Advances in Hemodialysis Therapy & Technology

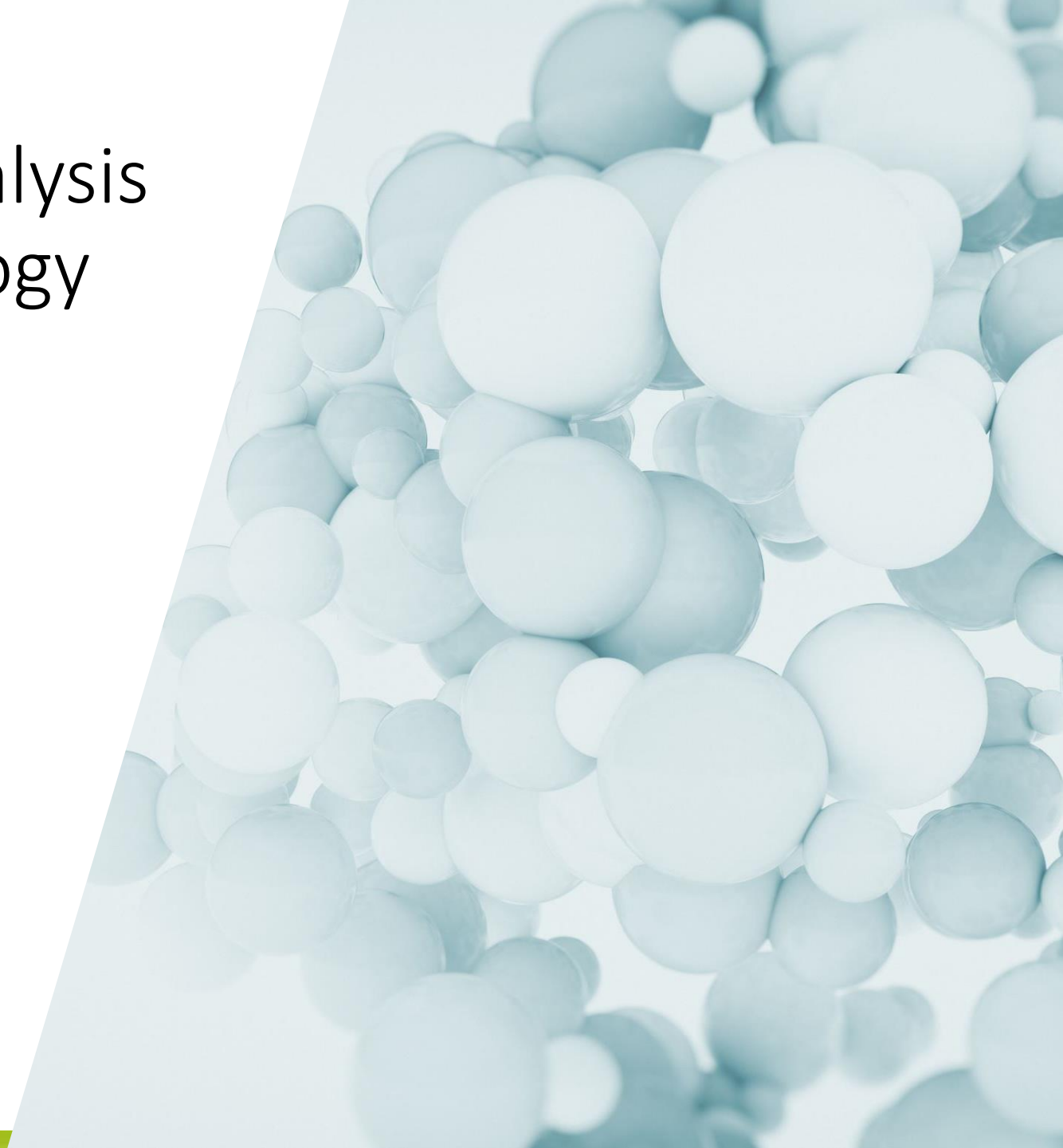
Hesham Elsayed

Emeritus Prof of Nephrology ASU

ESNT president elect

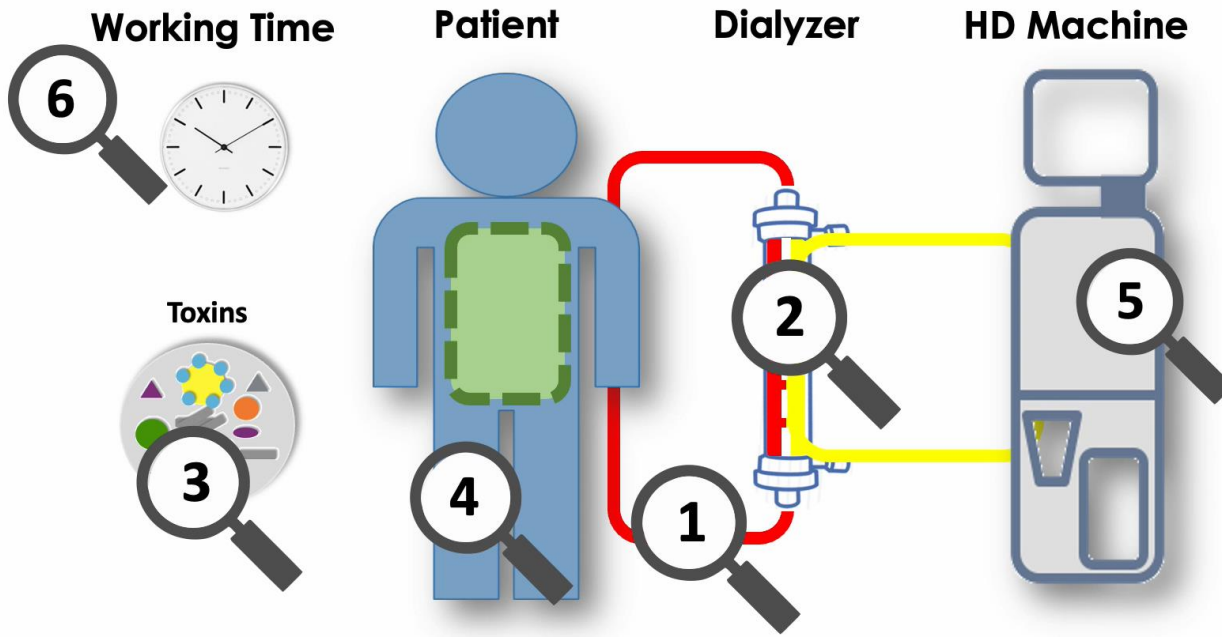
HD chapter chair

HD guideline editor



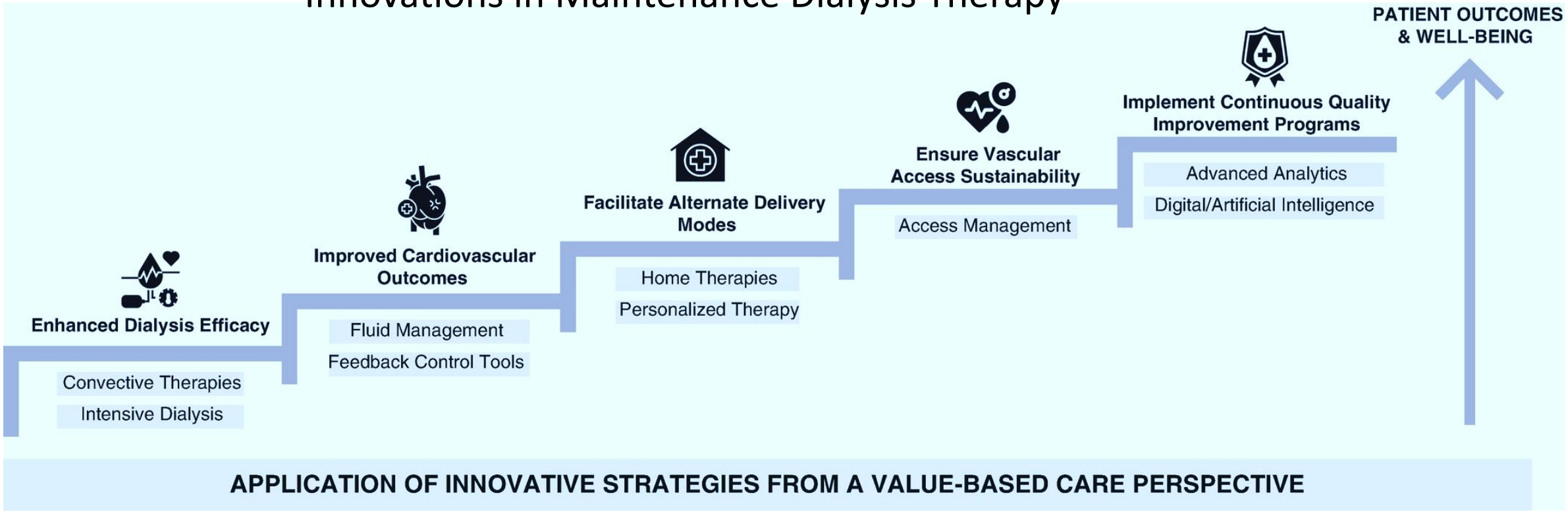
Agenda

- 1- Patient Centered Approach
- 2- Convection therapies , HDF and HDX
- 3- Extracorporeal therapies in ICU
- 4- Volume and Electrolyte control
- 5- DOACs in AF with ESKD patients
- 6- Cellular activation during HD
- 7- Home Hemodialysis
- 8- Future of intracorporeal HD



A Gap between HD Adequacy and Patient Centered Needs : A new Definition for improving outcomes

Innovations in Maintenance Dialysis Therapy



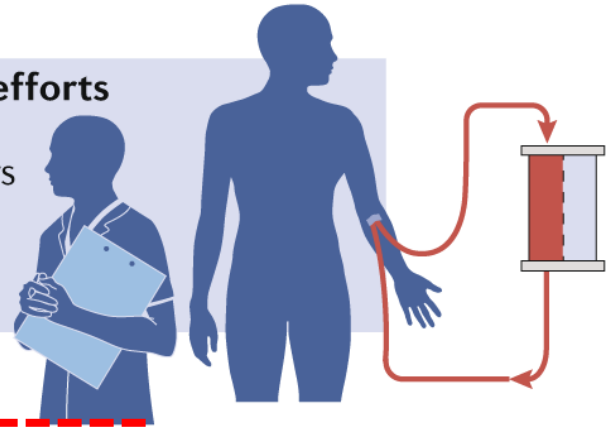
Incremental and collective application of different strategies to target improvement of patient outcomes in terms of reducing morbidity and mortality that is still high for the dialysis population

The current and future landscape of dialysis

Patient priorities
- Physical symptoms (fatigue, insomnia, cramps, pain)
- Mood symptoms (depression, anxiety, frustration, wash-out)
- Rehabilitation priorities (ability to work, ability to travel, impact on family and friends, mobility)

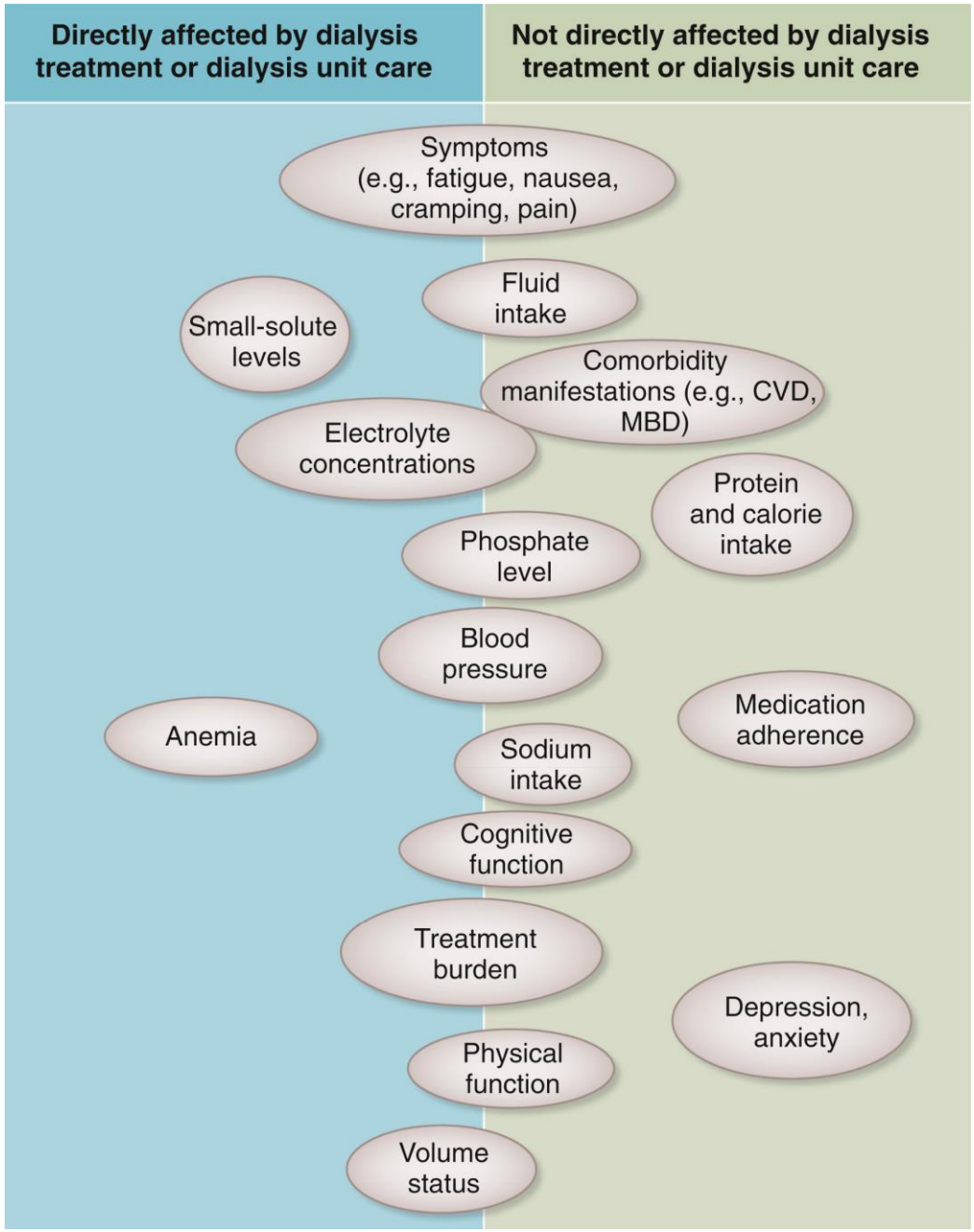
Top-down efforts (by government agencies, societies, NGOs, etc.)
- Regulatory considerations
- Reimbursement and other financial incentives
- Guidance on product development and clinical end points
- Support for comprehensive kidney care strategies
- Policy considerations

Bottom-up efforts
- Patients
- Researchers and innovators

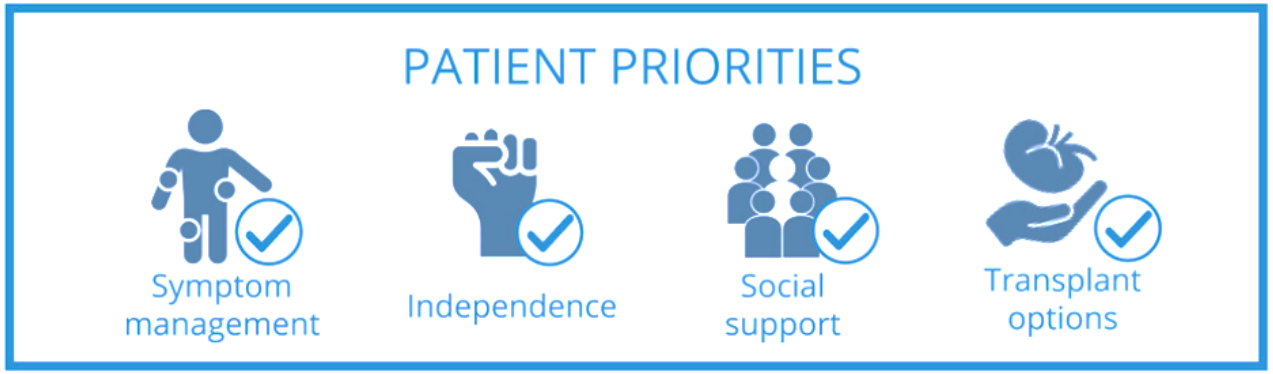


The goal
- Low-cost options
- Miniaturized devices for greater mobility (wearable, portable, implantable)
- Greener, water-efficient technology
- Technology that more closely mimics kidney function
- Better toxin removal
- Improved mortality and morbidity
- Improvements in physical and mood symptoms
- Robust, safe, complication free

Himmelfarb, Nature Reviews Nephrology volume 16, pages573–585 (2020)



Potential targets for goal-directed dialysis care



Providing "Adequate" Dialysis and Symptom

Patients may interpret "adequacy" differently than

The term "adequate dialysis" be changed to "goal-directed dialysis,"

KI REPORTS
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INTERNATIONAL SOCIETY OF NEPHROLOGY

KDIGO Controversies Volume 96, Issue 1p37-47July 2019

Changing the HD Adequacy to beyond Kt/V

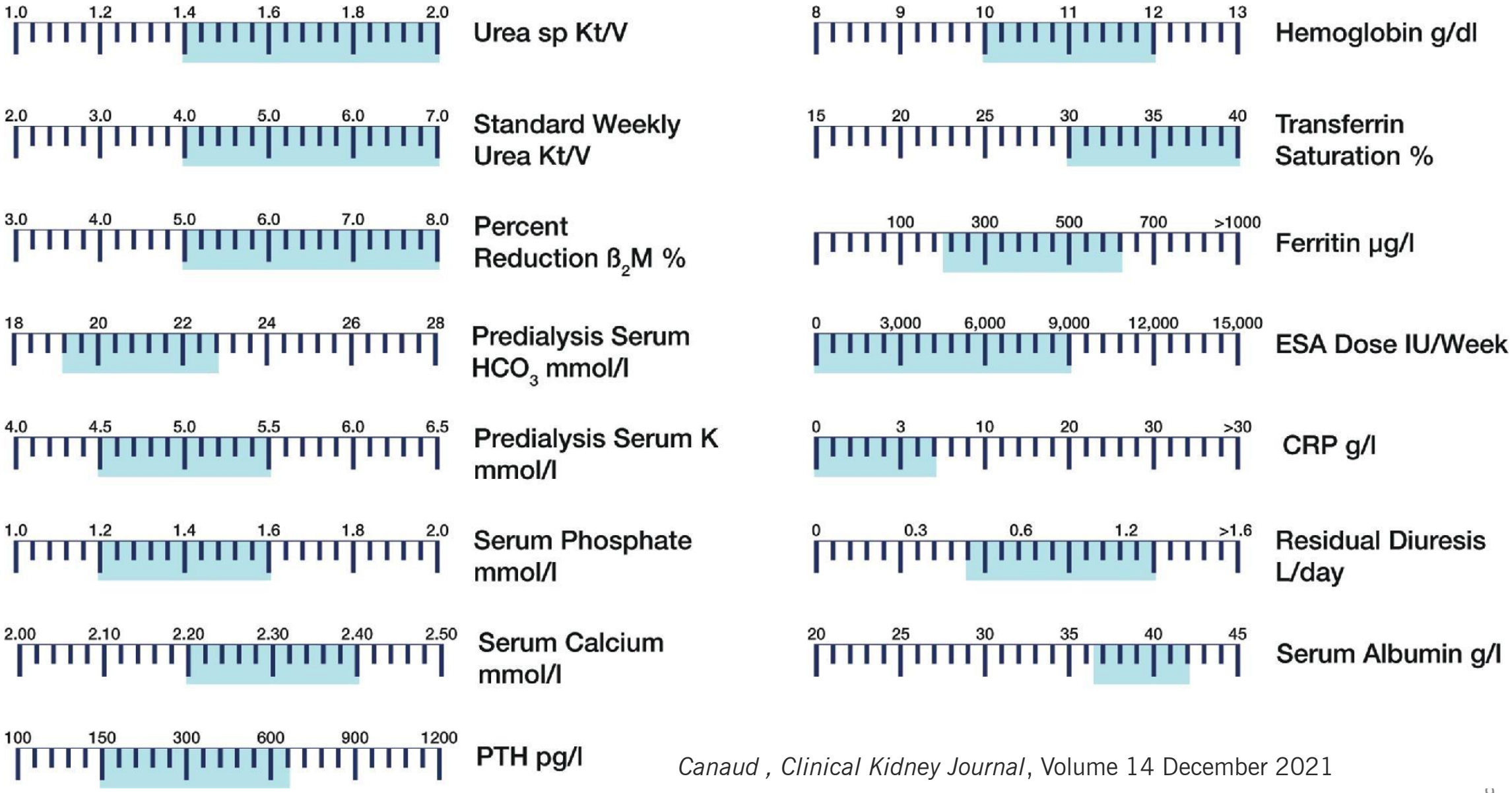
HD adequacy indicators as a broad and multitargeted approach covering individual patient needs

	Indicator	Target
1. Patient perception: Lack of symptomatology	Patient feeling Symptom free	
2. Fluid volume control: Dry weight probing	No edema – No dyspnea BCM – Lung US	
3. Blood pressure control	Pre – Post dialytic BP Heart Rate	
4. Hemodynamic stability – Tolerance	Intra Dialytic Hypotension Postdialysis Fatigue – Recovery time	
5. Dialysis doese monitoring - Small Molecule target - Middle – Large Molecule target	Urea Kt/V (sp/dp) – Iocnic Kt/V OCM Standard wk Kt/V $ß_2$-micoroglubulin % reduction / Predialysis	
6. Acid Base Control – Potassium Control	Serum Bicarbonate pre / post dialysis Serum K pre / post dialysis	
7. Phosphate – Calcium – Bone Metabolism control	Serum Phosphate pre / post dialysis Serum Calcium pre / post dialysis 25OHD3 – PTH	
8. Nutritional status control	SGA Albumin – nPCR – Dietary Caloric/Protein Intake	
10. Inflammation control	Hb – H Iron TSAT – Ferritin	
11. Preservation of residual kidney function	CRP Diuresis Residual GFR	
12. Health related quality of life – Patient reported outcome	HRQOL SF36 EuroQOL	

(high on the left end, low on right end)

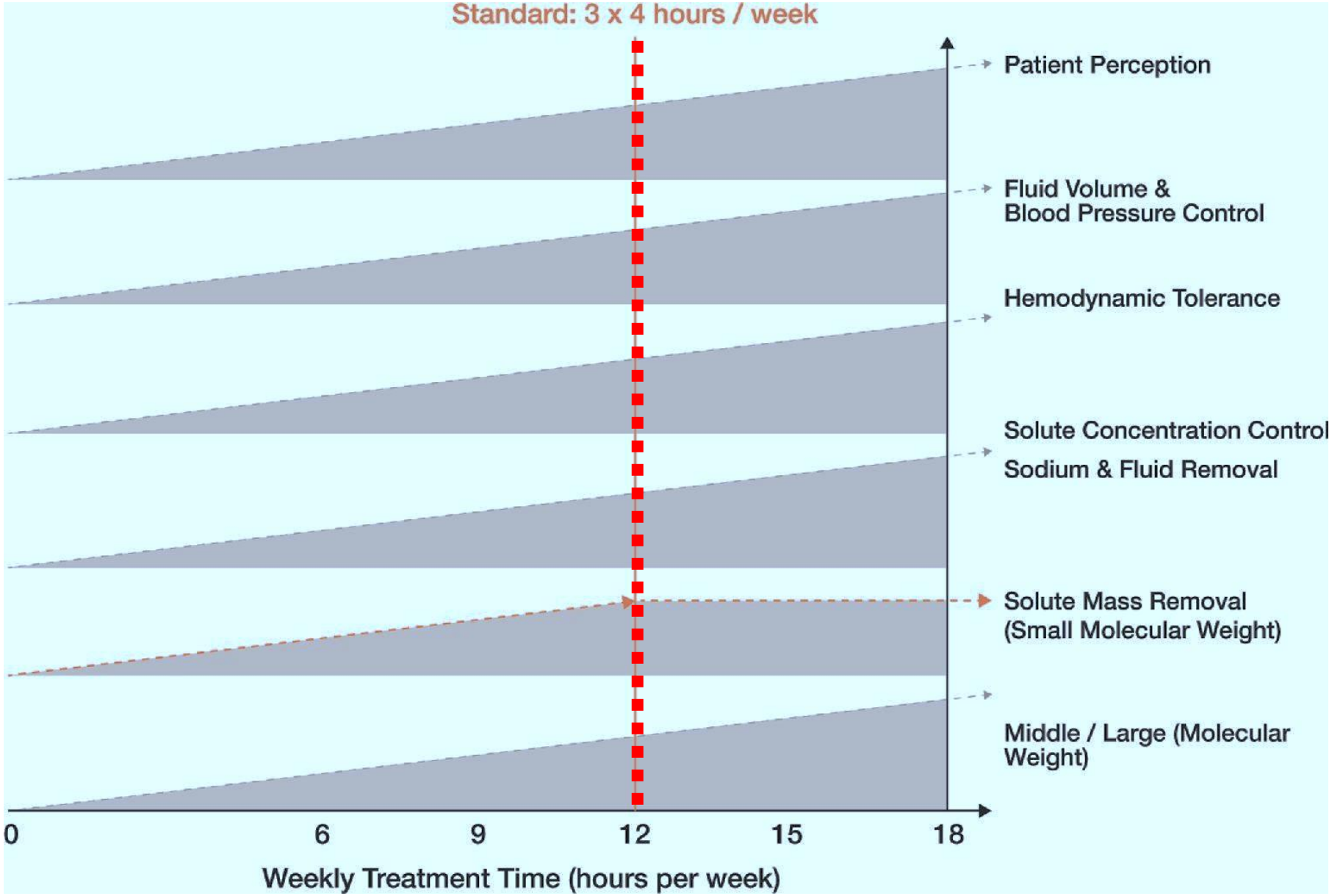
Canaud , Clinical Kidney Journal, Volume 14 December 2021

Key treatment and biochemical indicators used for assessing the adequacy and efficacy of dialysis in individual patients



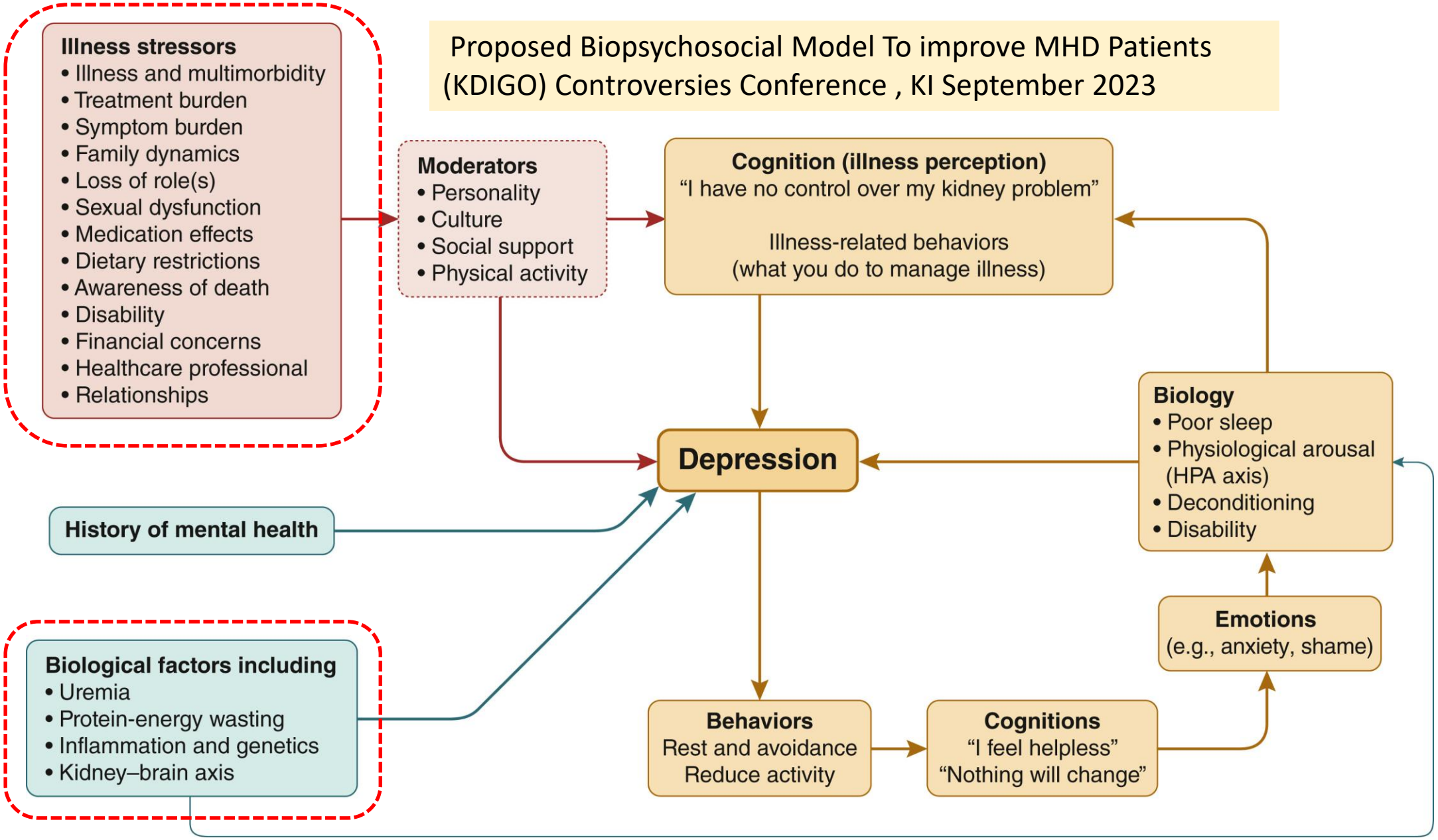
Canaud , Clinical Kidney Journal, Volume 14 December 2021

