Incremental Hemodialysis

a story about
Hemodialysis and
the *Residual Kidney Function*

- a fairy tale?

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B|BRAUN
SHARING EXPERTISE

Once uppon a time …

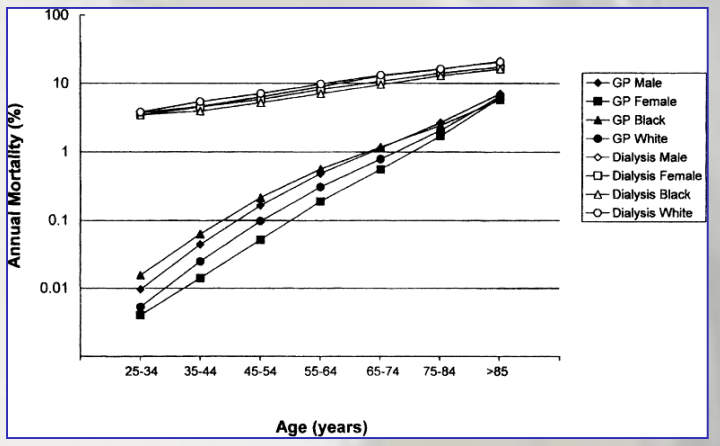
there was Hemodialysis

- saved life of thousends of people

Once uppon a time …

there was Hemodialysis

- saved life of thousends of people
- patients on HD had inferior survival and QoL compared to other patients
  - 7x higher mortality compared to general population



  - many factors responsible for high mortality

    age, gender, Caucasian race, physical inactivity, dyslipidemia, LVH, OSAS, depression, BMI, anemia, PTH (either high or low), hyperphosphatemia, malnutrition, chronic inflammation, increased oxidative stress, endothel dysfunction, high blood pressure, diabetes, congestive heart failure, volume overload, cardiovascular disease, quality of care (late referal), vascular access, …

High mortality on HD - are we giving enough HD?

Maybe we are not dialysing well enough.

Do patients with more intensive HD have greater survival ?

Let's intensify HD!

Let's aim for higher dialysis dose !

(based on urea clearance)

"For thrice-weekly dialysis, normalized whole body urea clearance (Kt/V) should be greater than or equal to 1.0 and less than approximately 1.5. Although this alone does not guarantee adequate dialysis, it does alert the dialysis staff to the potential for both under- and over-dialysis."

EFFECT OF THE HEMODIALYSIS PRESCRIPTION ON PATIENT MORBIDITY

Report from the National Cooperative Dialysis Study*

E. G. Lowrie, M.D., N. M. Laird, Ph.D., T. F. Parker, M.D., and J. A. Sargent, Ph.D.

Gotch&Keen, Introduction to dialysis, 1985: 73

Farrell PC, Artif Organs. 1986 Jun;10(3):195.

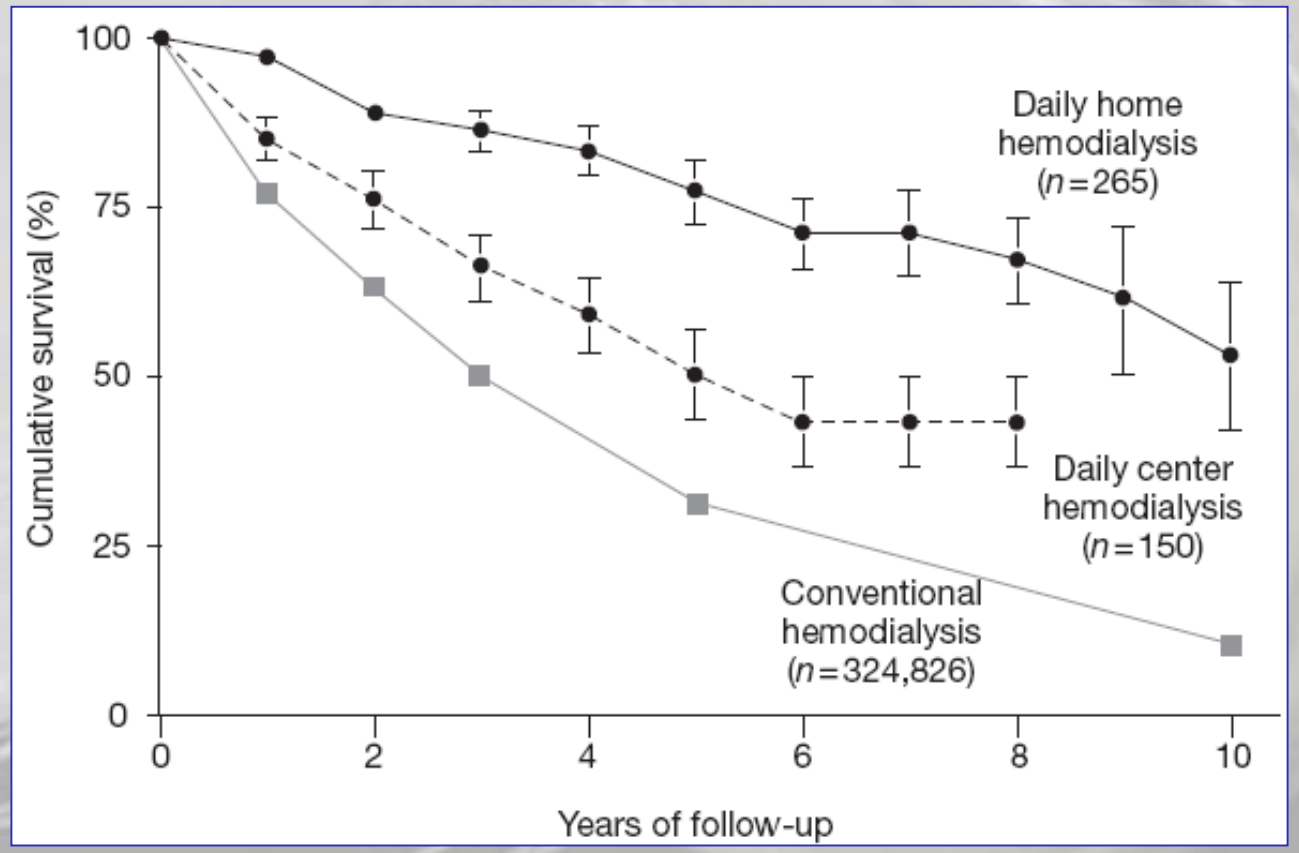
High mortality on HD - are we giving enough HD?

Maybe we are not dialysing well enough.

Patients more intensive HD had greater survival.

Let's intensify HD!

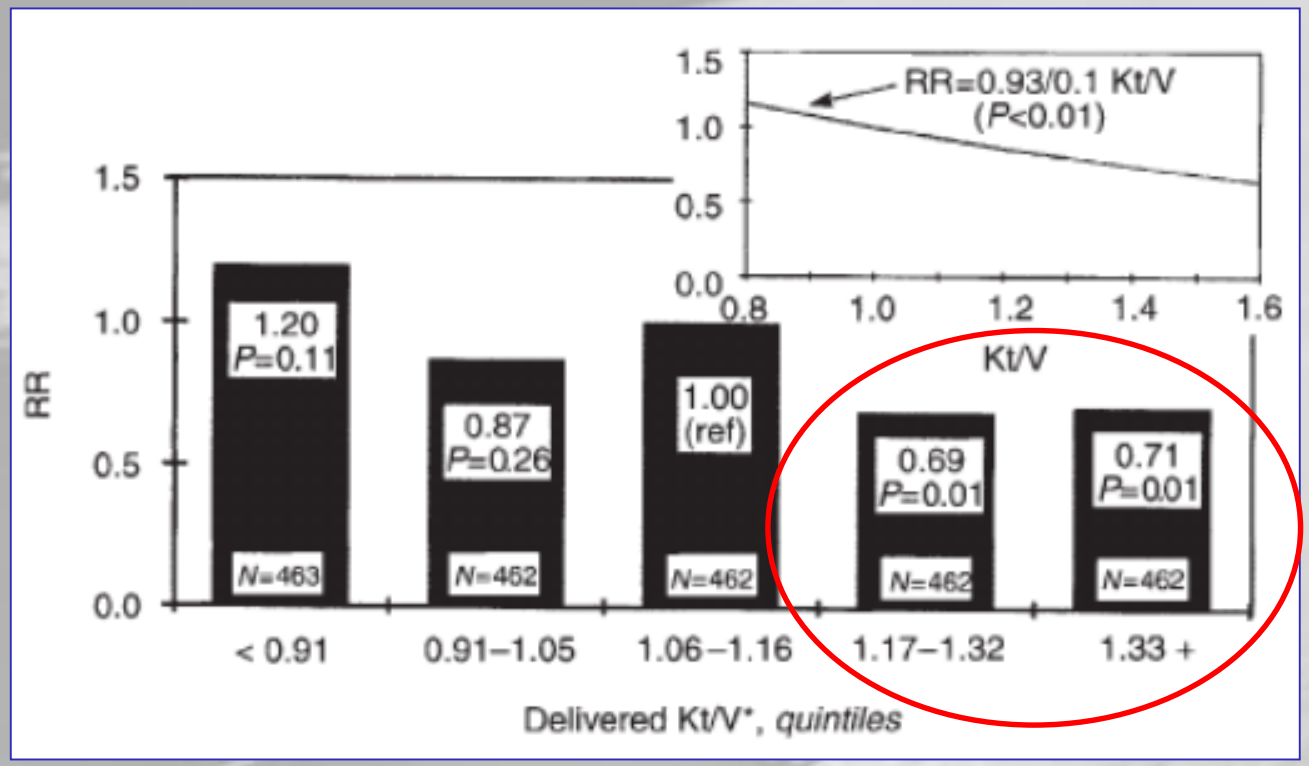
Let's aim for more dialysis !



Kjellstrand CM et al. NDT 2008; 23: 3283–3289

Aiming for more intensive hemodialysis (Kt/V) …

Relative risk of death in Kt/V groups



Kt/V for quantifying dialysis dose

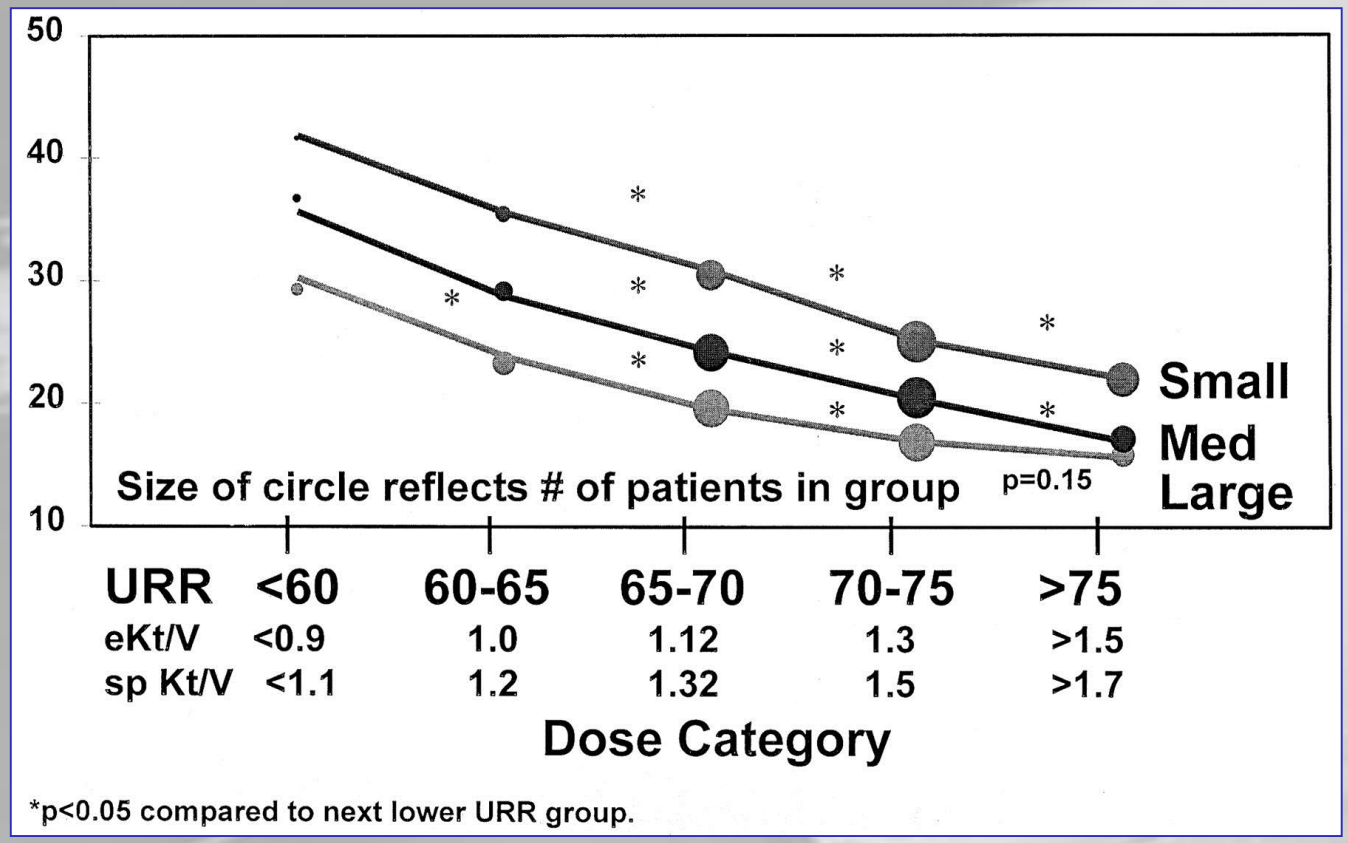
Kt/V was an important predictor of mortality

NKF-KDOQI & other guidelines advocated high Kt/V

One of the earliest reports

Held et al, Kidney Int. 1996; 50:550—556

Aiming for more intensive hemodialysis (Kt/V) …



Dialysis dose and mortality
in 3 BMI strata

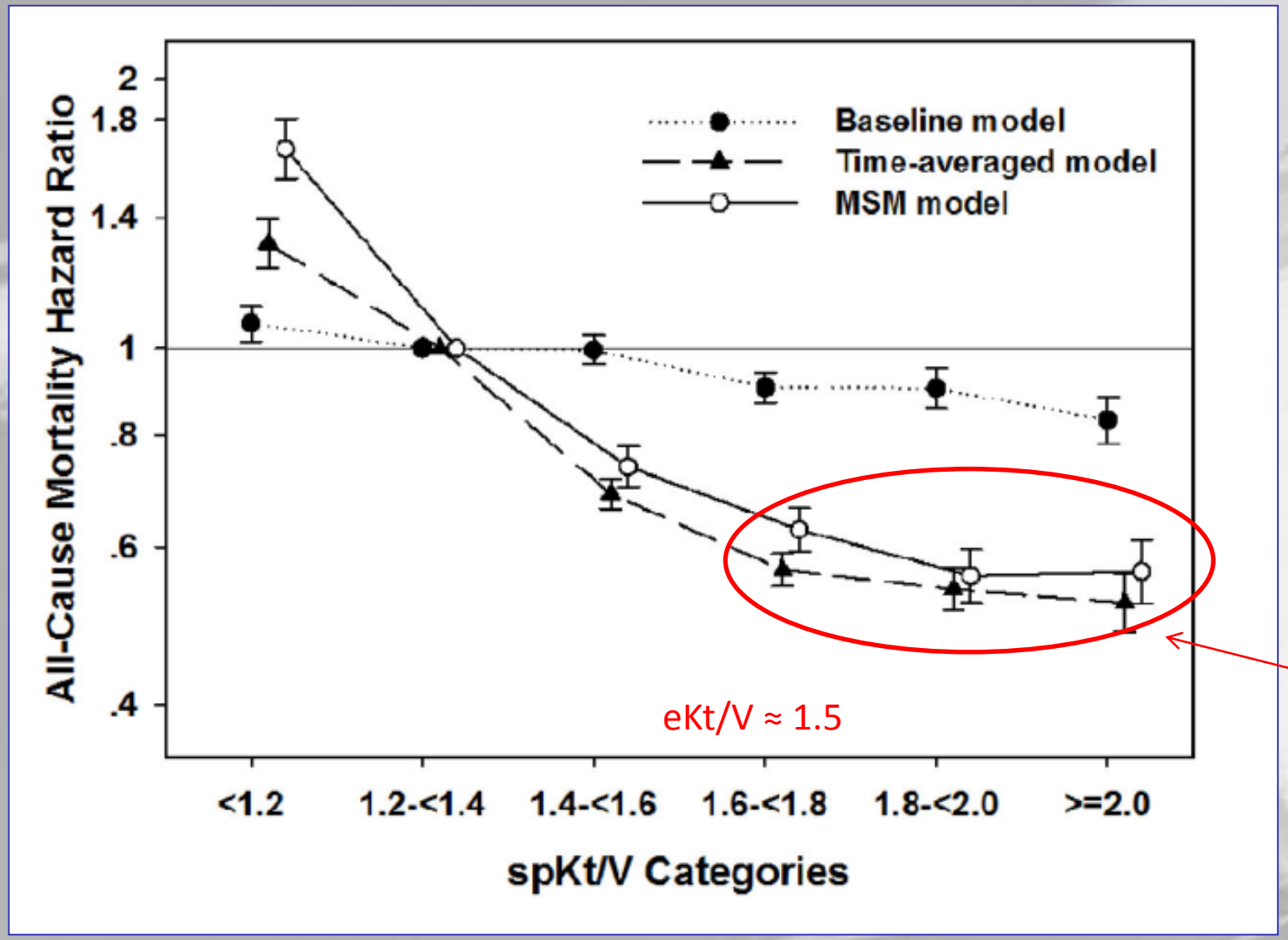
Kt/V for quantifying dialysis dose

Kt/V was an important predictor of mortality

NKF-KDOQI & other guidelines advocated high Kt/V

Friedrich K. Port et al. JASN 2002;13:1061-1066

Aiming for more intensive hemodialysis (Kt/V) ...



we learned how to improve Kt/V ...

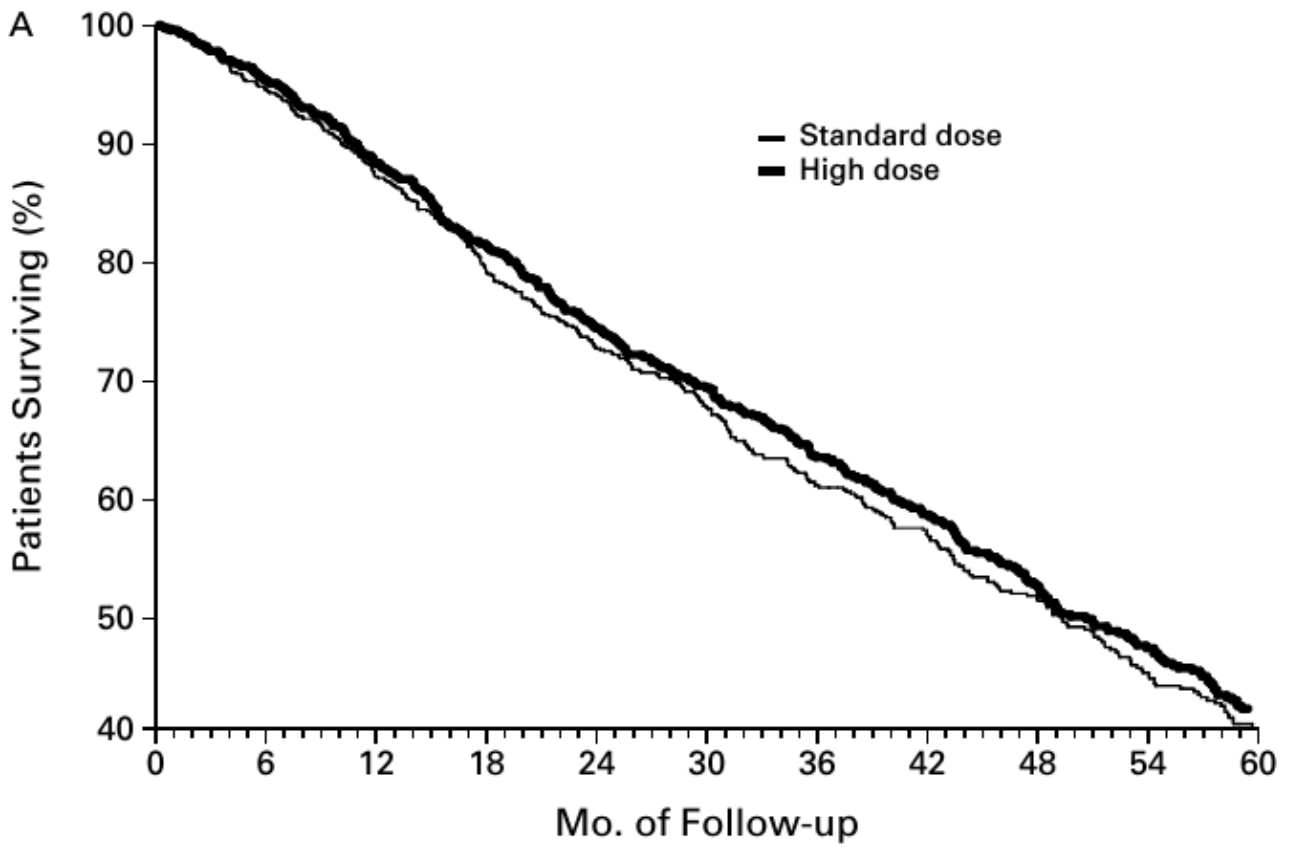
Models adjusted for:
age, gender, race, dialysis duration, insurance type, vascular access type, comorbidities, smoking status, dialysis parameters, bmi, albumin, creatinine, iron status, Ca, P, hgb, wbc

no further survival advantage

P Lertdumrongluk, E. Streja et al, Am J Nephrol. 2014 ; 39(5): 383–391

Aiming for more intensive hemodialysis (Kt/V) …

HEMO study: higher Kt/V does not improve survival



No. at Risk

Standard dose	854	759	630	524	451	382	315	253	197	149
High dose	857	753	637	538	470	399	327	266	219	166

Standard dose	spKt/V: 1.32 eKt/V: 1.16
High dose	spKt/V: 1.71 eKt/V: 1.53

Patients with residual kidney function were excluded.

Eknoyan et al, N Engl J Med. 2002 ;347(25):2010-9.

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Peritoneal Dialysis

- survival advantage compared to hemodialysis
- more individualized treatments
- factors associated with better outcome
  - ...
  - higher dialysis dose does not improve survival

Survival on peritoneal dialysis - the CANUSA study

Table 2. Cox model of relative risk of death with time-dependent Ccr divided into peritoneal clearance and GFR and entered as time-dependent covariates[a]

Variable	Relative Risk	95% Confidence Limit
Age	1.02	1.005–1.044
CVD	2.42	1.499–3.904
Diabetes mellitus	1.25	0.769–2.036
Serum albumin	0.96	0.912–1.000
LA transport	1.66	0.379–7.218
HA transport	2.33	0.554–9.801
H transport	2.01	0.430–9.357
SGA	0.74	0.647–0.842
Ccrp (5 L/wk per 1.73 m^2 greater)	1.00	0.898–1.105
GFR (5 L/wk per 1.73 m^2 greater)	0.88	0.829–0.943

[a] CVD, cardiovascular disease; LA, low average; HA, high average; H, high; SGA, subjective global assessment.

Table 3. Cox model of relative risk for death with urine volume forced in as a time-dependent covariate

Variable	Relative Risk	95% Confidence Limits
Age (1 yr older)	1.02	1.002–1.041
CVD	2.37	1.465–3.821
Diabetes mellitus	1.31	0.807–2.134
Serum albumin (1 g/L increase)	0.96	0.914–1.003
LA transport	1.84	0.418–8.075
HA transport	2.71	0.631–11.623
H transport	2.46	0.523–11.590
SGA (1 unit greater)	0.78	0.672–0.876
Ccrp (5 L/wk per 1.73 m^2 greater)	0.93	0.795–1.079
GFR (5 L/wk per 1.73 m^2 greater)	0.99	0.943–1.044
Urine volume (250 ml daily greater)	0.64	0.508–0.800

0.5 ml/min higher GFR → 9% lower risk of death

Each 250ml urine → 36% reduction in mortality

Ccrp: peritoneal clearance
GFR: renal clearance

Bargman et al, J Am Soc Nephrol 12: 2158 –2162, 2001

Survival on peritoneal dialysis - the ADEMEX study

Table 3. Predictors of outcomes for the study population as a whole, by multivariate Cox regression analysis[a]

Factor	Reference Group (RR = 1.00)	Creatinine Clearance as Adequacy Measure		Urea Clearance as Adequacy Measure	
		RR	*P* Value	RR	*P* Value
Age	Per 10-yr increase	1.16	0.0074	1.16	0.0073
Gender	Male	1.09	0.4648	1.10	0.4951
Diabetes mellitus	No diabetes mellitus	1.76	<0.0001	1.77	<0.0001
Albumin[b]	Per 0.1 g/dl increase	0.91	<0.0001	0.91	<0.0001
nPNA	Per 0.1 g/kg per d increase	0.95	0.0671	0.95	0.0942
Peritoneal CrCl[b]	Per 10 L/wk per 1.73 m^2 increase	1.03	0.5576		
Renal CrCl[b]	Per 10 L/wk per 1.73 m^2 increase	0.89	0.0135		
PeritonealKt/V[b]	Per 0.10 increase			1.00	0.7809
Renal Kt/V[b]	Per 0.10 increase			0.94	0.0052

[a] RR, relative risk.
[b] Time-dependent factor or covariate.

