Il bilancio del sodio e la dialisi ipotermica per la prevenzione dell'ipotensione arteriosa in emodialisi

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Ospedale A. Manzoni, Lecco

It is well recognised that haemodialysis (HD) patients suffer excess cardiovascular morbidity and mortality

Despite recent improvements in dialysis patient outcomes, cardiovascular events remain the leading cause of death accounting for 50 to 55% of mortality according to estimates of the United States Renal Data System.

Severe arrhythmias and sudden cardiac death account for almost 28% of cardiac death while coronary ischemic disease, congestive heart failure or vascular events are responsible for the rest.

There is growing evidence focusing on the mechanisms underpinning this excess cardiac mortality including HD-induced cardiac injury

Fluid overload is quite common in hemodialysis patients. In a large cohort of incident hemodialysis patients (>40.000), moderate fluid overload (>2.5 l) assessed by multifrequency bioimpedance was noted in 46% of patients, while a more severe one (>6 l) was observed in about 10%.

Hypertension was noted in 20% of patients in the same cohort and more frequently associated with fluid overload.

In addition, cardiac health issues tended to aggravate over the next 12 months in about half of the patients, contributing to worsened outcomes and almost doubling the relative risk of death.

Left ventricular hypertrophy (LVH), a surrogate marker of chronic fluid overload and/or hypertension was detected up to 75% in patients starting dialysis with a continuous increase over time.

Hyponatremia, a biomarker strongly associated with poor outcome in dialysis patients, is observed in 10 to 19% of hemodialysis patients. In a recent study, it has been shown that hyponatremia was in fact associated with combined fluid overload (EC and IC fluid excess) with intercompartmental fluid imbalance, translating into the occurrence of an intercurrent illness (cardiac failure, inflammation, oxidative stress) being likely associated with protein energy wasting.

Lastly, pulmonary edema and related congestive heart decompensation episodes are among the most frequent causes of hospitalization (44%) and readmissions creating a significant burden both on patient and healthcare system.

Fluid volume depletion and care management of hemodialysis patients is another critical point that may affect outcomes.

Too aggressive dry weight policy based on high ultrafiltration rate (> 13 ml/hr/kg, for example), is associated with critical hypovolemia and serious intradialytic hypotension (IDH), that may lead to repetitive systemic hemodynamic stress episodes with end-organ damage.

Repetitive ischemic insults result from inadequate hemodynamic response to volume depletion but not only. In fact, ischemic insult is part of a broader multifactorial stress condition, namely dialysis-induced systemic stress syndrome, that includes hemobiological reactions, hypoxemia, thermal imbalance, osmotic and electrolytic shifts.
Dialysis induced systemic stress may contribute to morbidity and mortality in dialysis patients as a potent disease modifier including protein energy wasting process.

A call for action is needed to mitigate this additional cardiovascular risk in maintenance hemodialysis patients.

It is easily recognized that sodium and water related disorders contribute significantly to cardiac burden in hemodialysis patients, either from chronic fluid overload exposure during the interdialytic period or from acute fluid depletion during dialytic time

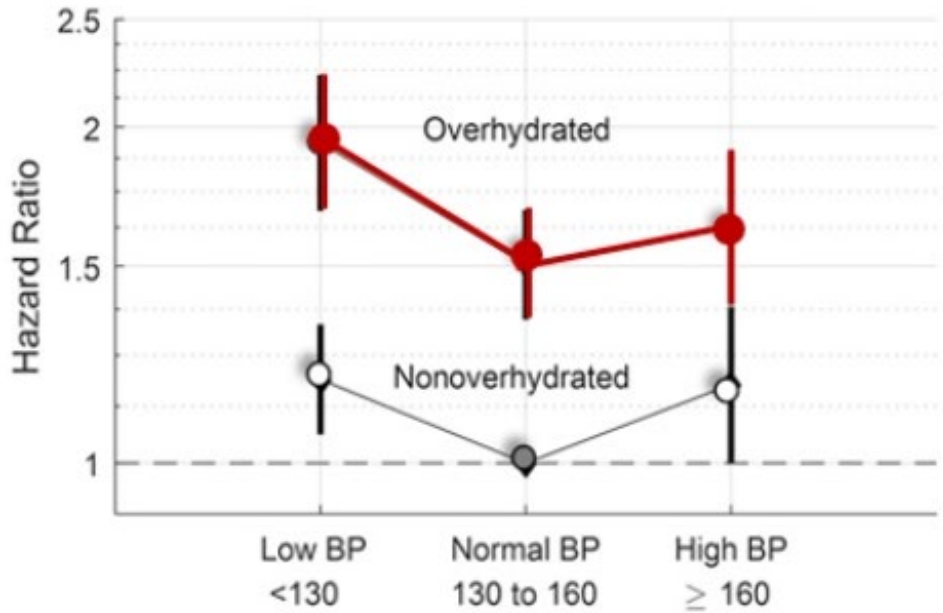
Chronic fluid overload and mortality in ESRD

39,566 patients with incident ESRD

Large dialysis network in 26 countries

Relationship of fluid overload with mortality

1 year cumulative FO-based analysis



Zoccali et al, *J Am Soc Nephrol* 2017

IPOTENSIONE ARTERIOSA INTRADIALITICA

-E’ l’ipotensione arteriosa che si verifica durante il trattamento emodialitico, in un paziente non ipoteso all’inizio della HD

-E’ frequente

-Può ridurre l’efficacia dialitica e contribuire all’eccesso di morbilità e mortalità associata all’HD

-Alcuni pazienti necessitano di una terapia infusionale ev per ripristinare valori pressori «normali» durantel’HD

IPOTENSIONE ARTERIOSA INTRADIALITICA

DEFINIZIONE (Kidney Disease Outcomes Quality Initiative (KDOQI), European Best Practice Guidelines):

- Riduzione della pressione sistolica ≥20 mmHg o una riduzione della pressione arteriosa media [(2*PAD + PAS)/3] ≥ 10 mmHg, associate con sintomi clinici e necessità di intervento infermieristico.

- Una riduzione della pressione arteriosa sistolica intradialitica <90 mmHg nel 30% delle sedute HD è associata con una maggiore mortalità

FREQUENZA

-L'ipotensione arteriosa durante (o immediatamente dopo) il trattamento HD complica dal 5 al 30% di tutti i trattamenti HD. In alcuni pazienti, più del 50% delle sedute di HD sono complicate da ipotensione arteriosa.

-Tra i fattori di rischio demografici associati all'ipotensione arteriosa intradialitica abbiamo: età avanzata, età dialitica elevate, diabete mellito, pressione arteriosa pre-HD bassa, bassa albuminemia, sesso femminile, etnicità ispanica e elevato BMI

IPOTENSIONE ARTERIOSA INTRADIALITICA

ETIOLOGIA

-In alcuni casi, i pazienti che sviluppano una ipotensione arteriosa, hanno delle condizioni cliniche serie che richiedono un'immediata valutazione.

Queste condizioni includono:
-infezioni sistemiche (sepsi)
-aritmie
-infarto miocardico
-emolisi
-emorragie
-embolia gassosa
-reazione al «filtro» (membrana) e/o alle linee

N.B. E' SEMPRE NECESSARIO ESCLUDERE QUESTE CONDIZIONI NEI PAZIENTI CHE SVILUPPANO UN'IPOTENSIONE INTRADIALITICA

IPOTENSIONE ARTERIOSA INTRADIALITICA

ETIOLOGIA

-Più frequentemente, l'ipotensione intradialitica si verifica in assenza delle condizioni cliniche serie/gravi viste prima.

-I fattori principali che contribuiscono all'ipotensione intradialitica sono:

- Eccessiva e/o rapida ultrafiltrazione
- Rapida riduzione dell'osmolarità plasmatica
- Prescrizione di un peso secco troppo basso
- Neuropatia autonomica
- Ridotta riserva cardiaca

-Altri fattori includono:

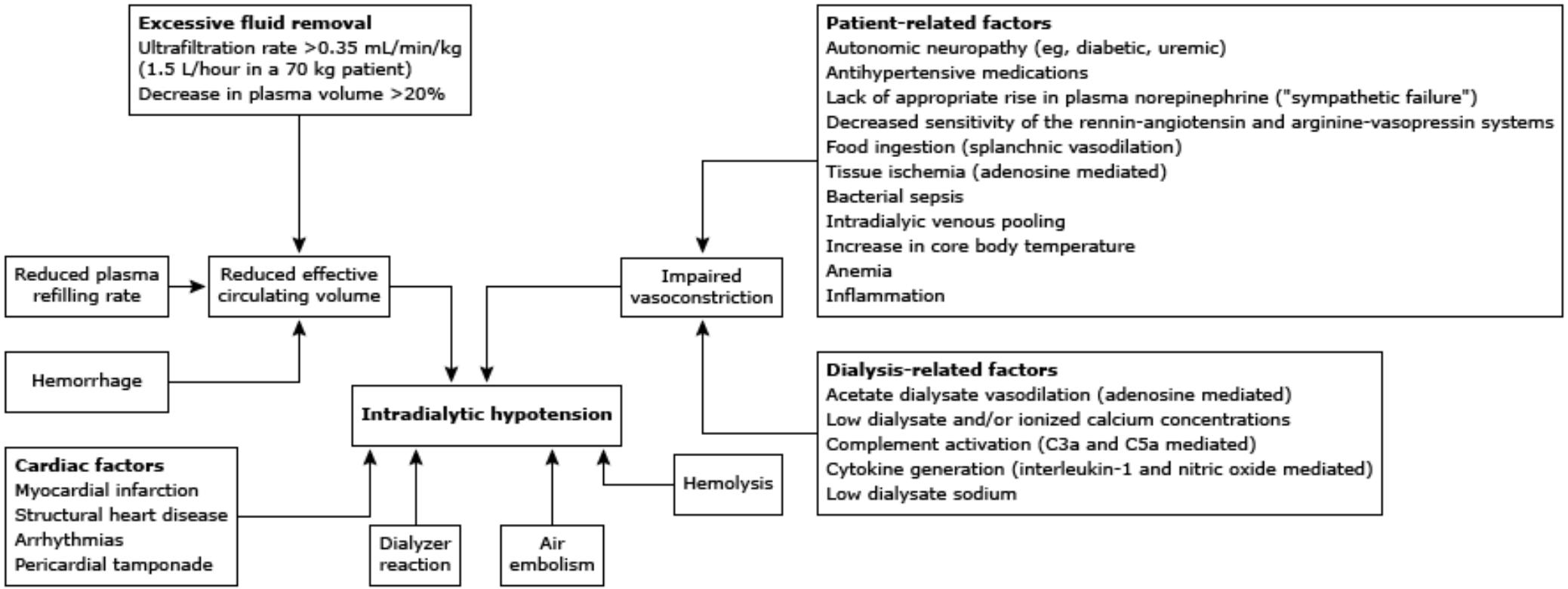
- Assunzione di farmaci antipertensivi prima del trattamento HD
- Assunzione di cibo (o bevande zuccherate) immediatamente prima o durante l'HD

-La composizione e la temperatura del dialisato possono contribuire all'ipotensione arteriosa intradialitica:

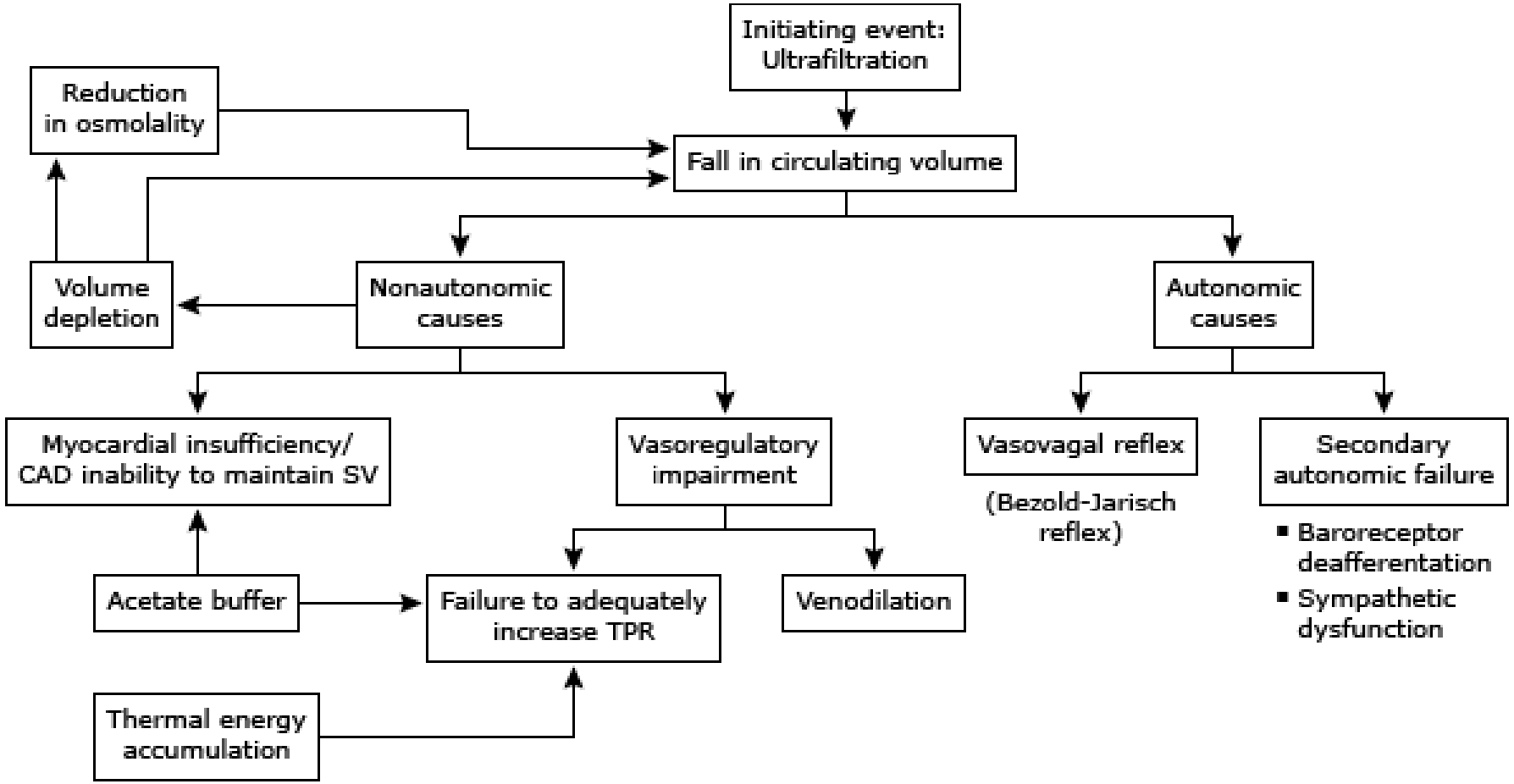
- Utilizzo dell'acetato, bassa concentrazione di sodio e calcio, elevata concentrazione di magnesio
- Temperatura del dialisato maggiore della temperature corporea

-Rilascio di adenosina durante l'ischemia d'organo, aumentata sintesi di vasodilatatori endogeni (ossido nitrico), inappropriate bassi livelli plasmatici di vasopressina

Causes of intradialytic hypotension



Physiologic response to hemodialysis that might be involved in the pathogenesis of intradialytic hypotension



CAD: coronary artery disease; TPR: total peripheral resistance.

IPOTENSIONE ARTERIOSA INTRADIALITICA

PREVENZIONE DEGLI EPISODI RICORRENTI

- I pazienti che hanno ripetuti episodi di ipotensione intradialitica devono essere accuratamente valutati e devono essere messe in atto delle misure preventive al fine di evitare il ripetersi delle ipotensioni.

- L'approccio deve essere per gradi, iniziando con semplice misure. Una valutazione ed un intervento successive dipenderà dalla risposta del paziente alle misure iniziali (European Best Practices Guideline).

IPOTENSIONE ARTERIOSA INTRADIALITICA

PREVENZIONE DEGLI EPISODI RICORRENTI

1. Approccio iniziale

Comprende:

-Rivalutazione del peso secco
-Evitare di mangiare durante il trattamento emodialitico
-Sospendere I farmaci antipertensivi prima della dialisi
-Dieta iposodica per limitare l’incremento ponderale interdialitico e per ridurre l’UF oraria

IPOTENSIONE ARTERIOSA INTRADIALITICA

PREVENZIONE DEGLI EPISODI RICORRENTI

2. Approccio di 2° livello

Comprende:
-Valutazione cardiologica: insufficienza cardiaca, cardiomegalia, malattia ischemica coronarica, versamento pericardico

-Utilizzo di una temperatura bassa nel dialisato

-Aumento del tempo dialitico: si può effettuare aumentando la durata del trattamento o effettuando un trattamento emodialitico supplementare durante la settimana

IPOTENSIONE ARTERIOSA INTRADIALITICA

PREVENZIONE DEGLI EPISODI RICORRENTI

3. Approccio di 3° livello

Se tutte le altre misure falliscono si possono utilizzare dei farmaci o cambiare metodica dialitica

-Midodrina (Gutron)

E' un agonista adrenergico alfa-1. Nei pazienti con neuropatia autonomica e in altri pazienti la midodrina può essere efficace se ben tollerata. In genere si somministrano 2.5-5 mg, 15-30 minuti prima della dialisi. Nei casi in cui l'ipotensione si verifica nella seconda parte del trattamento dialitico, la midodrina si può somministrare dividendo la dose e somministrando metà dose 30 minuti prima della dialisi e metà dose dopo la 2° ora di trattamento (in ogni caso dopo 3 ore dalla prima dose).
Tuttavia, gli studi al riguardo sono contrastanti e non viene utilizzata molto spesso

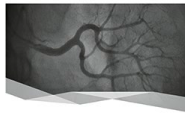
-Cambio della modalità dialitica

Nei pazienti che hanno delle ipotensioni intradialitiche ripetute e debilitanti si deve pensare anche al cambio della modalità dialitica come l'emodiafiltrazione, la dialisi peritoneale, la dialisi quotidiana o la dialisi notturna

-Altre terapie

Correggere sempre l'anemia
Sertralina, vasopressina, carnitina

Kidney and Blood Pressure Research



RESEARCH

Karger

The historical focus on small solute clearance precipitated by the NCDS study, improvements in HD technology and economic factors have driven an inexorable pressure to reduce treatment times

This has promoted a reliance on higher dialysate sodium concentrations from 130 to 145 mmol/l or more as this is thought to reduce adverse intradialytic symptoms and haemodynamics associated with shorter treatment times

However, truly adequate dialysis should be isonatric allowing for complete removal of the *inter*dialytic sodium gain and avoiding *intra* dialytic sodium loading and consequently higher interdialytic weight gain (IDWG)

Increased IDWG or increased ultrafiltration volumes are associated with increased blood pressure (BP), left ventricular mass and mortality

Furthermore, ultrafiltration volume is a potent and modifiable determinant of HD-induced myocardial stunning and this may be an integrating factor linking IDWG to excess mortality

CJASN
Clinical Journal of the American Society of Nephrology

Perspective

CJASN ePress. Published on September 18, 2020 as doi: 10.2215/CJN.08610520

Is It Time for Precision Dialysis?