Impact of the duration of the therapy session (treatment time)



Canaud , Clinical Kidney Journal, Volume 14 December 2021

Proposed Biopsychosocial Model To improve MHD Patients (KDIGO) Controversies Conference , KI September 2023



61ST ERA CONGRESS
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MAY 23-26, 2024

PaCE CKD - The impact of caregiving on health states and work productivity in chronic kidney disease: results from an international survey

Hesham M Elsayed,[1] Helmut Reichel,[2] Janani Rangaswami,[3] Ciro Esposito,[4] Richard Hull,[5] Ricardo Correa-Rotter,[6] Mai-Szu Wu,[7] Steven Chadban,[8] Juan Jose Garcia Sanchez,[9] Surendra Pentakota,[10] Thames Kularatne,[11] Simon Fifer[11]

[1]Ain Shams University Faculty of Medicine, Cairo, Egypt; [2]Nephrologisches Zentrum Villingen Schwenningen, Villingen-Schwenningen, Baden-Württemberg, Germany; [3]Nephrology Division, Washington DC VA Medical Center; Nephrology Division, George Washington University School of Medicine, Washington, DC; [4]Nephrology, IRCCS Maugeri, University of Pavia, Pavia, Italy; [5]St George's University Hospitals NHS Foundation Trust, London, United Kingdom; [6]National Institute of Medical Sciences and Nutrition Salvador Zubiran, Mexico City, Mexico; [7]Taipei Medical University, Taipei, Taiwan; [8]Royal Prince Alfred Hospital, Camperdown, NSW, Australia; [9]Health Economic and Payer Evidence, BioPharmaceuticals, AstraZeneca, Cambridge, United Kingdom; [10]Medical Affairs, BioPharmaceuticals, AstraZeneca, Cambridge, United Kingdom [11]CaPPRe: Community and Patient Preference Research, Sydney, NSW, Australia

KEY FINDINGS

This multinational survey shows caregiving for patients with chronic kidney disease (CKD) can lead to **considerable productivity losses to carers**

Caregivers of patients with CKD also experience a **reduction in health-related quality of life**

According to CarerQol-7D responses, caregivers report requiring support with their duties, problems with balancing caregiving with their daily life, and financial problems, which contribute to the **substantial detriment to their quality of life**

CONCLUSIONS

This global survey of informal caregivers of those at all stages of CKD establishes that **there is a global quality of life burden** for informal caregivers of those with CKD

By supporting those living with CKD, **caregivers experience financial burden** including through reduced work productivity, particularly when caring for those with advanced disease

Introduction

- Patients with CKD rely on caregivers for support with their disease, particularly as their condition worsens.
- Informal caregiving is associated with improved adherence to treatment regimens and patient health-related quality of life (HRQoL)[1]
- However, the impact of informal caregiving on the HRQoL for caregivers across all stages of CKD is unknown[2]
- Furthermore, limited data are available regarding the global burden of CKD on caregivers' work productivity and financial well-being[3]

Objective

To quantify the effect of CKD on informal caregivers' quality of life and work productivity across seven countries compared with matched general populations

Methods

- Informal caregivers of adults with CKD were enrolled to a non-interventional survey
- Recruitment took place in Egypt, Germany, Italy, Mexico, Taiwan, the UK and USA
- A general population cohort was also enrolled, matched for age, gender, and area of residence
- Work productivity was measured using the Work Productivity and Activity Impairment questionnaire by caregivers and the matched general population
- HRQoL was measured by ED-5D-5L index scores versus the matched general population and by dialysis status
  EQ-5D-5L could not be assessed in the Italian cohorts
- CarerQol-7D was measured via several domains including support with carrying out care tasks, financial problems because of care tasks and problems combining care tasks with daily activities
  Outcomes were stratified by the dialysis status of the patient

Definitions
Dialysis – self reporting as receiving dialysis
Non-dialysis - all those who do not report as receiving dialysis

Results

Table 1. Caregiver demographics and duties

	EGY	DEU	ITA	MEX	TWN	GBR	USA
Enrolled (n)	97	99	102	138	94	116	113
Dialysis status (%)†	54	65	25	65	48	67	81
Gender, male (%)	32	56	21	43	35	49	47
Employed (%)	46	72	71	90	71	79	85
Stage of CKD of person being cared for (%)							
Stage 1-2	30	21	30	33	11	13	12
Stage 3-4	34	66	51	57	54	57	51
Stage 5/KRT‡	34	8	13	9	35	24	35
Don't know	2	5	6	1	0	6	2
Caring for (%)§							
Parent	22	29	25	28	29	44	45
Partner	42	37	40	32	30	26	26
Other	36	33	35	41	41	30	29
Caring required (%) §							
Taking medications	87	88	56	83	55	88	88
Transport to/from hospital appointments	86	90	77	86	80	77	89

† Refers to the percentage of caregivers caring for a patient with CKD who is receiving dialysis

‡ Includes patients self-reporting as CKD stage 5 or dialysis treatment or transplant

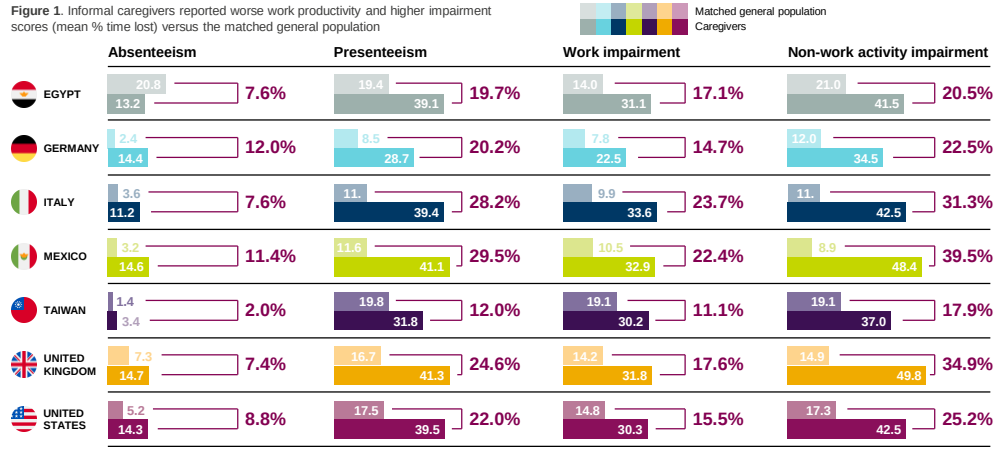
§ The remainder of caregivers enrolled may also care for a child, sibling or friend.

Caregiving duties may include accompanying or driving to/from medical appointments, help with general household tasks, help with personal care and providing emotional support.

KRT: kidney replacement therapy

Informal caregivers of patients with chronic kidney disease experience work productivity and activity impairment

Figure 1. Informal caregivers reported worse work productivity and higher impairment scores (mean % time lost) versus the matched general population



Informal caregivers of patients with chronic kidney disease reported reduced quality of life, particularly for those caring for patients on dialysis according to CarerQoL-7D measures

Figure 2. EQ-5D-5L index scores of informal caregivers of patients with CKD versus the general population

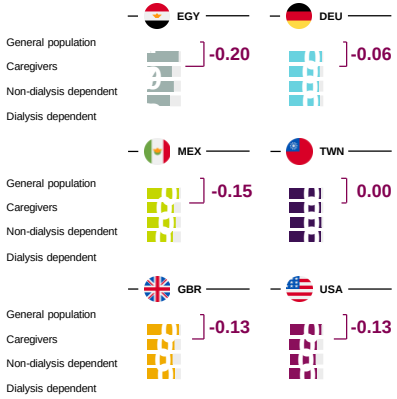
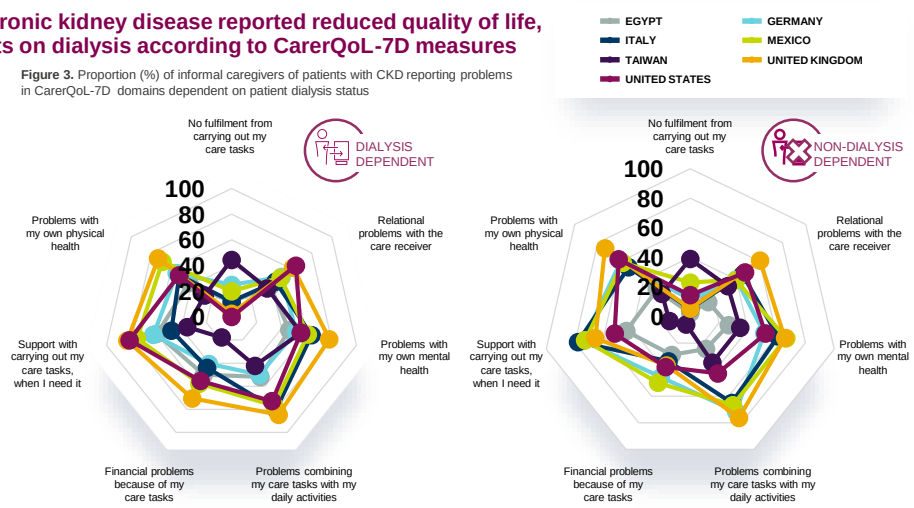


Figure 3. Proportion (%) of informal caregivers of patients with CKD reporting problems in CarerQoL-7D domains dependent on patient dialysis status

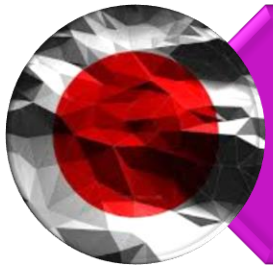


Acknowledgments
This research was supported by AstraZeneca. Medical writing support was provided by Peter Gabb and Rowena Jenkins of Health Economics and Outcomes Research Limited.

References
1. Ibrahim et al. *PLOS ONE*. 2015;10(7):e0129015; **2.** Adejumo et al. *Ghana Med J*. 2016;50(3):190-6; **3.** Michalopoulos et al. *Kidney Med*. 2022 Mar 7;4(4):100439.

International Trends in Mortality on Hemodialysis Through Changes in Hemodialysis Practices in the Dialysis Outcomes and Practice Patterns Study (DOPPS) *AJKD January 2025*

In Europe, we observed a 13% improvement in overall case-mix adjusted survival per decade. Trends in facility practice measures, especially Kt/V and phosphorus, explained 10% improvement in case-mix survival per decade, (10% explained of 13% improvement) of the observed improvement.



In Japan, 12%/decade improvement in case-mix adjusted survival could be attributed to facility practices, especially Kt/V and IDWG.

In the United States, 47%/decade improvement in case-mix adjusted survival could be attributed to facility practices, especially AVF use and phosphorus control.

AJKD January 2025

International Trends in Mortality on Hemodialysis Through Changes in Hemodialysis Practices

Aim and Population

DOPPS
Dialysis Outcomes and Practice Patterns Study

Observational prospective cohort study

Adult patients treated with hemodialysis:

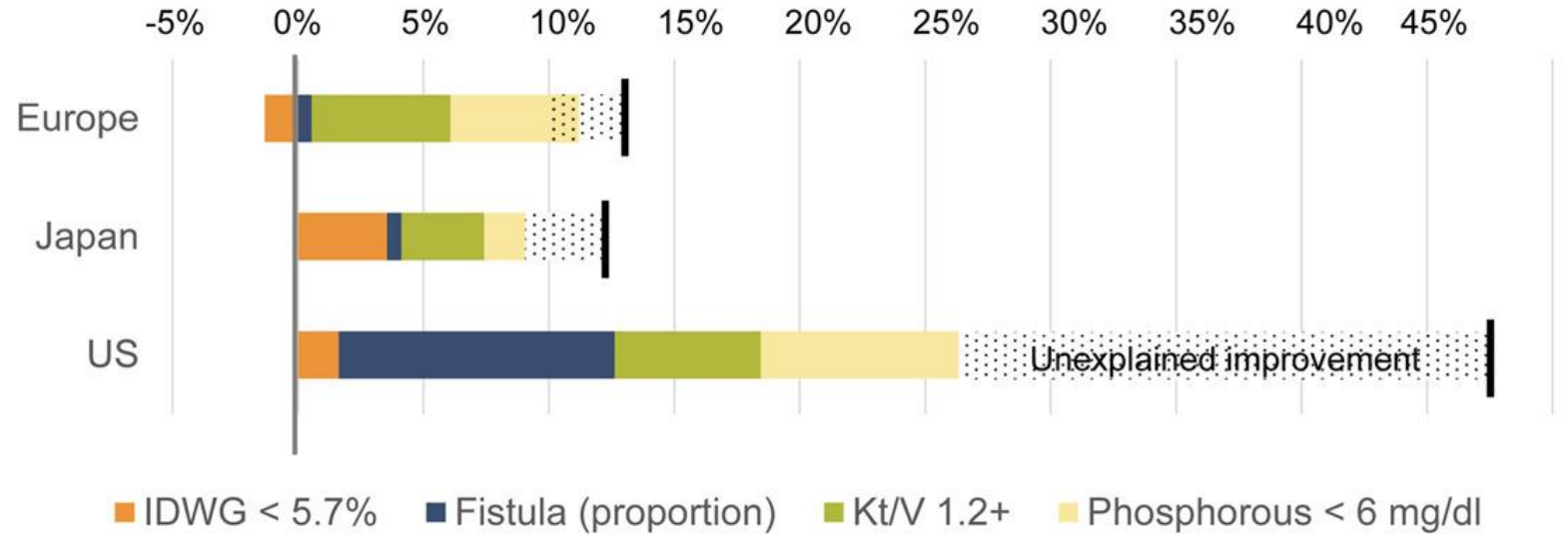
- **Europe*:** 26,264 patients
- **Japan:** 27,121 patients
- **US:** 34,773 patients

**Germany, Italy, Spain, & UK*

Findings

HD practices change over time, but trends differ by region

Proportional improvement in case-mix adjusted survival/decade mediated through practices



CONCLUSION: Improvements in adjusted HD patient survival in Europe, Japan, and the US from 1999-2015 can be largely explained by improvements in specific facility practices.

Keith P. McCullough, Hal Morgenstern, Hugh C. Rayner, et al

@AJKDonline | DOI: 10.1053/j.ajkd.2024.06.017

AJKD
American Journal of Kidney Diseases

Contributors to frailty in CKD and HD patients

Cognitive impairment
Depression
- Impaired executive function and neurophysiological activity
- Gait imbalance and incoordination

Malnutrition and protein-energy wasting
- Dietary restriction
- Impaired energy utilization

Uremia and inflammation
- Accelerated aging
- Immunosenescence

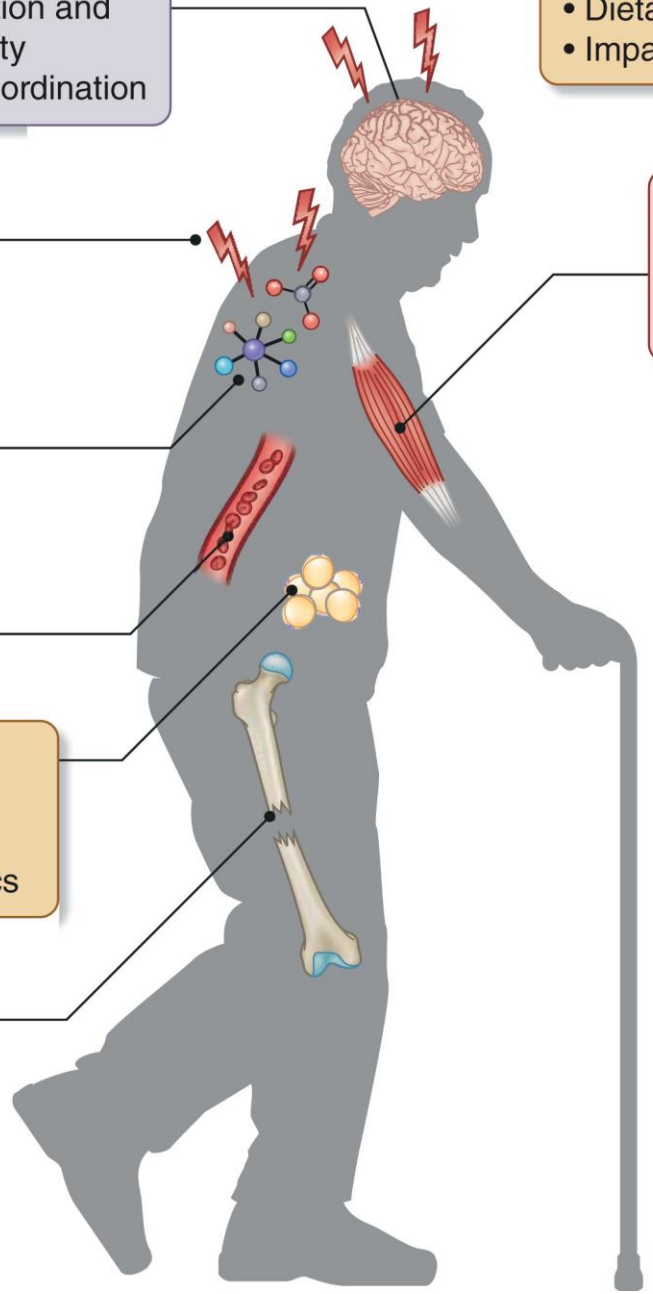
Sarcopenia
- Impaired anabolic hormone action
- Disrupted muscle metabolism
- Disuse atrophy

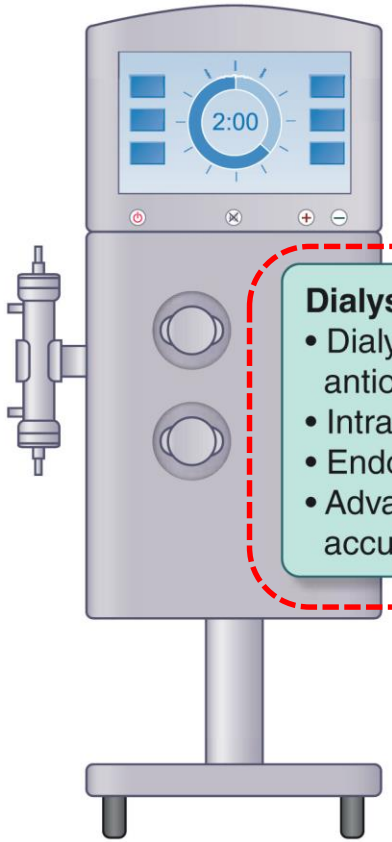
Polypharmacy
- Drug interactions
- Adverse drug events
- Drug nonadherence

Anemia
- Erythropoietin deficiency

Obesity
- Adipose browning
- Proinflammatory adipokine production
- Disrupted muscle contraction kinetics

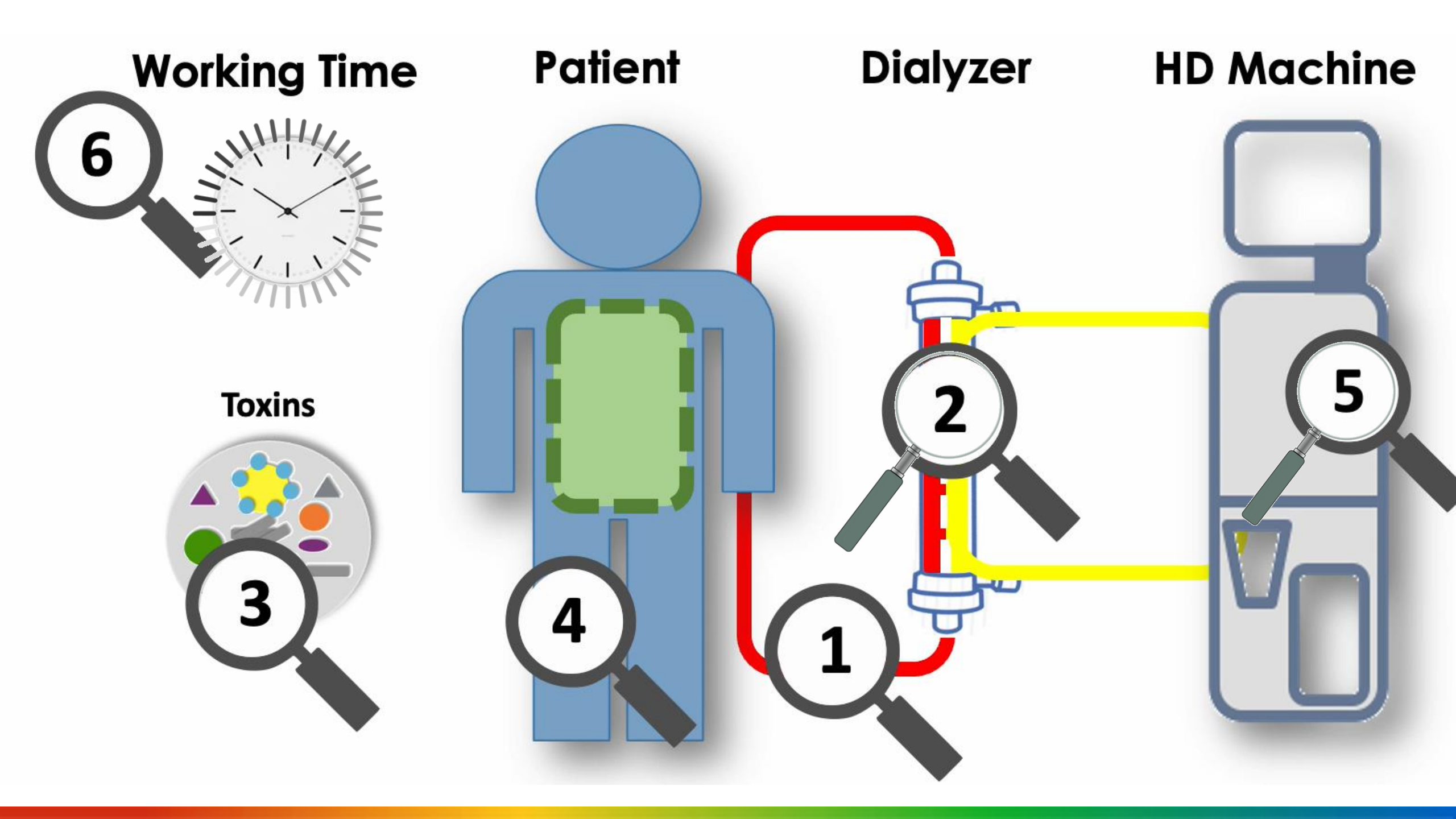
CKD–mineral bone disease
- Bone fragility and muscle incoordination
- Vascular calcification
- Impaired response to erythropoiesis-stimulating agents (ESA)





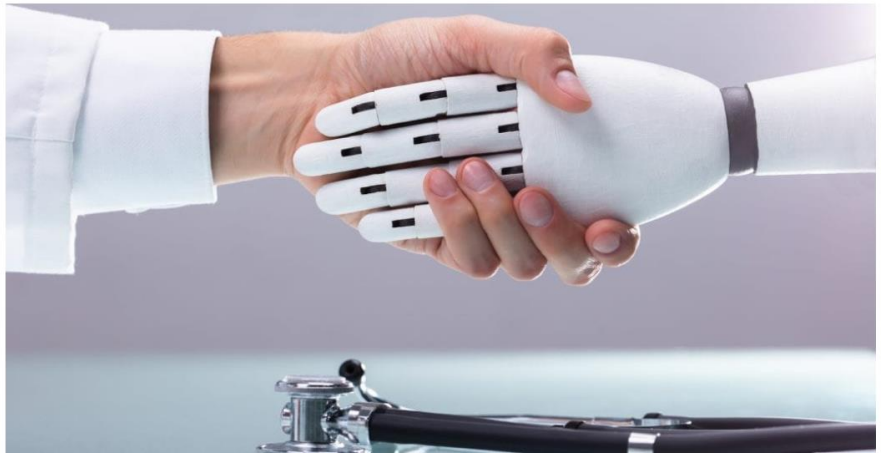
Dialysis-related factors
- Dialysis loss of nutrients and antioxidants
- Intradialytic hypotension
- Endotoxemia
- Advanced glycated end-product accumulation

Gordon , Kidney International , July 2024


Working Time
Patient
Dialyzer
HD Machine
6
Toxins
3
4
2
1
5

Could AI improve care for patients with kidney failure?

