SAPIENZA
UNIVERSITÀ DI ROMA

NefrologiaInterventistica

Corso Avanzato di Nefrologia Interventistica

La tecnologia al servizio della programmazione, creazione e gestione dell'accesso vascolare per emodialisi

L'emodialisi

Carlo Lomonte

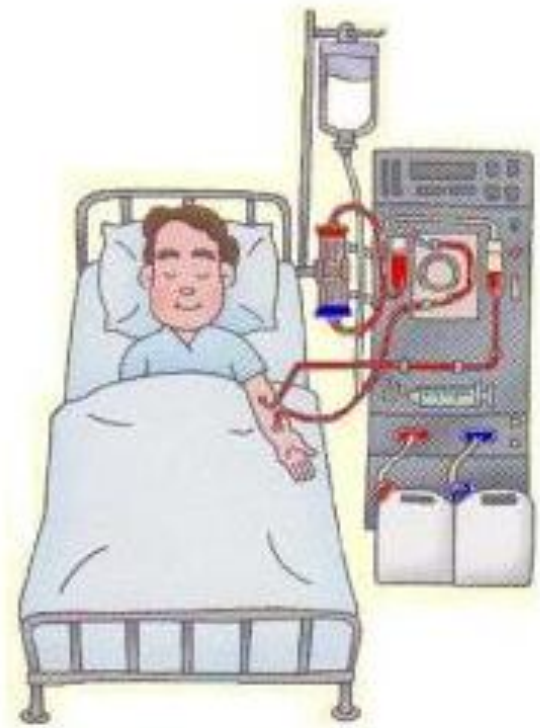
Ente Ecclesiastico
Ospedale Generale Regionale
MIULLI

Haemodialysis is an extracorporeal blood cleansing technique that is used to remove metabolic waste products that accumulate in patients with ESRD.

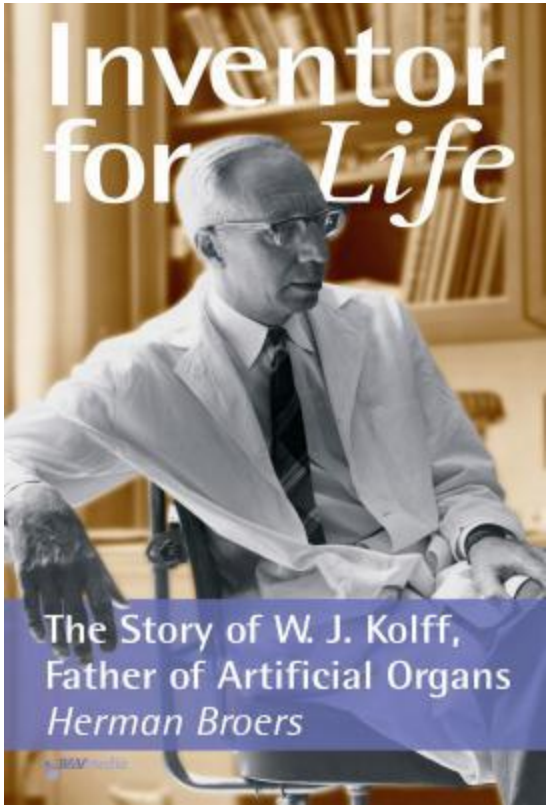
Solutes and water are removed through ***semipermeable membranes*** *using different mass separation mechanisms (****diffusion, convection and adsorption****).*

Ronco and Clark, *Nat Rev Nephrol* 2018

La dialisi non è una lavatrice



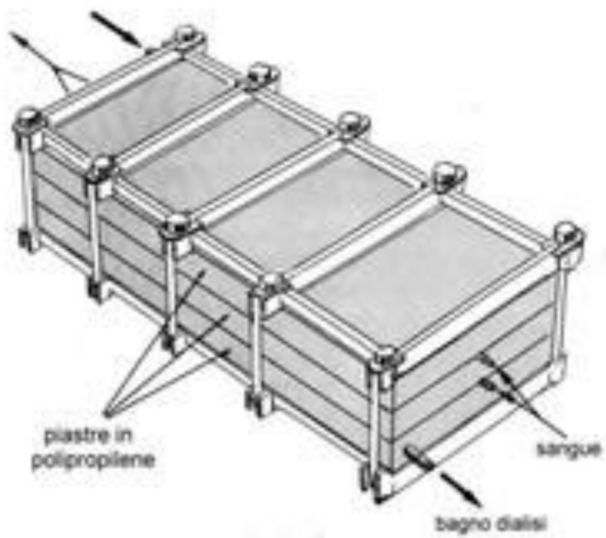
A Santoro, G Ital Nefrol 2017



rotating drum kidney

Modern hemodialysis therapy started on March 17, 1943, when Willem Kolff, a young Dutch physician in the small hospital of Kampen (the Netherlands), treated a 29-year-old woman suffering from malignant hypertension and "contracted kidneys."

1960



Dializzatore di Kiil

泌尿紀要15巻12号
１９６９年12月

Kiil 型人工腎による血液透析の研究

—過去２年間の経験と透析液の検討—

広島大学医学部泌尿器科学教室（主任：仁平寛巳教授）

福重　　満，田中　広見，田戸　　治，

松木　　暁，仁平　寛巳

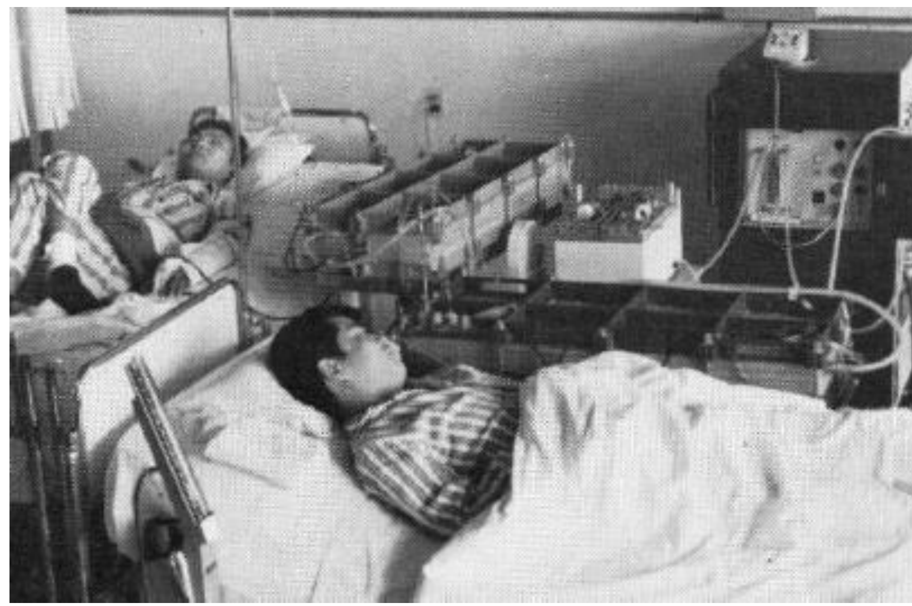
HEMODIALYSIS WITH KIIL-TYPE ARTIFICIAL KIDNEY

—TWO YEARS EXPERIENCE AND STUDY ON DIALYSATE—

Mitsuru FUKUSHIGE, Hiromi TANAKA, Osamu TADO, Satoru MATSUKI and Hiromi NIHIRA

From the Department of Urology, Hiroshima University School of Medicine

(Chairman : Prof. H. Nihira, M. D.)



23 August 1969 BRITISH MEDICAL JOURNAL 447

Clinical Evaluation of a Disposable Artificial Kidney

A. E. KULATILAKE,* M.B., F.R.C.S., F.R.C.S.ED. ; J. VICKERS,† B.SC. ; R. SHACKMAN,‡ M.B., F.R.C.S.

British Medical Journal, 1969, **3**, 447–449

- *For efficient intermittent haemodialysis the artificial kidney should have a low priming volume and preferably should be able to be operated without a blood pump.*
- *The countercurrent dialyser developed by* ***Kiil (1960)*** *and its subsequent modification (Cole et al., 1962,1963) fulfilled these requirements.*
- *These dialysers, however, take a considerable time to prepare and need trained staff, not always readily available, to dismantle, clean, reassemble, and test each machine.*

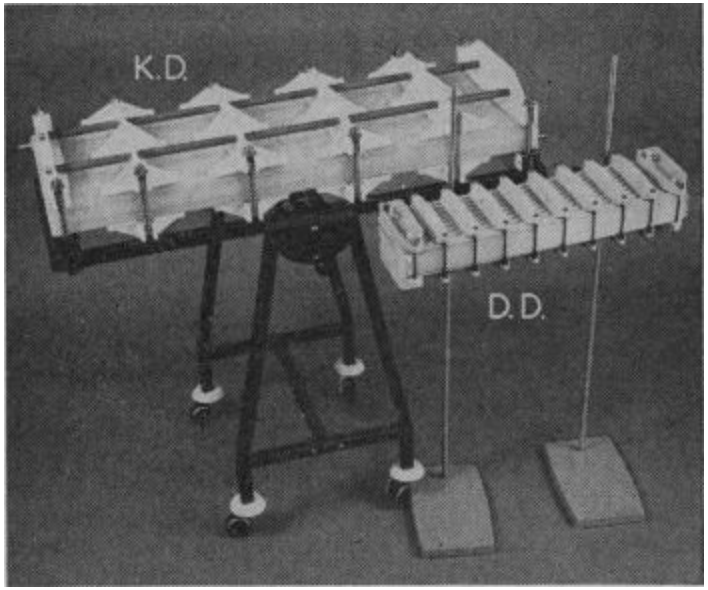
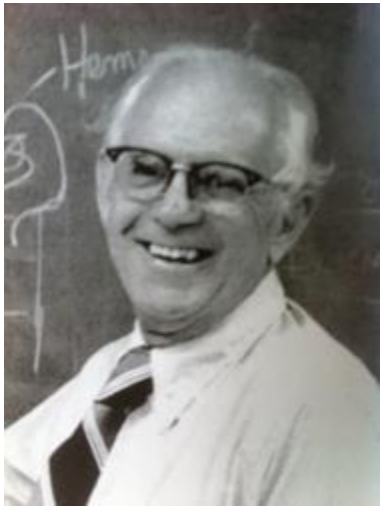


FIG. 2.-Comparison of sizes. K.D.=Kiil dialyser. D.D.=Disposable dialyser.



1960: Scribner-Quinton Shunt

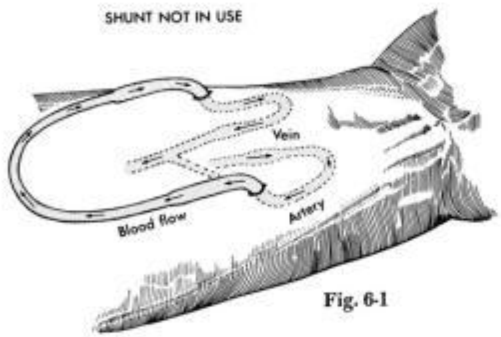


Fig. 6-1

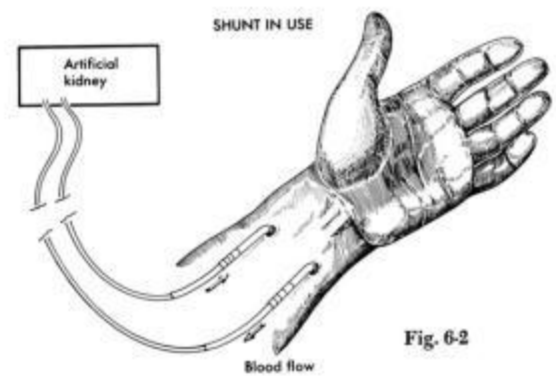
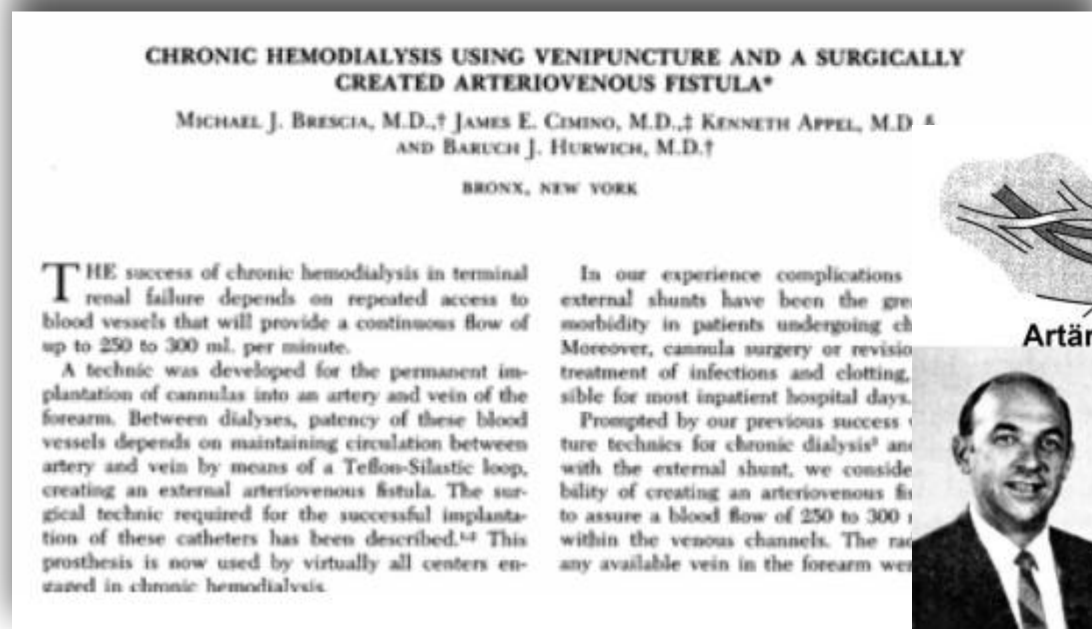


Fig. 6-2

1966: Cimino-Brescia AVF

Chronic hemodialysis using venipuncture and a surgically created arteriovenous fistula

Brescia, Cimino et al, *N Engl J Med* 1966



CHRONIC HEMODIALYSIS USING VENIPUNCTURE AND A SURGICALLY CREATED ARTERIOVENOUS FISTULA*

MICHAEL J. BRESCIA, M.D.,† JAMES E. CIMINO, M.D.,‡ KENNETH APPEL, M.D.