Nupur Gupta and *Jay B. Wish*

CJASN 16: ●●●–●●●, 2021. doi: https://doi.org/10.2215/CJN.08610520

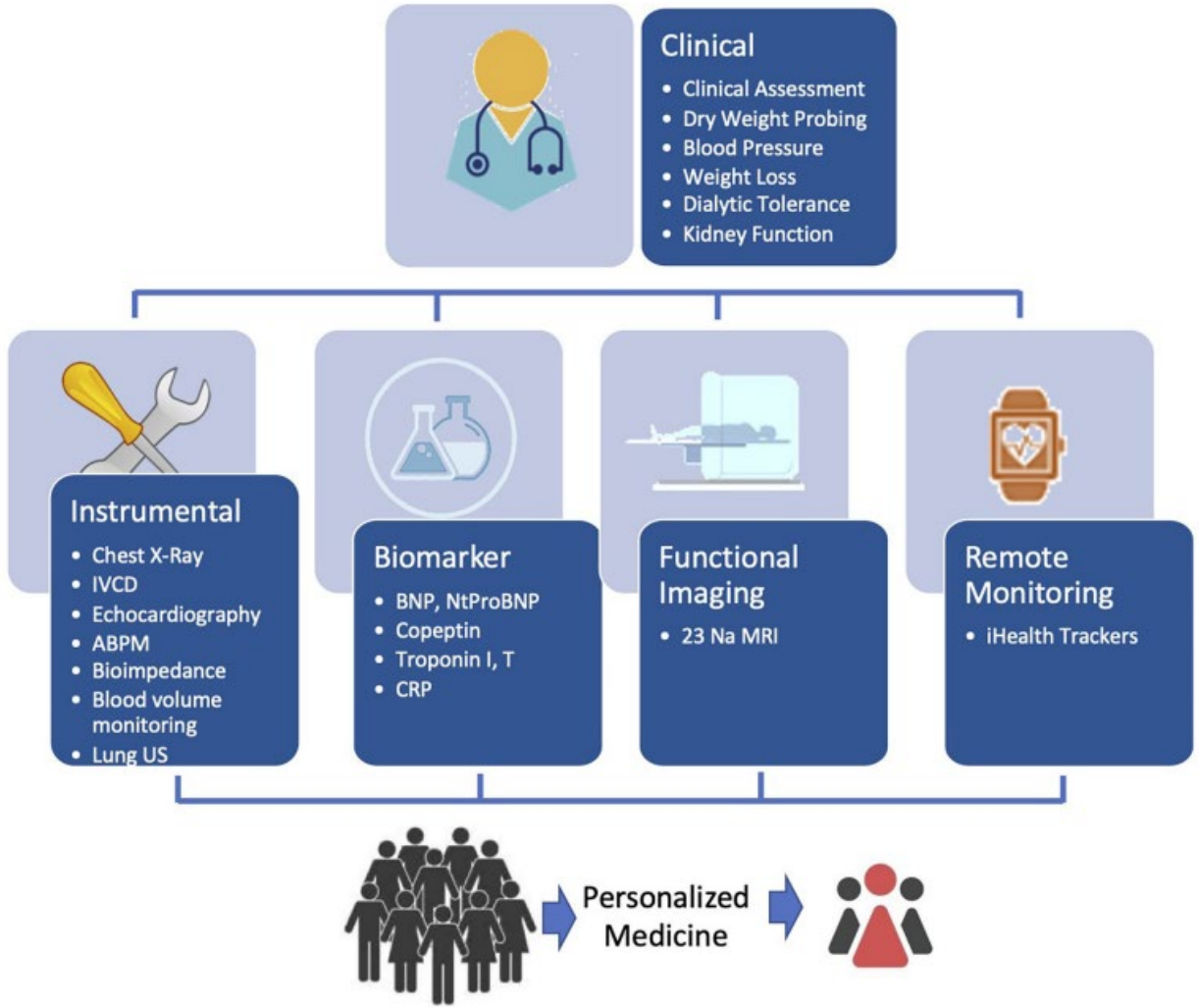


FIGURE 1 | Schematic diagram for optimizing and integrating tools for personalized guidance of fluid management in HD patients.

Artificial Organs

Zero Diffusive Sodium Balance in Hemodialysis Provided by an Algorithm-Based Electrolyte Balancing Controller: A Proof of Principle Clinical Study

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Artificial Organs 2019, 43(2):150–158

Restoring and controlling fluid volume homeostasis is still a challenge in contemporary end-stage kidney disease patients treated by intermittent hemodialysis (HD) or hemodiafiltration (HDF). This primary target is achieved by ultrafiltration (dry weight probing) and control of intradialytic sodium transfer (dialysate-plasma Na gradient). The latter task is mostly ignored in clinical practice
by applying a dialysate sodium prescription uniform for all patients of the dialysis center but unaligned to individual plasma sodium levels.

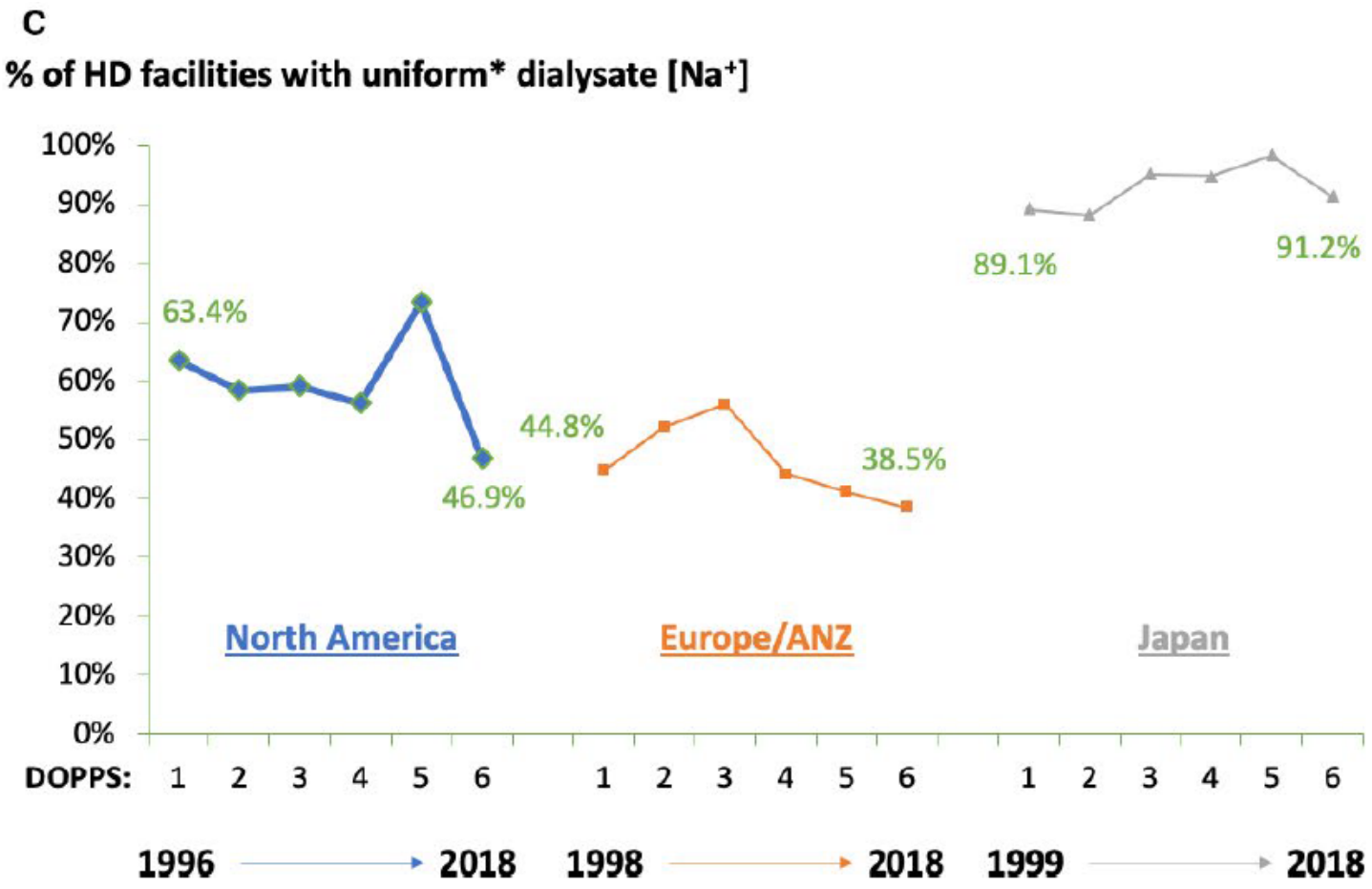
ORIGINAL ARTICLE

Seminars in Dialysis WILEY

Temporal changes in dialysate [Na^+] prescription from 1996 to 2018 and their clinical significance as judged from a meta-regression of clinical trials

Mark R. Marshall[1,2] | Angelo Karaboyas[3]

Seminars in Dialysis. 2020;33:372–381.



Country	Total	134	135	136	137	138	139	140	141	142	143
FR	2427		1,0%	3,1%	2,2%	24,9%	6,6%	52,6%	2,3%	6,8%	
SA	1580		1,2%	9,1%	0,3%	88,0%	0,5%	0,5%	0,1%	0,3%	
BA	1011		0,4%	2,3%	6,5%	81,4%	2,4%	5,4%	0,2%	1,3%	
CZ	1542		4,2%	9,4%	4,4%	66,7%	4,0%	8,6%	0,6%	1,4%	
EE	229		0,9%	2,6%	15,3%	76,4%	0,4%	4,4%	0,0%	0,0%	
HU	2143		3,5%	11,8%	0,0%	81,6%	0,5%	1,8%	0,0%	0,2%	
IE	280		1,1%	0,0%	22,1%	53,6%	0,7%	22,5%	0,0%	0,0%	
IT	2026		1,0%	2,0%	0,0%	13,7%	7,7%	46,5%	7,7%	15,4%	
NL	35		5,7%	0,0%	0,0%	82,9%	0,0%	11,4%	0,0%	0,0%	
PL	5914		1,4%	7,4%	4,1%	77,2%	1,0%	7,8%	0,3%	0,6%	
PT	4837		0,4%	2,2%	1,8%	56,9%	7,4%	29,2%	0,3%	1,7%	
RO	5920		17,4%	14,0%	11,5%	40,0%	3,4%	11,2%	0,5%	1,6%	
RU	7533		19,4%	24,9%	20,0%	27,2%	3,4%	1,8%	0,2%	0,3%	
SE	39		0,0%	7,7%	0,0%	79,5%	0,0%	7,7%	0,0%	5,1%	
SK	1841		0,6%	1,7%	0,8%	30,4%	1,8%	63,0%	0,2%	1,6%	
SL	376		0,3%	0,0%	0,0%	63,0%	0,3%	26,9%	0,5%	5,1%	
SP	4322		1,0%	3,8%	8,4%	50,3%	14,6%	20,3%	0,7%	0,8%	
SR	292		0,0%	0,7%	0,7%	83,9%	3,4%	10,3%	0,0%	0,3%	
TR	6906		4,2%	19,5%	8,7%	65,2%	0,3%	2,0%	0,0%	0,1%	
UK	3680		13,5%	9,6%	4,5%	64,7%	0,2%	7,1%	0,1%	0,0%	
Grand Total	52955	0,5%	6,9%	11,0%	7,5%	53,0%	3,8%	14,7%	0,6%	1,6%	0,4%

High Na dialysate concentration

Low Na dialysate concentration

Kidney Blood Pressure Research

Original Paper

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Use of Online Conductivity Monitoring to Study Sodium Mass Balance in Chronic Haemodialysis Patients: Prospects for Treatment Individualisation

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Christopher W. McIntyre[a, b]

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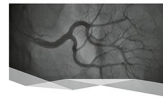
Kidney and Blood Pressure Research



Karger

The terminology of ‘high’ and ‘low’ dialysate sodium concentrations can be unclear.
Only the ionized proportion of sodium is available for diffusion, hence its movement is determined by the gradient between the concentrations of non-complexed, electrochemically active ions from plasma to dialysate as well as temperature and acidity.
The Gibbs-Donnan effect refers to a phenomenon caused by anionic plasma proteins too large to traverse the dialysis membrane, creating an electric field that attracts cations and reducing the amount of plasma diffusible sodium

Na Plasm. Diff. = Na^+ * Fattore Donnan
Es. 140*0.96 = 134.4 mmol/l
Se Na Dialisato = 140 mmol/l: guadagno diffusivo di Na durante la HD; UF con concentrazione di Na inferiore a quella del plasma

This results in a hypotonic ultrafiltrate and allows the movement of sodium and water to become uncoupled during HD

This makes it possible for patients to load sodium during dialysis, despite dialysate sodium concentration being lower than the predialysis plasma sodium concentration (commonly termed ‘low’ dialysate sodium concentration)

Though the effects of this may be negligible over a single HD session, the potential of this reservoir of sodium ions to buffer sodium transport over a longer period and influence BP and IDWG has not been fully elucidated.

It must be highlighted that sodium and fluid accumulation is a longstanding process aggravating along chronic kidney disease progression with a culminant point at the end stage of kidney disease.

In addition, specific conditions (i.e., aging) or diseases (i.e., hypertension, diabetes) are strong enhancers of this risk.

A more careful attention should be paid to this cause to address their consequences and better manage patients in order to mitigate their risks

frontiers | Frontiers in Nephrology

REVIEW
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Sodium First Approach, to Reset Our Mind for Improving Management of Sodium, Water, Volume and Pressure in Hemodialysis Patients, and to Reduce Cardiovascular Burden and Improve Outcomes

OPEN ACCESS

Edited by:
Nicholas M. Selby,
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review www.kidney-international.org

Sodium and water handling during hemodialysis: new pathophysiologic insights and management approaches for improving outcomes in end-stage kidney disease

OPEN

Bernard Canaud[1,2], Jeroen Kooman[3], Nicholas M. Selby[4], Maarten Taal[4], Susan Francis[5], Pascal Kopperschmidt[6], Andreas Maierhofer[6], Peter Kotanko[7,8] and Jens Titze[9,10,11]

Kidney International (2019) 95, 296–309

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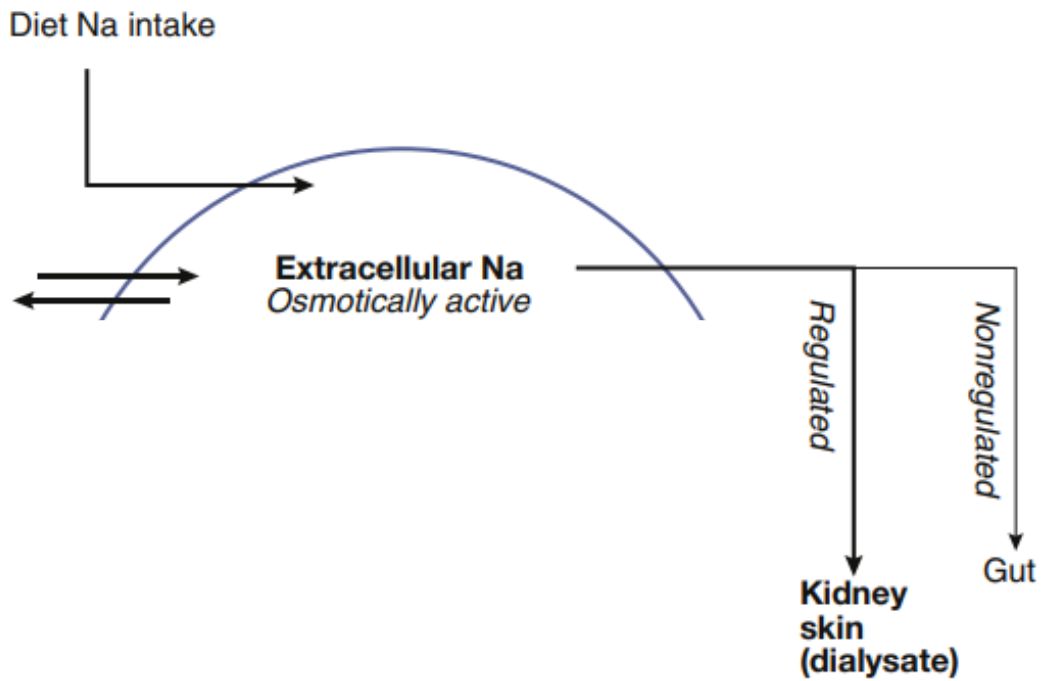

Figure 1 | Total body sodium (Na) homeostasis and location.