8th November 2019



AI in the Dialysis Space

Predicting intradialytic hypotension
Improve anemia management
Dialysis Adequacy
HD Machine K Testing and monitoring

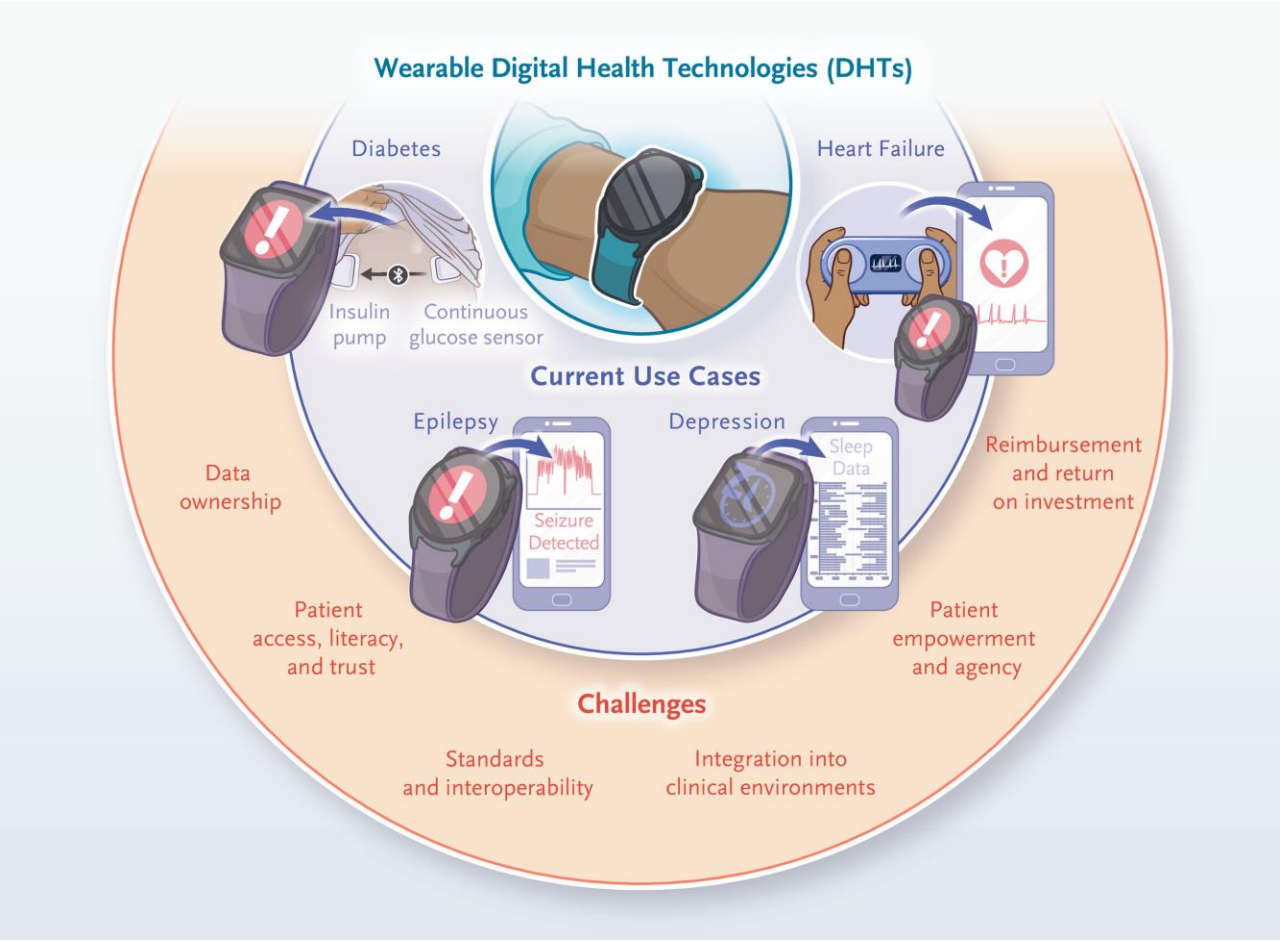
Innovation in dialysis delivery systems is needed to build an adaptive and self-improving process

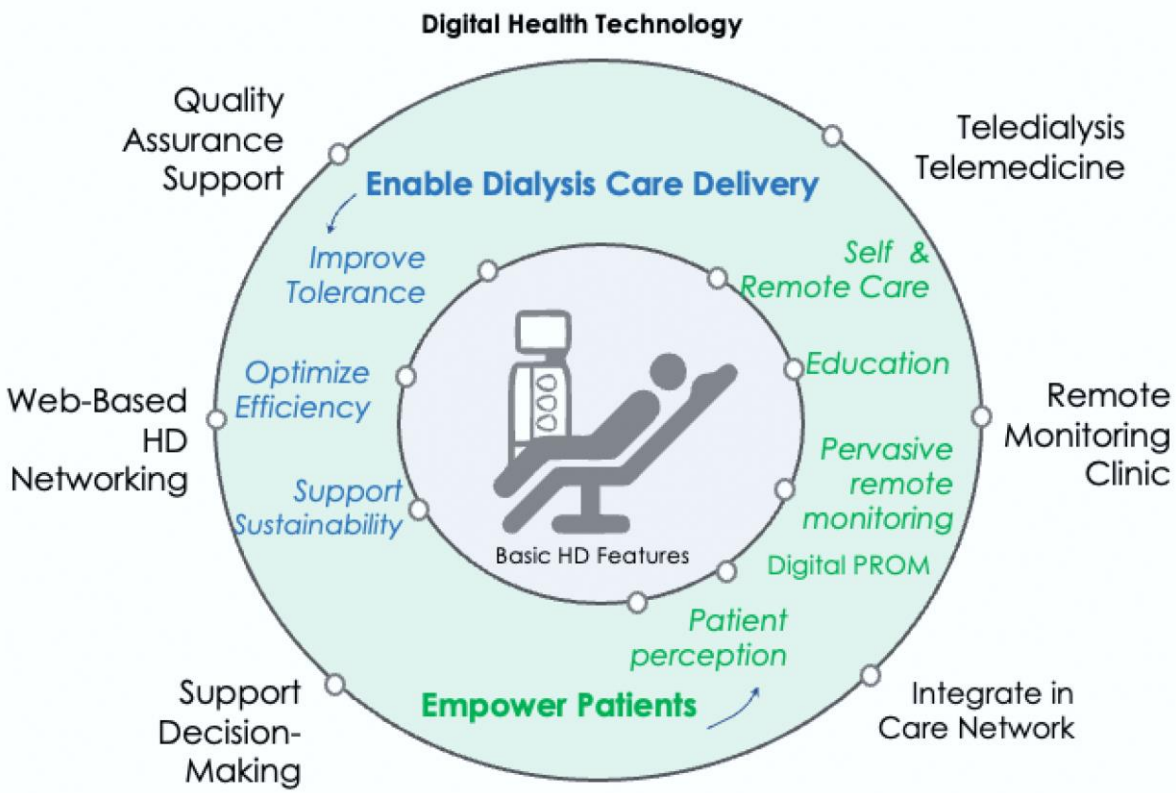
Minimizing the metabolic and hemodynamic “roller coaster” to change the status quo of dialysis care

The aim of transforming it from being reactive to being proactive

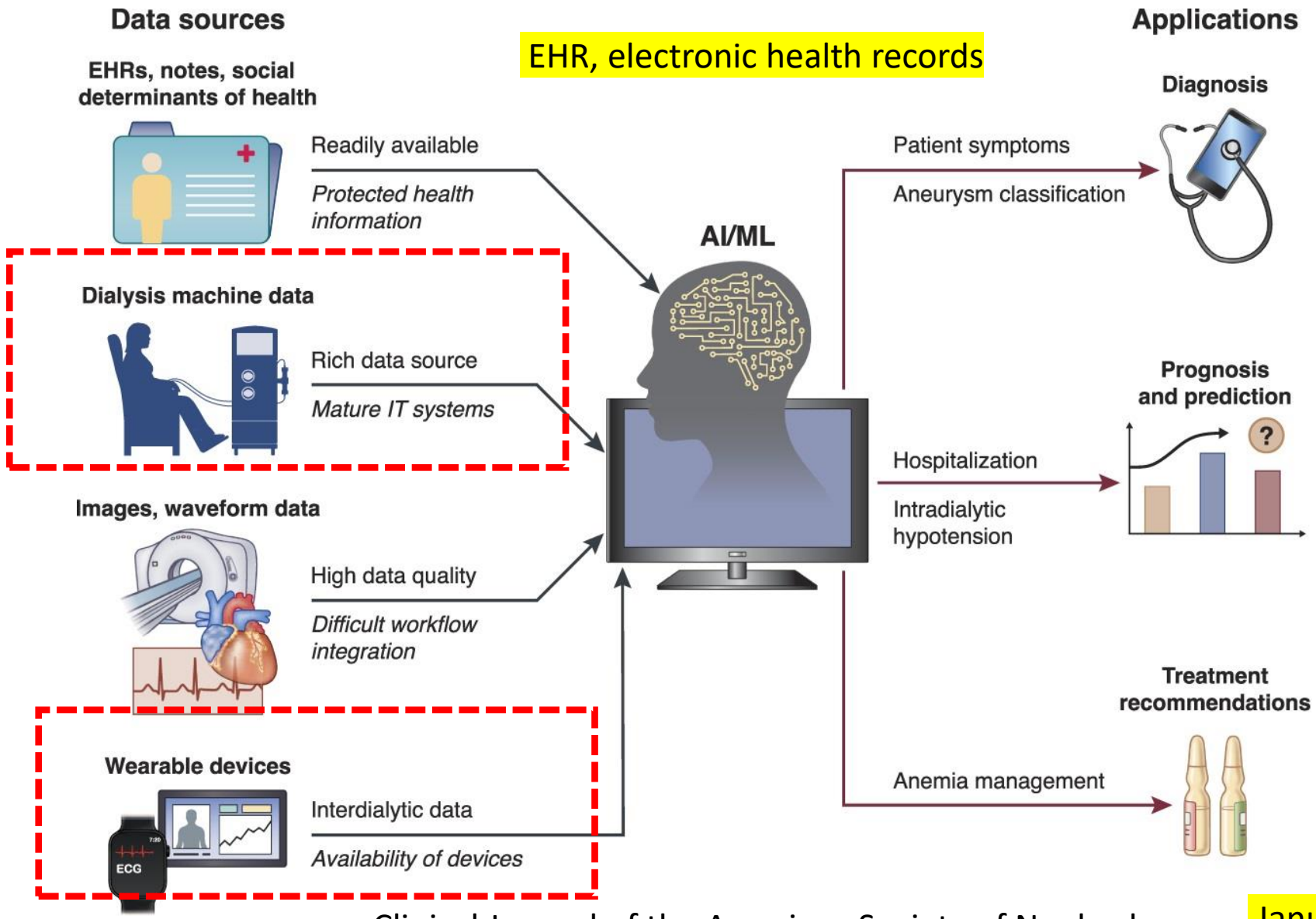
Nobakht, Kidney Medicine , September 2024

Integrating digital health technology (DHT) in HD





Geoffrey , N Engl J Med March 2024



EHR, electronic health records

Clinical Journal of the American Society of Nephrology January 27, 2023.

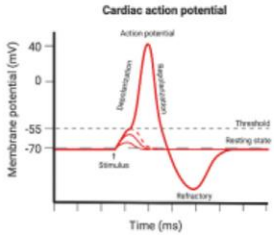
Deep Learning Using Electrocardiograms in Patients on Maintenance Dialysis

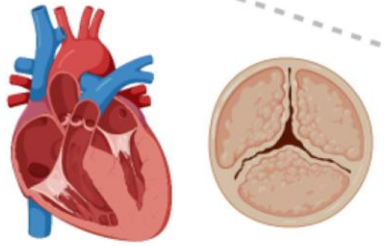
Arrhythmia prediction

To predict arrhythmia during dialysis based on 10 second EKG at the beginning of dialysis. Allowing real time change in dialysis prescription

Electrolyte abnormality prediction

Prediction of electrolytes prior to HD treatment will allow personalized dialysis prescriptions and in the future using wearables or single lead use AI EKG will help predict extreme changes in electrolytes in patients during interdialytic periods





Structural heart condition prediction

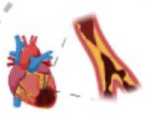
Structural heart abnormalities are common in dialysis population early detection, screening and monitoring with AI-EKG provides a novel opportunity

Intradialytic hypotension prediction

SBP drop ≥20 mmHg
or MAP drop ≥20 mmHg

Prediction of IDH based on EKG at the start of dialysis session

Future directions



To predict ischemic events, stroke, sudden cardiac death and avoid hemodialysis related cardiac events by personalized real time updated prescription changes

- 1- Patient Centered Approach
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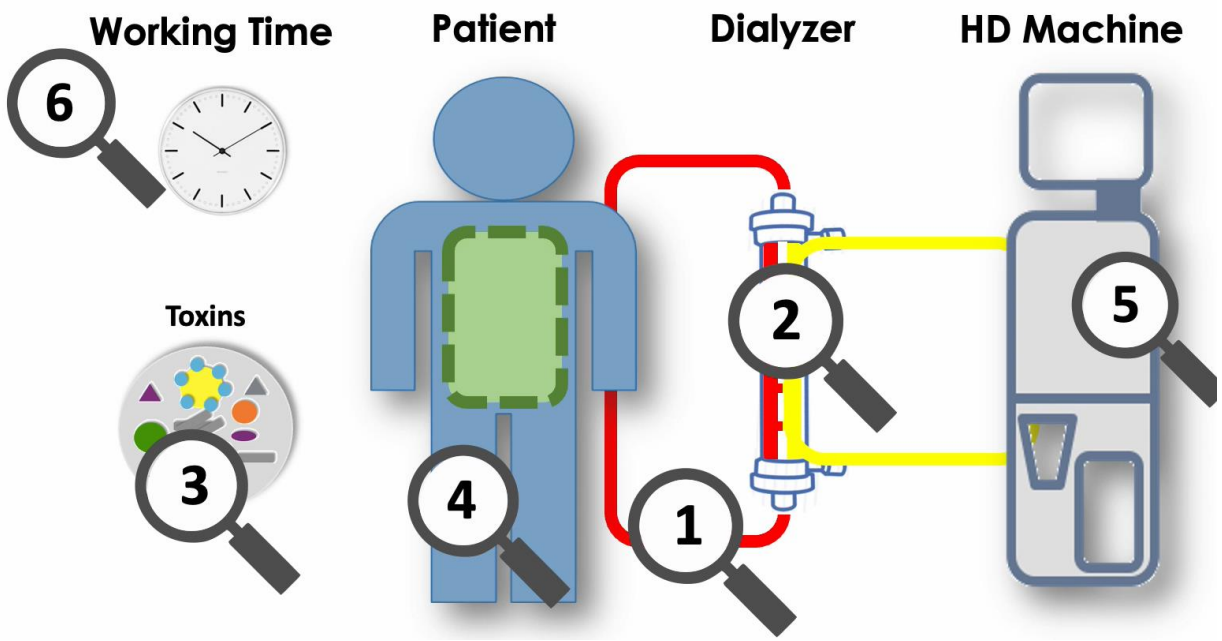
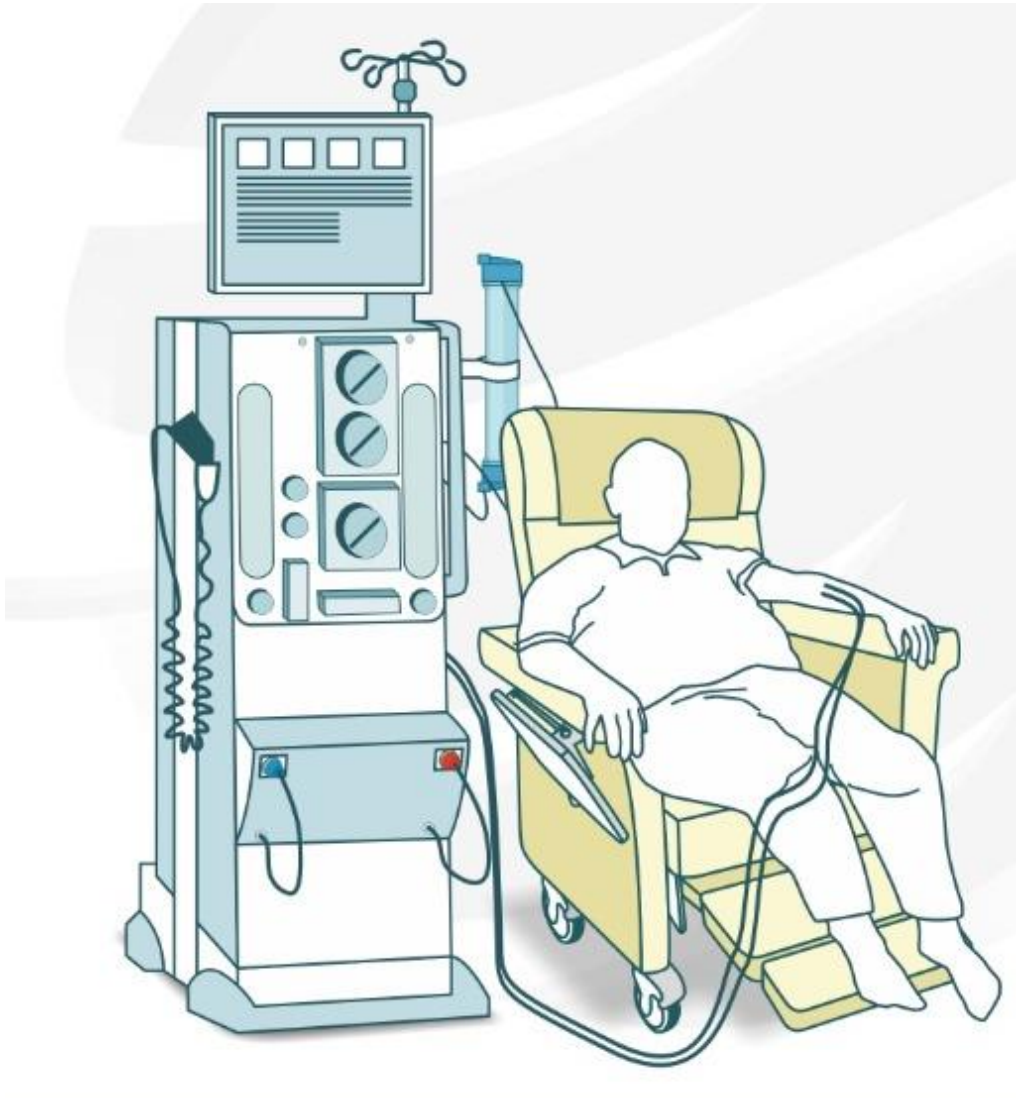
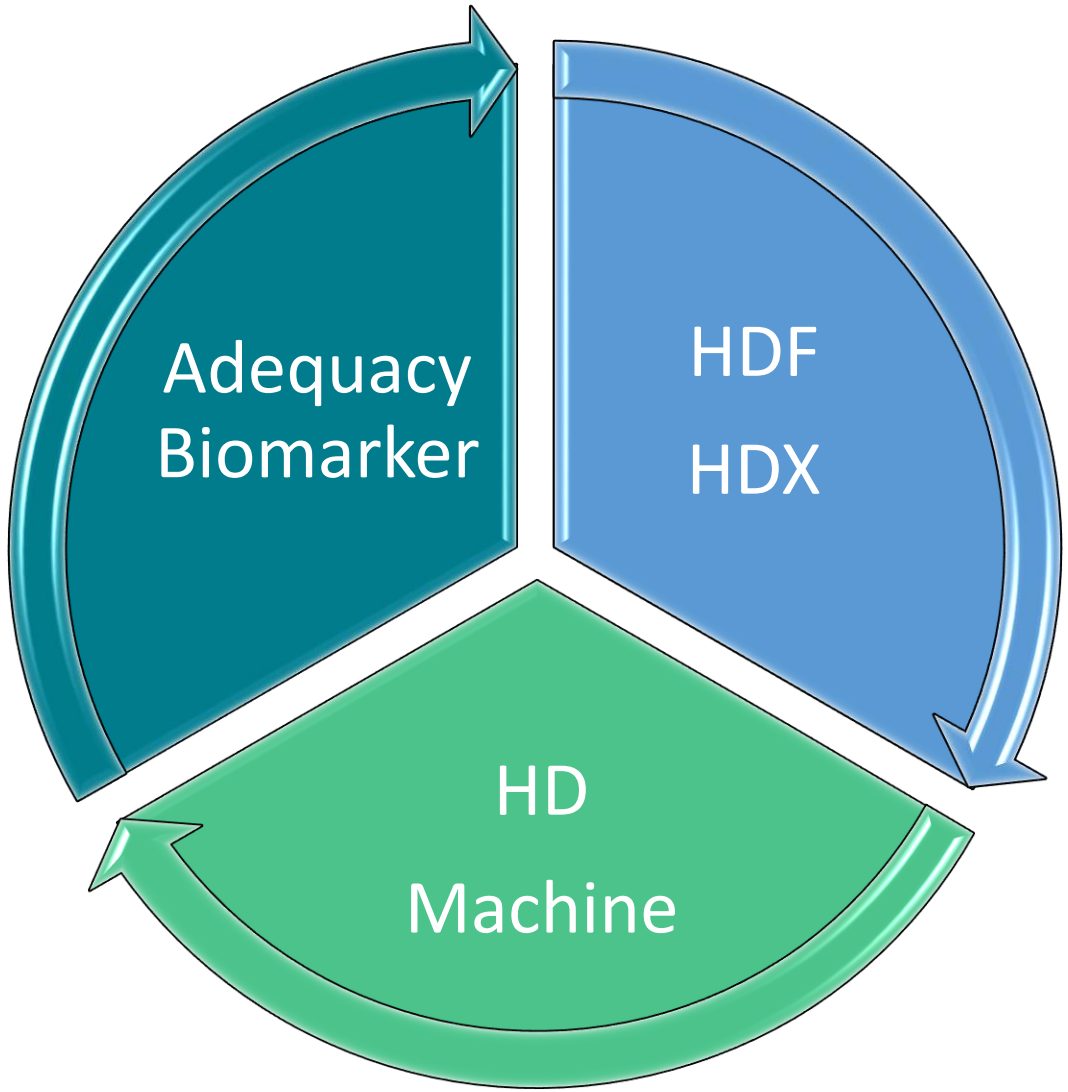
- 5- DOACs in AF with ESKD patients
- 6- Cellular activation during HD
- 7- Home Hemodialysis
- 8-Future of intracorporeal HD






Adequacy
Biomarker
HDF
HDX
HD
Machine

Starting hemodialysis The stress factors

Cardia stress

Arrythmia

Hypoxemia

PH changes

Solute Flux

Inflammation

THE LANCET

Five trials (n=4153 patients; 2070 receiving HD and 2083 receiving HDF)

ARTICLES · Volume 404, Issue 10464, P1742-1749, November 02, 2024

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Haemodiafiltration versus haemodialysis for kidney failure: an individual patient data meta-analysis of randomised controlled trials

Robin W M Vernooij, PhD [a] · Carinna Hockham, PhD [b] · Prof Giovanni Strippoli, PhD [c,d] · Prof Suetonia Green, PhD [e] · Prof Jörgen Hegbrant, PhD [f] · Prof Andrew Davenport, PhD [g] · et al. Show more

Affiliations & Notes Article Info Linked Articles (1)

HDF can be considered as a superior alternative to the present standard HD

Research | Open access | Published: 07 January 2025

Real-world effectiveness of hemodialysis modalities: a retrospective cohort study

Yan Zhang, Anke Winter, Belén Alejos Ferreras, Paola Carioni, Otto Arkossy, Michael Anger, Robert Kossmann, Len A. Usvyat, Stefano Stuard & Franklin W. Maddux

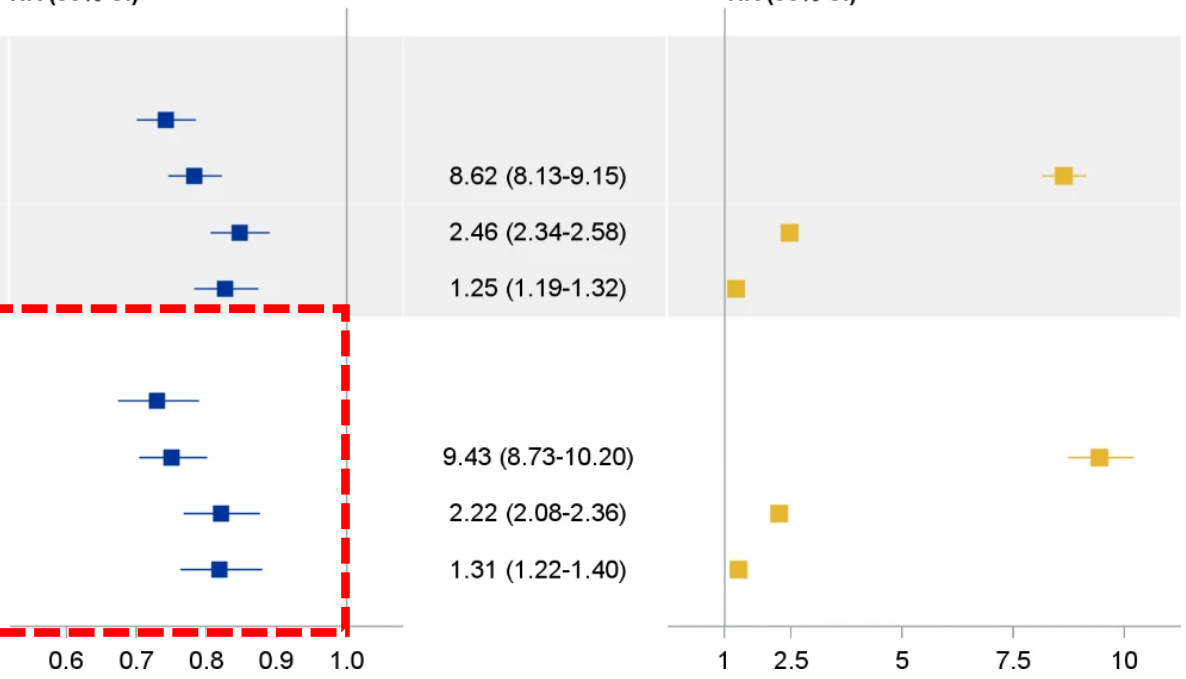
BMC Nephrology **26**, Article number: 9 (2025) | Cite this article

Retrospective cohort study during 2019–2022

Among patients receiving HDF (mean convection volume ≥ 23 L), the risk of death was reduced by 30% (HR, 0.70 [95% CI, 0.68–0.72]). Hemodiafiltration was also associated with a 31% reduced risk of cardiovascular death.

All-cause mortality in yearly-cohort analysis.

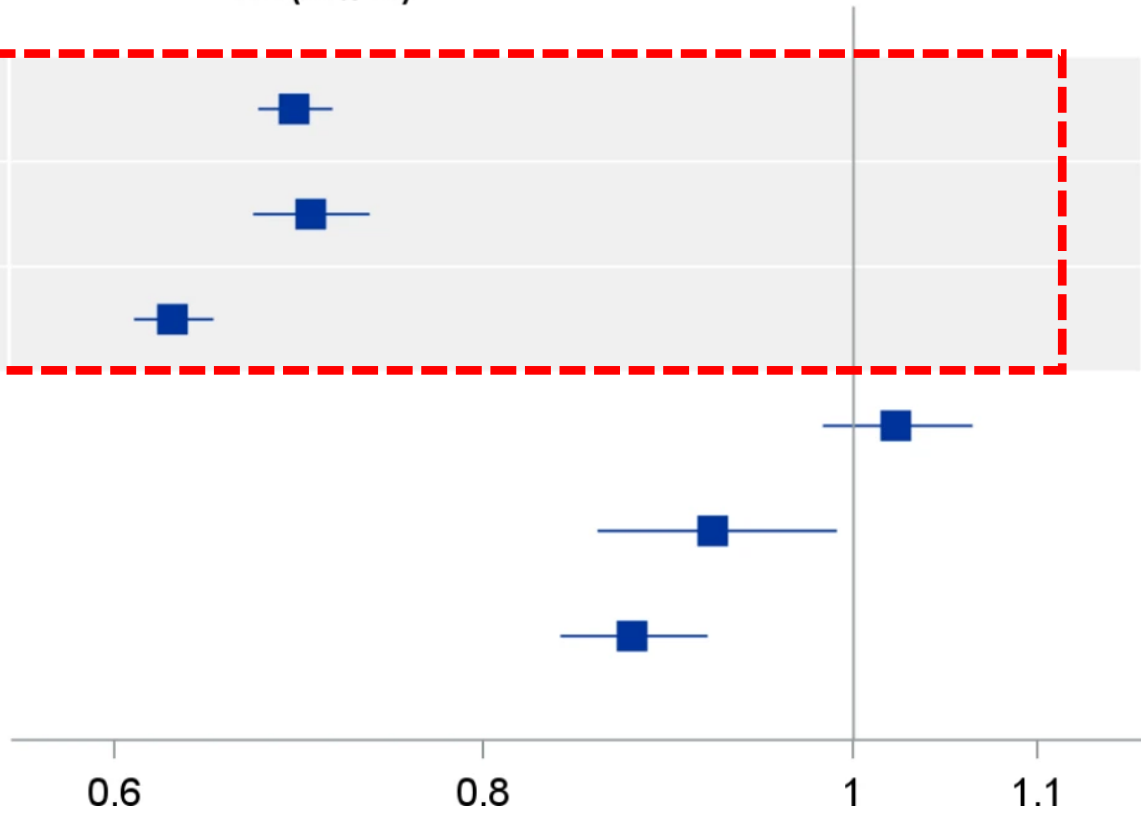
Cohort	No. Events /No. Patients	Rate /100 Person-Years	Hemodiafiltration vs. Hemodialysis HR (95% CI)	COVID-19+ vs. COVID-19- HR (95% CI)
Yearly cohort[a]				
2019	5323/ 54,837	12.19	0.74 (0.70-0.78)	
2020	7471/ 55,062	16.71	0.78 (0.75-0.82)	8.62 (8.13-9.15)
2021	7063/ 53,206	16.77	0.85 (0.81-0.89)	2.46 (2.34-2.58)
2022	5682/ 51,851	13.87	0.83 (0.78-0.87)	1.25 (1.19-1.32)
Yearly cohort (sensitivity analysis)[b]				
2019	3471/ 32,758	11.82	0.73 (0.67-0.79)	
2020	5226/ 36,779	15.71	0.75 (0.70-0.80)	9.43 (8.73-10.20)
2021	4888/ 35,166	15.65	0.82 (0.77-0.88)	2.22 (2.08-2.36)
2022	4049/ 35,565	12.76	0.82 (0.76-0.88)	1.31 (1.22-1.40)



Zhang , BMC Nephrology volume 26, Article number: 9 (2025)