Paniagua et al, J Am Soc Nephrol 13: 1307–1320, 2002

Clearence & Outcomes on peritoneal dialysis

Table 5. Summary of pertinent literature[a]

Year	Reference	Study Size	Study Type	Clearance Effect on Outcomes		
				Total	Peritoneal	Renal
1990	Teehan *et al.* (19)	51	Observational	Yes[b,c]	NE	NE
1991	Blake *et al.* (18)	76	Observational	No[b]	NE	NE
1992	Brandes (49)	18	Observational	Yes[b]	NE	NE
1992	De Alvaro *et al.* (20)	102	Observational	Yes[d]	NE	NE
1992	Lameire *et al.* (21)	16	Observational	Yes[d]	NE	NE
1995	Genestier *et al.* (22)	201	Observational	Yes[b,c]	NE	NE
1995	Maiorca *et al.* (23)	68	Observational	Yes,[b,d] no[c]	NE	Yes[b, c, d]
1996	Fung (50)	31	Observational	Yes[d]	NE	Yes[d]
1998	Davies (51)	210	Observational	Yes,[b] no[c]	NE	Yes[b,c]
1999	Diaz-Buxo *et al.* (2)	673	Observational	NE	No[c]	Yes[c]
1999	Merkus (52)	106	Observational	NE	No[c]	Yes[c]
1999	Jager *et al.* (11)	118	Observational	NE	No[b]	Yes[b]
1999	Szeto *et al.* (8)	168	Observational	Yes[d]	NE	NE
2000	Szeto *et al.* (7)	270	Observational	Yes[c]	No[c]	Yes[c]
2000	Mak *et al.* (9)	82	Interventional	Yes[b]	NE	NE
2000	Rocco *et al.* (12)	873	Observational	NE	No[c]	Yes[c]
2001	Szeto *et al.* (13)	140	Observational	NE	Yes[c]	NE
2001	Bargman *et al.* (28)	601	Observational	NE	No[c]	Yes[c]

[a] NE, not examined in the study as published.
[b] Univariate analysis.
[c] Multivariate analysis.
[d] Dichotomous analysis.

very consistent literature

Paniagua et al, J Am Soc Nephrol 13: 1307–1320, 2002

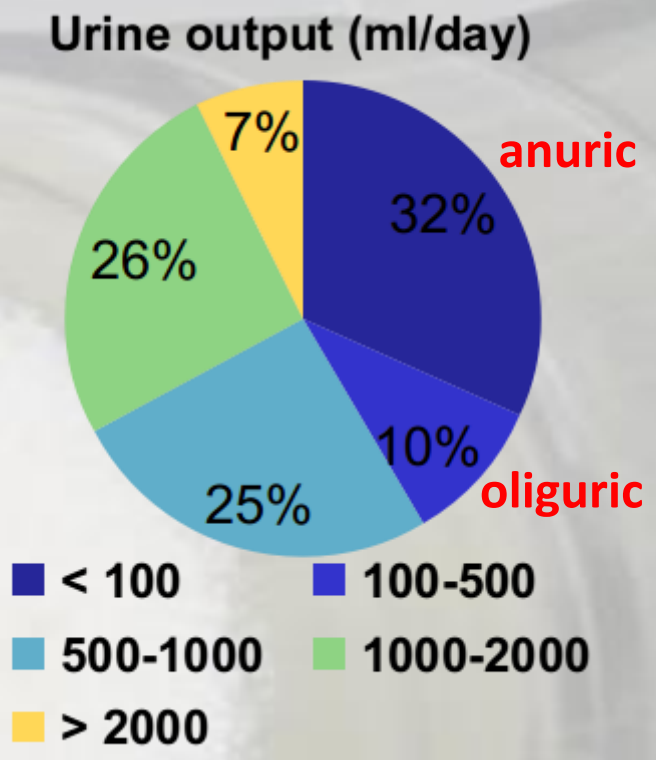
Residual renal function on hemodialysis

Some patients on HD do make urine !

Earlier (in the XX. century), hemodialysis patients were deemed anuric, or having negligible amount of urine
→ studies did not assess / include RRF as a predictor.

Residual renal function on hemodialysis

Some patients on HD do make urine !



Earlier (in the XX. century), hemodialysis patients were deemed anuric, or having negligible amount of urine
→ studies did not assess / include RRF as a predictor.

Residual renal function, dialysis dose and survival

Table 3. Multivariate Cox regression model on patient survival

NECOSAD-2

	Adjusted Relative Risks of Death (n = 740/238 Death Events)		
	RR	95% CI	P Value
Age at entry (yr)	1.03	1.02 to 1.05	<0.0001
Male gender	0.84	0.64 to 1.10	0.2098
Davies' comorbidity score at entry			
high	4.74	3.04 to 7.40	<0.0001
intermediate	2.35	1.63 to 3.39	
low	1.00 ref		
Primary kidney disease			0.0855
diabetes	1.43	0.98 to 2.09	
glomerulonephritis	0.67	0.38 to 1.20	
renal vascular disease	1.18	0.86 to 1.62	
others	1.00 ref		
Albumin baseline (for each 0.1 g/dl increase)[b]	0.98	0.95 to 1.01	0.1355
SGA (scale 1–7) at baseline	0.89	0.80 to 0.99	0.0389
BMI (kg/m^2)	0.96	0.93 to 0.99	0.0252
Residual rKt/V_{urea} (/wk)	0.44	0.30 to 0.65	<0.0001
Dialysis sp-dKt/V_{urea} (/wk)	0.76	0.64 to 0.92	0.0035

[a] The residual renal function (rKt/V_{urea}) and dose of dialysis (sp-dKt/V_{urea}) were included as time-dependent variables. RR, relative risk; CI, confidence interval.

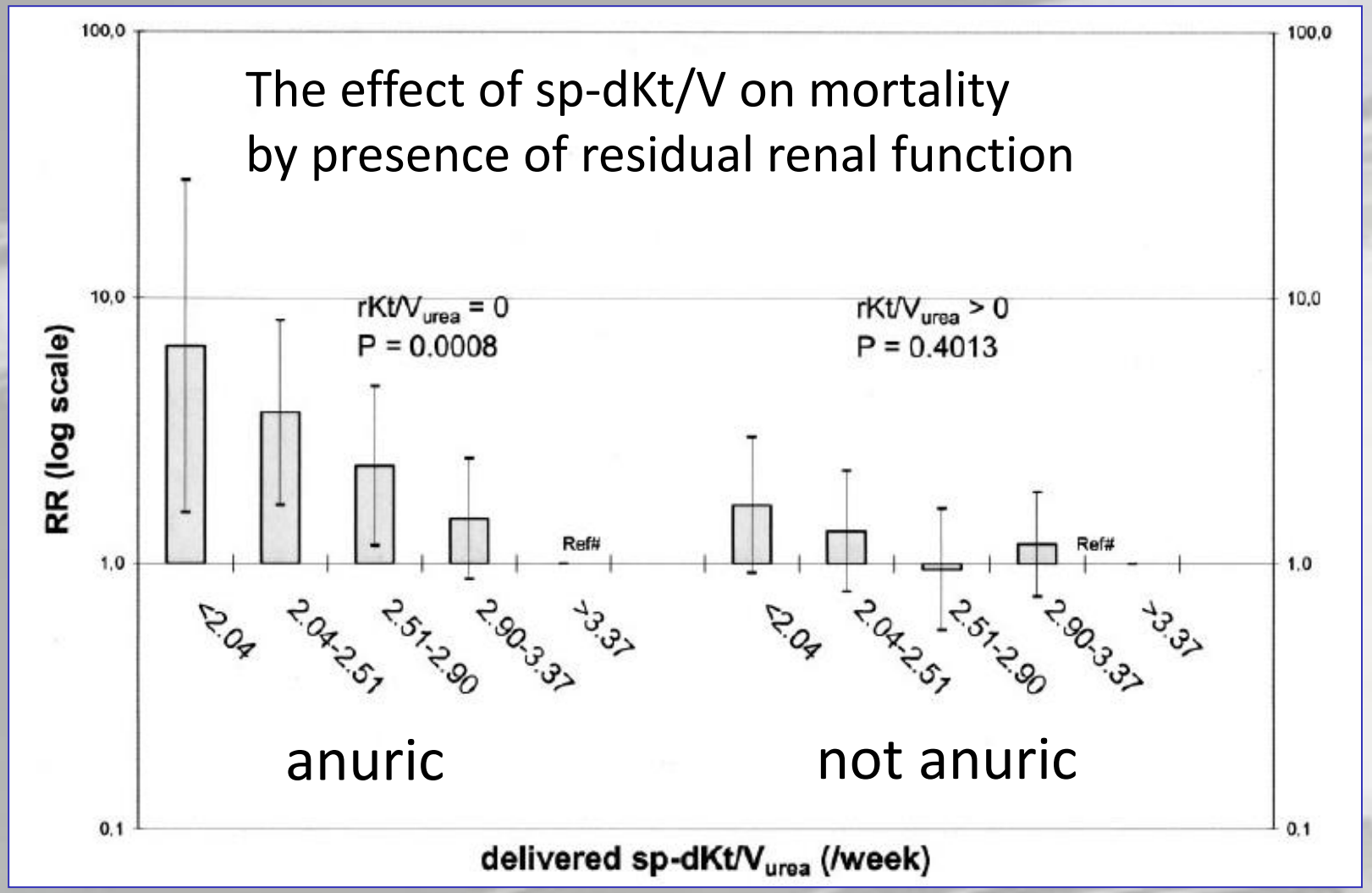
[b] To convert albumin in g/dl to g/L, multiply by 10.

Multicenter, prospective, observational study in the Netherlands

Thermorshuizen et al, J Am Soc Nephrol 15: 1061–1070, 2004

Residual renal function, dialysis dose and survival

NECOSAD-2



The more HD, the better?
- only in anuric patients !

The rKt/V and sp-dKt/V were included as time-dependent variables.

The relative risks are adjusted for age, Davies' comorbidity score, primary kidney disease, subjective global assessment, and body mass index.

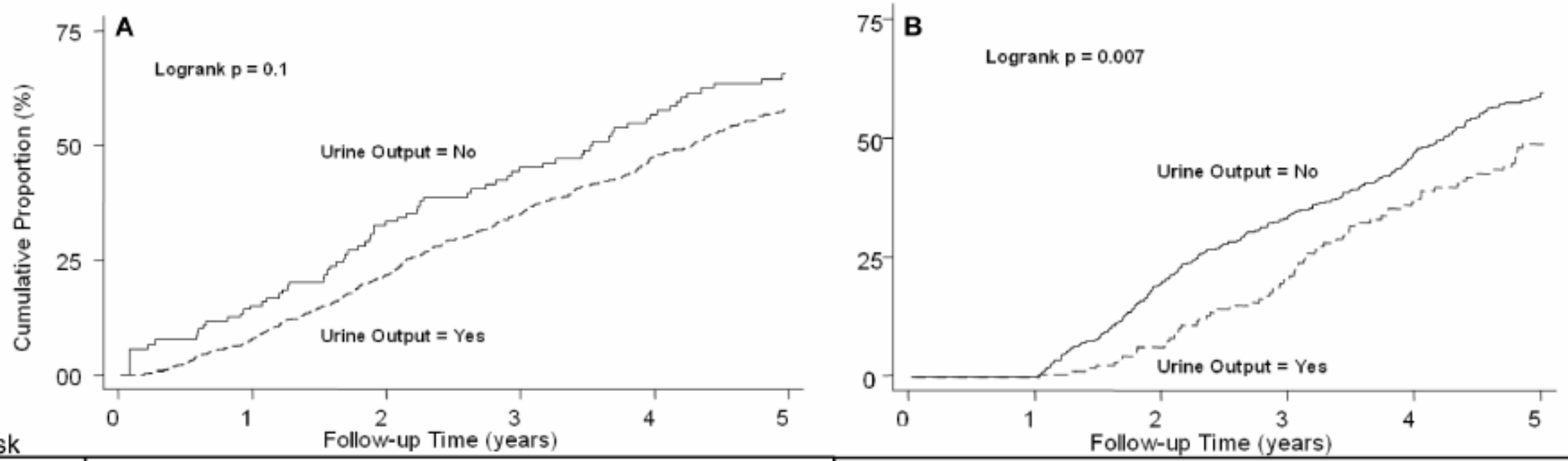
Thermorshuizen et al, J Am Soc Nephrol 15: 1061–1070, 2004

Residual renal function and survival

CHIOCE

734 incident hemodialysis patients, 3 year follow-up
def. urine output > 250ml/ day

Cumulative incidence of Mortality



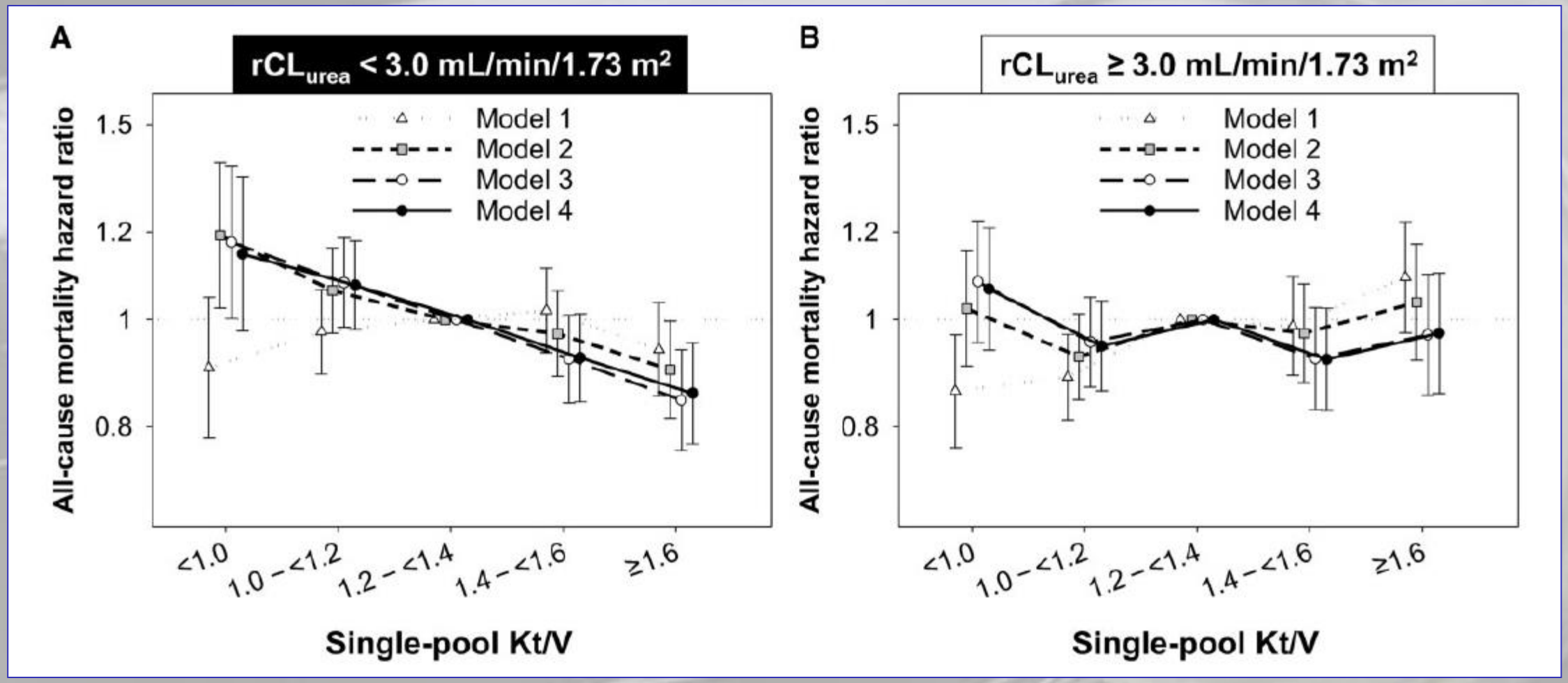
No. at risk

Urine ouput = No	117	97	73	57	43	32	416	311	244	180	129
Urine ouput = Yes	617	541	428	334	248	185	163	142	113	84	66

Shafi et al, Am J Kidney Dis. 2010; 56(2): 348–358.

Residual renal function, dialysis dose and survival

32251 incident HD patients in the US, retrospective analysis (2007-2011)
HD 3x weekly

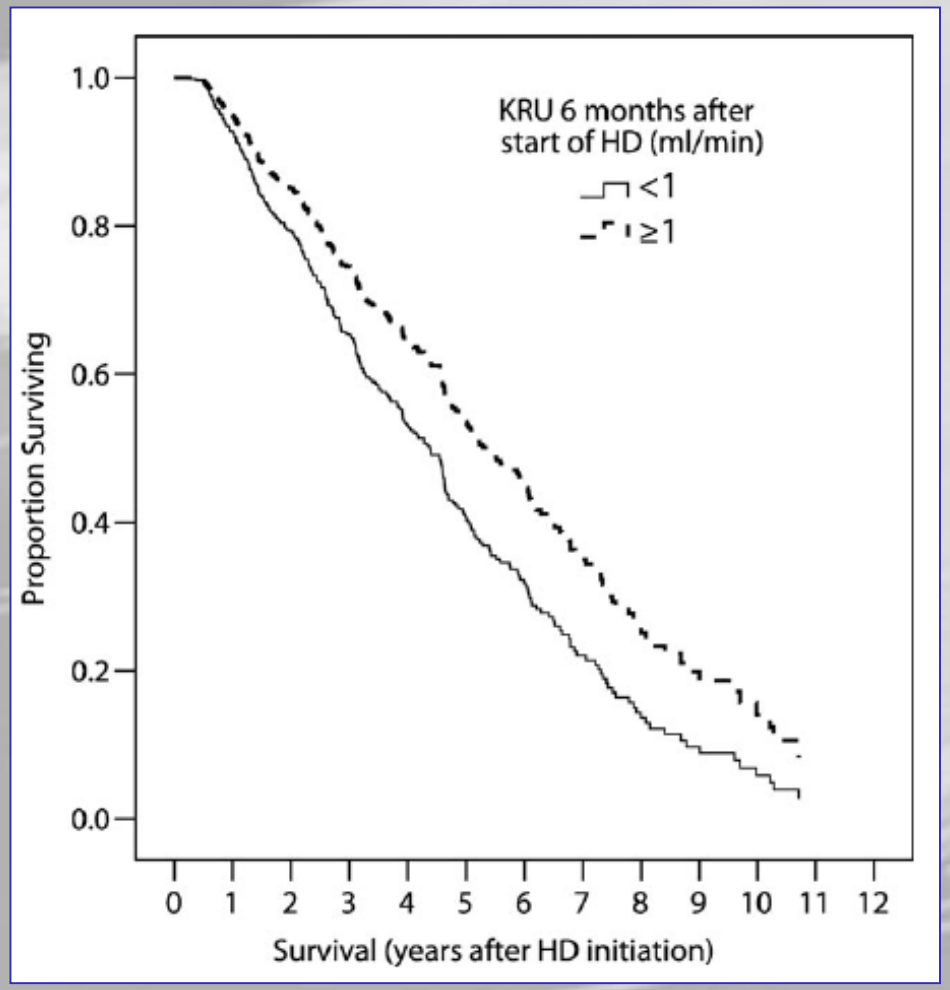


Wang et al, Nephrol Dial Transplant (2018) 1–9

Residual renal function and survival on hemodialysis

Even as small as 1ml/min urea clearance does count !

(in the first 6 months of HD)



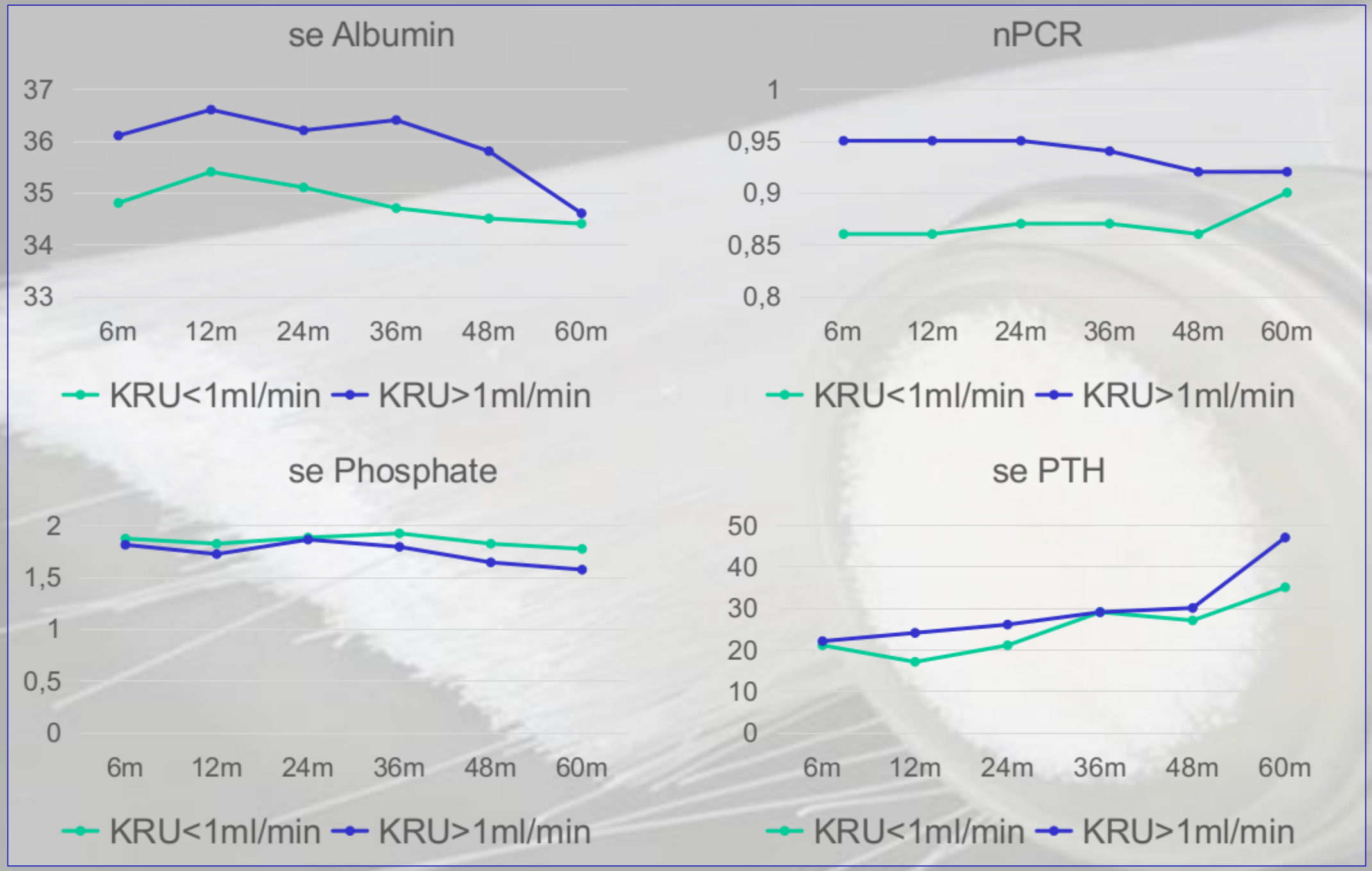
KRU: renal urea clearance

	P	HR	95% CI
Renal urea clearence	**0.029**	**0.932**	**0.875–0.993**
Diabetes	0.200	1.272	0.880–1.838
Age	**<0.001**	**1.030**	**1.019–1.041**
Albumin	**0.003**	**0.962**	**0.937–0.987**
HDF use	**<0.001**	**0.508**	**0.373–0.692**
Malignancy	**0.001**	**1.841**	**1.281–2.645**
Ischaemic heart diesase	0.589	0.925	0.698–1.227
Peripheral vasc. disease	0.684	1.070	0.773–1.481

Cox proportional hazards model comparing patient survival in subjects with a residual urea clearence ≥ or < 1 ml/min in the first 6 months of HD

Incremental hemodialysis program, 650 patients, over 15 years

Vilar et al, Nephrol Dial Transplant (2009) 24: 2502–2510



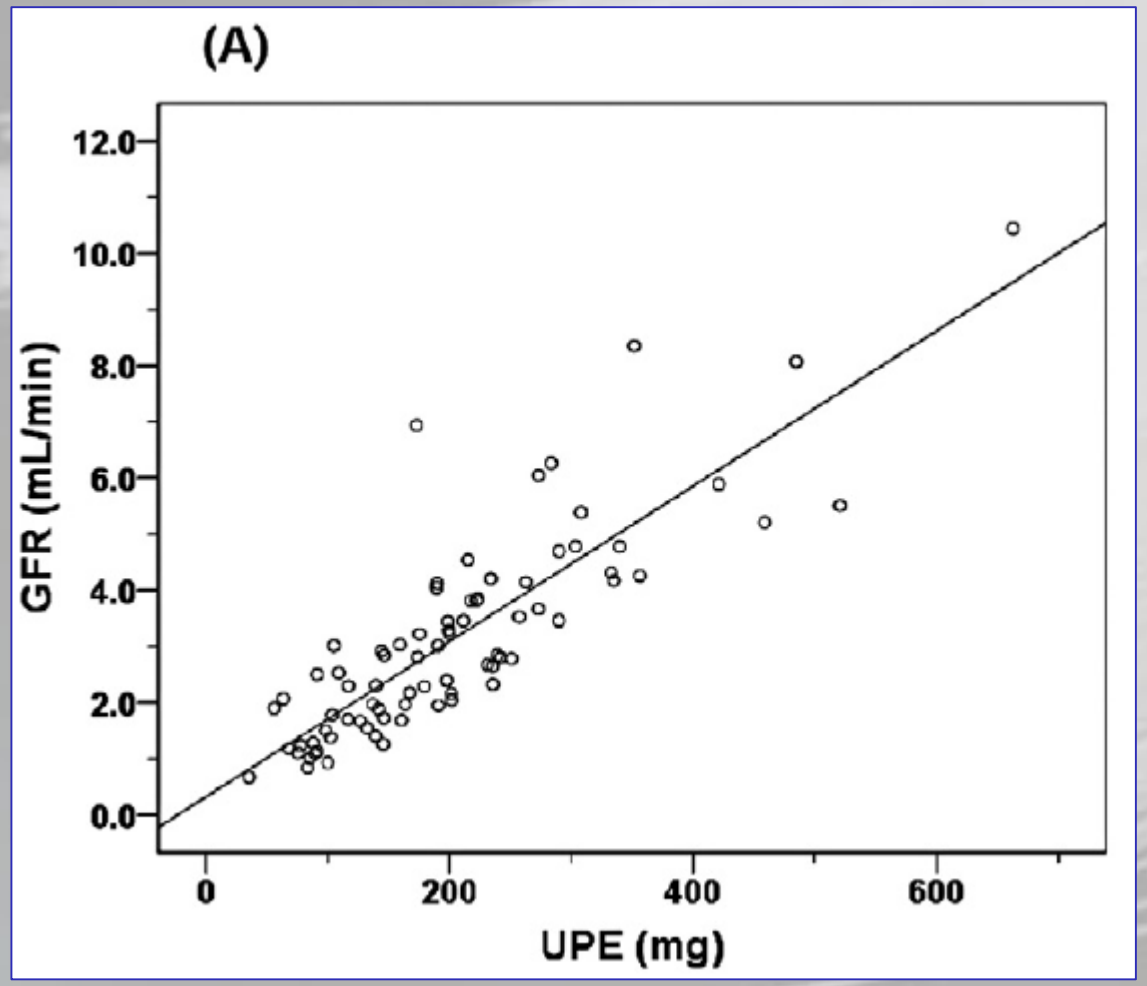
KRU: renal urea clearance

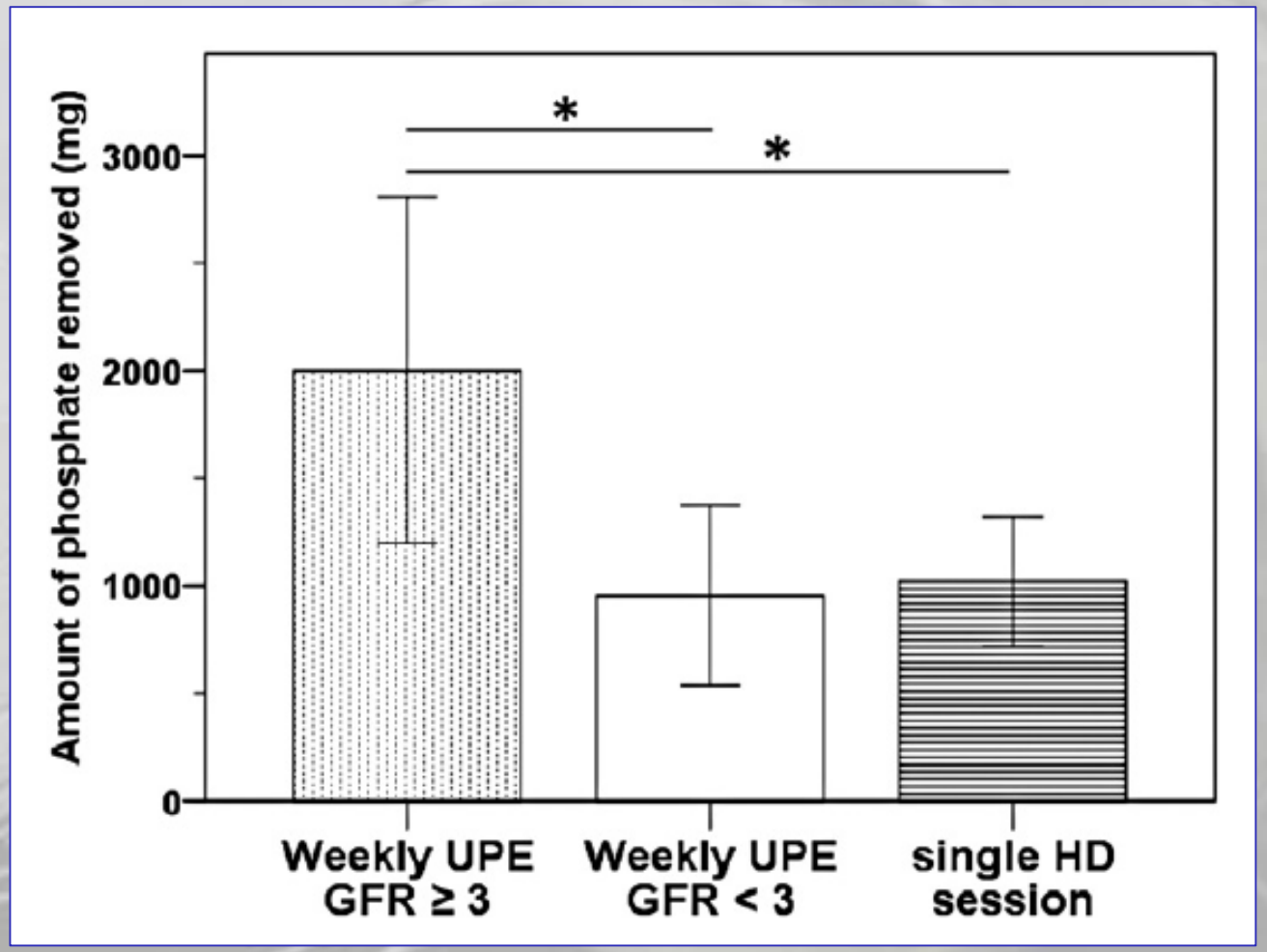
Vilar et al, Nephrol Dial Transplant (2009) 24: 2502–2510

