Home Dialysis University

Blood Pressure and Volume Issues in Dialysis

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USF HEALTH

INTERNATIONAL SOCIETY FOR PERITONEAL DIALYSIS

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Potential Conflict of Interest Disclosures:

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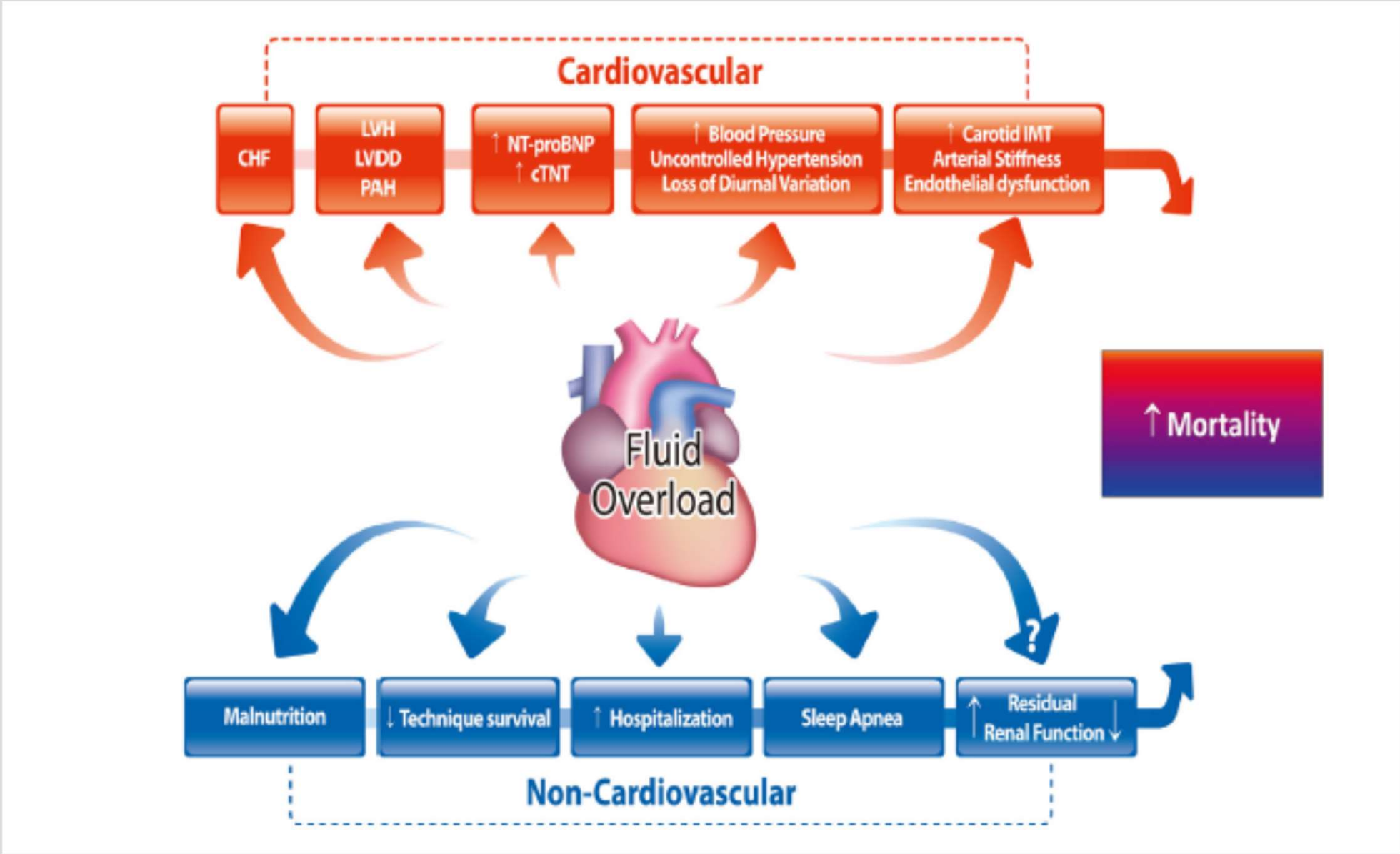
Items for Consideration

- Why should we care about volume homeostasis?
- How should we achieve euvolemia?
  - Diet
  - Kidney Function
  - Ultrafiltration
- Modality- specific considerations

Consequences of Volume Overload

Kim and Van Biesen. Sem Nephrol 37:43, 2017



Volume is an “Uremic” Toxin

- Retained in renal failure
- Biologically or biochemically active
- Deleterious effects on body function
  - Hypertension
  - LVH
  - Inflammation
- Removal improves outcomes

Courtesy Dr. Joel Glickman

Improving Volume Control Lowers BP

Improving Volume Control Lowers BP: The Tassin Long Duration HD Experience

Charra et al. Hemodial Int. 5:42, 2001

Probing For Dry Weight

- HD time ↑ from 3 to 8 hrs in 1 hr increments to 15–24 hrs/wk.
- UF (6–9 mL/kg/hr) to ↓ Post HD weight ≈ 0.5–1 kg/wk
- Strict low-Na diet
- Dialysate Na 138-140
- Dry weight decreases to lowest level in 1 month
- Dry body weight starts to increase because of improvement in appetite, but blood pressure continues to decrease

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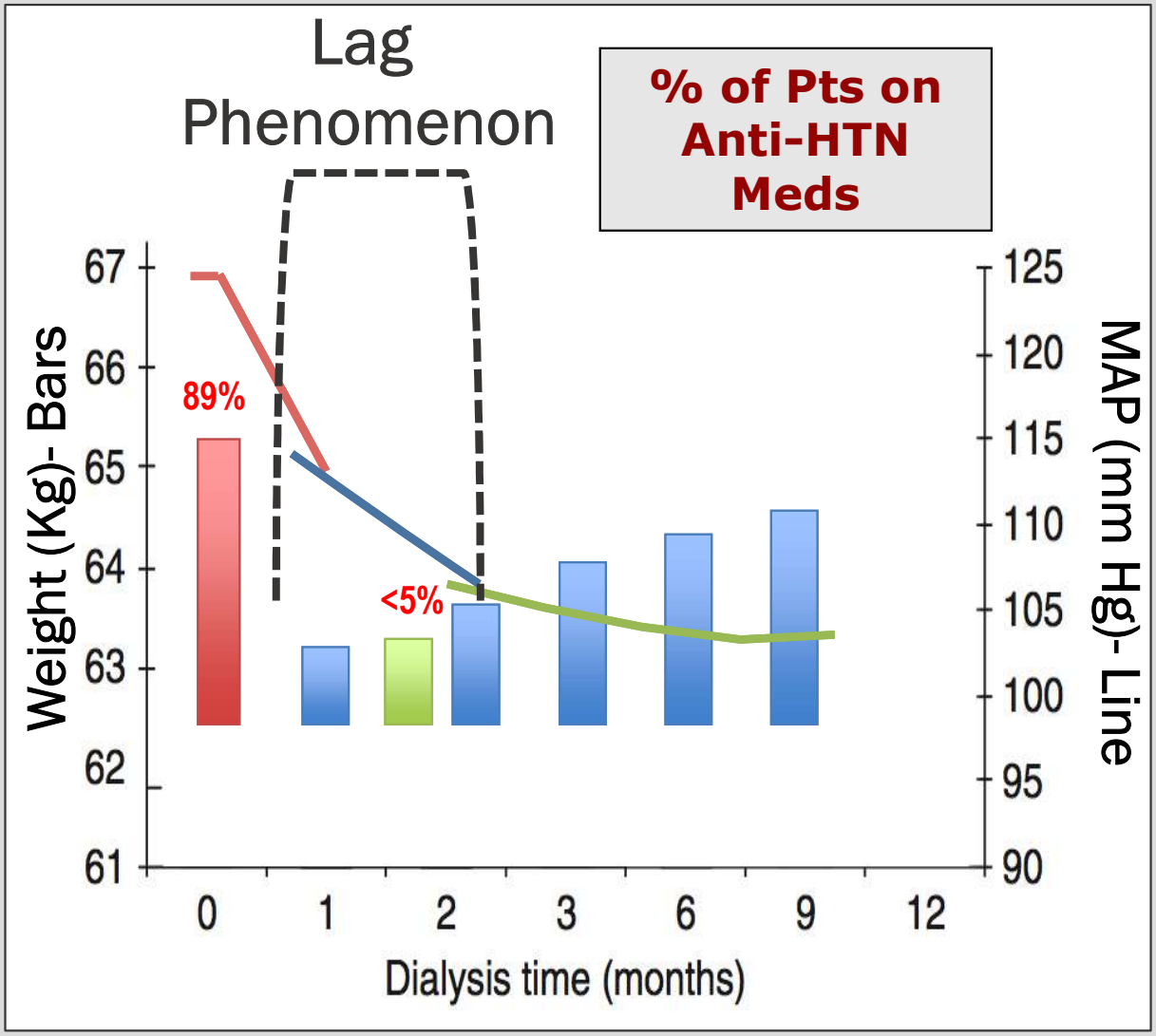
Improving Volume Control Lowers BP: The Tassin Long Duration HD Experience

Charra et al. Hemodial Int. 5:42, 2001



Courtesy: Dr. Joel Glickman

Increased Peritoneal UF Is Associated with Lower BP

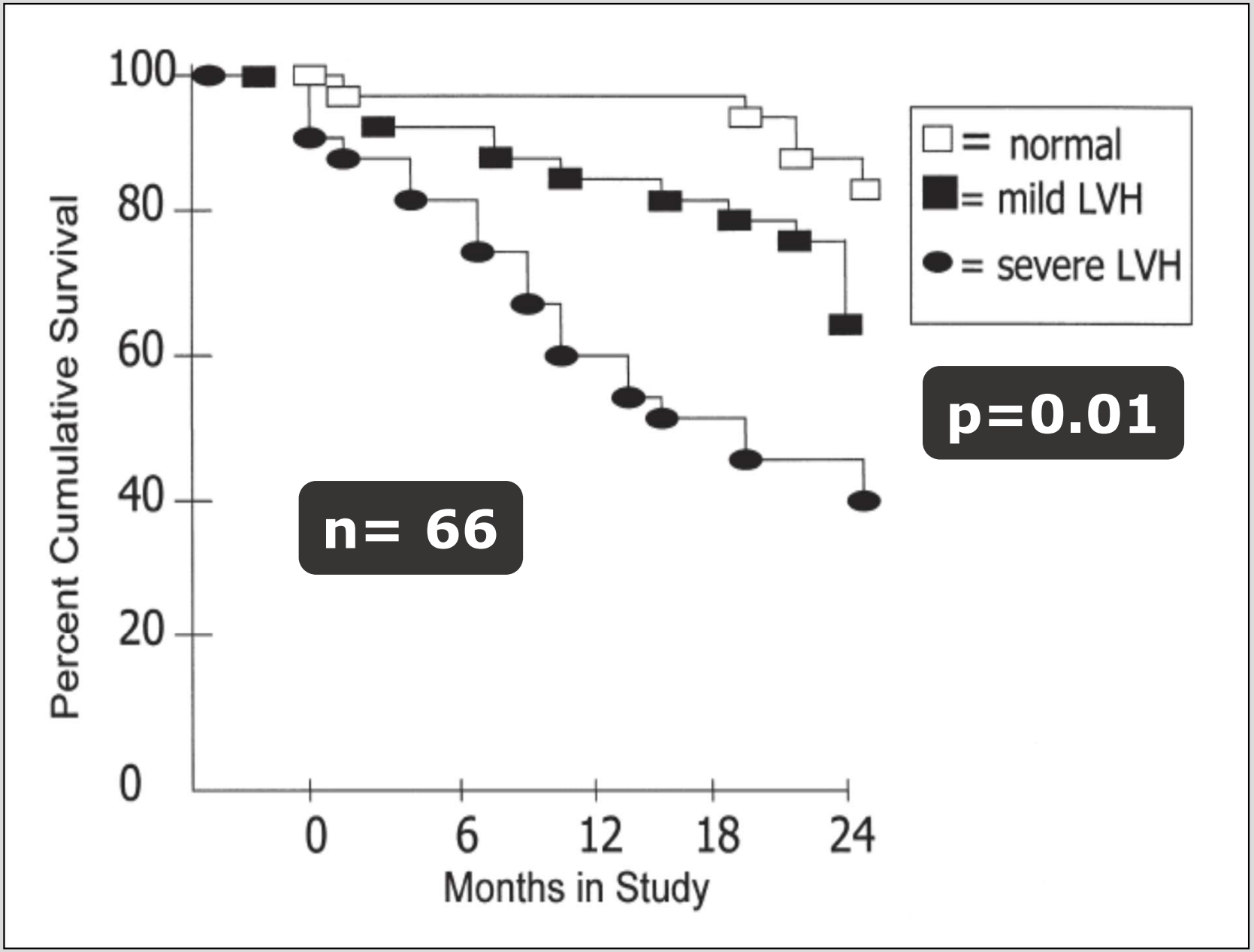
Tonbul et al Perit Dial Int 23:46, 2003

- Baseline:
  - 25 PD patients; mean time on PD 22.9 mo's
  - All patients on same regimen 3 x 1.5% & 1 x 4.25%
  - 13/25 had HTN (24 hour ABPM)- excluded those with obvious volume overload
  - Attempt to increase UF (4 APD, 3 increased number of exchanges, 6 more hypertonic fluid) with f/u at 1 month
- Results:
  - UF increased (1086±259 to 1493±225 mL, $p<0.001$)
  - Systolic BP (145±13 vs. 128±5 mmHg, $p<0.001$)
  - Diastolic BP (96±10 vs. 81±3 mmHg, $p<0.001$)
  - Weight decreased (67.3±8.9 to 65.5±8.7 Kg)
  - BP meds discontinued in 6/13

The Importance of Decreasing LVH

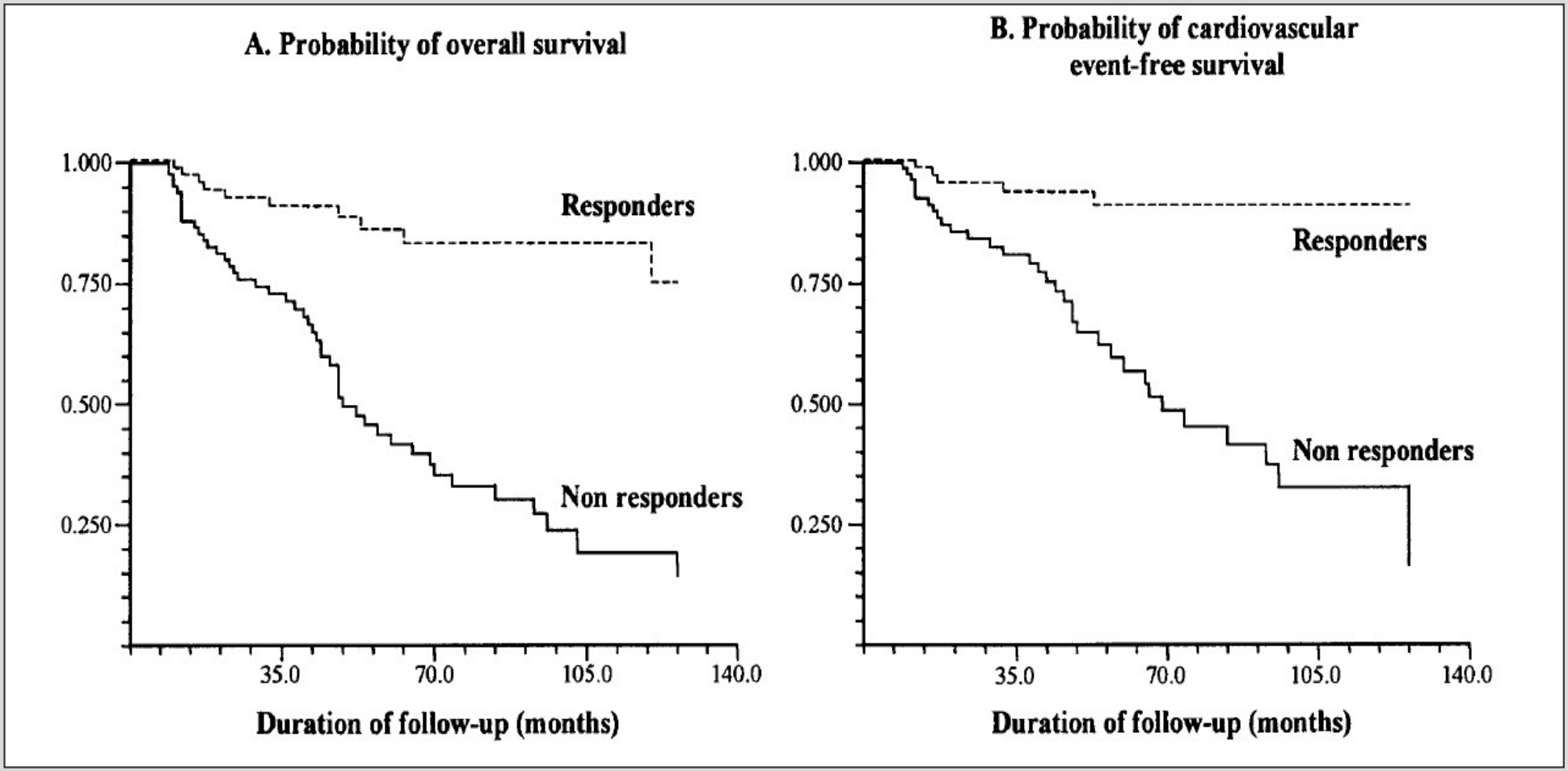
LVH is Associated with Reduced Survival in PD Patients