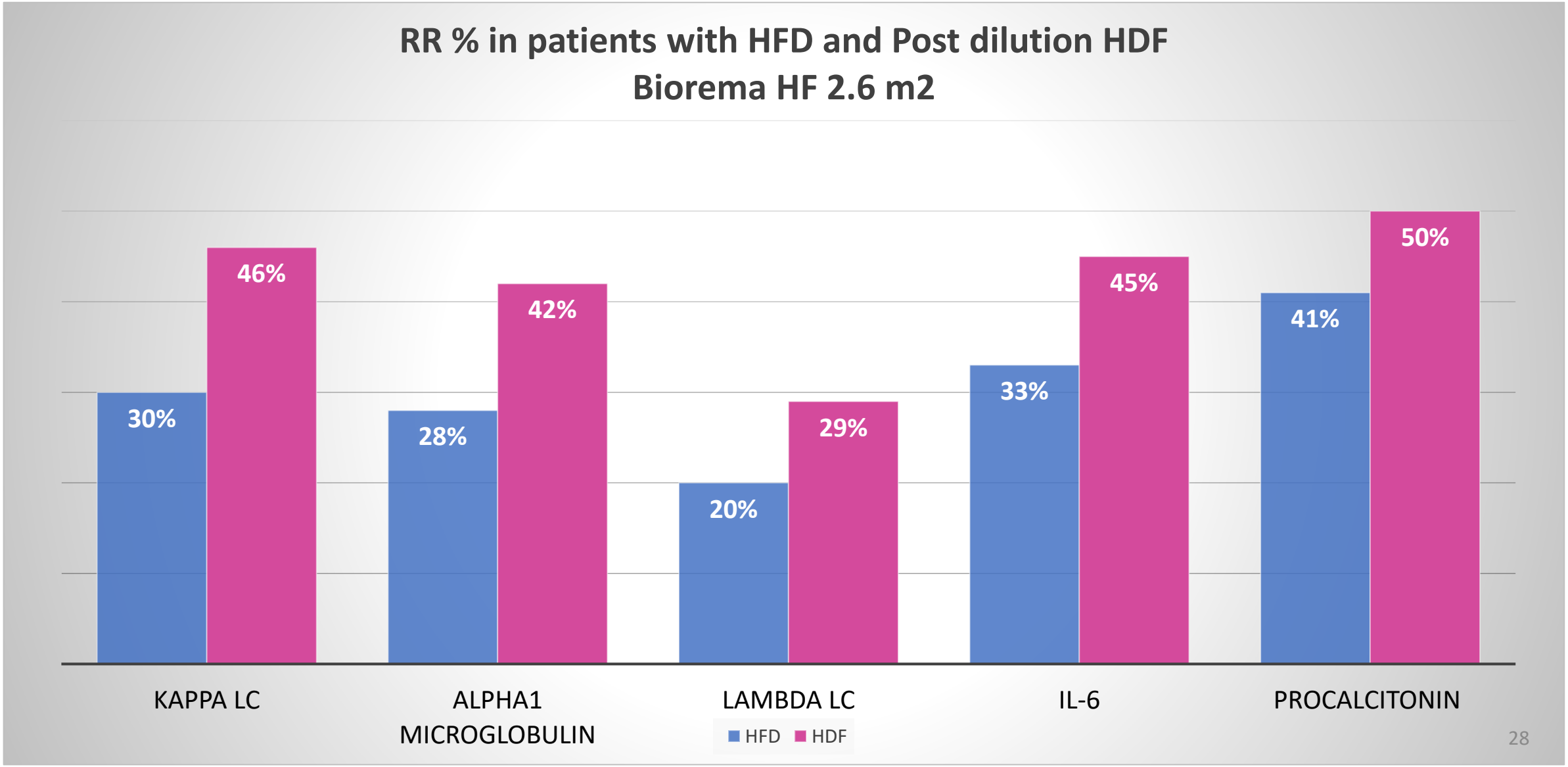
Association of High Volume HV-HDF and LV-HDF with all-cause mortality relative to HD

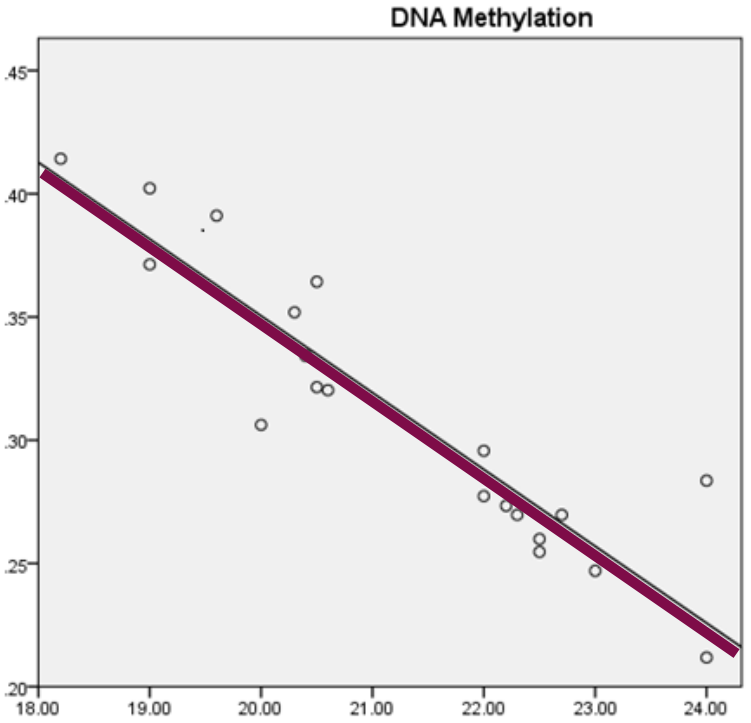
Modality	Model	HR (95% CI)
HV-HDF vs. HD	Model 1[a]	0.70 (0.68-0.72)
	Model 2[b]	0.71 (0.68-0.74)
	Model 3[c]	0.63 (0.61-0.65)
LV-HDF vs. HD	Model 1[a]	1.02 (0.98-1.06)
	Model 2[b]	0.92 (0.86-0.99)
	Model 3[c]	0.88 (0.84-0.92)



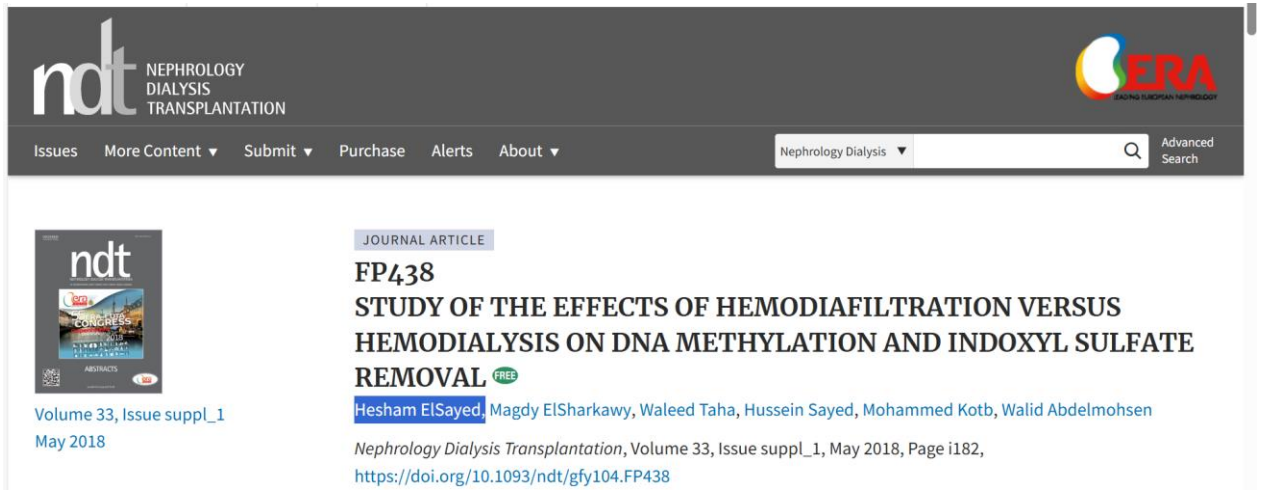
Zhang , BMC Nephrology volume 26, Article number: 9 (2025)

ASN, Hesham Elayed etail ASN 2022





Indirect correlation (r= -0.922, P < 0.001)



EFFECT OF OL-HDF on DNA methylation

Elsayed H, Elsharkawey M etal NDT May 2018

	DNA methylation	
	r	P
Substitution volume	-0.922	<0.001**
****; High Statistical Significant difference**		

EFFECT OF DIALYSIS MODALITY AND MEMBRANE PERMEABILITY ON FGF 23 LEVEL AND CARDIOVASCULAR CALCIFICATION IN ESRD PATIENTS.

Hesham Mohammed Elsayed1, Waleed Ahmed Beshary1, Khaled Mohamed Rezk1, Mostafa Abo Alkhair Mohamed1, Fatma Abdelrahman Ahmed1

Acute effects of online hemodiafiltration versus high-flux hemodialysis on serum levels of asymmetric dimethylarginine and tumor necrosis factor-alpha

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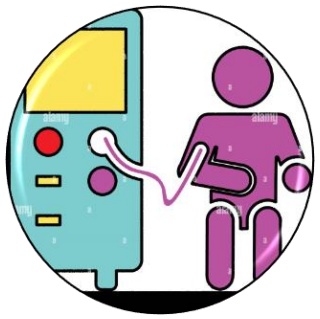
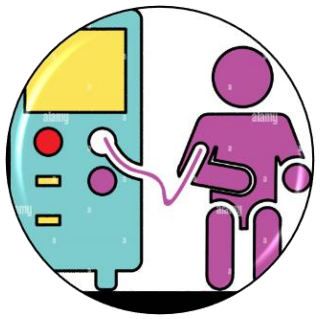
Journal of The Egyptian Society of Nephrology and Transplantation 2023, 23:3–10

Background
Chronic inflammation as a major determinant of 'dialysis syndrome' is considered as the main factor of morbidity and mortality in dialysis patients. Tumor necrosis factor-alpha (TNF-α) may play important roles in the development of T helper (Th) imbalance, cardiovascular disease, and wasting in the uremic milieu. Asymmetric dimethylarginine (ADMA) is an endogenous inhibitor of nitric oxide that may be an independent risk factor for endothelial dysfunction and cardiovascular disease. In hemodialysis (HD) patients, plasma ADMA is a strong and independent predictor of overall mortality and cardiovascular outcome.
The aim of this study to evaluate the acute effects of hemodiafiltration (HDF) compared with conventional HD on blood levels of ADMA and TNF-α.
Patients and methods
A cross-sectional study was conducted on 20 patients with end-stage renal disease receiving dialysis in the dialysis unit of Ain Shams Specialized Hospital receiving twice weekly HD session with high-flux (HF) dialyzer and once weekly HDF session. Blood samples were collected from all participants before and after HD session and from the same participants before and after HDF session. ADMA and TNF-α levels were assessed by enzyme-linked immunosorbent assay techniques.
Results

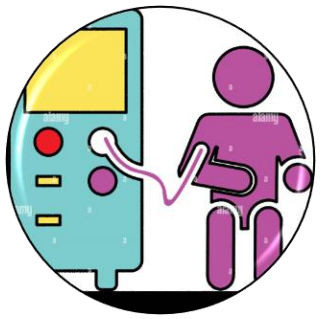
The optimum we are currently have



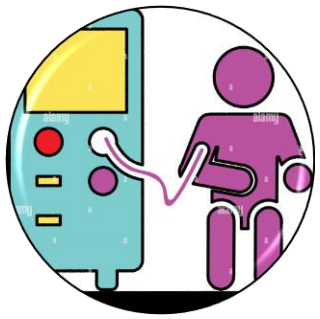
Higher convection therapies



Implementing HDF and Expanded HD

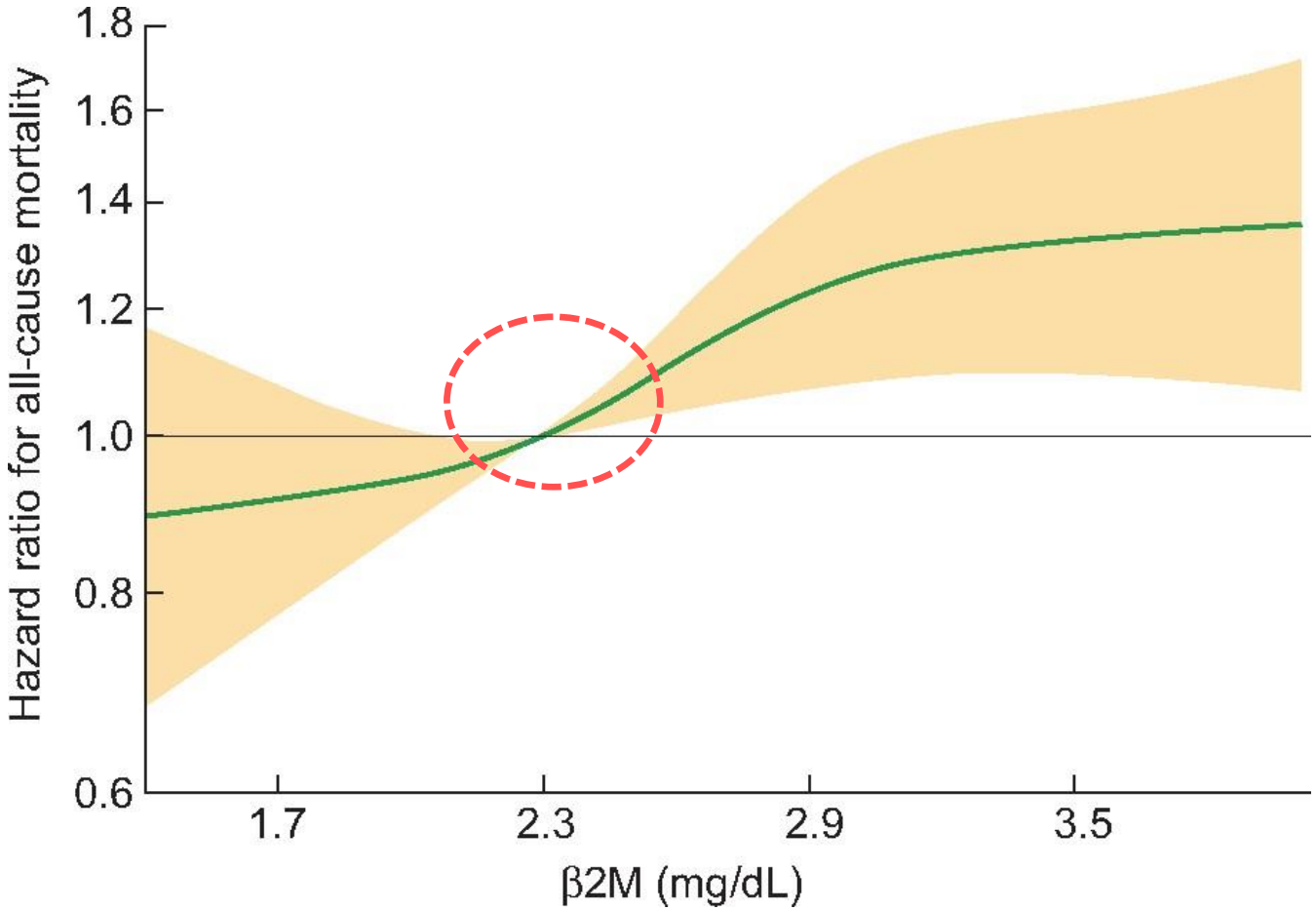


Pre-Dialysis serum B2M



RCT results for ACM and CVM

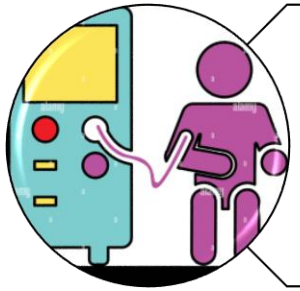
All-cause mortality by continuous β2M level, relative to a β2M of 2.3 mg/dL



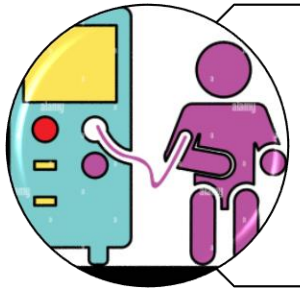
β2M and mortality in centers routinely measuring β2M spanned 2011–18 (n = 5332).

Adjusted for age, sex, region (Europe or Japan), DOPPS Phase, dialysis vintage, residual urine volume (≥200 or <200 mL/day), serum albumin and five comorbidities (diabetes, coronary heart disease, congestive heart failure, cerebrovascular disease and other cardiovascular diseases)

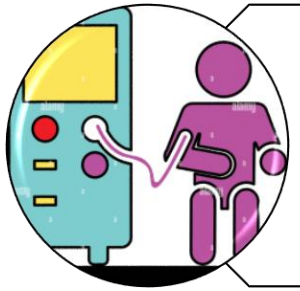
Kanda , Clinical Kidney Journal, Volume 14, Issue 5, May 2021



In summary, HDF and HDx represent potential alternatives to conventional high-flux HD with the aim of improving toxin clearance.



Significant improvements in mortality, cardiovascular outcomes, QoL, and hospitalization with HDF versus conventional HD.

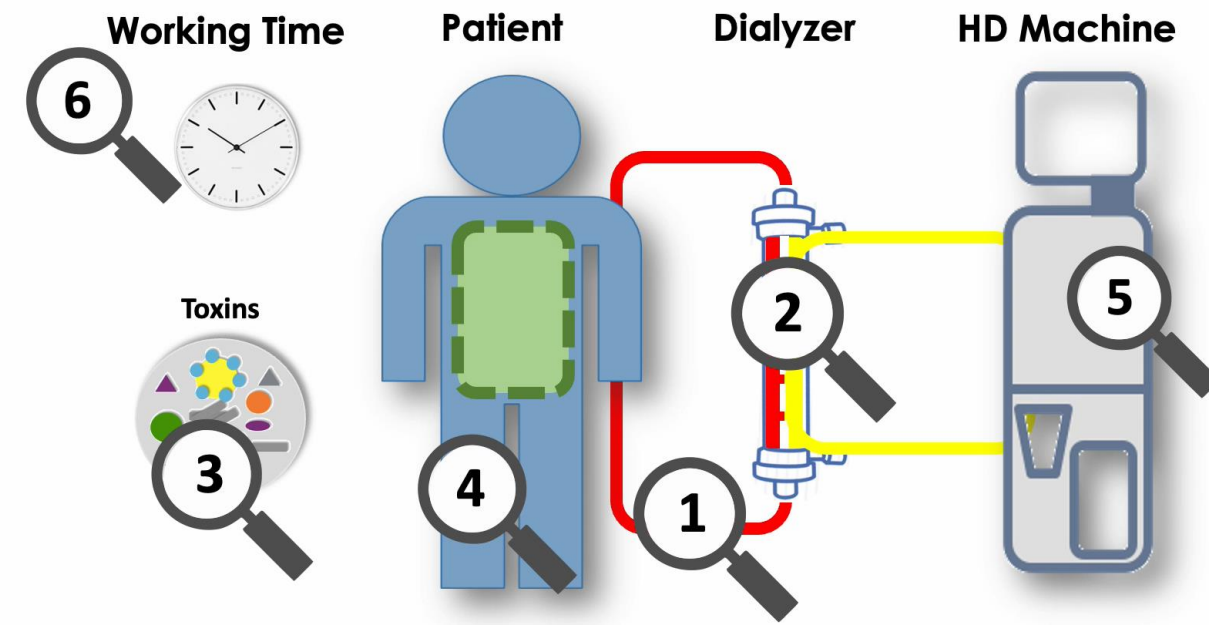


Published studies suggest short-term benefits with HDx in terms of intermediary clinical performance outcomes (e.g., solute clearance); more long-term data on hard clinical endpoints, such as mortality and morbidity, would be beneficial to support clinical decision-making.

Catherine eta , Semiars in Dialysis ,27 November 2024

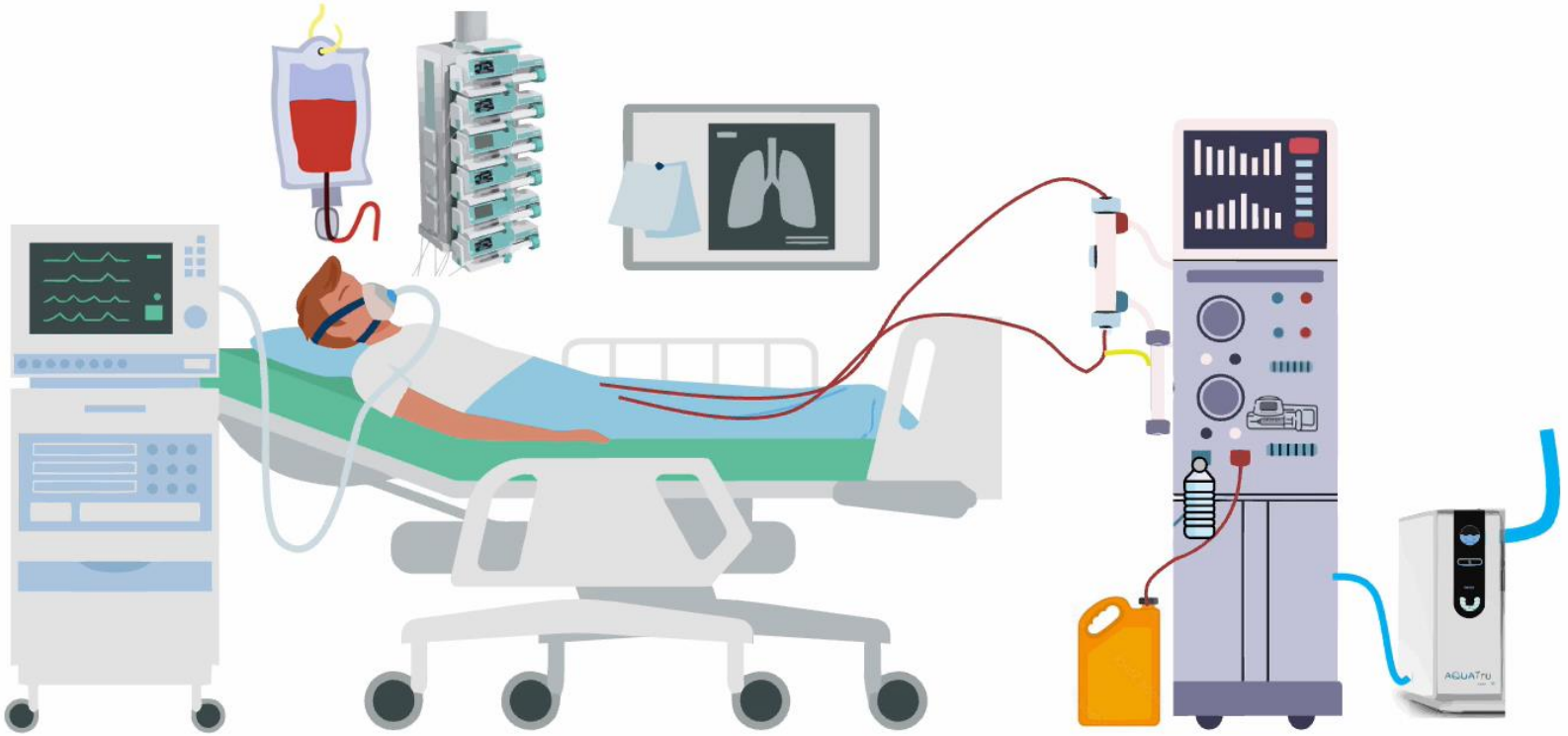
Agenda

- 1- Patient Centered Approach
- 2- Convection therapies , HDF and HDX
- 3- Extracorporeal therapies in ICU
- 4- Volume and Electrolyte control
- 5- DOACs in AF with ESKD patients
- 6- Cellular activation during HD
- 7- Home Hemodialysis
- Future of intracorporeal HD

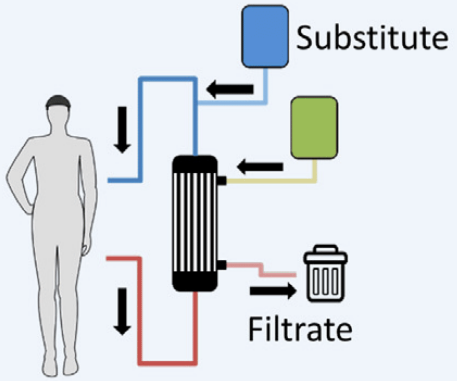


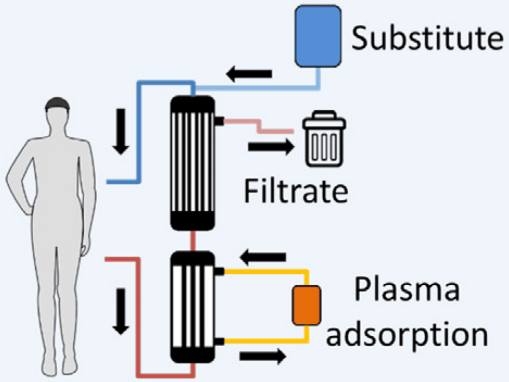
2

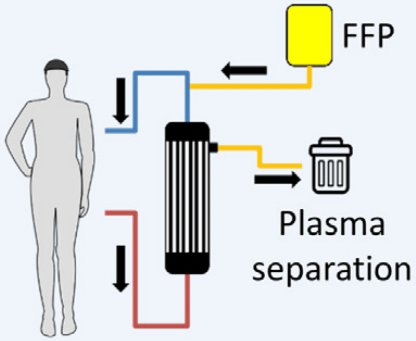
Typical Environment of AKI Patients in ICU with PIRRT (IHDF) Therapy



Extracorporeal Blood Purification Techniques







Convection Therapies	Adsorption Therapies	Combination Therapies	Other Therapies
High Cut-Off Membranes (HCO)	Specific Adsorption Polymyxin B (PMX) LPS Adsorber	Combined filtration and Adsorption (e.g. oXiris®)	Plasma Exchange
High Volume Hemofiltration (HVHF)	Unspecific Adsorption Hemoadsorption (e.g. CytoSorb®)	Coupled Plasma Filtration Adsorption (CPFA)	