Residual kidney function and urinary phosphate excretion

79 prevalent HD patients, with urine output > 100ml/min

35 patients with GFR>3ml/min vs 44 patients with GFR<3ml/min





urinary phosphate excretion

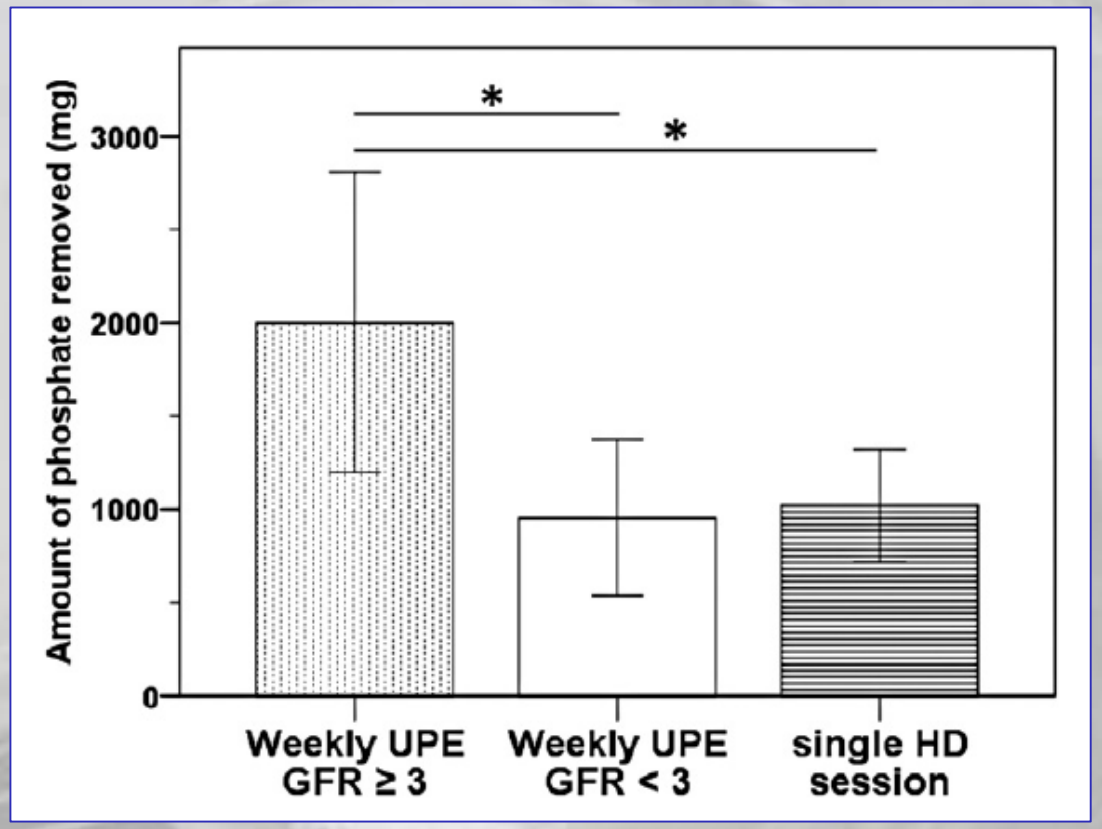
Iwasawa et al, Nephrology 18 (2013) 285–291

Residual kidney function and urinary phosphate excretion

79 prevalent HD patients, with urine output > 100ml/min

35 patients with GFR>3ml/min vs 44 patients with GFR<3ml/min

Parameter	All Patients ($n = 79$)	Group A (GFR ≥ 3, $n = 35$)	Group B (GFR < 3, $n = 44$)	*P*-value
sPi (mg//dL)	5.8 ± 1.1	5.5 ± 1.1	6.1 ± 1.1	0.02
(mmol/L)	1.9 ± 0.4	1.8 ± 0.4	2.0 ± 0.4	
iPTH (ng/L)	250 ± 182	306 ± 232	206 ± 113	0.02
FGF-23 (ng/L)†	2008 ± 1933	1296 ± 2142	2423 ± 1760	0.23
uPi (mg/dL)	17.2 ± 6.1	18.8 ± 6.0	15.9 ± 6.0	0.03
(mmol/L)	5.6 ± 2.0	6.1 ± 1.9	5.1 ± 1.9	
TRP (%)	35.0 ± 13.9	39.2 ± 13.3	31.7 ± 13.6	0.02
TmP/GFR (mg/dL)	2.0 ± 0.8	2.2 ± 0.9	1.9 ± 0.8	0.12
(mmol/L)	0.7 ± 0.3	0.7 ± 0.3	0.6 ± 0.3	
UPE (mg/day)	203 ± 113	283 ± 115	139 ± 57	0.001
(mmol/day)	6.6 ± 3.6	9.1 ± 3.7	4.5 ± 1.8	



urinary phosphate excretion

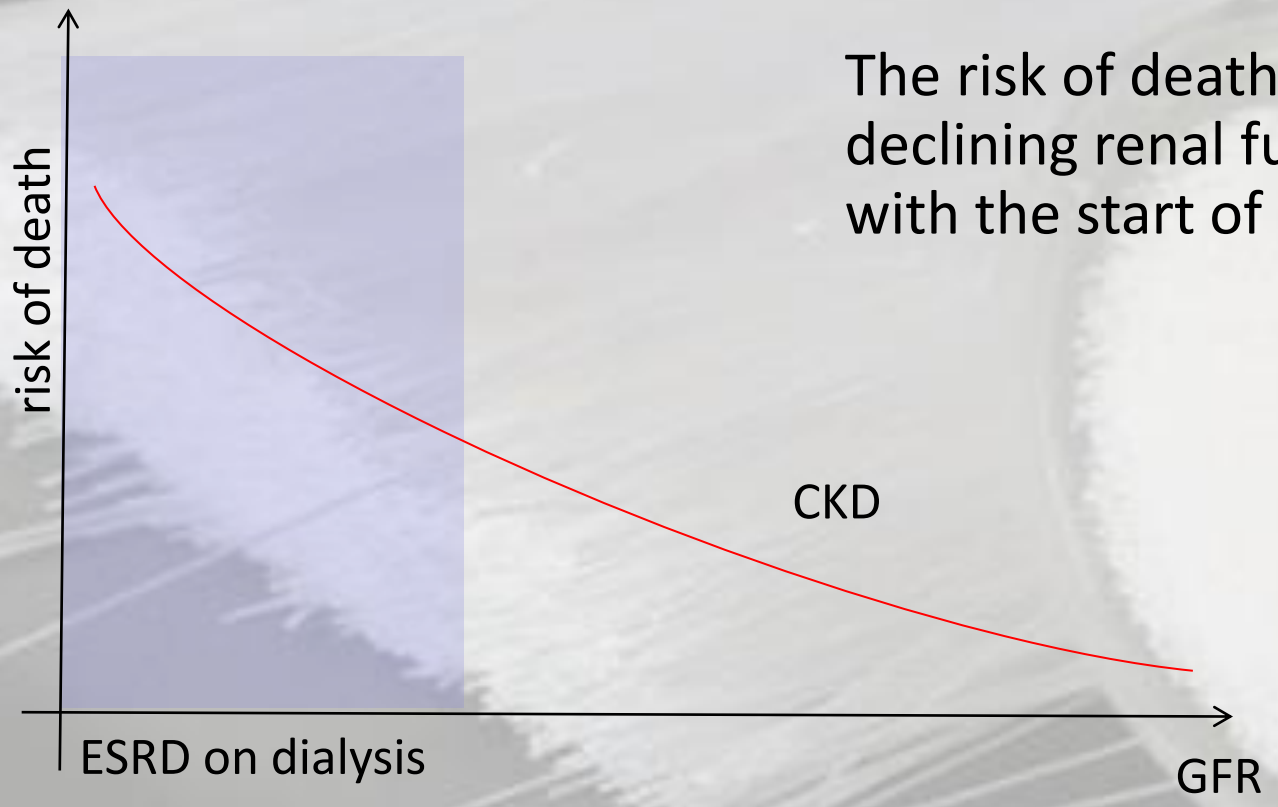
Iwasawa et al, Nephrology 18 (2013) 285–291

How residual renal function affects survival?

- RRF is just associated with being a healthier patient
- better clearence of middle molecular weight and protein bound uremic toxins
- better maintenance of euvolemia
  - less hypervolemia → better BP control and decreased LVH
  - less ultrafiltration → fewer hypotensive episodes
- better nutritional status
- intrinsic anti-inflammatory effect
- lower potassium, phosphate levels (FGF-23 ?)
- less calcification
- ... ?

Ajanovic et al, BANTAO Journal 2015; 13(2): 73-78;
Fernández-Lucas et al, Nefrologia 2012;32(6):767-76
Weerd et al, PLoS ONE 2012; 7(7): 1-18;
Penne et al, Clin J Am Soc Nephrol. 2011 Feb; 6(2): 281–289.
Merkus et al, Am J Kidney Dis. 1997 Apr;29(4):584-92.
Shin et al, PLoS ONE 2017;12(9): e0185296

How residual renal function affects survival?



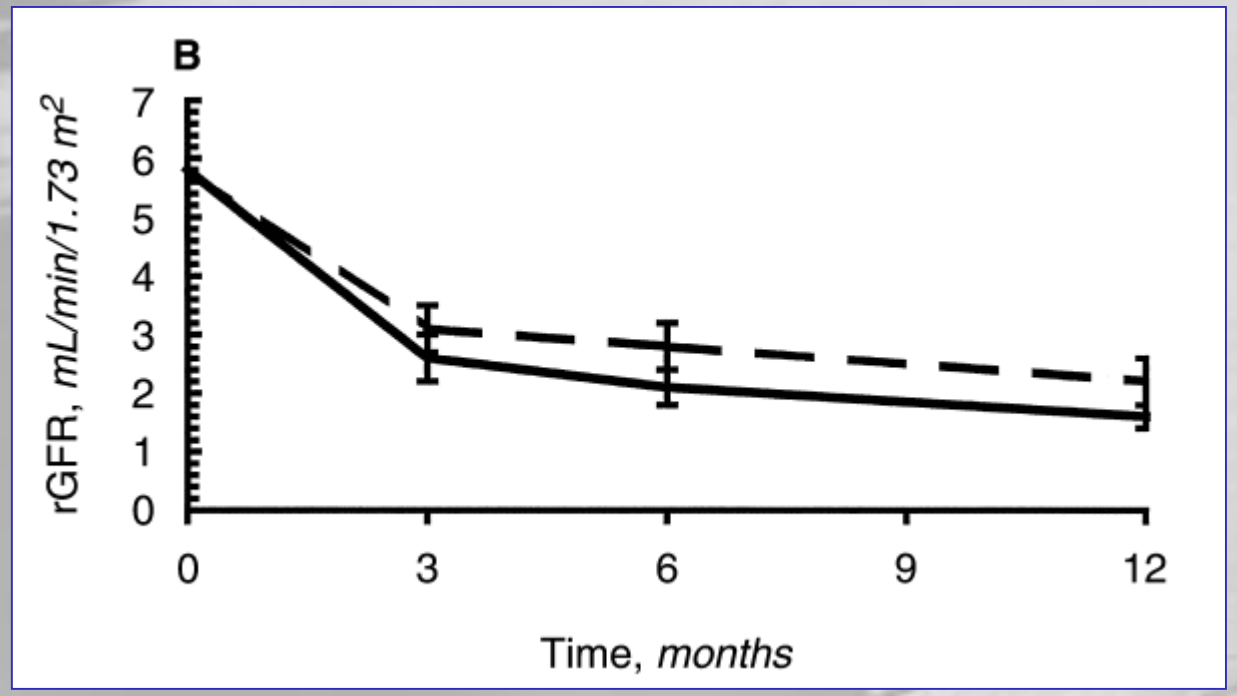
The risk of death associated with declining renal function does not stop with the start of dialysis.

What happens to residual renal function in patients on hemodialysis?

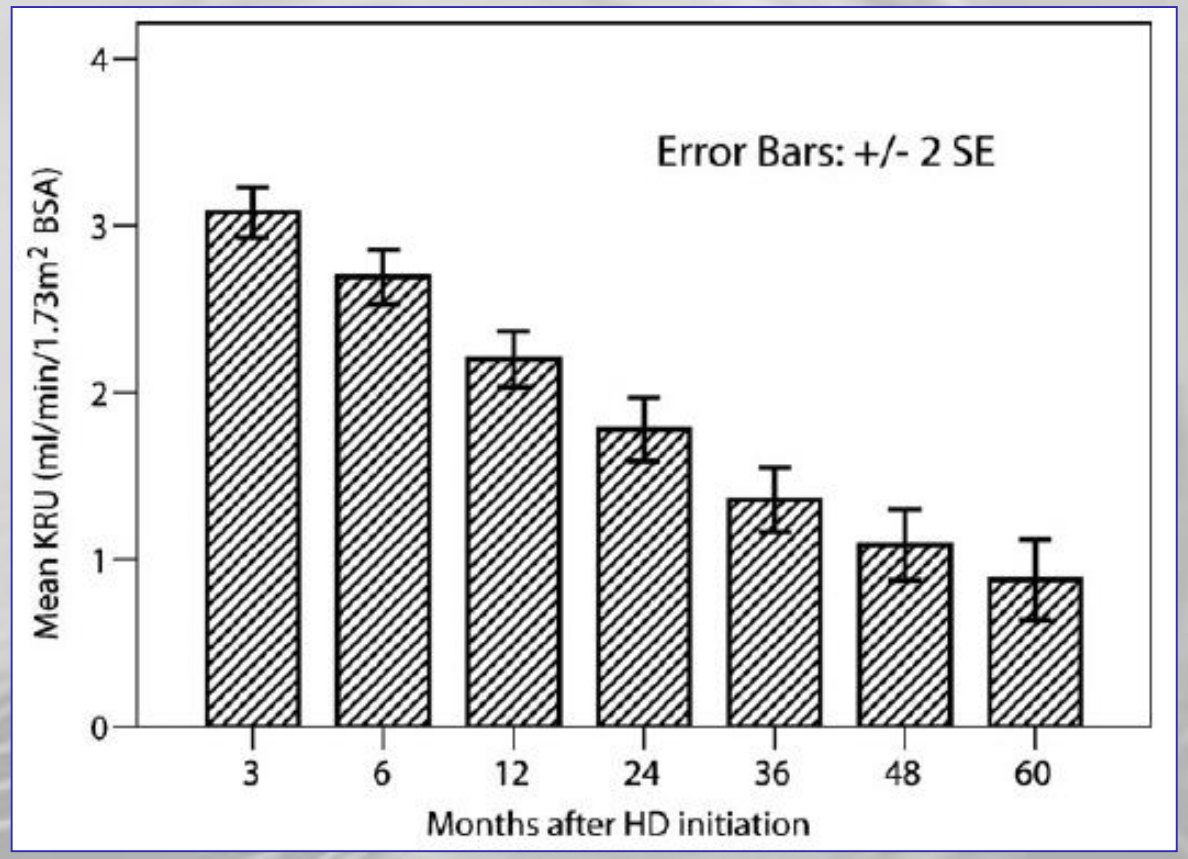
Residual renal function declines over time

Decline of residual kidney function after initiation of hemodialysis

Short term

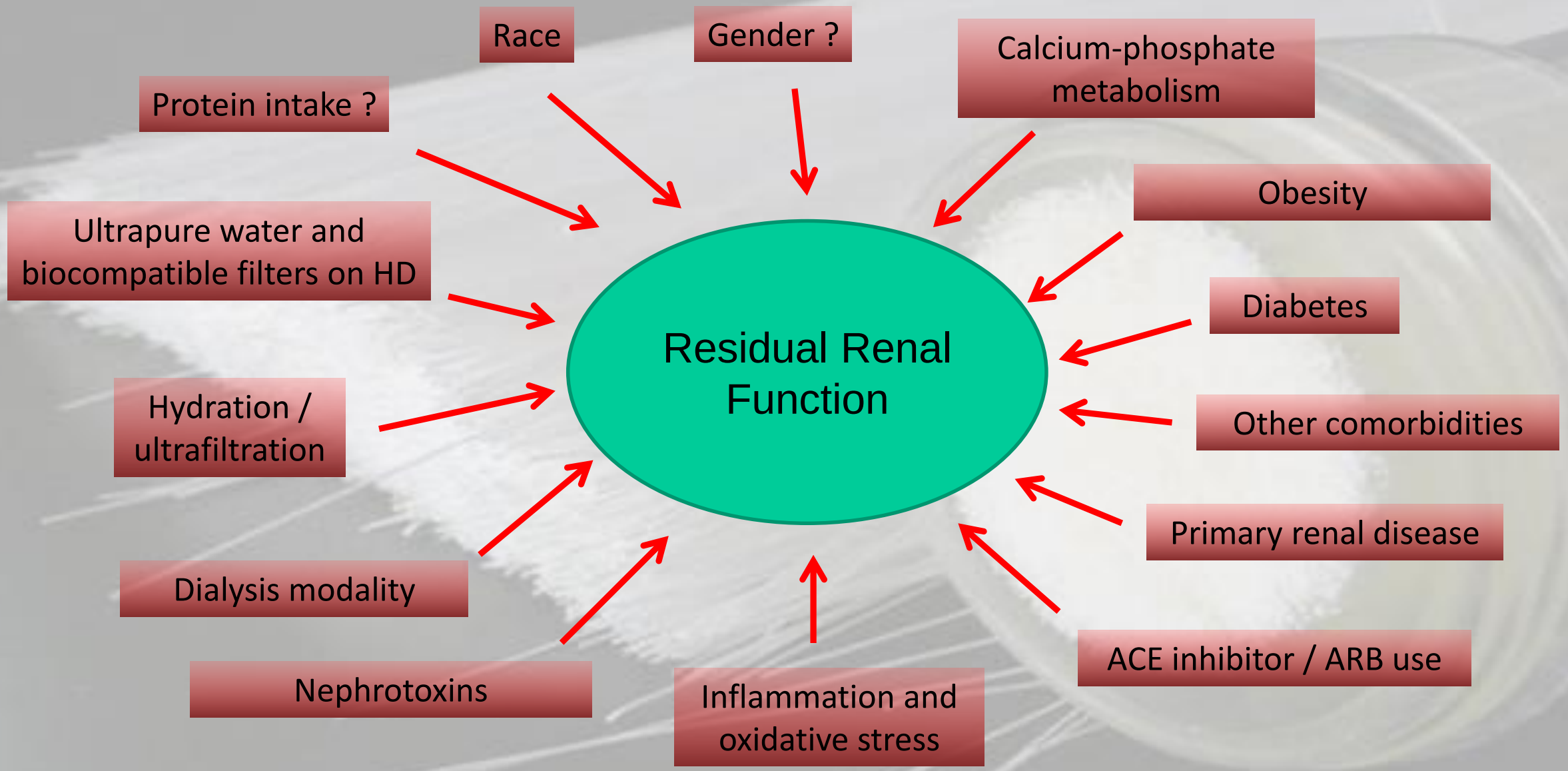


Long term

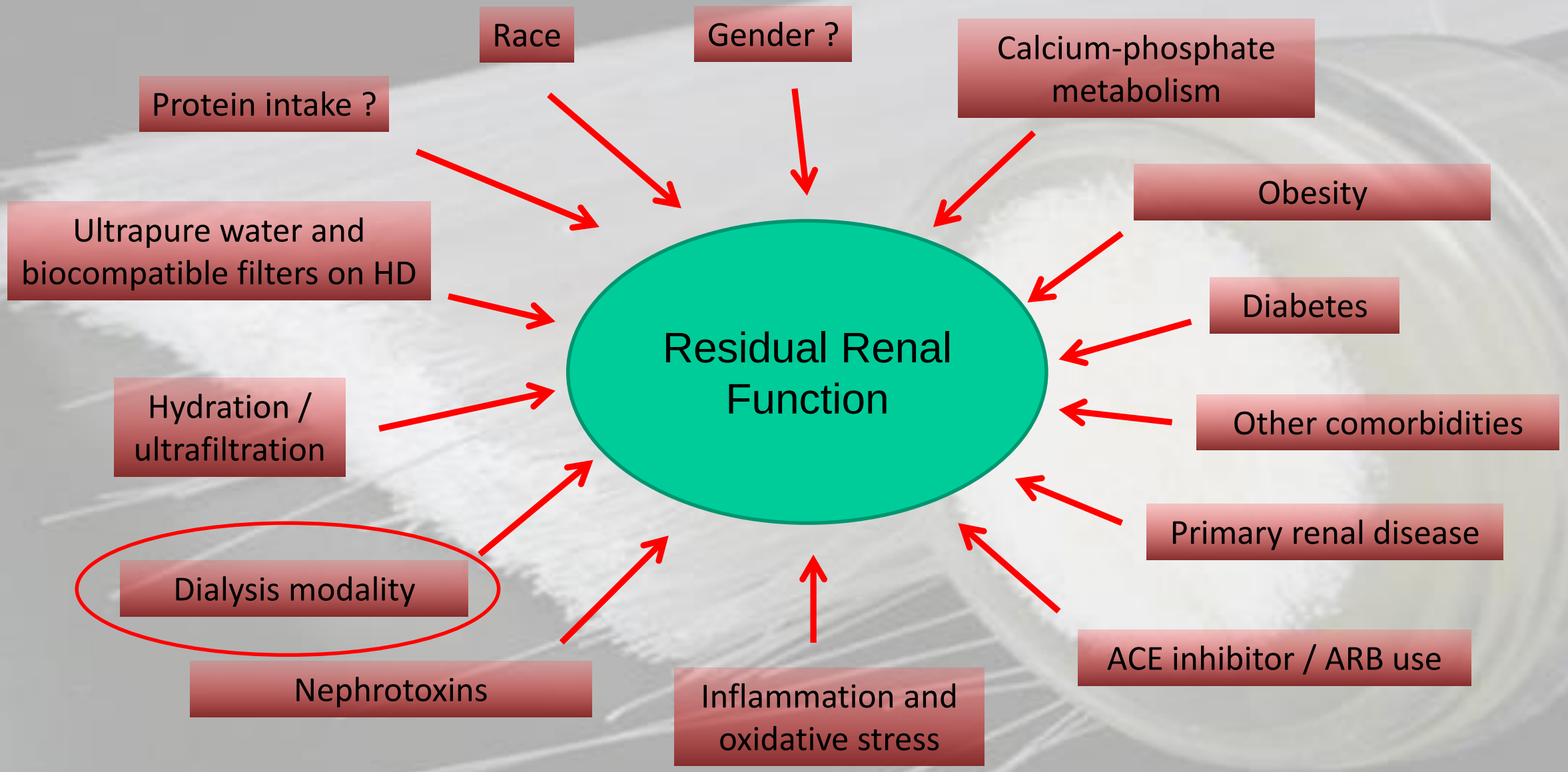


Jansen et al, Kidney International, 62(3), 1046–1053.
Vilar et al, Nephrol Dial Transplant (2009) 24: 2502–2510

Predictors of loss of residual renal function



Predictors of loss of residual renal function



Predictors of loss of residual renal function

Table 2. Adjusted odds ratios for RRF loss[a]