AND BARUCH J. HURWICH, M.D.†

BRONX, NEW YORK

THE success of chronic hemodialysis in terminal renal failure depends on repeated access to blood vessels that will provide a continuous flow of up to 250 to 300 ml. per minute.

A technic was developed for the permanent implantation of cannulas into an artery and vein of the forearm. Between dialyses, patency of these blood vessels depends on maintaining circulation between artery and vein by means of a Teflon-Silastic loop, creating an external arteriovenous fistula. The surgical technic required for the successful implantation of these catheters has been described.[1,2] This prosthesis is now used by virtually all centers engaged in chronic hemodialysis.

In our experience complications external shunts have been the gre morbidity in patients undergoing ch Moreover, cannula surgery or revisio treatment of infections and clotting, sible for most inpatient hospital days.

Prompted by our previous success ture technics for chronic dialysis[3] and with the external shunt, we conside bility of creating an arteriovenous fi to assure a blood flow of 250 to 300 within the venous channels. The rac any available vein in the forearm we

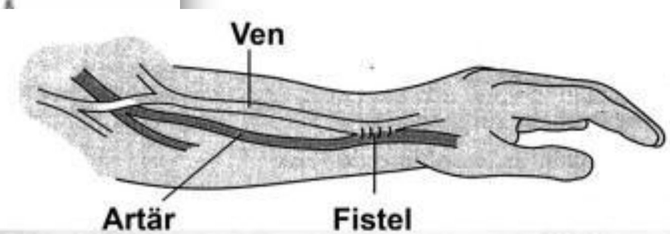


Table 1. Key Components of the Hemodialysis Prescription.

Component	Comments
Dialyzer	
Configuration	Hollow-fiber dialyzers are preferred owing to improved safety.
Membrane biomaterials	Synthetic membranes are used more frequently than cellulose membranes owing to fewer blood–membrane interactions.
Membrane permeability	High-flux membranes are constructed with larger pores, which allow greater removal of higher-molecular-weight solutes, with similar removal of lower-molecular-weight solutes as compared with low-flux membranes.
Treatment time	Usual treatment time is about 4 hours. Longer treatment times allow more fluid removal with less risk of intradialytic hypotension, and the removal of compartmentalized solutes such as phosphate is increased; nevertheless, increased dialysis time has limited effects on removal of many solutes because of decreasing plasma concentrations.
Treatment frequency	Usual frequency is 3 times per week. Increasing the frequency of dialysis to >3 times per week improves solute clearance and fluid removal; effects on clinical outcomes and quality of life are being evaluated in randomized trials.
Blood flow rate	Usual prescription is 200 to 400 ml per minute. Achievable blood flow depends on the type and quality of vascular access. Increasing blood flow increases solute removal; however, increased flow resistance will eventually limit the augmented clearance.
Dialysate flow rate	Usual rate is twice the achieved blood flow rate in order to attain near-maximal solute clearance.
Ultrafiltration rate	Should be less than 10 ml per kilogram of body weight per hour to reduce the risk of intradialytic hypotension.
Dialysate composition	
Sodium	Between 130 and 145 mmol per liter. Higher sodium concentrations decrease the risk of intradialytic hypotension but increase thirst and interdialytic weight gain.
Potassium	Generally 2 to 3 mmol per liter. Lower levels of dialysate potassium are associated with sudden cardiac death; intradialytic potassium removal is highly variable, and plasma potassium levels rebound about 30% after dialysis.
Calcium	Generally 1.25 to 1.75 mmol per liter. Only non–protein-bound calcium is removed; higher levels of dialysate calcium increase intradialytic blood pressure.
Magnesium	Generally 0.5 mmol per liter. The optimal level of magnesium is unresolved, and magnesium flux is difficult to predict.
Alkaline buffers	Commonly 30 to 40 mmol per liter. Predominantly bicarbonate with a small amount of acetate; bicarbonate concentration can be adjusted to correct metabolic acidosis.
Chloride	Defined by prescribed cations and alkaline buffers in dialysate.
Glucose	Commonly 100 to 200 mg per deciliter. Higher levels of glucose promote hypertriglyceridemia.
Intradialytic medications	Erythropoietin, iron, vitamin D analogues, antibiotics.
Anticoagulation	Heparin or other agents.

Himmelfarb, *NEJM* 2010

Table 2. Clinical Care of Patients Receiving Hemodialysis.*

Variable	Goals and Targets
Dialysis dose	Monitor urea kinetic modeling; target single-pool Kt/V_{UREA} >1.4.†
Fluid management and estimated body weight	Carry out individualized management and assessment; interdialytic weight gain should ideally be less than 5% of total body weight.
Dialysate quality	Monitor endotoxin and bacteria concentrations in water used for dialysate; the use of ultrapure dialysate may reduce inflammation.[49]
Anemia	Try to attain a hemoglobin level of 10 to 12 g per deciliter (although current recommendations may change on the basis of results from clinical trials involving patients with chronic kidney disease[50-53]); avoid high-dose erythropoietin; evaluate patients with erythropoietin resistance for inflammation and iron deficiency; monitor iron levels and treat iron deficiency; the long-term safety and efficacy of iron administration in patients with high ferritin levels have not been well established.[54]†‡
Vascular access	Implement strategies to increase the placement and use of fistulas and eliminate catheter use whenever feasible[55]; monitor to detect possible access dysfunction.†§
Bone and mineral disorders	Aim for a serum calcium level of 8.4 to 9.5 mg per deciliter and a serum phosphate level of 3.5 to 5.5 mg per deciliter; monitor serum levels of intact PTH; although the optimal target PTH level has not been well defined, maintain PTH level at >2 times the upper limit of the normal range to minimize risk of low bone turnover; suppress rising PTH levels with vitamin D analogues, calcimimetics, and phosphate binders.¶
Nutrition	Aim for serum albumin level >4.0 g per deciliter; consider enteral supplementation for progressive signs of protein energy wasting; refer patient to dietitian for nutritional counseling; restrict phosphorus, sodium, and potassium intake, as guided by laboratory studies.†
Blood pressure	Optimal targets and management strategies have not been well defined.[57]
LDL cholesterol	Aim for LDL cholesterol level of <100 mg per deciliter; the relationship between LDL cholesterol and cardiovascular risk is confounded by inflammation; statins are without proven benefit.[58-60]
Diabetes management	Balance benefits of tighter glycemic control, which carries an increased risk of hypoglycemia, by means of individualized therapy; glycated hemoglobin targets have not been well defined[61]; manage other aspects of diabetes, such as peripheral vascular disease, intestinal dysmotility, and eye problems.
Transplantation referral	Provide education about transplantation and timely referrals for suitable candidates; monitor status of wait-listed patients.§
Quality-of-life and psychosocial evaluation	The evaluation, conducted by a social worker with the support of a multidisciplinary team, should be aimed at optimizing adjustment to kidney failure and its treatment; the Kidney Disease Quality of Life (KDQOL-36) instrument is often used for the evaluation.[6]

Himmelfarb, *NEJM* 2010

Haemodialysis membranes

In the past: the major distinction was between **cellulosic** and **non-cellulosic** membr

Cellulosic membranes

cuprammonium rayon-based membranes (also known as cuprophan)

cellulose acetate

cellulose triacetate

Non-cellulosic membranes (synthetic membranes)

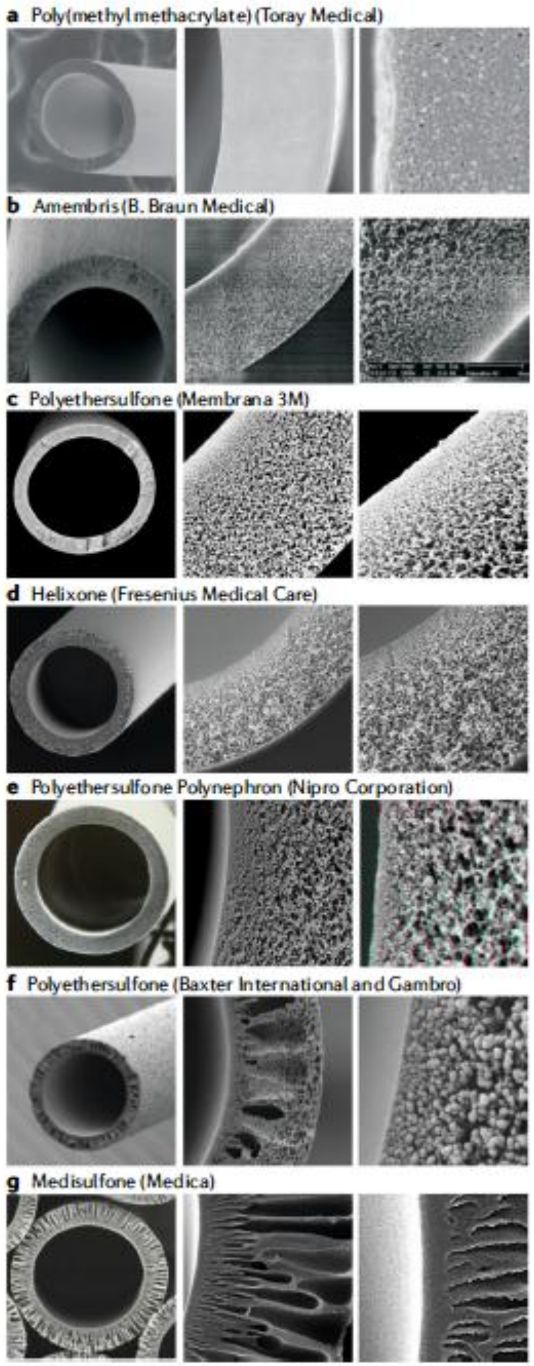
polyamide, PS,

polyethersulfone,

polyarylethersulfone,

PAN,

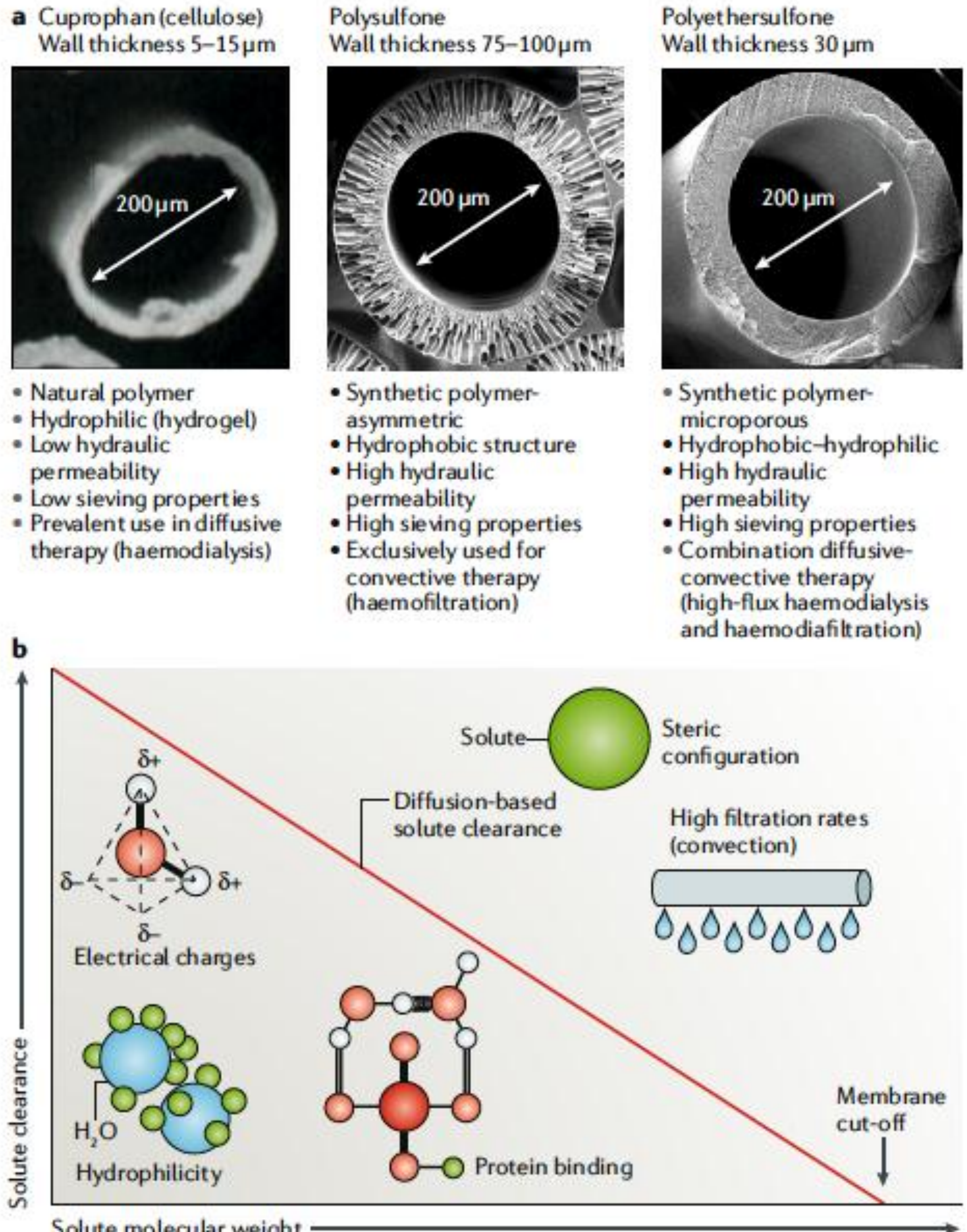
polymethylmethacrylate.