Jarczak , Int. J. Mol. Sci. 2024

Agenda

- 1- Patient Centered Approach
- 2- Convection therapies , HDF and HDX
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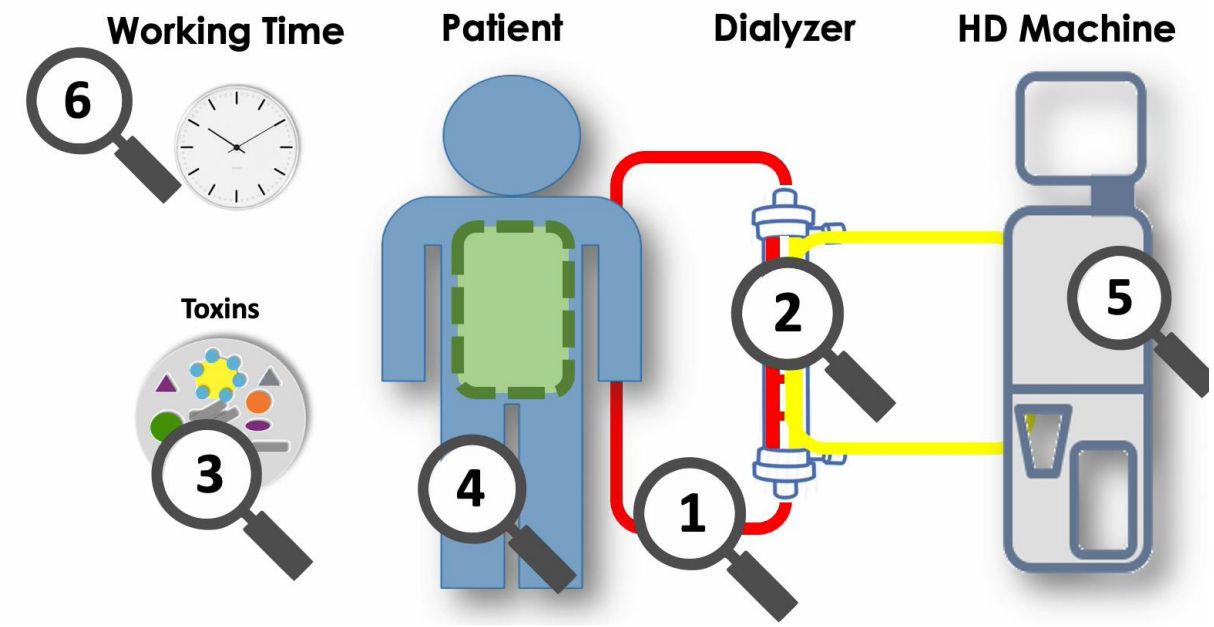
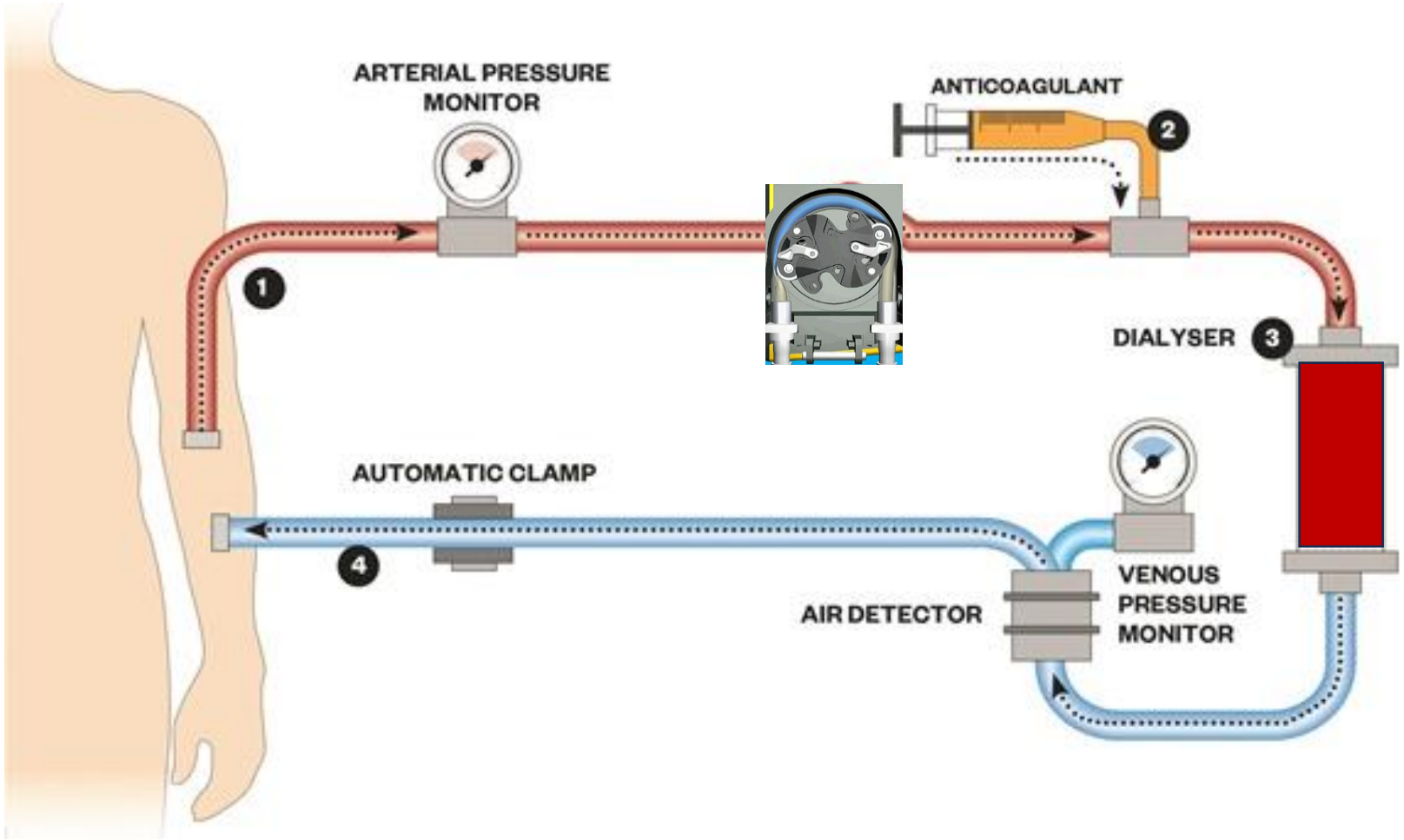
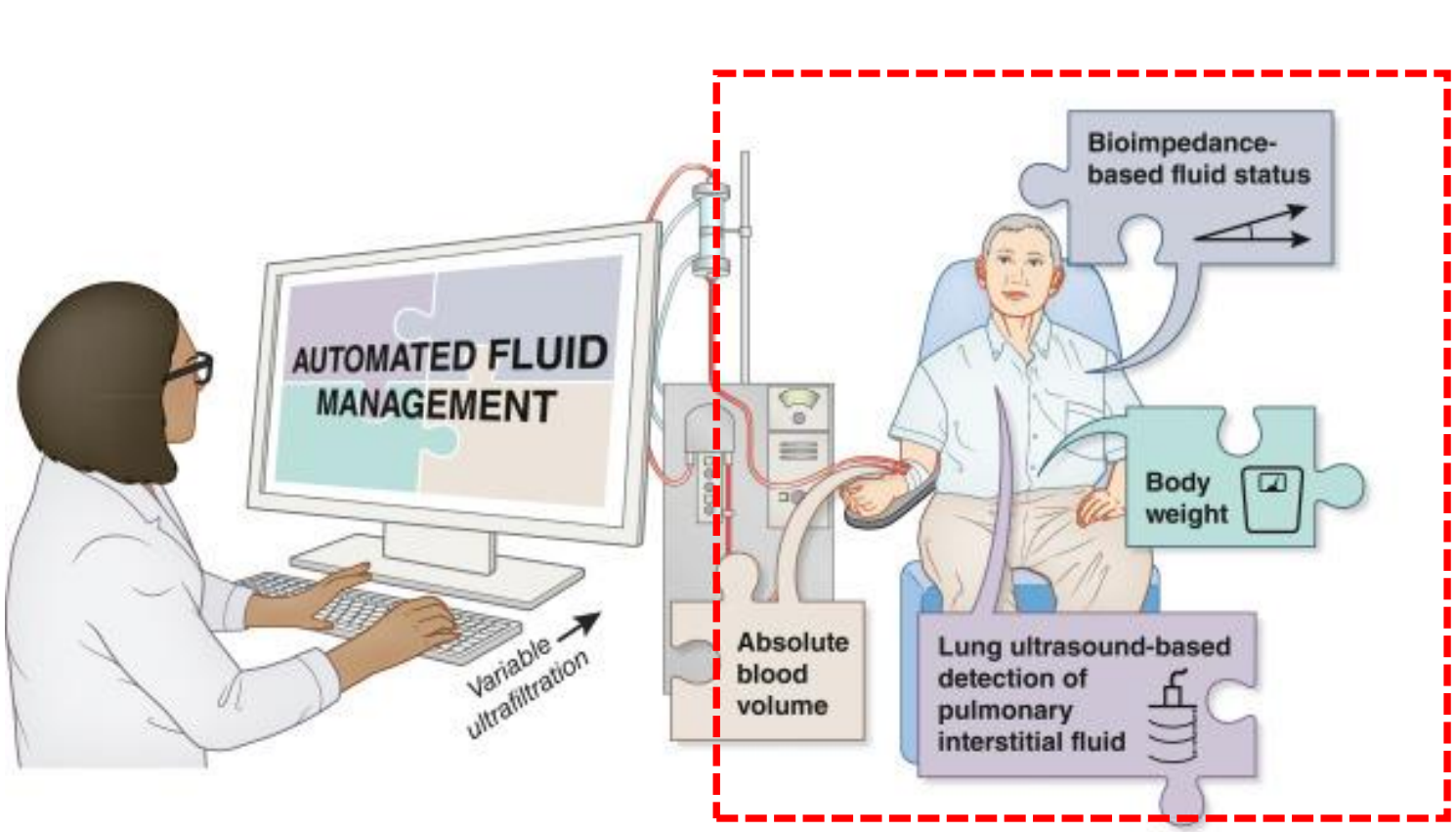
- 5- DOACs in AF with ESKD patients
- 6- Cellular activation during HD
- 7- Home Hemodialysis
- 8-Future of intracorporeal HD

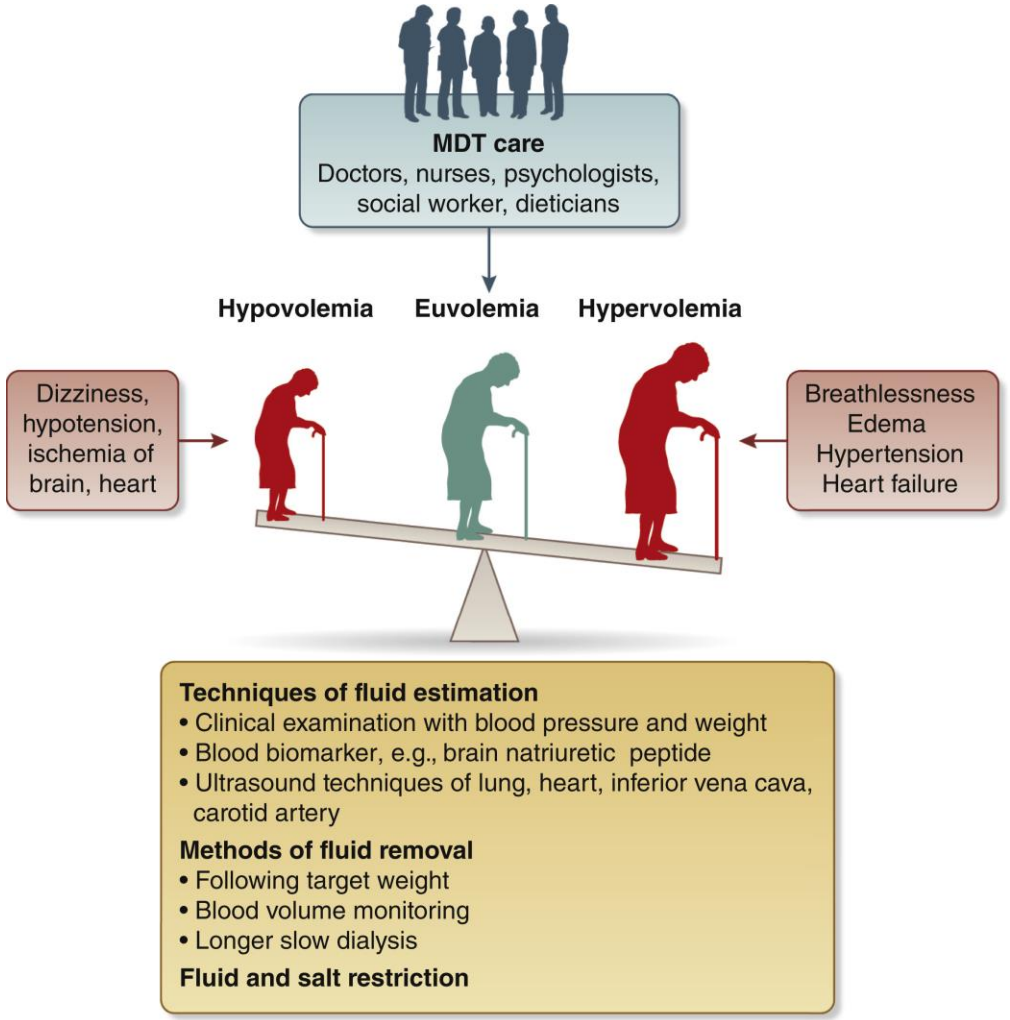


Sodium First Approach

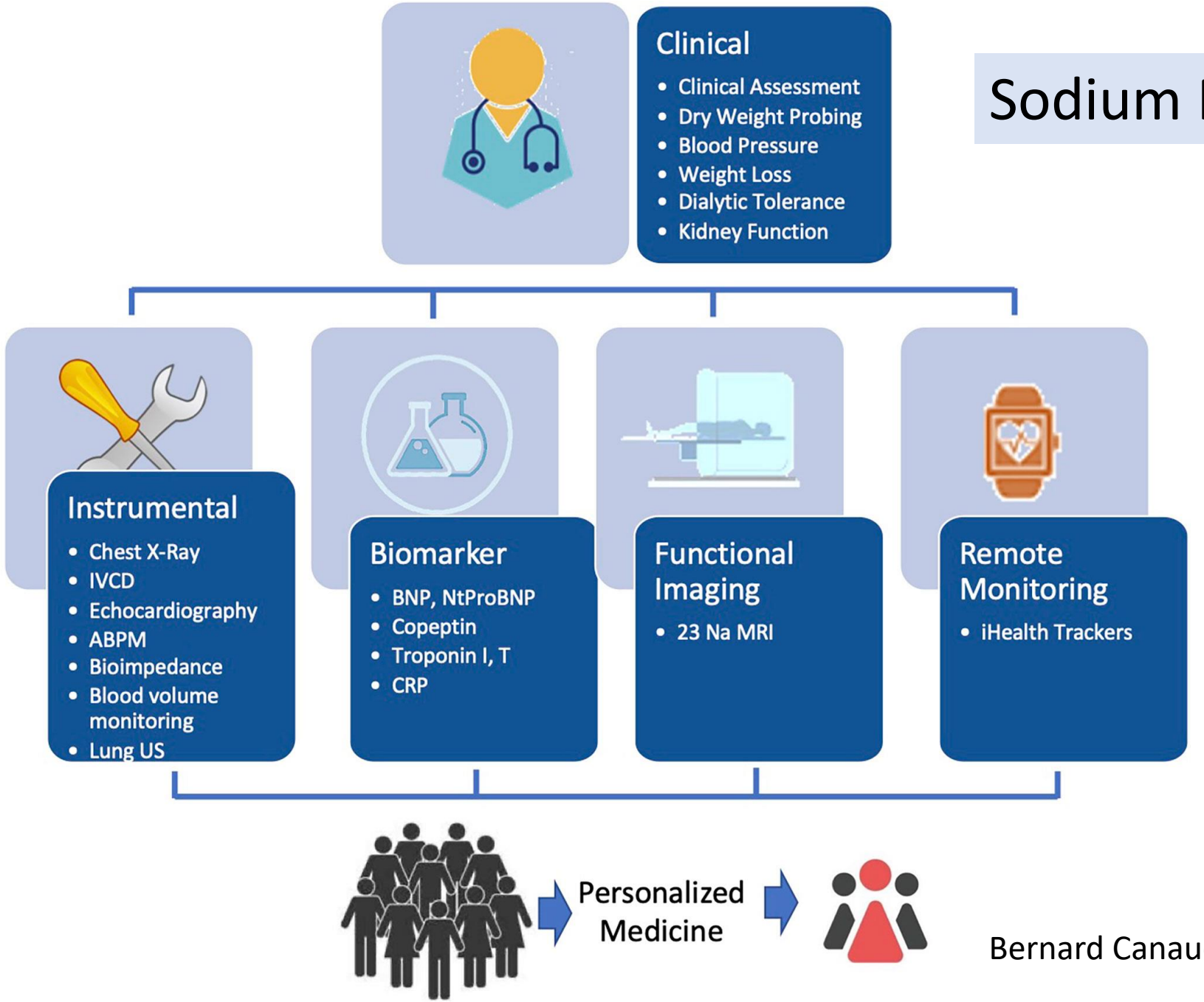


- 80 Liters Blood
- 120 Liter Dialysate
- 23000 mmol Electrolytes
- Swinging in PH
- 4% loss of weight in 4 Hours


AUTOMATED FLUID MANAGEMENT
Variable ultrafiltration
Bioimpedance-based fluid status
Body weight
Absolute blood volume
Lung ultrasound-based detection of pulmonary interstitial fluid


MDT care
Doctors, nurses, psychologists, social worker, dieticians
Hypovolemia
Euvolemia
Hypervolemia
Dizziness, hypotension, ischemia of brain, heart
Breathlessness Edema Hypertension Heart failure
Techniques of fluid estimation
• Clinical examination with blood pressure and weight
• Blood biomarker, e.g., brain natriuretic peptide
• Ultrasound techniques of lung, heart, inferior vena cava, carotid artery
Methods of fluid removal
• Following target weight
• Blood volume monitoring
• Longer slow dialysis
Fluid and salt restriction

Sodium First Approach



Bernard Canaud Front. Nephrol., 07 July 2022

Integrated approach to reduce intradialytic hypotension and to reduce dialysis induced systemic stress

Clinical Decision Support Tools

On-Line Tools

- Blood Pressure Monitor
- Blood Volume Monitor & Control (UF Control)
- UF & Na Profile
- Blood Thermal Control (Iso-Hypothermic)
- Automated Sodium Control

Off-Line Tools

Multifrequency Bioimpedance Spectroscopy
Fluid status - FO

Cardiac Biomarkers

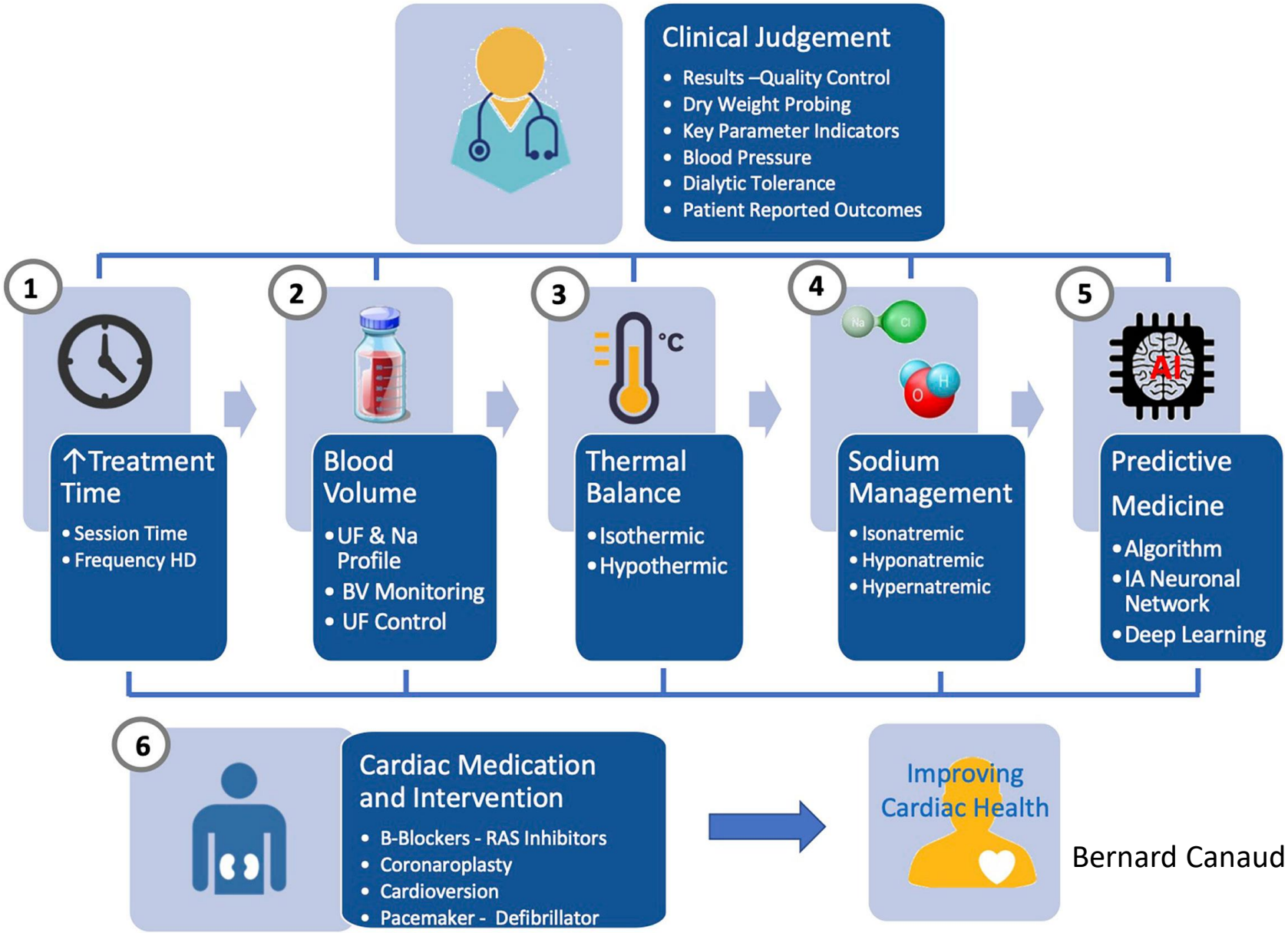
Ambulatory Blood Pressure & Vital Monitoring

Lung US
B-Lines

Artificial Intelligence

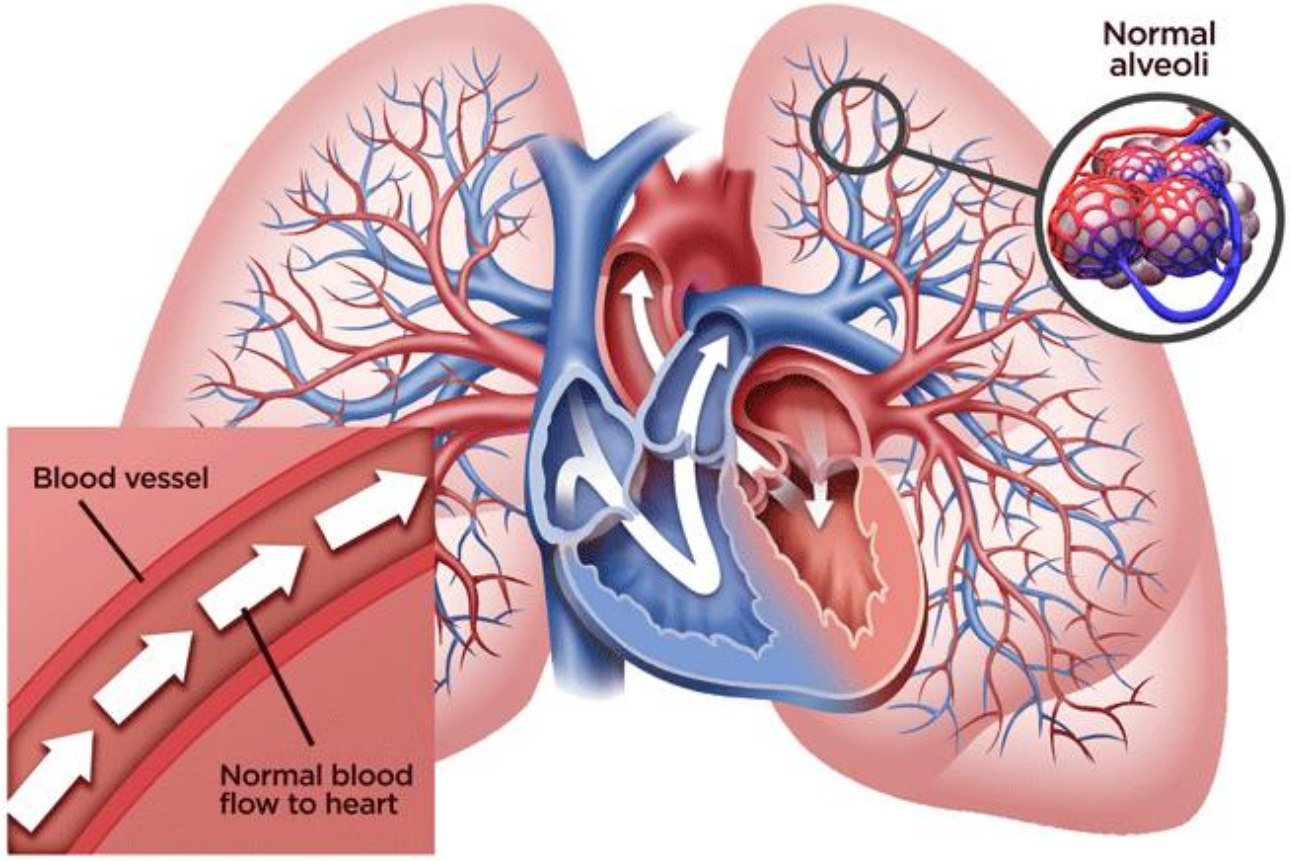
Bernard Canaud Front. Nephrol., 07 July 2022

Advanced management of sodium, fluid and blood pressure

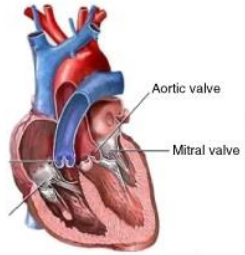


Bernard Canaud Front. Nephrol., 07 July 2022

Pulmonary edema and pulmonary hypertension
right ventricular strain

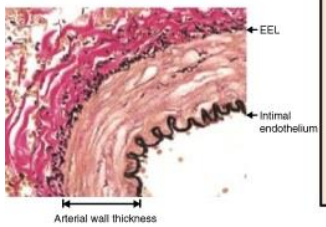


- Pulmonary hypertension during hypoxemia, pulmonary edema can increase right ventricular afterload.
- Consequent right ventricular dysfunction can affect left ventricular preload, leading to hemodynamic instability.

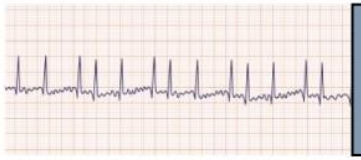


Valvular heart disease
Aortic stenosis, mitral regurgitation

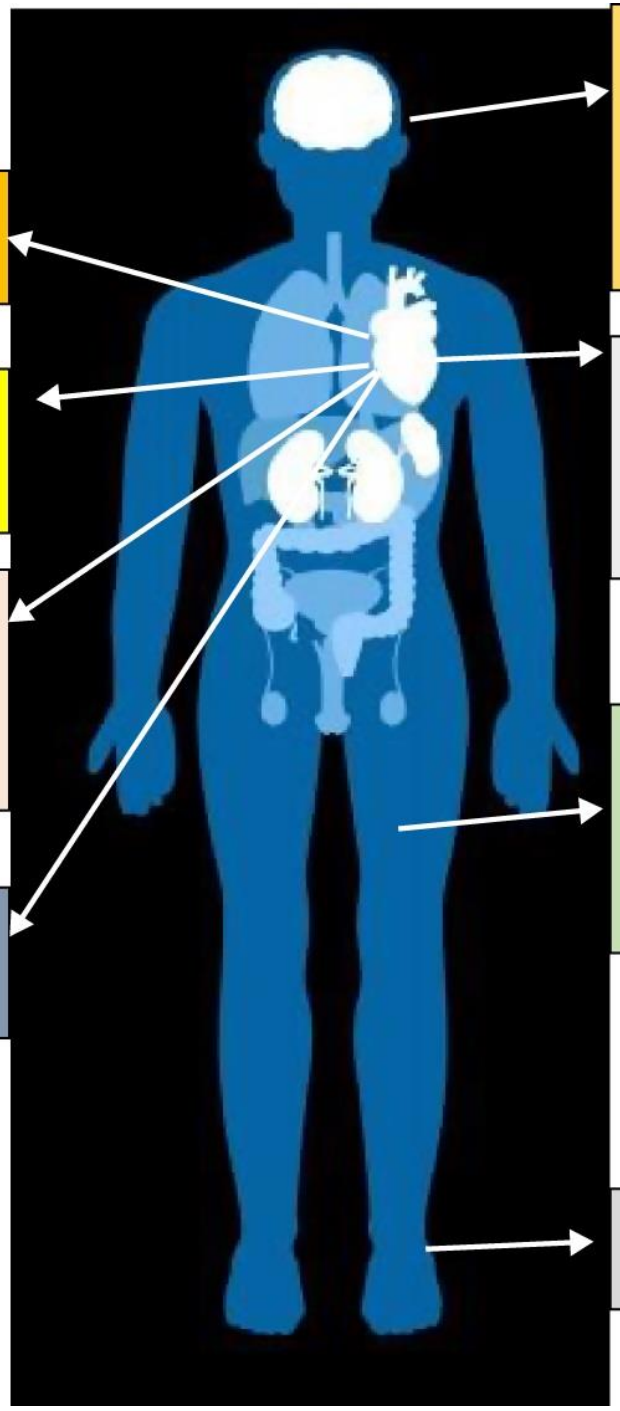
Coronary artery disease
Medial thickening with smaller luminal area
Extensively calcified fibroatheromatous plaques



Microvascular disease
Extensive arteriolar wall thickening with capillary rarefaction
Ischemia despite normal coronaries and predisposition to vasoconstriction due to endothelial dysfunction

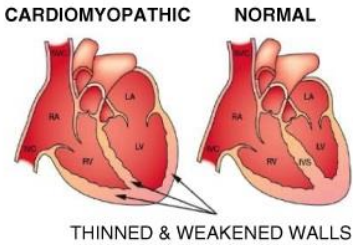


Dysrhythmias
Atrial fibrillation
Sudden cardiac death



Cerebrovascular disease
Ischemic stroke from intimal calcifications
Hemorrhagic stroke from medial calcifications
Small vessel disease including white matter rarefaction
Cerebral microbleeds 5–10 mm in size, and microinfarcts,
White matter or global atrophy, increased perivascular spaces

Uremic cardiomyopathy
Left ventricular hypertrophy
Left ventricular systolic and/or diastolic dysfunction
Subclinical cardiomyopathy with normal left ventricular ejection fraction



Vascular calcification
Patchy calcification of intima close to atherosclerotic lipid deposits
Monkeberg's medial calcific sclerosis with arterial stiffness
Increase in pulse pressure and left ventricular hypertrophy especially seen in diabetics

Peripheral vascular disease
Intermittent claudication, pain, ulceration, and gangrene

Does lung ultrasound (LUS) compared to standard approach, improve the accuracy for diagnosis of acute decompensated heart failure (ADHF)?

Methods and Cohort
Randomized controlled trial

N=518

Dyspnea

ER

2 Centers - Italy

Comparison
Diagnostic work-up

Chest X-ray
NT-proBNP

Lung Ultrasound
B-Lines 8 zones

Outcomes

Diagnostic accuracy			Time to
AUC	Sens	Spec	Diagnosis
0.87	85%	89%	104 min
0.95	94%	96%	5 min

Conclusions Integration of LUS with clinical assessment for the diagnosis of ADHF in the emergency department seems to be more accurate than the current diagnostic approach based on CXR and NT-proBNP.