Variable (reference)	Overall (n = 1843)				PD only (n = 1032)		HD only (n = 811)	
	"Adjusted" Univariate[b]		Multivariate[c]					
	AOR	*P* Value	AOR	*P* Value	AOR	*P* Value	AOR	*P* Value
Adjusting variables								
time to follow-up (per month)	1.10	0.0005	1.06	0.03	1.11	0.01	1.02	0.86
estimated GFR at ESRD onset (ml/min)	0.97	0.07	0.97	0.09	0.94	0.04	0.99	0.74
Demographics								
age (per 10 yr)	1.02	0.0001	1.01	0.18	1.01	0.24	1.00	0.60
female (*versus* male)	1.42	0.0006	1.45	<0.001	1.42	0.02	1.38	0.06
non-white race (*versus* white)	1.72	0.0001	1.57	<0.001	1.94	<0.001	1.08	0.66
Etiology of ESRD								
glomerulonephritis (reference)	1.00	(ref)	1.00		1.00		1.00	
diabetes mellitus	1.76	0.002	0.68	0.14	0.59	0.13	0.81	0.61
hypertension	1.61	0.01	1.17	0.43	1.47	0.14	1.02	0.94
other causes	1.26	0.24	1.05	0.82	1.35	0.25	0.78	0.47
Pre-ESRD care								
late referral (<4 mo pre-ESRD)	1.23	0.04	.99	.99	1.04	0.85	0.93	0.72
dietary consult	0.90	0.33						
Comorbid factors								
diabetes mellitus	1.59	0.0001	1.82	0.006	2.17	0.01	1.66	0.10
coronary artery disease	1.40	0.002	1.13	0.33	1.25	0.19	0.98	0.89
cerebrovascular disease	1.17	0.31						
congestive heart failure	1.60	0.0001	1.32	0.03	1.5	0.02	1.16	0.45
peripheral vascular disease	1.28	0.06						
left ventricular hypertrophy	1.57	0.0006	1.27	0.08	1.30	0.17	1.26	0.26
MAP (per 10 mmHg)	0.993	0.003	01.03	0.49	1.04	0.41	0.87	0.04
body mass index (per kg/m^2)	0.99	0.49						
Laboratory parameters								
serum albumin (per g/dl)	0.88	0.18						
blood hematocrit (per %)	0.98	0.04	.99	0.68	0.99	0.94	1.01	0.53
serum calcium (per mg/dl)	0.90	0.02	0.81	0.05	0.99	0.94	0.79	0.006
phosphate (per mg/dl)	1.05	0.07						
total cholesterol (per 10 mg/dl)	0.99	0.03	1.00	0.93	1.01	0.47	1.01	0.42
Treatment parameters								
PD (*versus* HD)	0.28	0.0001	0.35	0.001	NA	NA	NA	NA
pre/post dialysis delta MAP(HD)	1.04	0.0001	1.00	0.33	NA	NA	0.99	0.87
ACE inhibitor (*versus* no)	0.74	0.01	0.68	<0.001	0.70	0.02	0.71	0.06
calcium channel blocker (*versus* no)	0.77	0.01	0.77	0.01	0.71	0.02	0.81	0.21
diuretics (*versus* no)	0.90	0.41						
EPO (*versus* no)	1.29	0.05	1.12	0.37	1.15	0.39	0.69	0.12
HMG CoA reductase inhibitor (*versus* no)	0.60	0.001	0.81	0.17	0.95	0.78	0.56	0.03
NSAIDS (*versus* no)	0.72	0.43						
vitamin D (*versus* no)	1.02	0.89						
Included in PD only analysis								
APD (*versus* CAPD)					0.96	0.96	NA	NA
Included in HD only analysis								
biocompatible membrane (*versus* cellulose)					NA	NA	0.84	0.42

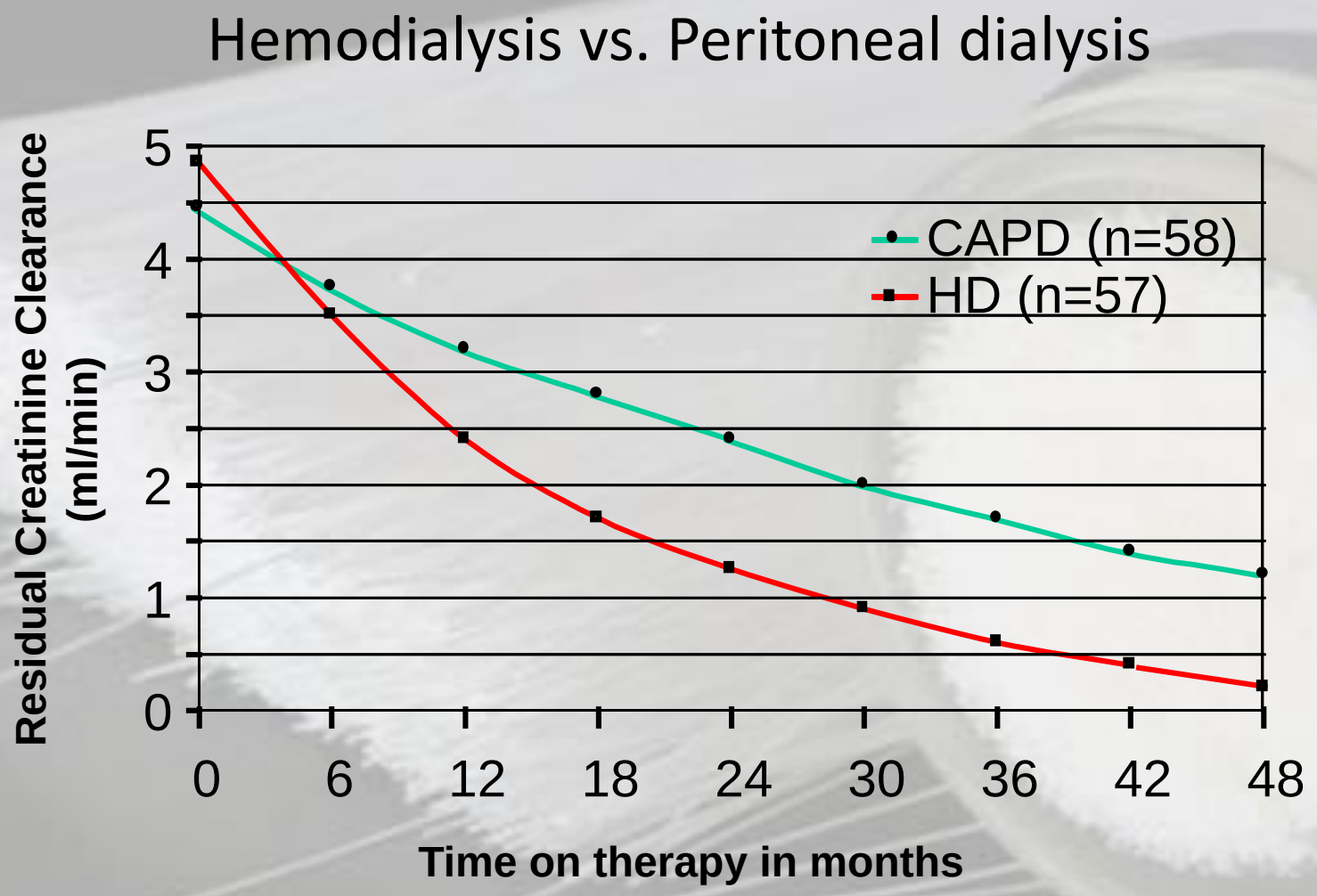
[a] AOR, adjusted odds ratio; APD, ambulatory peritoneal dialysis; NA, not applicable; other abbreviations as in Table 1.
[b] Adjusted for time to follow-up and estimated GFR at ESRD onset only.
[c] Adjusted for all covariates significant in univariate analysis.

	OR	P
female gender	1.45	<0.001
non-white race	1.57	<0.001
diabetes	1.82	0.006
CHF	1.32	0.03
LVH	1.27	0.08
Ca (+1mg/dl)	0.81	0.05
PD (vs HD)	**0.35**	**0.001**
ACE inhibitor use	0.68	<0.001
Ca channel blocker use	0.77	0.01
HD only: biocomp. membr.	0.84	0.42

adjusted for GFR at dial entry, follow-up time, all other covariates significant in univar. analysis

Moist et al , JASN 11:556, 2000

Residual renal function declines over time



Lysaght et al, *ASAIO Trans*, 1991; 37:598-604

Preservation of residual renal function

is PD better than HD?

Confounding factors:

- patients on PD are in general healthier
- PD is rather suggested for patients with RRF
- patients with rapid loss of RRF might intentionally be switched to HD (due to problems with hypervolemia)

Predictors of loss of residual renal function

NECOSAD study: incident dialysis patients

PD patients had a higher rGFR than HD patients. - a selection bias?
This relative difference increased over time. - an effect of dialysis itself?

Possible effects of the dialysis procedure on the decline rate between 0 and 3 months:

HD: hypotensive episodes during HD

Table 3. Effect of hypotensive episodes on rGFR at three months in HD patients at different levels of adjustment

HD patients: hypotensive episodes	$\beta \pm SE^a$	P
Model 1; Adjusted for baseline GFR	-0.94 ± 0.32	0.003
Model 2; Adjusted for 1, and for age, sex, PKD, and comorbidity	-0.95 ± 0.32	0.004
Model 3; Adjusted for 1, 2, and for dialysis Kt/V_{urea} at 3 months	-0.76 ± 0.32	0.02

[a] β gives the effect in mL/min/1.73 m^2 on rGFR at 3 months

PD: episodes with dehydration

Table 4. Effect of dehydration on rGFR at three months in PD patients at different levels of adjustment

PD patients: underhydration	$\beta \pm SE^a$	P
Model 1; Adjusted for baseline GFR	-1.93 ± 0.64	0.003
Model 2; Adjusted for 1, and for age, sex, PKD, and comorbidity	-1.94 ± 0.64	0.003
Model 3; Adjusted for 1, 2, and for dialysis Kt/V_{urea} at 3 months	-1.84 ± 0.63	0.004

[a] β gives the effect in mL/min/1.73 m^2 on rGFR at 3 months

Jansen et al, Kidney International, 2002;62(3), 1046–1053.

Residual renal function and target weight assessment

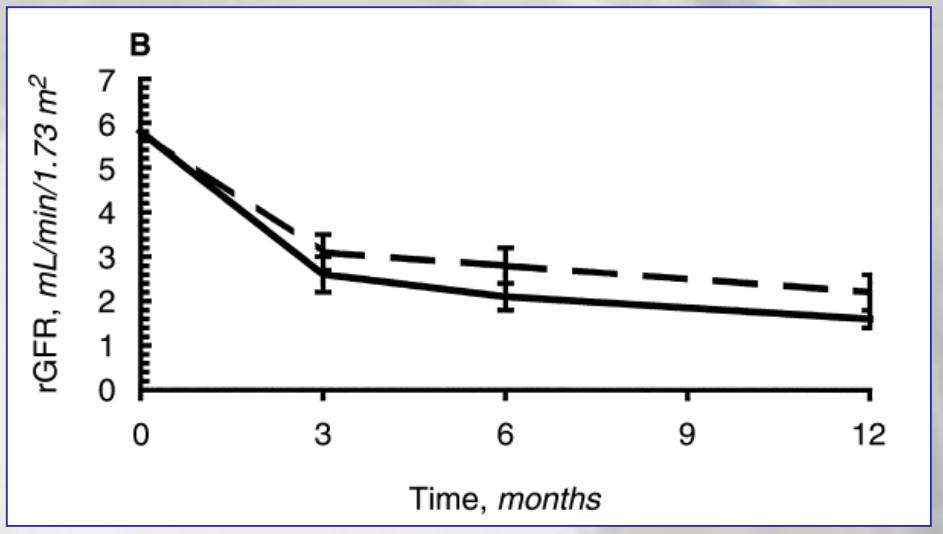
Rapid decline of RRF in the first 3 months after HD initiation
Time of dry weight probing !

Estimating target weight is very difficult
- hypervolemia is usually overestimated

Probing target weight by drying-out patients
- until patient is asymptomatic
- until blood-pressure medication is required

Very common but harmfull strategy
- episodes of (unrecognized) intradialytic hypotension

extreme example ...



Jansen et al, Kidney International, 2002;62(3), 1046–1053.

The Tassin experiment

Long dialysis, sodium restriction and aggressive ultrafiltration

HD patients in Tassin, France

long dialysis sessions: 3x8h

low dialysate sodium: 138mmol/l

sodium restriction

aggressive dry-weight reduction within 2-3 months

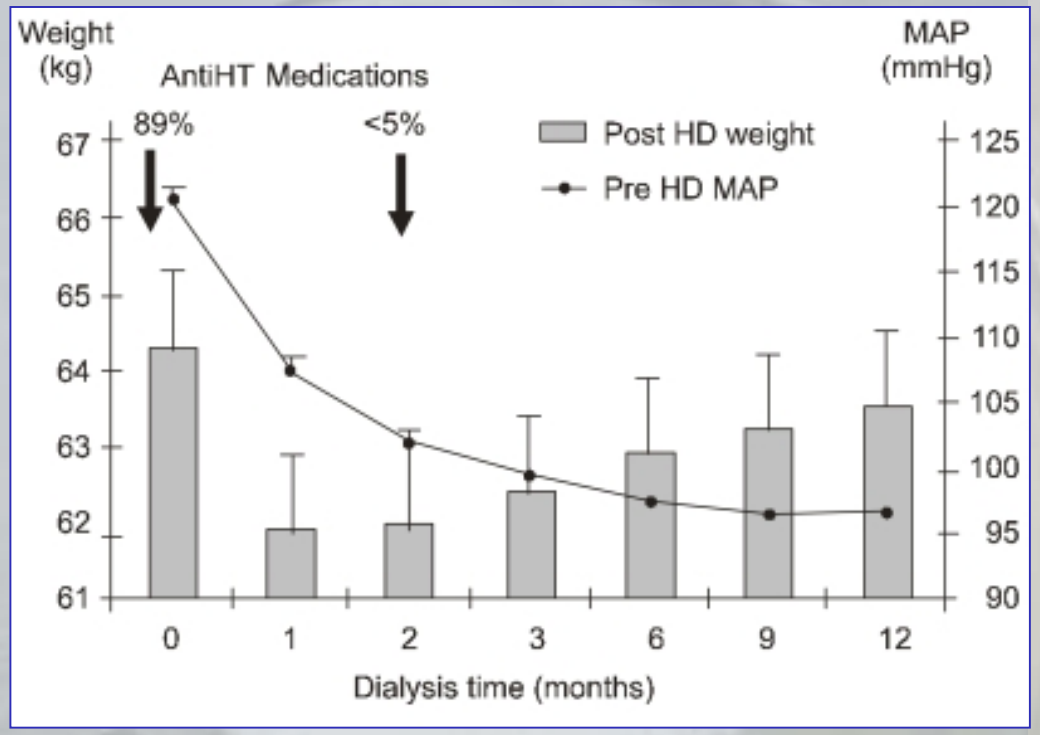
Charra et al, Blood Purif 1994; 12:252.
Charra et al, Hemodial Int. 2007 Jan; 11(1):21-31.

The Tassin experiment

Long dialysis, sodium restriction and aggressive ultrafiltration

The good thing:
good survival
excellent blood-pressure control

The bad thing:
early loss of residual renal function



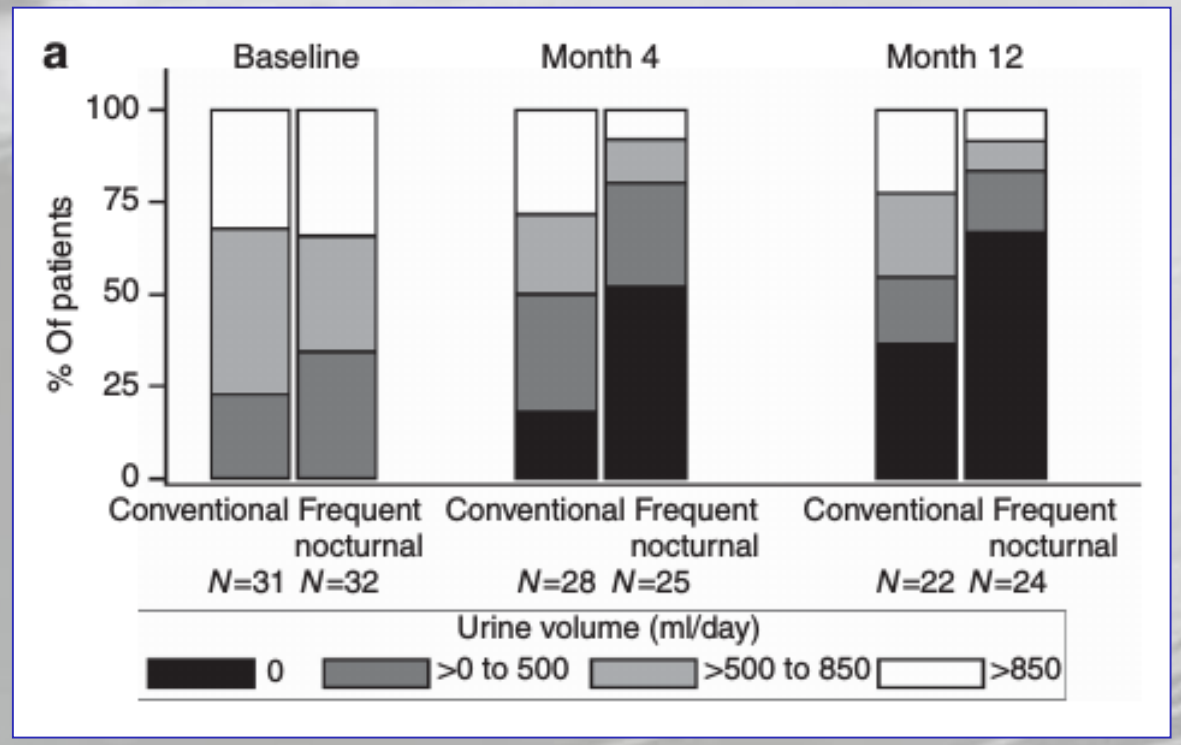
Charra et al, Blood Purif 1994; 12:252.
Charra et al, Hemodial Int. 2007 Jan; 11(1):21-31.

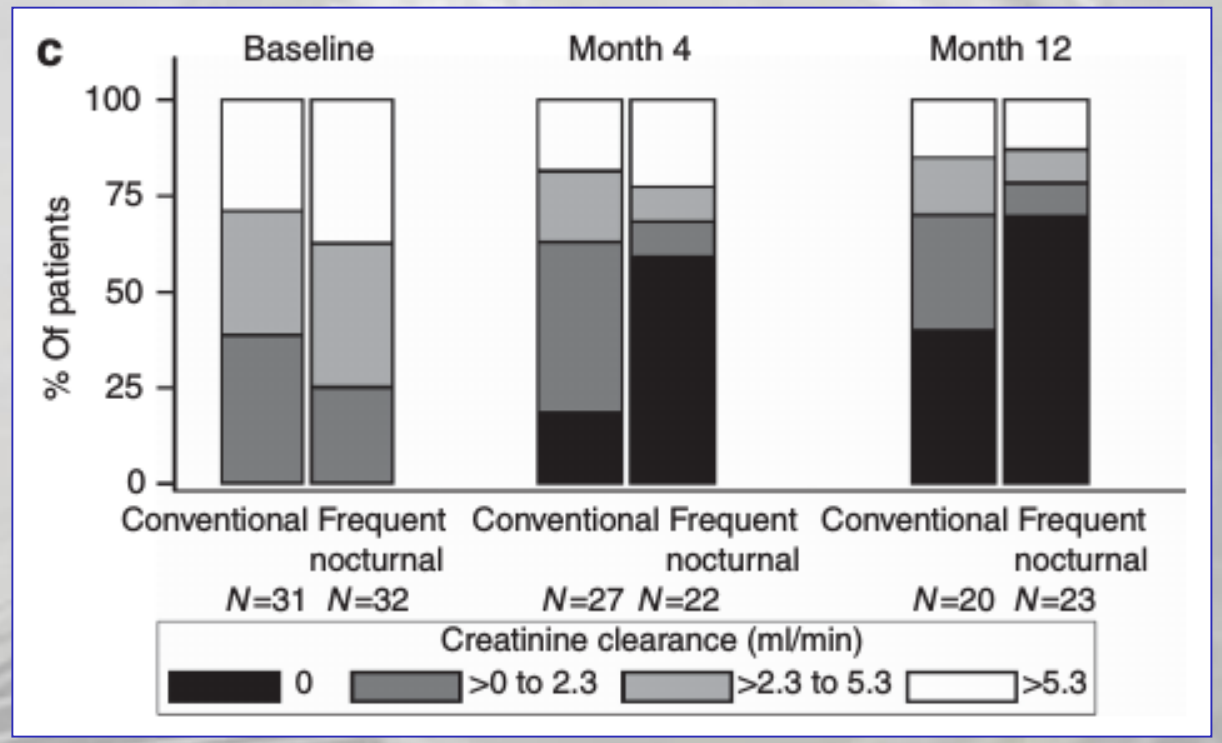
Residual renal function and high dose HD

Patients on daily, nocturnal HD have the greatest survival (and best quality of life) among patients on dialysis

long dialysis sessions - low ultrafiltration rate

The effect of frequent nocturnal vs standard hemodialysis on residual renal function

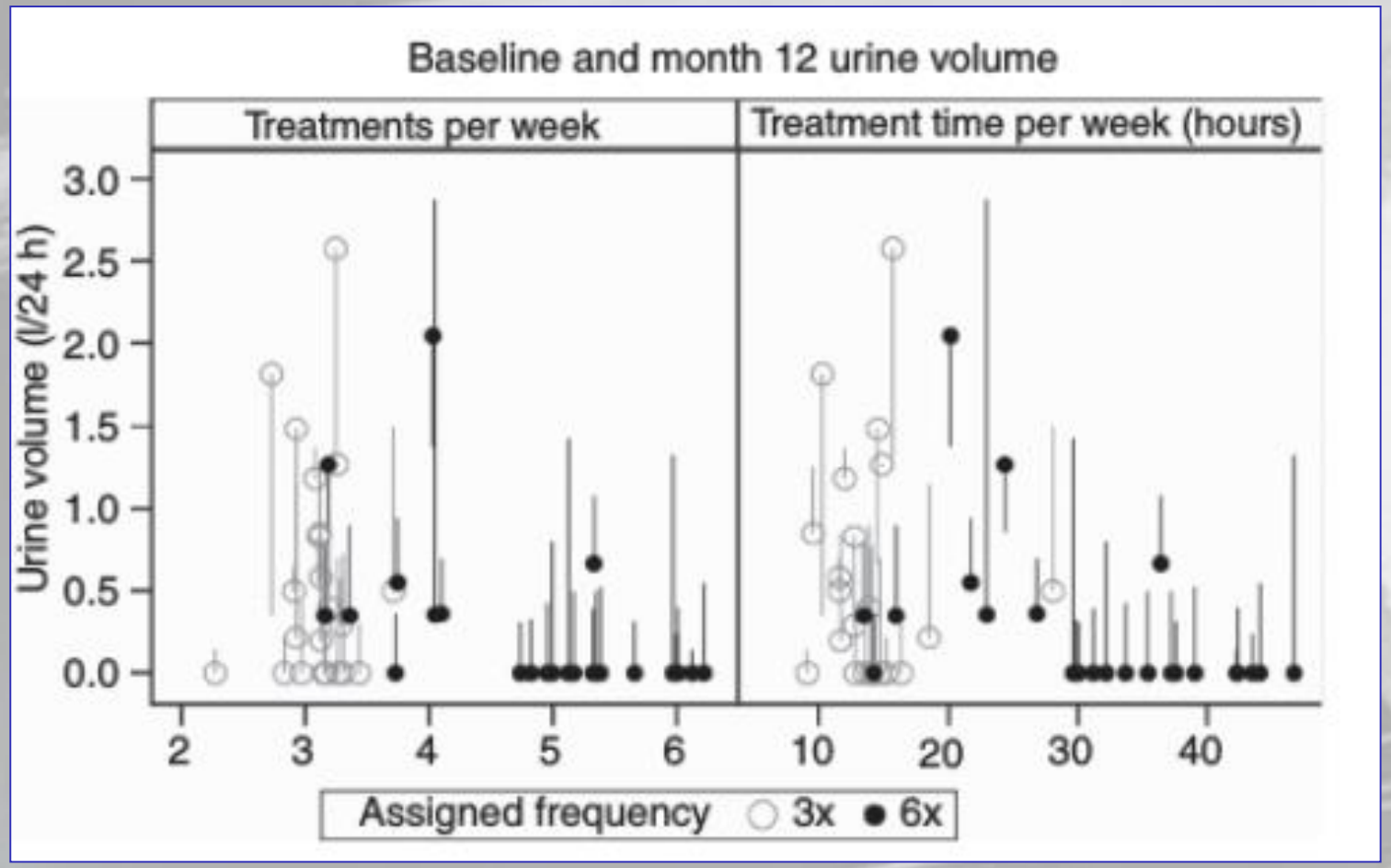




Daugirdas et al, Kidney Int (2013) 83, 949–958

Residual renal function and high dose HD

Loss renal function despite lower ultrafiltration rate with slow, nocturnal treatments.



The effect of frequent nocturnal vs standard hemodialysis on urine output

All but one patient in the daily nocturnal dialysis goup lost all residual kidney function by month 12

Daugirdas et al, Kidney Int (2013) 83, 949–958

How does HD accelerate loss of renal function?

Ultrafiltration

frequent, asymptomatic BP drops during HD
vasoconstriction, tissue hypoperfusion
stunned myocardium after HD

Increased inflammation and oxidative stress

leukocyte and platelet activation,
hsCRP and several markers of oxidative stress increase during each HD session
(+ loss of antioxidant agents)
→ accelerated renal interstitial fibrosis

Aggressive solute / UREA removal

possibly leading to lower renal plasma flow, less osmotic drive for diuresis

Other factors - ??

Doing less ... is more !

For patient starting hemodialysis with *"sufficient"* kidney function.

Less intensive hemodialysis

?

Preserved residual renal function

?

Improved survival

Incremental Hemodialysis

Tailoring hemodialysis parameters to the patient's renal function

=

lower hemodialysis dose until patient has renal function

+

all possible measures to preserve residual renal function

Incremental / less frequent Hemodialysis

In the developing world & India, many patients receive once or twice weekly HD due to logistcal and financial issues.

Outcomes with Incremental / less frequent HD

Observational cohorts, most retrospective, very heterogenous, different criteria and indications for less frequent HD.

authors (year of publication)	cohort (n)	survival: 2x (*1x) vs 3x weekly HD
Hanson (1999)	incident (4888), prevalent (10179)	better survival
Vilar (2009)	incident (650)	better survival
Stankuviene (2010)	incident (2428)	* higher mortality
Lin (2012)	incident (639), prevalent (673)	*similar survival*
Elamin (2012)	prevalent (2012)	higher 1 year mortality
Fernandez-Lucas (2012)	incident (95)	better survival
Fernandez-Lucas (2014)	incident (134)	*similar survival*
Obi (2016)	incident (23645)	better survival
Obi (2016)	incident (6538)	better survival
Mathew (2016)	incident (50756)	*similar survival*
Hwang (2016)	prevalent (685)	higher mortality
Park (2017)	incident (927)	*similar survival*
Yan (2018)	prevalent (1265)	*similar survival*

based on: Basile et al, J Nephrol. 2017;30(4):521.