Silaruk et al. Perit Dial Int 20:461, 2000



Regression of LVH Improves Survival in HD

London et al. J Am Soc Nephrol 12:2759, 2001

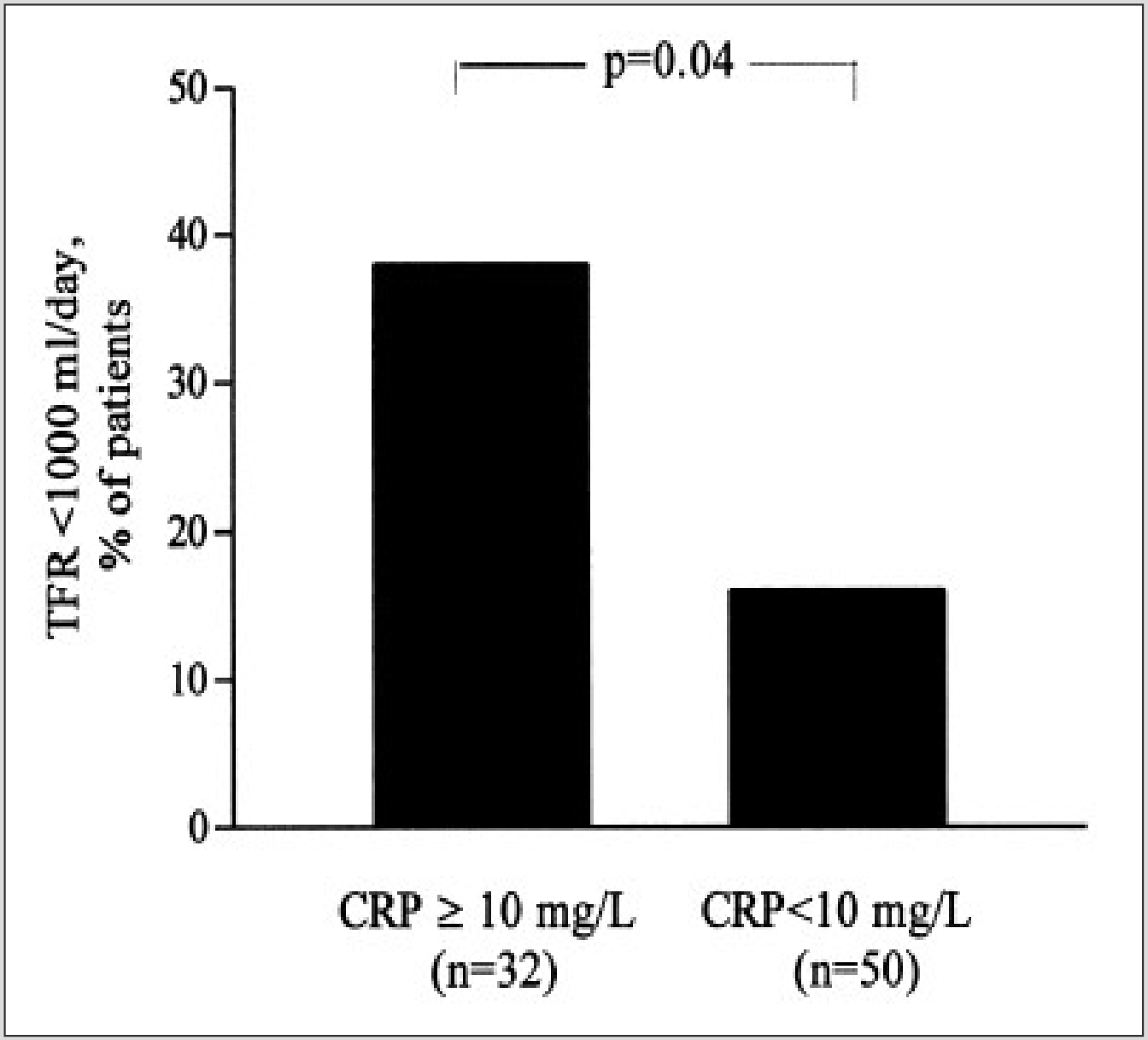


p <0.001 for both

Inflammation and Volume Overload

Association Between Inflammation and Total Fluid Removal in PD Patients

Chung SH et al. Perit Dial Int 23:174, 2003



Inflammation Is Increased in Volume-Overloaded HD Patients…

Jacobs LH et al. Nephrol Dial Transpl 25:243, 2010

- Single- center study in the Netherlands
- 44 HD patients followed for 6 months
- NT- proBNP and hsCRP measured every 2 months
- NT- proBNP levels were “significantly” predictive of hsCRP (p = 0.015 ??)

…and Mortality Is Increased in Their Combined Presence

Dekker MJE et al. Kid Int 91:1214, 2017

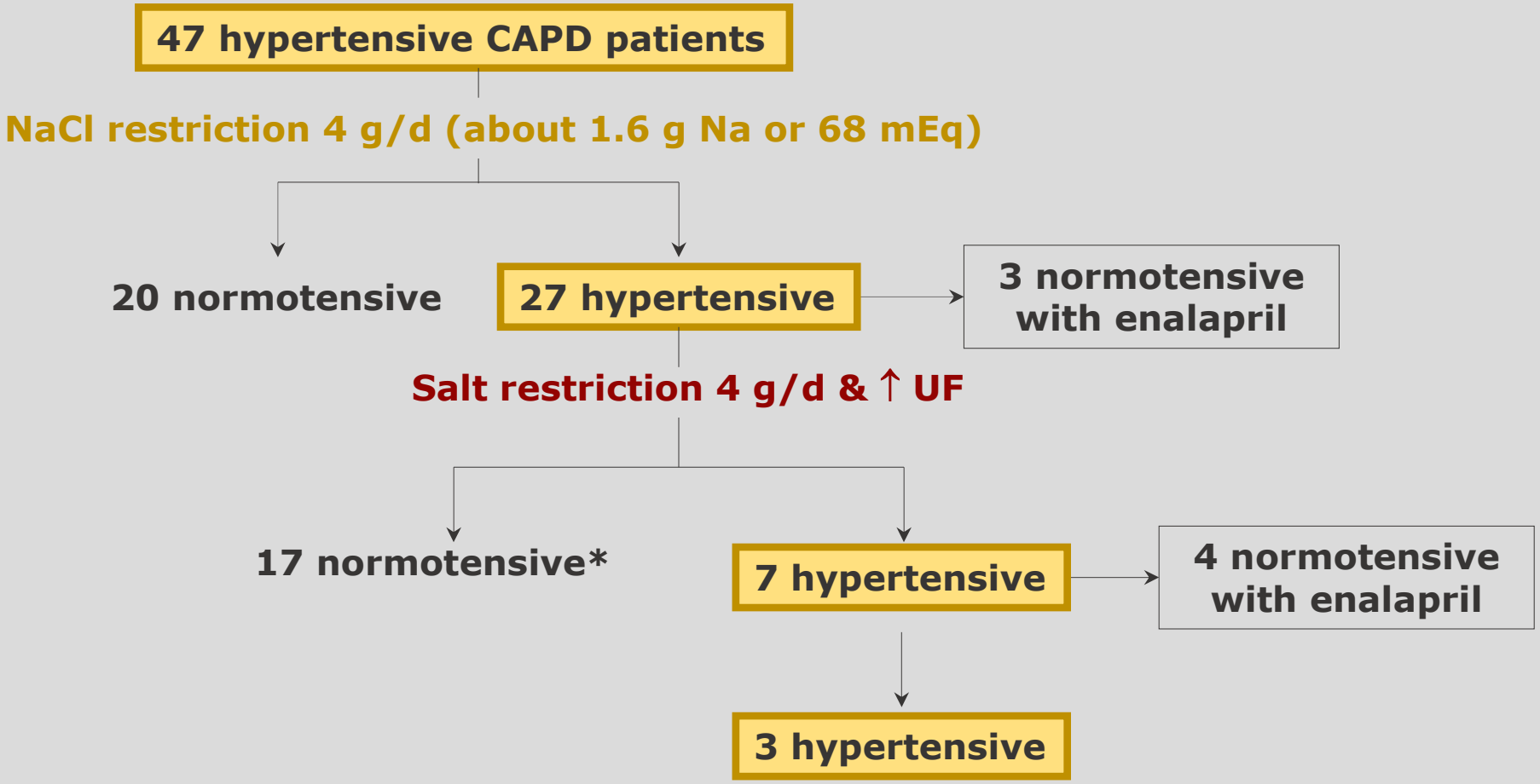
	Predialysis fluid status (l)		HR
CRP ≤ 6 mg/l	Fluid depletion	≤ −1.1	2.78
	Normovolemia	> −1.1 to +1.1	
	Moderate FO	> +1.1 to +2.5	1.67
	Severe FO	> +2.5 to +5.0	3.09
	Extreme FO	> +5.0	4.05
CRP > 6 mg/l	Fluid depletion	≤ −1.1	4.19
	Normovolemia	> −1.1 to +1.1	2.53
	Moderate FO	> +1.1 to +2.5	3.99
	Severe FO	> +2.5 to +5.0	6.02
	Extreme FO	> +5.0	9.83

At any level of volume, HR for mortality is more than doubled with high CRP

The Importance of Dietary Sodium Restriction

Salt Restriction, Volume Reduction, and BP Control

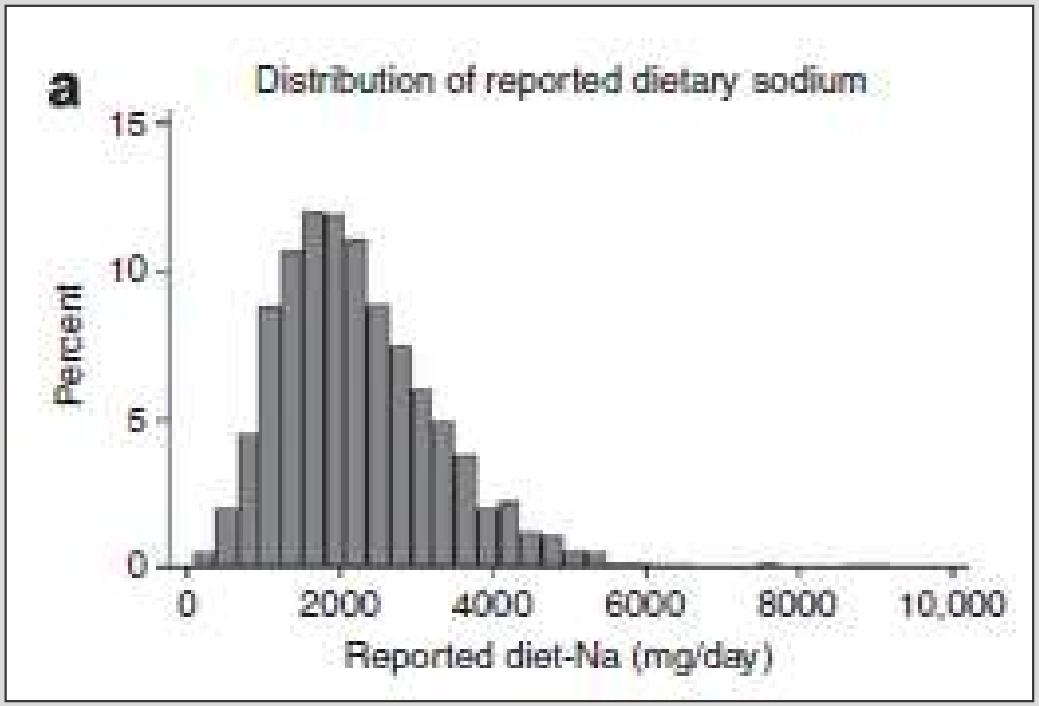
Gunal et al. Am J Kid Dis 37:588, 2001

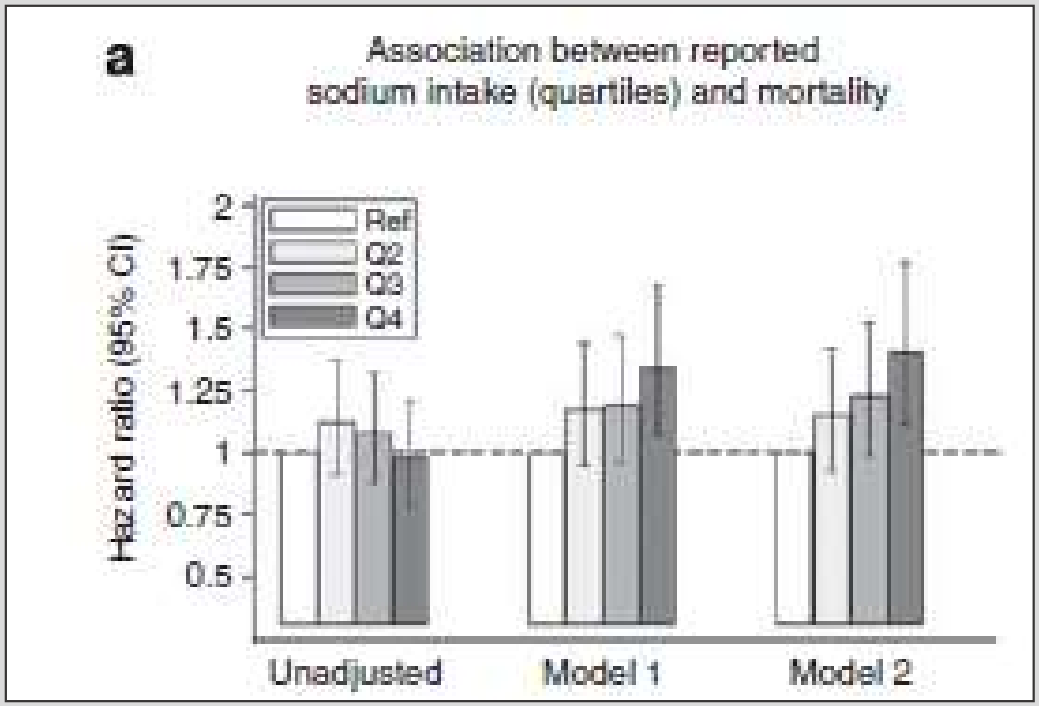


In total 37 patients achieved normotension with volume control alone

Increased Dietary Sodium Is an Independent Predictor of Mortality in HD Patients

McCausland FR et al. Kid Int 82:204, 2012





Utilizing Residual Kidney Function: Diuretic Use in ESRD

Diuretic Use in Peritoneal Dialysis

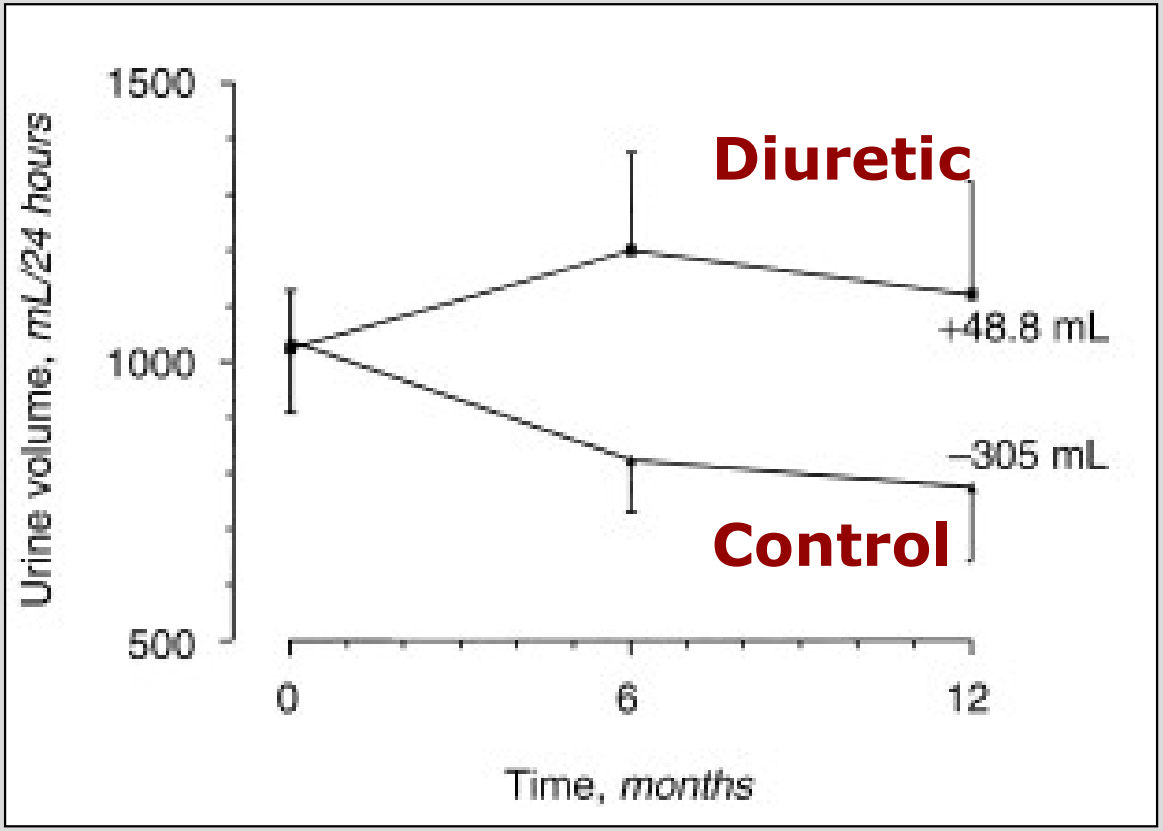
- Do diuretics increase renal clearance in PD patients?

- Is it safe to use diuretics at high doses?

Effect of Furosemide on UOP and RKF in Chronic PD- 1

Medcalf JF et al. Kid Int 59:1128, 2001

- 61 incident PD patients randomized to 250 mg of furosemide daily vs. no diuretic therapy
- UOP increased in diuretic therapy group but no change in RKF



Effect of Furosemide on UOP and RKF in Chronic PD- 2

Medcalf JF et al. Kid Int 59:1128, 2001

	Control	Diuretic	*P* value
Δ Urine volume *mL/month*	−23.3 ± 11.2	+6.47 ± 9.52	0.047
Δ 24-hour urinary sodium *mmol/24 h*	−2.57 ± 1.51	+0.72 ± 0.85	0.041
Δ Creatinine clearance *mL/min/month*	−0.071 ± 0.04	−0.12 ± 0.05	0.45
Δ Urinary Kt/v *per month*	−0.019 ± 0.01	−0.020 ± 0.01	0.92

Acute Effects of High-Dose Furosemide in PD Patients

Van Olden RW et al Perit Dial Int 23:339, 2003

Change From Baseline After 2 days of Furosemide 2g/day

Urine volume (mL/day)	↑ 400
Urine Na (mmol/day)	↑ by 54
GFR (mL/min)	no change

n=7 patients

WIMPY Diuretic Use in the US…

High Dose Diuretics in Patients with AKI
Brown CB et al. Clin Nephrol 15:90, 1981

- RPCT of 56 patients with AKI on HD or PD
  - Furosemide 4 mg/min x 4 hr only
  - Furosemide 4 mg/min x 4 hr, then 3 grams/day (either 2 mg/min continuously or 1 g tid po) to maintain urine output at 150-200 mL/hr and/or Scr < 300 μM (3.38 mg/dL)

- 2 patients developed ototoxicity while on long-term furosemide therapy
  - 1 developed transient deafness after 11 days
  - 1 developed irreversible deafness; a clerical error led to 12 mg/min furosemide given for 3 days (17.3 g/d)
  - Both had been on an aminoglycoside during furosemide therapy

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Safety of High Dose Diuretics - 1

Kuchar DL and O'Rourke MF. Eur Heart Jrl 6:954, 1985

- 24 patients with refractory CHF
- Treated with an average of 700 mg/day of furosemide (maximum 8 grams/ day at any time) for mean of 12 months
- Transient tinnitus was observed in 1 patient

SLIDE HIDDEN

Safety of High Dose Diuretics- 2

Gerlag PGG and van Meijel JJM. Arch Int Med 148:286, 1988

- 35 patients with refractory CHF
- Treated in hospital with IV furosemide up to 4000 mg/day (some by continuous infusion, some intermittent boluses). Patients surviving to discharge then received up to 2500 mg/day orally.
- Mean survival 11.3 months
- No observed tinnitus or ototoxicity. The most frequent complication was hypokalemia (31/35)