Reference Pivetta E, et al. **Lung ultrasound integrated with clinical assessment for the diagnosis of acute decompensated heart failure in the emergency department: a randomized controlled trial.** Eur J Heart Fail. 2019

@aldorodrigo

Lung Ultrasound to Diagnose Pulmonary Congestion Among Patients on Hemodialysis: Full Versus Abbreviated Scanning Protocols

Methods

98 patients on maintenance HD evaluated in an ED with a 28-zone lung ultrasound

Patient Outcomes

Mortality

Median follow up: 778 ± 175 d

B-line score* < 15: 43% (n = 12)

B-line score* ≥ 15: 49% (n = 34)

***P* = 0.8**

*on 28-zone study

Comparison With 28-Zone Ultrasound

	AUC (95% CI)	
	A: superomedial	B: inferomedial
	C: superolateral	D: inferolateral
4 zones	A: 0.83 (0.75-0.90)	B: 0.83 (0.74-0.90)
	C: 0.91 (0.84-0.96)	D: 0.88 (0.80-0.93)
6 zones	A: 0.86 (0.78-0.93)	B: 0.86 (0.77-0.92)
	C: 0.95 (0.88-0.98)	D: 0.91 (0.84-0.96)
8 zones	A: 0.93 (0.86-0.97)	B: 0.88 (0.80-0.94)
	C: 0.94 (0.88-0.98)	D: 0.94 (0.87-0.98)

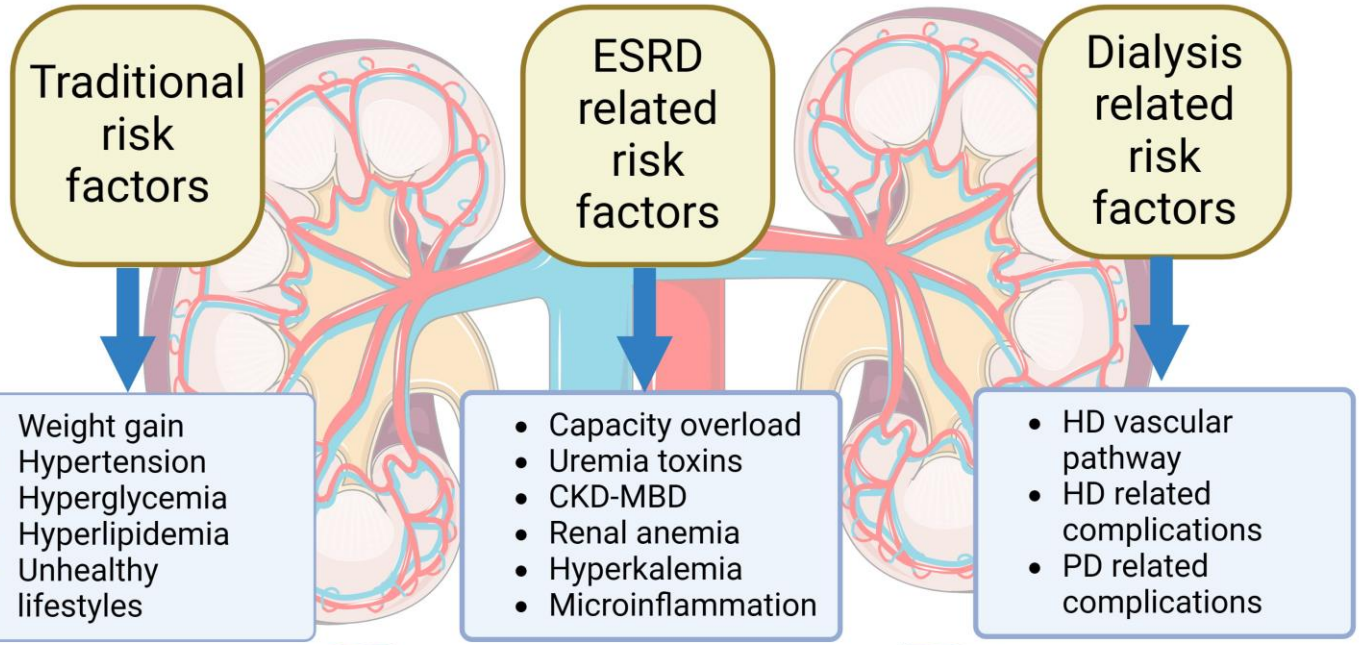
CONCLUSION: Among patients on maintenance HD presenting to an ED, 4-, 6-, or 8-zone lung ultrasound compared favorably to 28-zone studies for assessing pulmonary congestion.

Nathaniel Reisinger, Sadichhya Lohani, Jesper Hagemeier, et al (2021)

@AJKDonline | DOI: 10.1053/j.ajkd.2021.04.007

AJKD AMERICAN JOURNAL OF KIDNEY DISEASES

Heart Failure in HD Patients



Traditional risk factors

- Weight gain
- Hypertension
- Hyperglycemia
- Hyperlipidemia
- Unhealthy lifestyles

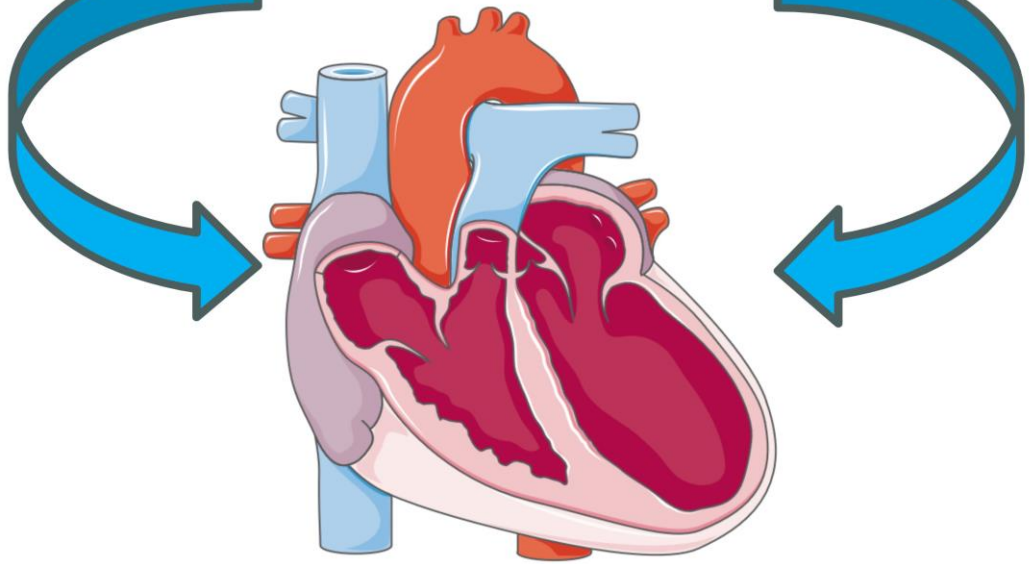
ESRD related risk factors

- Capacity overload
- Uremia toxins
- CKD-MBD
- Renal anemia
- Hyperkalemia
- Microinflammation

Dialysis related risk factors

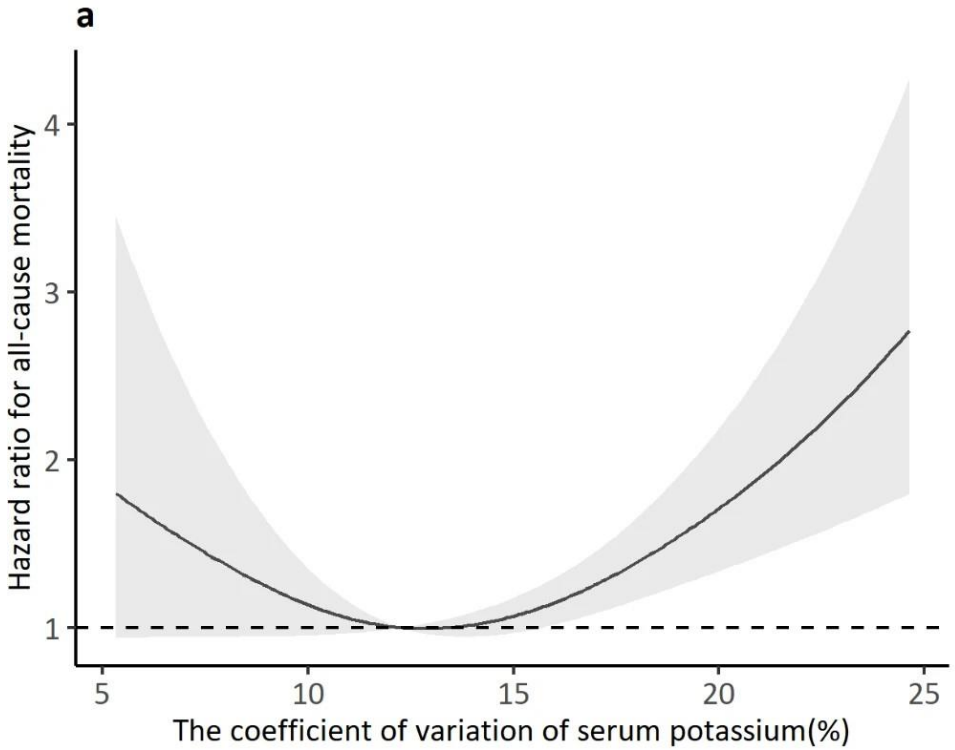
- HD vascular pathway
- HD related complications
- PD related complications

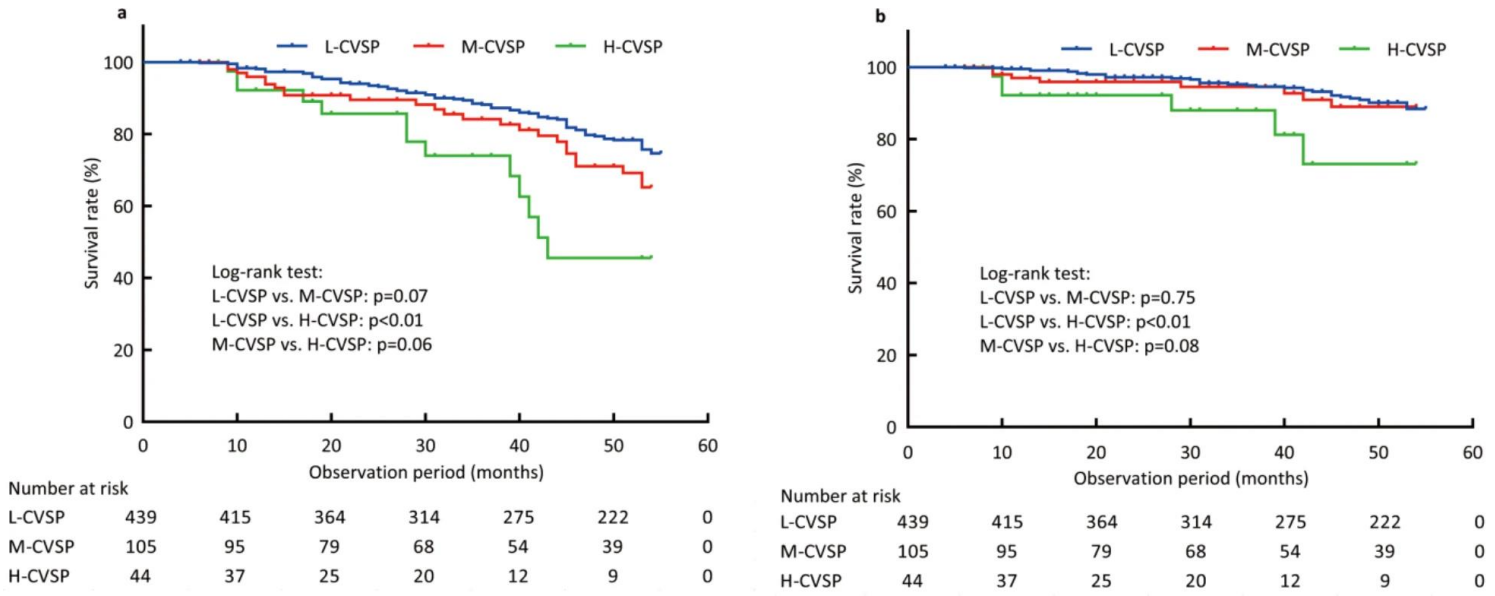
- Reduced vascular compliance
- Myocardial remodeling
- Arrhythmias



- Myocardial ischemia and stunning
- Reduced left ventricular mass
- Myocardial cell damage

Associations between serum potassium variability and mortality in MHD patients





Hazard ratio of CVSP for all-cause (**a**) and cardiovascular (**b**) mortality

mortality according to serum potassium variability. (a) all-cause mortality; (b) cardiovascular mortality.

588 hemodialysis patients for 45 months

Ru Men , Scientific Reports volume 14, Article number: 29998 (2024)

Effects of dialysate potassium concentration of 3.0 mmol/l with sodium zirconium cyclosilicate on dialysis-free days versus dialysate potassium concentration of 2.0 mmol/l alone on rates of cardiac arrhythmias in hemodialysis patients with hyperkalemia

kidney INTERNATIONAL

ISN INTERNATIONAL SOCIETY OF NEPHROLOGY

Patients and methods

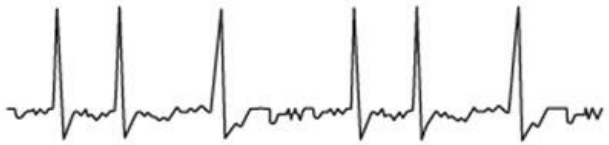
Adults (*N* = 88) with kidney failure:

- Received HD 3 days/week for ≥3 mo with hyperkalemia: two pre-dialysis sK^+ of 5.1–6.5 mEq/l during screening
- Had a cardiac loop recorder implanted
- Randomized to either a 2.0 K^+/2.5 Ca^{2+} mEq/l dialysate without SZC or to a 3.0 K^+/2.5 Ca^{2+} mEq/l dialysate with SZC on non-dialysis days titrated to maintain pre-dialysis sK^+ within 4.0–5.5 mEq/l range
  8 wks → treatment crossover → 8 wks
- Rate of AF events (duration ≥2 min, primary outcome); clinically significant cardiac arrhythmia (CSCA) events; % sK^+ measurements outside 4.0–5.5 mEq/l.

Outcomes

3.0K^+/SZC vs. **2.0K^+/noSZC**

AF episodes ≥2 minutes



Modelled RR (95% CI):
0.52 (0.41–0.65); *P* < 0.001

sK^+ outside optimal window

OR (95% CI): **0.27** (0.12–0.35)

Clinically significant arrhythmias

Modelled RR (95% CI):
0.47 (0.38–0.58); *P* < 0.001

Post-dialysis hypokalemia

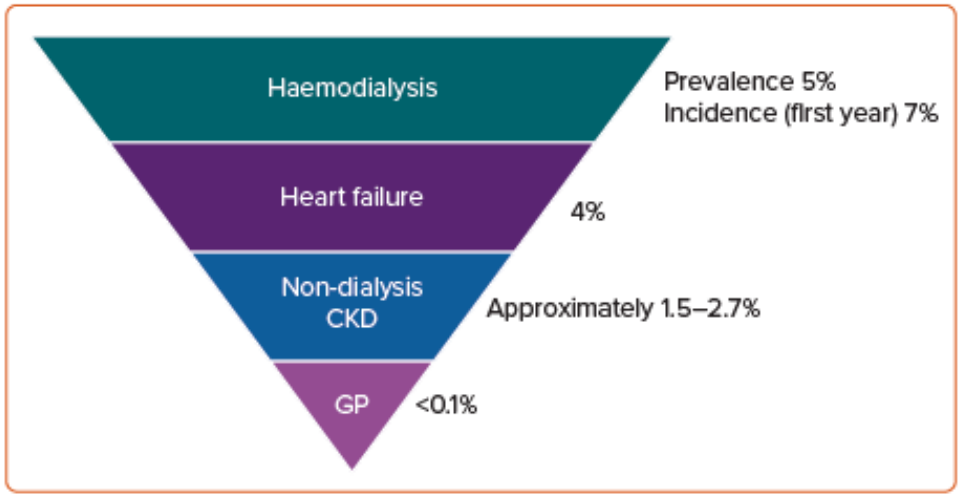
Rate/yr (95% CI):
5.9 (4.5–7.2) vs. **16.5 (14.3–18.7)**

Charytan DM, et al. 2024

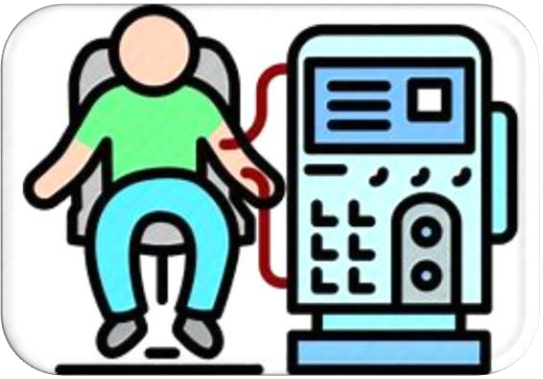
CONCLUSION In patients with hyperkalemia on maintenance HD, dK^+ 3.0 mEq/l and SZC on HD days reduced rates of AF, other clinically significant arrhythmias, and post-dialysis hypokalemia compared with dK^+ 2.0K^+/noSZC

Adjusting the HD prescription against SCD

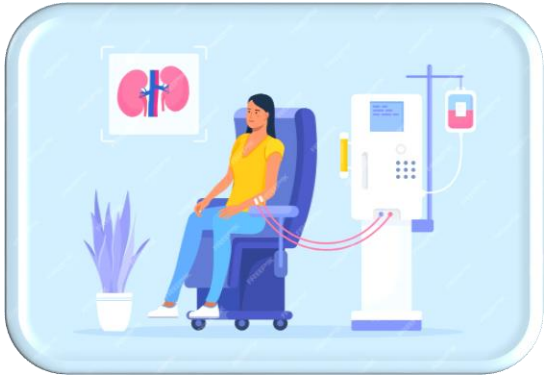
Figure 2: Annual Rates of Sudden Cardiac Death



CKD = chronic kidney disease; GP = general population. Source: Turakhia et al. 2019.[41]
Reproduced with permission from Oxford University Press.

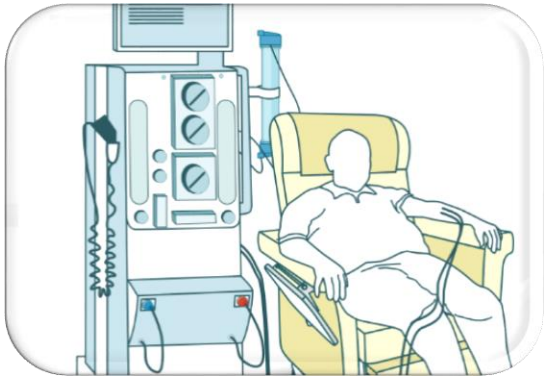


Avoid low potassium Dialysate (< 2mEq/L)



Avoid Low calcium dialysate (<2.5 mEq/L) has been associated with a 40% increase in the risk of SCD.

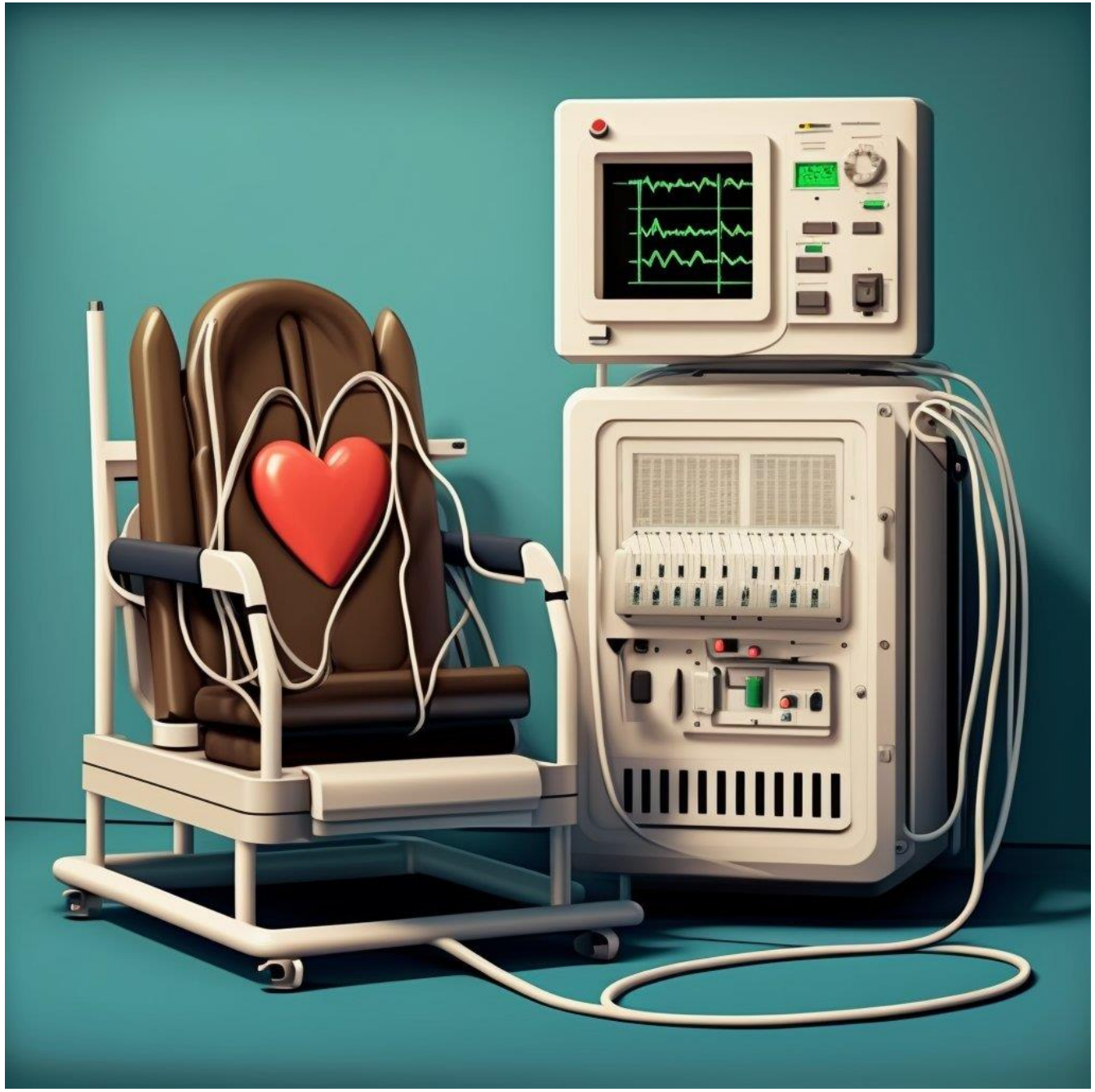
Avoid large shifts in volume from high ultrafiltration rates

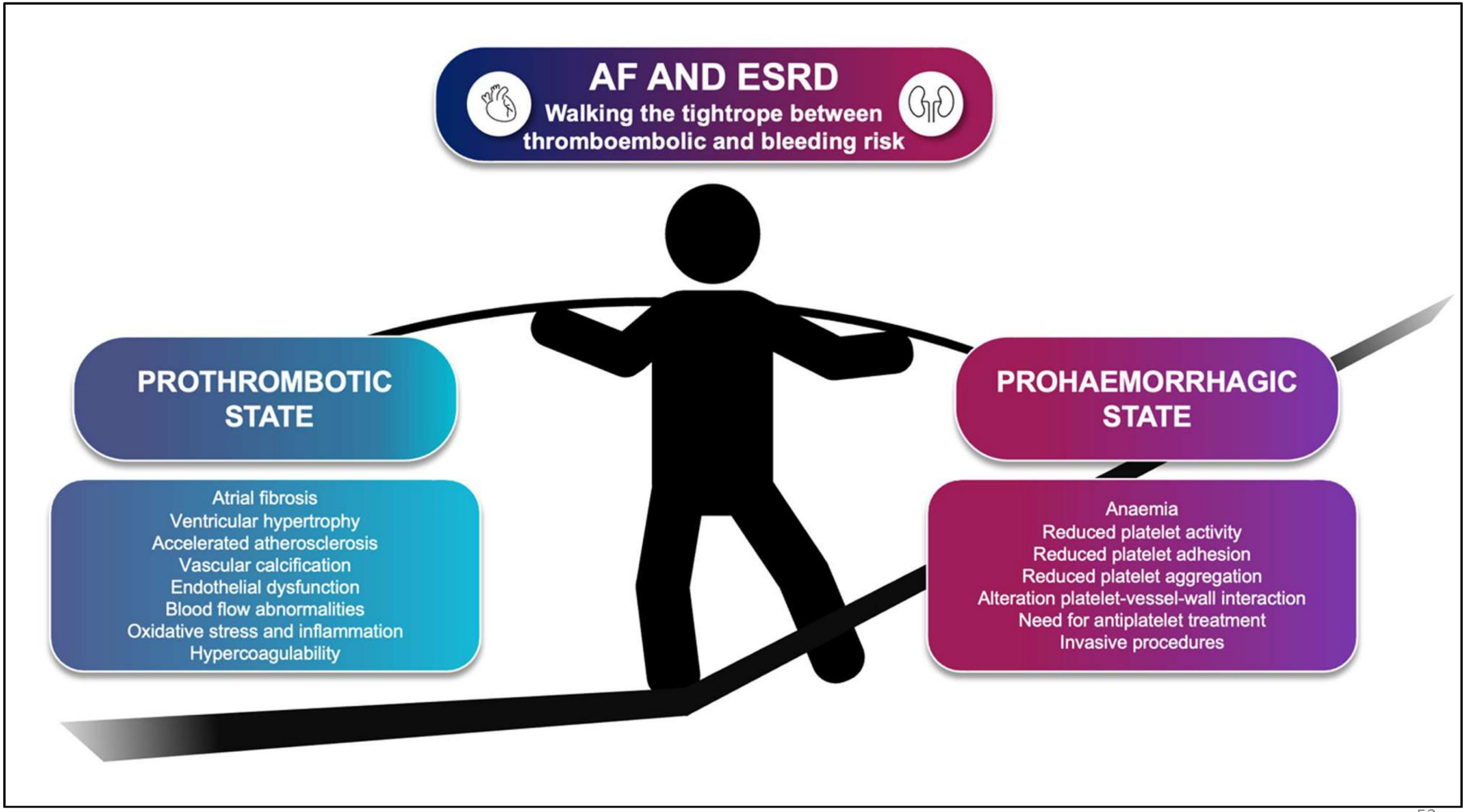


Dialysate cooling

Jadol , CJASN. 2012 , Pun Kidney Int. 2011;79

Atrial Fibrillation in MHD patients




AF AND ESRD
Walking the tightrope between thromboembolic and bleeding risk
PROTHROMBOTIC STATE
Atrial fibrosis
Ventricular hypertrophy
Accelerated atherosclerosis
Vascular calcification
Endothelial dysfunction
Blood flow abnormalities
Oxidative stress and inflammation
Hypercoagulability
PROHAEMORRHAGIC STATE
Anaemia
Reduced platelet activity
Reduced platelet adhesion
Reduced platelet aggregation
Alteration platelet-vessel-wall interaction
Need for antiplatelet treatment
Invasive procedures

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Real-world data in this population suggests that apixaban is likely at least comparably effective as warfarin at preventing thromboembolic events and is likely safer when evaluating bleeding risk. Rivaroxaban data is more limited,

Articles Publish Topics About Contact

REVIEW · Volume 10, Issue 1, P40-53, January 2025 · *Open Access*

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Direct Oral Anticoagulants in Patients With ESRD and Kidney Transplantation

Nicholas W. Lange · Justin Muir · David M. Salerno

Affiliations & Notes Article Info

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Both apixaban and rivaroxaban display alterations in their pharmacokinetic profiles with renal insufficiency, though neither are appreciably removed by hemodialysis

Drug	Standard Dosing	Dose adjustments	Elimination	Protein binding	Half-life
apixaban[7]	AF: 5 mg twice daily VTE: 10 mg twice daily × 7 days, then 5 mg twice daily	AF: adjust to 2.5 mg twice daily if at least 2 factors: age ≥ 80 yrs, weight ≤ 60 kg, creatinine ≥ 1.5 mg/dl	27% renal clearance (unchanged drug) Biliary and intestinal excretion in feces	87%	12 h
rivaroxaban[8]	AF: 20 mg daily VTE: 15 mg twice daily × 21 days, then 20 mg daily	AF: 15 mg daily for CrCl ≤ 50 ml/min VTE: avoid use for CrCl < 15 ml/min	36% renal clearance (unchanged drug) Excretion in feces	92%–95%	5–9 h

Oral Anticoagulant Agents in Patients With Atrial Fibrillation and CKD: A Systematic Review and Pairwise Network Meta-analysis

Setting & Participants

8 RCTs and 46 observational studies

AF and CKD stages 3-5D

Using oral anticoagulants (OACs)

170,059 participants

Methods

1. Pairwise meta-analysis

DOACs (direct OACs) vs Warfarin

OACs vs No OACs

2. Bayesian network meta-analysis

DOAC vs DOAC

Results

- DOACs are superior to warfarin

↓14% Thromboembolic events risk

↓19% Bleeding events risk

AF patients with GFR 15 to 60 mL/min

- OACs without significant benefits

↑28% Bleeding events risk

AF patients on dialysis

- Dose-adjusted apixaban seem to be superior to other DOACs

AF patients with GFR 25/30 to 60 mL/min

CONCLUSION: In patients with AF and mild to moderate kidney disease, DOACs are superior to warfarin, while the preferred agent of DOACs still cannot be determined.

