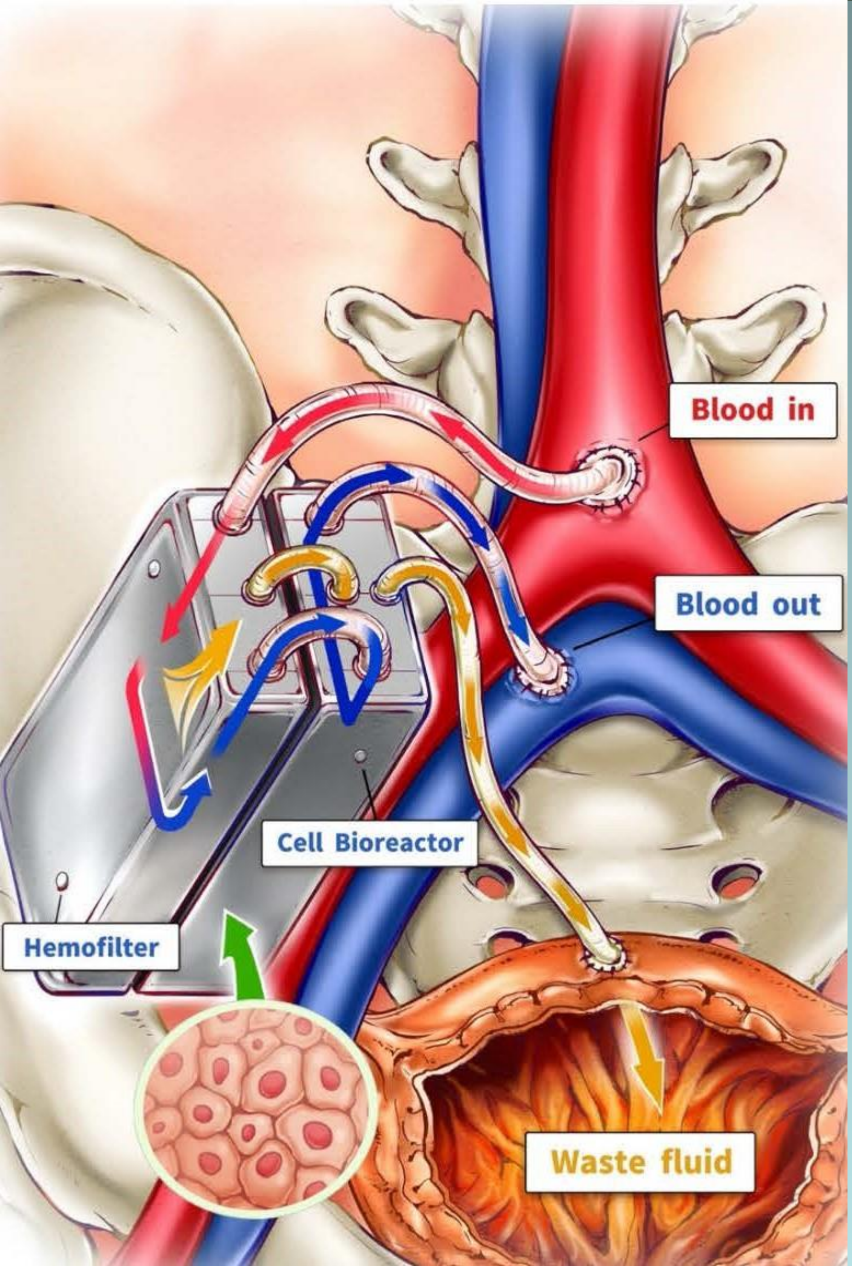




The current and future landscape of dialysis

Jonathan Himmelfarb, Raymond Vanholder, Rajnish Mehrotra and Marcello Tonelli

MEMBRANE IL FUTURO: *Rene artificiale impiantabile*



Rene impiantabile: il sangue, per la differenza di pressione nell'arteria e nella vena, passa attraverso il rene impiantabile, che è composto da un emofiltro e da un bioreattore cellulare.

La membrana è costituita da silicio con nanopori, il fluido di scarto creato dall'emofiltrazione fluisce nel paziente in
vescica urinaria. Il sangue dializzato viene trasferito al bioreattore cellulare dopo l'emofiltrazione.