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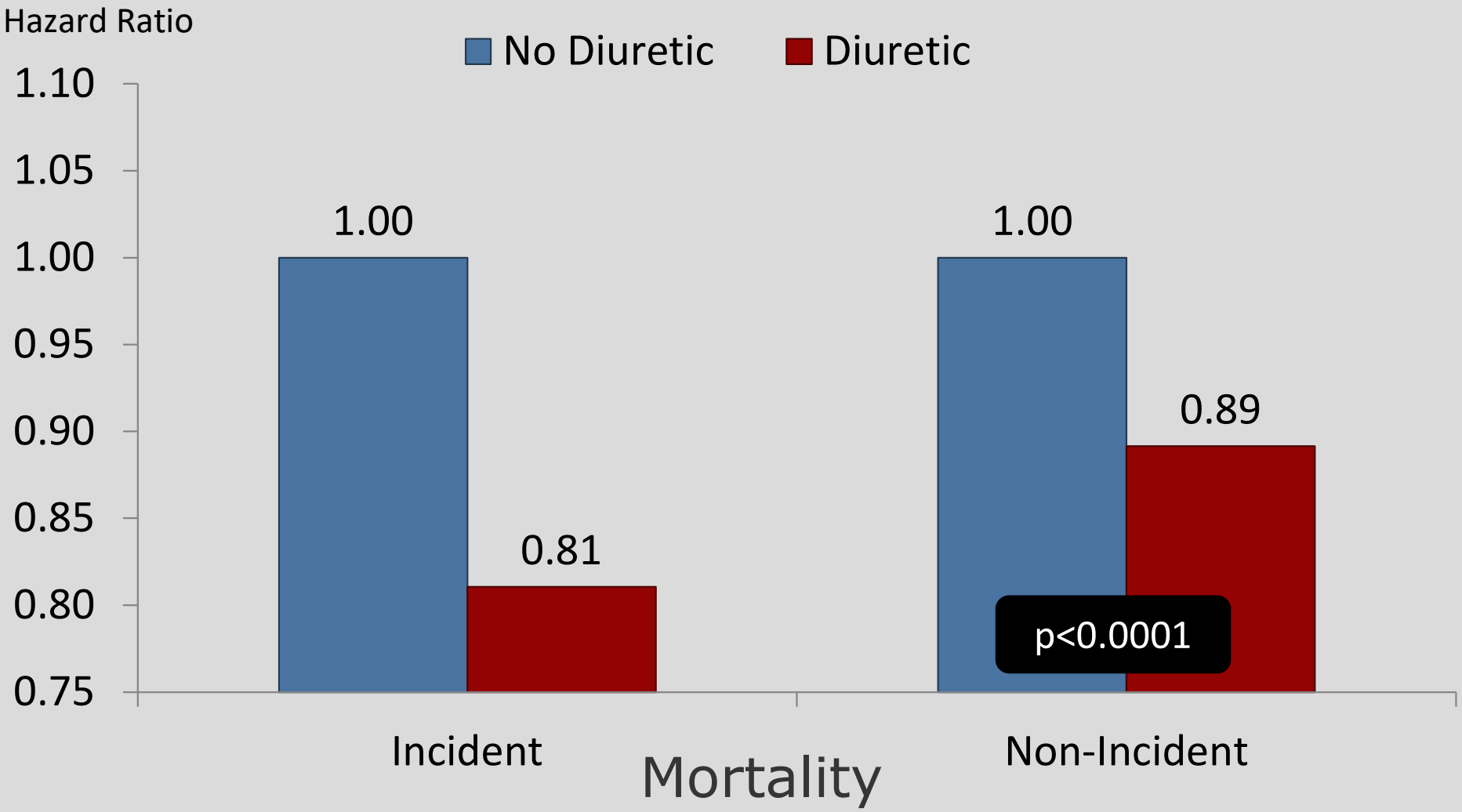
Long Term Safety and Efficacy of Furosemide in Peritoneal Dialysis

Faller B and Lameire N. Neplrol Dial Transpl 9:280, 1994

- 7 year observational study of UOP in two Belgian centers, one using furosemide 250- 500 mg /day, the other not using diuretics:
  - At the center where diuretics were used only 3 of 11 patients became anuric. In contrast…
  - …at the center where diuretics were not used 9 of 12 patients became anuric ($p < 0.01$)
- Diuretics are now routinely recommended in Belgium (Perit Dial Int 21:206, 2001), Toronto (Adv Perit Dial 19:44, 2003), Nashville (Golper, personal communication) and for my patients in Denver.

Diuretic Prescription and Outcomes among PD Patients in the BRAZPD Study



Dr. R. Pecoits- Filho, Personal Communication

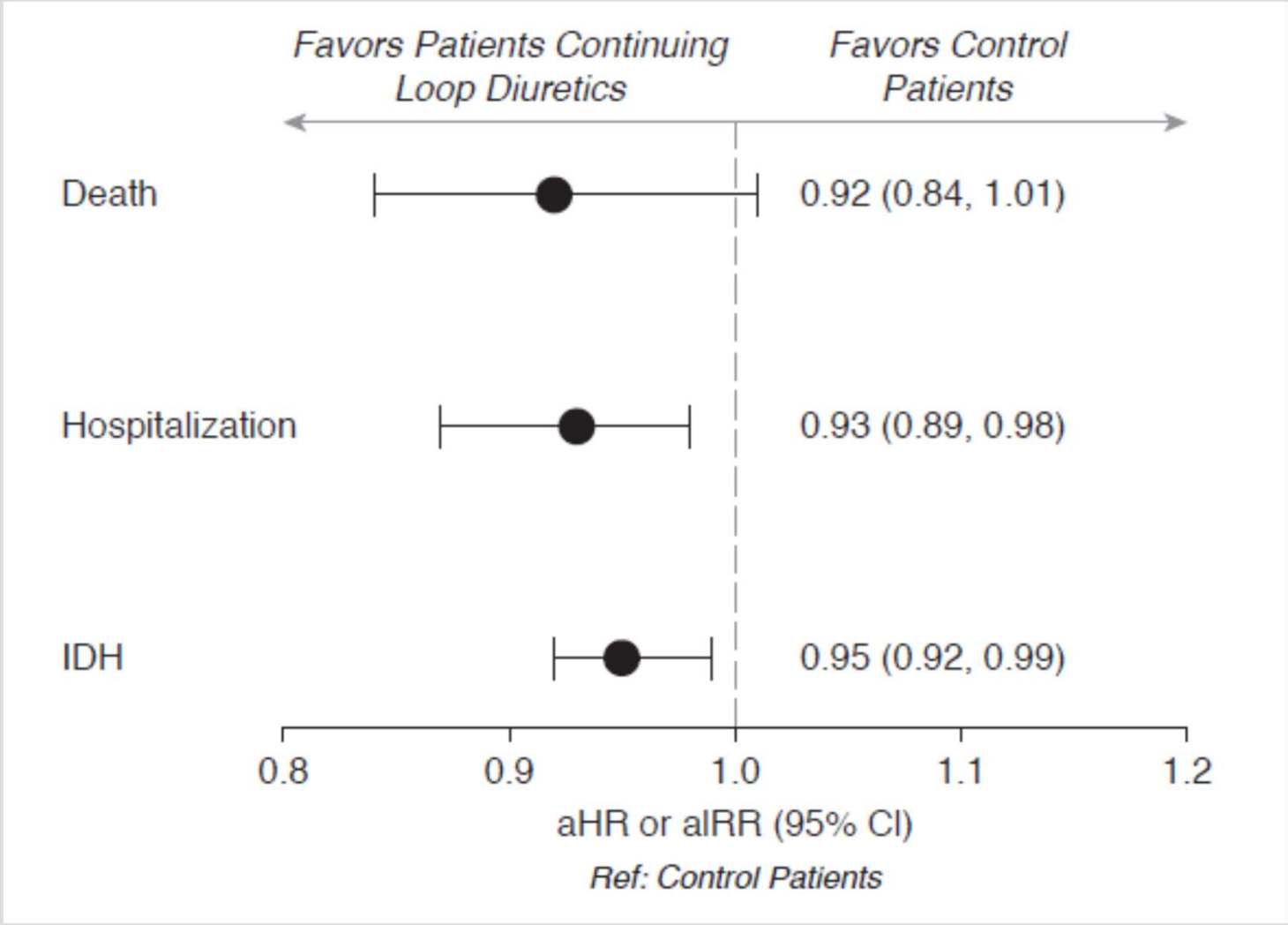
Efficacy and Safety of High Dose Furosemide in HD Patients

Van Olden RW Am J Nephrol 12:351, 1992

- Single- center in the Netherlands
- Short- term study:
  - 10 patients with mean RKF of 1.9 mL/min/1.73m^2 (Ccr)
  - Furosemide dose-1 gram bid x 7 days
  - UOP increased from mean of 340 to 1010 mL/ day ($p < 0.005$)
  - Interdialytic weight gain decreased by 1 kg ($p < 0.005$)
- Long- term study:
  - 13 patients with mean RKF of 5.6 mL/min/1.73m^2 (Ccr)
  - Furosemide dose- 250 mg to 1 gram daily
  - Response diminished over time as RKF declined
- No ototoxicity in either group

Beneficial Effects of Continued Loop Diuretic Use in HD Patients

Sibbel S et al. Clin J Am Soc Nephrol 14:95, 2019



There is also a significant (p=0.03) decrease in inter-dialytic weight gain.

Ultrafiltration and Survival: Peritoneal Dialysis

Increased Mortality with Volume Overload

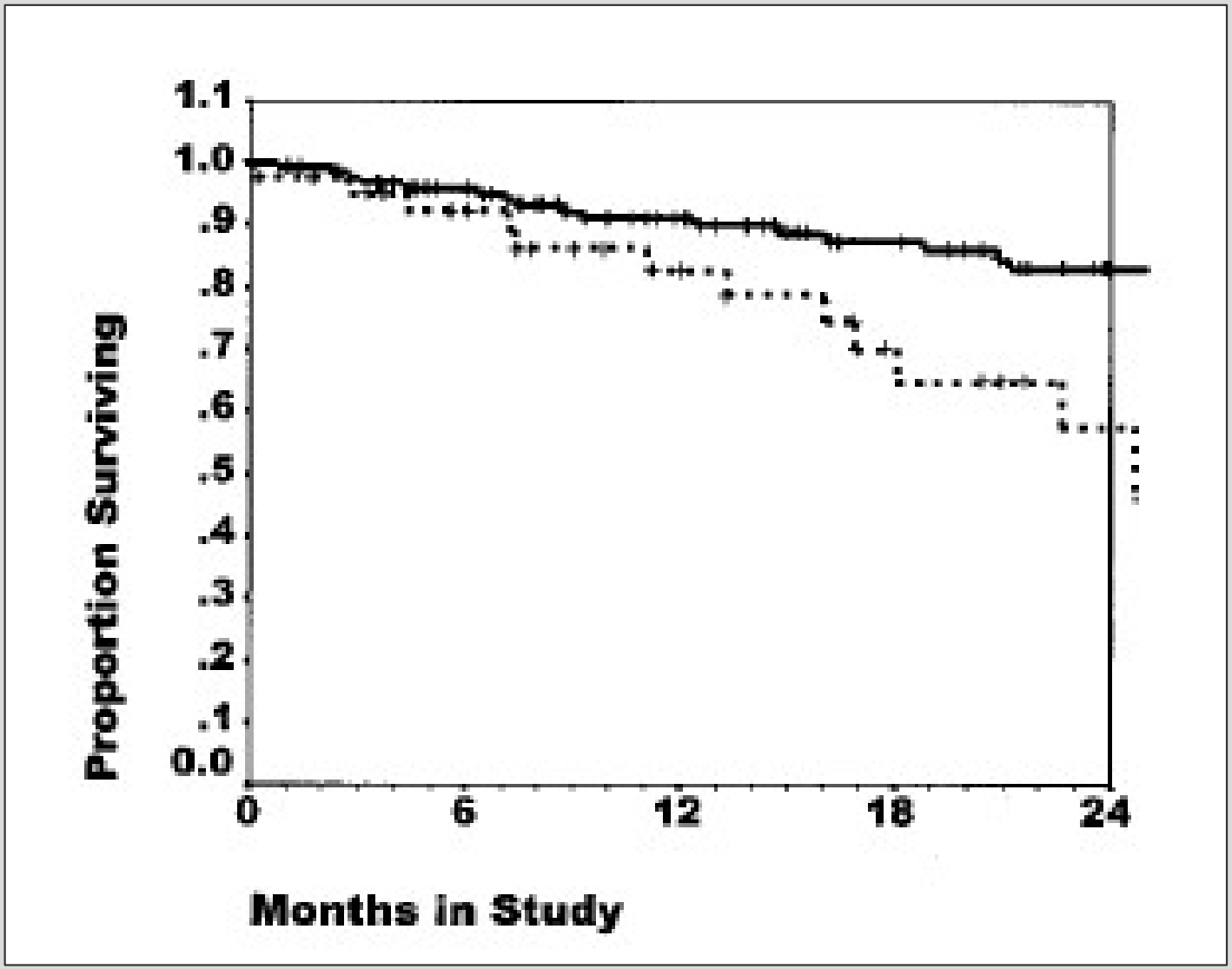
Van Biesen W et al. Clin J Am Soc Nephrol 14:882, 2019

Parameter		Subdistribution Hazard Ratio	Lower 95% CI	Upper 95% CI	*P* Value
Relative volume overload	Relative volume overload >17.3%	1.59	1.08	2.33	0.02
Age	per 1 year	1.06	1.04	1.07	<0.001
Cardiovascular disease	Yes	1.86	1.29	2.68	<0.001
Liver disease	Yes	2.11	1.14	3.90	0.02
Diabetes	Yes	1.49	1.04	2.15	0.03

n= 1054; volume measured by bioimpedance spectroscopy and compared to "expected" obtained via a validated model

EAPOS: Survival Stratified by Baseline UF

Brown EA et al. J Am Soc Nephrol 14: 2948, 2003



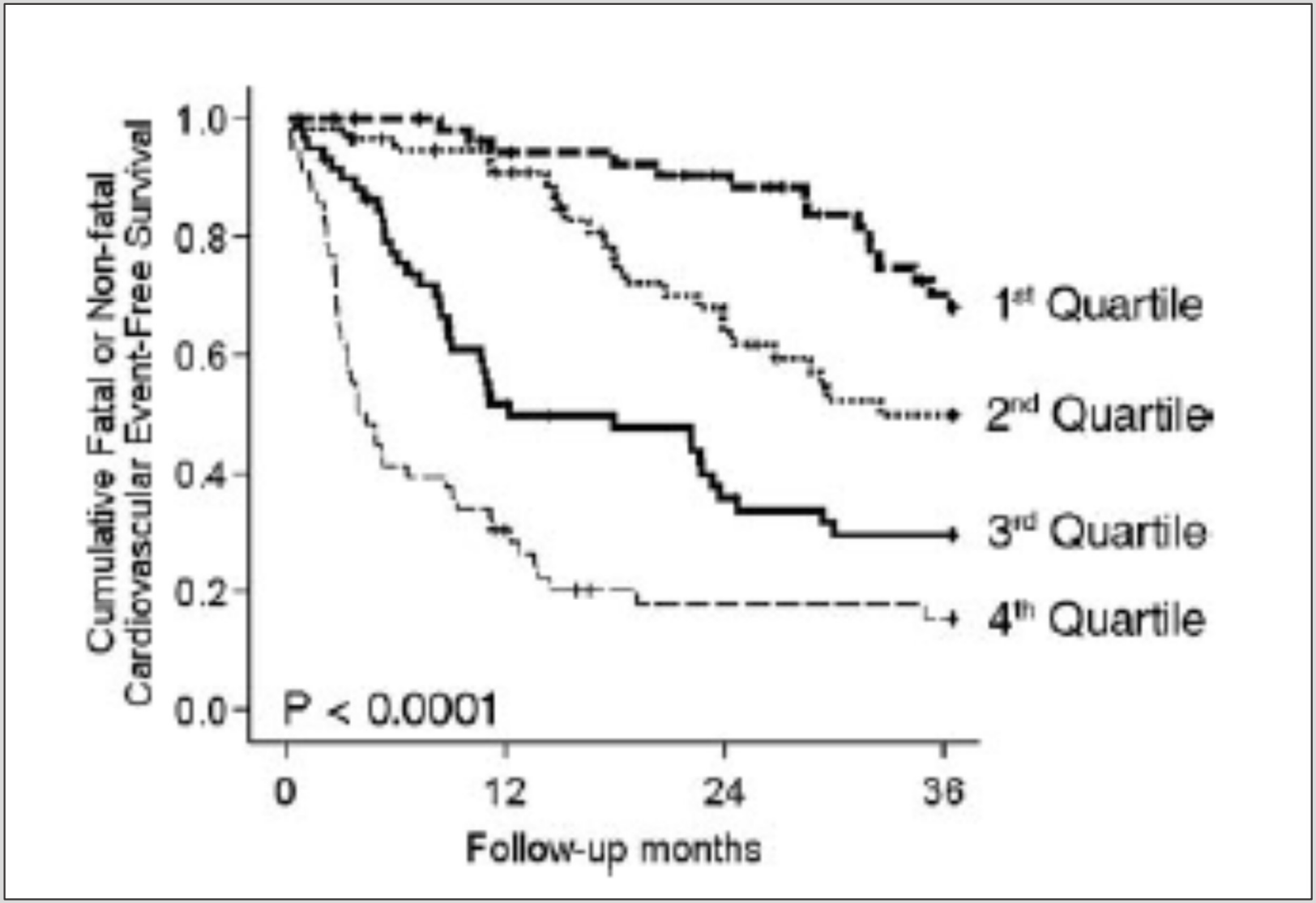
> 750 ml/ day

p = 0.0048

< 750 ml/ day

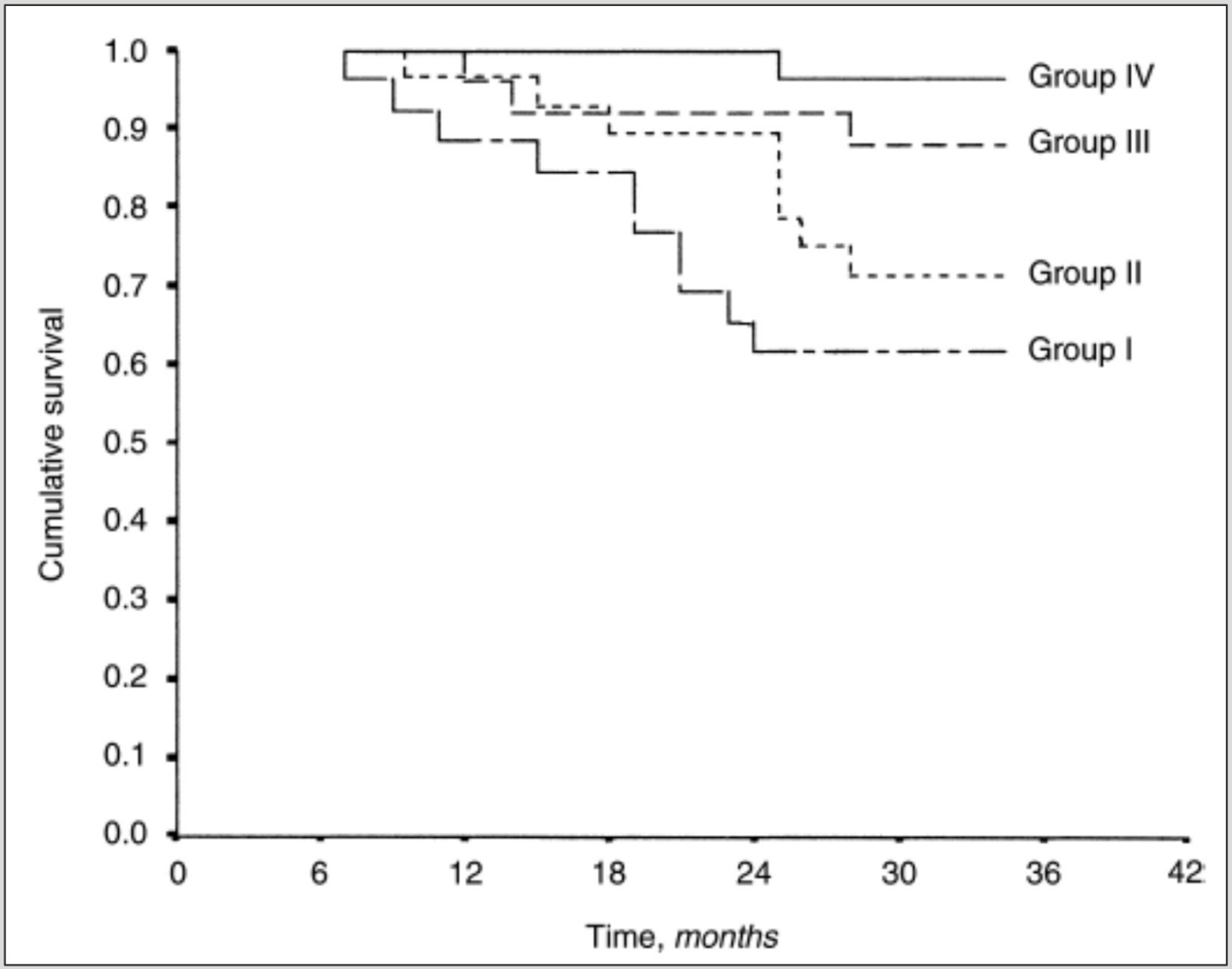
Relationship Between NT- pro- BNP and Mortality