Xiaole Su, Bingjuan Yan, Lihua Wang et al (2021)
@AJKDonline | DOI: 10.1053/j.ajkd.2020.02.328

AJKD
AMERICAN JOURNAL OF KIDNEY DISEASES

Comparative Safety and Effectiveness of Warfarin or Rivaroxaban Versus Apixaban in Patients With Advanced CKD and Atrial Fibrillation

Setting & Participants

Propensity score matched cohort study

2 nationwide US claims databases, 2013-2022

Patients with atrial fibrillation (AF) and CKD stages 4-5 newly initiated on:

Warfarin vs apixaban	Rivaroxaban vs apixaban
(N = 12,488)	(N = 5,720)

Findings

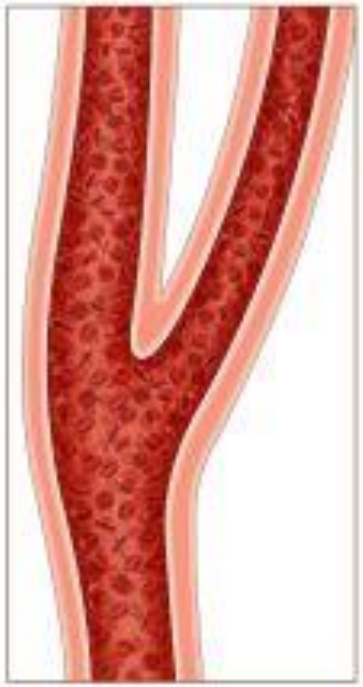
	Warfarin vs Apixaban HR (95% CI)	Rivaroxaban vs Apixaban HR (95% CI)
Major bleeding	1.85 (1.59-2.15)	1.69 (1.33-2.15)
Ischemic stroke	1.14 (0.83-1.57)	0.71 (0.40-1.24)
All-cause mortality	1.08 (0.98-1.18)	0.94 (0.81-1.10)

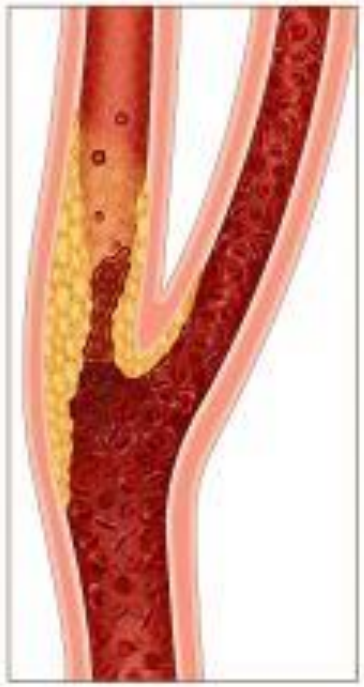
CONCLUSION: In patients with AF and advanced CKD, rivaroxaban and warfarin were associated with a higher rate of major bleeding compared with apixaban.

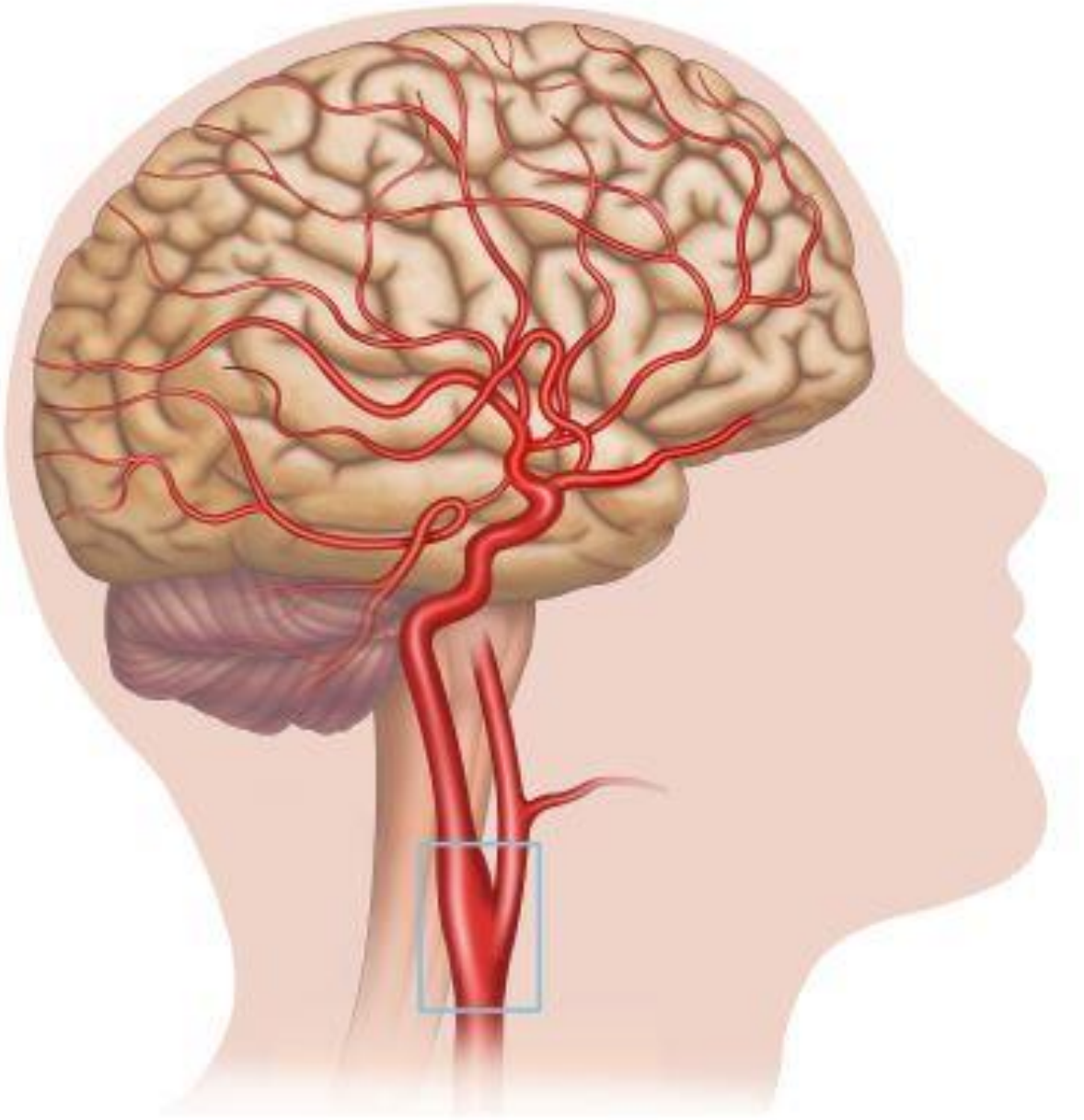
Edouard L. Fu, Rishi J. Desai, Julie M. Paik, et al

@AJKDonline | DOI: 10.1053/j.ajkd.2023.08.017

AJKD AMERICAN JOURNAL OF KIDNEY DISEASES







Cerebrovascular disorders in HD

Cerebrovascular Stress : increase the risk of stroke; dialysis patients experience a 10-fold higher incidence, with case fatality rates reaching 90%

High hemodynamic fluctuations

Higher incidence of AF

Up to 10-fold increased risk of stroke in dialysis patients

Vascular calcification (VC)

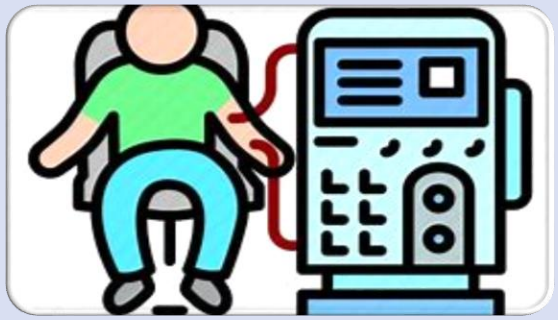
DM

HTN

HD Vintage

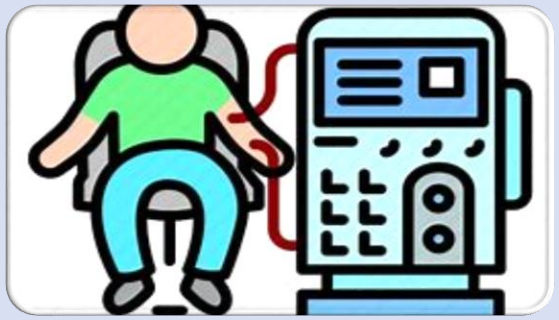
Miglinas, Front Cardiovasc Med 2020;

Seizures caused by electrolyte and glycemic disturbances



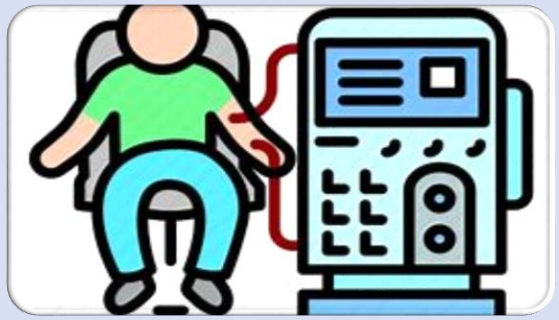
Hyponatremia

Rapid decreases in serum sodium concentrations can trigger generalized tonic–clonic seizures



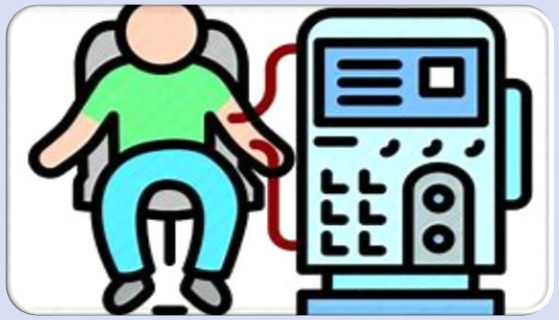
Hypocalcemia

increased neuronal excitability due to reduced extracellular concentration of calcium



Hypomagnesemia

usually at levels <1 mEq/L



Hypo–hyperglycemia

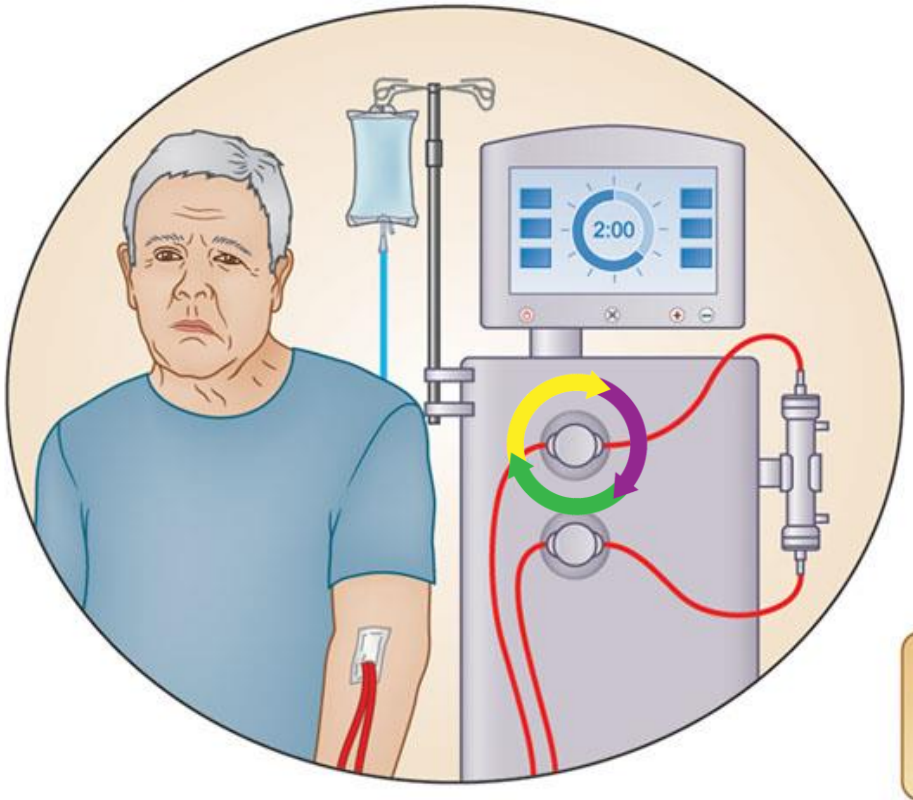
more pronounced in hemodialysis with low glucose dialysate. Nonketotic hyperglycemia most commonly occurs in older diabetic adults and can cause focal motor seizures.

Gungor , Nephrology Dialysis Transplantation, Volume 38, Issue 2, February 2023

Time dialysis sessions with essential rehabilitation services

Consider delaying dialysis if patient particularly at risk of raised ICP

Consider using cooled dialysate



Consider continuous forms of therapy (e.g. CVVHD) if patient particularly at risk of raised ICP

Exercise caution with anticoagulation in acute ischemic stroke and avoid in ICH

For peritoneal dialysis patients, try to minimize hypertonic large volume glucose exchanges

Avoid using dialyzers with large surface areas

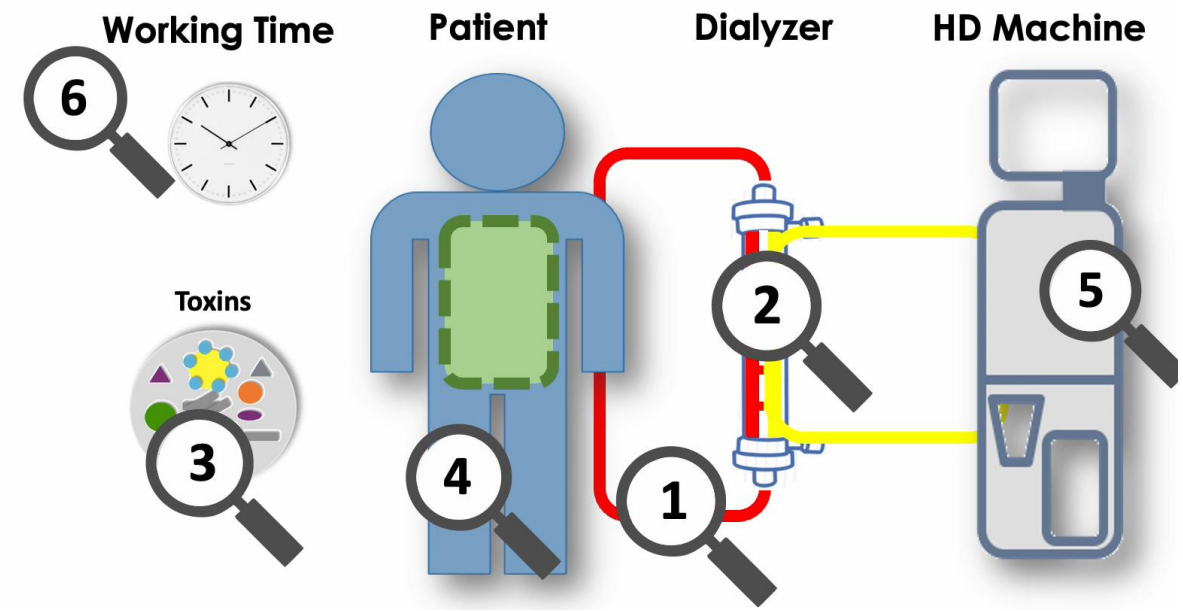
Consider shortening the dialysis session

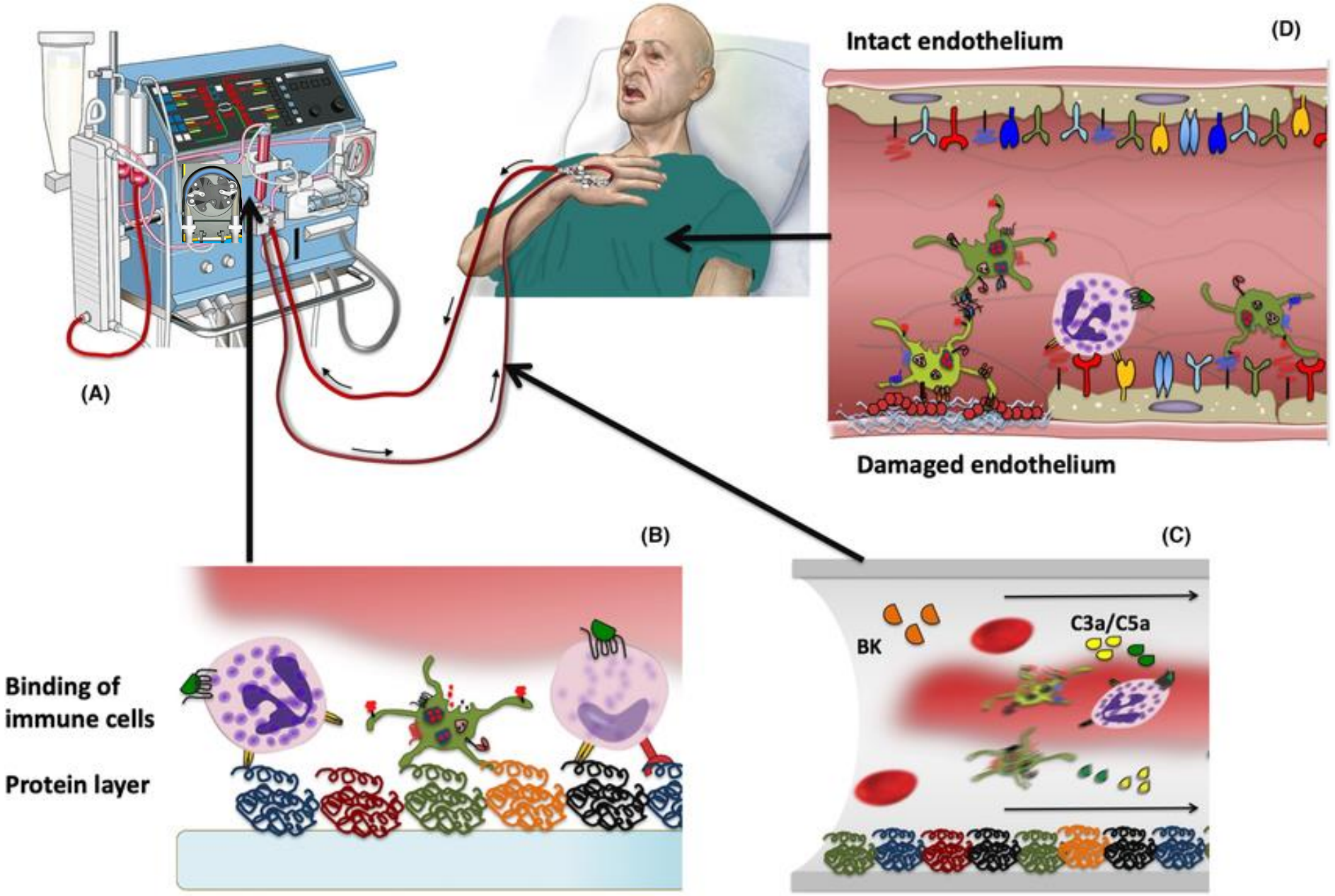
Avoid large hemodynamic shifts. Start blood flow slowly and increase gradually

Gentle fluid removal. Excessive ultrafiltration may reduce systemic arterial blood pressure and increase cerebral ischemia

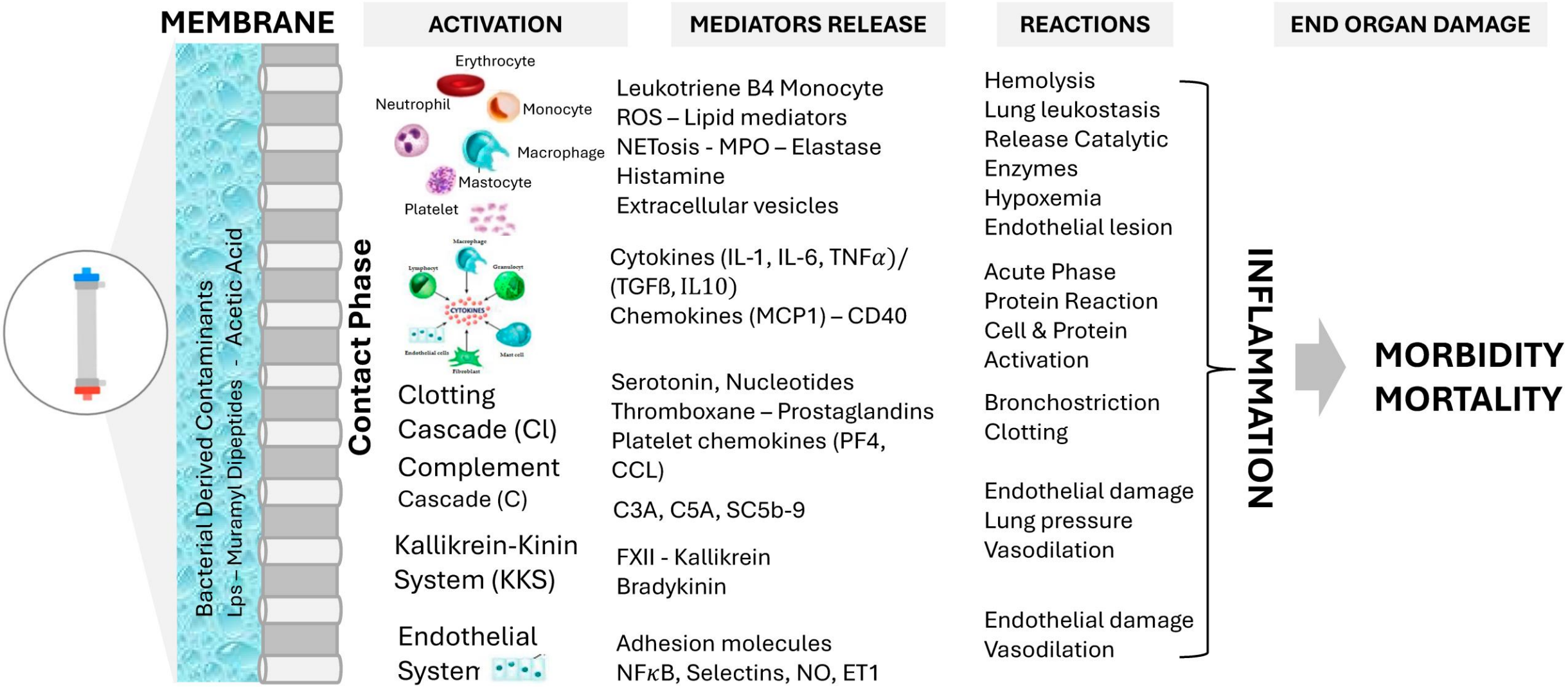
Suggestions for dialysis prescribing in acute stroke Kelly , Stroke , June 2021

- 1- Patient Centered Approach
- 2- Convection therapies , HDF and HDX
- 3- Extracorporeal therapies in ICU
- 4- Volume and Electrolyte control
- 5- DOACs in AF with ESKD patients
- 6- Cellular activation during HD
- 7- Home Hemodialysis
- 8-Future of intracorporeal HD

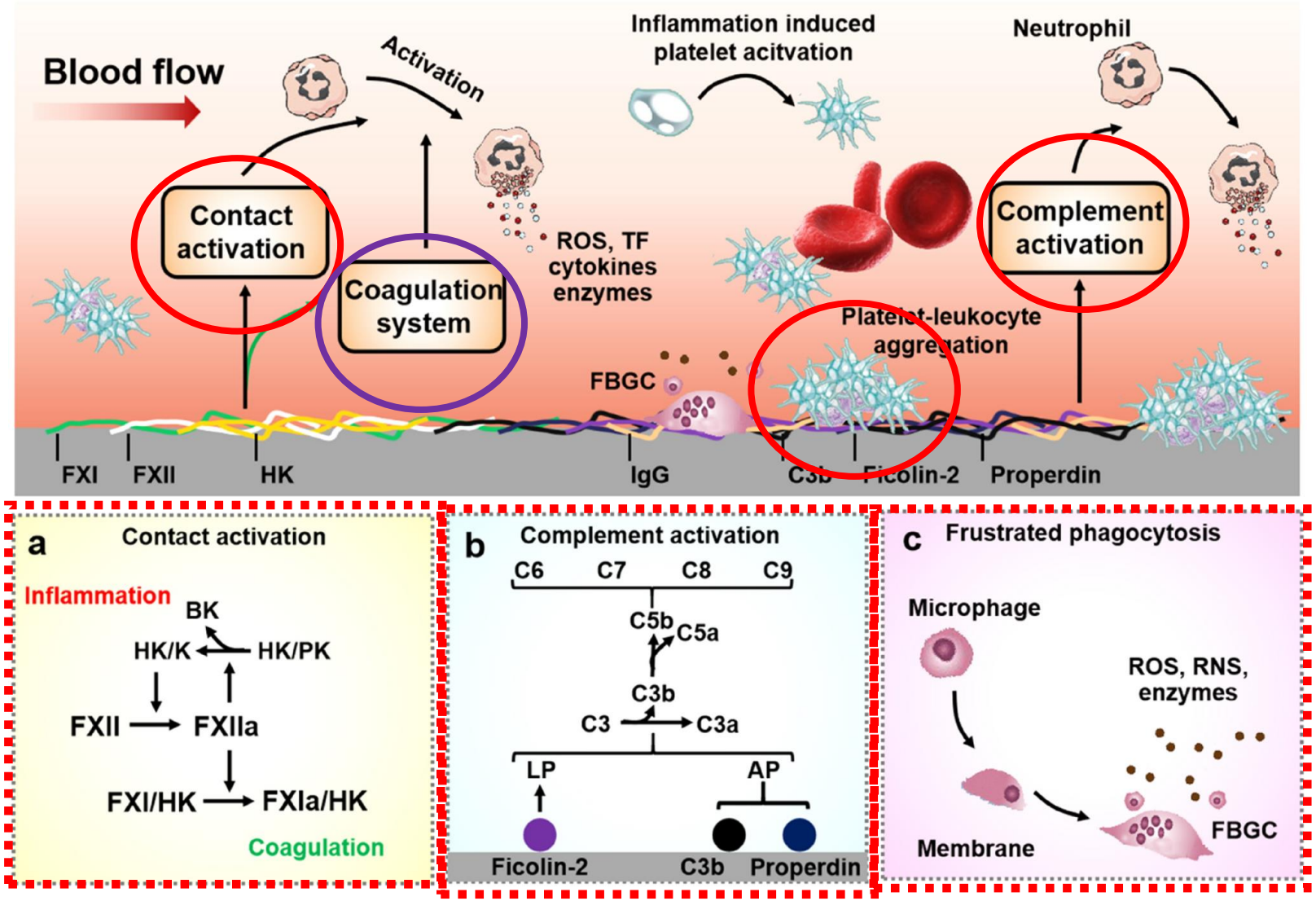



(A)
(B)
(C)
(D)
Intact endothelium
Damaged endothelium
Binding of immune cells
Protein layer
BK
C3a/C5a

Hemoincompatibility reactions induced by membrane contact and dialysis fluid contaminants result in the activation of various protein cascades and cells