Sodium and water handling during hemodialysis: new pathophysiologic insights and management approaches for improving outcomes in end-stage kidney disease

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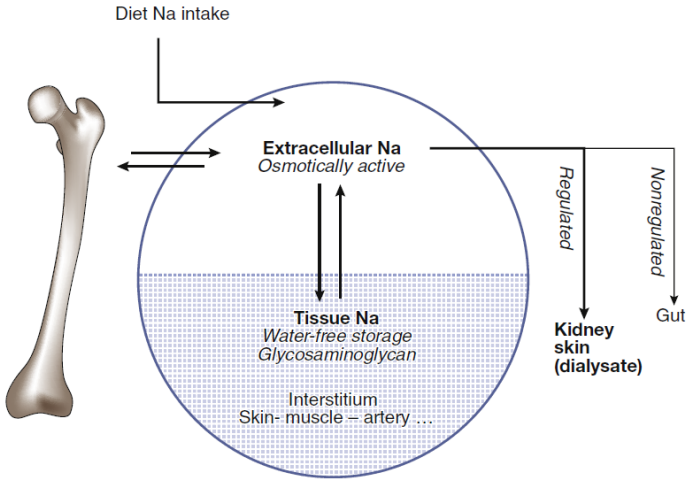

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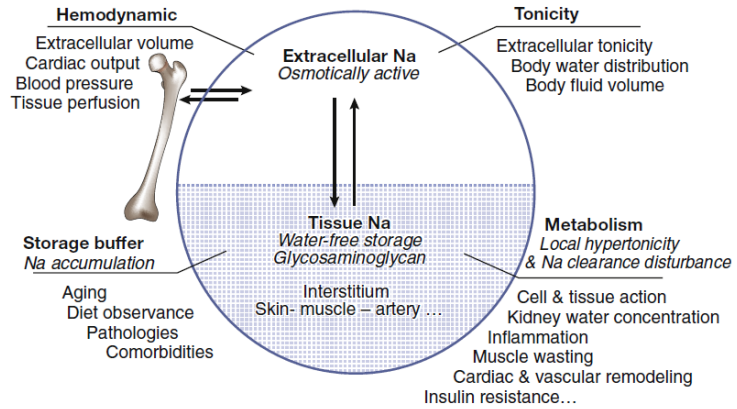

Figure 2 | Role of sodium (Na) according to the new understanding of physiology.

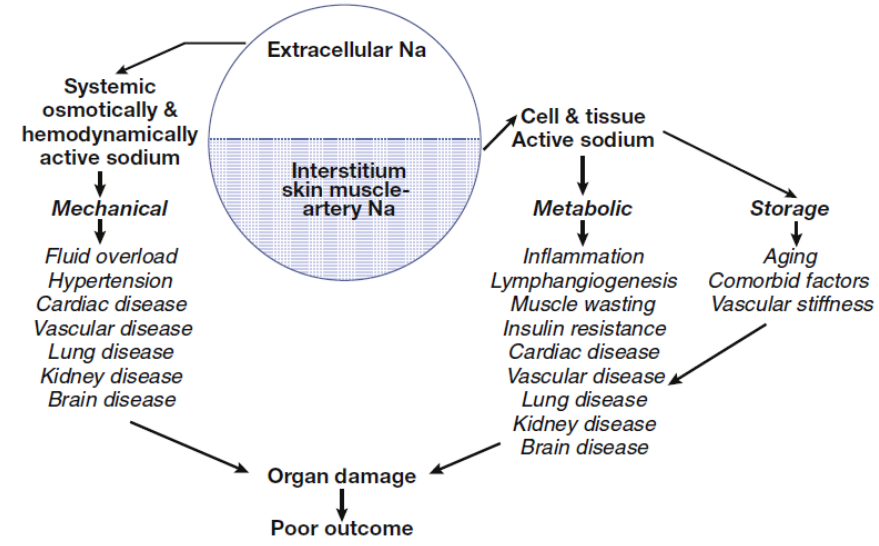

Figure 3 | Pathophysiologic role of sodium (Na) accumulation and cross-talk.

Sodium and water handling during hemodialysis: new pathophysiologic insights and management approaches for improving outcomes in end-stage kidney disease

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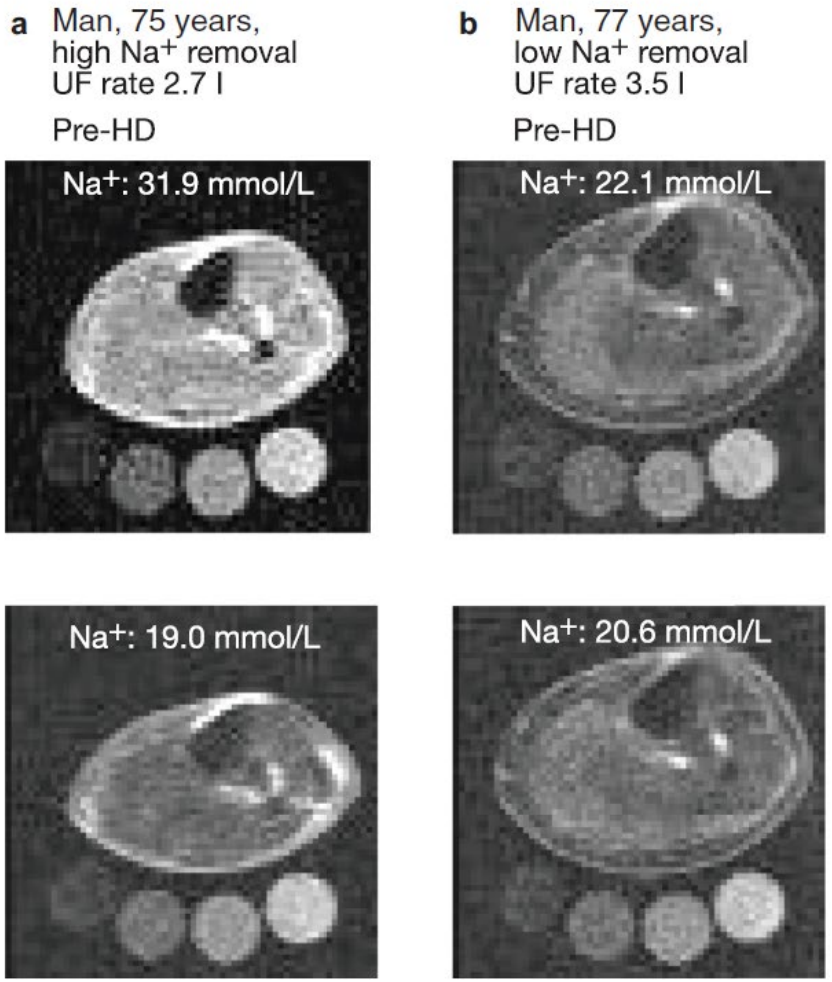
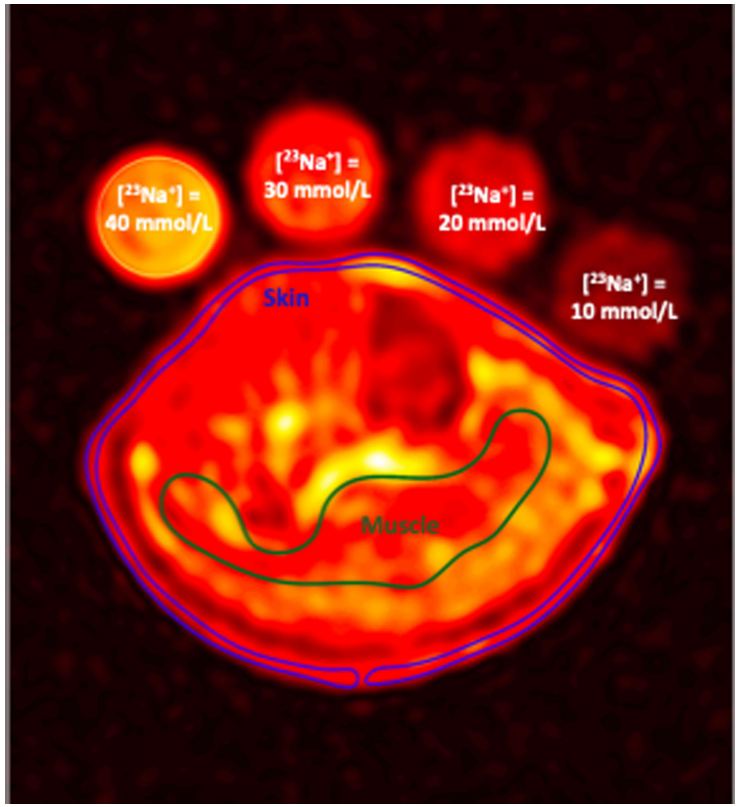


Figure 5| Representative lower-limb 23Na magnetic resonance imaging (Na-MRI) features from 2 end-stage renal disease patients before and after hemodialysis (HD). (**a**) Patient with high sodium ion (Na^+) removal after HD; ultrafiltration (UF) rate: 2.7 l. (**b**) Patient with low Na^+ removal; UF rate: 3.5 l. Standards as represented by lower circles contain 10, 20, 30, and 40 mmol/l Na^+. Reprinted from Dahlmann A, Dörfelt K, Eicher F, et al. Magnetic resonance-determined sodium removal from tissue stores in hemodialysis patients. *Kidney Int*. 2015;87:434–441,[43] with permission from Elsevier. Copyright © 2015 International Society of Nephrology.



Sandrine Lemoine, Fabio R. Salerno, Alireza Akbari, Robert S. McKelvie and Christopher W. McIntyre. Circulation: Cardiovascular Imaging. Tissue Sodium Storage in Patients With Heart Failure: A New Therapeutic Target?, Volume: 14, Issue: 11, DOI: (10.1161/CIRCIMAGING.121.012910)

JASN
JOURNAL OF THE AMERICAN SOCIETY OF NEPHROLOGY

Clinical Research

Effect of Low-Sodium versus Conventional Sodium Dialysate on Left Ventricular Mass in Home and Self-Care Satellite Facility Hemodialysis Patients: A Randomized Clinical Trial

Mark R. Marshall, Alain C. Vandal, Janak R. de Zoysa, Ruvin S. Gabriel, Imad A. Haloob, Christopher J. Hood, John H. Irvine, Philip J. Matheson, David O.R. McGregor, Kannaiyan S. Rabindranath, John B.W. Schollum, David J. Semple, Zhengxiu Xie, Tian Min Ma, Rose Sisk and Joanna L. Dunlop

JASN May 2020, 31 (5) 1078-1091; DOI: https://doi.org/10.1681/ASN.2019090877

Effect of low versus conventional sodium dialysate on left ventricular mass in home and self-care satellite facility hemodialysis patients – a randomized clinical trial

METHODS

Patients undergoing home/self-care satellite facility HD (n=99) in New Zealand

Randomization

Dialysate [Na^+] 135 mM for 12 months (n=49)

Dialysate [Na^+] 140 mM for 12 months (n=50)

OUTCOMES AT 12 MONTHS

Outcome, adjusted for baseline values	Low dialysate [Na^+]	Conventional dialysate [Na^+]
LV mass index by CMR (g/m^2)	-3.94 (-10.52, 2.63)	Ref
Interdialytic weight gain (kg)	-0.57 (-0.86, -0.27)	Ref
B-type natriuretic peptide	0.49 (0.27, 0.90] times lower	Ref
Intradialytic hypotension	3.6 (0.5, 28.8) times more common	Ref
No effect on QoL, thirst, xerostomia, or dietary Na^+ intake. 5 participants in intervention arm could not complete trial due to intradialytic hypotension.		

CONCLUSION Over 12 months follow-up, dialysate [Na+] of 135 mM did not reduce LV mass relative to dialysate [Na+] of 140 mM, despite improving fluid status.

doi: 10.1681/ASN.2019090877

JASN
JOURNAL OF THE AMERICAN SOCIETY OF NEPHROLOGY

Do practices in managing fluid volume and intradialytic hypotension affect patient outcomes?

CJASN
Clinical Journal of American Society of Nephrology

Methods and Cohort

DOPPS Phase 4 (2009-2012)


N = 10250


273 facilities


12 countries


10 facility practices investigated

Findings

	All-cause mortality	CV mortality	CV events	Hospitalization
Dry weight assessment protocol	HR 0.78 (99% CI 0.64-0.94)	HR 0.72 (99% CI 0.55-0.95)		
Orthostatic BP measurement			HR 0.85 (99% CI 0.73-0.98)	HR 0.86 (99% CI 0.77-0.97)
Use of lower dialysate temperature		HR 0.76 (99% CI 0.58-0.98)		
On-line volume indicator				HR 1.19 (99% CI 1.02-1.38)
Sodium modelling/ profiling	HR 1.36 (99% CI 1.14-1.63)	HR 1.34 (99% CI 1.04-1.73)	HR 1.21 (99% CI 1.03-1.43)	

Conclusions Hemodialysis facility practices relating to the management of fluid volume and intradialytic hypotension are associated with patient outcomes.

Indranil Dasgupta, G Neil Thomas, Joanne Clarke, Alice Sitch, et al. ***Associations Between Hemodialysis Facility Practices to Manage Fluid Volume and Intradialytic Hypotension and Patient Outcomes.*** CJASN doi 10.2215/CJN.08240718. **Visual Abstract by Michelle Lim, MBChB**

Indranil Dasgupta et al. CJASN 2019;14:385-393

CJASN
Clinical Journal of the American Society of Nephrology

RCT

A randomized controlled trial of two dialysate sodium concentrations in hospitalized hemodialysis patients

Background

The optimal dialysate sodium concentration and implications of intra-dialytic hypotension (IHD) in maintenance hemodialysis (HD) remains unclear

This study compares higher vs. lower dialysate sodium in hospitalized patients on maintenance HD

Methods

Single center

Adult HD patients
n = 139

1:1

Baseline characteristics:
age 60 ± 14 years,
57% male, 33% Black

Lower dialysate sodium, 138 mmol/L
n = 69

Higher dialysate sodium, 142 mmol/L
n = 70

Outcomes:

- Decline in systolic blood pressure (SBP)
- Proportions of total sessions complicated by IDH (SBP decline ≥ 20 mmHg from pre-HD SBP)

Results

Mean pre-HD SBP = 138 ± 21 mmHg
Mean intra-dialytic SBP = 113 ± 21 mmHg

	Dialysate sodium		
Decline in SBP (mmHg)	23 ± 16	26 ± 16	p = 0.57
IDH complication	59%	54%	
Adverse events	66%	68%	

Odds of developing IDH in the higher (vs. lower) dialysate sodium groups: **0.72***

*(95% CI 0.36–1.44, p=0.35)

Conclusion

There was no significant difference in the absolute SBP decline in HD patients between lower or higher dialysate sodium concentration. Post-hoc adjusted analyses suggested a lower risk of IDH with higher DNa.

NEPHROLOGY DIALYSIS TRANSPLANTATION

Mc Causland et al. NDT (2021)
@NDTSocial

Kidney & Blood Pressure Research

Original Paper

Kidney Blood Press Res 2011;34:439–446
DOI: 10.1159/000329355

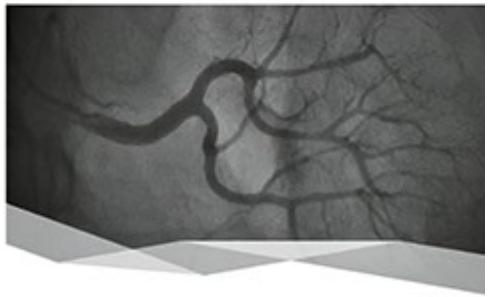
Received: November 18, 2010
Accepted: May 10, 2011
Published online: July 27, 2011

OPEN ACCESS
Kidney and Blood Pressure Research

Use of Online Conductivity Monitoring to Study Sodium Mass Balance in Chronic Haemodialysis Patients: Prospects for Treatment Individualisation

Aghogho Odudu[a] Stewart Lambie[a] Maarten W. Taal[a] Richard J. Fluck[a]
Christopher W. McIntyre[a, b]

[a]Department of Renal Medicine, Royal Derby Hospital, Derby, and [b]School of Graduate Entry Medicine and Health, University of Nottingham, Nottingham, UK



RESEARCH

Karger

This has culminated in a situation where the goal of an individualised isonatric HD prescription has been hampered by the lack of effective and simple tools to study the consequences of dialysate sodium concentration to sodium mass balance in routine clinical practice

E’ necessario misurare il bilancio del Na durante la HD
Come fare?