Wang AY et al. J Am Soc Nephrol 18: 321, 2007



Patient Survival on PD Stratified by Total Fluid Removal (ml/ 1.73 m^2/ day)

Ateş et al. Kid Int 60: 767, 2001



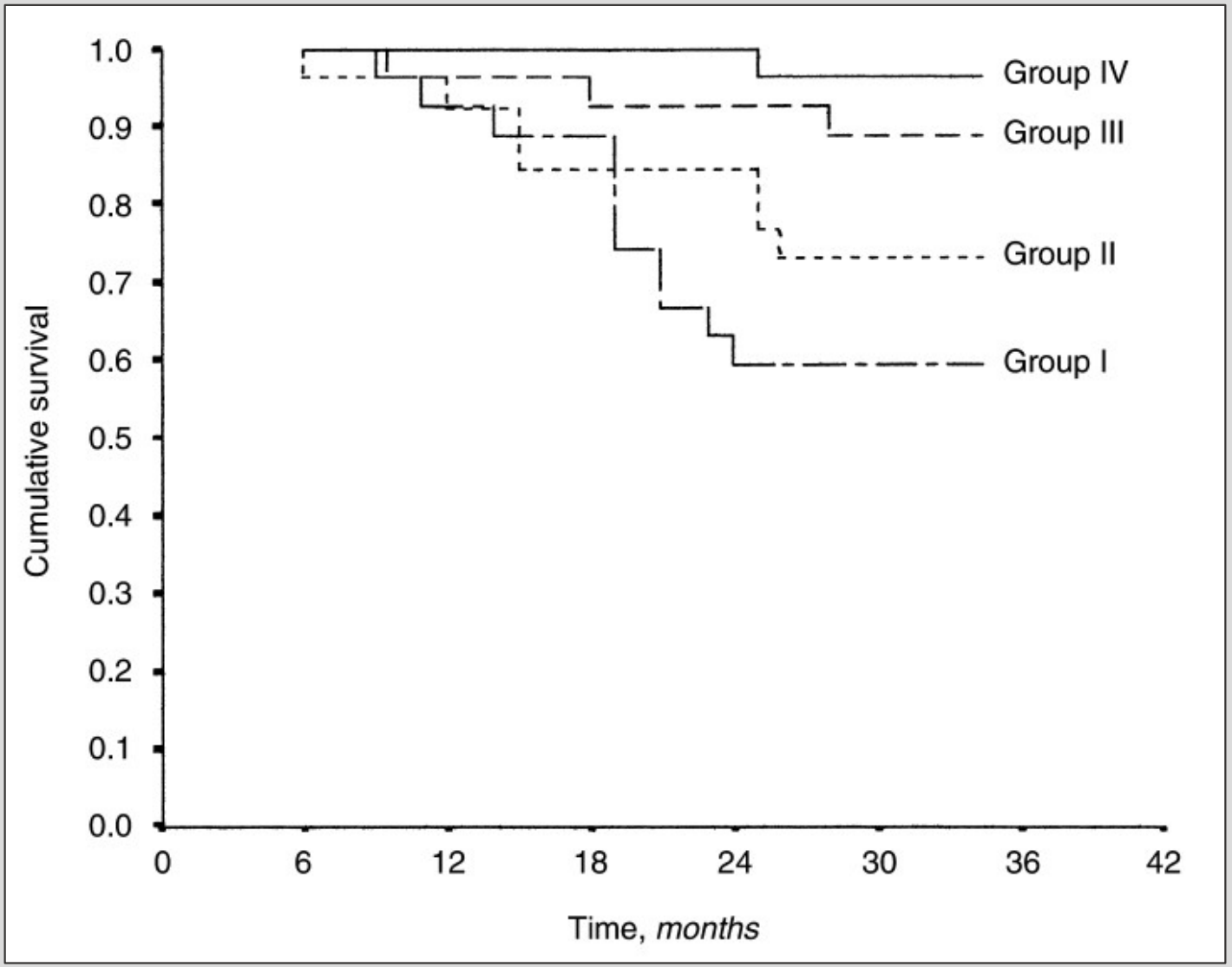
> 2035

p < 0.01

< 1265

Patient Survival on PD Stratified by Total Sodium Removal (ml/ 1.73 m^2/ day)

Ateş et al. Kid Int 60: 767, 2001



> 232

p < 0.01

< 130

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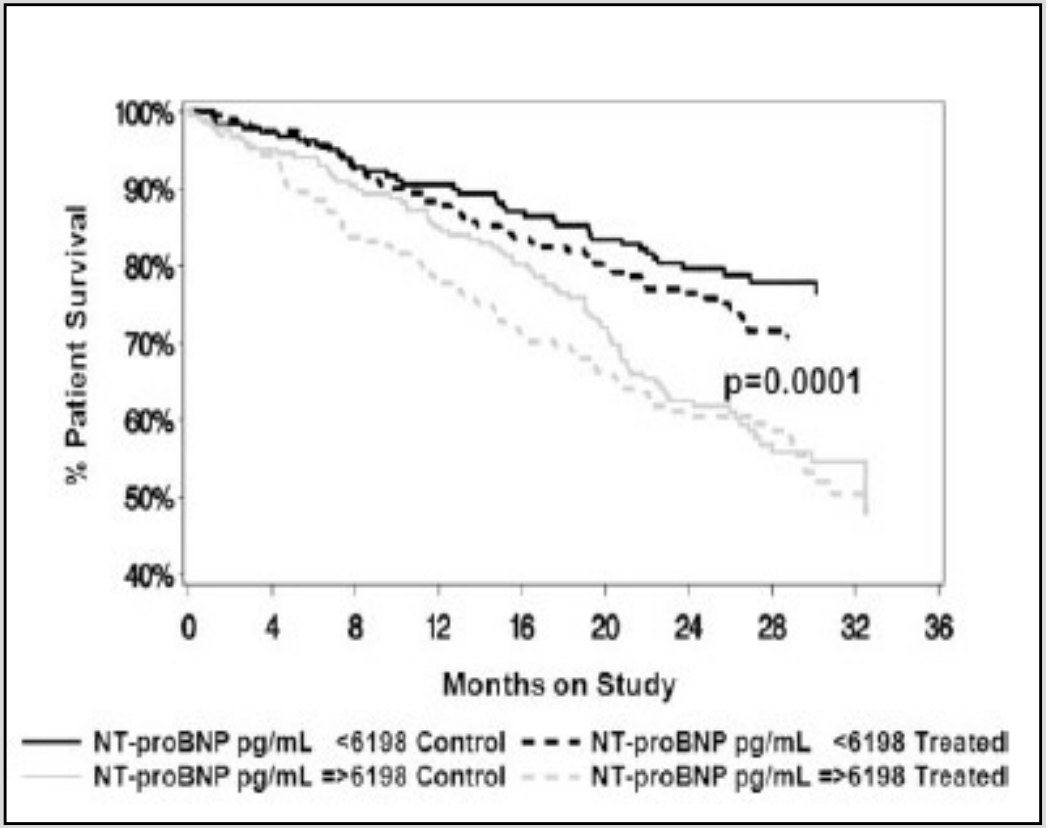
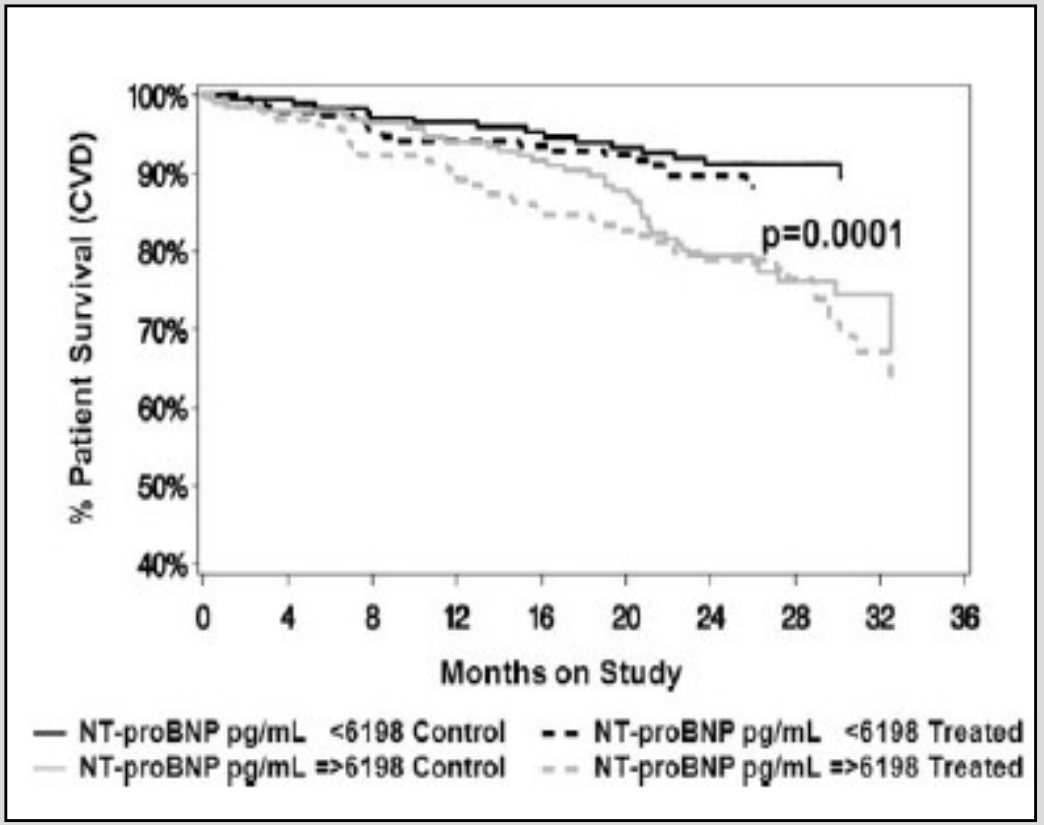
Relationship Between NT- pro- BNP and Mortality

Paniagua R et al. Clin J Am Soc Neph 3:407, 2008

All Cause Mortality



Cardiovascular Mortality



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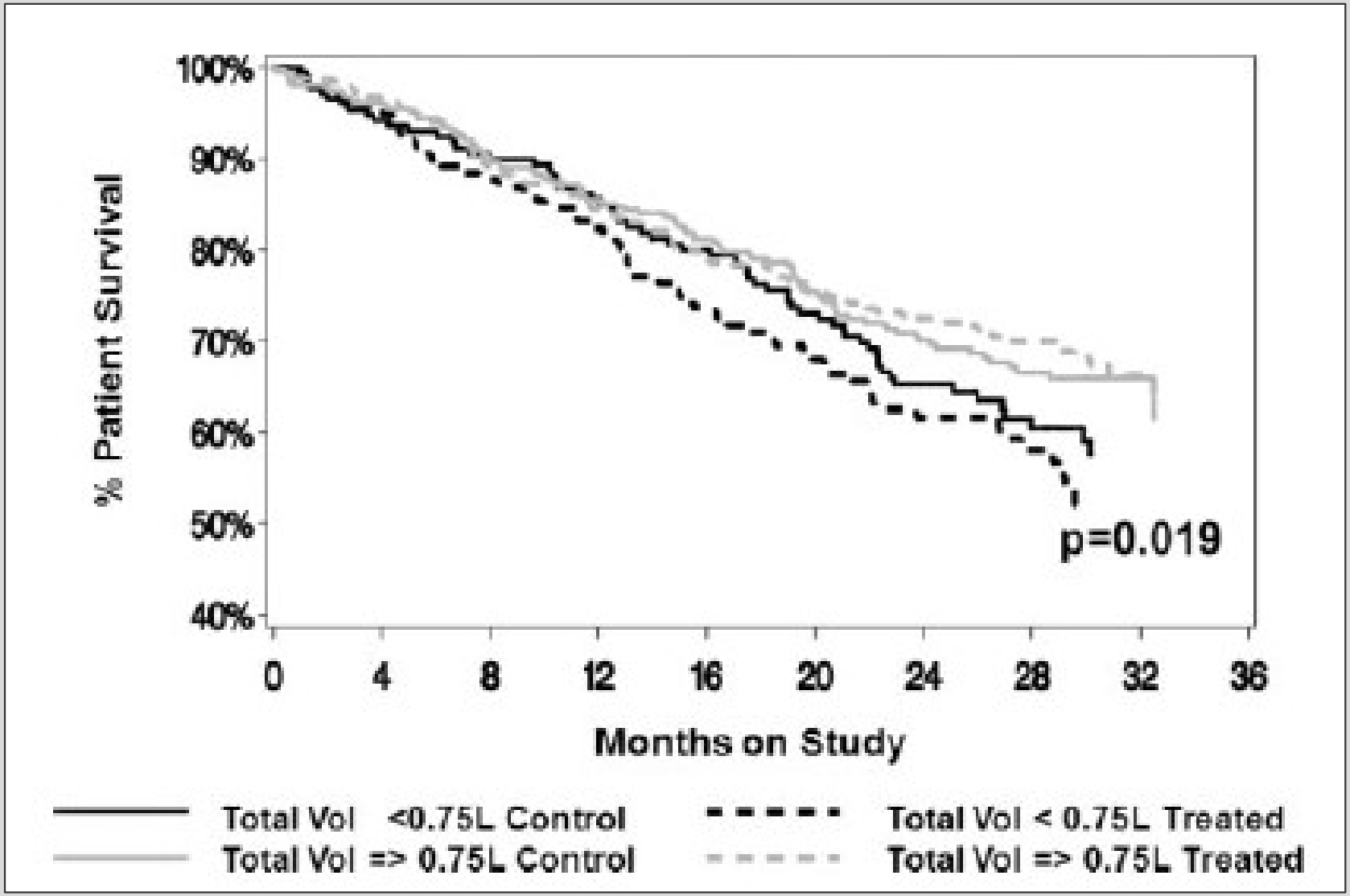
Effect of Total Fluid Removal (UF + Urine) on Mortality

Paniagua R et al. Clin J Am Soc Neph 3:407, 2008



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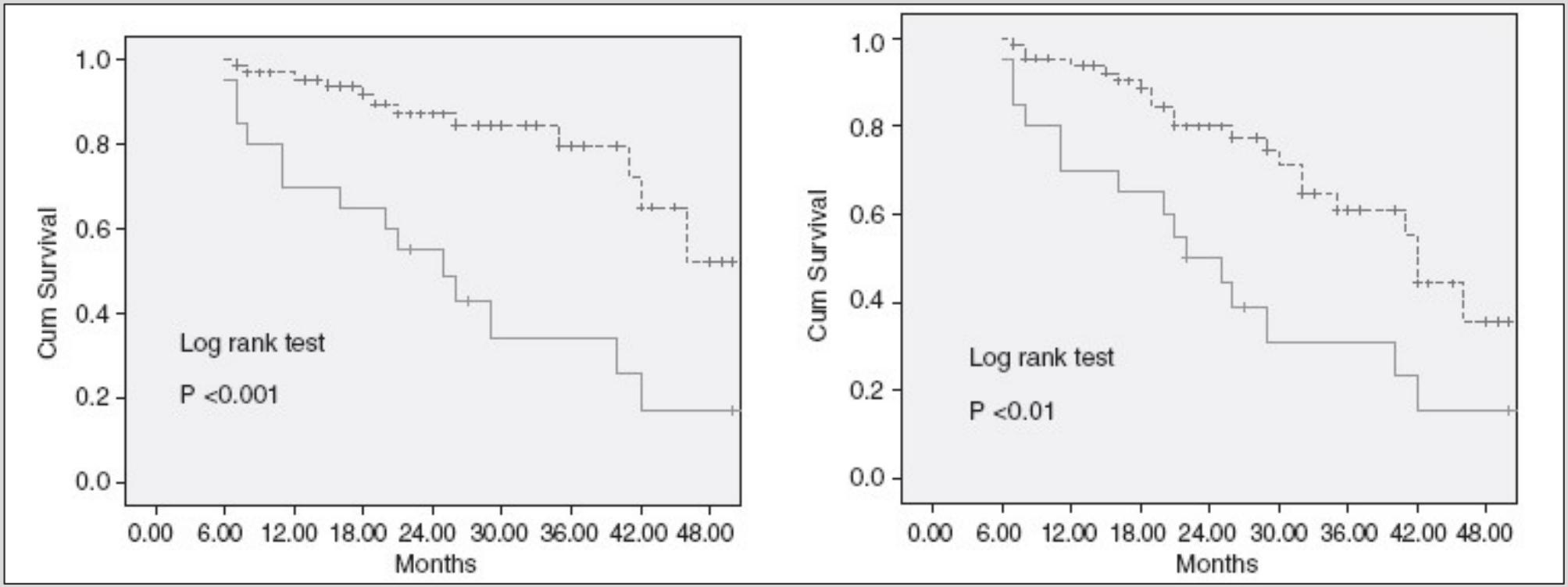
Effect of UF Volume on Patient (L) and Technique (R) Survival in Anuric PD Patients

Lin X et al. Nephrol Dial Transpl 25: 2322, 2010



≥ 1L/ day .....
< 1L/ day ——

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Independent Predictors of Mortality and Technique Failure (Cox Multivariate Analysis)

Lin X et al. Nephrol Dial Transpl 25: 2322, 2010

Mortality

	RR	95% CI	*P*-value
Age (1 year)	1.064	1.019–1.111	0.005
Serum albumin (1 g/L)	0.850	0.744–0.973	0.018
UF(t) (100 ml/24 h)	0.800	0.709–0.901	0.000