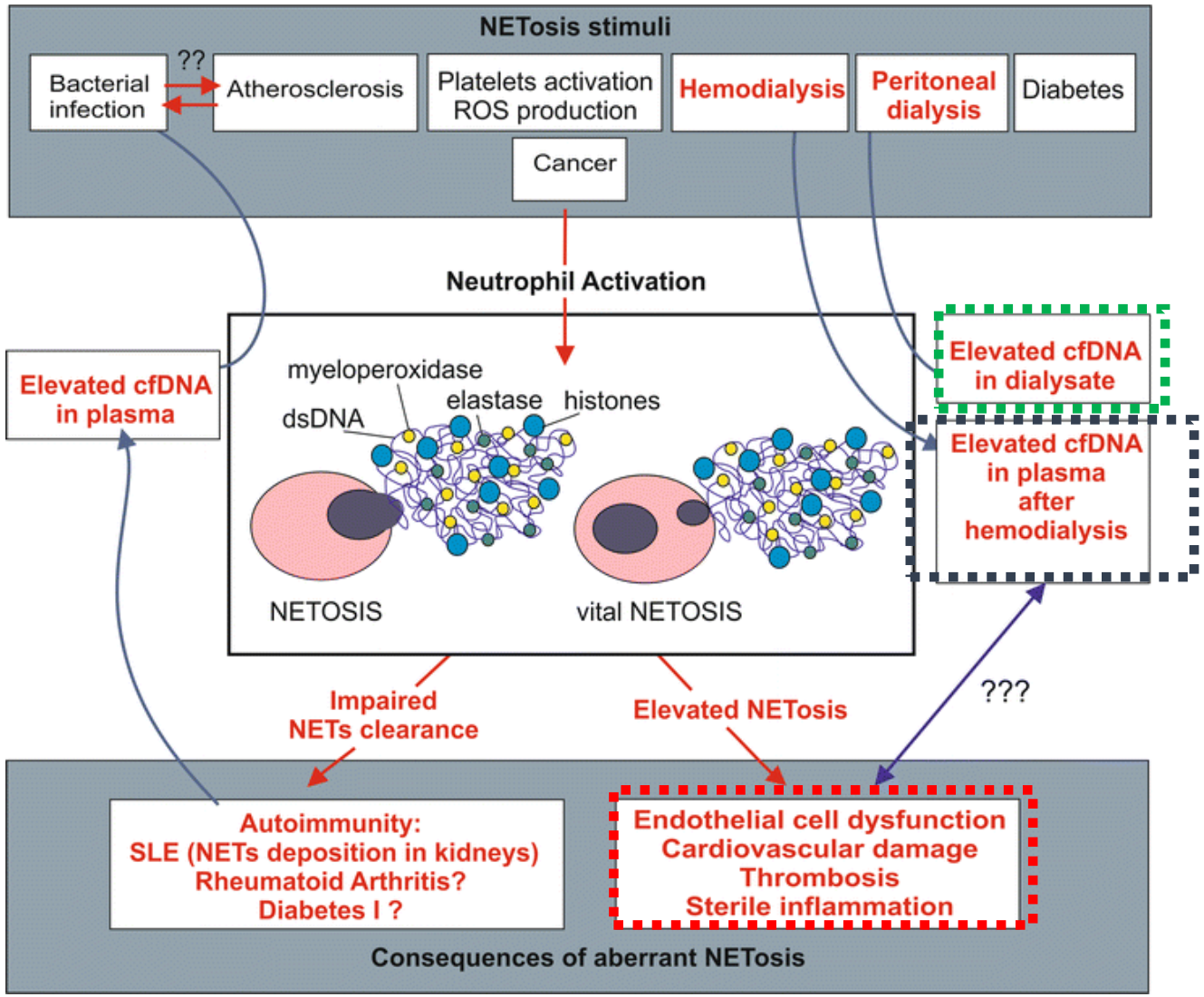


Hornig , J. Clin. Med. October , 2024



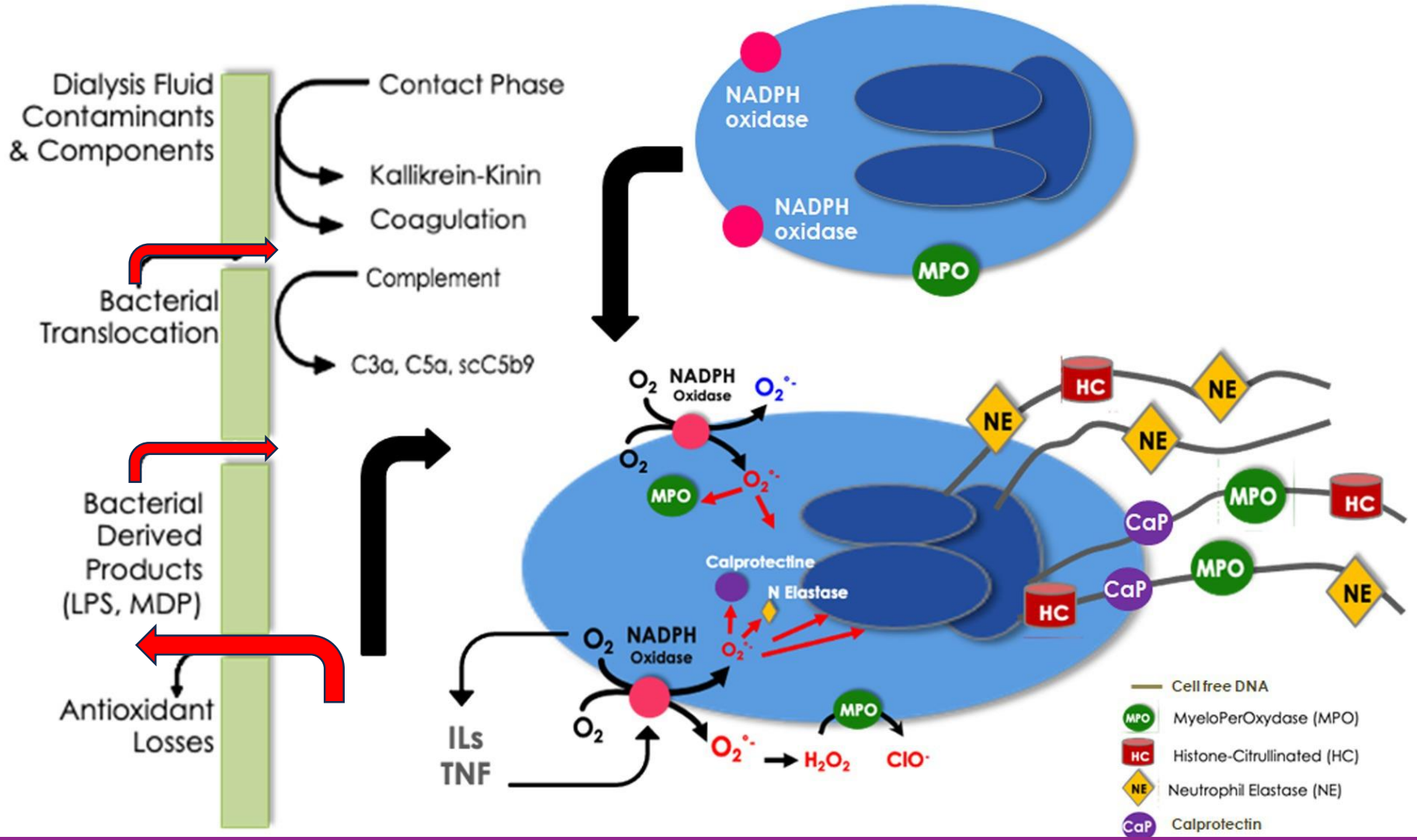
Haifeng , Advanced Fiber Materials (2023)

HD induced inflammation.



Elevated plasma levels of cell-free DNA after a hemodialysis procedure may be activated by NETosis which occurs as a consequence of activation of neutrophils during the process of hemodialysis.

Plasma cell-free DNA levels



Neutrophil extracellular traps in bioincompatibility: formation and factors implicated in dialysis-induced systemic stress. Crestol , Fronters , Volume 10 - 2023

Received: 4 November 2022 | Revised: 26 December 2022 | Accepted: 4 February 2023

DOI: 10.1111/1744-9987.13975

ORIGINAL ARTICLE

Therapeutic Apheresis and Dialysis

WILEY

Effect of dialyzer geometry on coagulation activation in the extracorporeal circuit in maintenance hemodialysis patients: Prospective randomized trial

Hesham ElSayed | **Khalid Samir Sayed** | **Mohamed Sary Gharib**

Division of Nephrology, Department of Internal Medicine, Faculty of Medicine, Ain Shams University, Cairo, Egypt

Correspondence
Mohamed Sary Gharib, Division of

Abstract

Background and Objectives: The coagulation cascade is activated during hemodialysis (HD) due to interaction of blood with the dialysis circuit. There is a paucity of data on the effect of the physical structure of the dialyzers on coagula-

Comparison of coagulation activation parameters according to dialyzer membrane type				
Parameter	Helixone FX80	Platinum H4	z/t value	P value
TAT at T0h (µg/l), median (IQR)	1.90 (0.52, 2.57)	1.80 (0.82, 2.50)	–0.637	0.524
TAT at T4h (µg/l), median (IQR)	3.00 (2.02, 3.77)[a]	2.65 (1.92, 3.97)[b]	–0.583	0.560
TAT absolute change, (µg/l), median (IQR)	1.15 (0.65, 1.75)	1.15 (0.67, 2.05)	–0.894	0.371

Hesham ElSayed etal Therapeutic apheresis February 2023

Agenda

- 1- Patient Centered Approach
- 2- Convection therapies , HDF and HDX
- 3- Extracorporeal therapies in ICU
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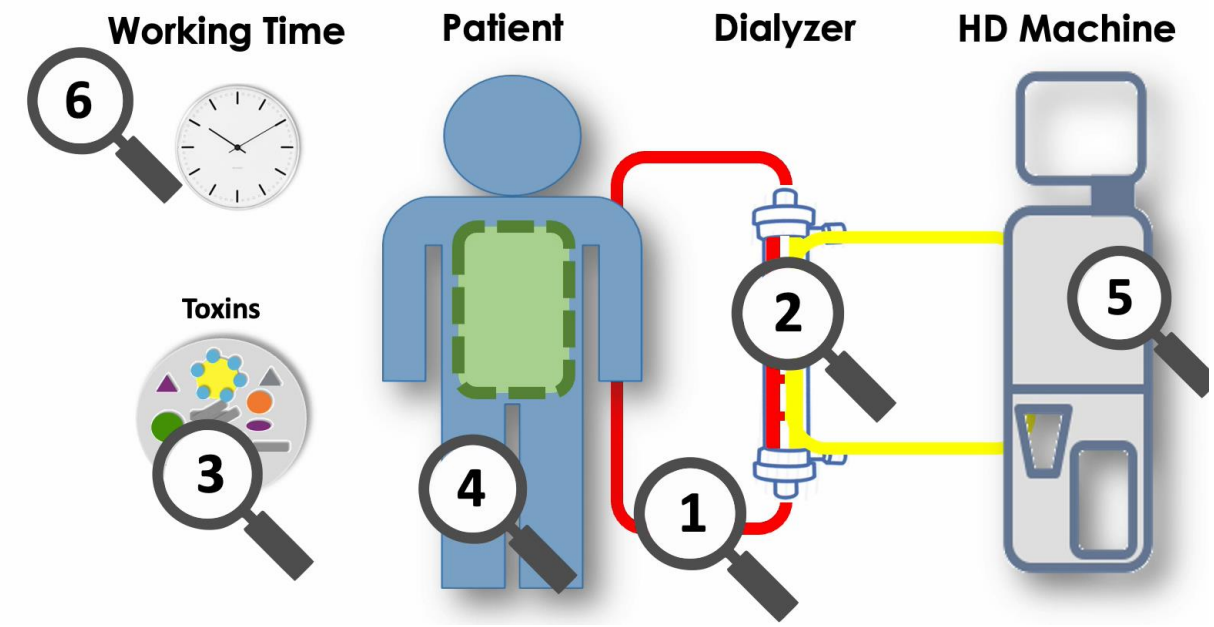
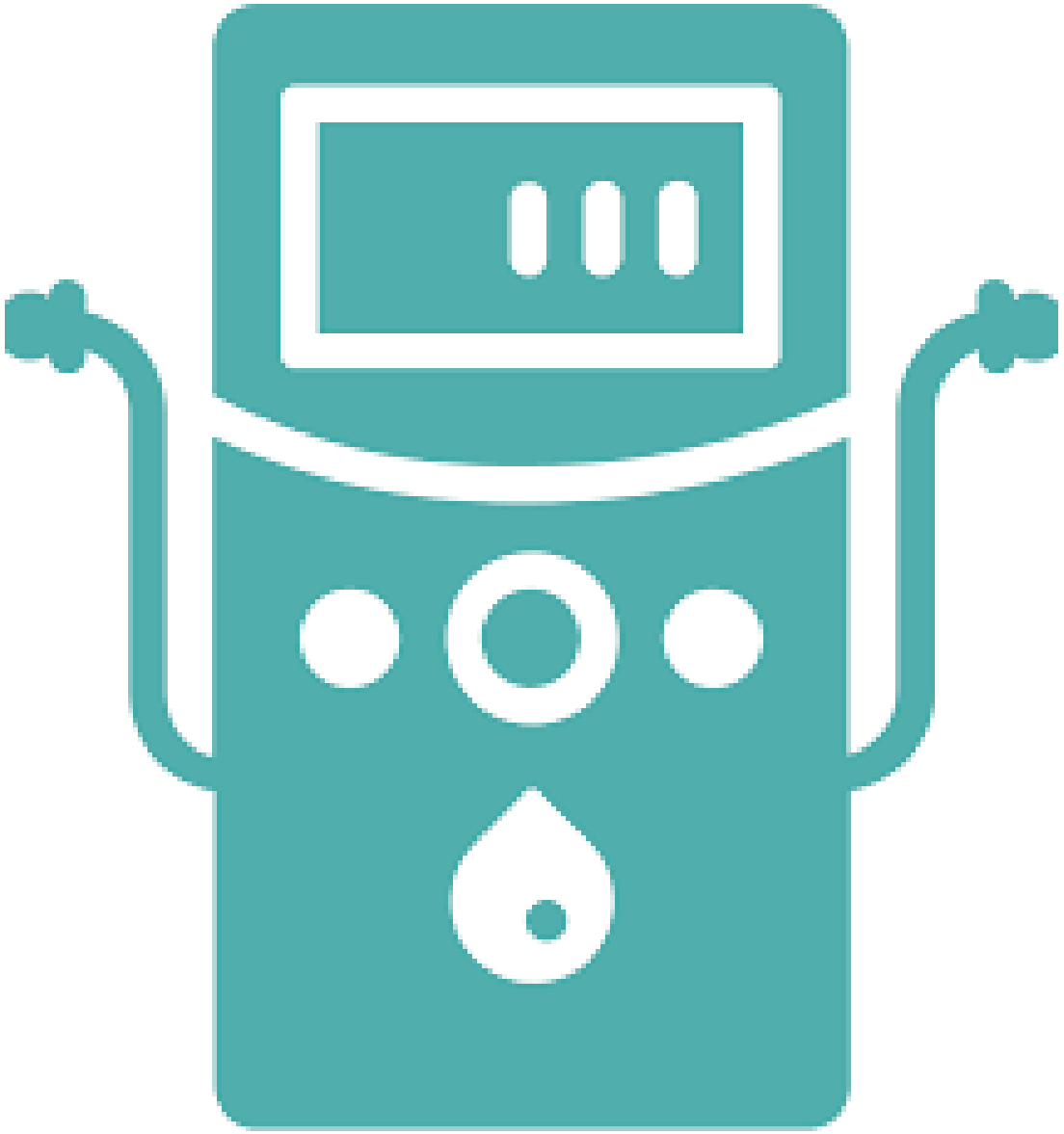
- 7- Home Hemodialysis
- 8- Future of intracorporeal HD






homes without walls
HHD
HOME
PD
EMPOWERE
SELF-CARE
HOME
THERAPIES
COMMUNITIES
WITHOUT
BORDERS
TRANSITIONAL CARE
GOAL
HOME DIALYSIS
%
2022
COMMUNITY CENTER
TELEMEDICINE

Portable Home Hemodialysis

Standard Duration

Thrice Weekly In-Center Hemodialysis

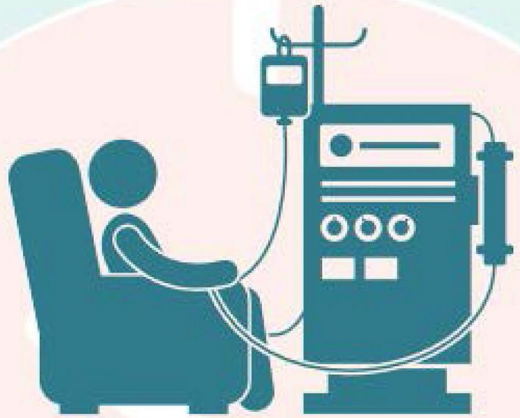
242 ± 10 min

vs

418 ± 54 min

Extended Duration

Thrice-Weekly Home Hemodialysis



- Increased Survival
- Lower Hospitalization Rate
- Decreased Systolic BP

Agenda

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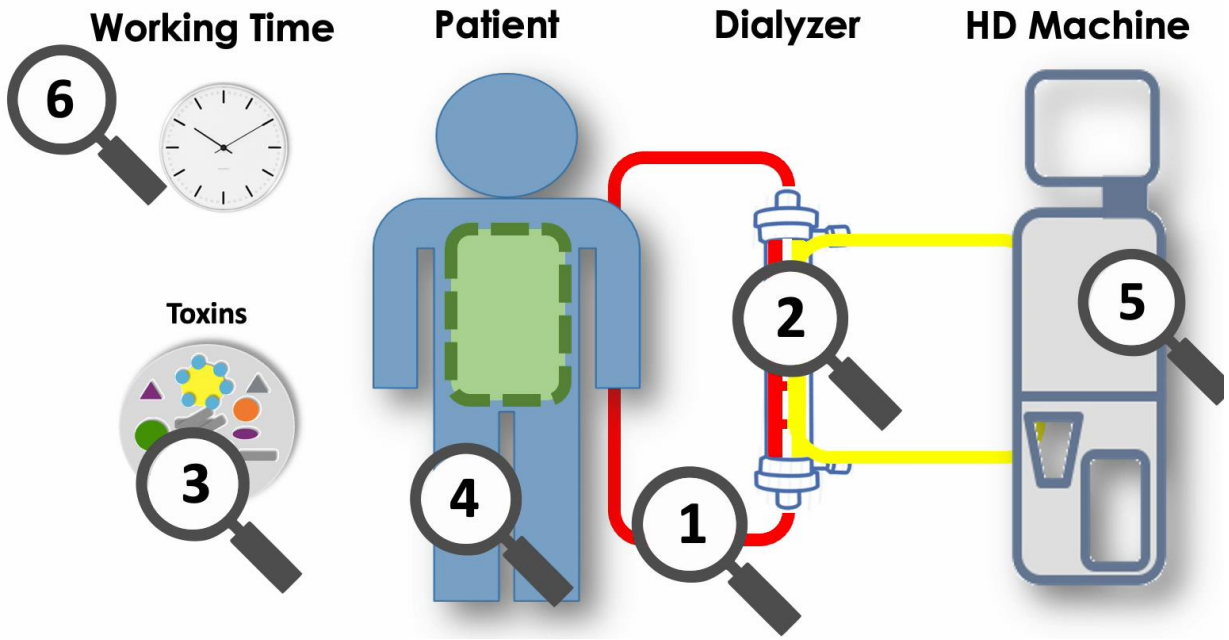
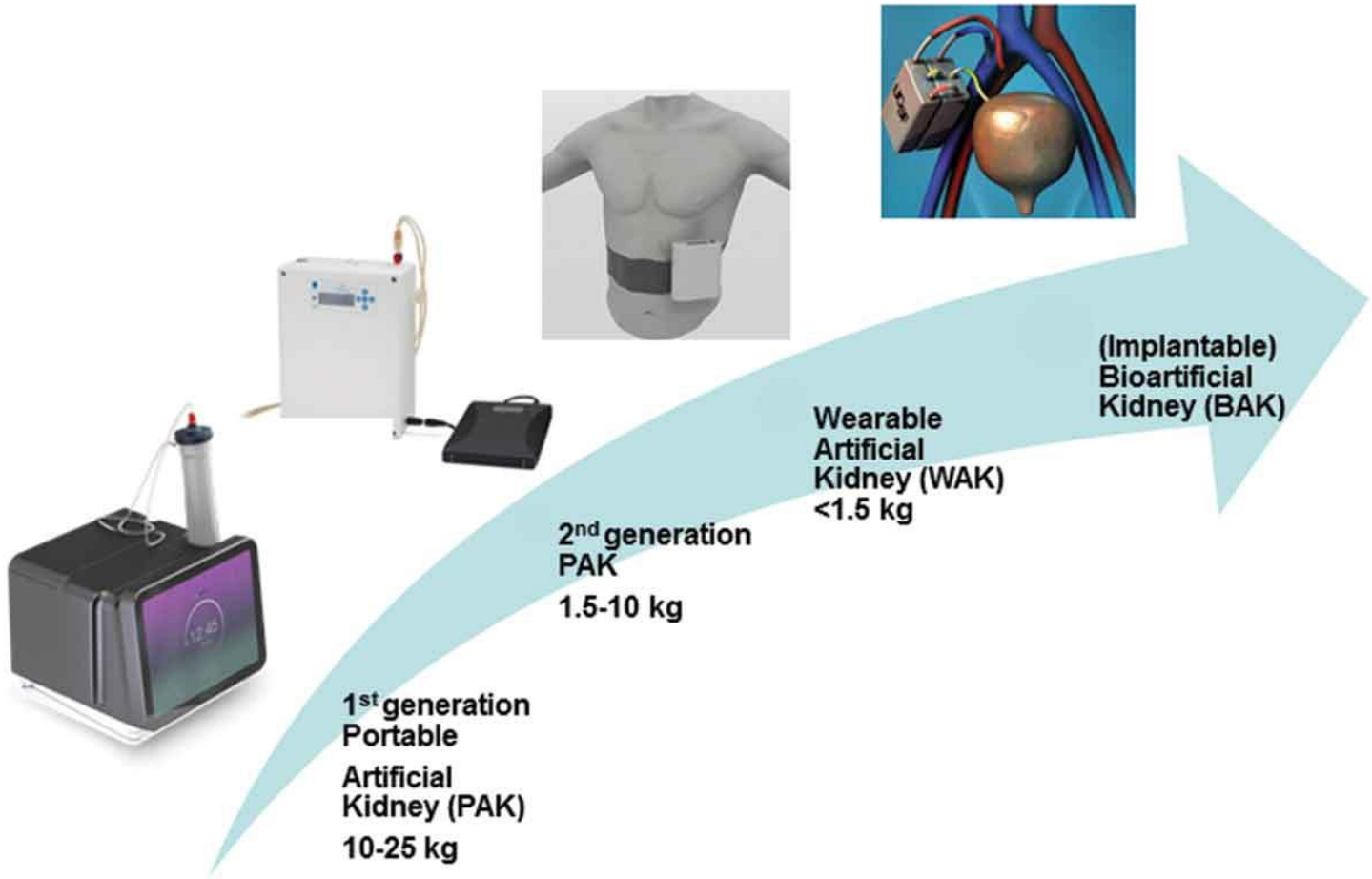




The road map of dialysis improvements

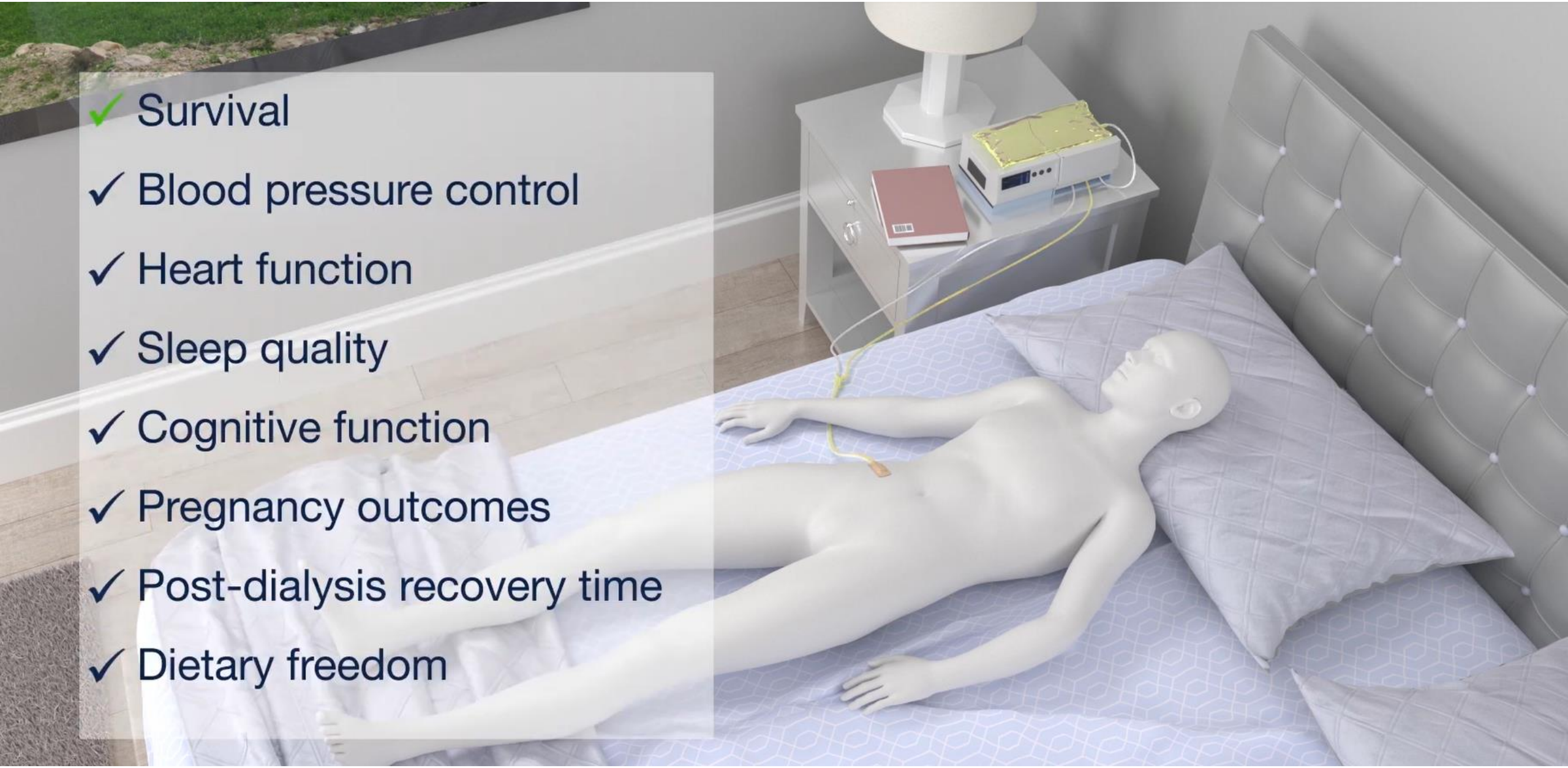
Creating a bioartificial kidney as a permanent solution to kidney failure

The cells in the bioreactor are isolated from the patient's immune system by the scaffold

Anticipate a GFR value of 20-30 ml/min with this device implanted.

IHEMO , Hemofilter and Portable dialysate pump


iHemo


✓ Survival
✓ Blood pressure control
✓ Heart function
✓ Sleep quality
✓ Cognitive function
✓ Pregnancy outcomes
✓ Post-dialysis recovery time
✓ Dietary freedom

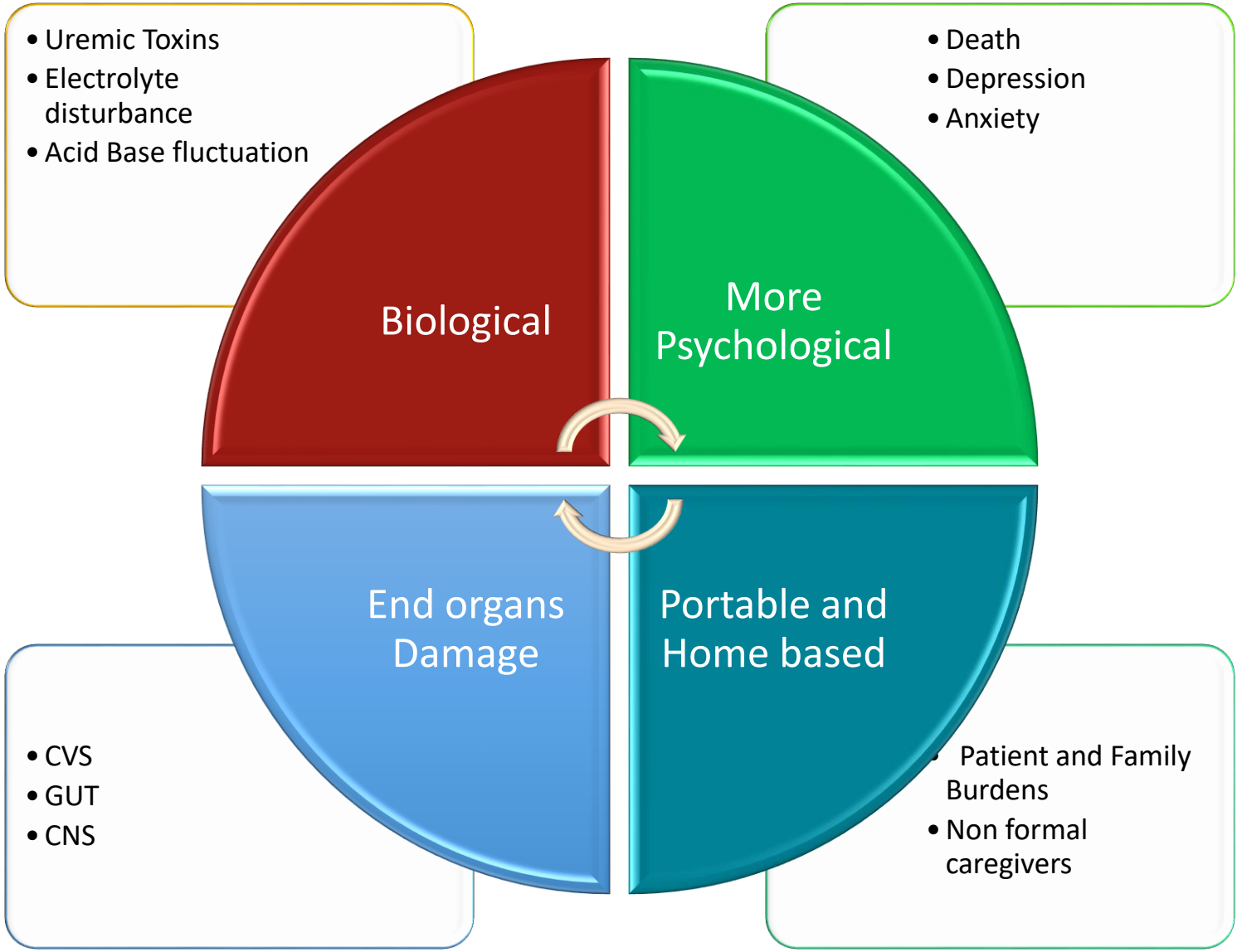

iHemo

Always there is a lot to think but actually a little we can have

Innovation is the bridge between Ideas and their reality

My bilevels
hesham Elsayed

Conclusion Defining HD Adequacy



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