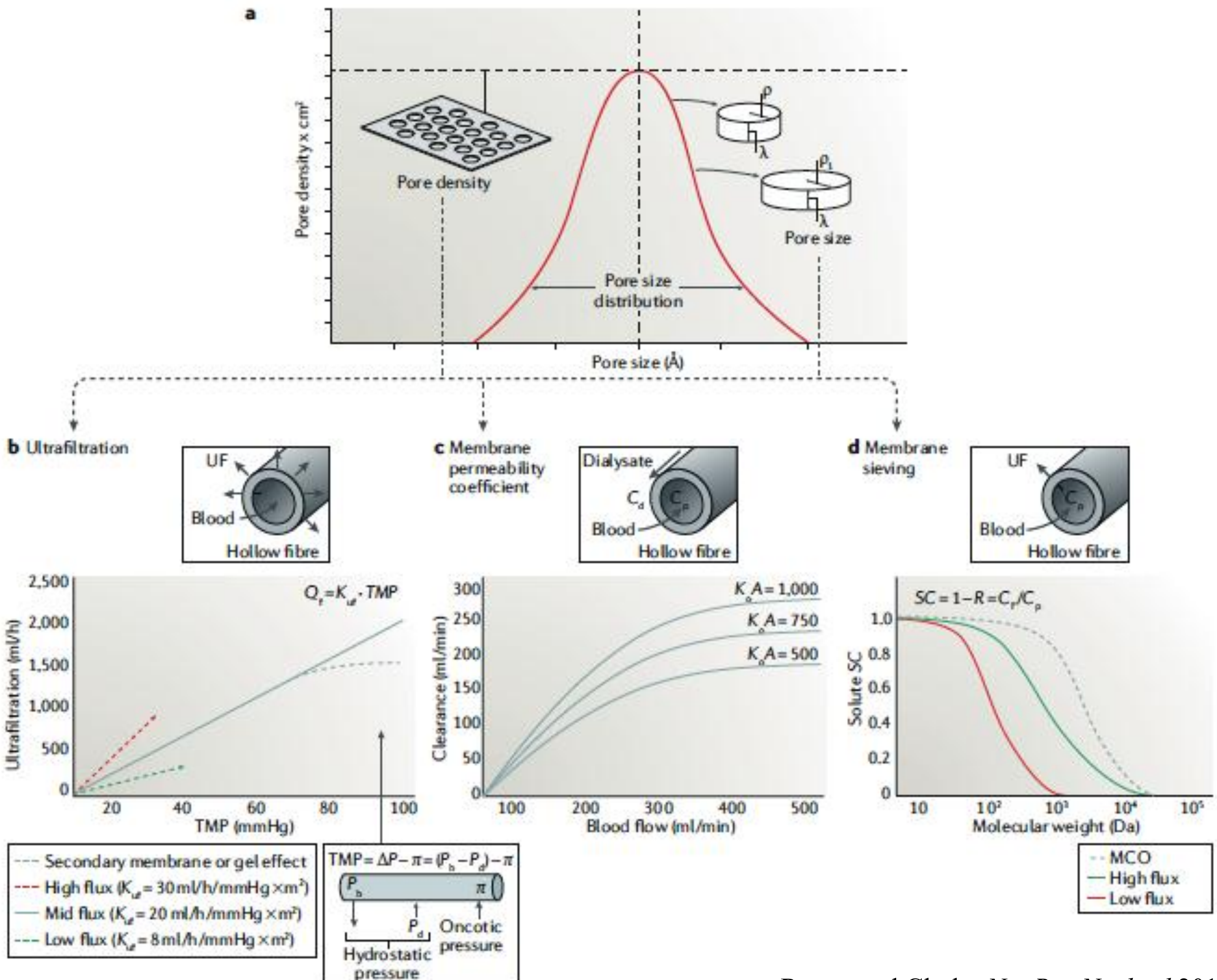
Structural characteristics of some commercially available synthetic dialysis membranes

Scanning electron micrographs of the fibre (left), fibre wall (middle) and a magnified cross-sectional view of the internal skin layer (right).
For reference, the inner diameter of the fibres is ~200 μm. Different structural features of the membranes are discernible, and the membranes have varying degrees of **asymmetric configuration,** ranging from minimum asymmetry (sponge-like; parts a–e) to maximum asymmetry (finger-type; parts f,g).

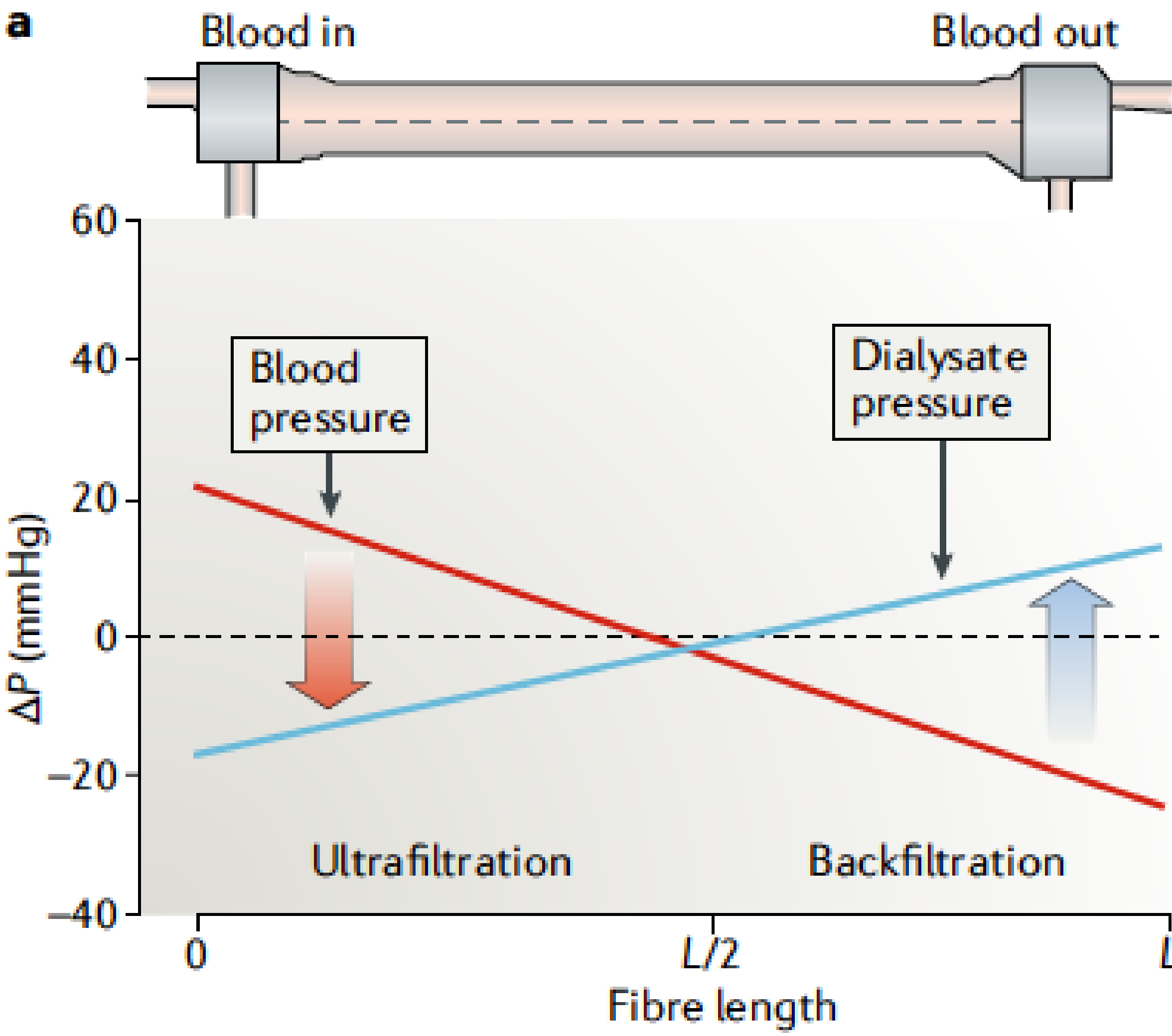
Ronco and Clark, *Nat Rev Nephrol* 2018



Ronco and Clark, *Nat Rev Nephrol* 2018

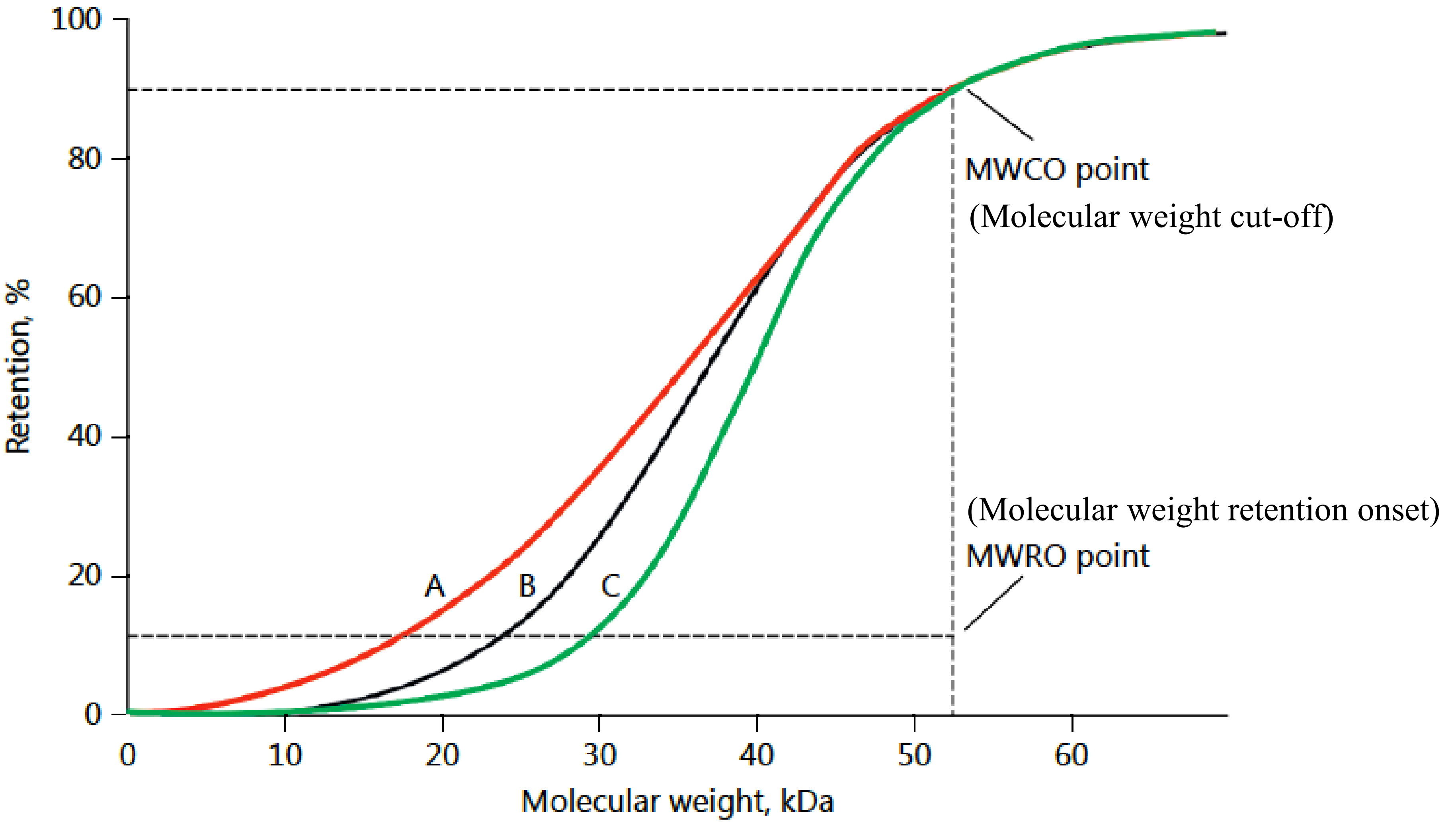


Ronco and Clark, *Nat Rev Nephrol* 2018



“expanded haemodialysis" utilize membranes designed to produce a high degree of internal filtration

Ronco and Clark, *Nat Rev Nephrol* 2018

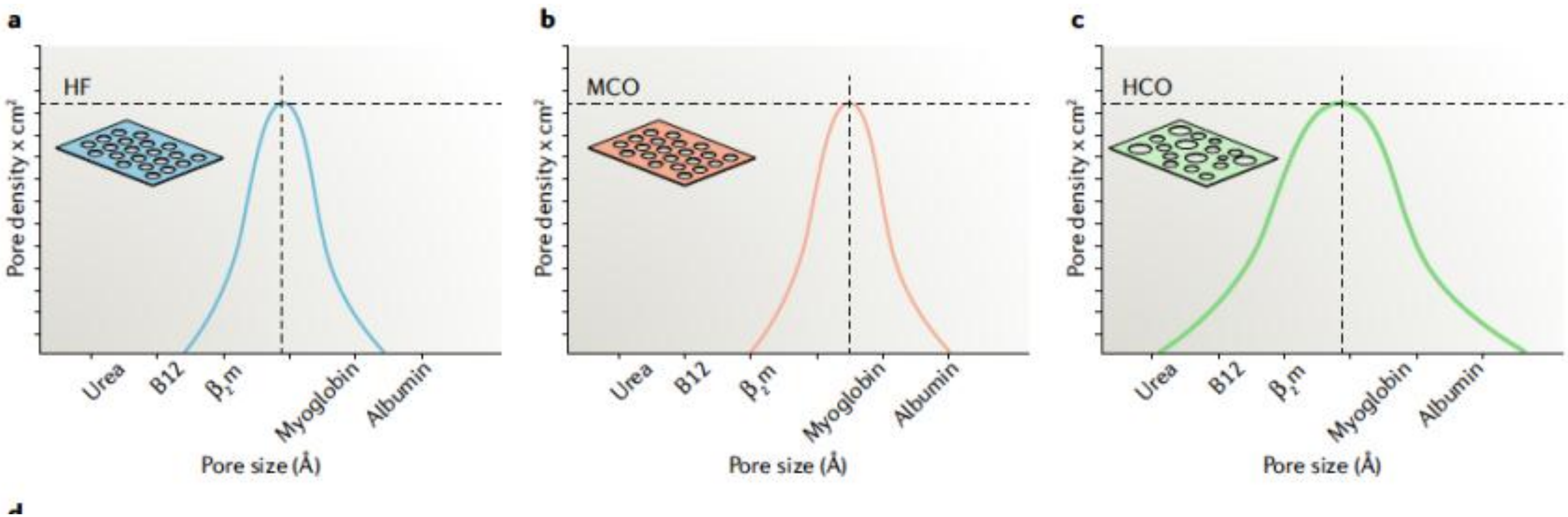


Ronco C (ed): Expanded Hemodialysis – Innovative Clinical Approach in Dialysis.
Contrib Nephrol. Basel, Karger, 2017, vol 191, pp 115–126