Technique Failure

	RR	95% CI	*P*-value
Serum albumin (1 g/L)	0.917	0.829–1.016	0.096
UF(t) (100 ml/24 h)	0.878	0.802–0.962	0.005
Systolic BP (mmHg)	1.127	0.985–1.291	0.083

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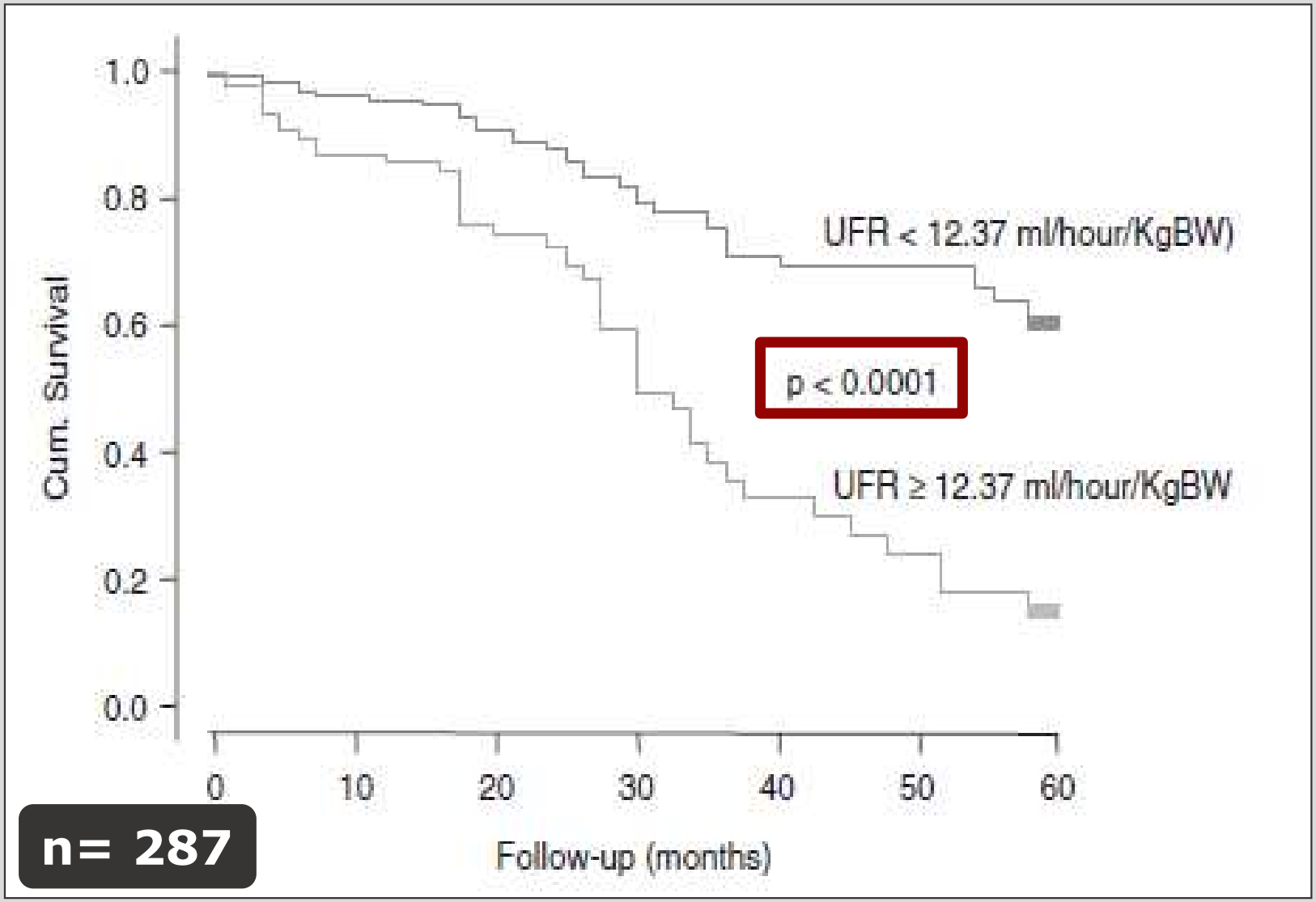
Ultrafiltration and Survival in Hemodialysis

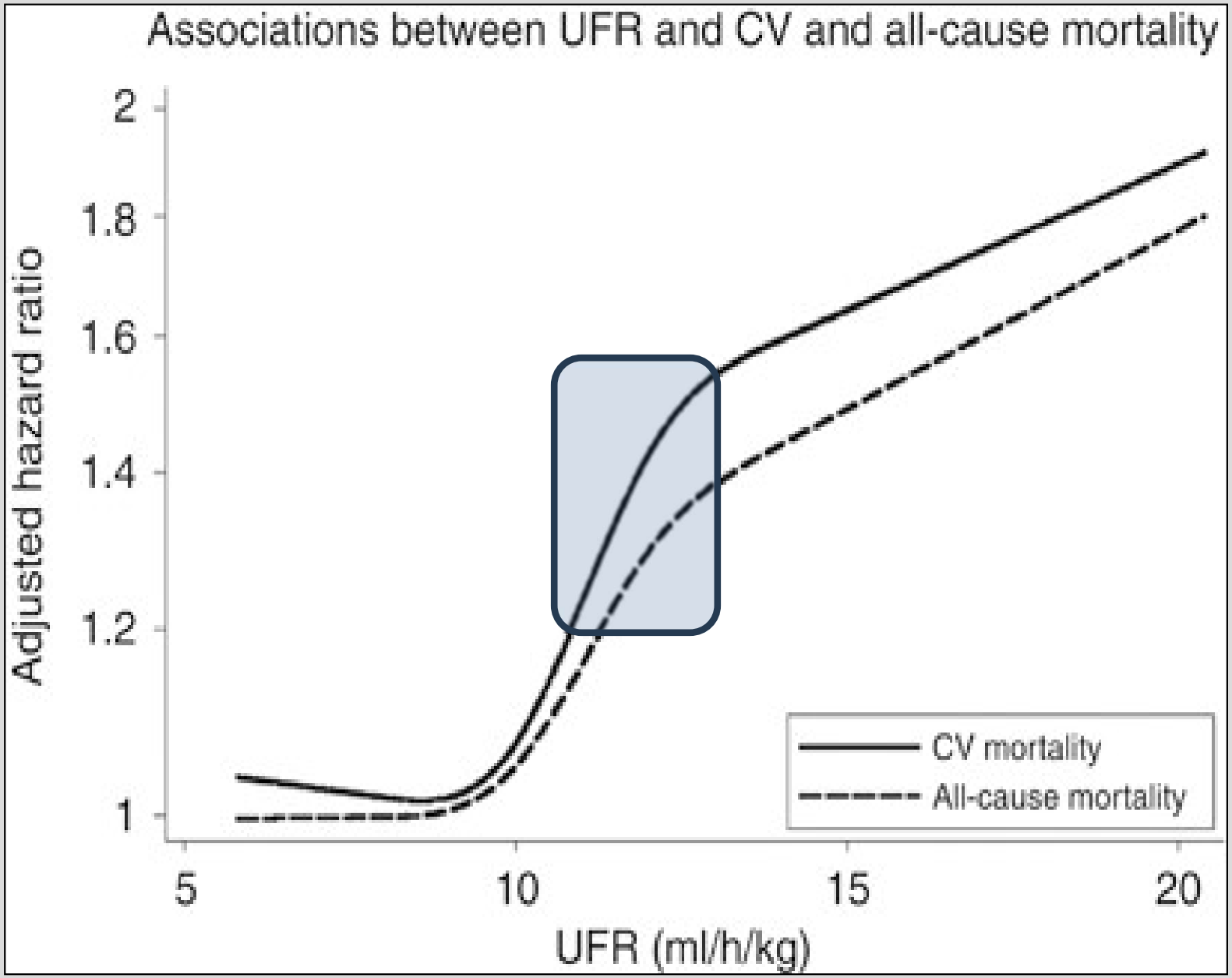
Effect of Ultrafiltration Rate on Mortality

Movilli E et al. Nephrol Dial Transplant 22:3547, 2007



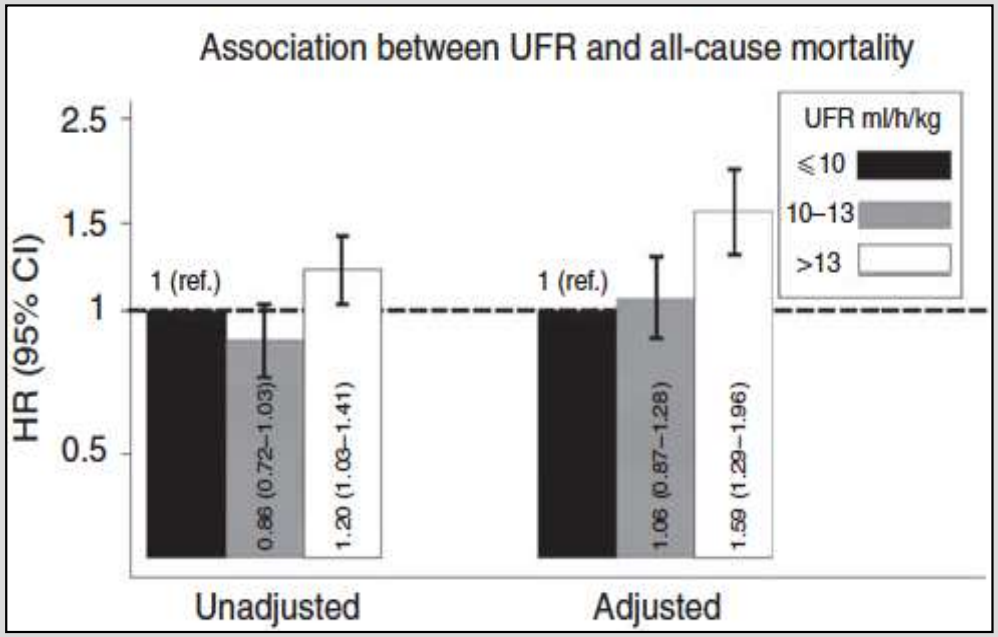
Hemodialysis: Higher UF Rates Are Associated with Increased Mortality

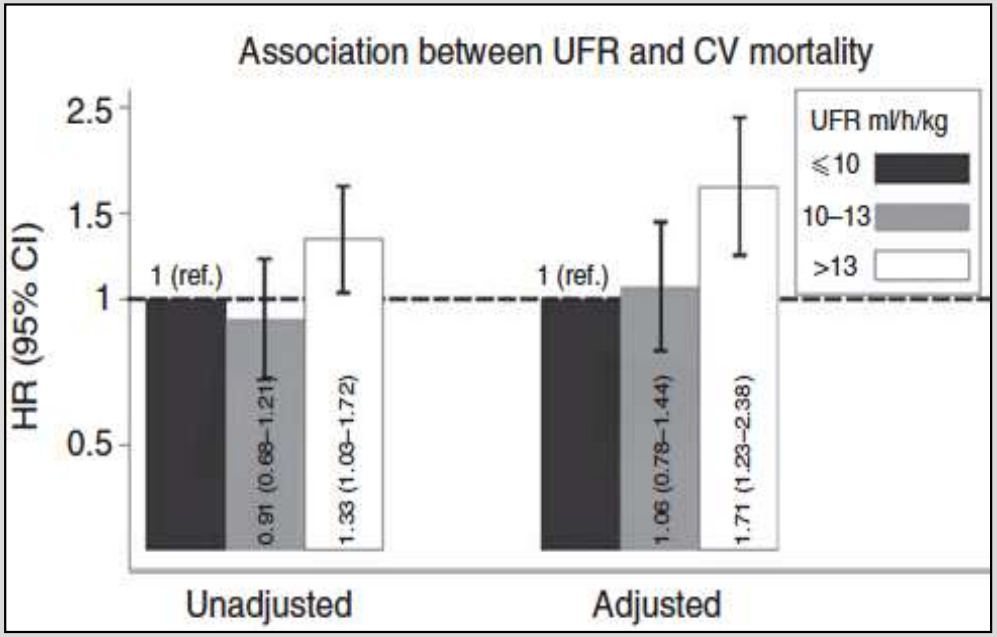
Flythe JE et al. Kid Int 79:250, 2011



Increased All- Cause (L) and CV (R) Mortality with Faster UF

Flythe JE et al. Kid Int 79:250, 2011





n=1846

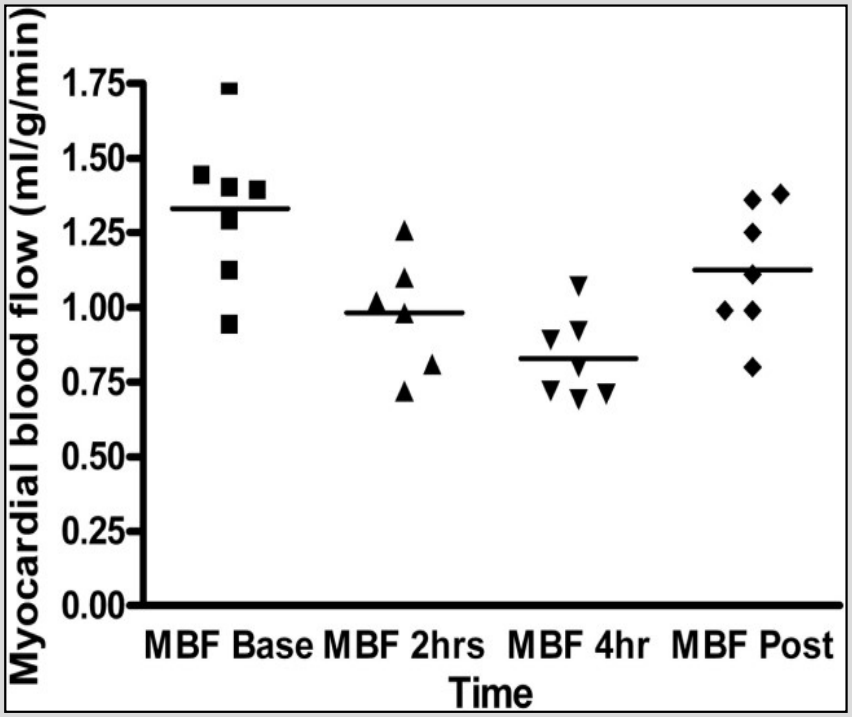
The Heart During Dialysis

McIntyre CW et al. Clin J Am Soc Nephrol 3:19, 2008; Burton JO et al. Clin J Am Soc Nephrol 4:914, 2009

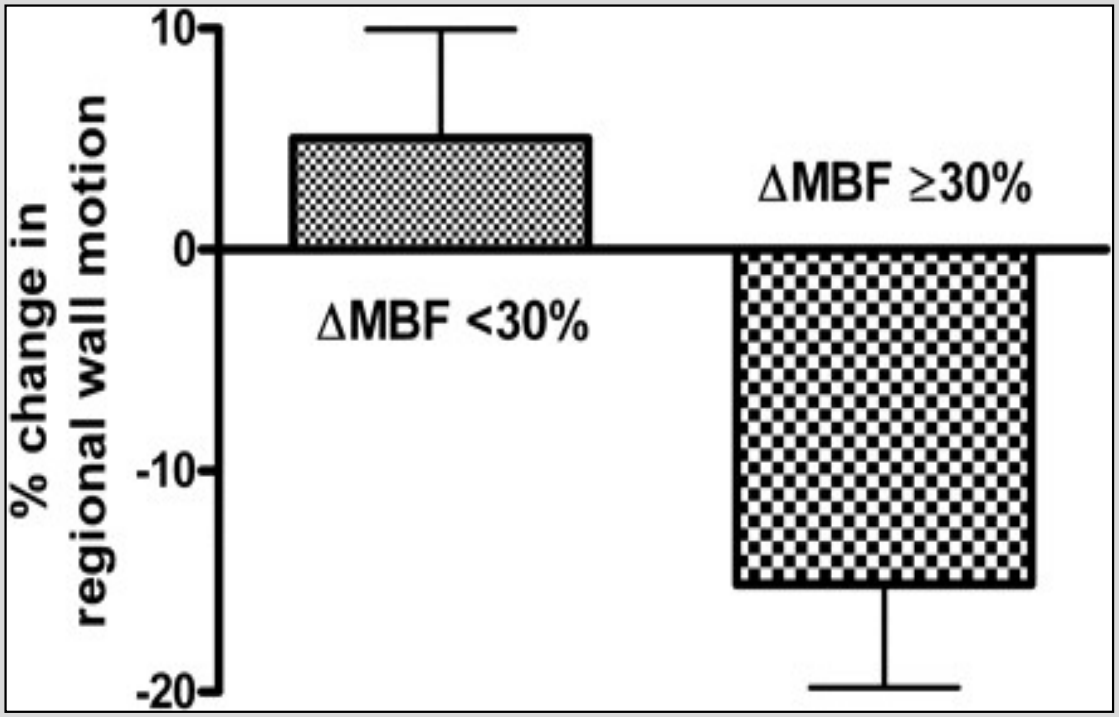
- Transient RWMAs (myocardial stunning) occur during hemodialysis and are common.
- RWMAs are related to decrease in myocardial blood flow (MBF).
- Decrease in MBF occurs during hemodialysis.
- Decrease in MBF occurs even in the absence of large vessel coronary artery disease.
- Decrease in MBF correlates with UF but also occurs without UF.