1. Quantificazione diretta
2. «Inventory» balance
3. Modello cinetico
4. Bilancio della conducibilità ionica

EXPERT REVIEW OF MEDICAL DEVICES, 2016
VOL. 13, NO. 10, 933–943
http://dx.doi.org/10.1080/17434440.2016.1230494

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REVIEW

OPEN ACCESS

On-line monitoring of electrolytes in hemodialysis: on the road towards individualizing treatment

Manoj K. Sharma[a], Fokko P. Wieringa [b,c], Arjan J. H. Frijns[a] and Jeroen P. Kooman[d]

[a]Department of Mechanical Engineering, Eindhoven University of Technology, Eindhoven, Netherlands; [b]TNO Science & Industry, Division of Medical Equipment, Delft, Netherlands; [c]Faculty of Health, Medicine and Life Sciences, Maastricht University, Maastricht, Netherlands; [d]Department of Internal Medicine, Division of Nephrology, University Hospital Maastricht, Maastricht, Netherlands

Table 3. Summary of electrolyte and urea monitoring technologies.

Measuring technology	Detection method	Advantage(s)	Disadvantage(s)	Direct fluid contact needed?	Proof-of-concept /Commercialization
ISEs	Electrochemical (potentiometric)	Mature technology, selective, relatively inexpensive hardware	Interferences from other ions, selectivity to a single ion is difficult. Interference, drift over time. Needs frequent recalibration	Yes	Commercial product, suitable for electrolyte monitoring
Conductivity measurement	Electrochemical (conductivity)	Simple, has been integrated in the dialysis machine	No ion-selectivity, interference, drift over time	Yes	Commercialized and integrated in dialysis machine for ioninc dialysance measurement of Na (like Diacontrol by Hospal Gambro and OCM by Fresenius Medical)
Flame photometry	Optical	Mature technology, highly elective	Bulky (gas reservoir) and not practical to integrate in dialysis machines	Yes	Commercialized and used in clinical laboratory for determination of electrolyte concentrations [69]
UV-absorbance	Optical	Simple, robust, good signal strength	Solute size dependent. Limited ion-selectivity	No (through the optical window)	Commercialized for urea monitoring (e.g. DiaSens [70])
NIR spectroscopy	Optical	Good selectivity to solutes	Weak signal strength and complex instrumentation	No (through the optical window)	Proof-of-concept reported in literature for urea monitoring [48]
Fluorescent PET sensors	Optical (requires fluid contact with membrane) (fluorescence)	Highly selective, robust, possibility to detect single molecule	pH sensitive, complex integration of the molecules on a substrate	Yes	Commercial product to off-line measure whole blood samples (Opti Lion Electrolyte Analyzer) [58]
LIBS	Optical (no contact with fluid needed)	Highly selective, simultaneous measurement of all chemical elements possible down to ppm-levels (provided enough laser power)	High-power laser source needed, partially destructive (photochemistry inside laser-induced plasma spark volume)	No (through the optical window)	Proof-of-concept in dialysate available. Also many portable LIBS systems for gases and solid surfaces have been demonstrated or are commercially available [65]

ISEs: Ion selective electrodes; UV: ultraviolet; NIR: near-infrared; PET: photoinduced electron transfer; LIBS: laser-induced breakdown spectroscopy.

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REVIEW

OPEN ACCESS

On-line monitoring of electrolytes in hemodialysis: on the road towards individualizing treatment

Manoj K. Sharma[a], Fokko P. Wieringa [b,c], Arjan J. H. Frijns[a] and Jeroen P. Kooman[d]

[a]Department of Mechanical Engineering, Eindhoven University of Technology, Eindhoven, Netherlands; [b]TNO Science & Industry, Division of Medical Equipment, Delft, Netherlands; [c]Faculty of Health, Medicine and Life Sciences, Maastricht University, Maastricht, Netherlands; [d]Department of Internal Medicine, Division of Nephrology, University Hospital Maastricht, Maastricht, Netherlands

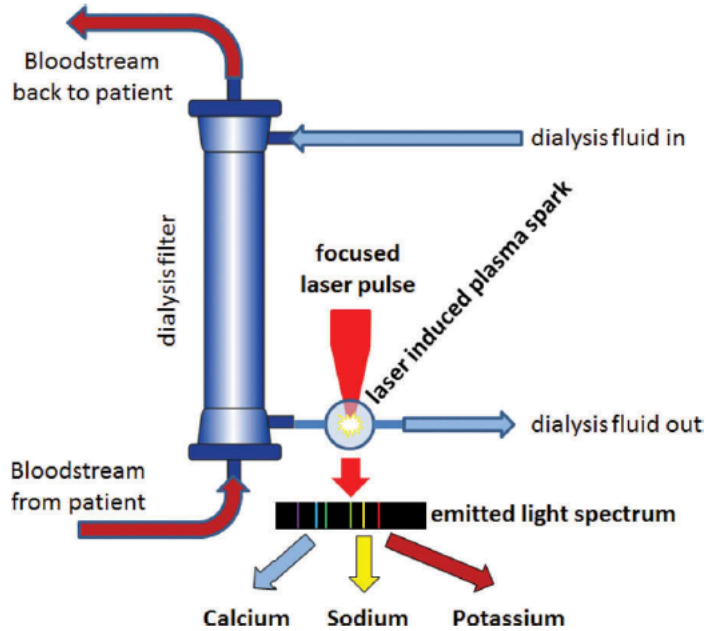


Figure 3. Principle of laser induced breakdown spectroscopy (LIBS): a tiny volume inside the dialysate stream is temporarily atomized by a focused high-energy pulsed laser. Light emitted from this high-temperature spark is collected and dispersed, where the atoms present in the specimen can be identified by specific peaks in the atomic emission spectrum. [67,68].

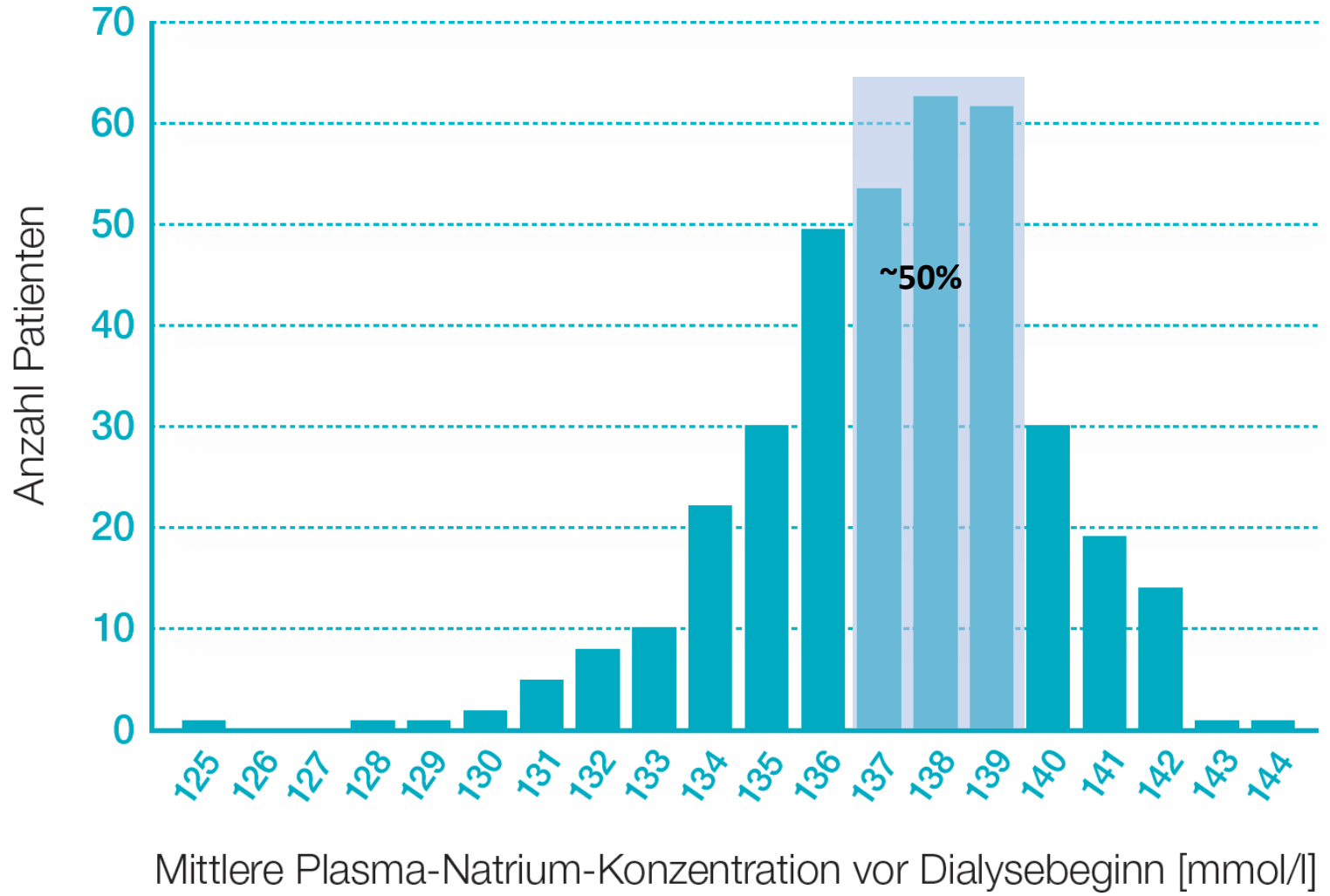
Sodium Management – background

- **ASSUNZIONE DI SODIO NEL PERIODO INTERDIALITICO**
  ALIMENTAZIONE – PERDITA FUNZIONE RENALE

- **DURANTE IL TRATTAMENTO SI VERIFICANO DUE MODALITÀ DI TRASFERIMENTO DEL SODIO:**
  I. **RIMOZIONE CONVETTIVA DEL SODIO (PROGRAMMA UF)**
  II. **RIMOZIONE DIFFUSIVA DEL SODIO**
  POSITIVO/NEUTRO/NEGATIVO (GRADIENTE Na PLASMA/Na Dialisato)

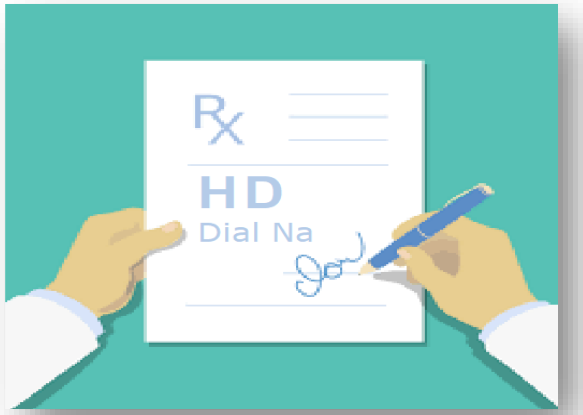
- **COME CONSEGUENZA DEL GRADIENTE ESISTENTE, IL PAZIENTE POTREBBE PERDERE O RICEVERE UNA QUANTITÀ DI SODIO NON ADEGUATA**

Sodium Management – background: Na plasmatico pre-dialisi



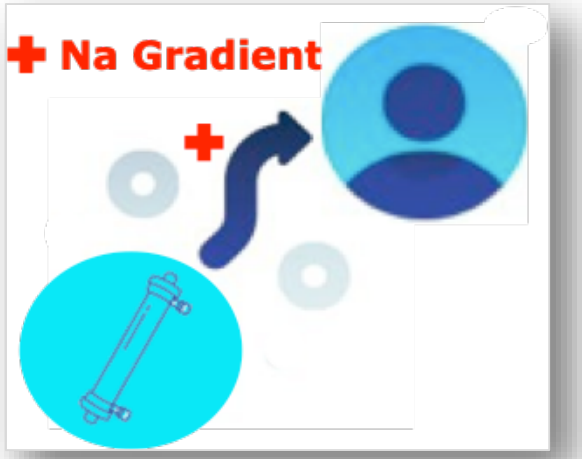
** Lindley EJ et al., Reducing Sodium Intake in Hemodialysis Patients, Semin Dial. 2009 May-Jun; 22(3):261.*

Sodium Management – background: Pratica clinica

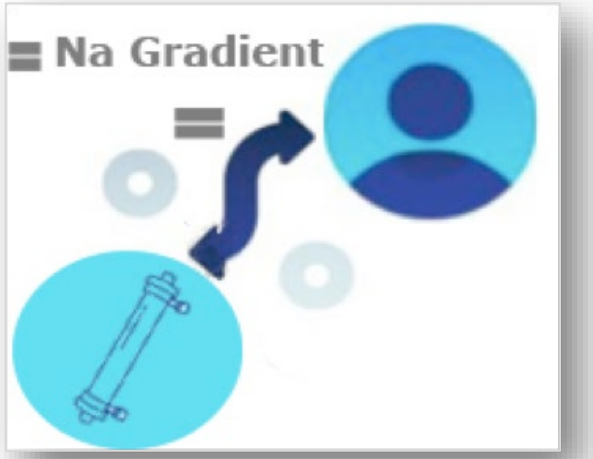


Esempio:

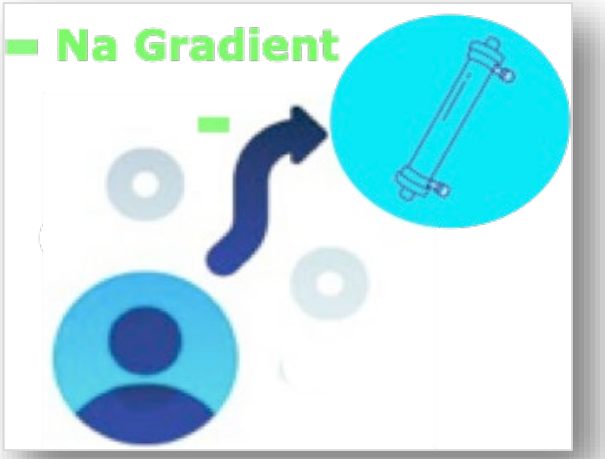
Na pre: **138 mmol/l**



Na dialisato: **140 mmol/l**



Na dialisato: **138 mmol/l**



Na dialisato: **136 mmol/l**

Sodium Management – background: Il sodio in dialisi

- Un ridotto carico diffusivo di sodio può portare a:[1,2,3]
  - Una riduzione della sete
  - Una riduzione dell'incremento ponderale interdialitico
  - Un cambiamento degli outcome a breve termine grazie al ridotto sovraccarico idrico e ad una ridotta pressione sanguigna

- Prevenire una rimozione eccessiva del sodio attraverso la diffusione può potenzialmente ridurre sintomi intradialitici

1. Lindley EJ, Reducing sodium intake in hemodialysis patients. Semin Dial. 2009 May-Jun;22(3):260-3.
2. Raimann JG, Thijssen S, Usvyat LA, et al., Sodium alignment in clinical practice–implementation and implications. Semin Dial. 2011;24:587–592.
3. Sagova et al., Automated individualization of dialysate sodium concentration reduces intradialytic plasma sodium changes in hemodialysis. Artif Organs. 2019 Apr 2. doi: 10.1111/aor.13463. Epub ahead of print.

Sodium and water handling during hemodialysis: new pathophysiologic insights and management approaches for improving outcomes in end-stage kidney disease

Check for updates

OPEN

Bernard Canaud[1,2], Jeroen Kooman[3], Nicholas M. Selby[4], Maarten Taal[4], Susan Francis[5], Pascal Kopperschmidt[6], Andreas Maierhofer[6], Peter Kotanko[7,8] and Jens Titze[9,10,11]

[1]Centre for Medical Excellence, Fresenius Medical Care Deutschland, Bad Homburg, Germany; [2]Montpellier University, Montpellier, France; [3]Maastricht Universitair Medisch Centrum – Maastricht, Netherlands; [4]Centre for Kidney Research and Innovation, University of Nottingham, Royal Derby Hospital Campus, Derby, UK; [5]Sir Peter Mansfield Imaging Centre, University of Nottingham, UK; [6]Fresenius Medical Care Deutschland, GRD, Schweinfurt, Germany; [7]Renal Research Institute, New York, New York, USA; [8]Icahn School of Medicine at Mount Sinai, New York, New York, USA; [9]Division of Cardiovascular and Metabolic Disease, Duke-NUS, Singapore; [10]Division of Nephrology, Duke University Medical Center, Durham, North Carolina, USA; and [11]Division of Nephrology and Hypertension, University Clinic Erlangen, Germany