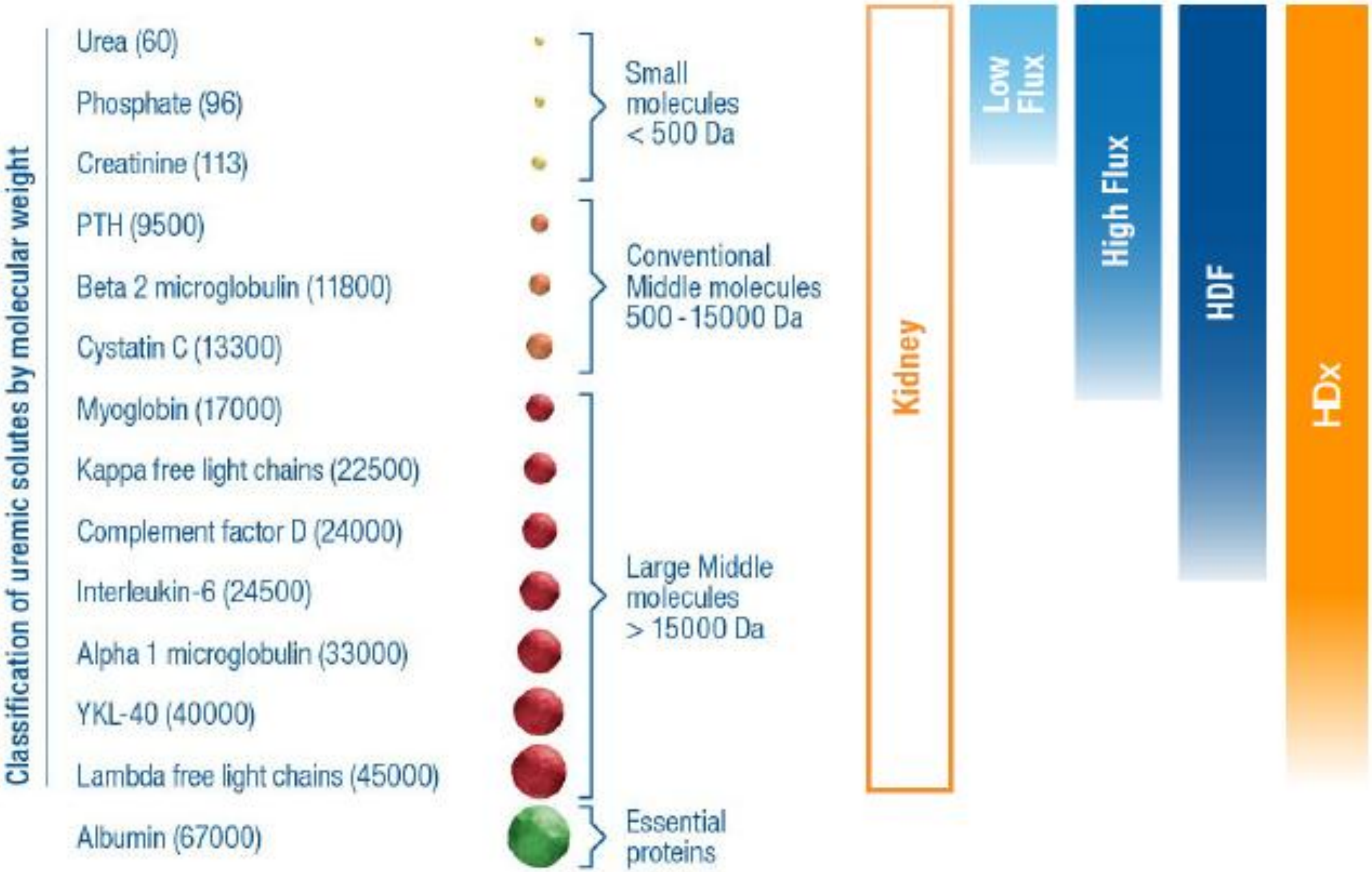
Performance characteristics of HD membrane

Kuf 20-40 ml/h/mmHg/m2
SC beta2 0.7-0.8
Albumin < 0.5 g

Kuf > 40 ml/h/mmHg/m2
SC beta2 1.0
Albumin 2-6 g



Ronco and Clark, *Nat Rev Nephrol* 2018

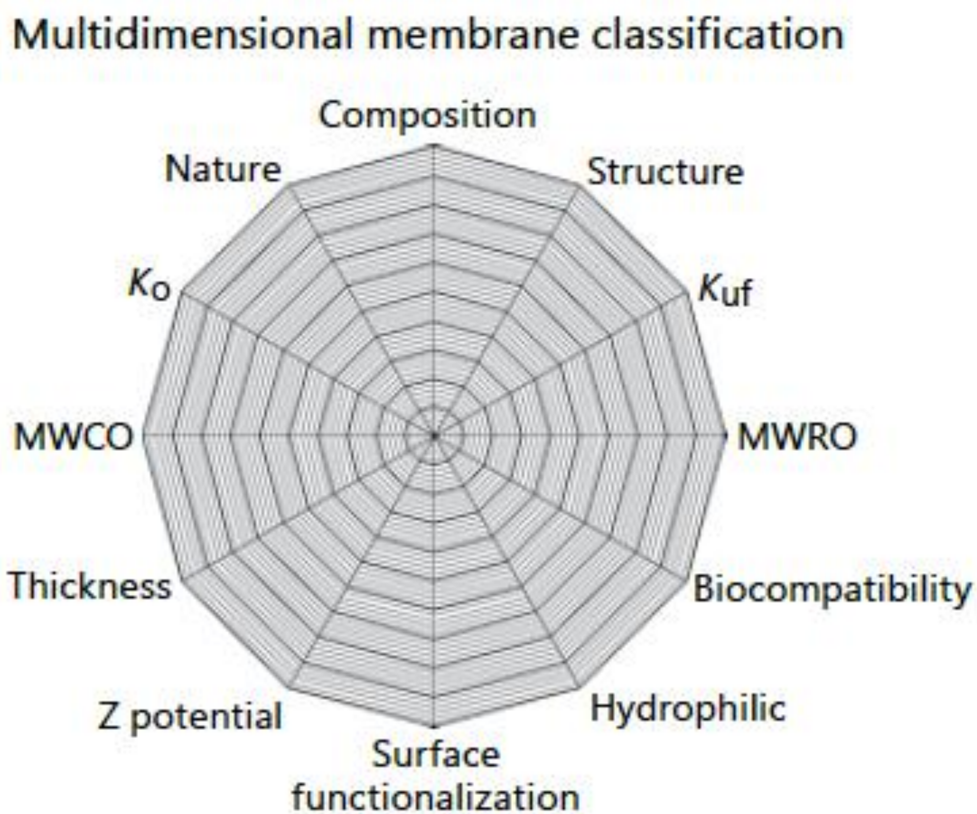


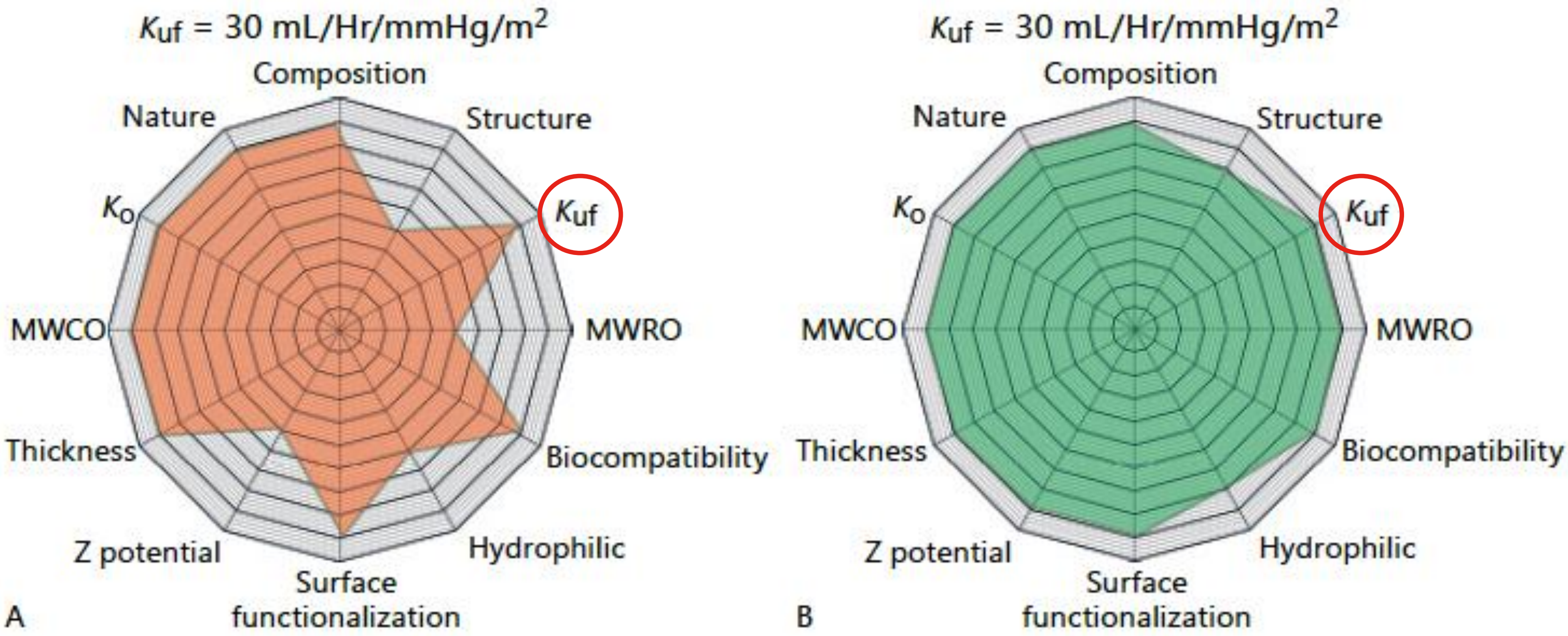
Classification of uremic solutes by molecular weight
Urea (60)
Phosphate (96)
Creatinine (113)
PTH (9500)
Beta 2 microglobulin (11800)
Cystatin C (13300)
Myoglobin (17000)
Kappa free light chains (22500)
Complement factor D (24000)
Interleukin-6 (24500)
Alpha 1 microglobulin (33000)
YKL-40 (40000)
Lambda free light chains (45000)
Albumin (67000)
Small molecules < 500 Da
Conventional Middle molecules 500 - 15000 Da
Large Middle molecules > 15000 Da
Essential proteins
Kidney
Low Flux
High Flux
HDF
HDx

Ronco C (ed): Expanded Hemodialysis – Innovative Clinical Approach in Dialysis.
Contrib Nephrol. Basel, Karger, 2017, vol 191, pp 115–126 (DOI: 10.1159/000479260)

Multidimensional Classification of Dialysis Membranes

Claudio Ronco[a, b] · Mauro Neri[b] · Anna Lorenzin[b] · Francesco Garzotto[a, b] · William R. Clark[c]





Ronco C (ed): Expanded Hemodialysis – Innovative Clinical Approach in Dialysis.
Contrib Nephrol. Basel, Karger, 2017, vol 191, pp 115–126

Key points

- Traditional schemes for the classification of dialysis membranes, based simply on composition and water permeability, are outdated and **new approaches are needed.**

- Dialyser utilization in clinical practice has evolved over time and is now dominated by devices with **synthetic high-flux membranes**.

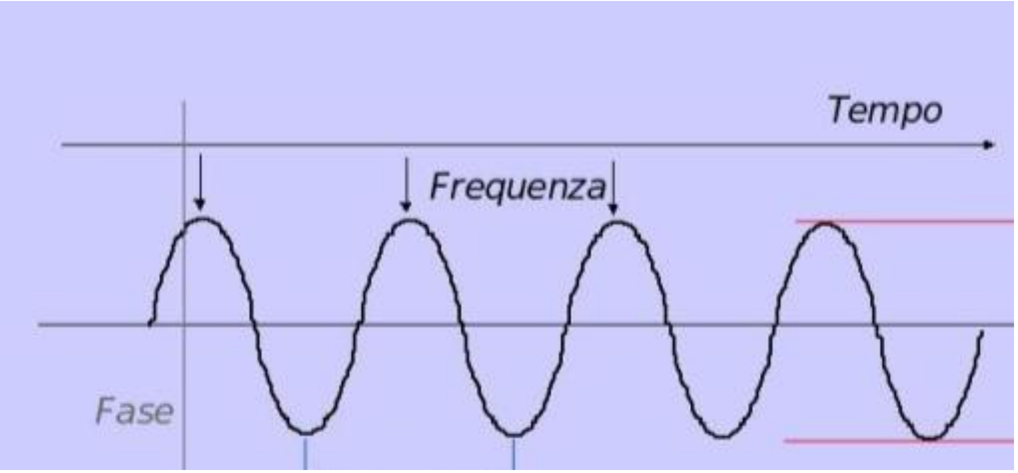
- Rational treatment prescription by clinicians requires an **understanding of the basic mechanisms** underlying solute and water removal in dialysis — namely, diffusion, convection, adsorption and ultrafiltration.

- New therapies (including **expanded haemodialysis**) that utilize membranes designed to produce a high degree of internal filtration are undergoing clinical evaluation as potential alternatives to convective therapies, such as on-line haemodiafilitration.

Ronco and Clark, *Nat Rev Nephrol* 2018

Treatment time

Frequency of dialysis



Alla fine degli anni ‘60 la durata della dialisi era di 8-12 ore per 3 volte alla settimana.

Short dialysis schedules (SDS)-finally ready to become routine?

V Cambi et al, *Proc Eur Dial Transplant Assoc* 1975

EMODIALISI

a) **Convenzionale intermittente**

3-5 ore, tre volte alla settimana

b) **Lunga intermittente**:

> 5 ore, tre volte alla settimana

c) **Breve quotidiana**:

2-3 ore, sei o sette volte alla settimana

d) **Lunga quotidiana notturna**:

6-10 ore, sei o sette notti alla settimana

EBPG guideline on dialysis strategies
J Tattersal et al. *Nephrol Dial Transplant* 2007;S2:ii5-ii21

Suggested Taxonomy of Intensive Hemodialysis (HD)

Treatment Time

Classification	Hours
Prolonged/ nocturnal	>6 hours
Standard	3–6 hours
Short	<3 hours

Treatment Frequency

Classification	HD/week
Frequent	>4/week
Alternate	3.5 or 4/week
Standard	3/week

"__________ - __________ HD"

Marshall, *Kidney Int,* 2018

Long Interdialytic Interval and Mortality among Patients Receiving Hemodialysis

Robert N. Foley, M.B., David T. Gilbertson, Ph.D., Thomas Murray, M.S., and Allan J. Collins, M.D.