Outcomes with Incremental / less frequent HD
inferior

Elamin et al (2012)

1011 prevalent HD patients in Sudan,

2x weekly HD: 74.8% ! - *indication / reason not clear*

1 year survival: 2x weekly HD: 85%, 3x weekly HD: 89%

mortality risk factors:

- <u>not documented dialysis adequacy</u>
- poor functional capacity
- lack of AV fistula
- age > 65 years
- cardiovascular disease
- hgb < 100g/l

Elamin et al, Arab J Nephrol Transplant 5:81–86

Outcomes with Incremental / less frequent HD
inferior

Hwang et al (2016)

Multicenter cohort in Korea, 3 years follow-up, retrospective analysis

685 patients on hemodialysis for > 3 months, in center HD for 4 hrs

Patient groups: 2x weekly HD with RRF
3x weekly HD with RRF
3x weekly HD without RRF

<u>RRF (residual renal function): urine output > 100ml/day</u>

Hwang et al, Medicine 95(7), February 2016, p e2767

	Twice-Weekly HD With RKF (n = 113)	Thrice-Weekly HD With RKF (n = 137)	Thrice-Weekly HD Without RKF (n = 435)	*P* Value
Age (yr)	61.0 ± 14.2†	59.7 ± 11.6	57.3 ± 13.1	0.01
Male (%)	66 (58.4)	83 (60.6)	219 (50.3)	0.06
Dialysis duration (mo)	20.3 ± 21.3†	25.1 ± 22.0†	55.3 ± 52.9	<0.001
BMI (kg/m^2)	22.0 ± 2.9	22.4 ± 3.2	22.1 ± 3.4	0.66
SBP (mm Hg), predialysis	136.7 ± 21.1†	139.9 ± 21.3†	144.8 ± 21.8	<0.001
DBP (mm Hg), predialysis	74.3 ± 14.1†	75.6 ± 11.0†	79.7 ± 13.5	<0.001
Smoking (%)	41 (36.6)	60 (43.8)	157 (36.4)	0.29
History of CV disease (%)	32 (37.2)	34 (30.9)	89 (34.0)	0.65
ESA use (%)	102 (91.1)	118 (86.1)	339 (78.1)	0.002
Primary renal disease				
Diabetes (%)	52 (46.0)	69 (50.4)	211 (49.4)	0.77
Hypertension (%)	31 (27.4)	30 (21.9)	75 (17.6)	0.06
Glomerulonephritis (%)	19 (16.8)	16 (11.7)	72 (16.9)	0.33
Polycystic kidney disease (%)	1 (0.9)	7 (5.1)	8 (1.9)	0.08
Others (%)	8 (7.1)	7 (5.1)	26 (6.1)	0.81
Unknown (%)	2 (1.8)	8 (5.8)	35 (8.0)	0.05
Davies' comorbidity score				
No (%)	35 (31.5)	111 (26.6)	40 (29.2)	0.23
Intermediate (%)	65 (58.6)	270 (64.7)	92 (67.2)	
Severe (%)	11 (9.9)	36 (8.6)	5 (3.6)	
Dialyzer membrane				
Low flux (%)	85 (75.2)	75 (54.7)	235 (54.0)	< 0.001
High flux (%)	28 (24.8)	62 (45.3)	200 (46.0)	
Vascular access				
AVF (%)	67 (59.3)	110 (80.3)	332 (76.3)	< 0.001
AVG (%)	27 (23.9)	22 (16.1)	70 (16.1)	
Catheter (%)	19 (16.8)	5 (3.6)	33 (7.6)	

AVF = arteriovenous fistula; AVG = arteriovenous graft; BMI = body mass index; CV = cardiovascular; DBP = diastolic blood pressure; ESA = erythropoietin stimulating agent; HD = hemodialysis; RKF = residual kidney function; SBP = systolic blood pressure.
† $P < 0.05$ vs. thrice-weekly HD without RKF.

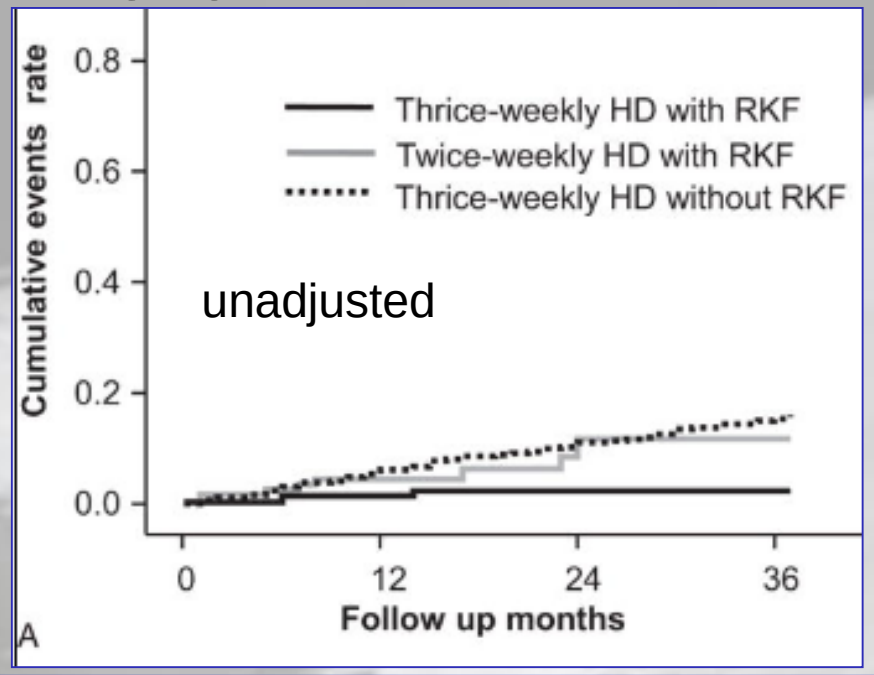
<u>2xHD + RRF (vs 3xHD):</u>

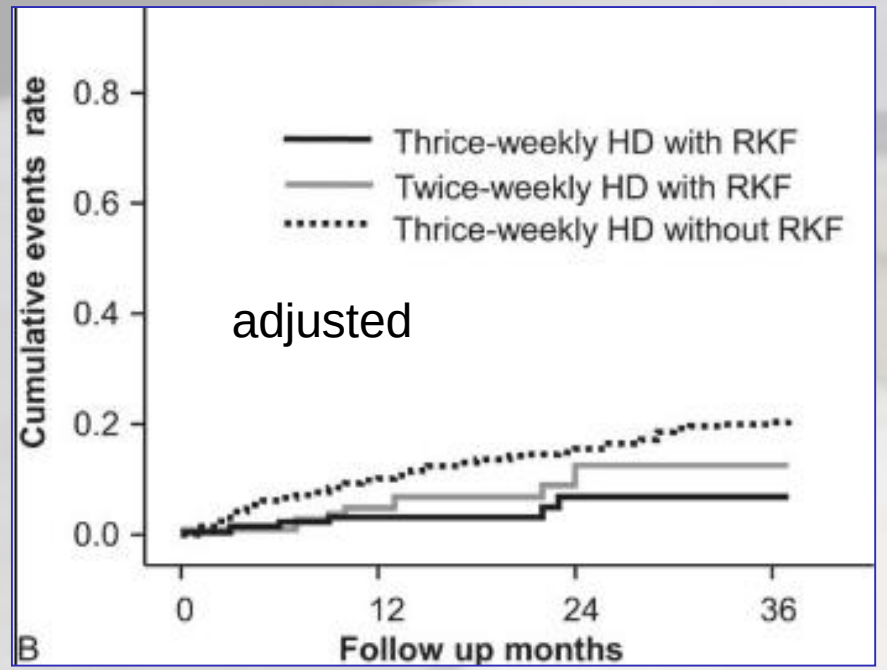
younger
shorter HD vintage
lower SBP
lower ESA dose
lower % of
high-flux membrane
higher % of catheter

Hwang et al, Medicine 95(7), February 2016, p e2767

Outcomes with Incremental / less frequent HD

inferior





RRF > 100ml/d
maybe not enough?

	No. of Events (%)	*P* Value	Unadjusted HR (95% CI)	Adjusted HR (95% CI)
Death from any cause				
Thrice-weekly HD with RKF	3 (2.2)	<0.001	Reference	Reference
Twice-weekly HD with RKF	8 (7.1)		5.03 (1.33, 19.04)	4.20 (1.02, 17.32)
Thrice-weekly HD without RKF	59 (13.6)		6.34 (1.99, 20.22)	5.04 (1.39, 18.33)
Hospitalization for CVE				
Thrice-weekly HD with RKF	6 (4.4)	<0.001	Reference	Reference
Twice-weekly HD with RKF	8 (7.1)		1.62 (0.56, 4.68)	1.44 (0.49, 4.21)
Thrice-weekly HD without RKF	73 (16.8)		2.93 (1.27, 6.78)	2.40 (1.02, 5.68)

CI = confidence interval; CVE = cardiovascular event; HD = hemodialysis; HR = hazard ratio; RKF = residual kidney function.

Hwang et al, Medicine 95(7), February 2016, p e2767

Outcomes with Incremental Hemodialysis

prospective cohort, 2006-2011, Spain

95 incident HD patient

Incremental HD (2x weekly): 41 patients (43%)

- if eGFR > 2.5ml/min and asymptomatic
  + 80mg furosemid daily
- eGFR (urea clearence) measured every 2 months
- switched to conventional HD if eGFR < 2.5ml/min

Conventional HD (3x weekly): 54 patients (57%)

- if eGFR < 2.5ml/min or symptomatic heart failure or severe hypertension

Fernández-Lucas et al, Nefrologia 2012;32(6):767-76

Outcomes with Incremental Hemodialysis

Table 1. Data from the start of dialysis

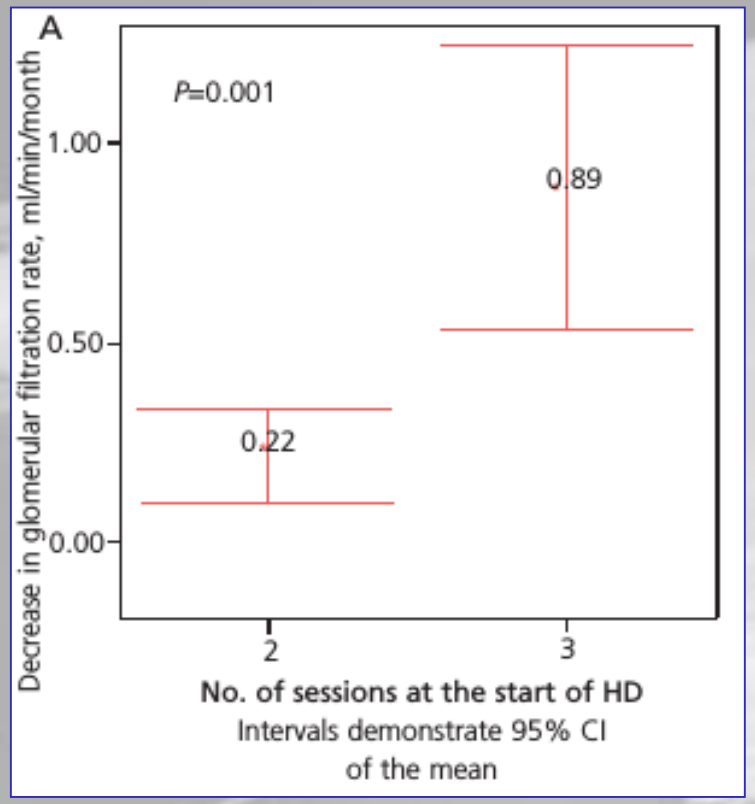
Variable	2 HD/week (n = 41)	3 HD/week (n = 54)	*P*
Predialysis (n=77)	38 (49 %)	39 (51 %)	0.024
Kidney transplant (n=18)	3 (16 %)	15 (84 %)	
Age	62±13	63±13	0.65
Female/male	15/26	14/40	0.26
Baseline diuresis (ml/24 h)	2113±1022	1177±676	0.000
Baseline glomerular filtration rate (ml/min)	6±1.8	4.6± 2	0.002
Charlson index	5.4±2.3	6.6±2.4	0.017
Programmed start; n (%)	27(65 %)	27 (50 %)	0.12
Nephropathy; n (%)			0. 431
Unknown	4 (9.7)	8 (14.8)	
Nephroangiosclerosis	6 (14.6)	10 (18.5)	
Interstitial	7 (17.1)	9 (16.7)	
Diabetes	7 (17.1)	12 (22.2)	
Glomerular	8 (19.5)	5 (9.3)	
PKD	5 (12.2)	3 (5.5)	
Other	4 (9.7)	7 (13)	

2 HD/week: two haemodialysis sessions per week; 3 HD/week: three haemodialysis sessions per week; PKD: polycystic kidney disease.

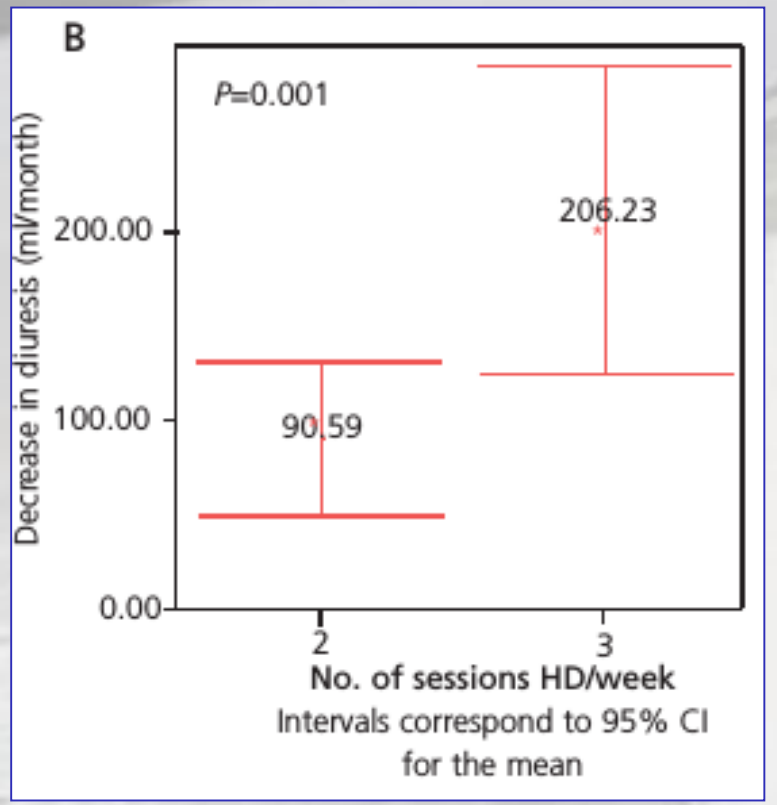
Fernández-Lucas et al, Nefrologia 2012;32(6):767-76

Outcomes with Incremental Hemodialysis

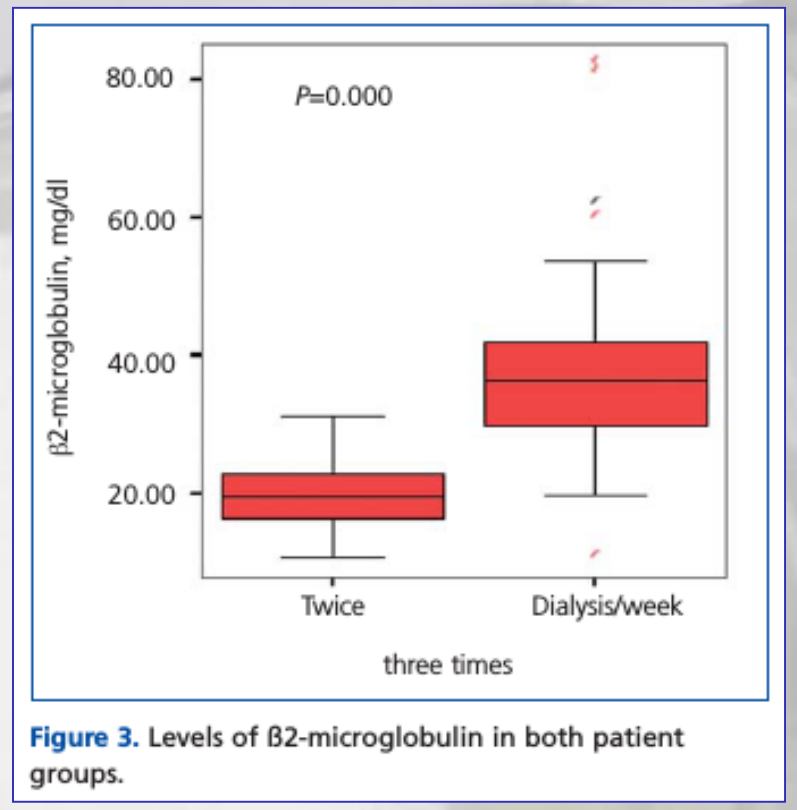
changes after 5 years



preservation of GFR



preservation of urine output



greater clearence of β2-MG

Fernández-Lucas et al, Nefrologia 2012;32(6):767-76

Outcomes with Incremental Hemodialysis

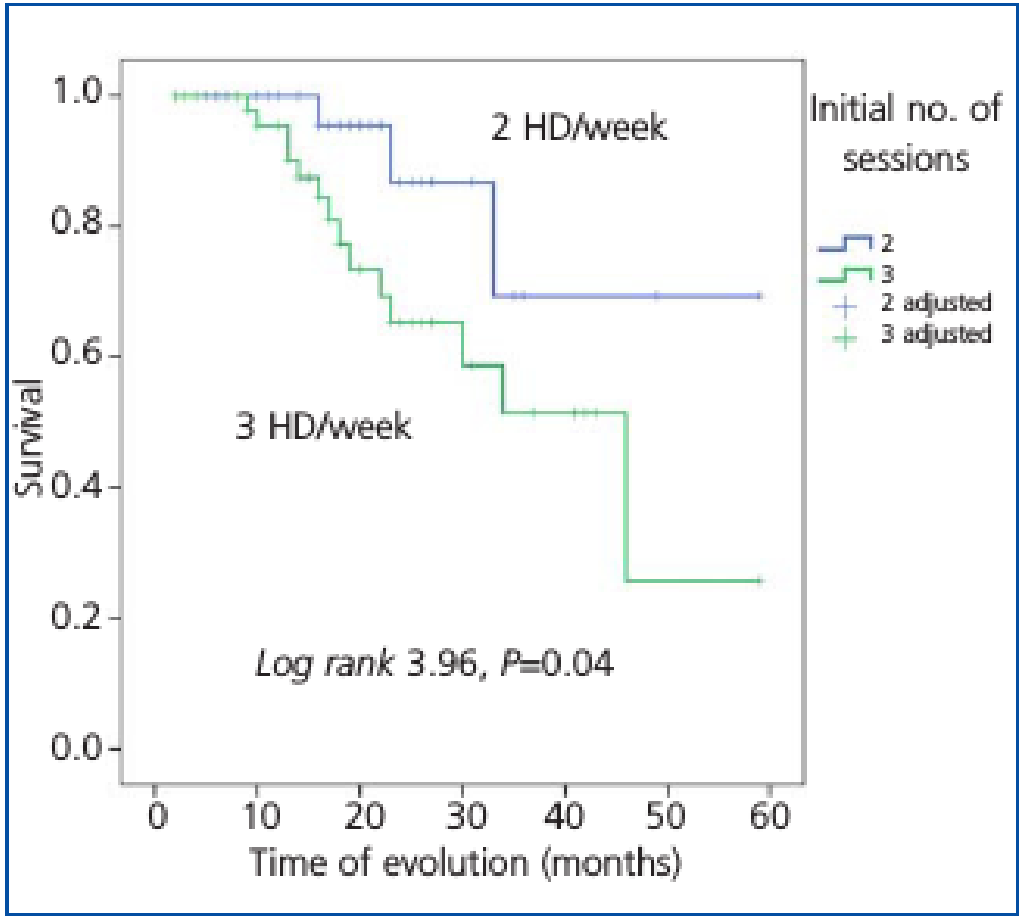


Figure 1. Actuarial survival in both patient groups.
2 HD/week: two haemodialysis sessions per week; 3 HD/week: three haemodialysis sessions per week.

greater survival

Fernández-Lucas et al, Nefrologia 2012;32(6):767-76

Outcomes with Incremental Hemodialysis

prospective cohort, 2006-2011, Spain

182 incident HD patient, 134 pts included

excluded: previous PD or TX

Incremental HD (2x weekly): 70 patients (52%)

if eGFR > 2.5ml/min and asymptomatic
+ 80mg furosemid daily

eGFR (urea clearence) measured every 2 months until anuric

switched to conventional HD if eGFR < 2.5ml/min

Conventional HD (3x weekly): 64 patients (48%)

if eGFR < 2.5ml/min or symptomatic heart failure or severe hypertension

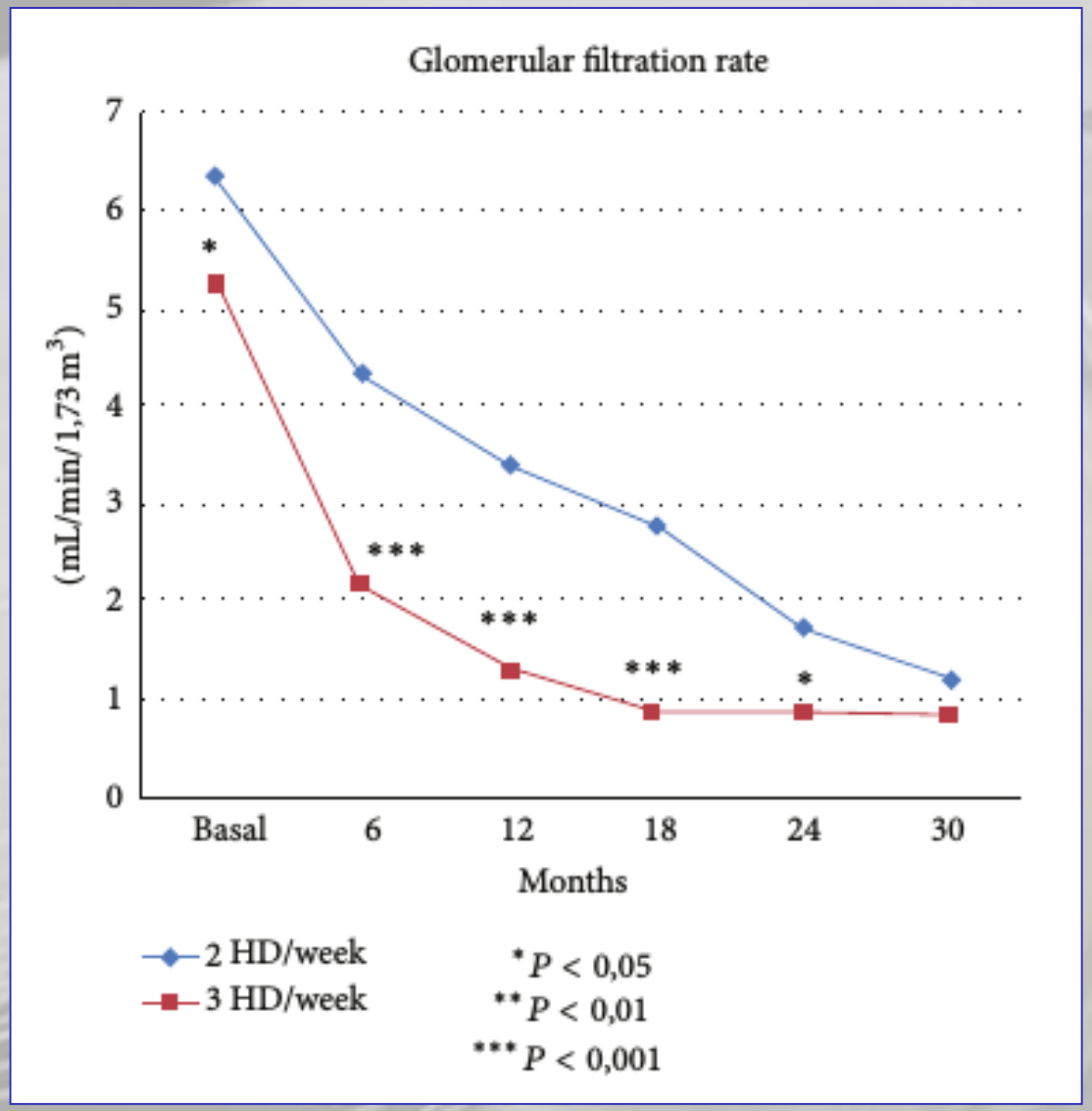
Similar survival

Fernández-Lucas et al, Adv in Nephrol, 2014, ID 236245

Outcomes with Incremental Hemodialysis

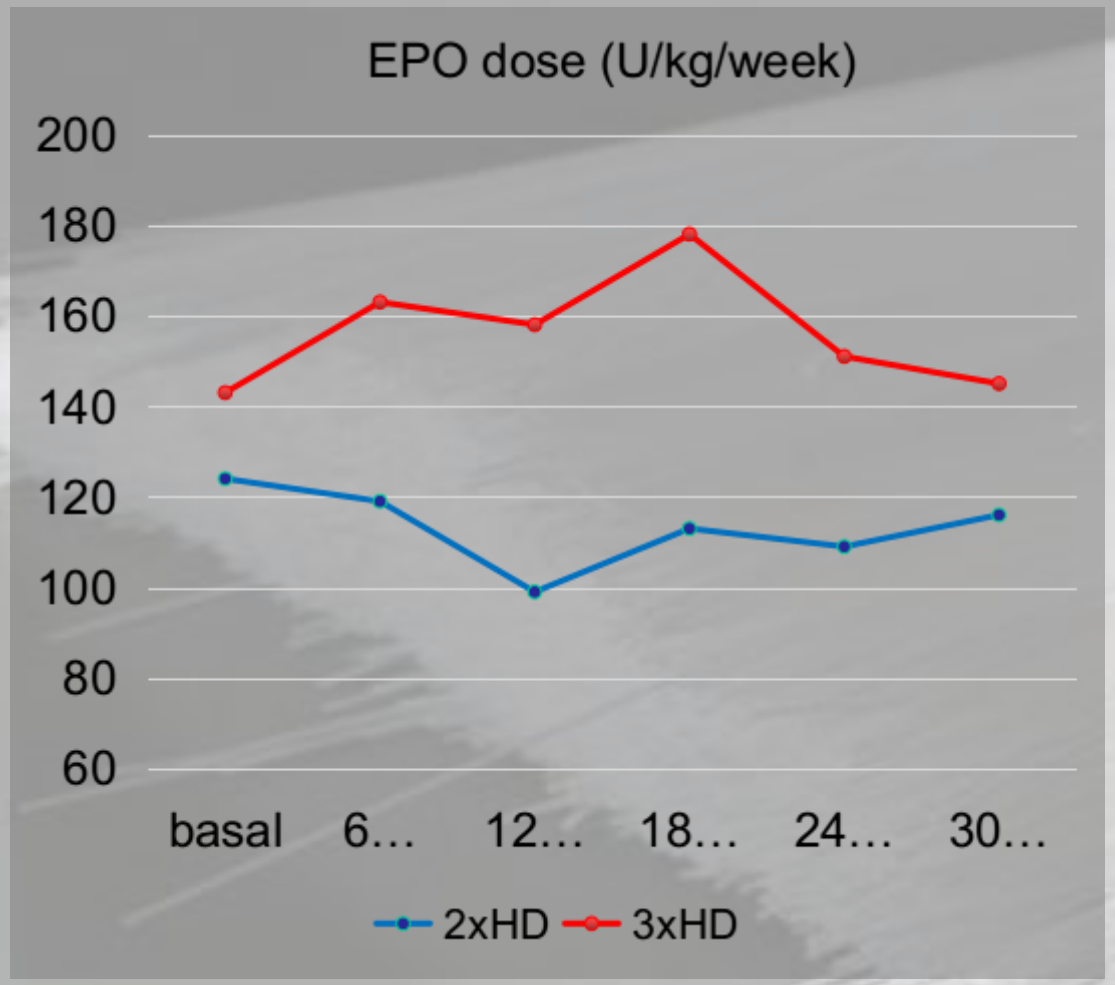
Table 1: Baseline data of the patients.