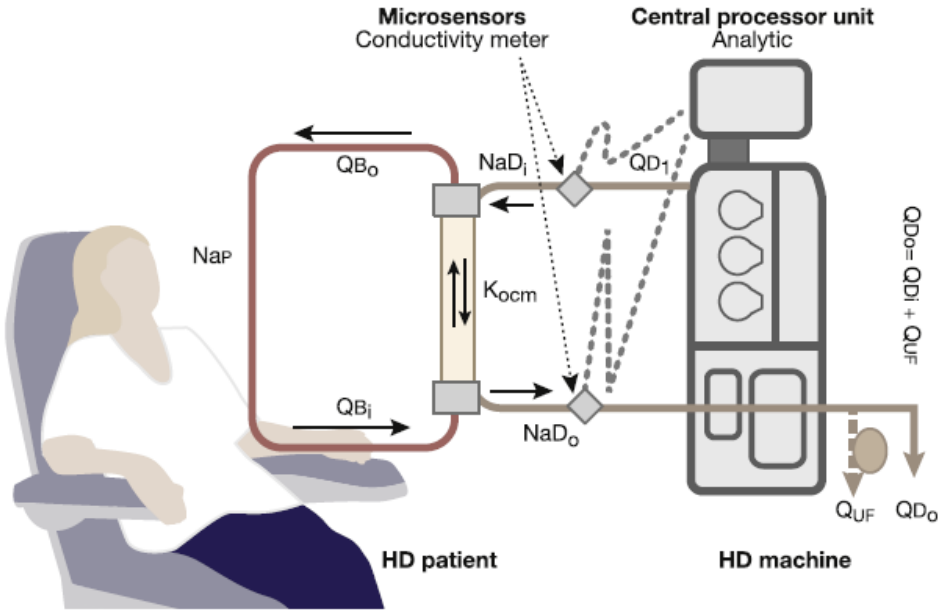
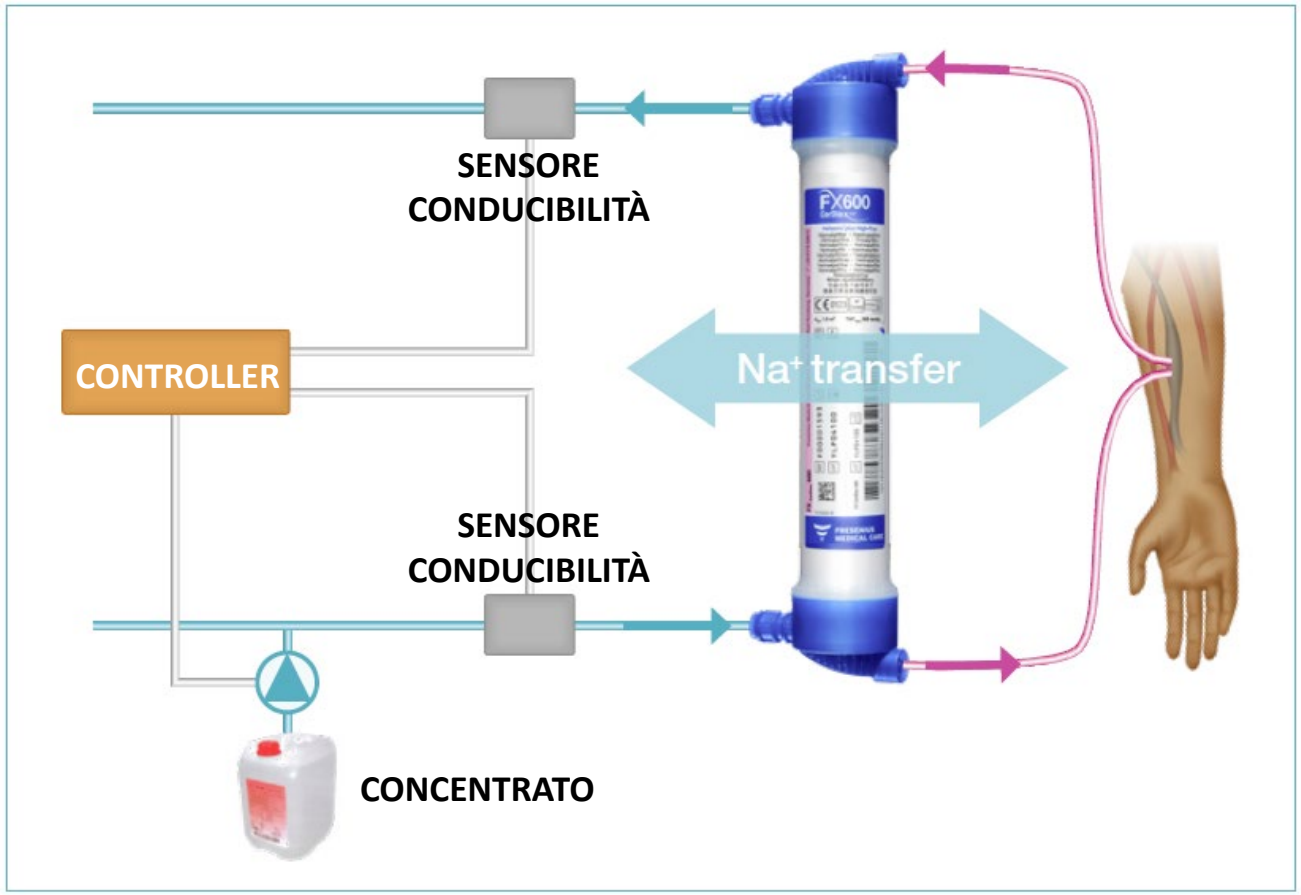


Figure 6| Schematic representation of the electrolyte balancing control (EBC) module embedded in the hemodialysis (HD) monitoring device. The EBC integrates sodium and water handling capacity based on microsensoring ionic fluxes (inflow, outflow) and integrating sodium mass balance equivalent (overall: diffusive + convective [UF]) based on central processor unit (CPU) analytics. UF, ultrafiltration.

Sodium Management: Schema operativo

BIOFEEDBACK PER IL CONTROLLO DEL SODIO PLASMATICO



$$\Delta J = Q_d\,(c_{di} - c_{do}) - Q_f c_{do}$$

Sodium Management: Schema operativo

BIOFEEDBACK PER IL CONTROLLO DEL SODIO PLASMATICO

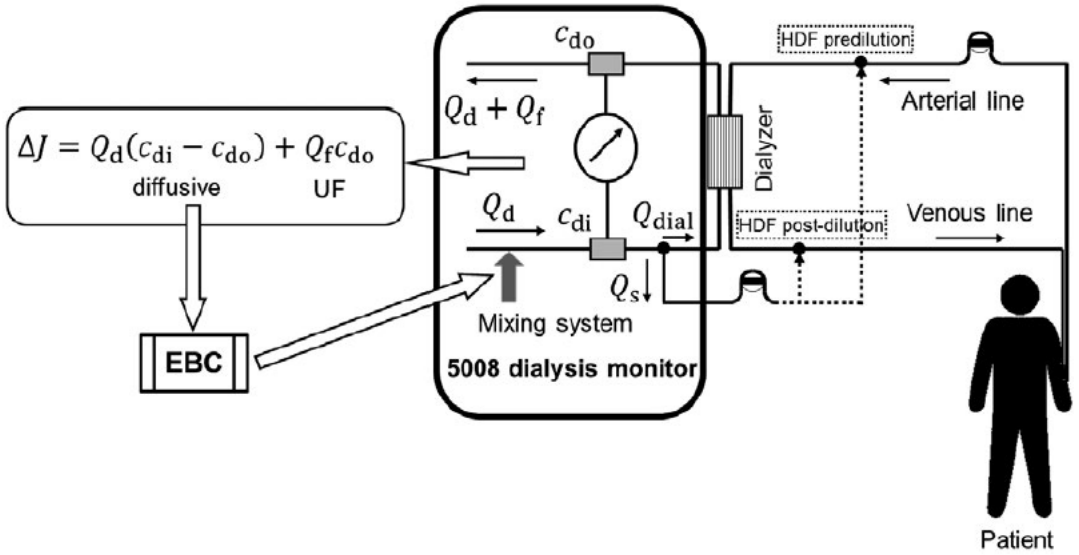


FIG. 1. Schematic view of the electrolyte balancing controller (EBC). Inlet and outlet dialysate conductivities c_{di} and c_{do} are measured by conductivity cells and used together with the total dialysate flow Q_d and ultrafiltration rate Q_f as input for the EBC. The controller adjusts the dialysate inlet sodium concentration in order to achieve zero diffusive sodium balance.

Artificial Organs

Zero Diffusive Sodium Balance in Hemodialysis Provided by an Algorithm-Based Electrolyte Balancing Controller: A Proof of Principle Clinical Study

*Uwe Kuhlmann, †Andreas Maierhofer, †Bernard Canaud, ‡Joachim Hoyer and §Malte Gross

*Klinikum Bremen Mitte, Medizinische Klinik III, Bremen, Germany; †Fresenius Medical Care GmbH, Bad Homburg; ‡Universitätsklinik Marburg, Klinik für Innere Medizin, Nephrologie und Internistische Intensivmedizin, Marburg; §Faculty of Mechatronics and Medical Technology, Ulm University of Applied Sciences, Ulm, Germany

Artificial Organs 2019, 43(2):150–158

Sodium Management: I potenziali benefici

RIDOTTO CARICO DI SODIO DURANTE IL TRATTAMENTO

BIOFEEDBACK SCAMBIO DIFFUSIVO

INFORMAZIONI SULL'ASSUNZIONE DI SALE DEL PAZIENTE

EDUCAZIONE NUTRIZIONALE

MONITORAGGIO DEL SODIO PLASMATICO PRE-DIALISI

QUADRO PATOLOGICO

Sodium Management: Stima del sodio plasmatico

CONDUCTIVITY BASED ONLINE ESTIMATION OF PREDIALYTIC PLASMA SODIUM: CLINICAL ASSESSMENT

Andreas Maierhofer[1] , Bruno Pinto[2], Ralf Wojke[3], Pedro Ponce[2]

[1]Fresenius Medical Care Deutschland GmbH, Global Research & Development, Schweinfurt, Germany
[2]Fresenius Medical Care Portugal, NephroCare, Lisbon, Portugal
[3]Fresenius Medical Care Deutschland GmbH, Clinical & Epidemiological Research, EMEA Medical Office, Bad Homburg, Germany

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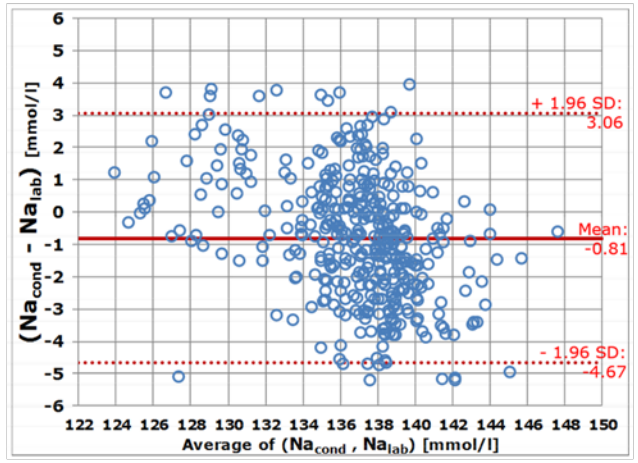
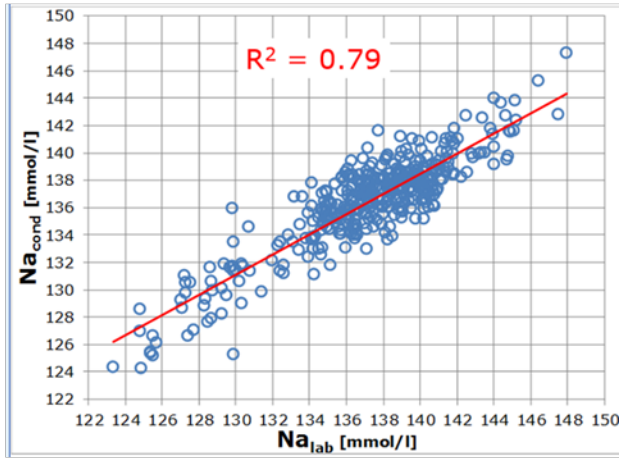
Poster FP546
EDTA 2019

- Comparison **predialytic plasma Na** from dialysis machine vs. BGA
- 384 treatments





Mean deviation: 0.8 ± 2.0 mmol/l

Sodium Management: Gestione in biofeedback del sodio plasmatico

Automated individualization of dialysate sodium concentration reduces intradialytic plasma sodium changes in hemodialysis

Michaela Ságová[1] | Ralf Wojke[2] | Andreas Maierhofer[2] | Malte Gross[3] |
Bernard Canaud[2] | Adelheid Gauly[2]

Artificial Organs

Artif Organs. 2019 Feb;
43(2):150-158.
doi: 10.1111/aor.13328.

AUTOMATED INDIVIDUALIZATION OF DIALYSATE SODIUM CONCENTRATION REDUCES INTRADIALYTIC PLASMA SODIUM CHANGES IN HEMODIALYSIS

Michaela Ságová,[1] Ralf Wojke,[2] Andreas Maierhofer,[3] Malte Gross,[4] Bernard Canaud,[2] Adelheid Gauly,[2]

[1] Fresenius Medical Care-DS, Prague, Czech Republic, [2] Fresenius Medical Care Deutschland GmbH, Bad Homburg, Germany,
[3] Fresenius Medical Care Deutschland GmbH, Schweinfurt, Germany, [4] University of Applied Sciences, Ulm, Germany

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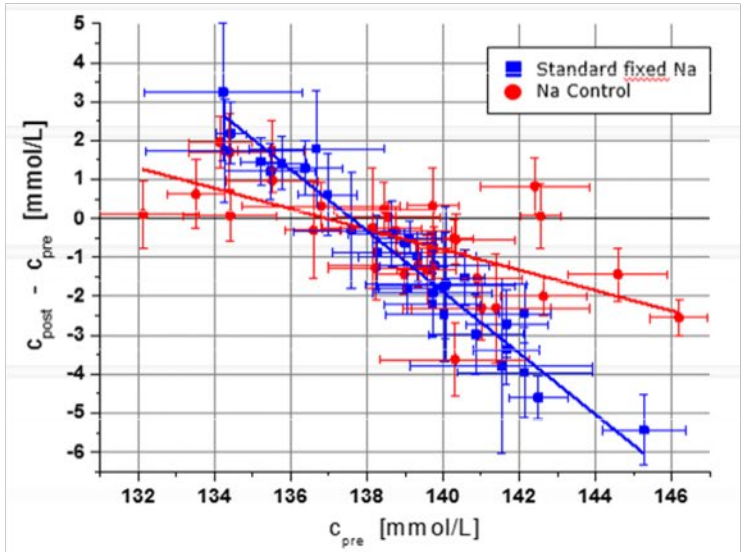
Poster FP527
EDTA 2019



Sodium Management: Gestione in biofeedback del sodio plasmatico

Sodium and water handling during hemodialysis: new pathophysiologic insights and management approaches for improving outcomes in end-stage kidney disease

Bernard Canaud[1,2], Jeroen Kooman[3], Nicholas M. Selby[4], Maarten Taal[4], Susan Francis[5] Pascal Kopperschmidt[6], Andreas Maierhofer[6], Peter Kotanko[7,8] and Jens Titze[9,10,11]

ISN kidney INTERNATIONAL
OFFICIAL JOURNAL OF THE INTERNATIONAL SOCIETY OF NEPHROLOGY

Kidney Int. 2019 Feb; 95(2):296-309.
doi: 10.1016/j.kint.2018.09.024

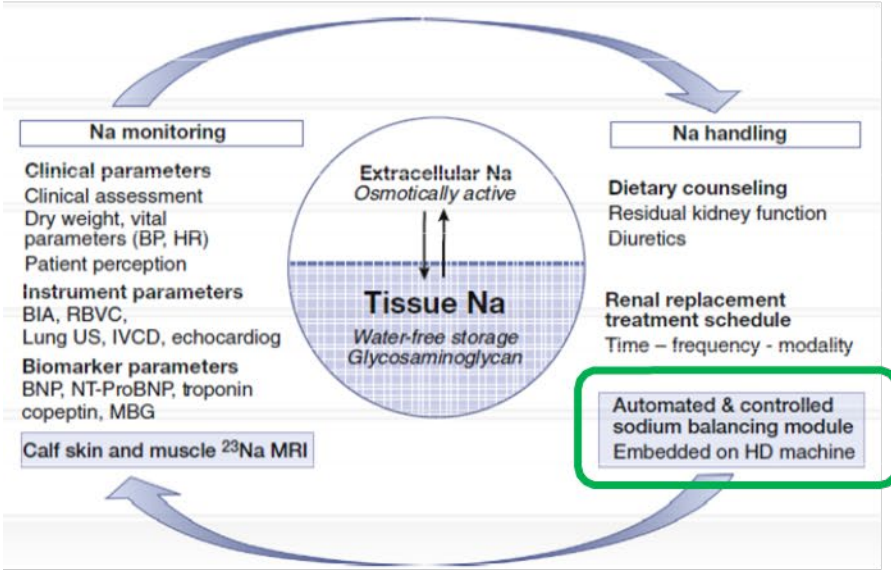


Figure 4 | Precise management of sodium (Na) in hemodialysis (HD) patients.

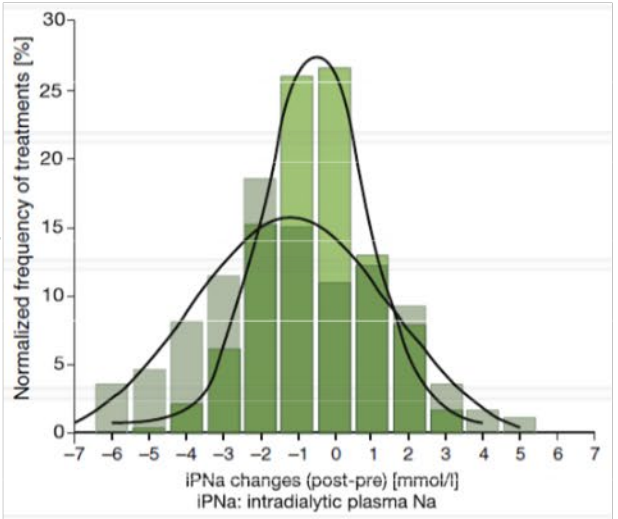


Figure 7 | Frequency distribution of intradialytic plasma sodium (iPNa) changes when dialyzing 30 patients either with a standard fixed dialysate sodium (Na) of 138 mmol/l (bars with horizontal lines) or with automated sodium control and a target of 0 diffusive transfer (bars with vertical lines). Each treatment phase consists of 100 hemodialysis (HD) sessions. The SD of the distribution was reduced by approximately 36% when switching from standard to sodium-controlled treatments.