ABSTRACT

BACKGROUND

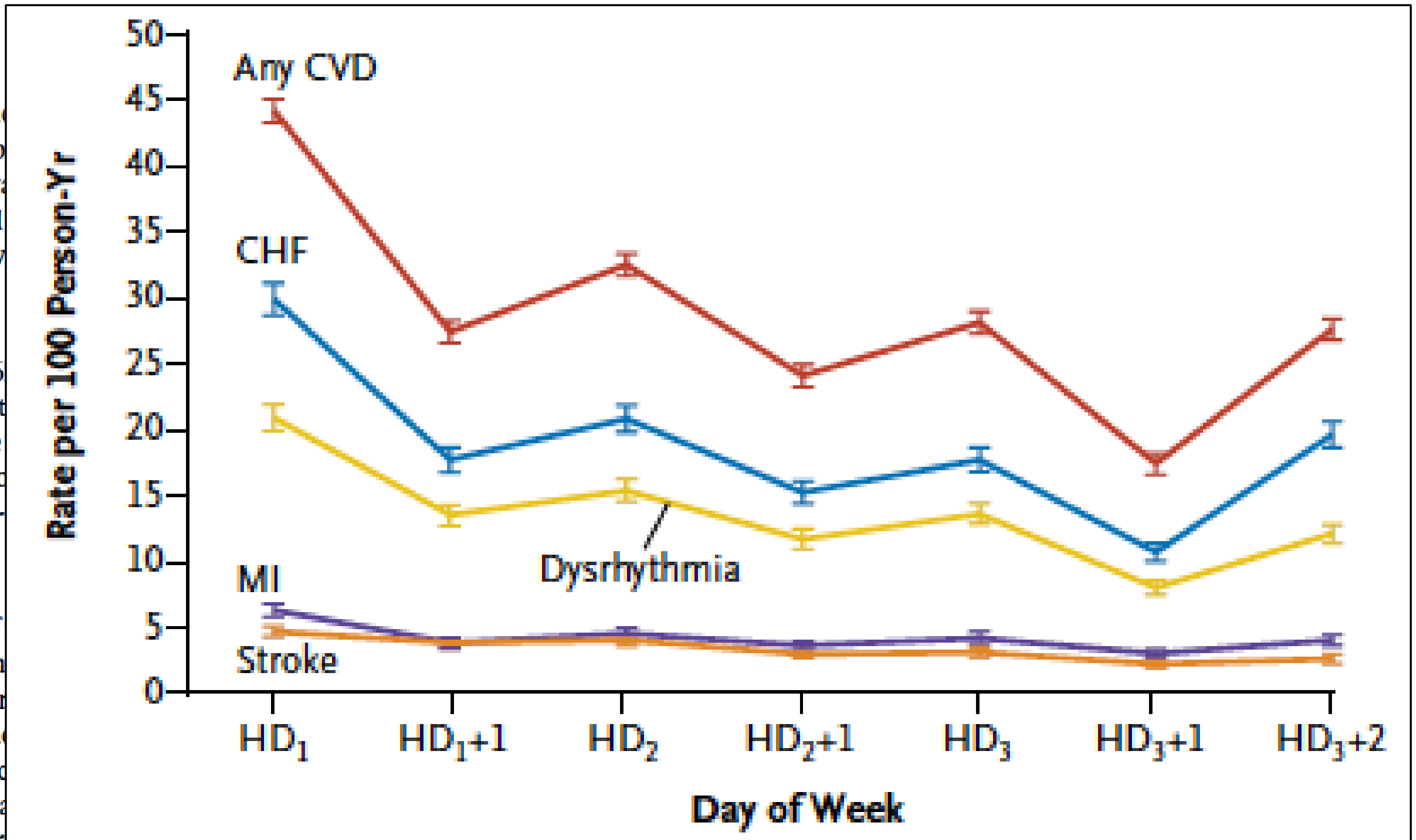
Patients with en
metabolic and vo
alence of cardiov
we hypothesized
in patients receiv

METHODS

We studied 32,06
Measures Project
modialysis three
compared rates o
after the long (2-

RESULTS

The mean age of
dialysis treatmen
following event r
days: all-cause m
ity from cardiac c
P=0.007), mort
myocardial infar
tion (6.3 vs. 3.9, P<0.001), congestive heart failure (29.9 vs. 16.9, P<0.001), stroke (4.7 vs. 3.1, P<0.001), dysrhythmia (20.9 vs. 11.0, P<0.001), and any cardiovascular event (44.2 vs. 19.7, P<0.001).



N Engl J Med 2011;365:1099-107.

clinical investigation www.kidney-international.org

Short daily-, nocturnal- and conventional-home hemodialysis have similar patient and treatment survival

see commentary on page 10

Karthik K. Tennankore[1,2], Yingbo Na[3], Ron Wald[3], Christopher T. Chan[4] and Jeffrey Perl[3,4]

[1]Division of Nephrology, Department of Medicine, Dalhousie University, Halifax, Nova Scotia, Canada; [2]Nova Scotia Health Authority, Halifax, Nova Scotia, Canada; [3]Division of Nephrology, Department of Medicine, St. Michael's Hospital, University of Toronto, Toronto, Ontario, Canada; and [4]Division of Nephrology, Department of Medicine, University Health Network, University of Toronto, Toronto, Ontario, Canada

A nationally representative cohort of Canadian HHD patients from 1996-2012 was studied.

202, short daily HHD (2-3 hours/5 plus sessions per week)

508, nocturnal HHD (6-8 hours/5 plus sessions per week)

600, conventional HHD (3-6 hours/2-4 sessions per week)

…patients receiving short daily and nocturnal HHD had similar patient/treatment survival compared with patients receiving conventional HHD

Kidney Int 2018

In-center hemodialysis six times per week versus three times per week

FHN Trial Group, Chertow GM. NEJM 2010

Frequent hemodialysis was associated with favorable results with respect to the composite outcomes of death or change in left ventricular mass and death or change in a physical-health composite score but prompted ***more frequent interventions related to vascular access.***

The effects of frequent nocturnal home hemodialysis: the Frequent Hemodialysis Network Nocturnal Trial.

Rocco et al. Kidney Int 2011

*There was a trend for i****ncreased vascular access events in the nocturnal arm****. Thus, we were unable to demonstrate a definitive benefit of more frequent nocturnal hemodialysis for either coprimary outcome*

Long-term Effects of Frequent Nocturnal Hemodialysis on Mortality: The Frequent Hemodialysis Network (FHN) Nocturnal Trial.

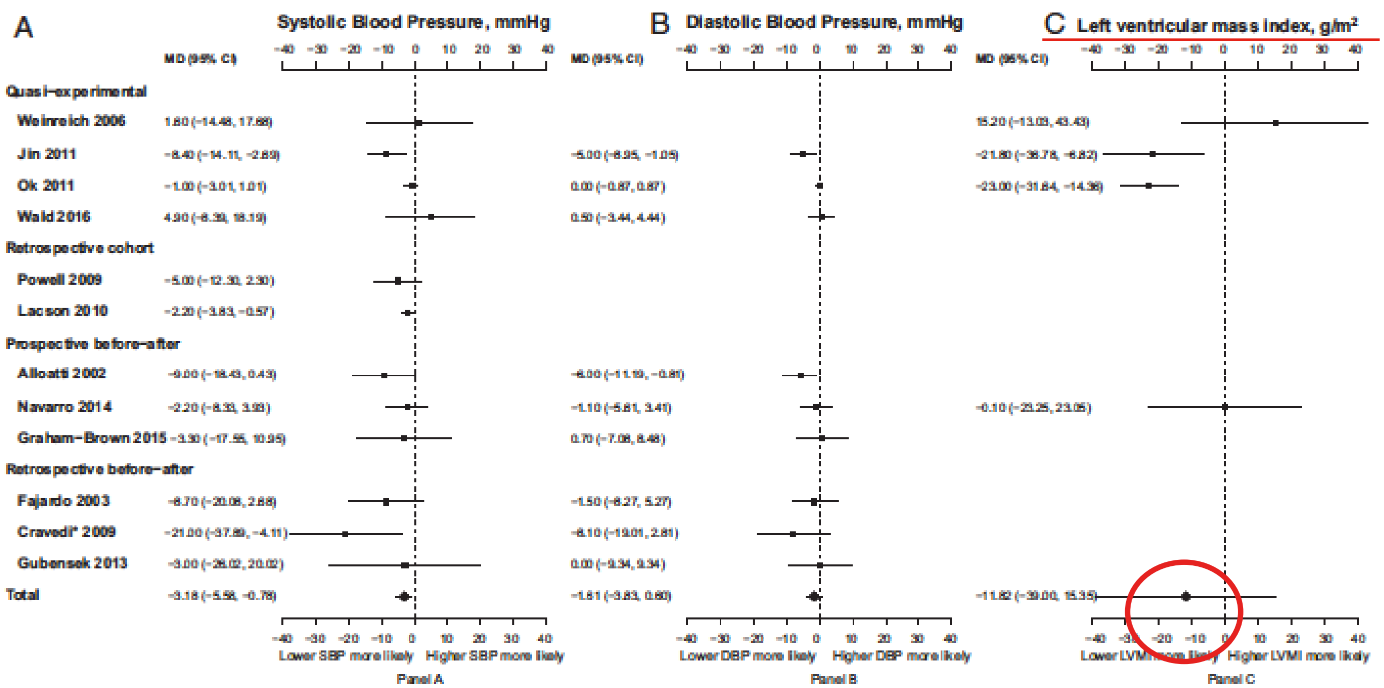
Patients randomly assigned to nocturnal hemodialysis had a higher mortality rate than those randomly assigned to conventional dialysis.

Rocco et al. AJKD 2015

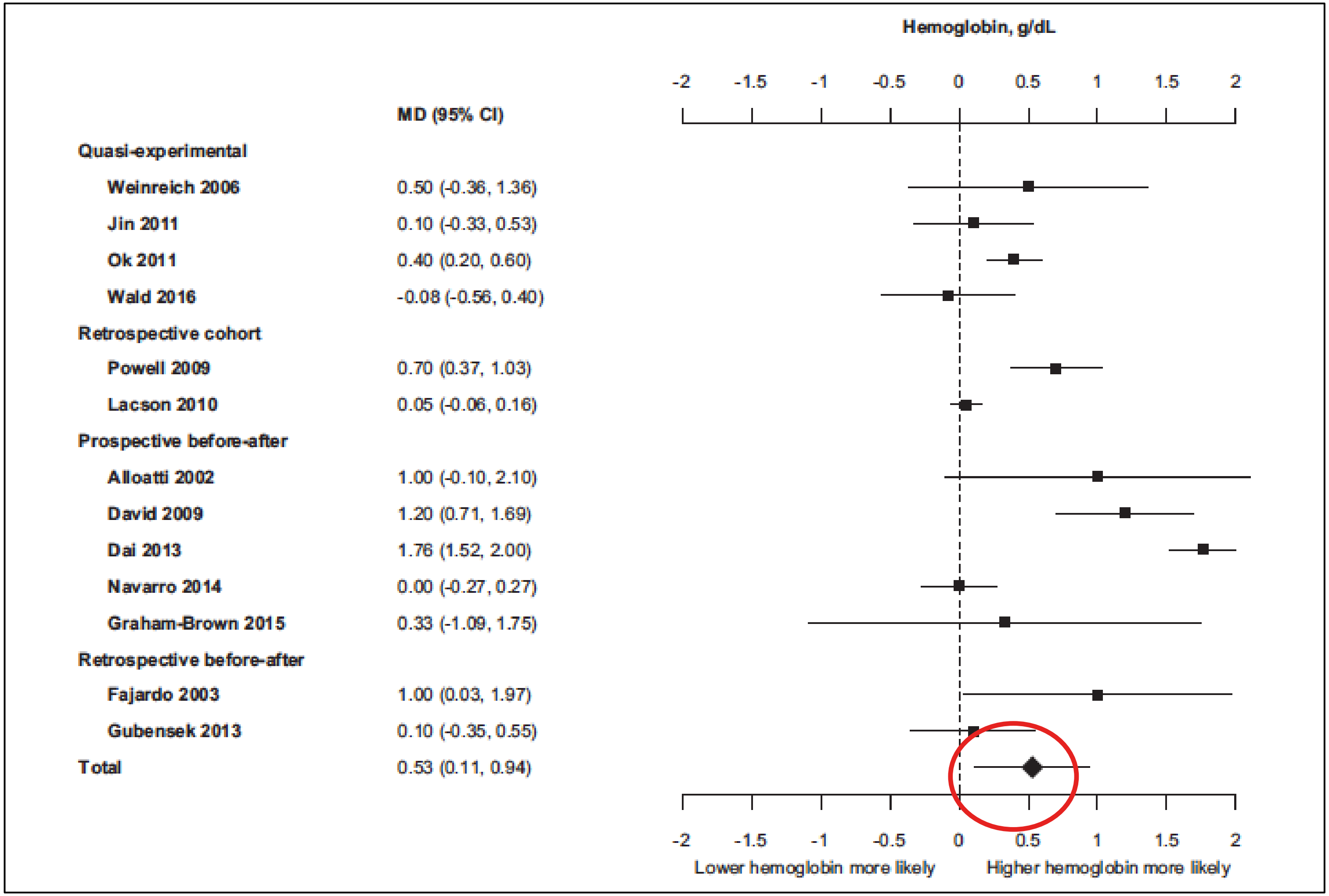
In-Center Nocturnal Hemodialysis Versus Conventional Hemodialysis: A Systematic Review of the Evidence

2,086 identified citations, 21 met the inclusion criteria, comprising a total of 1,165 in-center nocturnal HD patients and 15,865 conventional HD patients.