La funzione metabolica renale è ripristinata dalle cellule del tubulo renale protette nel bioreattore cellulare

Shuvo Roy UoCSFU. The Kidney Project. 2021. Available online:

MEMBRANE IL FUTURO: *Bioartificial Kidney (BAK)*

Check for updates

REVIEW

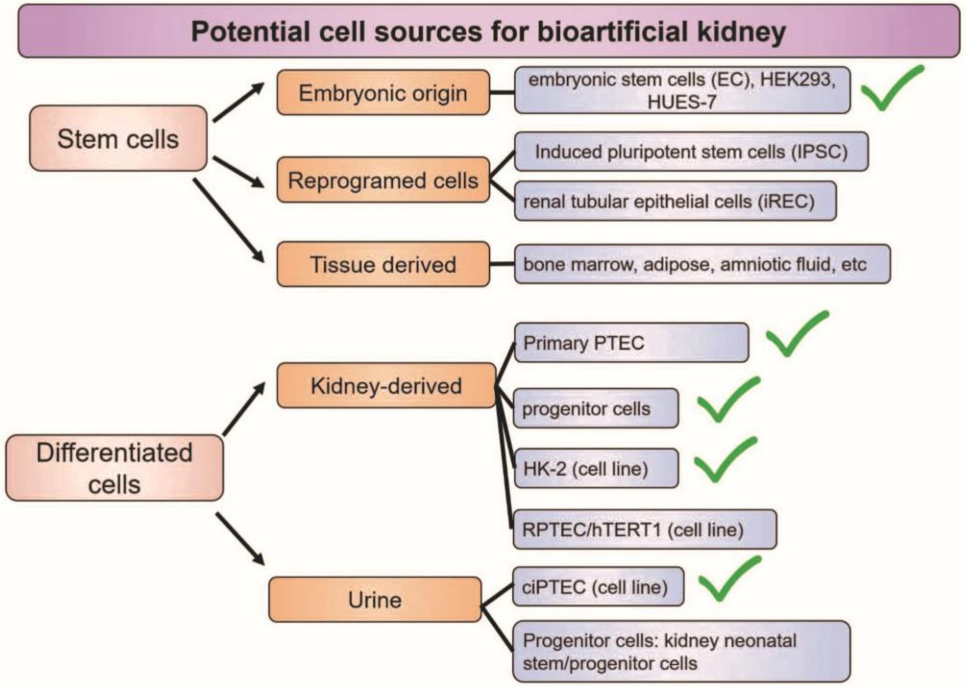
Bioengineered Organs

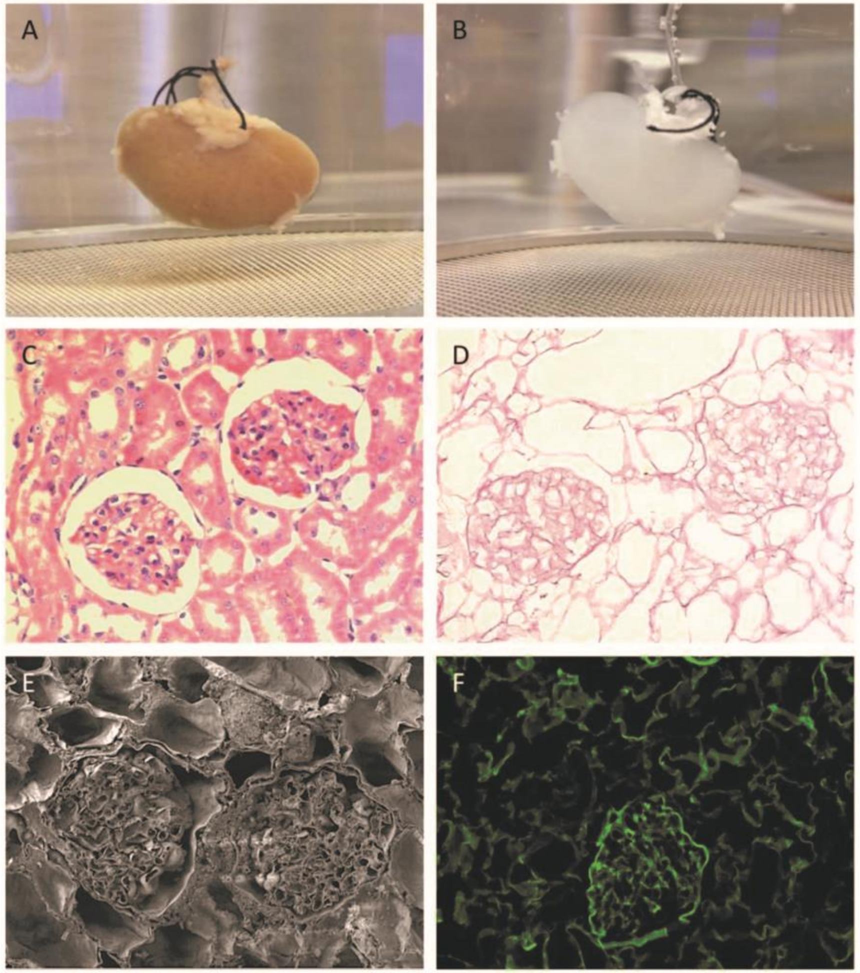
ADVANCED HEALTHCARE MATERIALS

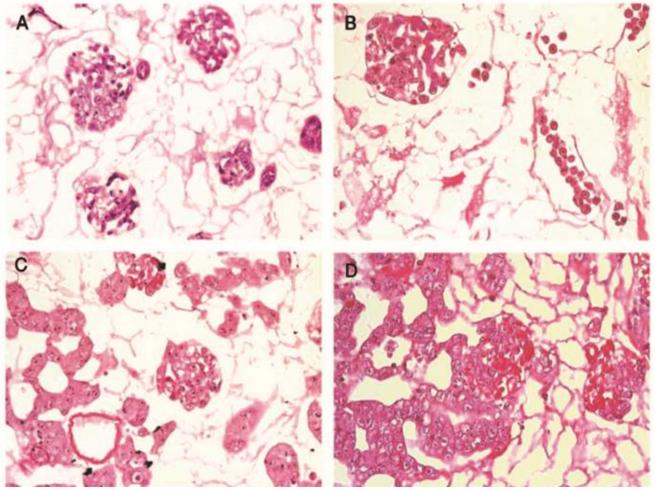
www.advhealthmat.de

Bioengineering Organs for Blood Detoxification

*Cécile Legallais, Dooli Kim, Sylvia M. Mihaila, Milos Mihajlovic, Marina Figliuzzi, Barbara Bonandrini, Simona Salerno, Fjodor A. Yousef Yengej, Maarten B. Rookmaaker, Natalia Sanchez Romero, Pilar Sainz-Arnal, Ulysse Pereira, Mattia Pasqua, Karin G. F. Gerritsen, Marianne C. Verhaar, Andrea Remuzzi, Pedro M. Baptista, Loredana De Bartolo, Rosalinde Masereeuw, and Dimitrios Stamatialis**







Adv. Healthcare Mater. **2018**, *7*, 180043

CONCLUSIONI

- Lo schema tradizionale di classificazione delle membrane, basato sulla composizione chimico fisica e sulla permeabilità all'acqua, è superato e sono necessari nuovi approcci
- Ogni membrana ha le proprie caratteristiche in termini di materiale e di performance
- La prescrizione dialitica richiede, da parte del clinico, la conoscenza dei meccanismi

***concludendo*…. le membrane non sono tutte uguali**

- Tali conoscenze possono permettere di utilizzare al meglio tutte le terapie che oggi abbiamo a disposizione che permettono di spaziare dalla diffusione semplice alla convezione pura, ai trattamenti misti convettivo diffusivi, a quelli con alto grado di filtrazione interna ed a quelli adsorbitivi
- La scelta della membrana dipende dalle necessità cliniche e dialitiche del paziente
- Non esiste una membrana dialitica perfetta ma la ricerca è in corso

Modificato da Ronco C, Clark WR Nature Reviews Nephrology 2018;14 (6): 394-410

GRAZIE PER L'ATTENZIONE