Relationship Between MBF and RWMAs During HD

McIntyre et al. Clin J Am Soc Nephrol 3:19, 2008



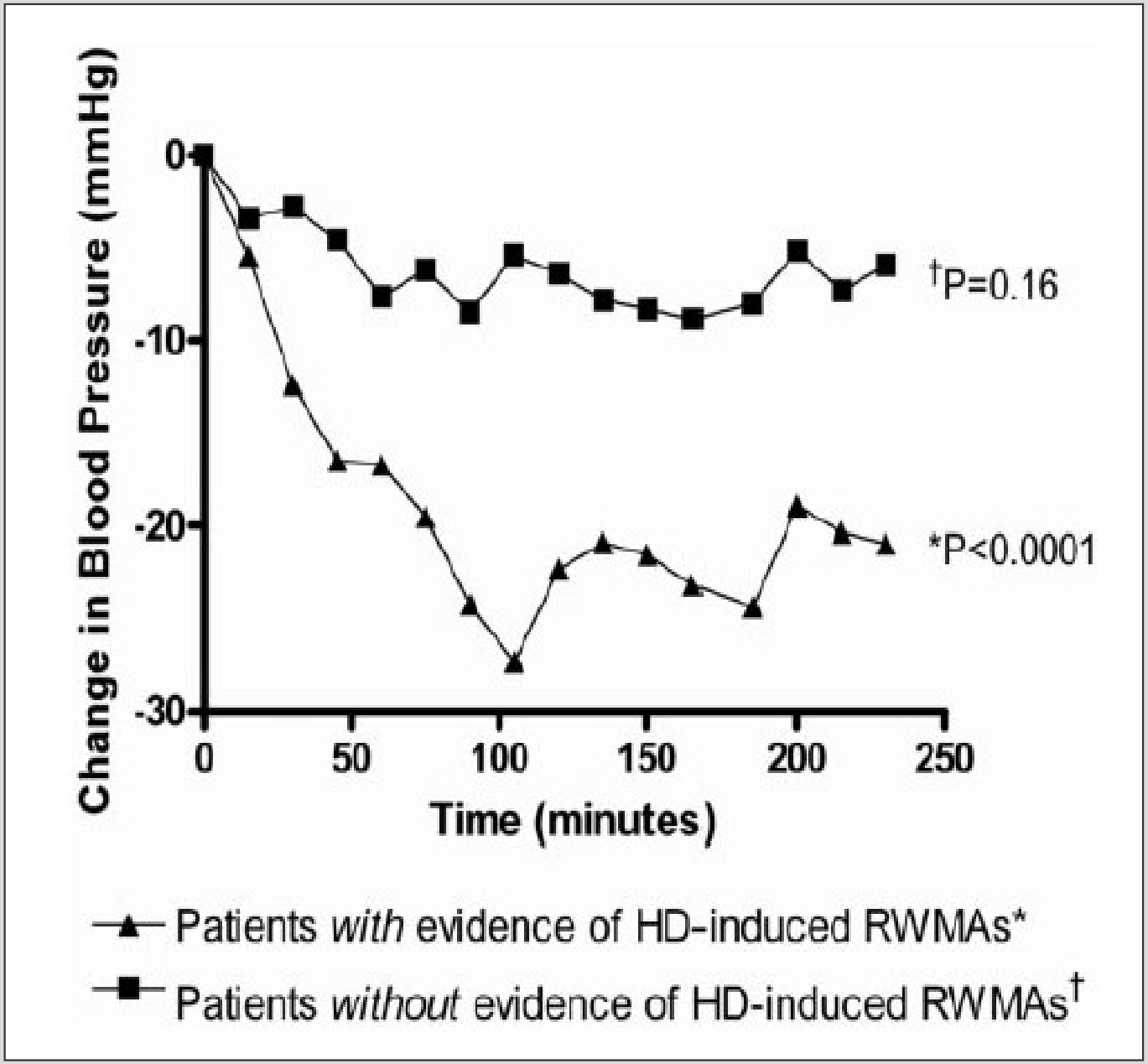
Myocardial blood flow during HD



RWMAs occur when MBF falls

Association of Low BP with RWMAs

Burton JO et al. Clin J Am Soc Nephrol 4: 914, 2009



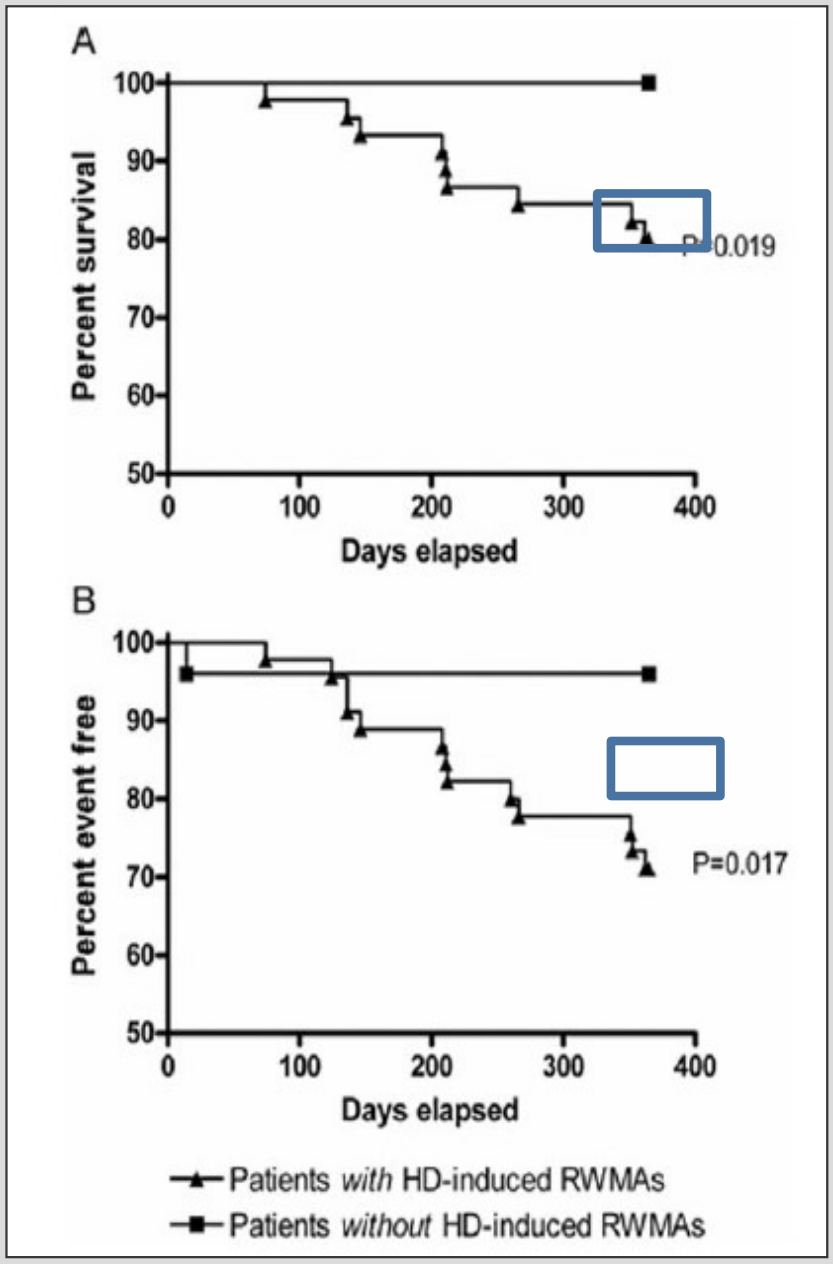
Determinants of Myocardial Stunning

Burton JO et al. Clin J Am Soc Nephrol 4: 914, 2009

Factor associated with presence of myocardial stunning	Odds Ratio
UF volume during HD of 1L	5.1
UF volume during HD of 1.5L	11.6
UF volume during HD of 2L	26.2
Maximum SBP reduction of 10 mmHg	1.8
Maximum SBP reduction of 20 mmHg	3.3
Maximum SBP reduction of 30 mmHg	6.0

Patients with RWMAs Have Worse Survival (Top) and More CV Events (Bottom)

Burton JO et al. Clin J Am Soc Nephrol 4: 914, 2009



Patients without RWMA: ZERO died

Patients with RWMA: 28% died

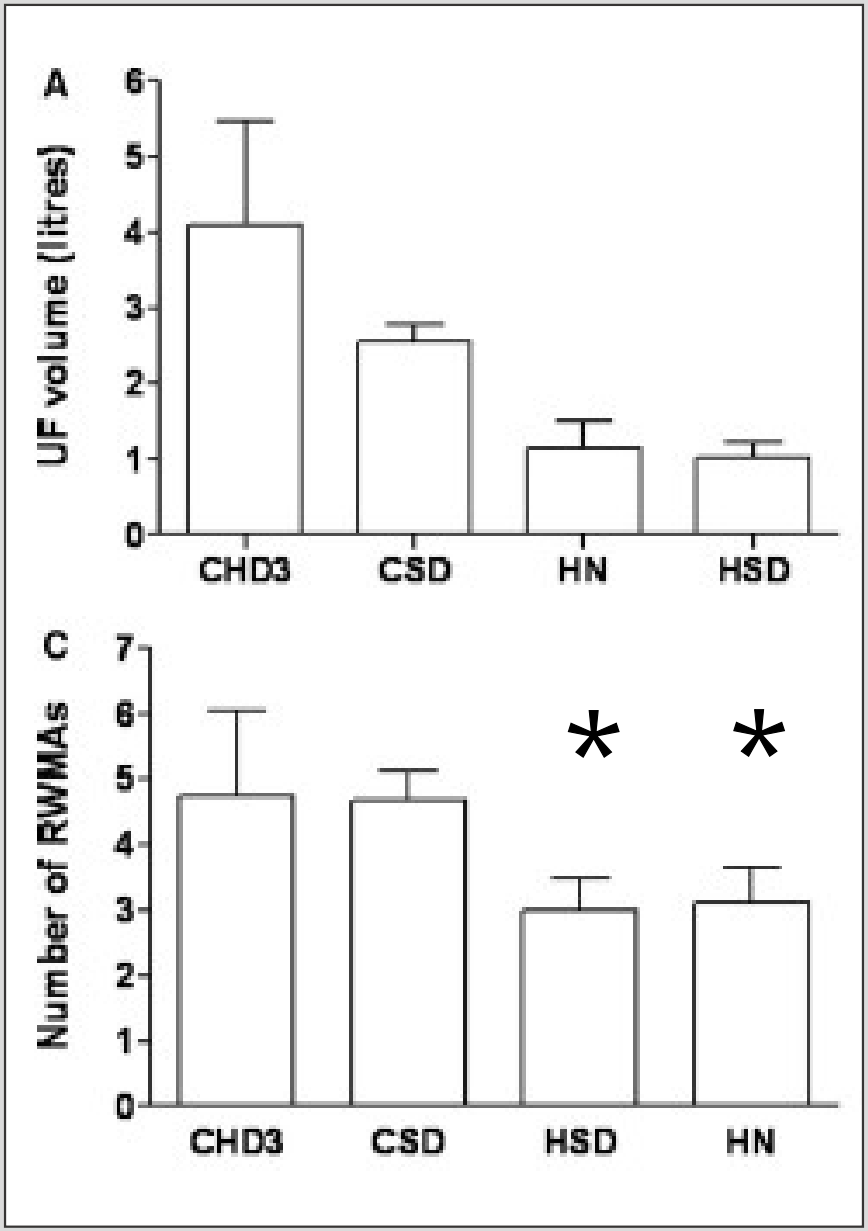
HR for mortality = 8

What Can We Do to Prevent RWMAs?

- Decrease UF rates
- Avoid intradialytic hypotension
  - More frequent hemodialysis
  - Cool dialysate
- Use diuretics to decrease inter-dialytic weight gain and intra-dialytic fluid removal
  - ? Outcome studies

Decreased Myocardial Stunning with Frequent Dialysis

Jefferies HJ et al. Clin J Am Soc Nephrol 6:1326, 2011



CHD3- center, thrice weekly

CSD- center, short daily

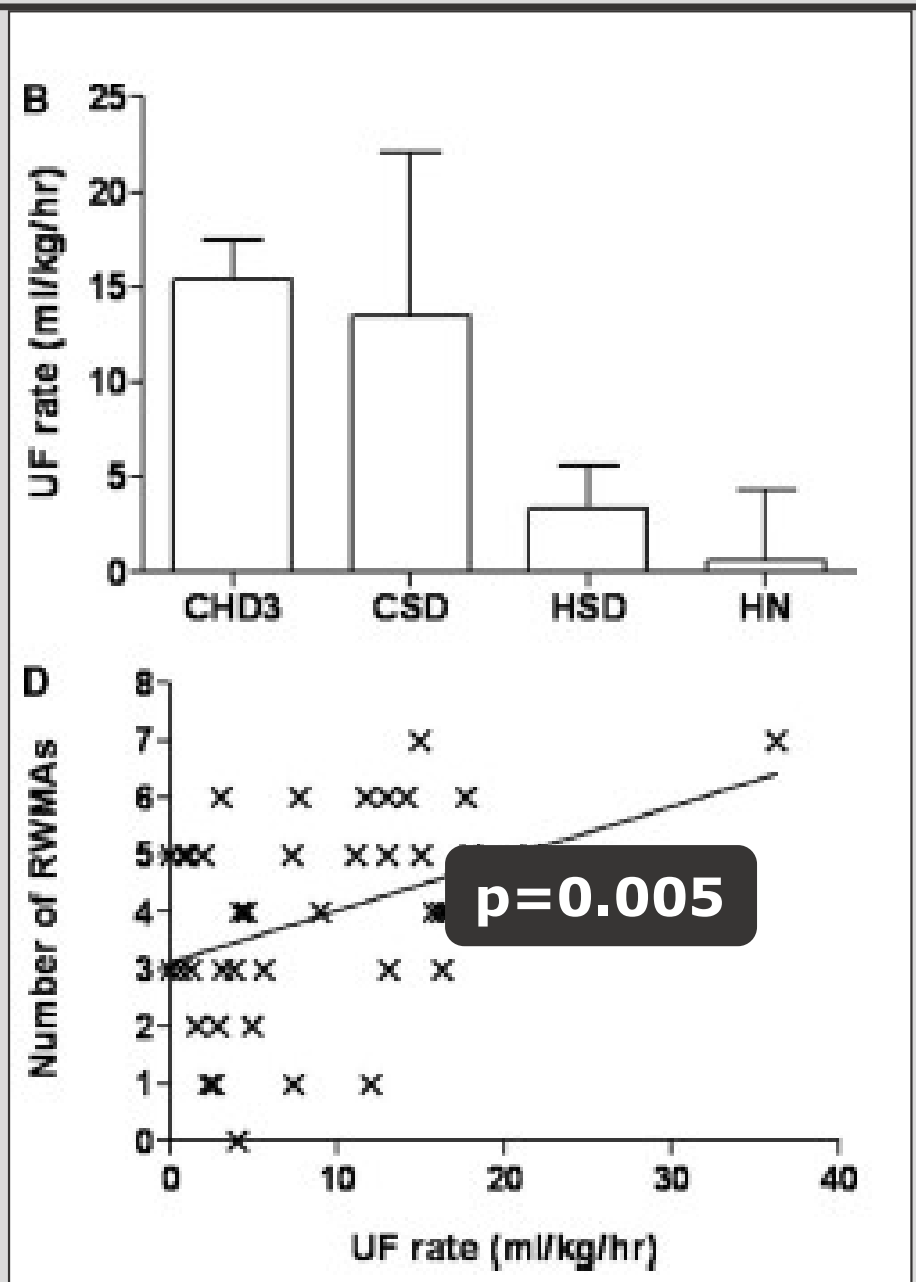
HN- home, nocturnal

HSD- home, short daily

* p< 0.001 vs. CHD3

Relationship Between RWMAs and UF

Jefferies HJ et al. Clin J Am Soc Nephrol 6:1326, 2011



CHD3- center, thrice weekly

CSD- center, short daily

HN- home, nocturnal

HSD- home, short daily

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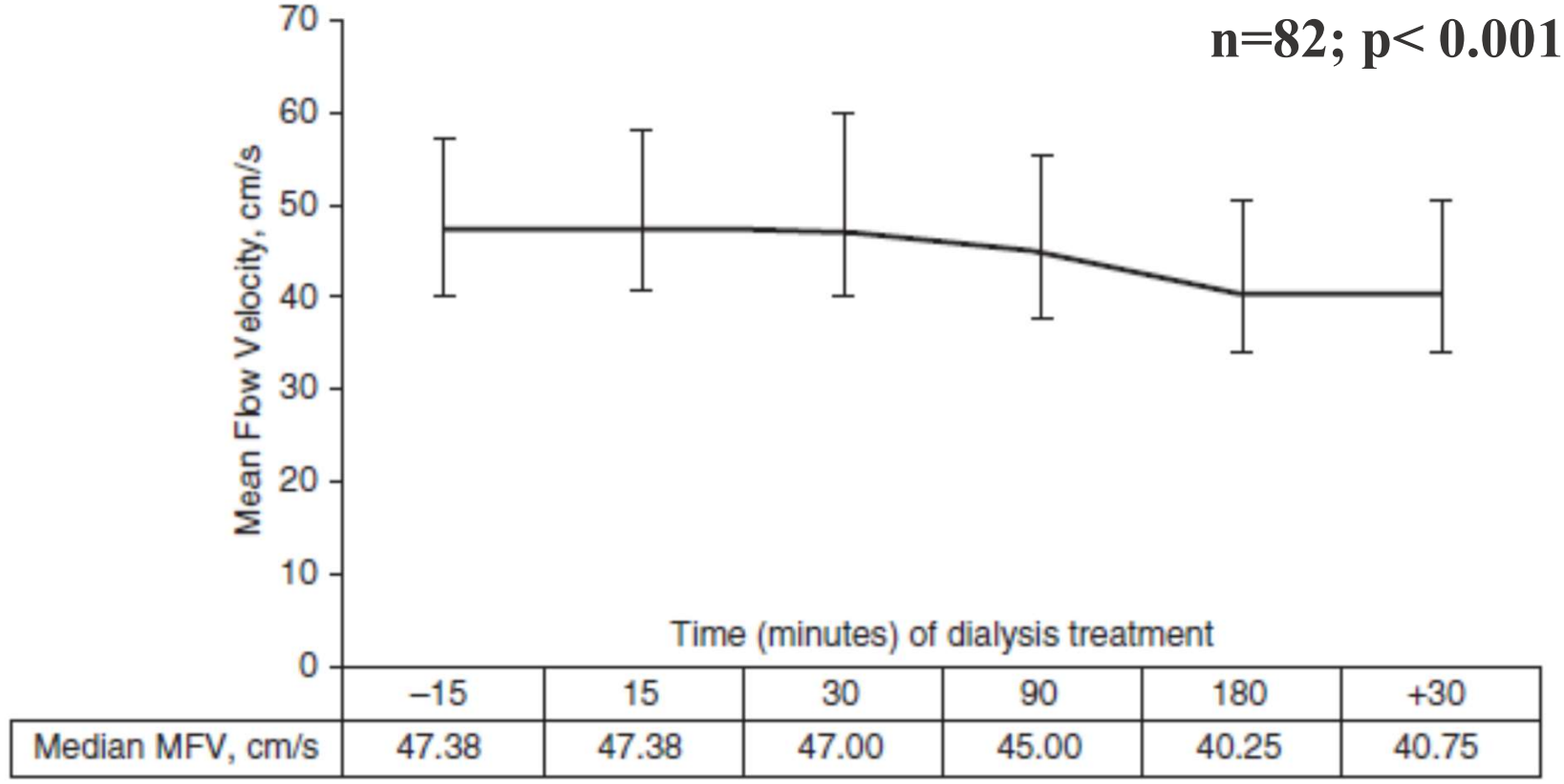
Peritoneal Dialysis Is Not Associated with Myocardial Stunning

Selby and McIntyre. Perit Dial Int 31:27, 2011

- 10 non-diabetic patients were studied during a 3.86% glucose dwell
- LVEF and regional wall motion abnormalities (RWMA; 10 regions per patient) were assessed by echocardiography
- Fractional shortening actually ***increased*** during PD:
  - 2 chamber: 3.06 to 4.26%; p= 0.001
  - 4 chamber: 3.00 to 3.67%; p= 0.021
- Only 5/100 RWMAs ; 6 patients with none, no patient with > 2