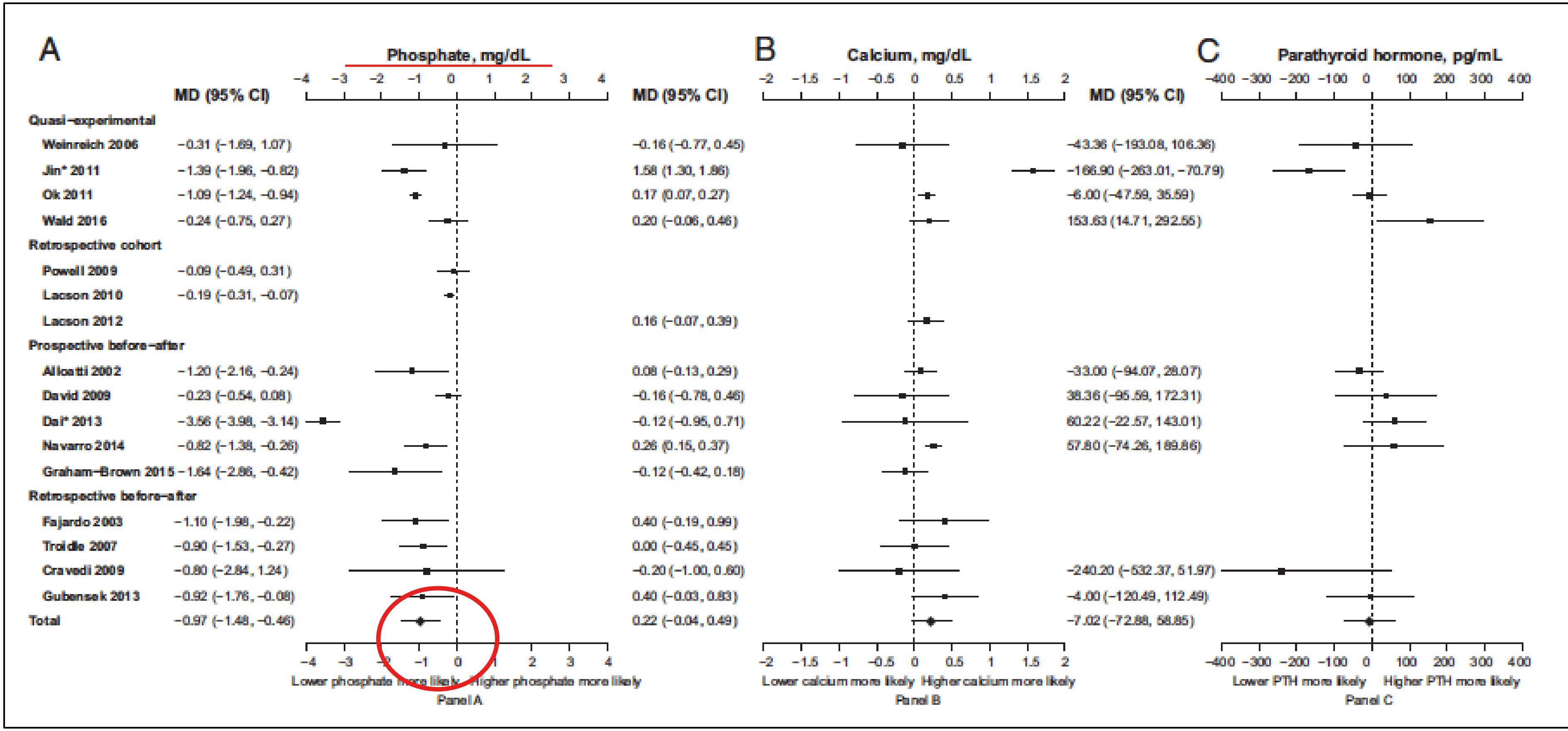
Relative to conventional HD, in-center nocturnal HD was associated with improvements in several clinically relevant outcomes.



Wong et al, AJKD 2017



Wong et al, AJKD 2017



Wong et al, AJKD 2017

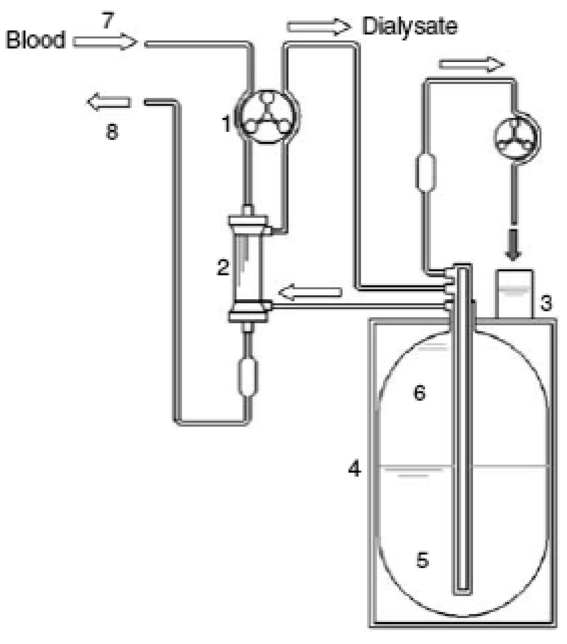
Can the effets of increased time be separated from increase dose?

- *"The role of time as an independent determinant factor of dialysis adequacy requires further study"*

EBPG guideline on dialysis strategies
J Tattersal et al. *Nephrol Dial Transplant* 2007;S2:ii5-ii21

Impact of hemodialysis duration on the removal of uremic retention solutes

9 pazienti stabili dializzati per 4, 6 e 8 ore, stesso volume di sangue e dialisato

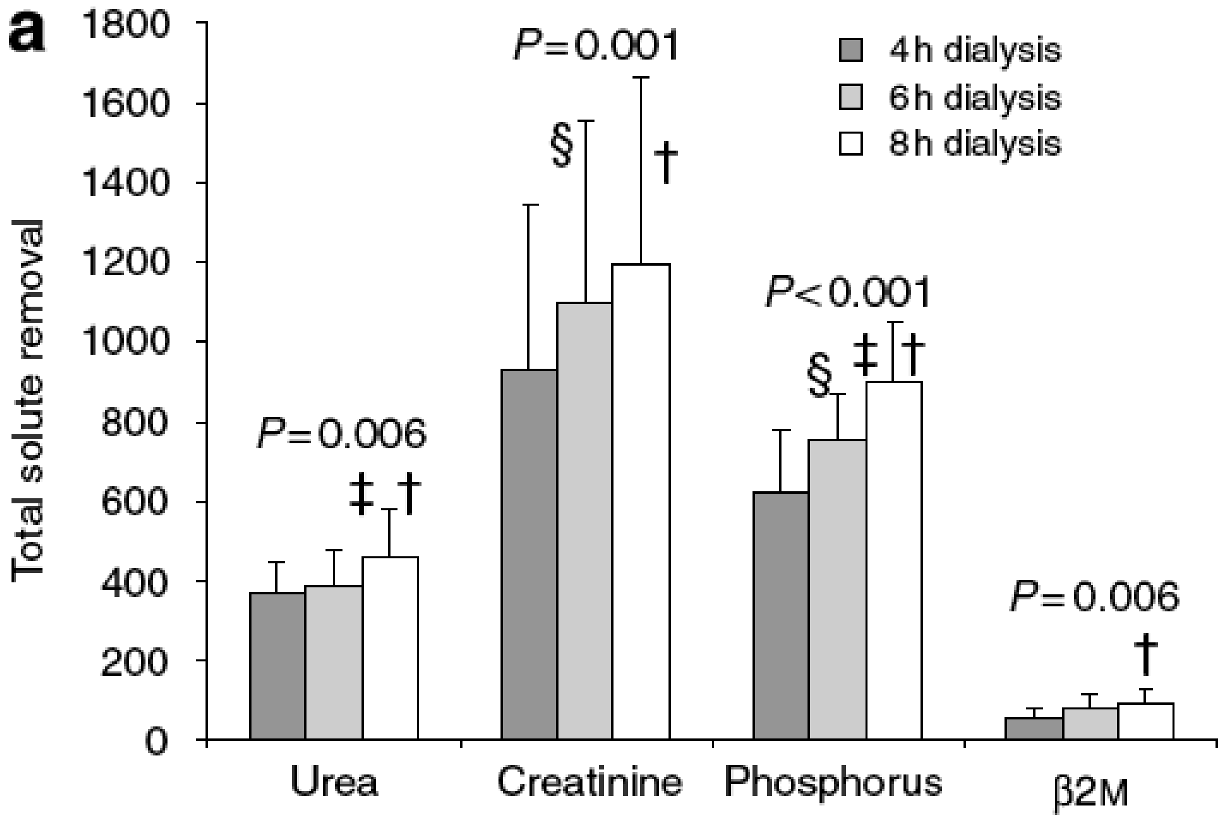


Durata, ore	4	6	8
Qb/Qd, ml/min	350	250	187,5

90 litri

S Eloot, Kidney Int 2008;73: 765,

Impact of hemodialysis duration on the removal of uremic retention solutes



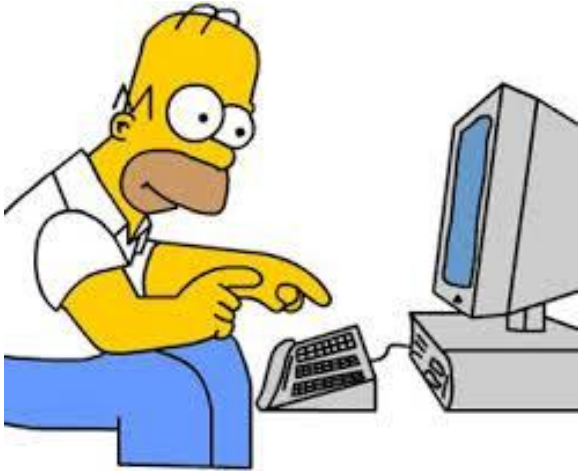
increase 4 vs 8 h	*26%*	*35%*	*48%*	*81%*

S Eloot, *Kidney Int* 73: 765, 2008

QUANTIFYING THE DOSE AND ADEQUACY OF DIALYSIS

Urea kinetic modeling predicts morbidity and mortality better than kinetic modeling of any other known solute.

The general perception is that dialysis kinetic modelling is a highly abstract research topic for mathematicians, sitting somewhere in an office far from the patient's bedside and from practical application.



Eloot, Schneditz,Vanholder, NDT 2012

Effect of the hemodialysis prescription of patient morbidity: report from the National Cooperative Dialysis Study

Lowrie et al. *N Engl J Med*, 1981

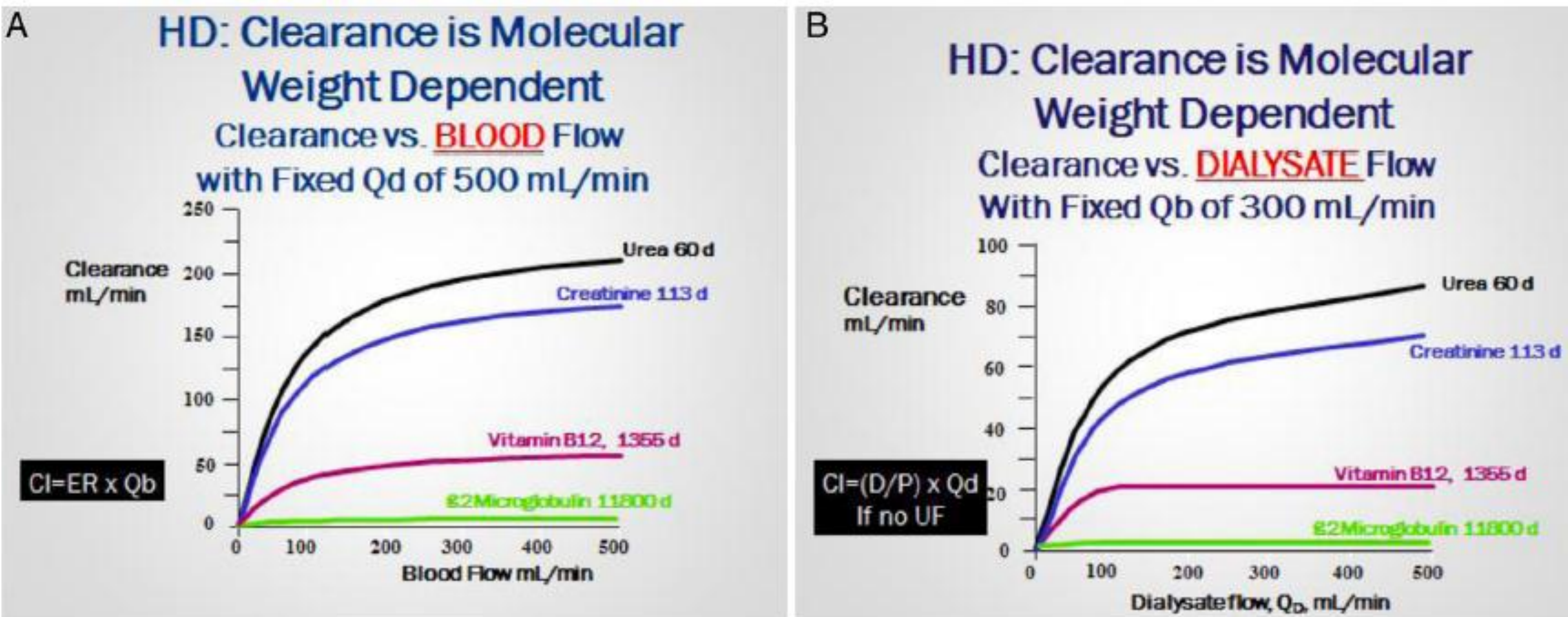
"patients randomized to higher time– average BUN (100 mg/dl) had worse survival than those randomized to lower BUN (50 mg/dl)"

A mechanistic analysis of the National Cooperative Dialysis Study (NCDS)

Gotch & Sargent. *Kidney Int,*1985

"… secondary analysis found a significantly worse survival in patients with ***Kt /V < 0.9****, independently of their treatment time or BUN"*

Measuring the clearance of solutes has become the mainstay for calculating the dose of dialysis and determining its adequacy as delivered