Sodium Management: Vantaggi

1. Le nuove apparecchiature di HD permettono di quantificare la rimozione/guadagno di Na diffusivo e convettivo durante tutte le HD/HDF

2. In casi selezionati (stabilità del Na pre-HD, non necessità di «uso farmacologico» della concentrazione di Na nel dialisato) si può impostare una diffusione di Na pari a zero (il paziente dovrebbe avere un natriemia identica all'inizio e fine trattamento)

3. Si può utilizzare per impostare un guadagno/perdita diffusiva di Na «controllata» durante il singolo trattamento

Sodium Management: Svantaggi

1. Se in tutti i pazienti viene impostata una rimozione/guadagno diffusivo pari a zero si potrebbero avere grossi problemi di tolleranza dialitica (ipotensione) nei pazienti che necessitano di un guadagno diffusivo di Na (pazienti con Na plasmatico pre-dialitico tendenzialmente basso) o di eccessivo guadagno diffusivo di Na con conseguente aumento di sete, incremento ponderale, ipertensione, etc (nei pazienti con Na plasmatico pre-dialitico tendenzialmente alto)

2. Il bilancio ionico misurato con la conducibilità non misura variazioni di tonicità plasmatica dovuta ad altre molecole differenti dagli elettroliti carichi elettricamente come il glucosio con possibilità di avere grossi problemi nei pazienti diabetici con non ottimale controllo della glicemia pre-dialitica

Sodium and water handling during hemodialysis: new pathophysiologic insights and management approaches for improving outcomes in end-stage kidney disease

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OPEN

Bernard Canaud[1,2], Jeroen Kooman[3], Nicholas M. Selby[4], Maarten Taal[4], Susan Francis[5], Pascal Kopperschmidt[6], Andreas Maierhofer[6], Peter Kotanko[7,8] and Jens Titze[9,10,11]

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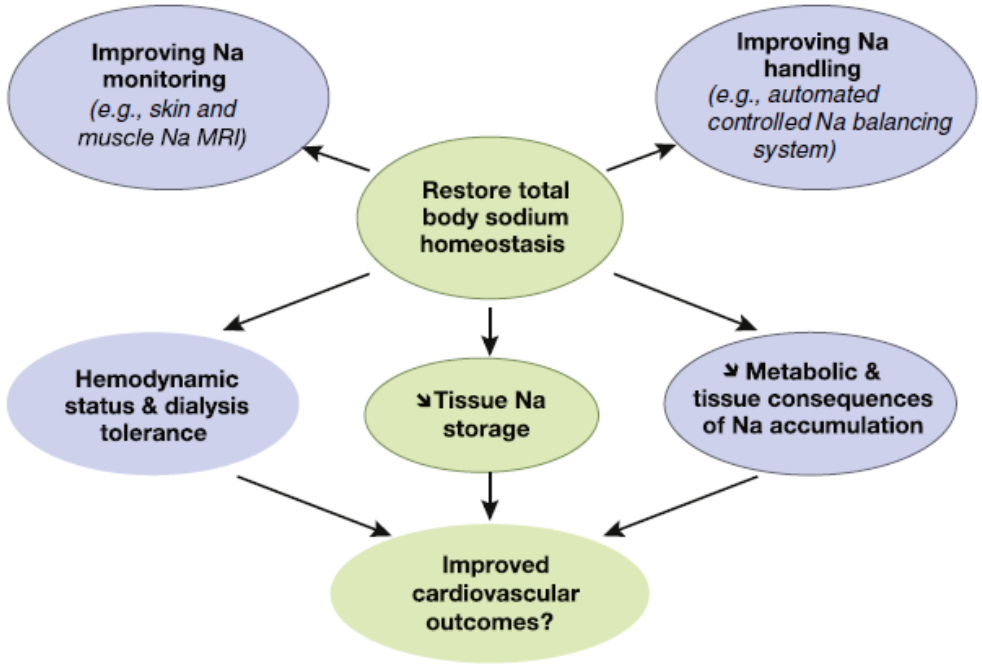


Figure 8| Potential benefits of a new technical solution, direct sodium (Na), and water control in hemodialysis patients for improving hemodialysis patient outcomes. MRI, magnetic resonance imaging.

Temperatura Corporea «Core»

- La temperatura alla quale un organismo vivente opera
- Propria delle strutture corporee «profonde», cioè dei visceri
- Misurata in pratica clinica attraverso sonde rettali, esofagee, vescicali, cateteri cardiaci (catetere di Swan-Ganz del cuore destro)

Qual è una temperatura «core» normale?

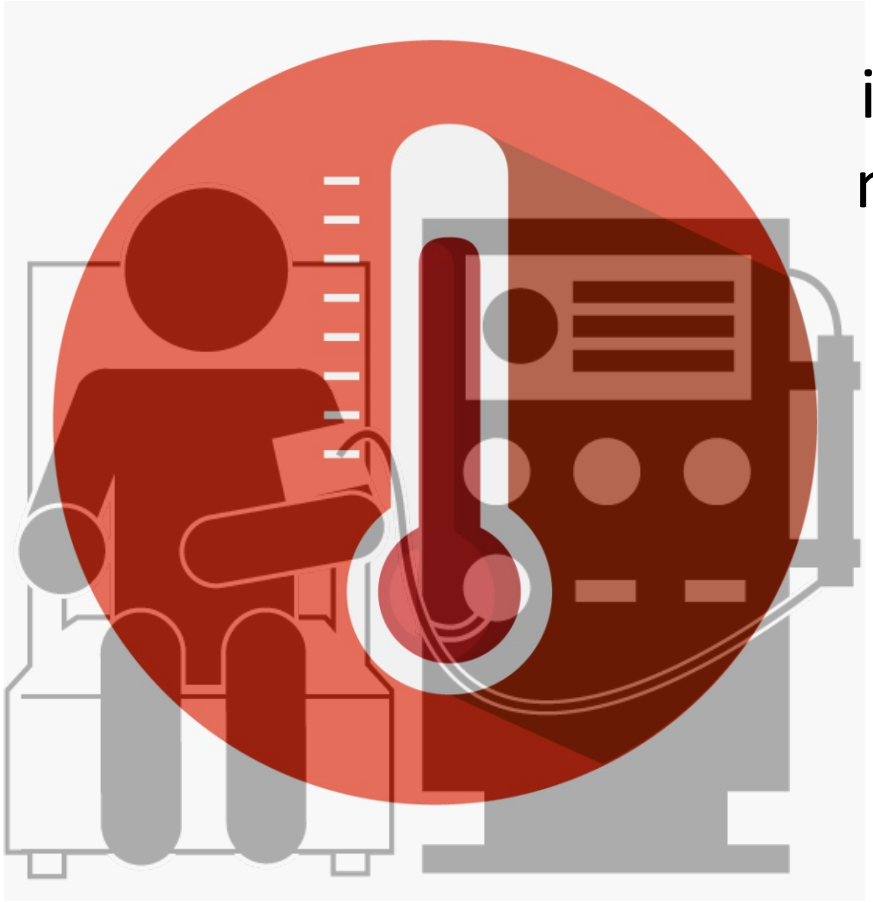
Essere umano sano	**Essere umano con uremia**
Tra 36.5°C e 37.5°C	**Tra 34.9°C e 37.4°C**
Media: 37.0°C	**Media: 36.5°C[1]**

*con variazioni circadiane, ormonali, legate all'età, al sesso, ad assunzione di cibo, sonno…

[1]Rosales et al, Am J Kidn Dis, 2000

Cosa succede durante una seduta di emodialisi?

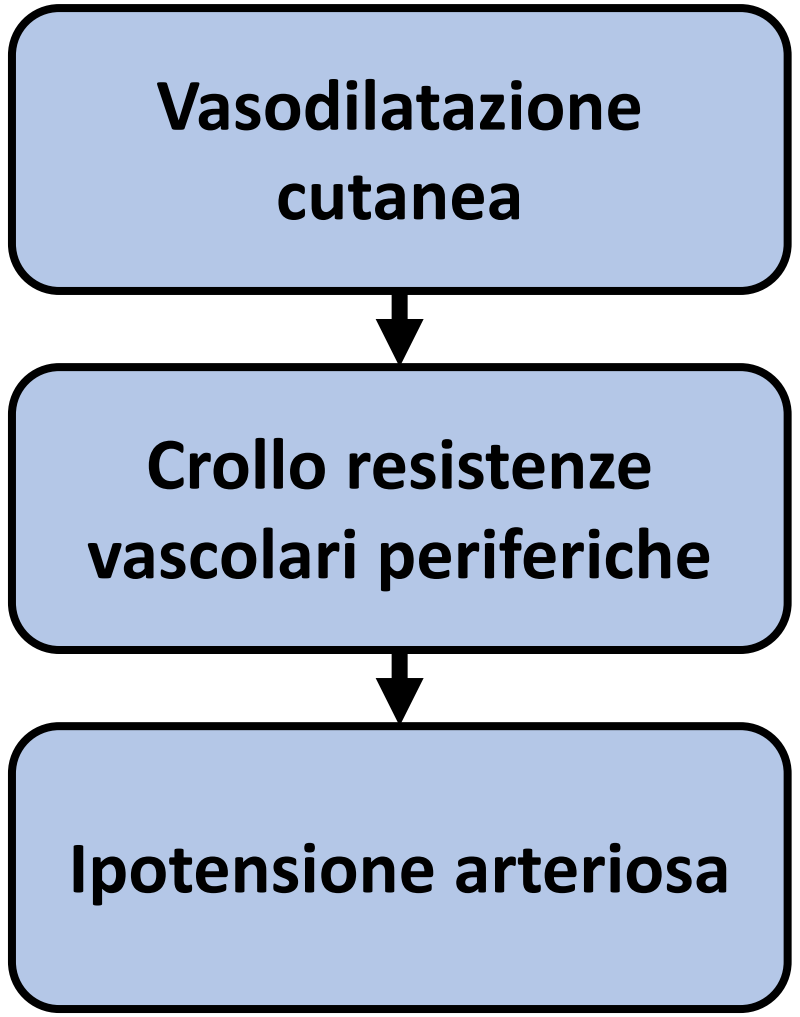
Apporto di calore dal circuito di dialisi:
T del dialisato



Apporto di calore interno: all'aumento del metabolismo energetico

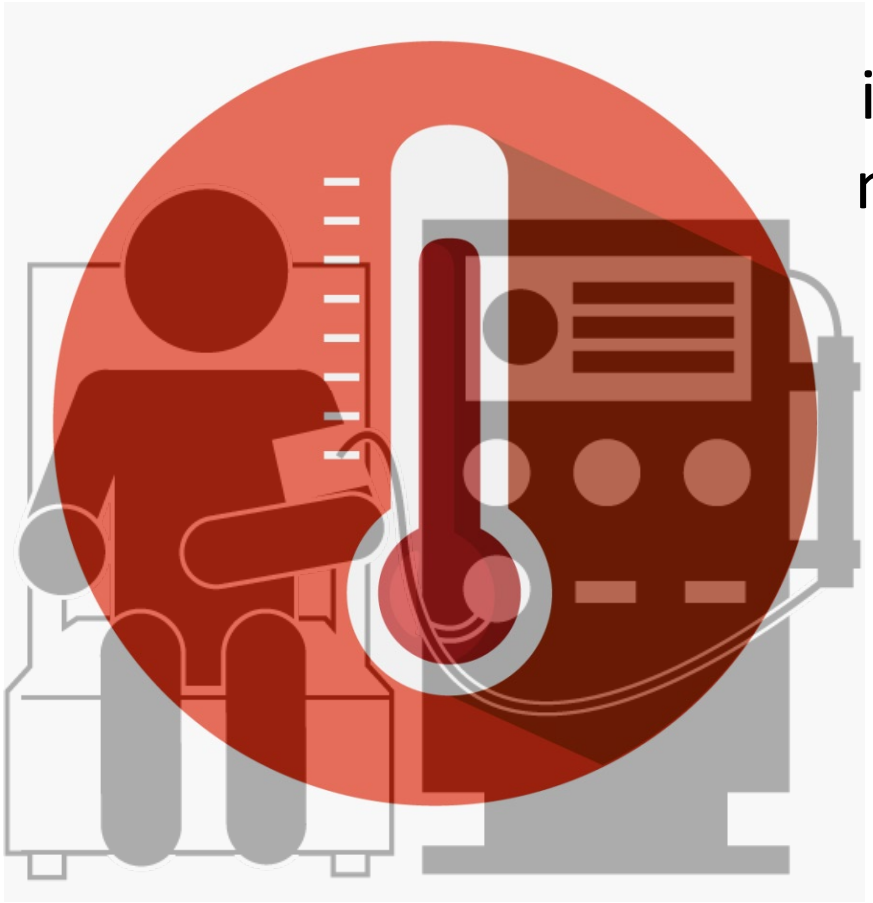
Ridotta dispersione di calore:
vasocostrizione arteriolare cutanea,
vasocostrizione venosa

Pressione arteriosa ∝
gittata cardiaca * resistenze vascolari periferiche



Ma quindi se imposto una T° dialisato = T° core?

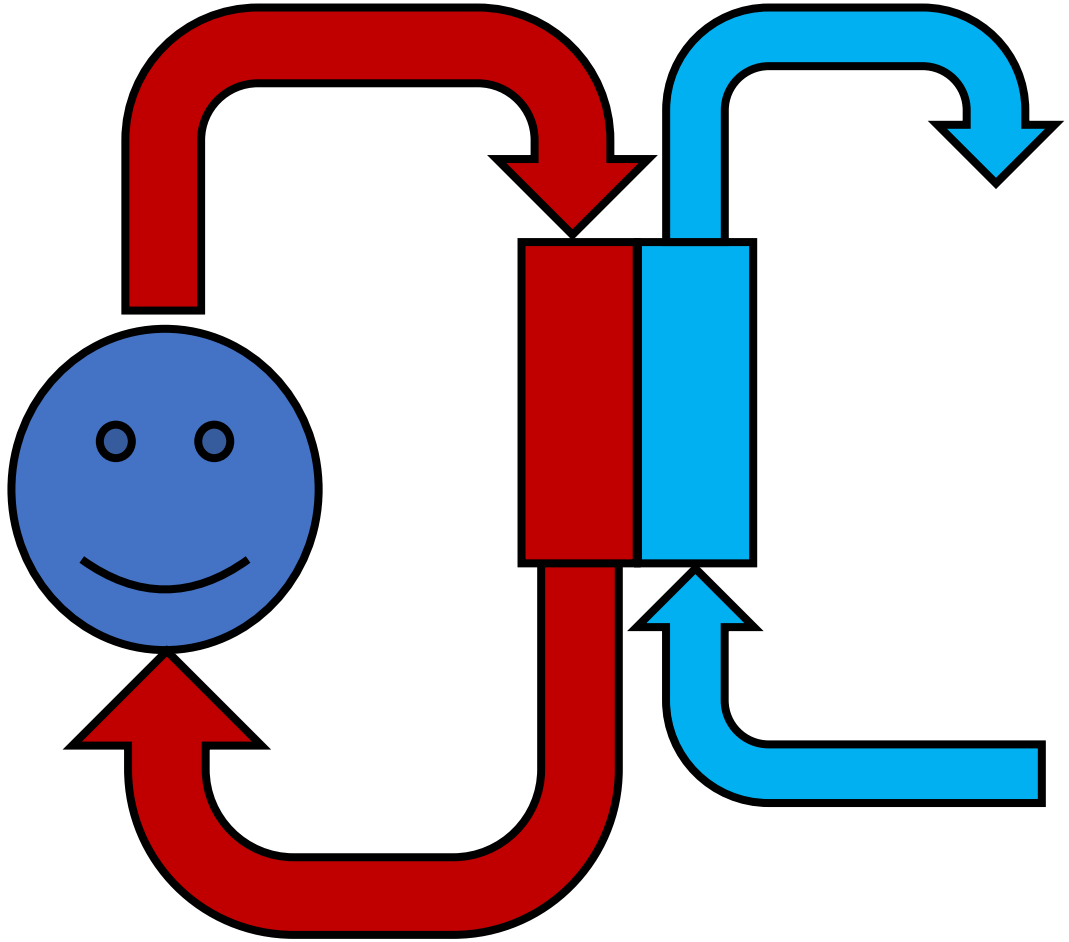
Appo di ca e dal
cir ito di si:
T l dia to



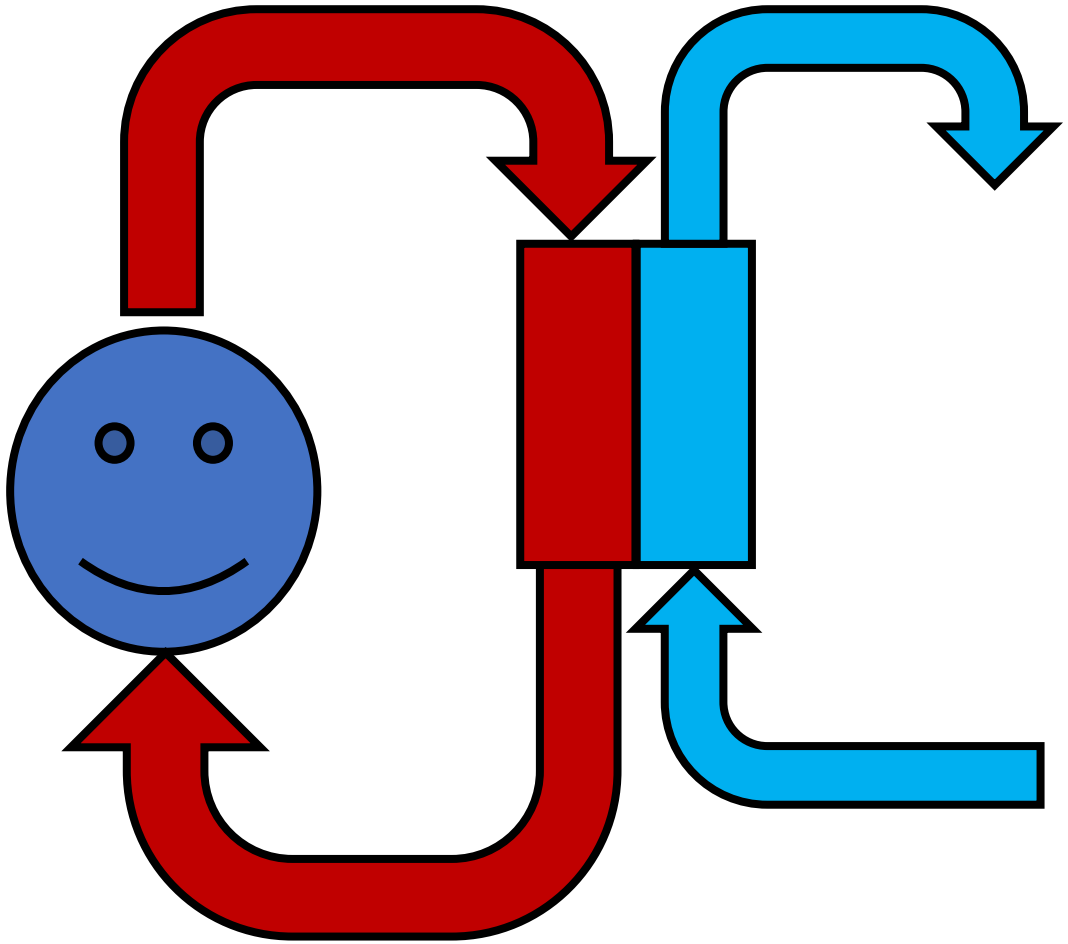
Apporto di calore interno: all'aumento del metabolismo energetico

Ridotta dispersione di calore: vasocostrizione arteriolare cutanea, vasocostrizione venosa

Dialisi Isotermica:
T° core fine dialisi = T° core inizio dialisi



Dialisi Ipotermica:
T° core fine dialisi < T° core inizio dialisi



T° core (inizio) = *x* °C

T° core (fine) = *x* – *y* °C

Ma la dialisi «fredda»?