Cerebral Blood Flow during Hemodialysis

Findlay MD et al. J Am Soc Nephrol 30:147, 2019



	–15	15	30	90	180	+30
Median MFV, cm/s	47.38	47.38	47.00	45.00	40.25	40.75

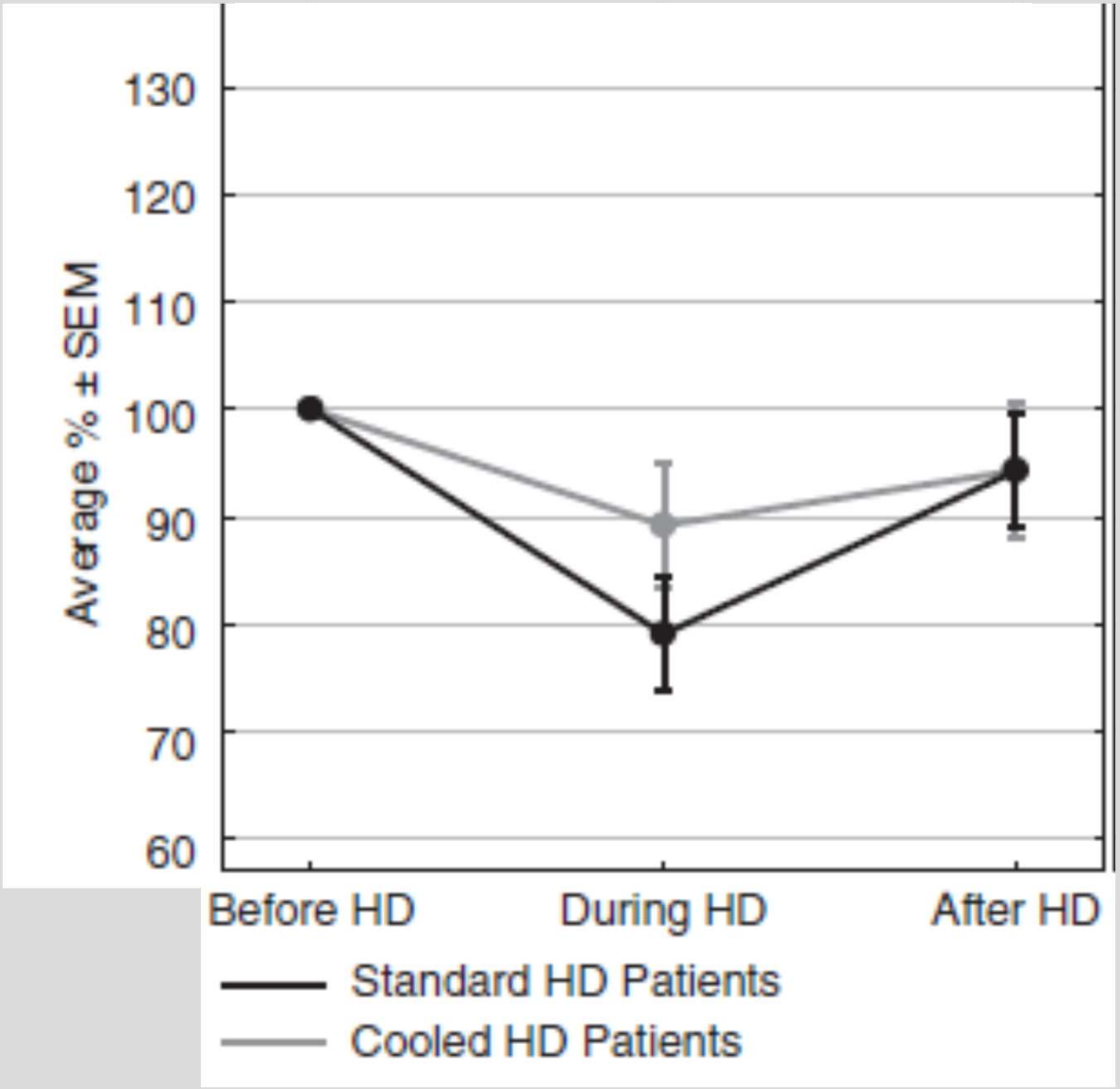
Determinants of Cerebral Flow Velocity in HD

Findlay MD et al. J Am Soc Nephrol 30:147, 2019

Variable	Spearman Rho	*P* Value
Ultrafiltration volume, ml	0.512	<0.001
Ultrafiltration rate, ml/h	0.493	<0.001
ΔSBP, mm Hg (pre−post)	0.196	0.08
ΔDBP, mm Hg (pre−post)	0.163	0.14
ΔWeight, kg (pre−post)	0.463	<0.001
ΔMAP, mm Hg (pre−post)	0.219	0.05
Diabetes mellitus	−0.304	0.005

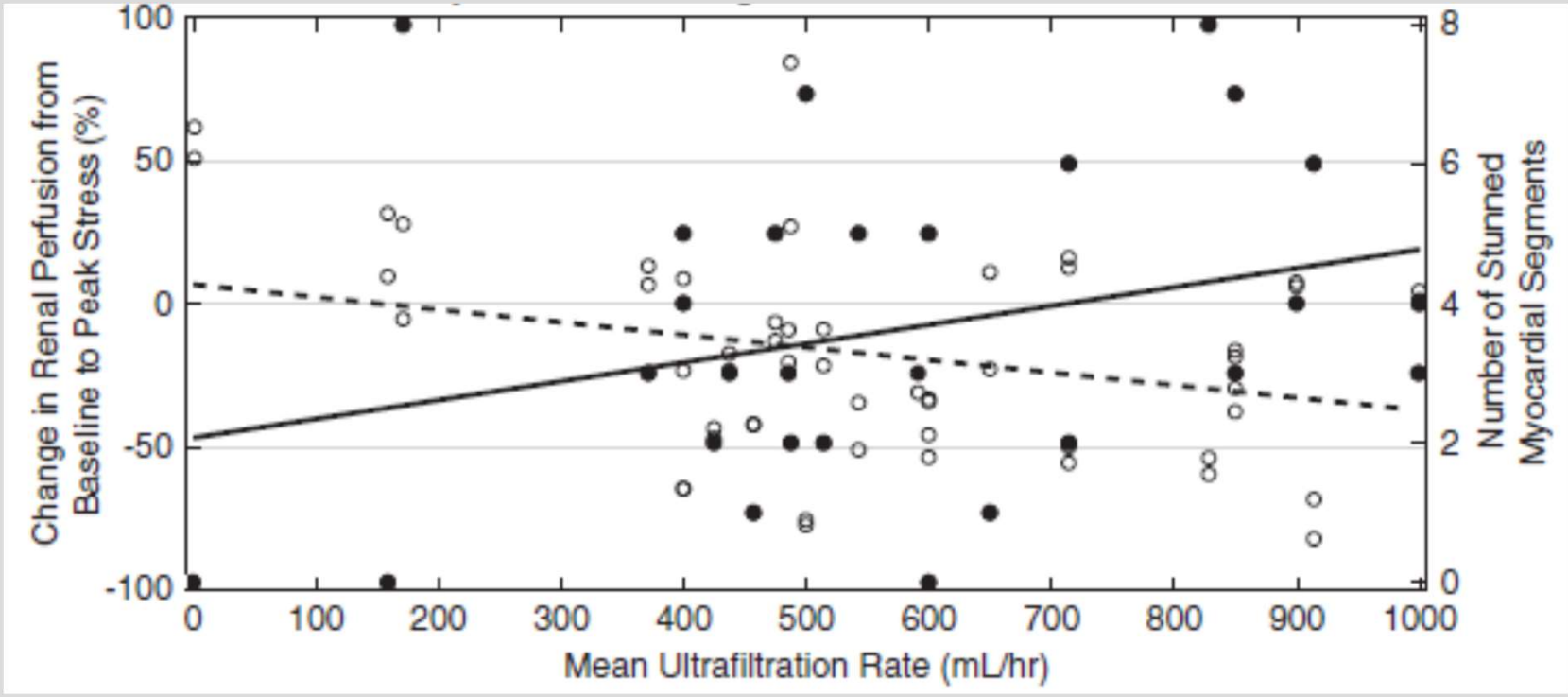
Effect of Hemodialysis on Renal Blood Flow

Marants R et al. J Am Soc Nephrol 30:1086, 2019



Relationship between UFR, RBF, and Myocardial Stunning (MS)

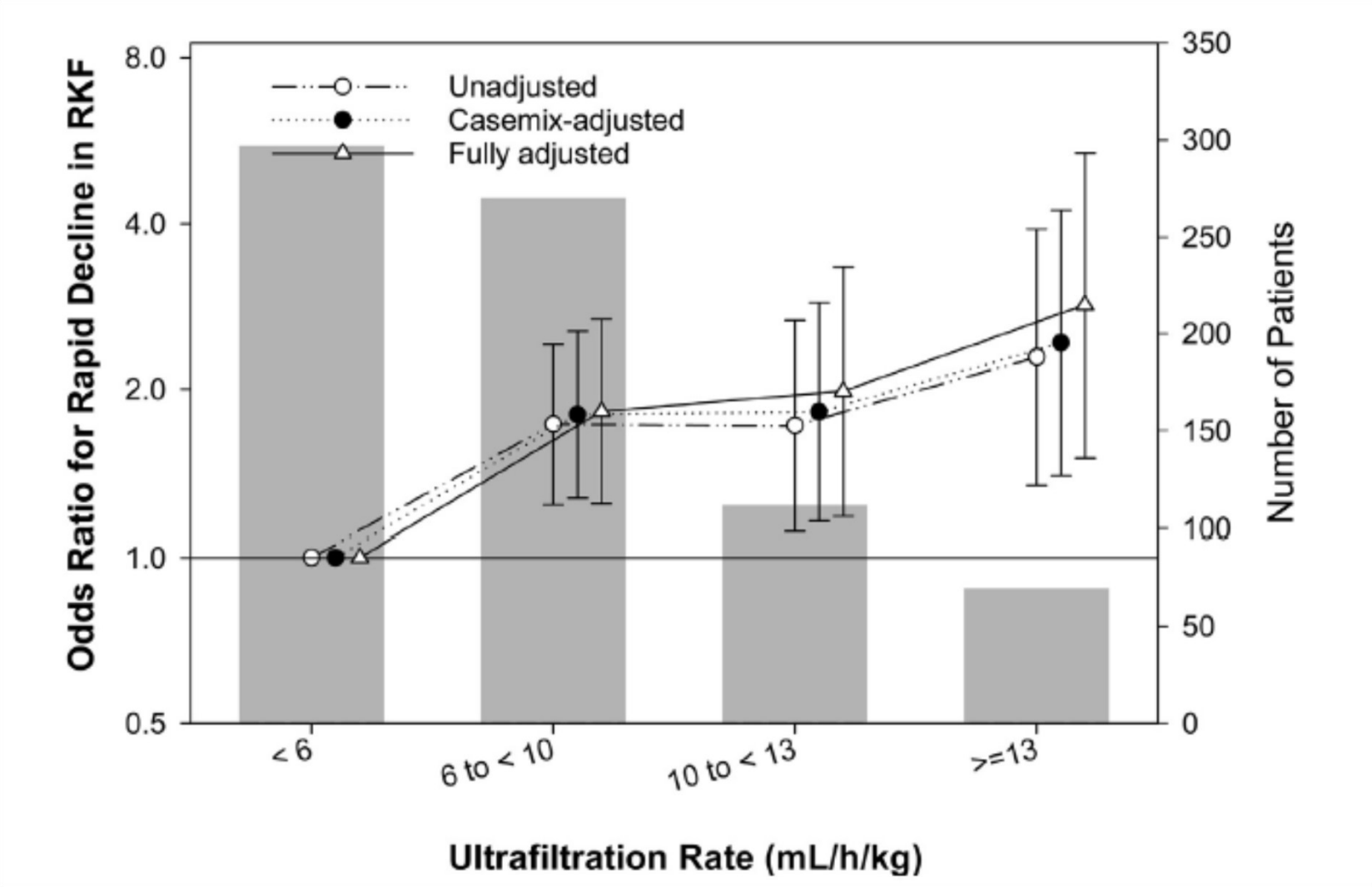
Marants R et al. J Am Soc Nephrol 30:1086, 2019



p <0.05 for changes in both RBF and MS

Relationship between UFR and Loss of RKF

Lee YJ et al. Am J Kid Dis 75:342, 2020



Rapid loss of RKF defined as rate of loss of KRU (mL/min) > median

Approach to the Hemodialysis Patient with Volume Overload

Volume Overload in the HD Patient Is Either…

- Too much in
  - Excessive inter-dialytic weight gain; too great to remove safely in the allotted time
- Not enough out
  - As above…
  - Volume removal limited by hypotension

How to Deal with Inadequate Volume Removal

- Extra treatments
  - ? SDHD
- Longer treatments
  - Consider nocturnal HD
- Concern that patient is being "rewarded" for non-compliance; how many patients really feel that additional treatments or extra-long treatments are a "reward"?

How to Deal with Inadequate Volume Removal on HD

- Longer treatments
  - Consider nocturnal HD
- Additonal UF only treatments
  - Baby K or Tablo; not NxStage
- Extra treatments
  - ? SDHD
- Concern that patient is being "rewarded" for non-compliance; how many patients really feel that additional treatments or extra-long treatments are a "reward"?

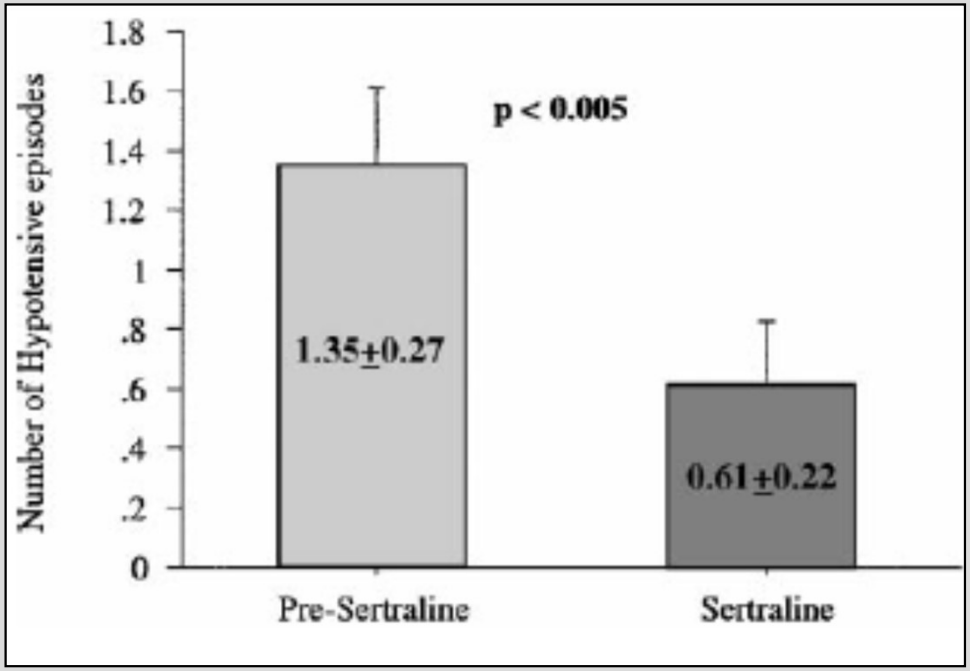
When Volume Removal Is Limited by Hypotension: Dialytic Strategies

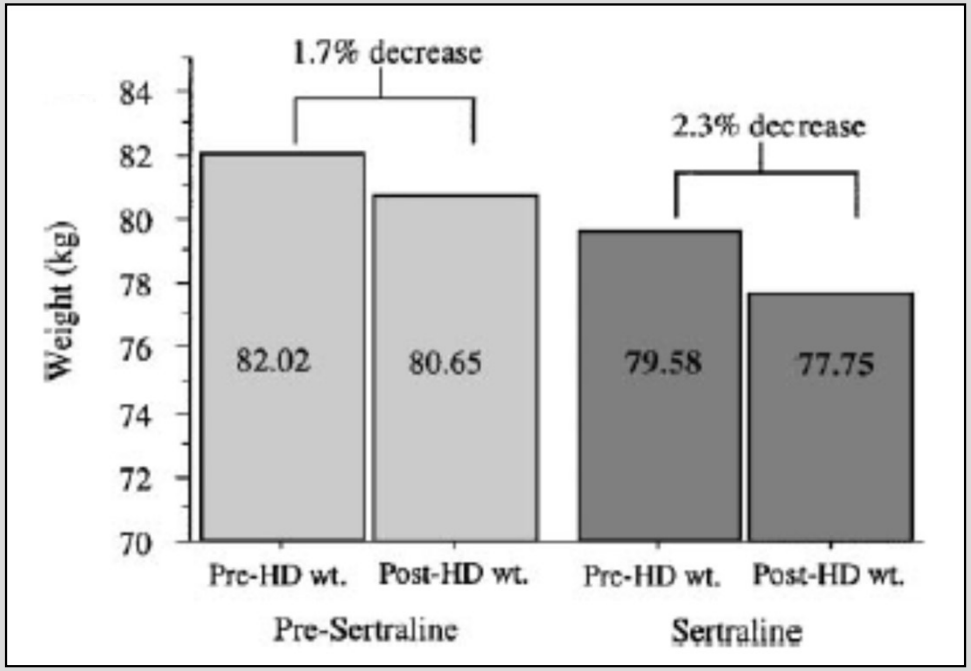
- Cool dialysate- patients don't commonly appreciate T <35.5° C
- No BP meds pre dialysis
- Avoid eating during treatment
- Slow down BFR- will negatively impact solute dialysis
- Increase dialysate Na- will stimulate thirst so should use step-wise modeling; no longer recommended.
- Separate UF from solute removal e.g. 1-2 hours pure UF followed by HD? Not effective when studied (Kid Int 59:1175, 2001)

When Volume Removal Is Limited by Hypotension: Medical Therapy

Sheenan S et al. Am J Kid Dis 31:624, 1998

- Support BP with midodrine (10-20 mg) or pseudoephedrine (60-120 mg) pretreatment; may need to re-dose mid run
- Patients on sertraline may experience less intradialytic hypotension (IDH)





Other Drugs Used to Limit IDH

- Caffeine/adenosine agonists
- Carnitine
- Intranasal lysine vasopressin

Strategies to Limit Excessive Interdialytic Weight Gain

- Avoid high dialysate sodium, particularly at end of procedure
- Use diuretics
- You can't give too much education or repeat it often enough…limit fluid intake!
- Incentivize patients
  - "Dialysis dollars" for patients who are compliant with their dialysis regimen and with interdialytic weight gain