Extraction ratio= (Cin - Cout)/Cin

Golper et al, *AJKD* 2013

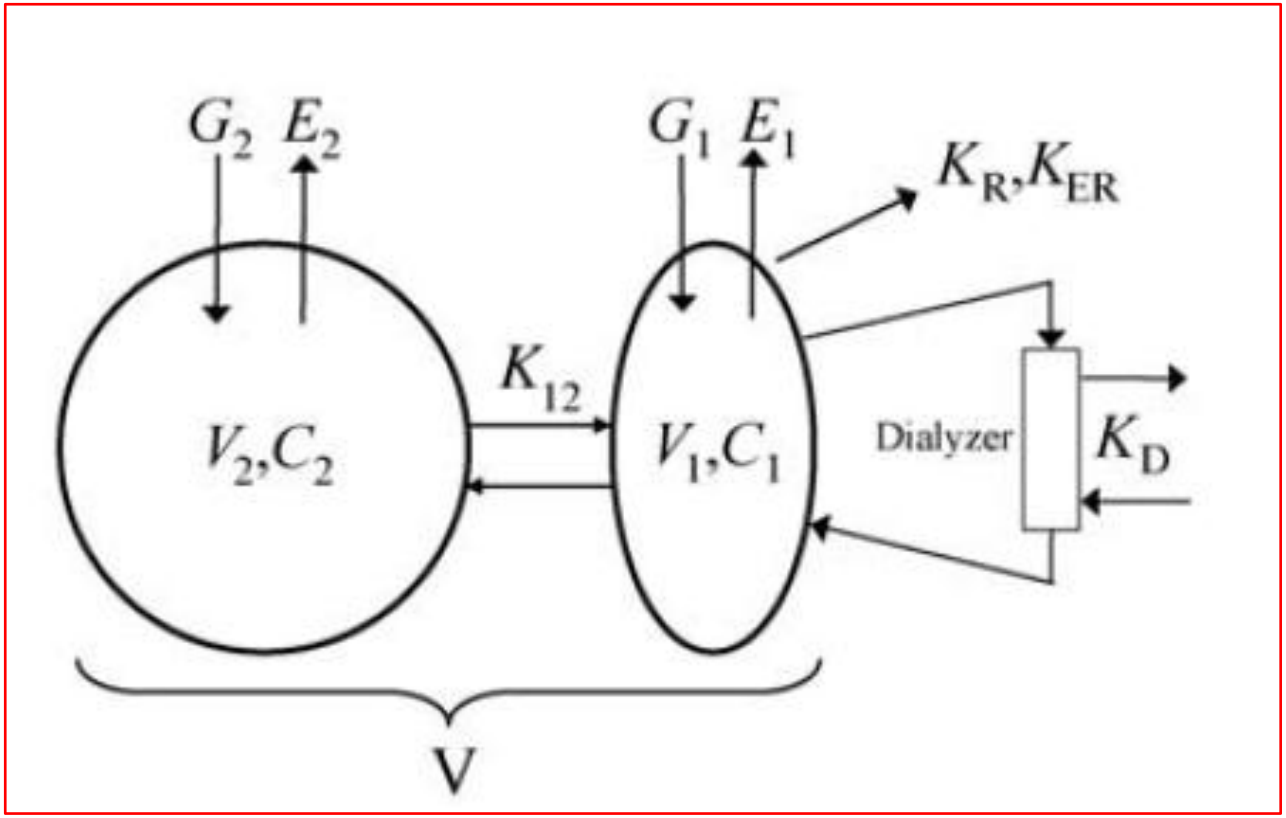
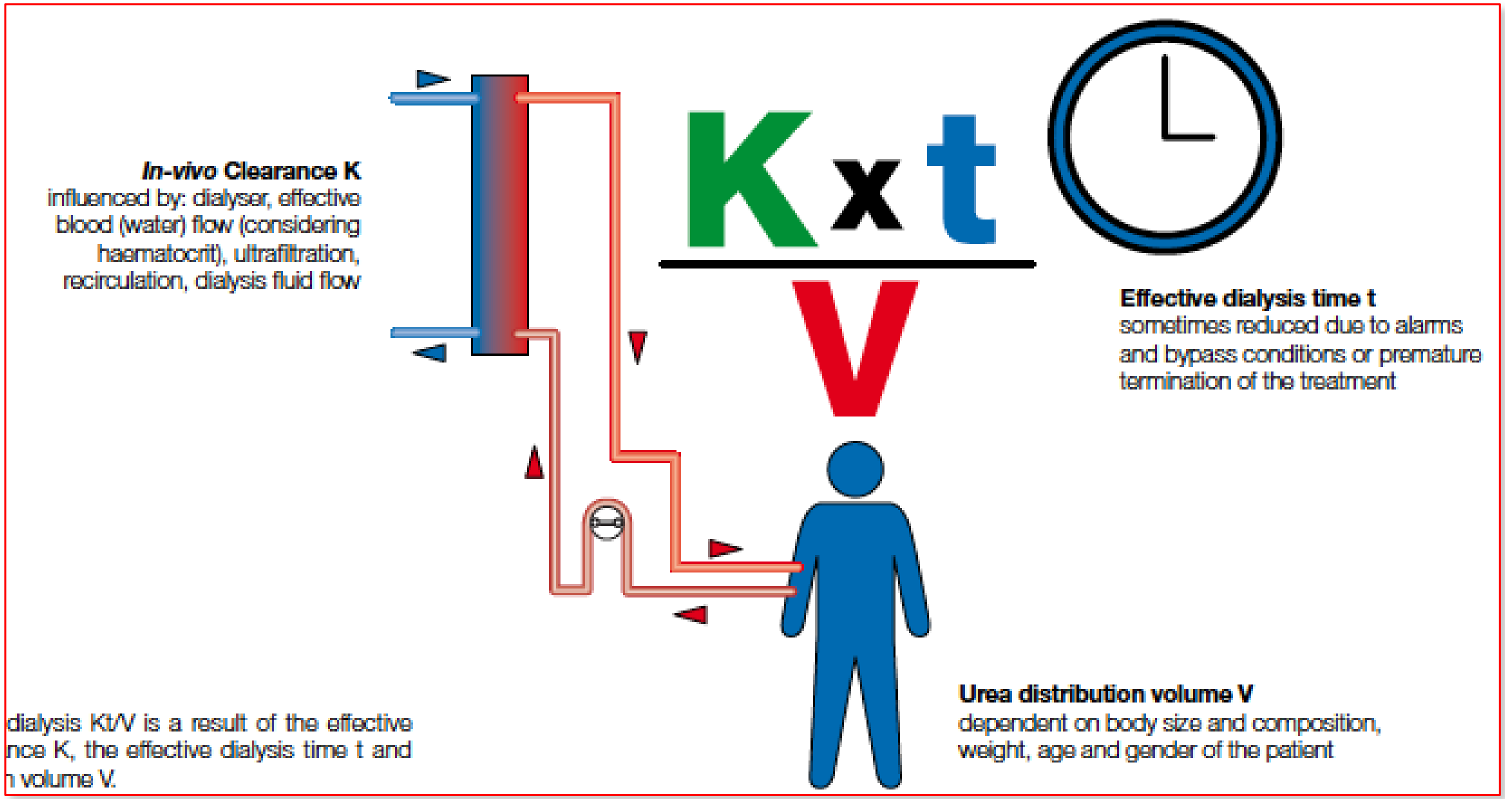


Fig. 2. The classic serial two-compartment model. V_1, plasma volume; V_2, non-plasmatic volume; V, total distribution volume; C_1, plasma concentration; C_2, non-plasmatic concentration; G_1 and G_2, generation rate in V_1 and V_2; E_1 and E_2, metabolic elimination in V_1 and V_2; K_R, renal clearance; K_{ER}, extra renal clearance; K_D, dialyser clearance; K_{12}, intercompartment clearance.

Eloot et al, *NDT* 2012



3.1 We recommend a target single pool Kt/V (spKt/V) of 1.4 per hemodialysis session for patients treated thrice weekly, with a minimum delivered spKt/V of 1.2. (1B)

Guideline 3: Measurement of Dialysis—Urea Kinetics

Urea kinetic modelling--are any of the 'bedside' Kt/V formulae reliable enough?

Aim: to test 'gold-standard' UKM-Kt/V with various shortcut bedside formulae

507 dialysis sessions in 50 patients

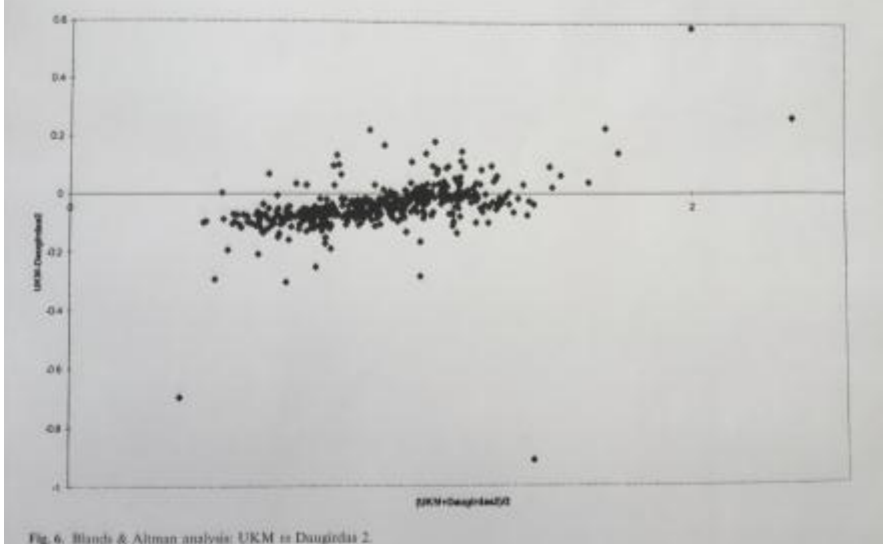


Fig. 6. Blands & Altman analysis: UKM vs Daugirdas 2.

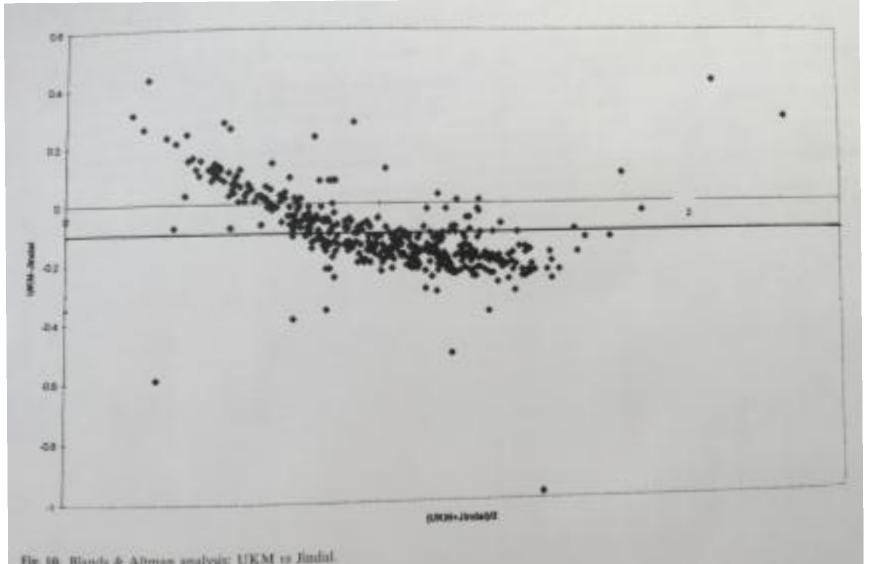


Fig. 10. Blands & Altman analysis: UKM vs Jindal.

Covic et al, *NDT* 1998

Daugirdas 2

$$Kt/V = - \ln (Ct/C0 - 0.008t) + (4 - 3.5 \times Ct/C0) \times Uf/Wt$$

Jindal

$$Kt/V = 0.04 ((C0 - Ct)/C0 \times 100) - 1.2$$

	Mean	DS
UKM	0.949	0.27
Jindal	1.054	0.35
Daugirdas 2	0.995	0.24

Covic et al, *NDT* 1998

Seminars in Dialysis

Editorial 2016

Hemodialysis Time and *Kt/V*: Less May Be Better

James Tattersall
Department of Renal Medicine, St. James's Hospital, Leeds, United Kingdom

- Twice Weekly Dialysis
- Fluid Homeostasis
- Phophate
- Potassium
- Residual Renal Function

J Nephrol
DOI 10.1007/s40620-017-0391-0

REVIEW

Is incremental hemodialysis ready to return on the scene? From empiricism to kinetic modelling

Carlo Basile[1] · Francesco Gaetano Casino[1,2] · Kamyar Kalantar-Zadeh[3,4,5]

Summary of studies examining the association between infrequent HD and clinical outcomes

Obi Y et al AJKD -2016	Incident HD patients (n = 23, 645)	2HD/wk	Greater preservation of RKF. Higher mortality after the first year of dialysis in patients with the lowest RKF
Obi Y et al. JASN – 2016	Incident HD patients (n = 6,538)	2HD/wk	Graded association of RKF decline during the first year of dialysis with all-cause mortality
Mathew AT et al. KI – 2016	Incident HD patients (n = 50,756)	2HD/wk	Comparable results to 3HD/wk initiation for modeled mortality risk in selected patients with adequate RKF and reasonable general health
Park JI et al. NDT – 2017	Incident HD patients (n = 927)	2HD/wk	Comparable results to 3HD/wk initiation for health-related quality of life, RKF and all-cause mortality

*Taken together, the majority of the available literature suggests a **non-inferiority** related to survival, in that there appears to be no overtly harmful effects on survival to patients by reducing dialysis dose so long as a significant RKF is present*

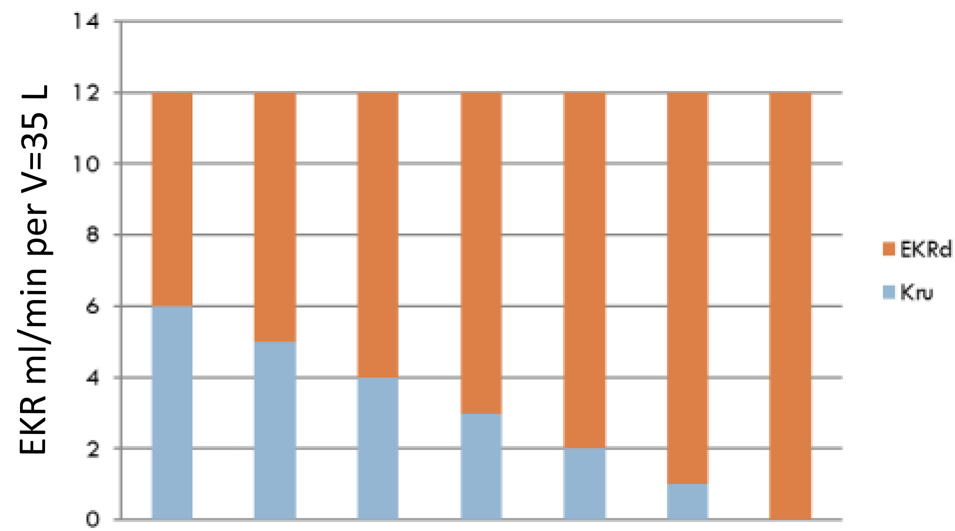
Nephrol Dial Transplant (2017) 32: 182–190
doi: 10.1093/ndt/gfw339
Advance Access publication 14 October 2016