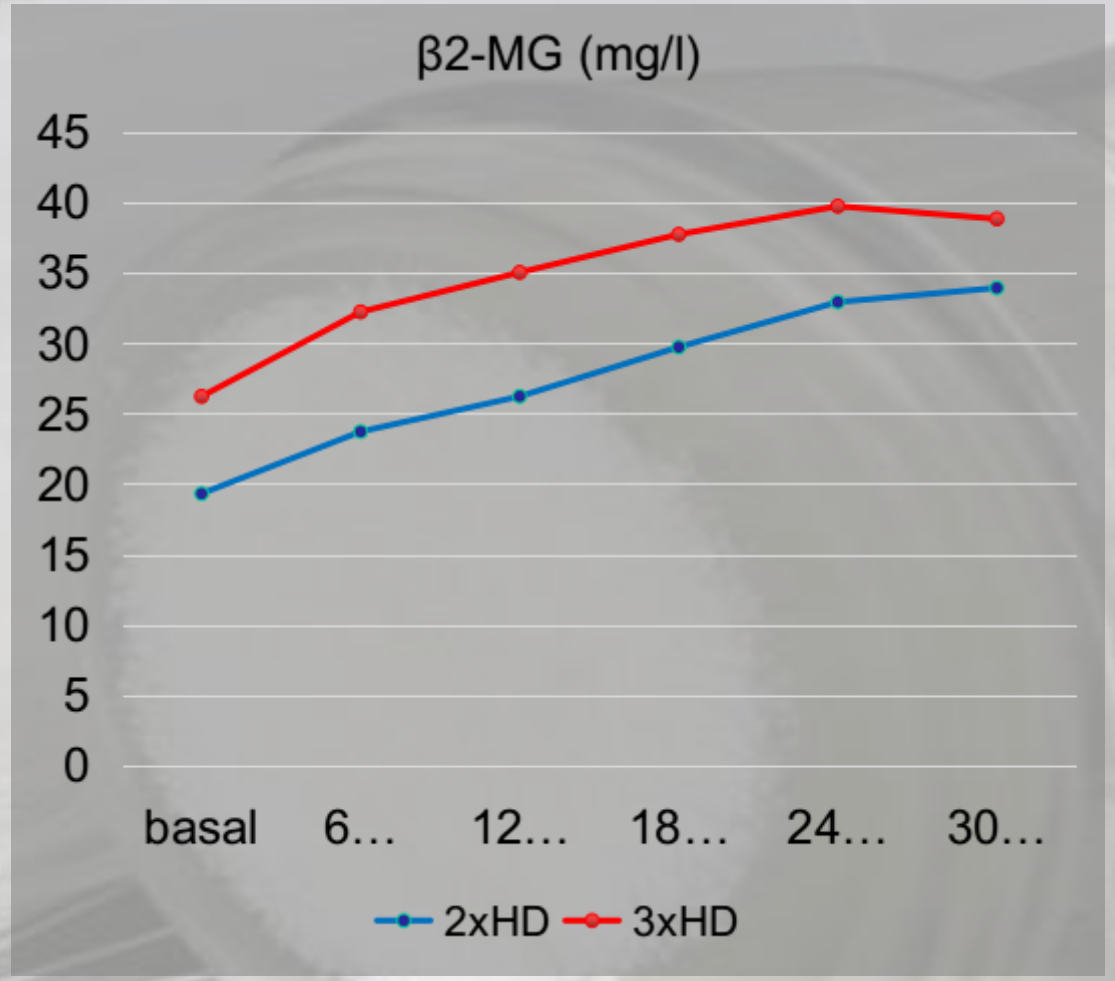
	Group 2 HD/week	Group 3 HD/week	
N	70 (52%)	64 (48%)	
Age (years)	62,2 ± 15,1	62,6 ± 11,9	$P = 0{,}847$
Male gender	49 (70%)	50 (78%)	$P = 0{,}382$
Primary renal diagnosis:			
Glomerulonephritis	12 (17,1%)	8 (12,5%)	
Renal vascular disease	8 (11,4%)	10 (15,6%)	
Interstitial nephropathy	14 (20%)	10 (15,6%)	
Diabetic nephropathy	14 (20%)	13 (20,3%)	$P = 0{,}296$
Polycystic kidney disease	7 (10%)	6 (9,4%)	
Other	10 (14,3%)	10 (15,6%)	
Unknown	5 (7,1%)	7 (10,9%)	
Kidney transplant failure	11 (16%)	15 (23%)	$P = 0{,}362$
Body mass index (kg/m^2)	25,9 ± 5,1	25 ± 4,8	$P = 0{,}294$
Charlson index	6,2 ± 2,7	6,6 ± 2,5	$P = 0{,}362$
Arteriovenous fistula as initial vascular access	41 (59%)	33 (51%)	$P = 0{,}461$
Daily urinary volume (mL)	1618 ± 832	1153 ± 676	$P < 0{,}001$
GFR (mL/min/1,73 m^2)	6,35 ± 2,35	5,22 ± 2,74	$P = 0{,}010$



Fernández-Lucas et al, Adv in Nephrol, 2014, ID 236245

Outcomes with Incremental Hemodialysis





Fernández-Lucas et al, Adv in Nephrol, 2014, ID 236245

Outcomes with Incremental / less frequent HD

Retrospective analysis of a multi-center cohort in South Korea

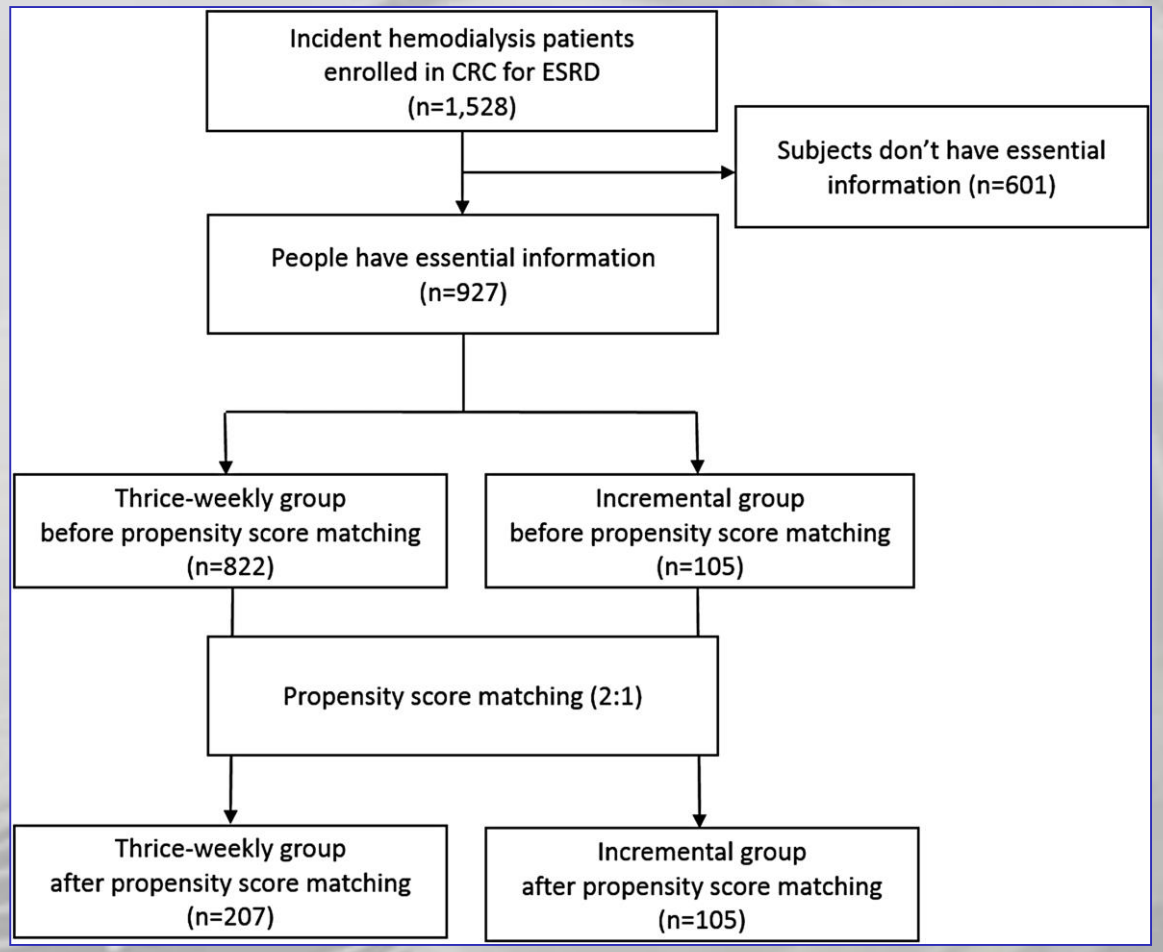
927 incident HD patients

(1-2x weekly: 105, 3x weekly: 822)

after propensity-score matching: 105 and 207

adjusted for: age, gender, primary renal disease, 24h urine volume, albumin, BUN

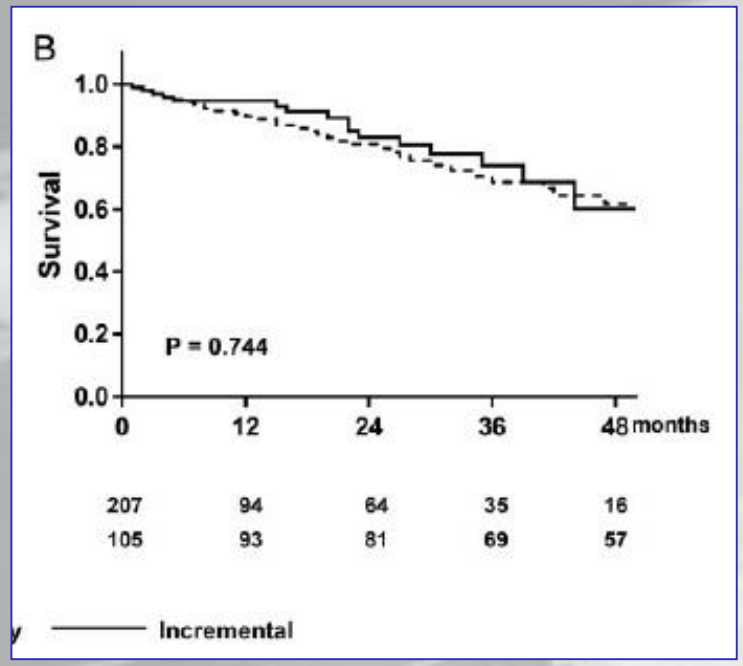
	After PSM		
	Thrice-weekly group ($n = 207$)	Incremental group ($n = 105$)	P-value
24-h urine volume			0.622
<500 mL	48 (23.2)	27 (25.7)	
≥500 mL	159 (76.8)	78 (74.3)	
Single-pool Kt/V	1.4 ± 0.3	1.4 ± 0.3	0.683
Weekly Kt/V	4.0 ± 1.0	2.7 ± 0.6	<0.001
Urea reduction rate (%)	67.5 ± 10.1	68.3 ± 8.0	0.652
UF/session (kg)	1.2 ± 1.0	1.1 ± 1.0	0.501
Weekly UF (kg)	3.6 ± 3.0	1.8 ± 1.8	<0.001
Weekly fluid ingestion (L)	6.8 ± 4.4	6.5 ± 4.5	0.601

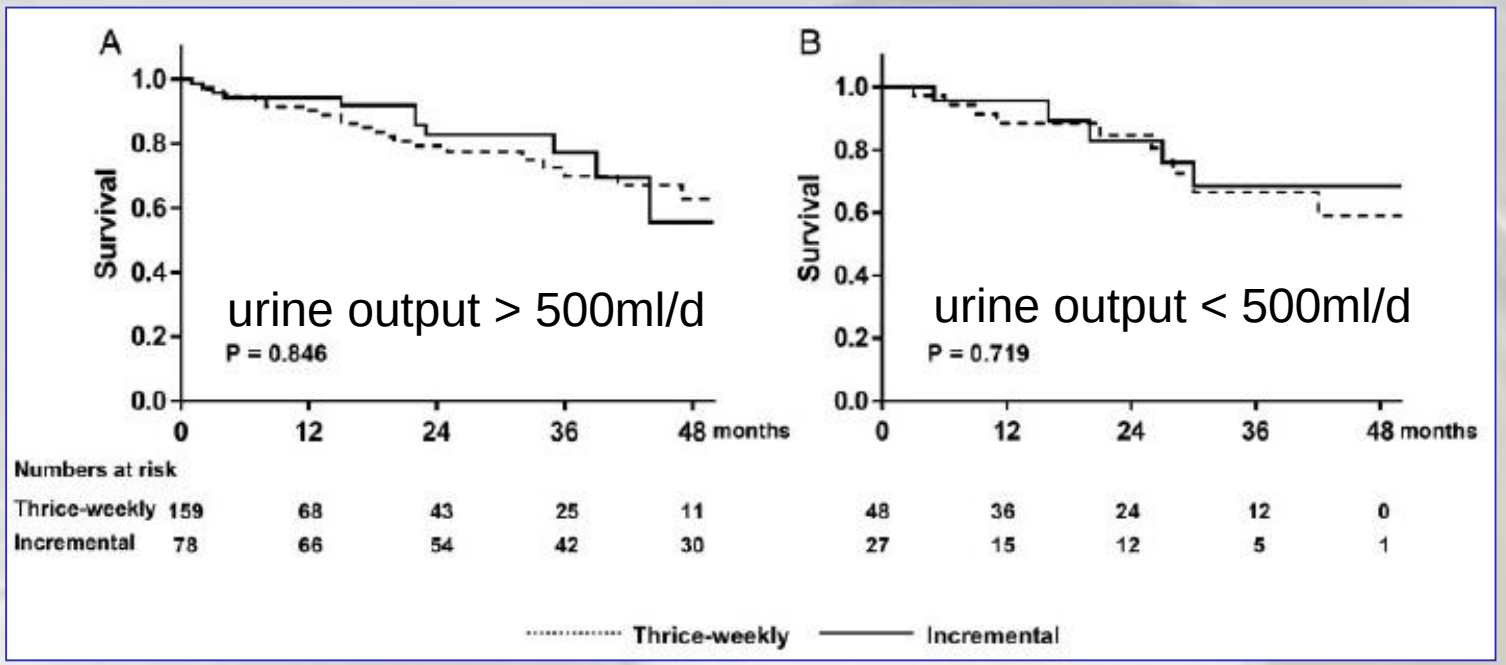


Park et al, Nephrol Dial Transplant. 2017;32(2):355-363.

Outcomes with Incremental / less frequent HD

Survival: similar in incremental and conventional group





<u>Quality of life</u> (SF-36, in the 1st year): similar in all domains

Park et al, Nephrol Dial Transplant. 2017;32(2):355-363.

Patient characteristics on less frequent HD

China DOPPS

	Mean (SD) or %		Odds ratio: 2 sessions per week versus 3	
Patient characteristics	2× per week(n = 304)	3× per week(n = 982)	Unadjusted[a],OR (95% CI	Adjusted[b], OR (95% CI)
Age, years [OR per 10 years]	59.0 (15.2)	59.6 (14.4)	0.95 (0.86–1.05)	1.12 (0.99,1.26)
Female, %	52.0	44.6	1.31 (1.07–1.62)*	1.28 (1.06,1.54)*
Dialysis vintage, years	3.51 (3.54)	5.16 (4.82)	0.91 (0.86–0.95)*	0.94 (0.90,0.98)*
BMI, kg/m^2	21.6 (3.4)	21.9 (3.6)	0.98 (0.95–1.01)	0.99 (0.96,1.02)
Urine output >200 mL/day, %	52.5	25.1	3.39 (2.33–4.93)*	2.92 (1.92,4.43)*
<12 years education	14.8	8.7	1.48 (1.07–2.04)*	1.55 (1.08,2.21)*
Comorbidities, % [OR – yes versus no]				
Diabetes	16.9	26.1	0.54 (0.39–0.75)*	0.49 (0.34,0.71)*
Hypertension	85.5	90.9	0.51 (0.32–0.81)*	0.51 (0.31,0.83)*

in addition: higher out-of-pocket costs, without national health insurance coverage
lack of capacity was rare and not associated with twice-weekly HD.

Bieber et al, Nephrol Dial Transplant (2014) 29: 1770–1777

Outcomes with Incremental / less frequent HD

China DOPPS - **3 years follow-up**

15 (out of 45) randomly selected dialysis facilities
1265 prevalent patients

Patient groups based on

- Urine output: anuric and non-anuric (urine output > 200ml/day)
- HD frequency: 3x and 2x weekly HD - for whatever reason

2x weekly group:
less insurance coverage
lower frequency of diabetes and coronary artery disease

Yan et al, Kidney Int Rep, 2018; 3(4), 889–896.

Patient characteristics on less frequent HD

China DOPPS - **3 years follow-up**

15 (out of 45) randomly selected dialysis facilities

1265 prevalent patients: anuric and non-anuric (urine output > 200ml/day), 2x vs 3x weekly HD

	Urine output ≥1 cup/day		Urine output <1 cup/day	
Patient characteristics	**2-Times weekly**	**3-Times weekly**	**2-Times weekly**	**3-Times weekly**
Patients, n	123	290	133	719
Demographics				
Age, yr	61.3 (15.6)	58.2 (15.1)	57.7 (15.2)	60.0 (14.7)
Male, %	57%	60%	50%	54%
Time on dialysis, yr	1.70 (1.97)	1.89 (2.44)	3.45 (3.36)	5.38 (4.87)
Time on dialysis <1 yr, %	54%	54%	28%	15%
Insurance coverage <90%	44%	29%	57%	29%
Body mass index, kg/m^2	21.6 (3.0)	22.6 (4.0)	21.0 (3.0)	21.7 (3.7)
Postdialysis weight, kg	58.6 (9.8)	62.0 (12.7)	56.4 (9.9)	59.2 (11.5)
Urine output per day, %[a]				
200–500 ml	35%	60%	—	—
500–1000 ml	48%	29%	—	—
>1000 ml	17%	11%	—	—
Travel time to facility <1 h, %	81%	86%	70%	81%
Facility size (#HEMODIALYSIS pts)	109 (89)	107 (102)	136 (71)	130 (99)
Dialysis prescription				
Standardized dialysis Kt/V	1.38 (0.23)	2.07 (0.27)	1.47 (0.17)	2.12 (0.25)
eKt/V, per session	1.18 (0.35)	1.14 (0.25)	1.30 (0.27)	1.18 (0.25)
Intradialytic weight loss, kg	1.71 (1.11)	2.00 (1.02)	2.61 (1.10)	2.37 (0.83)
Dialysis session length, min	244 (31)	236 (15)	253 (26)	239 (14)
Ultrafiltration rate, ml/h per kg	8.15 (5.55)	8.60 (4.43)	11.8 (4.9)	10.6 (3.7)
Catheter use, %	21%	18%	9%	10%

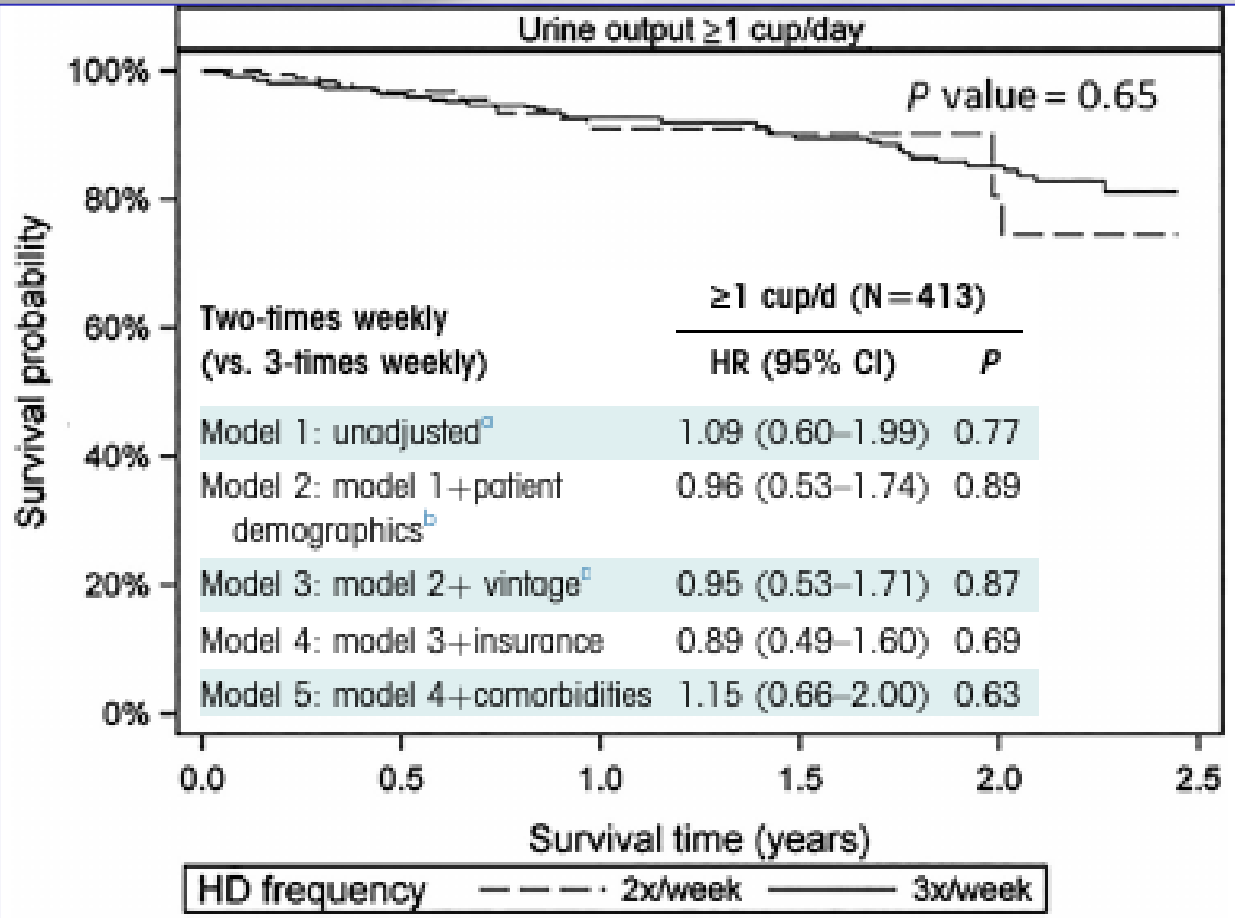
Yan et al, Kidney Int Rep, 2018; 3(4), 889–896.

Outcomes with Incremental / less frequent HD

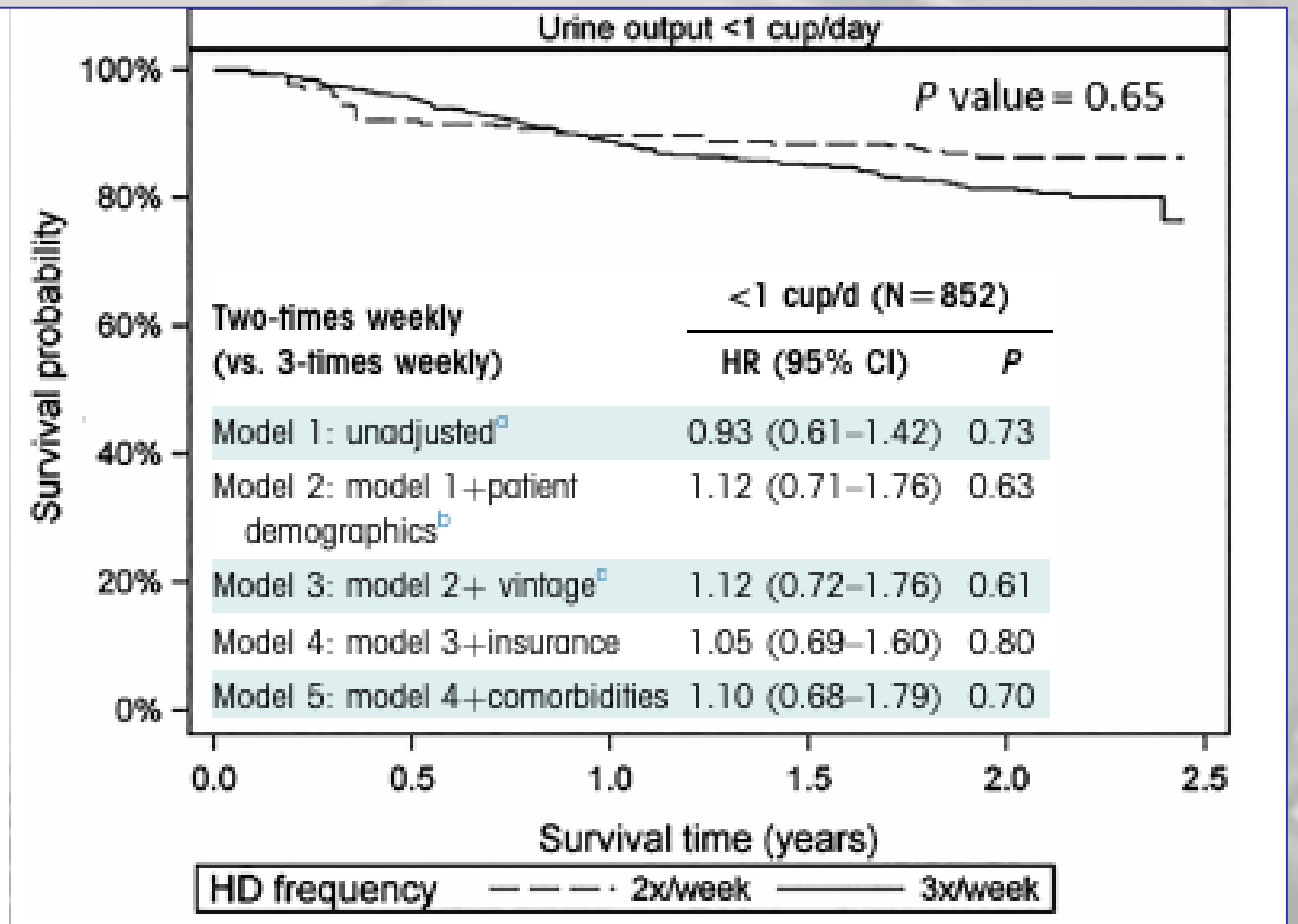
China DOPPS - **3 years follow-up**

Survival: 2x vs 3x weekly HD

Model1: adjusted for propensity score



Two-times weekly (vs. 3-times weekly)	≥1 cup/d (N=413) HR (95% CI)	P
Model 1: unadjusted[a]	1.09 (0.60–1.99)	0.77
Model 2: model 1+patient demographics[b]	0.96 (0.53–1.74)	0.89
Model 3: model 2+ vintage[c]	0.95 (0.53–1.71)	0.87
Model 4: model 3+insurance	0.89 (0.49–1.60)	0.69
Model 5: model 4+comorbidities	1.15 (0.66–2.00)	0.63



Two-times weekly (vs. 3-times weekly)	<1 cup/d (N=852) HR (95% CI)	P
Model 1: unadjusted[a]	0.93 (0.61–1.42)	0.73
Model 2: model 1+patient demographics[b]	1.12 (0.71–1.76)	0.63
Model 3: model 2+ vintage[c]	1.12 (0.72–1.76)	0.61
Model 4: model 3+insurance	1.05 (0.69–1.60)	0.80
Model 5: model 4+comorbidities	1.10 (0.68–1.79)	0.70

Yan et al, Kidney Int Rep, 2018; 3(4), 889–896.