T° core (inizio) = *x* °C

T° dialisato = *x – 0.5* °C

BLOOD TEMPERATURE AND VASCULAR STABILITY DURING HEMODIALYSIS AND HEMOFILTRATION

Q. Maggiore, F. Pizzarelli, S. Sisca, C. Zoccali,
S. Parlongo, F. Nicolò, and G. Creazzo

Vol. XXVIII Trans Am Soc Artif Intern Organs 1982

The Effects of Control of Thermal Balance on Vascular Stability in Hemodialysis Patients: Results of the European Randomized Clinical Trial

Quirino Maggiore, MD, Francesco Pizzarelli, MD, Antonio Santoro, MD, Giovanni Panzetta, MD,

Table 3. Changes in Hemodynamic Parameters During the Two Treatment Types

	Thermoneutral HD	Isothermic HD	*P*
ΔSystolic blood pressure, 210-0 min (mm Hg)	−20.5 ± 15.7	−14.2 ± 16.5	<0.05
ΔDiastolic blood pressure, 210-0 min (mm Hg)	−8.8 ± 8.4	−5.8 ± 8.1	<0.05
ΔHeart rate, 210-0 min (beats/min)	6.3 ± 8.1	2.9 ± 7.1	<0.05

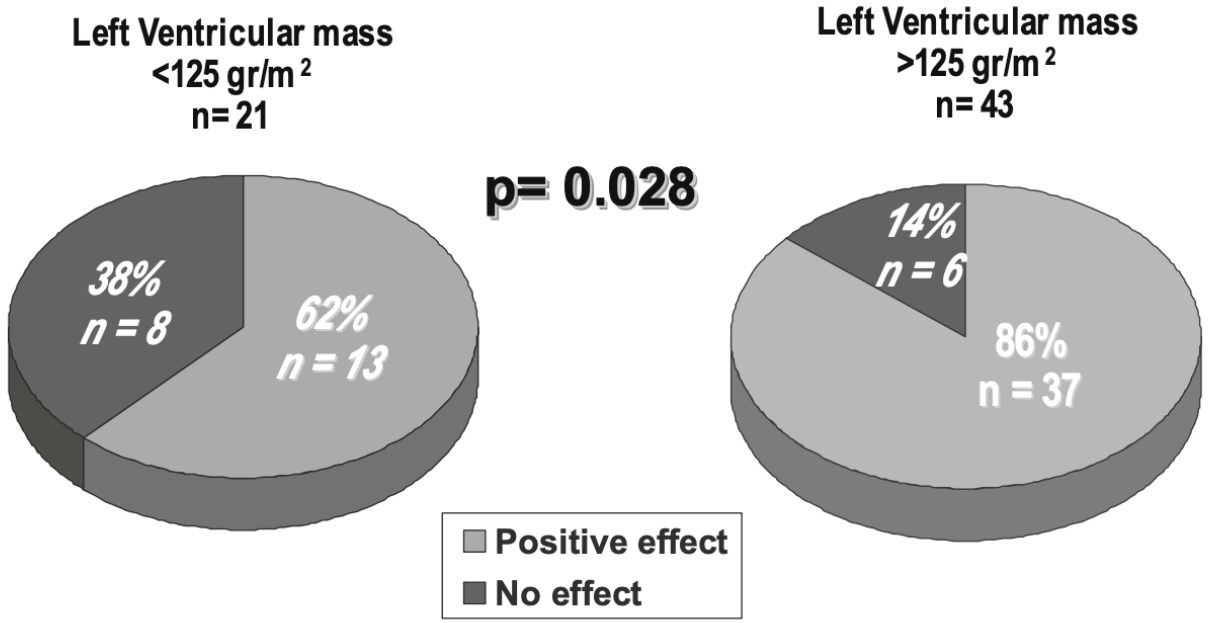


Fig. 20.6 Comparison of the effect the "cold" dialysis on the incidence of dialysis hypotension in patients without and with left ventricular hypertrophy (LVH). The positive effect was significantly higher in patients with LVH compared to patients without.

Randomized Controlled Trial of Individualized Dialysate Cooling for Cardiac Protection in Hemodialysis Patients

Aghogho Odudu,[*†‡] *Mohamed Tarek Eldehni,*[†‡] *Gerry P. McCann,*[§‖] *and Christopher W. McIntyre*[¶]

Abstract

Background and objectives Cardiovascular disease is the most common cause of death in patients on hemodialysis (HD). HD-associated cardiomyopathy is appreciated to be driven by exposure to recurrent and cumulative ischemic insults resulting from hemodynamic instability of conventionally performed intermittent HD treatment itself. Cooled dialysate reduces HD-induced recurrent ischemic injury, but whether this confers long-term protection of the heart in terms of cardiac structure and function is not known.

Design, setting, participants, & measurements Between September 2009 and January 2013, 73 incident HD patients were randomly assigned to a dialysate temperature of 37°C (control) or individualized cooling at 0.5°C below body temperature (intervention) for 12 months. Cardiac structure, function, and aortic distensibility were assessed by cardiac magnetic resonance imaging. Mean between-group difference in delivered dialysate temperature was 1.2°C±0.3°C. Treatment effects were determined by the interaction of treatment group with time in linear mixed models.

Results There was no between-group difference in the primary outcome of left ventricular ejection fraction (1.5%; 95% confidence interval, –4.3% to 7.3%). However, left ventricular function assessed by peak systolic strain was preserved by the intervention (–3.3%; 95% confidence interval, –6.5% to –0.2%) as was diastolic function (measured as peak diastolic strain rate, 0.18 s^{-1}; 95% confidence interval, 0.02 to 0.34 s^{-1}). Reduction of left ventricular dilation was demonstrated by significant reduction in left ventricular end-diastolic volume (–23.8 ml; 95% confidence interval, –44.7 to –2.9 ml). The intervention was associated with reduced left ventricular mass (–15.6 g; 95% confidence interval, –29.4 to –1.9 g). Aortic distensibility was preserved in the intervention group (1.8 $mmHg^{-1}\times10^{-3}$; 95% confidence interval, 0.1 to 3.6 $mmHg^{-1}\times10^{-3}$). There were no intervention-related withdrawals or adverse events.

Conclusions In patients new to HD, individualized cooled dialysate did not alter the primary outcome but was well tolerated and slowed the progression of HD-associated cardiomyopathy. Because cooler dialysate is universally applicable at no cost, the intervention warrants wider adoption or confirmation of these findings in a larger trial.

Clin J Am Soc Nephrol 10: 1408–1417, 2015. doi: 10.2215/CJN.00200115

CLINICAL RESEARCH www.jasn.org

Randomized Clinical Trial of Dialysate Cooling and Effects on Brain White Matter

Mohamed T. Eldehni, Aghogho Odudu, and Christopher W. McIntyre

Division of Medical Sciences and Graduate Entry Medicine, School of Medicine, University of Nottingham, Nottingham, United Kingdom

ABSTRACT

Hemodialysis is associated with significant circulatory stress that could produce recurrent and cumulative ischemic insults to multiple organs, such as the brain. We aimed to characterize hemodialysis-induced brain injury by longitudinally studying the effects of hemodialysis on brain white matter microstructure and further examine if the use of cooled dialysate could provide protection against hemodialysis-associated brain injury. In total, 73 patients on incident hemodialysis starting within 6 months were randomized to dialyze with a dialysate temperature of either 37°C or 0.5°C below the core body temperature and followed up for 1 year. Brain white matter microstructure was studied by diffusion tensor magnetic resonance imaging at baseline and follow-up (38 patients available for paired analysis). Intradialytic hemodynamic stress was quantified using the extrema points analysis model. Patients on hemodialysis exhibited a pattern of ischemic brain injury (increased fractional anisotropy and reduced radial diffusivity). Cooled dialysate improved hemodynamic tolerability, and changes in brain white matter were associated with hemodynamic instability (higher mean arterial pressure extrema points frequencies were associated with higher fractional anisotropy [peak r=0.443, P<0.03] and lower radial diffusivity [peak r=−0.439, P<0.02]). Patients who dialyzed at 0.5°C below core body temperature exhibited complete protection against white matter changes at 1 year. Our data suggest that hemodialysis results in significant brain injury and that improvement in hemodynamic tolerability achieved by using cooled dialysate is effective at abrogating these effects. This intervention can be delivered without additional cost and is universally applicable.

J Am Soc Nephrol 26: 957–965, 2015. doi: 10.1681/ASN.2013101086

Dialysis-Induced Regional Left Ventricular Dysfunction Is Ameliorated by Cooling the Dialysate

Nicholas M. Selby,* James O. Burton,* Lindsay J. Chesterton,* and Christopher W. McIntyre*†

Randomized Controlled Trial of Individualized Dialysate Cooling for Cardiac Protection in Hemodialysis Patients

Aghogho Odudu,†‡ Mohamed Tarek Eldehni,†‡ Gerry P. McCann,§‖ and Christopher W. McIntyre¶*

ORIGINAL ARTICLE

Seminars in Dialysis WILEY

Absolute blood volume variations during hemodialysis: Does dialysate temperature play a role?

Marta Álvarez Nadal[1] | Irene Martín Capón[1] | Elizabeth Romelia Viera Ramírez[1] | Milagros Fernández Lucas[1,2]

Cool dialysate reduces asymptomatic intradialytic hypotension and increases baroreflex variability

Lindsay J. CHESTERTON,[1] Nicholas M. SELBY,[1] James O. BURTON,[1] Chris W. McINTYRE[1,2]

Article

Effect of Lowering the Dialysate Temperature in Chronic Hemodialysis: A Systematic Review and Meta-Analysis

Reem A. Mustafa,[†] Fadi Bdair,[†] Elie A. Akl,[*‡] Amit X. Garg,[*§‖] Heather Thiessen-Philbrook,[¶] Hassan Salameh,[†] Sood Kisra,[†] Gihad Nesrallah,[**] Ahmad Al-Jaishi,[§] Parth Patel,[††] Payal Patel,[‡‡] Ahmad A. Mustafa,[§§] and Holger J. Schünemann[*‖‖]*

Abstract

Background and objectives Lowering the dialysate temperature may improve outcomes for patients undergoing chronic hemodialysis. We reviewed the reported benefits and harms of lower temperature dialysis.

Design, setting, participants, & measurements We searched the Cochrane Central Register, OVID MEDLINE, EMBASE, and Pubmed until April 15, 2015. We reviewed the reference lists of relevant reviews, registered trials, and relevant conference proceedings. We included all randomized, controlled trials that evaluated the effect of reduced temperature dialysis versus standard temperature dialysis in adult patients receiving chronic hemodialysis. We followed the Grading of Recommendations Assessment, Development and Evaluation approach to assess confidence in the estimates of effect (*i.e.*, the quality of evidence). We conducted meta-analyses using random effects models.

Results Twenty-six trials were included, consisting of a total of 484 patients. Compared with standard temperature dialysis, reduced temperature dialysis significantly reduced the rate of intradialytic hypotension by 70% (95% confidence interval, 49% to 89%) and significantly increased intradialytic mean arterial pressure by 12 mmHg (95% confidence interval, 8 to 16 mmHg). Symptoms of discomfort occurred 2.95 (95% confidence interval, 0.88 to 9.82) times more often with reduced temperature compared with standard temperature dialysis. The effect on dialysis adequacy was not significantly different, with a Kt/V mean difference of −0.05 (95% confidence interval, −0.09 to 0.01). Small sample sizes, loss to follow-up, and a lack of appropriate blinding in some trials reduced confidence in the estimates of effect. None of the trials reported long-term outcomes.

Conclusions In patients receiving chronic hemodialysis, reduced temperature dialysis may reduce the rate of intradialytic hypotension and increase intradialytic mean arterial pressure. High–quality, large, multicenter, randomized trials are needed to determine whether reduced temperature dialysis affects patient mortality and major adverse cardiovascular events.

Clin J Am Soc Nephrol 11: 442–457, 2016. doi: 10.2215/CJN.04580415

Personalised cooler dialysate for patients receiving maintenance haemodialysis (MyTEMP): a pragmatic, cluster-randomised trial

*The MyTEMP writing committee**

Summary

Background Haemodialysis centres have conventionally provided maintenance haemodialysis using a standard dialysate temperature (eg, 36·5°C) for all patients. Many centres now use cooler dialysate (eg, 36·0°C or lower) for potential cardiovascular benefits. We aimed to assess whether personalised cooler dialysate, implemented as centre-wide policy, reduced the risk of cardiovascular-related death or hospital admission compared with standard temperature dialysate.

Lancet 2022; 400: 1693–703

Published Online
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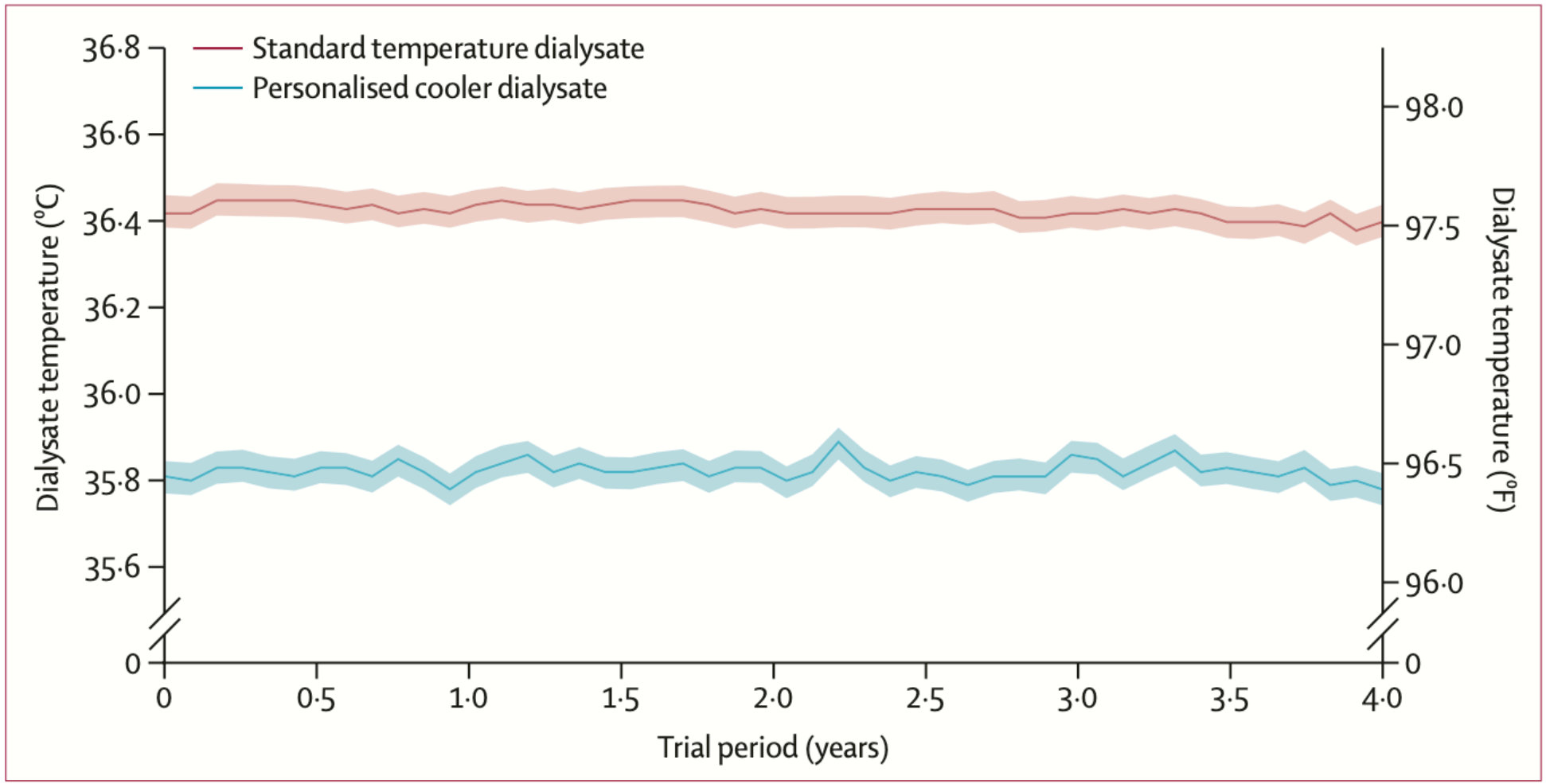
S0140-6736(22)01805-0