The variable target model: a paradigm shift in the incremental haemodialysis prescription

Francesco Gaetano Casino[1,2] and Carlo Basile[1]

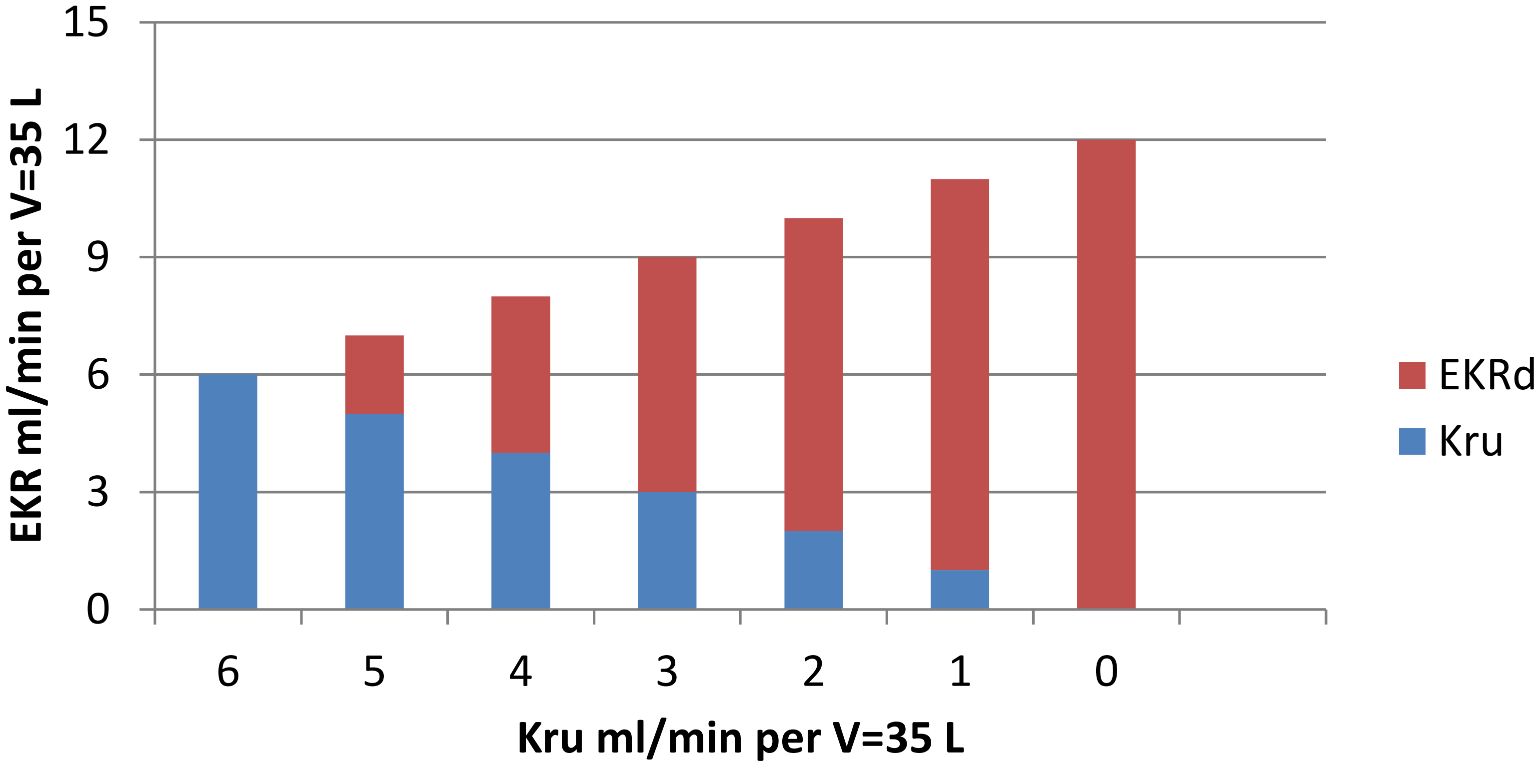
The current guidelines (K/DOQI and European Best Practice Guidelines) advise to achieve a total EKR (dialytic = EKRd + renal = KRU) at least equal to the adequacy value corresponding to an equilibrated Kt/V (eKt/V) of 1.2 in an anuric patient on a 3HD/wk regimen = 12 ml/min/35 L

total EKR = EKRd + KRU = 12 ml/min/35 L



It is the so called **Fixed Target Model** (FTM): the sum of KRU and EKRd should achieve the fixed total EKR target of 12 ml/min/35 L

*The **Variable Target Model (VTM)**, gives more clinical weight to the RKF and allows less frequent HD treatments at lower RKF as opposed to the FTM, based on the wrong concept of the clinical equivalence between KRU and dialytic clearance.*



Casino and Basile, *NDT* 2017

La personalizzazione della terapia emodialitica: la dialisi non è una lavatrice

Antonio Santoro[1]

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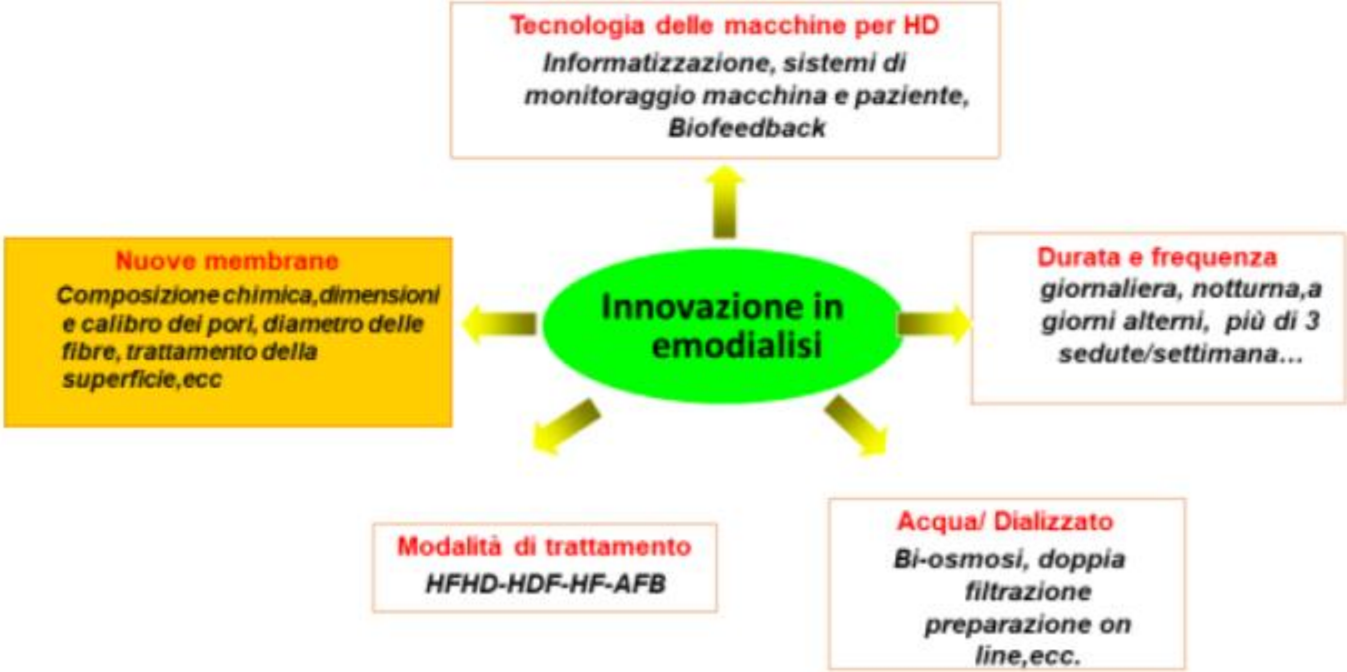
Antonio Santoro

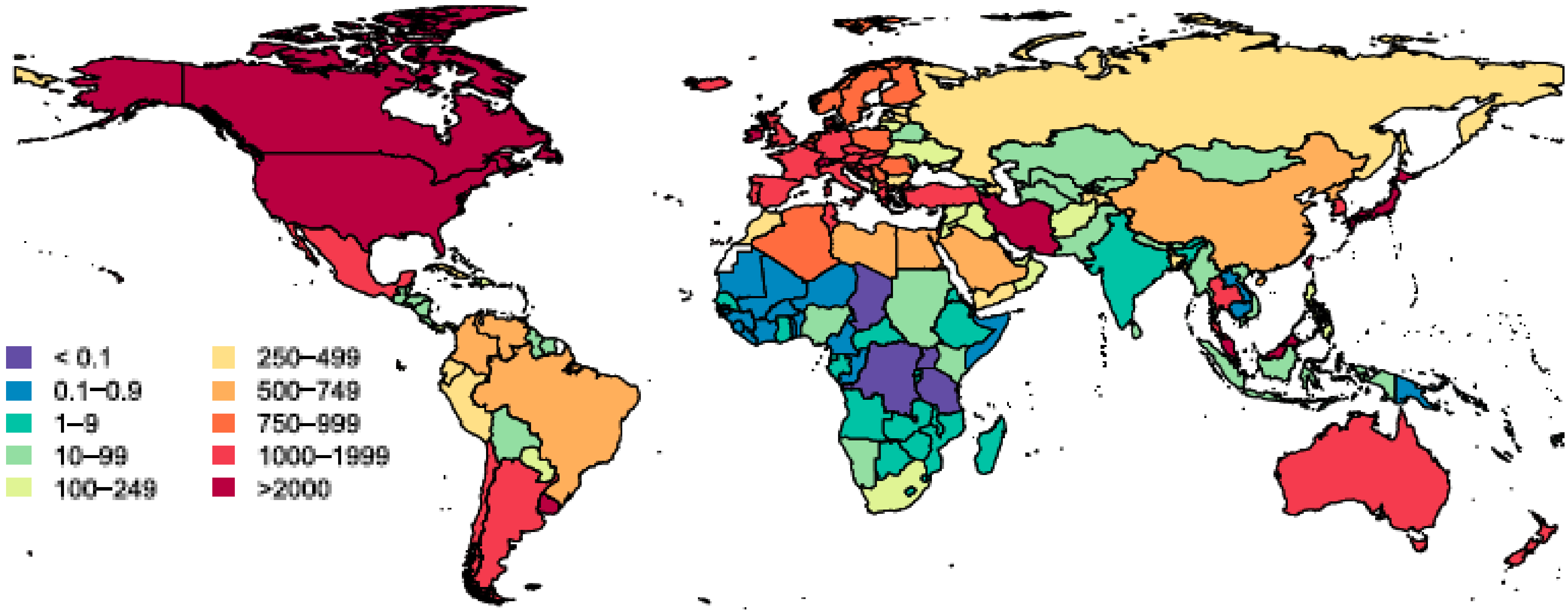


G Ital Nefrol 2017

Il Registro Italiano di Dialisi e Trapianto della Società Italiana di Nefrologia nel 2015 ha censito
42.375 *pazienti in HD,*
4.438 *in PD*
23.467 *portatori di trapianto renale*

La ***prevalenza*** *è risultata di* ***770*** *per milione di abitanti, l'****incidenza*** *era di* ***154*** *pazienti per milione di abitanti*
Circa 7 milioni di trattamenti eseguiti ogni anno in Italia, con un impegno di spesa annua che va oltre i 2 miliardi di euro

Nordio M. Report RDT 2015. Congresso della Società italiana di Nefrologia, Rimini 4-7 ottobre 2017



Thomas B et al, *J Am Soc Nephrol* 2015

Hemodialysis International 2013; 17:474–478

Editorial

It is time for "green dialysis"

INTRODUCTION

On the great global issue of climate change . . . is it, or is it not occurring? . . . and, if it is, is human activity contributing, or is it a purely natural phenomenon? . . . there are "the believers," and the "non-believers."

However, science overwhelmingly supports both notions: That climate change is occurring, and that we have much to answer for as we continue to devastate our natural environment and resources in pursuit of health, wealth, and comfort.[1] And, on both issues, science does now seem to have the "ear" of governments.

As a result, increasing pressure is being brought to bear on all governments—first, developing and third world alike—to increase the use of renewable resources, to reduce greenhouse gas emissions, and to better design and manage waste disposal systems, all in an effort to minimize carbon generation.

In turn, governments are now beginning to impose carbon reduction programs on their populations: A variety of carbon credit and/or trading schemes, carbon tax initiatives, and other mechanisms, in order to lessen their national carbon footprints.[2] Government departments are also being increasingly "required" to submit forward environmental plans that project their contribution to the national and global whole. With this top-down process in

WHERE A NATIONAL APPROACH HAS ALREADY BEEN TAKEN

In the United Kingdom, the National Health Service has encouraged, funded, and actively supported a sustainable health care program and, within it, a Green Nephrology initiative that has changed the face of dialysis programs throughout the United Kingdom within the remarkably short time frame of 3 years since its inception in 2009/2010.[3] In a recent news article in the Green Nephrology network, Frances Mortimer, the director of the Green Nephrology program in the United Kingdom, writes:[4] "commenting on a Green Nephrology study into savings from green initiatives in kidney units, National Clinical Director for Kidney Care, Dr Donal O'Donoghue, said 'it is not unreasonable to expect approaching £1 billion per year saving if the enthusiasm and focused work of the kidney community spread across the whole NHS'."[5]

WATER AND POWER

While it is impossible to precisely quantify the impact of dialysis on global water and power resources and there are no data—either at a global or at a national level—to inform reasonable debate, if estimates[6] that there are

- Use ~156 billion L of water (discarding two-thirds as reject water).[7]
- Consume ~1.62 billion kW/h of power.[7]
- Generate (~2.5 kg per treatment) ~625,000 ton of disposable waste.[8]

John W. M. AGAR
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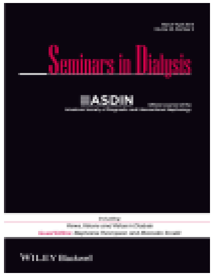

Green Dialysis:
The Environmental Challenges Ahead

1. Minimize water use and wastage
2. Consider strategies to reduce power consumption and/or use alternative power options
3. Develop optimal waste management and reusable material recycling programs
4. Design smart buildings that work with and for their environment

Agar JW, *Semin Dial* 2015

Grazie per l’attenzione