Outcomes with Incremental Hemodialysis

retrospective 5 year cohort of incident HD patients in the USA (n=87718)

- 682 incremental HD start (< 3x weekly)
  older, non-Hispanic white, less co-morbidity
- conventional HD (3x weekly)
- 201 frequent HD (>3 weekly)
  younger, male, more likely catheter as access, higher comorbidity

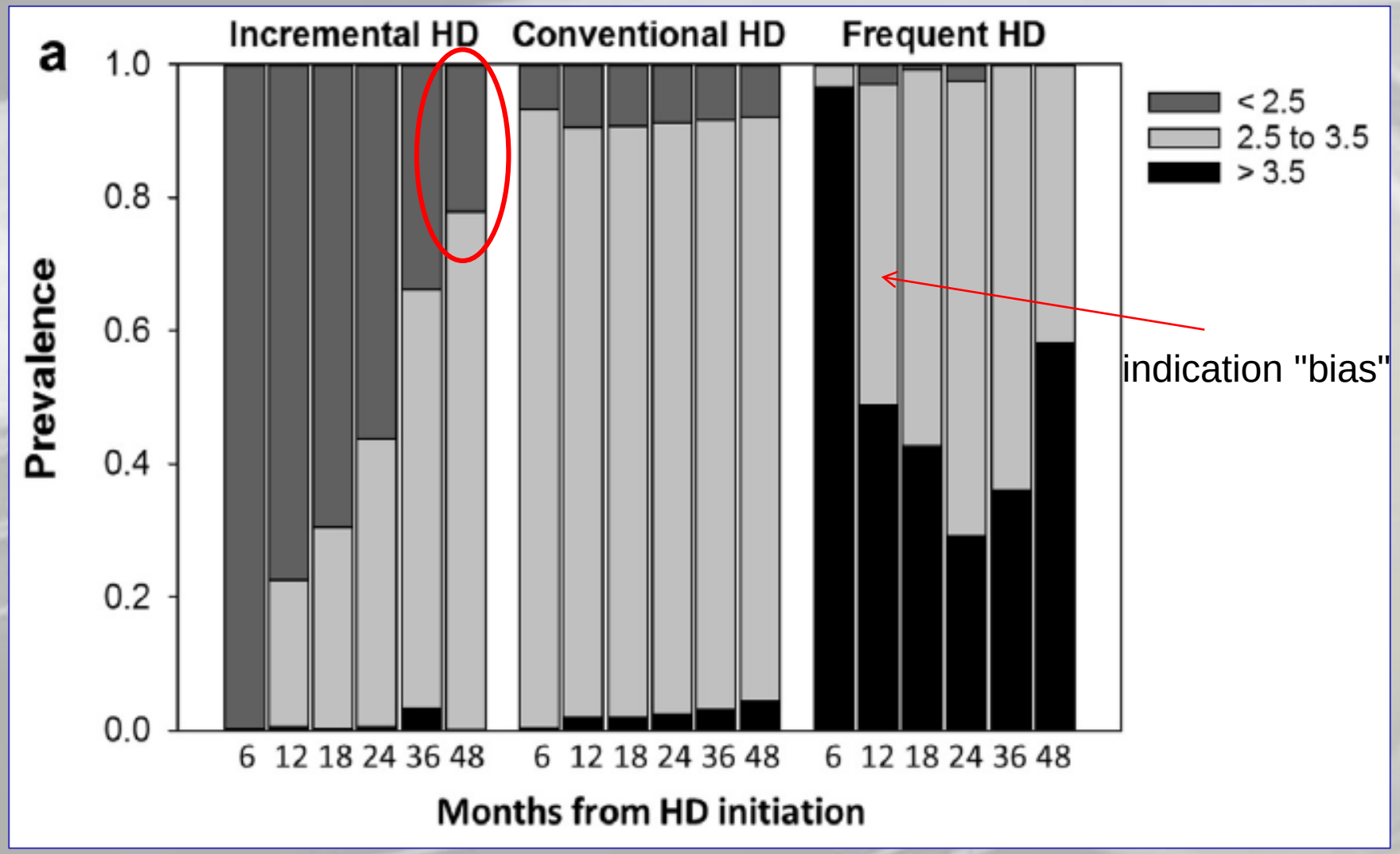
matched cohorts (age, gender, race, ethnicity, comorbidity index, access)

	frequent	conventional	incremental
n	160	50612	434
fluid overload (prevalence)	64%	6%	
weekly interdialytic weight gain (%)	9.5%	7.7%	5.8%
BMI (kg/m^2)	30.6	26.8	
renal urea clearence (ml/min)	1.9	3.1	5.4
creatinine (mg/dl / umol/l)		5.9 / 522	4.4 / 389
phosphorous (mg/dl / mmol/l)		5.0 / 1.62	4.3 / 1.39

Methew et al, Kidney Int 2016; 90: 1071-1079

Transitions between frequency groups

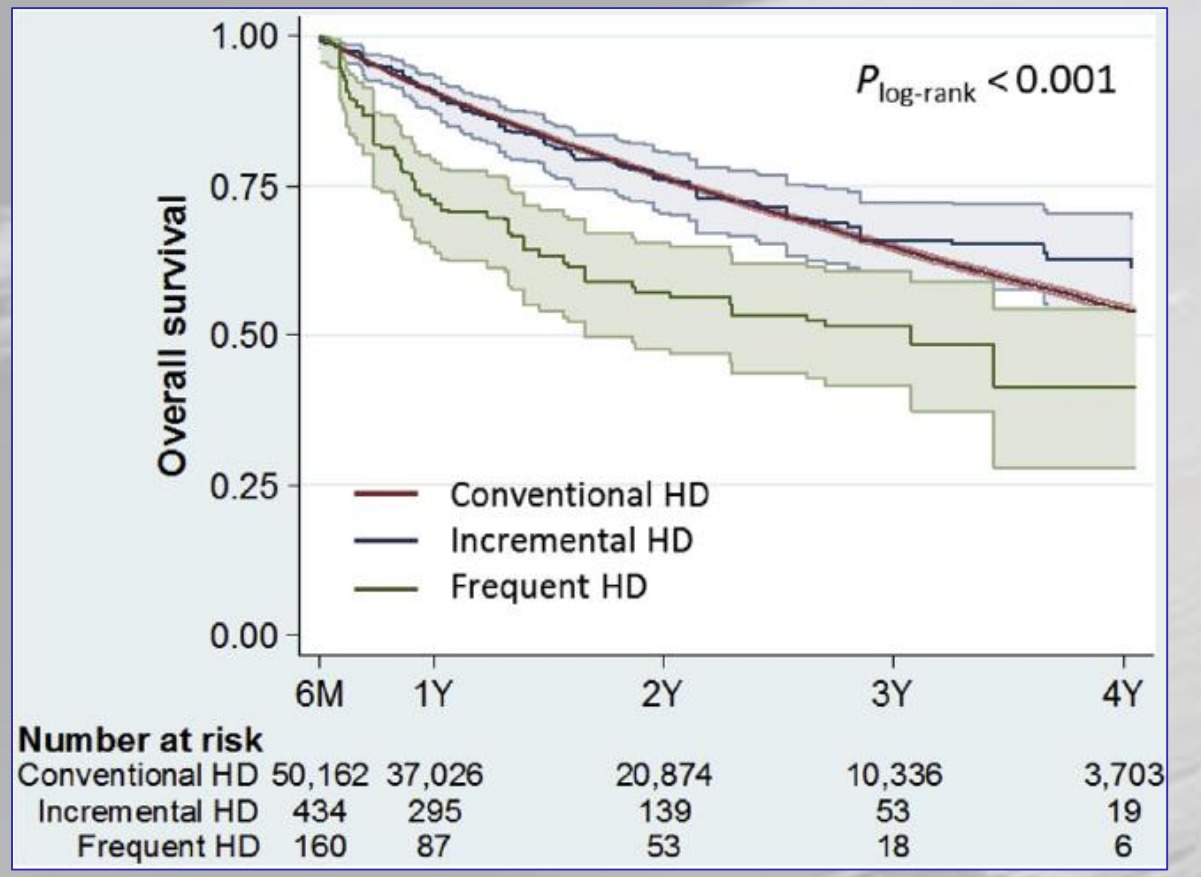
After 4 years, 20% of patients who started incremental HD were still on 2x weekly HD

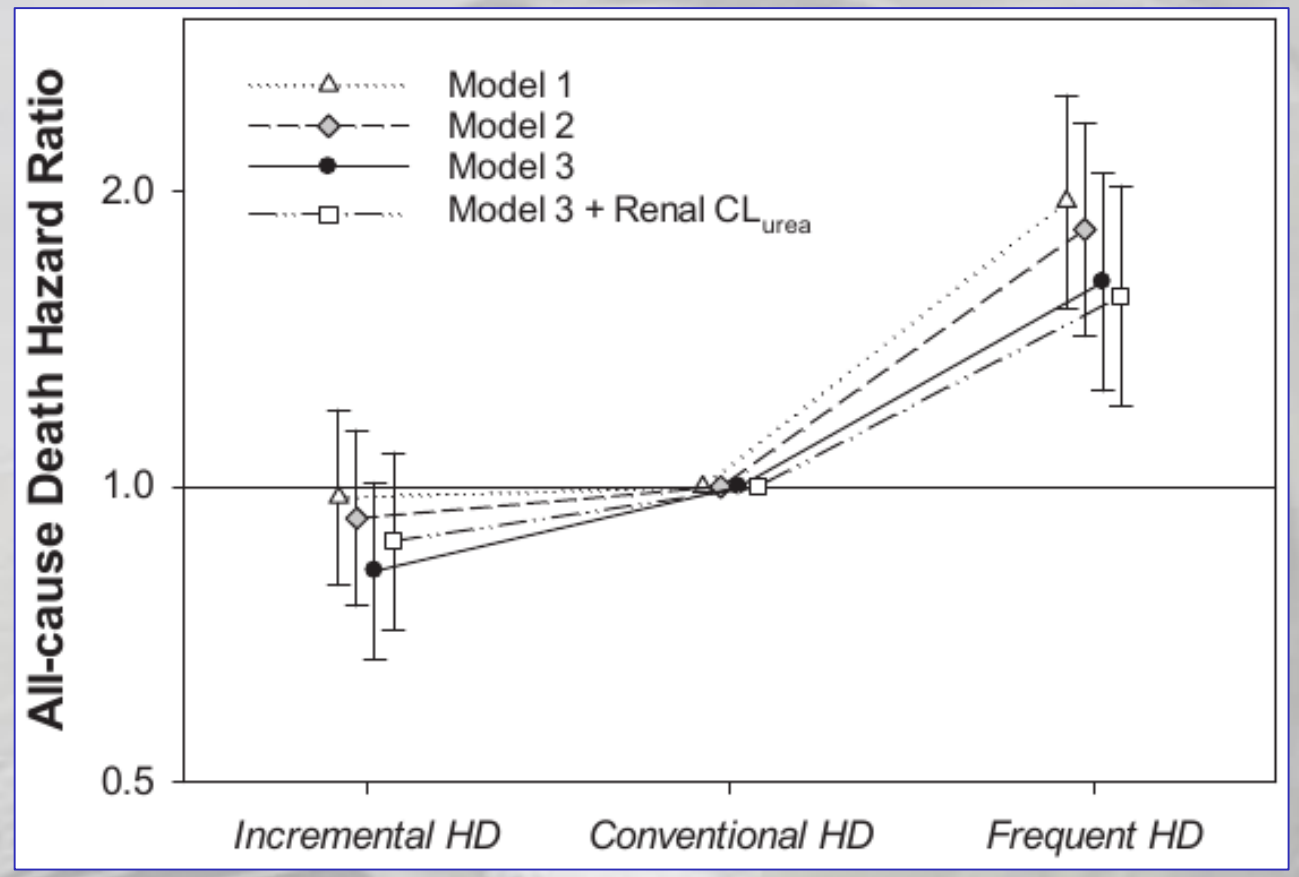


Methew et al, Kidney Int 2016; 90: 1071-1079

Outcomes with Incremental Hemodialysis

Patients who required more frequent HD had worse survival





Methew et al, Kidney Int 2016; 90: 1071-1079

Outcomes with Incremental Hemodialysis

retrospective analysis of DaVita database (n=23645)
incident patients included who survived 1 year on HD

- 2x weekly HD: 351 patients
- 3x weekly HD: 23294 patients

analysis: matched cohorts based on baseline urea clearence, urine volume, age, gender, race, vascular access, diabetes

Obi et al, AJKD 2016

Outcomes with Incremental Hemodialysis

Proportion of patients with adequate urea clearence (Kt/V > 2.1)

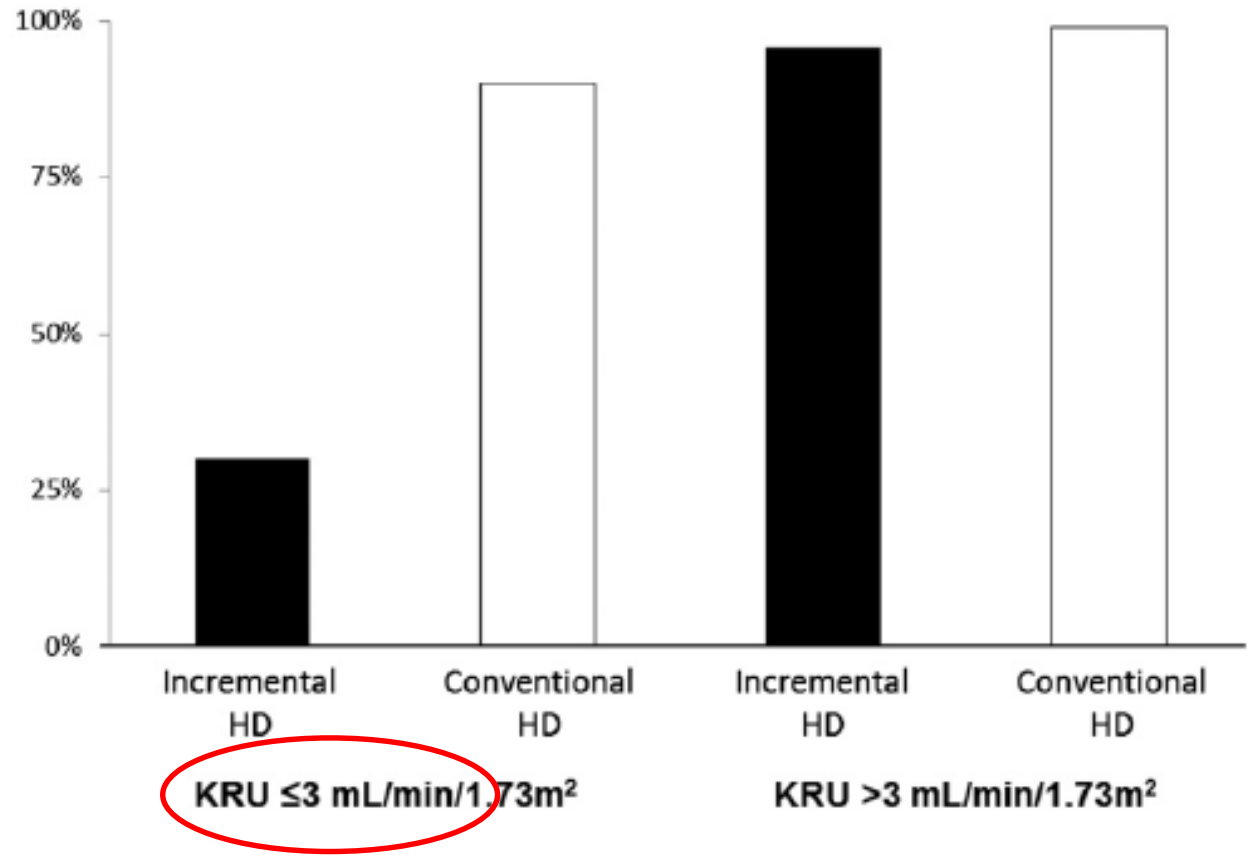
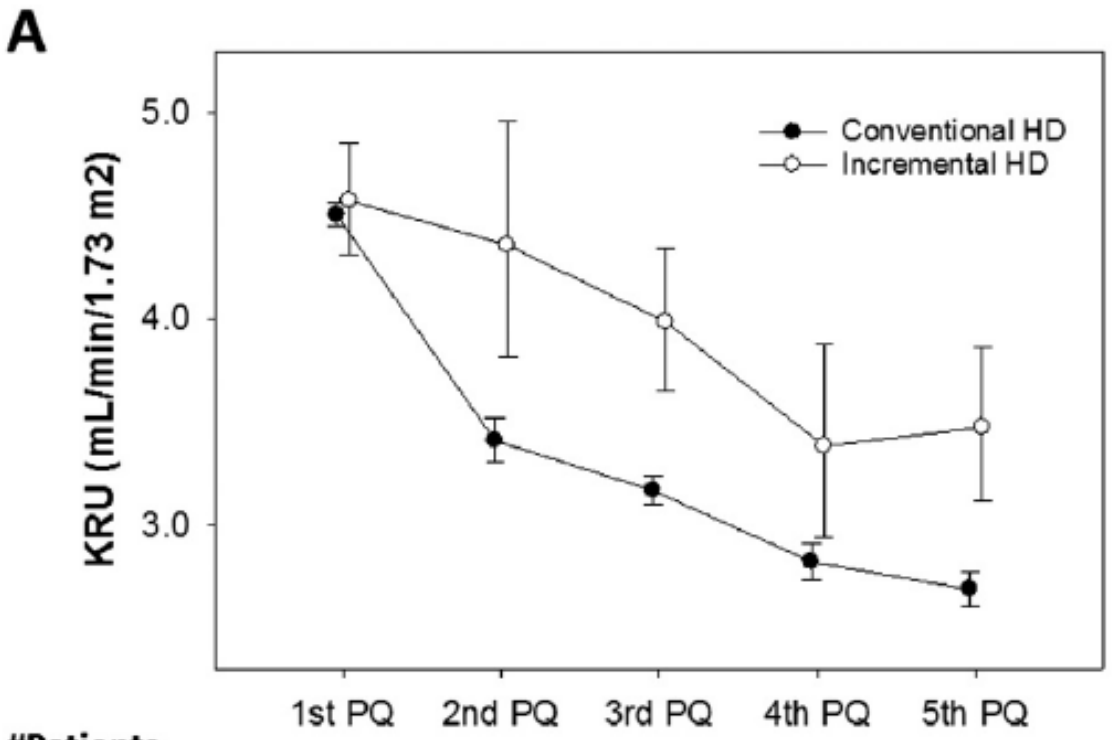


Figure 1. Achievement rate of the minimum total standard Kt/V > 2.1 among patients with the incremental and conventional hemodialysis (HD), stratified by renal urea clearance (KRU).

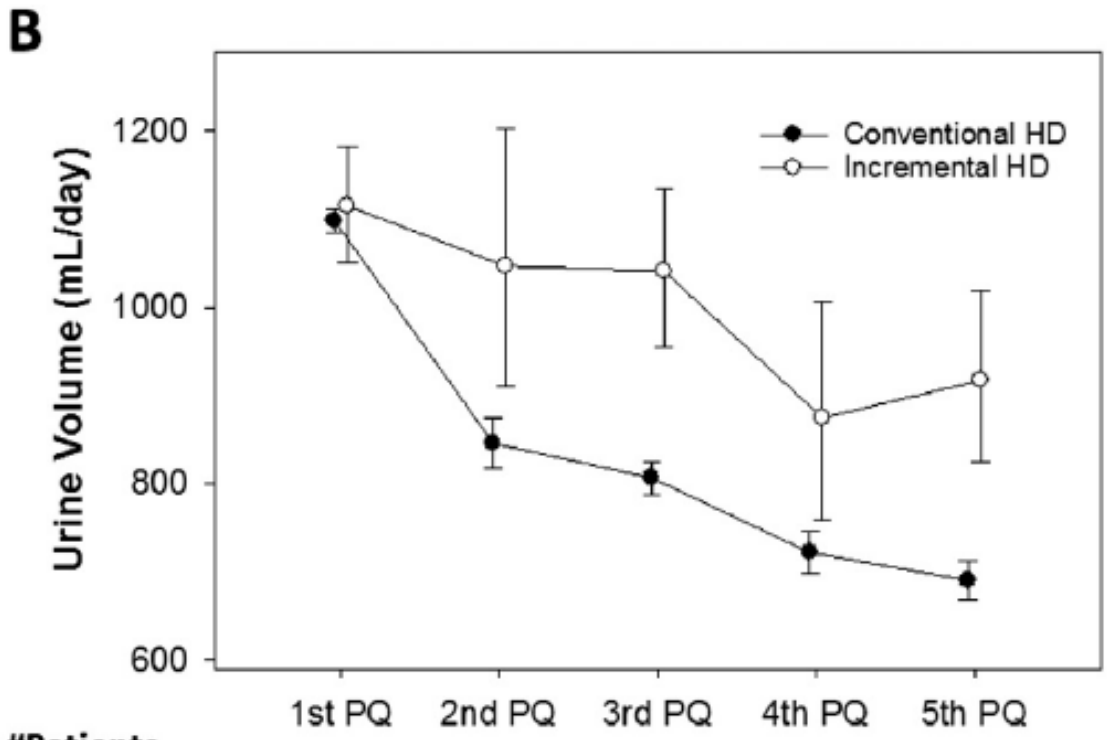
Obi et al, AJKD 2016

Outcomes with Incremental Hemodialysis

Changes in urea clearence and urine volume



#Patients	1st PQ	2nd PQ	3rd PQ	4th PQ	5th PQ
Conventional HD	8,068	1,934	4,292	2,499	2,792
Incremental HD	351	84	222	104	146



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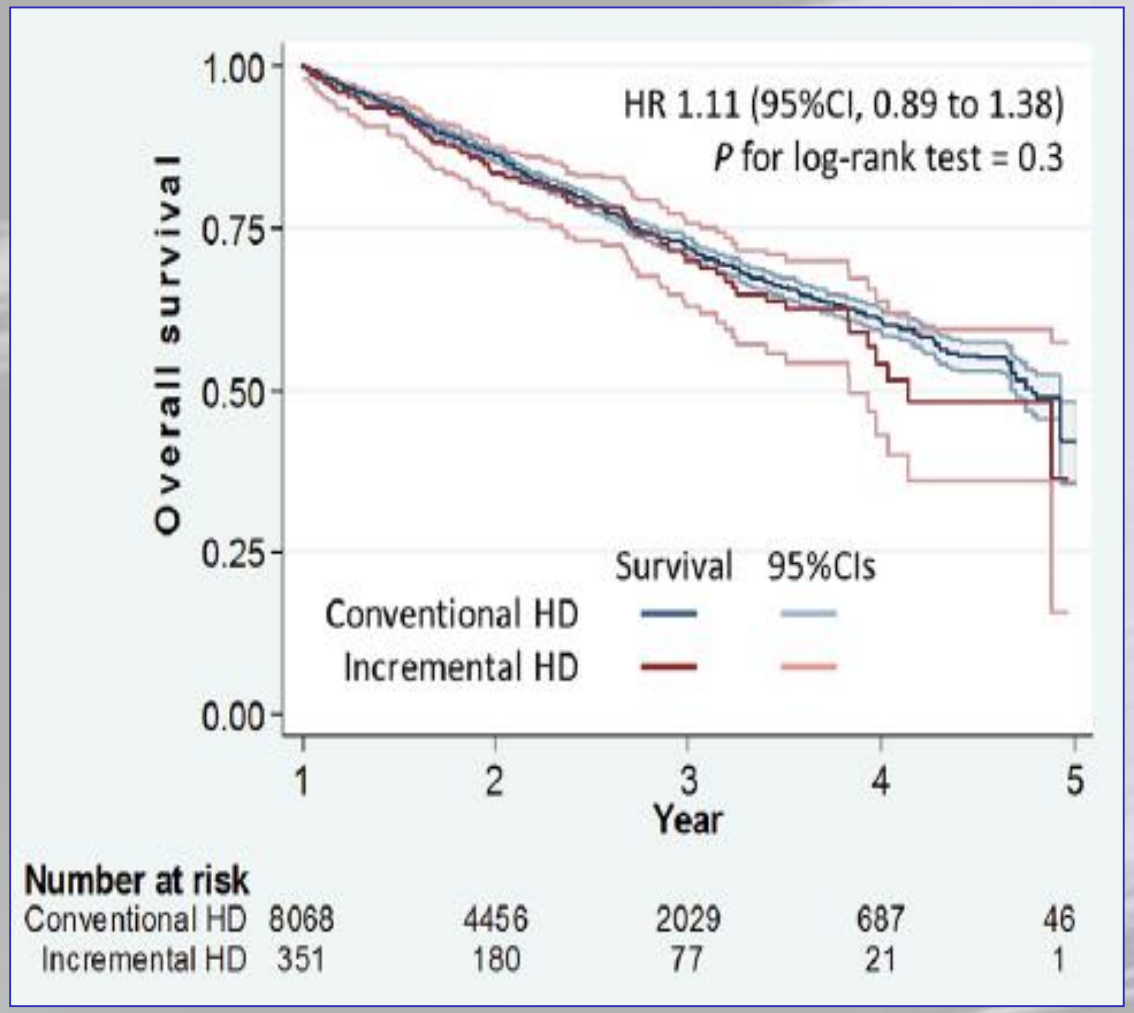
Conventional HD	8,068	1,934	4,292	2,499	2,792
Incremental HD	351	84	222	104	146

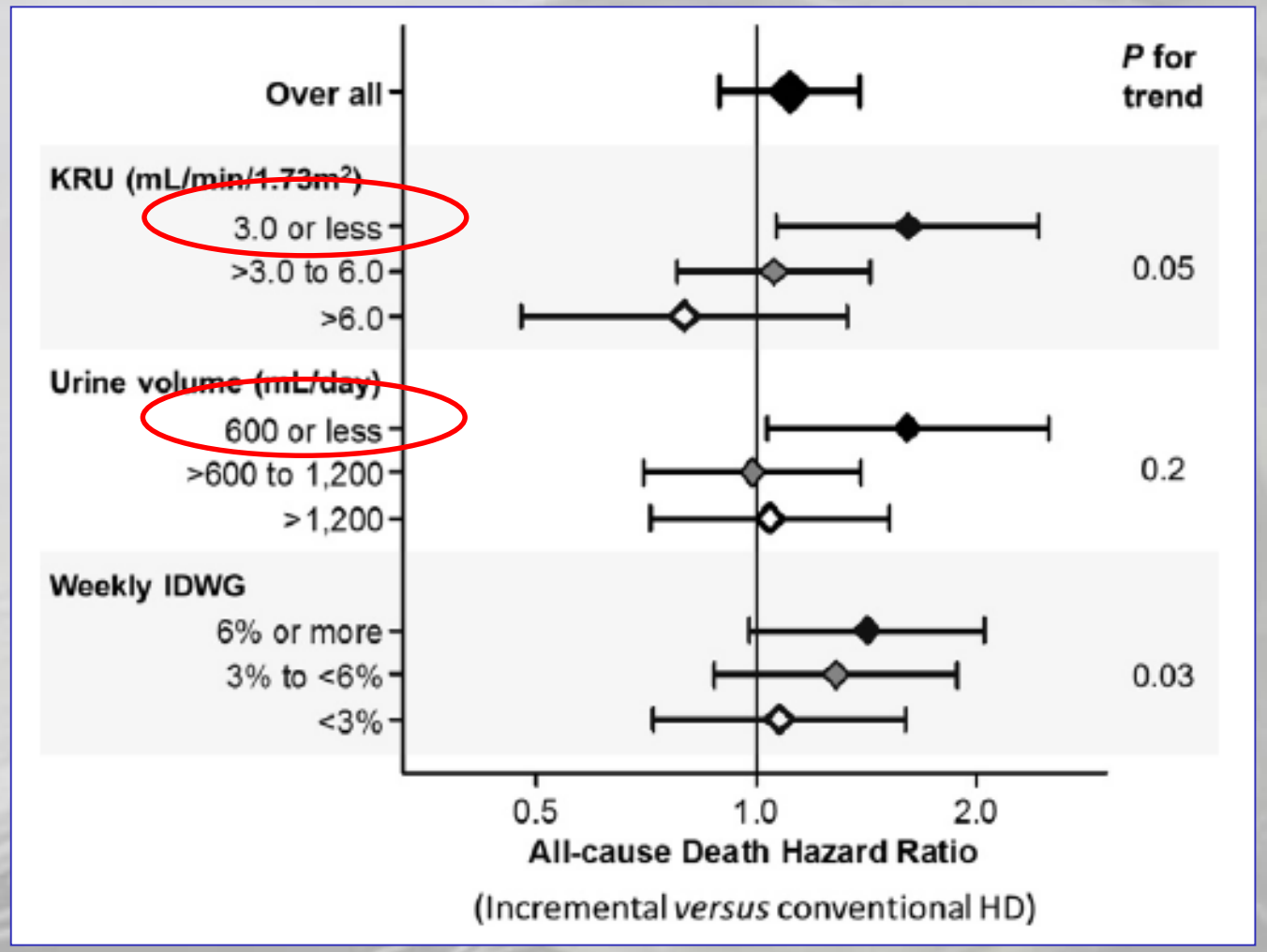
Obi et al, AJKD 2016

Outcomes with Incremental Hemodialysis

Overall, no survival difference after 1 year



Who is more likely to die on less frequent HD?