Personalised cooler dialysate for patients receiving maintenance haemodialysis (MyTEMP): a pragmatic, cluster-randomised trial

*The MyTEMP writing committee**

- Studio randomizzato su 84 centri dialisi nella provincia dell'Ontario, Canada
- Tutti i pazienti afferenti ad un singolo centro venivano randomizzati a uno di due trattamenti:
  - Dialisato 0.5-0.9°C al di sotto della temperatura corporea rilevata, con minimo di 35.5°C
  - Dialisato a 36.5°C per tutti i trattamenti
- In circa 4 anni di studio, sono stati trattati 15.413 pazienti per un totale di circa 4.3 milioni di trattamenti emodialitici


Standard temperature dialysate
Personalised cooler dialysate
Dialysate temperature (°C)
36·8
36·6
36·4
36·2
36·0
35·8
35·6
0
Dialysate temperature (°F)
98·0
97·5
97·0
96·5
96·0
0
0
0·5
1·0
1·5
2·0
2·5
3·0
3·5
4·0
Trial period (years)

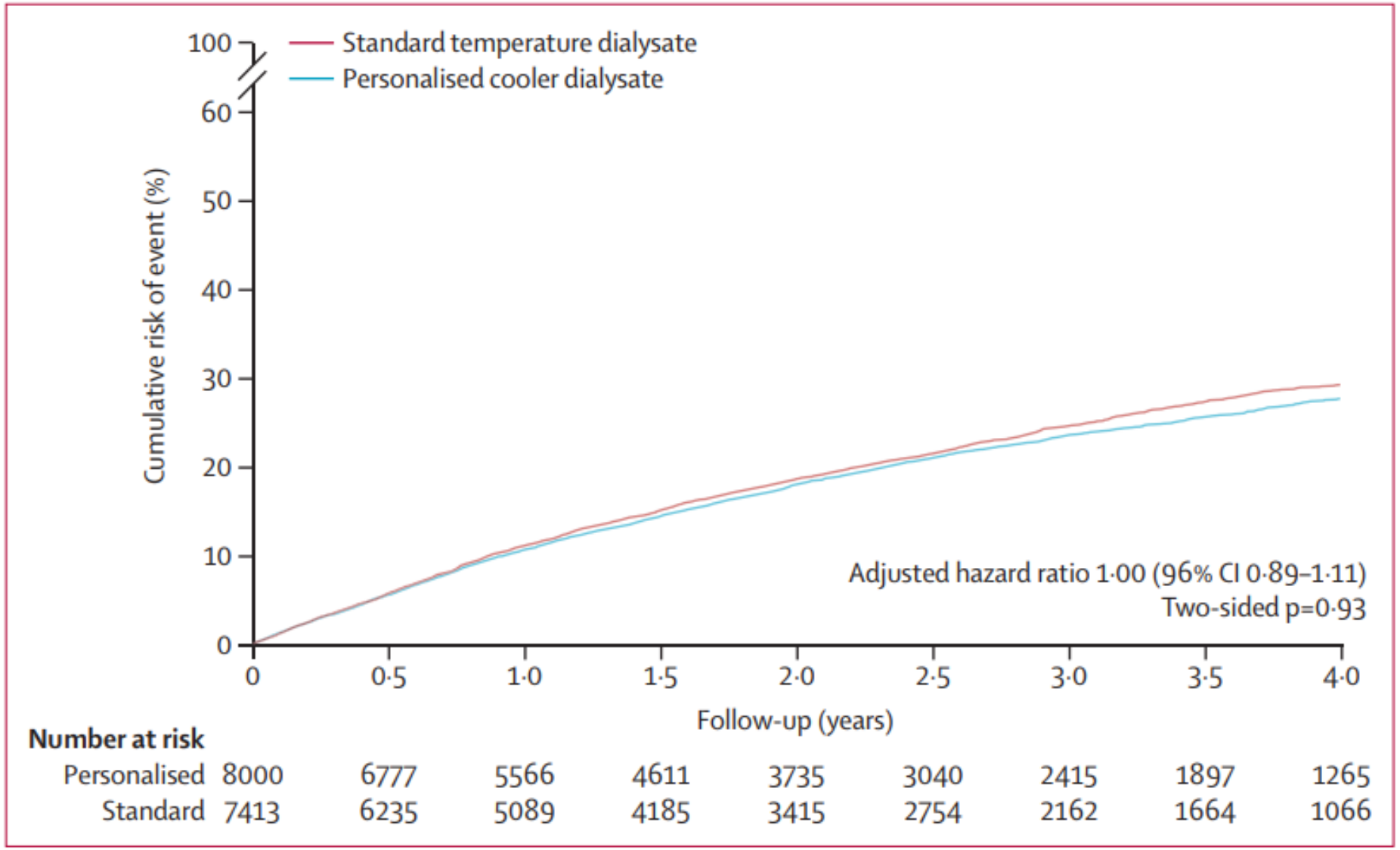


***Figure 3*: Cumulative incidence estimates of the primary outcome**

The primary outcome was a composite of cardiovascular mortality or hospital admission with myocardial infarction, ischaemic stroke, or congestive heart failure. Non-cardiovascular mortality was considered a competing risk when calculating the cumulative incidence function.

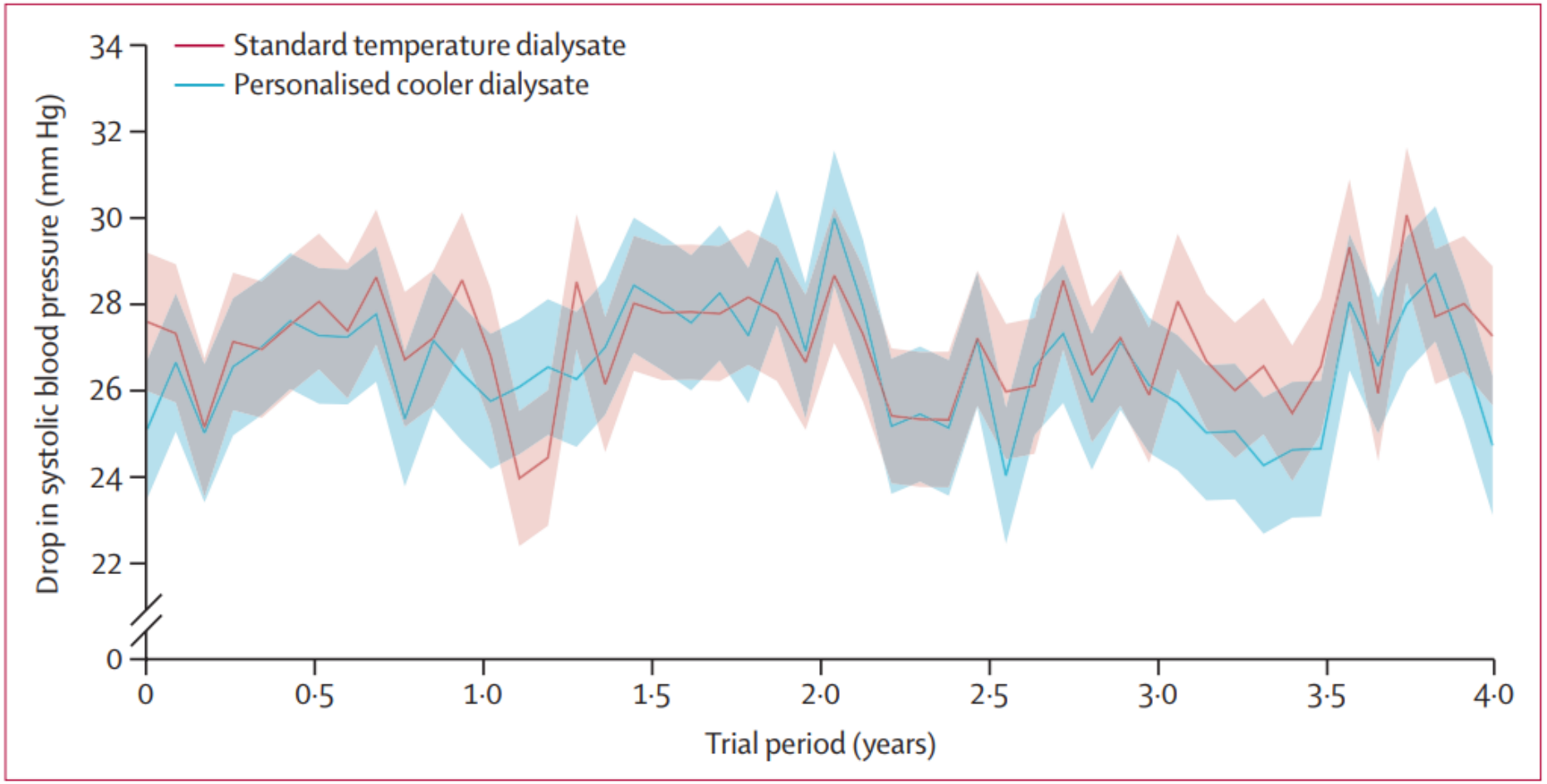


Figure 4: **Drop in intradialytic systolic blood pressure**

Average values of the drop in intradialytic systolic blood pressure each month in the two groups; the shaded areas are 95% pointwise CIs. The drop in intradialytic systolic blood pressure was defined as the systolic blood pressure measured before the start of a haemodialysis treatment minus the nadir systolic blood pressure measured during the treatment. During the trial, the mean drop in intradialytic systolic blood pressure was 26·6 mm Hg in the personalised cooler dialysate group and 27·1 mm Hg in the standard temperature dialysate group (mean difference –0·5 mm Hg, 99% CI –1·4 to 0·4; p=0·14).

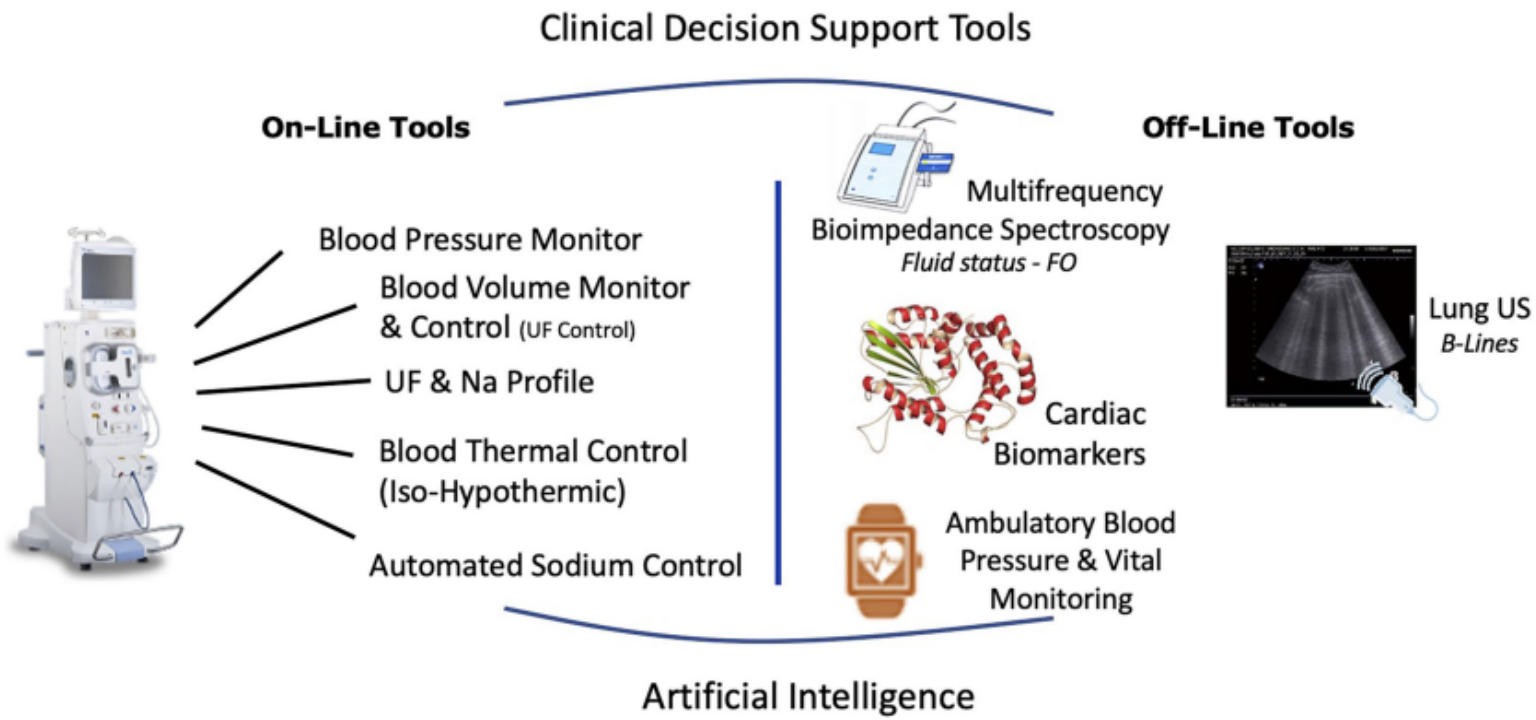


FIGURE 2 | Integrated approach to reduce intradialytic hypotension and to reduce dialysis induced systemic stress relying on current available integrated tools on HD machines and potentially supported by specific cardiac intervention.

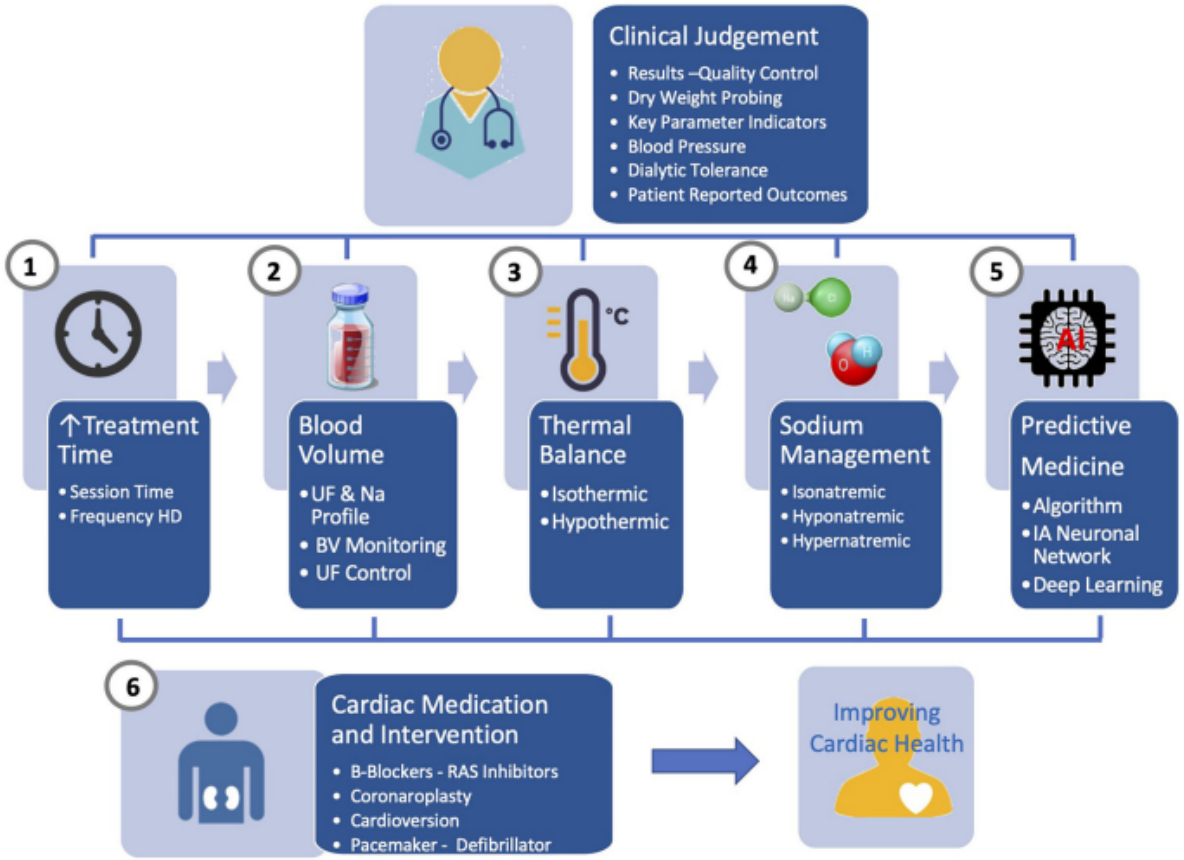


FIGURE 3 | Advanced management of sodium, fluid and blood pressure in hemodialysis patients integrating currently available online and offline tools under the clinical supervision and supported by artificial intelligence.