Obi et al, AJKD 2016

Important questions about incremental HD

- Who is eligible?
- What is sufficient kidney function?
- How can we reliably measure kidney function on hemodialysis?
- What are the benefits?
- What are the risks?
- For how long can we maintain residual renal function?

Who is eligible for Incremental Hemodialysis?

- urine output must be sufficient, > 500ml/day
- no history of heart failure, overt fluid overload
- limited fluid retention between HD sessions (< 2.5kg)

- no uremic symptoms
- good nutritional status, not in hypercatabolic state
- hyperkalemia or hyperphosphatemia well controlled
- managable co-morbid conditions

How many patients do you have ? ...

... who could be eligible for incremental hemodialysis ?

Feasibility of 2x weekly HD in incident patients

single center retrospective cohort study over the past 14 years

all patients who survived > 6 months, with urine output > 100ml/day

n=410 eligible patients

Criteria for 2x weekly HD

- total weekly Kt/V >= 2.3 with 2x4hrs HD - stdKt/V (dialysis) + stdKt/V (renal)
- ultrafiltration rate <13ml/kg/h estimated for 2x4hrs HD
- hemodynamic stability: pre-post HD ΔSBP<=10mmHg, post HD DBP>=90mmHg
- unfrequent symptoms during HD (nausea, cramping, hypotension)

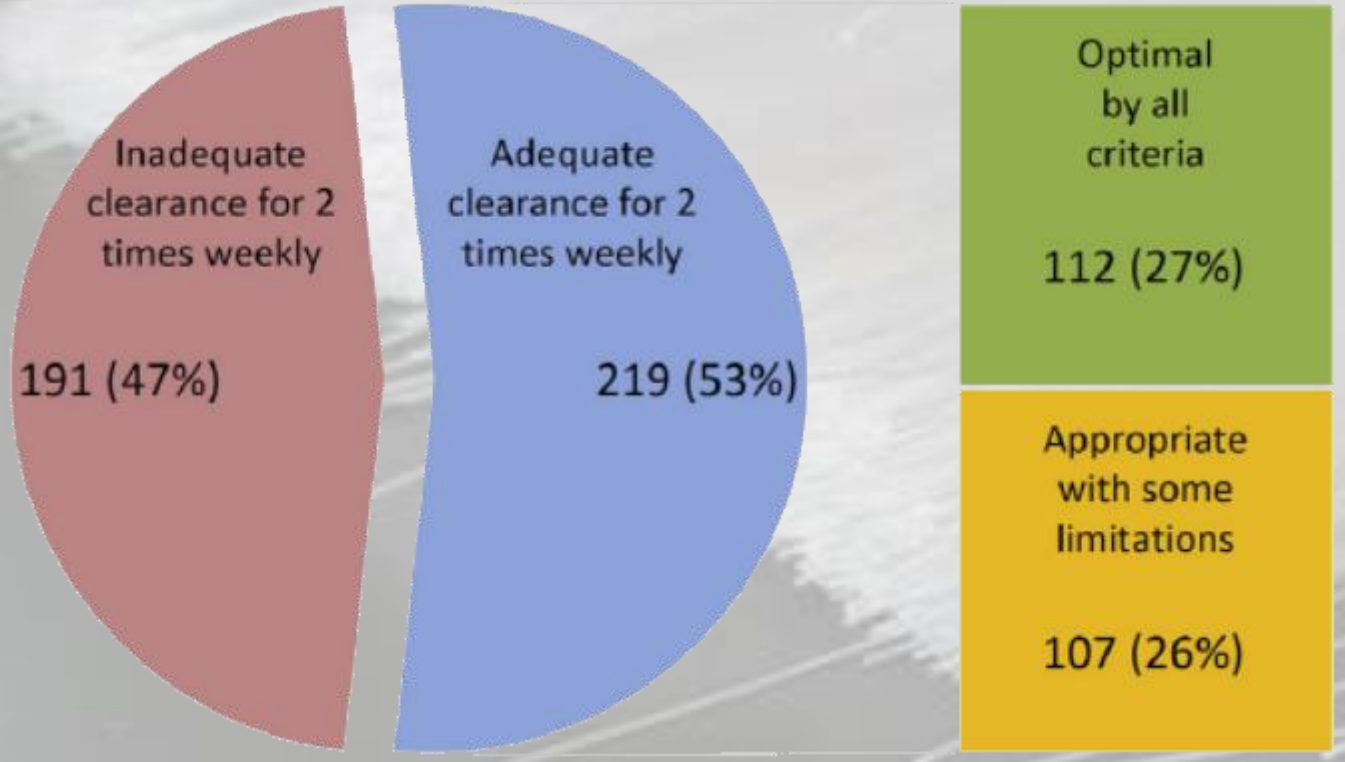
Chin et al, Kidney Int Rep (2017) 2, 933–942

Feasibility of 2x weekly HD in incident patients

single center retrospective cohort study over the past 14 years

all patients who survived > 6 months, with urine output > 100ml/day

n=410 eligible patients



urea clearance wKt/V >= 2.3

ultrafiltration rate <13ml/kg/h 2x4 hrs

hemodynamic stability

unfrequent symptoms during HD

Chin et al, Kidney Int Rep (2017) 2, 933–942

Potential benefits of Incremental Hemodialysis

- Better preservation of residual kidney function
- Better survival (?)
- Better quality of life
- Better preservations of functional status (elderly patients)
- Fewer access complications
- Lower costs (?)

Potential risks of Incremental Hemodialysis?

- Under-dialysis
  - unrecognized loss of kidney function - frequent reassessment needed !
  - inappropriate assessment of kidney function
  - patient refuses increasing dialysis frequency
- Subclinical chronic fluid overload
  - how can we diagnose without drying out the patient?
- Low adherence to volume control and diet
- Malnutrition ?
- Increased risk of hypertension, heart failure, metabolic complications

Potential problems with Incremental Hemodialysis?

- Only observational studies
  - The amount of residual kidney function was not used to determine the prescribed dose
- Need for frequent reassessment.
  - is the patient still doing well on 2x HD? When to switch to 3x HD?
  - "uremic symptoms"
- The cut-off for "significant RRF" needs to be defined.
- Measurement of residual renal function is problematic
  - urine output itself is not very reliable
  - urea based models are not sufficient
    - influenced by dialysis, chalenging calculation or <u>requires urine collection</u>
  - other tools in development: β2-microglobulin, β-trace protein, cystatin C, ... ?

Estimating renal function in Hemodialysis

altenative endogenous filtration markers

NECOSAD study, development cohort: n=44, validation cohort n=826

beta-trace protein (BTP): 25 000Da

beta2-microglobulin (B2M): 11600Da

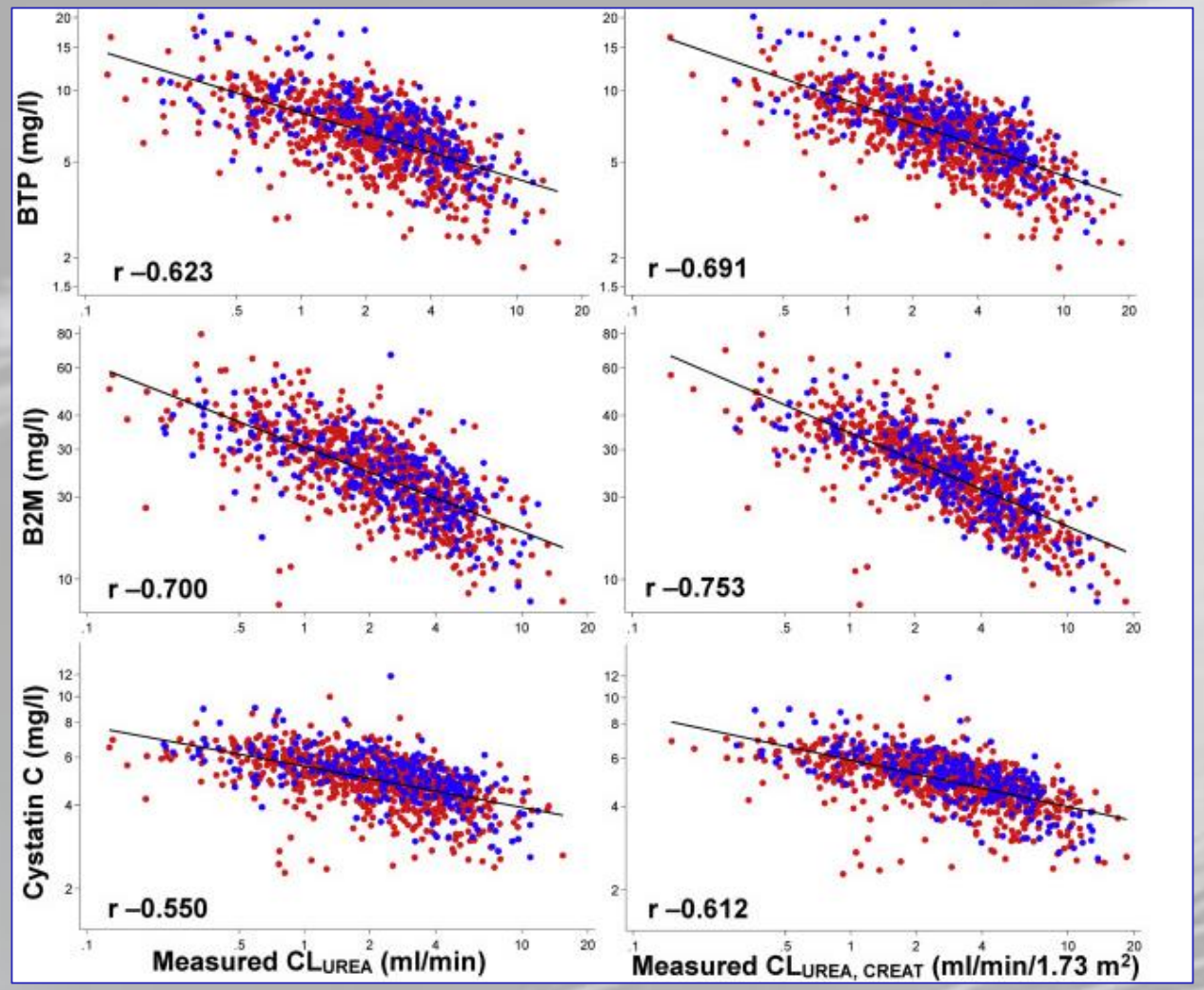
cystatin-C: 13300Da

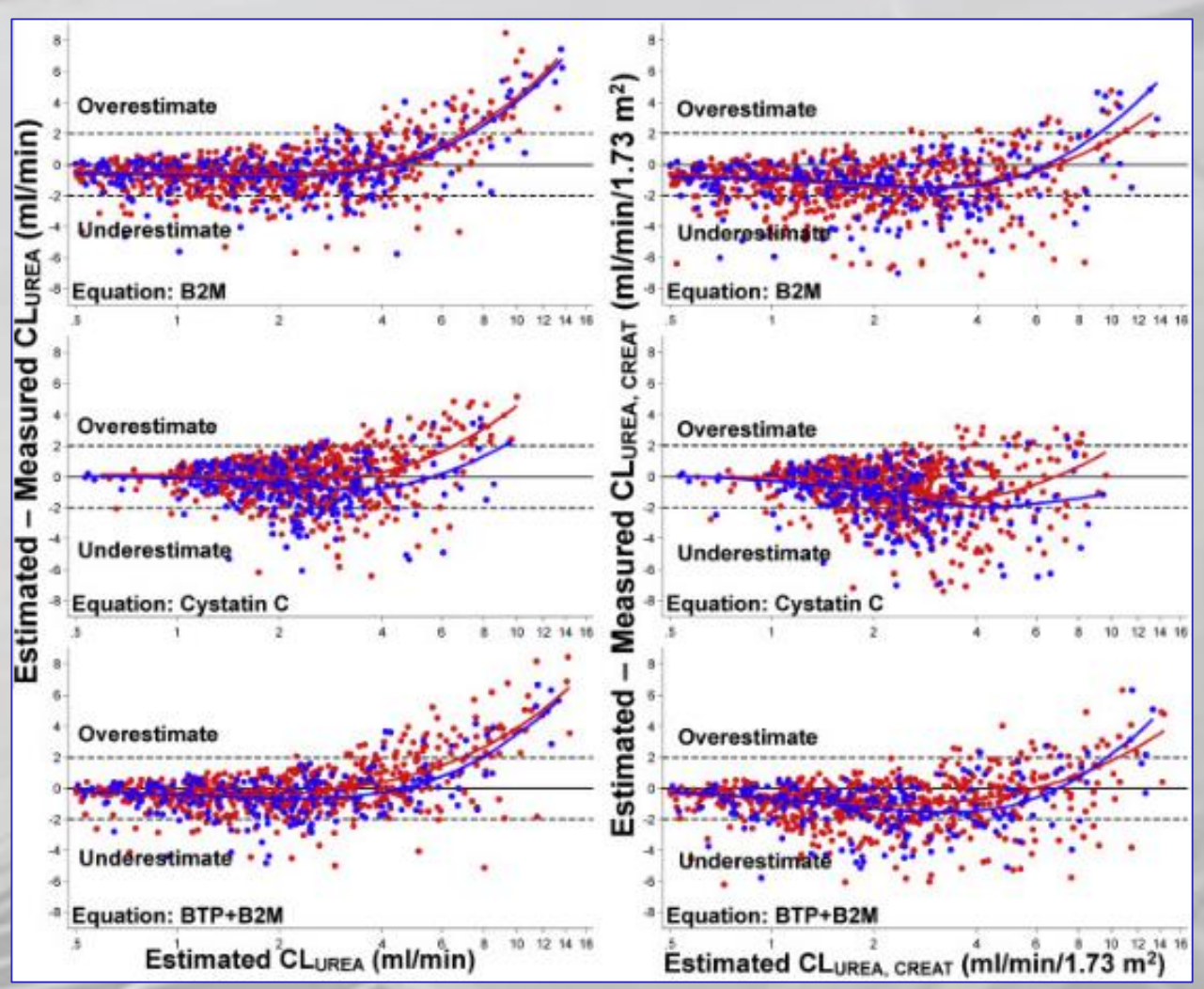
urea and creatiine clearance based on 24hrs urine collection

Shafi et al, Kidney International (2016) 89, 1099–1110

Estimating renal function in Hemodialysis

altenative endogenous filtration markers





Shafi et al, Kidney International (2016) 89, 1099–1110

Estimating renal function in Hemodialysis

beta-2 microglobulin

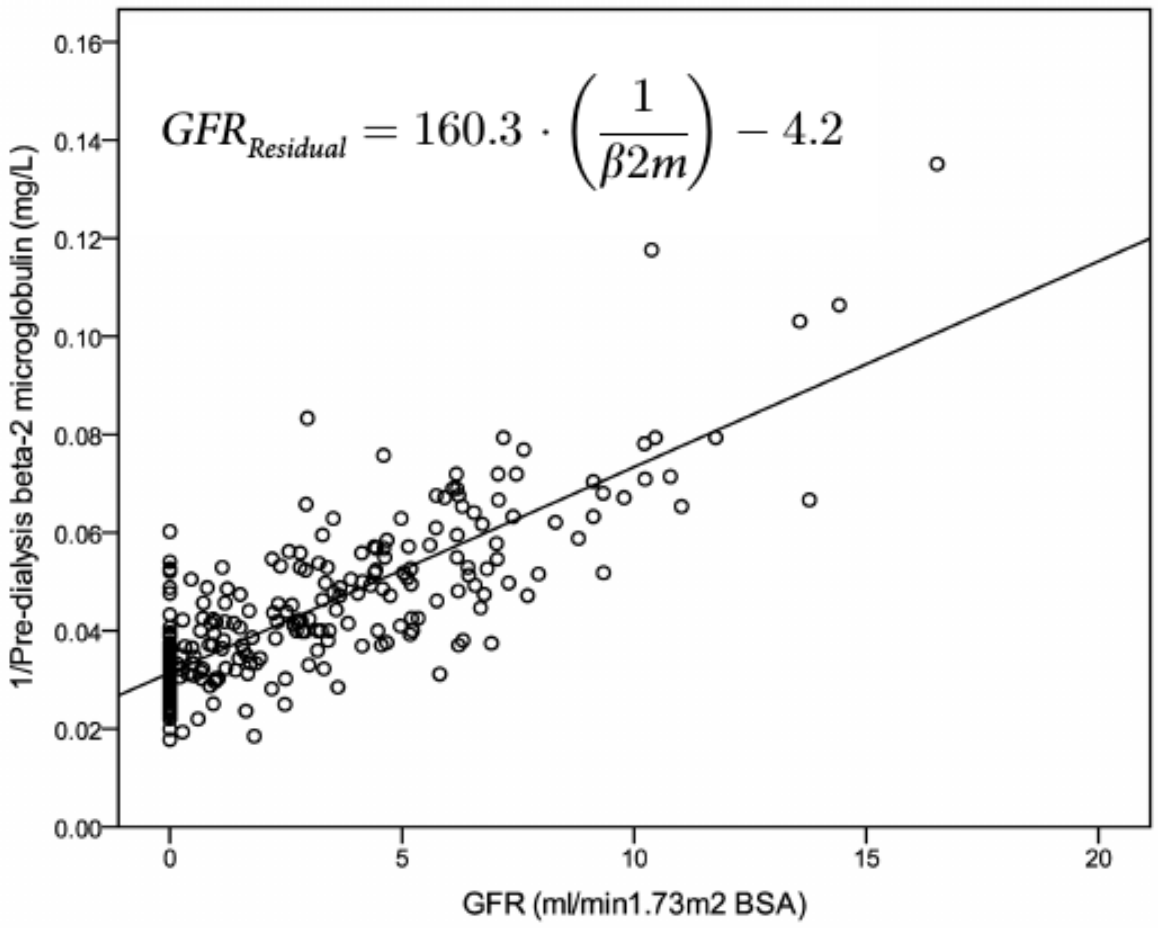


Fig 1. Relationship of GFR with the reciprocal of pre-dialysis β2 microglobulin levels. GFR shown is calculated from mean of urea and creatinine clearance. For the linear regression shown r2 was 0.67.

doi:10.1371/journal.pone.0143813.g001

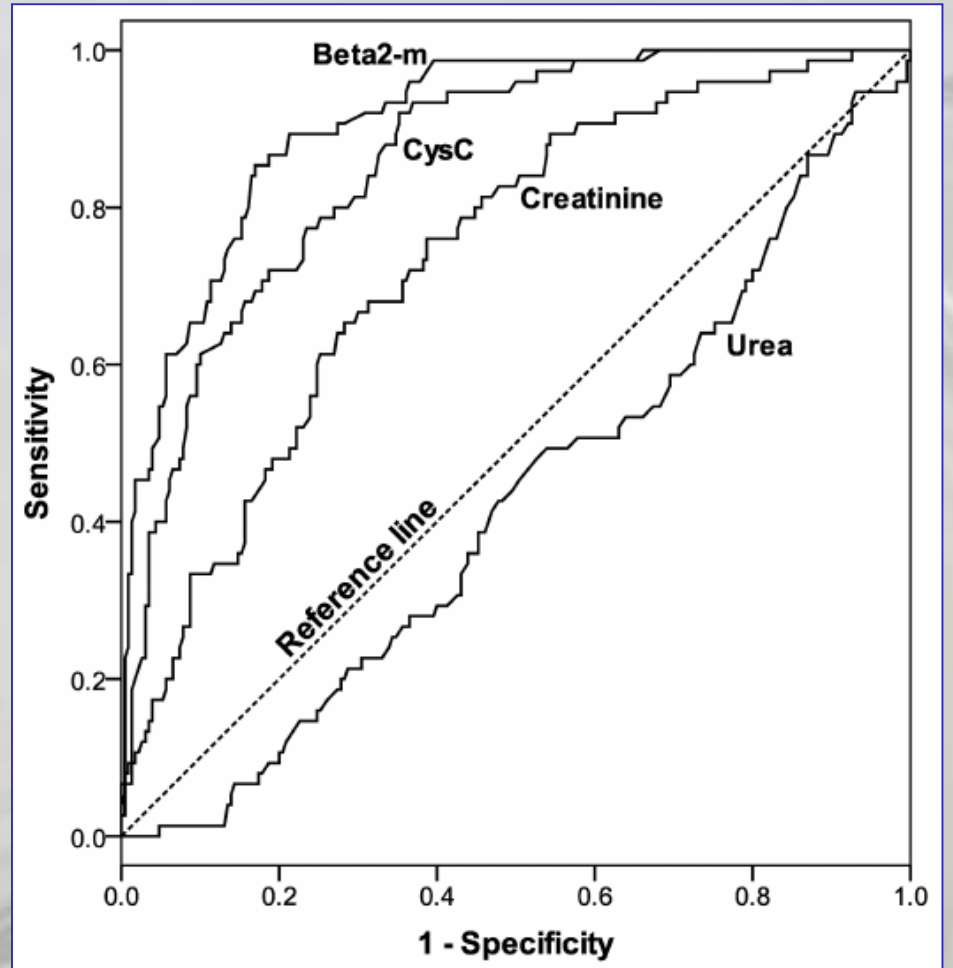


Fig 3. ROC analysis of pre-dialysis levels of Cystatin C, β2-microglobulin, urea and Cystatin C to identify patients with significant residual renal urea clearance ≥2ml/min/1.73m² BSA. The greatest area under the curve was for β2-microglobulin.

doi:10.1371/journal.pone.0143813.g003

Predicting eGFR > 2ml/min : beta2-MG < 19.2mg/l (90% specificity, 65% sensitivity)

Vilar et al, PLoS ONE 2015, 10(12): e0143813.

Potential problems with Incremental Hemodialysis?

- Current quality measures do not recognize residual renal function
  - might influence reimbursement

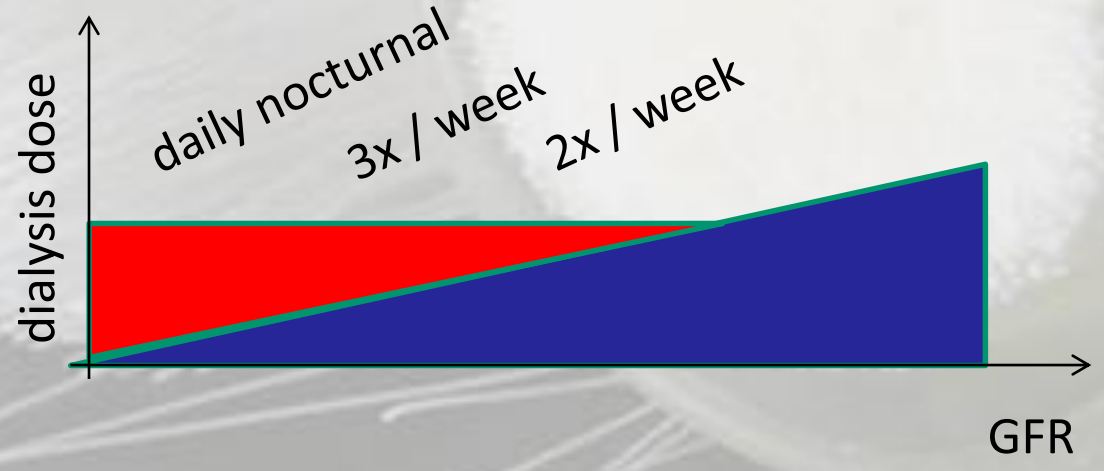
- Incremental hemodialysis is difficult to introduce in ***commercial settings***
  - reimbursement is based on treatment numbers
  - not flexible for individualization of the therapy

Final thoughts

- Several methods to lower dialysis dose
  - fewer sessions, shorter sessions, lower blood flow, smaller dialyzer
  - effect on residual renal function not yet tested

- Incremental hemodialyis also means to <u>further increase dialysis</u> (time / frequency - not Kt/V) <u>in anuric patients !!</u>

  - 3x weekly
  - 5x weekly
  - long sessions
  - daily nocturnal



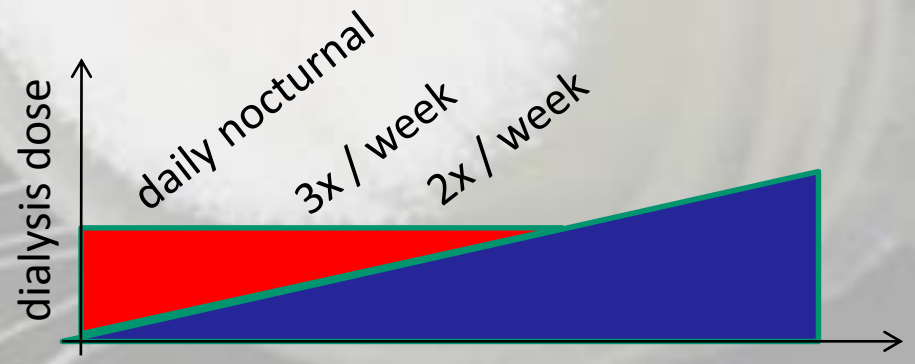
Summary - recommendations

- Start patients on dialysis only when necessary (early start has no benefit!)

- If patient has residual kidney function (eGFR>3-5ml/min ?)
  - start on Peritoneal Dialysis
  - or on Incremental Hemodialysis (2x weekly)
- Use diuretics and avoid ultrafiltration whenever possible

- Other measures to preserve kidney function
  - prescribe ACEi, ARB, avoid nephrotoxins

- <u>Reassess patient and dialysis requirement</u>
  Increase dialysis dose when
  kidney function deteriorates




This Is No
Fairy Tale
THANK YOU !