Approach to the Peritoneal Dialysis Patient with Volume Overload

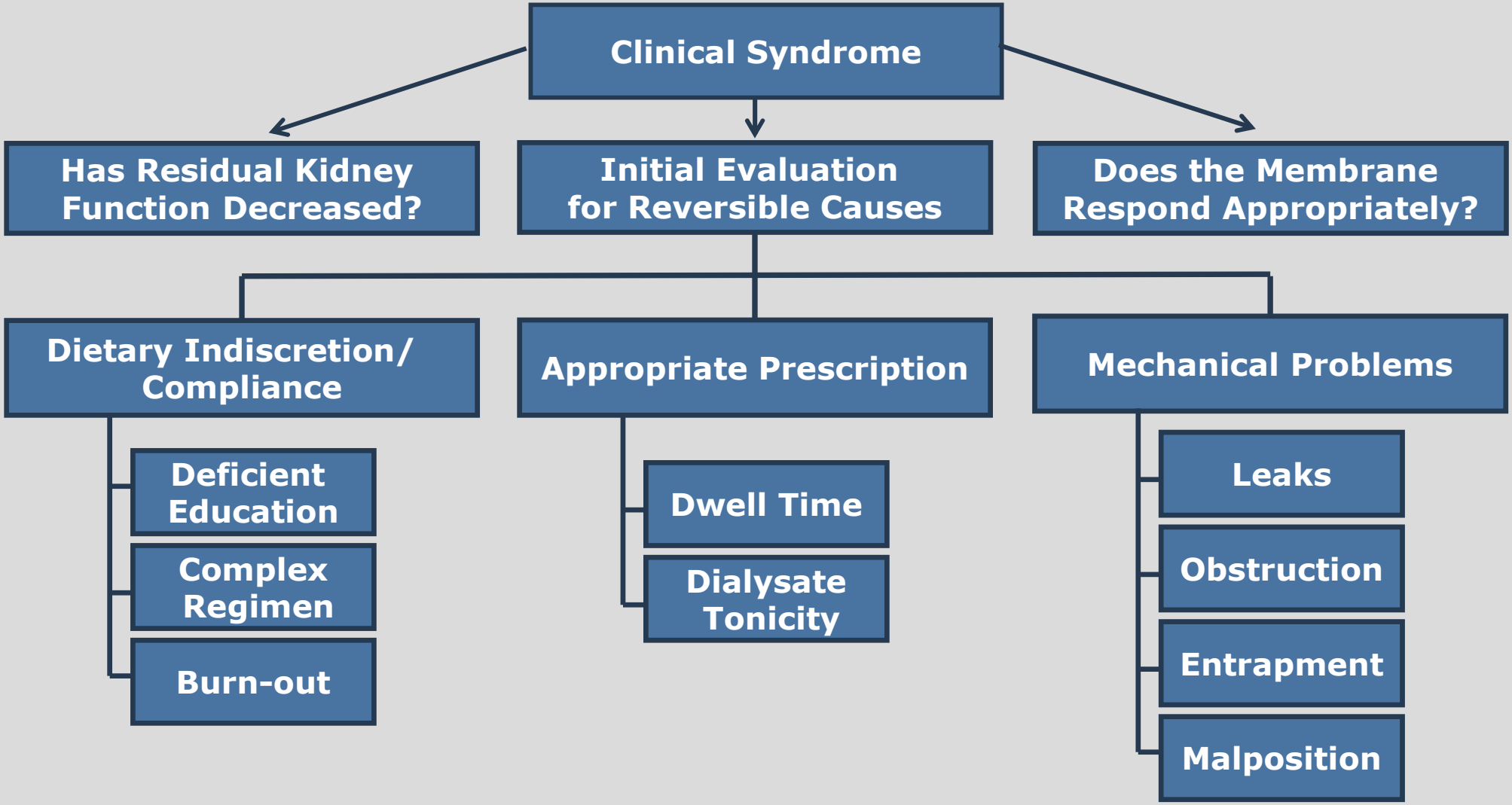
Ultrafiltration Failure: Definitions

- Clinical
  - Failure to maintain volume homeostasis despite fluid restriction and use of at least 3 hypertonic (2.5 or 4.25%) exchanges per day

- Technical definition of peritoneal membrane dysfunction
  - Less than 400 mL UF after 4 hour dwell with 2L of 4.25% dialysate

Approach to the Patient with Volume Overload- 1

Mujais et al. Perit Dial Int 20: S5, 2000



Factors Affecting Fluid Balance: Non-Compliance

- Dietary non- compliance
  - Na and fluid
- PD treatment non- compliance
  - Missed exchanges
  - Skipped cycler nights
  - Draining inflow volume directly into drain bag

Consequences of Hyperglycemia that Adversely Affect UF

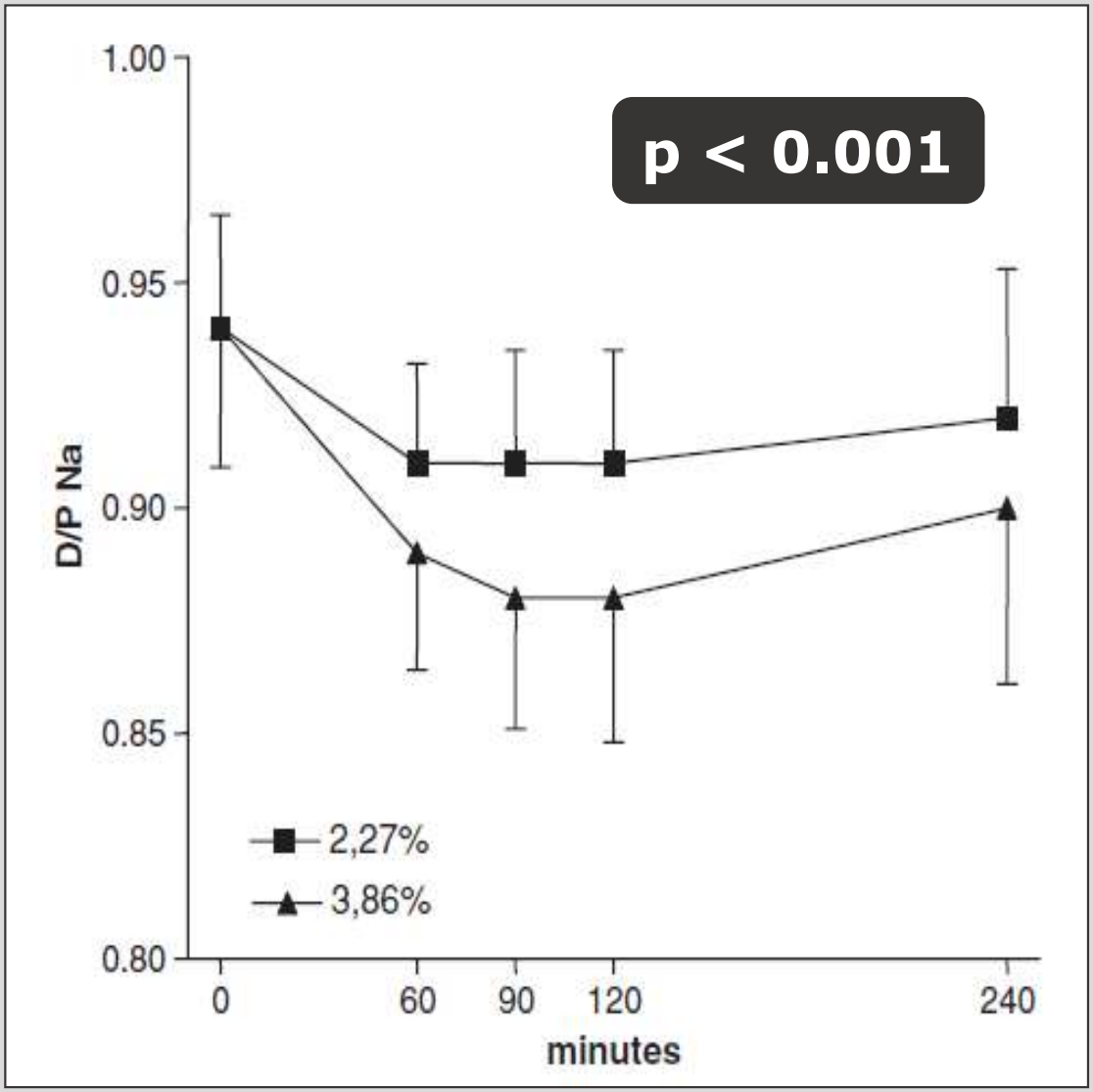
- Hyperosmolality causing increased thirst
- Hyperinsulinemia with increased tubular reabsorption of Na
- Decreased osmotic gradient for UF
- Nevertheless, trials with low glucose fluids, while lowering HbA1C, did not demonstrate better volume control- to the contrary (Li et al. J Am Soc Nephrol. 24:1889, 2013)

Inappropriate PD Prescription

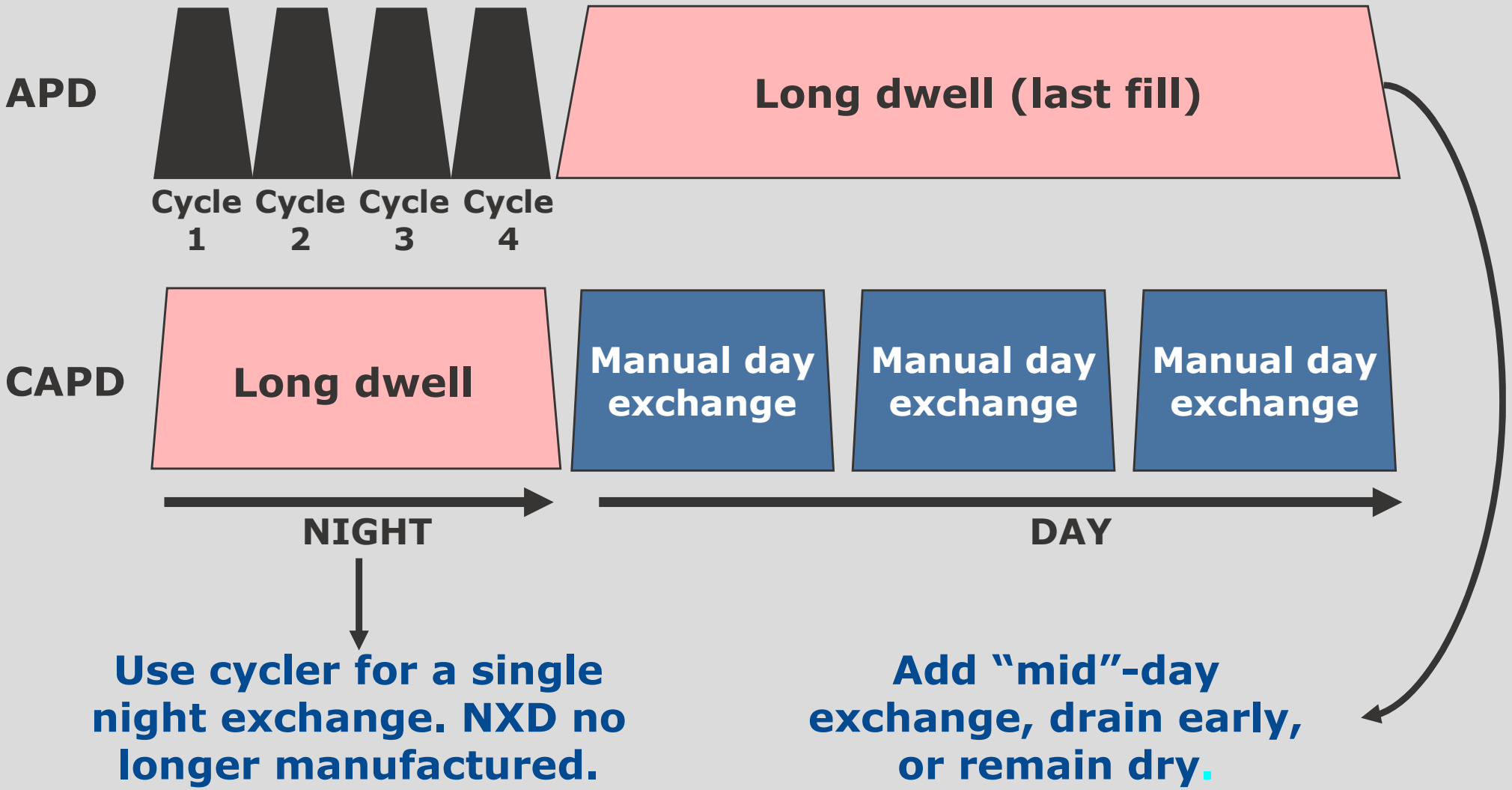
- Often becomes apparent only when RKF is lost
- Clinical Features:
  - History unremarkable except for previous PET and recent decrease in urine output
  - No mechanical problems with rapid in and out exchange
  - No change in peritoneal transport on 4.25% PET
- Due to fluid absorption during long dwells
  - Rx: shorten dwell, hypertonic fluids, icodextrin
- Due to excessive Na sieving (hypernatremia, increased thirst)
  - Rx: lengthen duration of cycler dwells.

Changes In Dialysate Sodium During Dwell (Sodium Sieving)

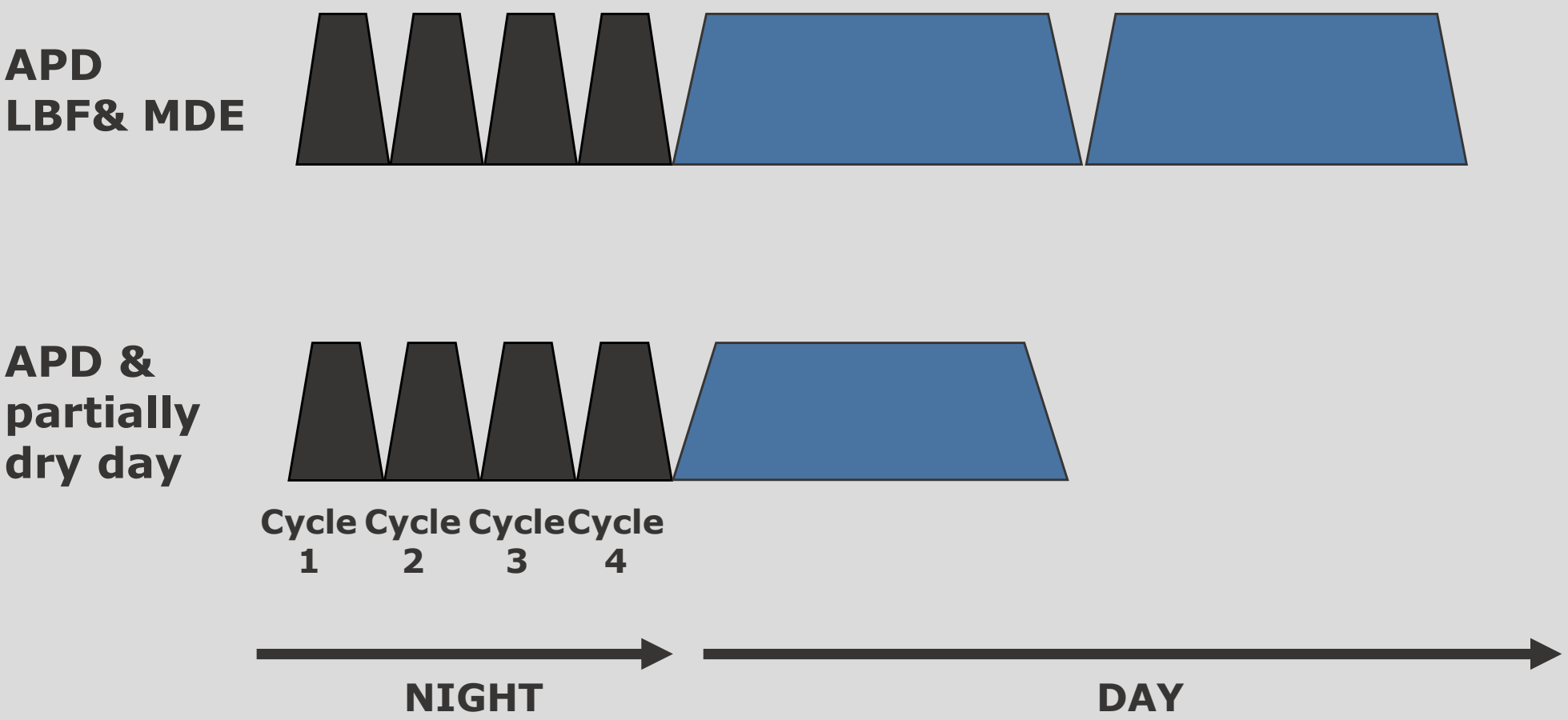
Gomes AM et al. Nephrol Dial Transpl 24:3513, 2009



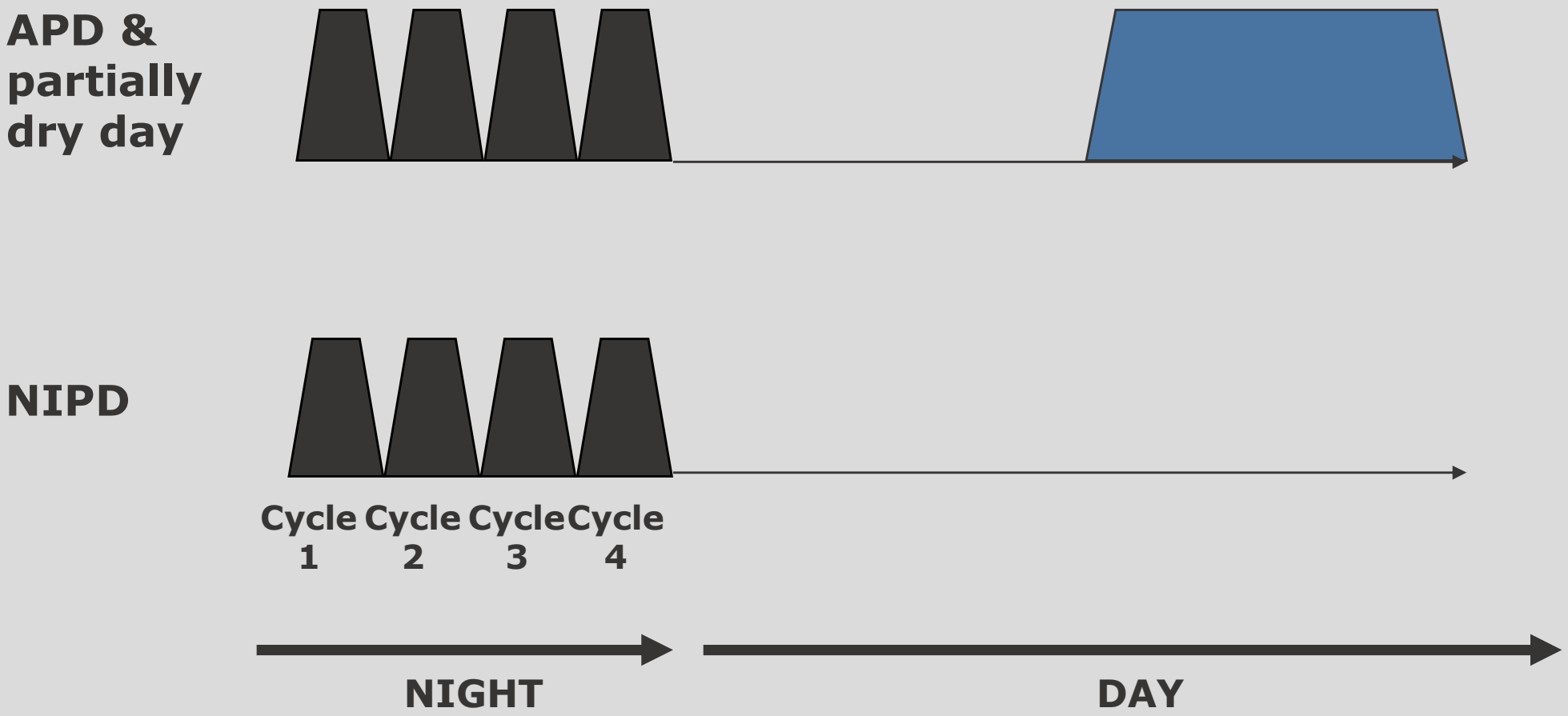
When the Long Dwell Is Too Long…



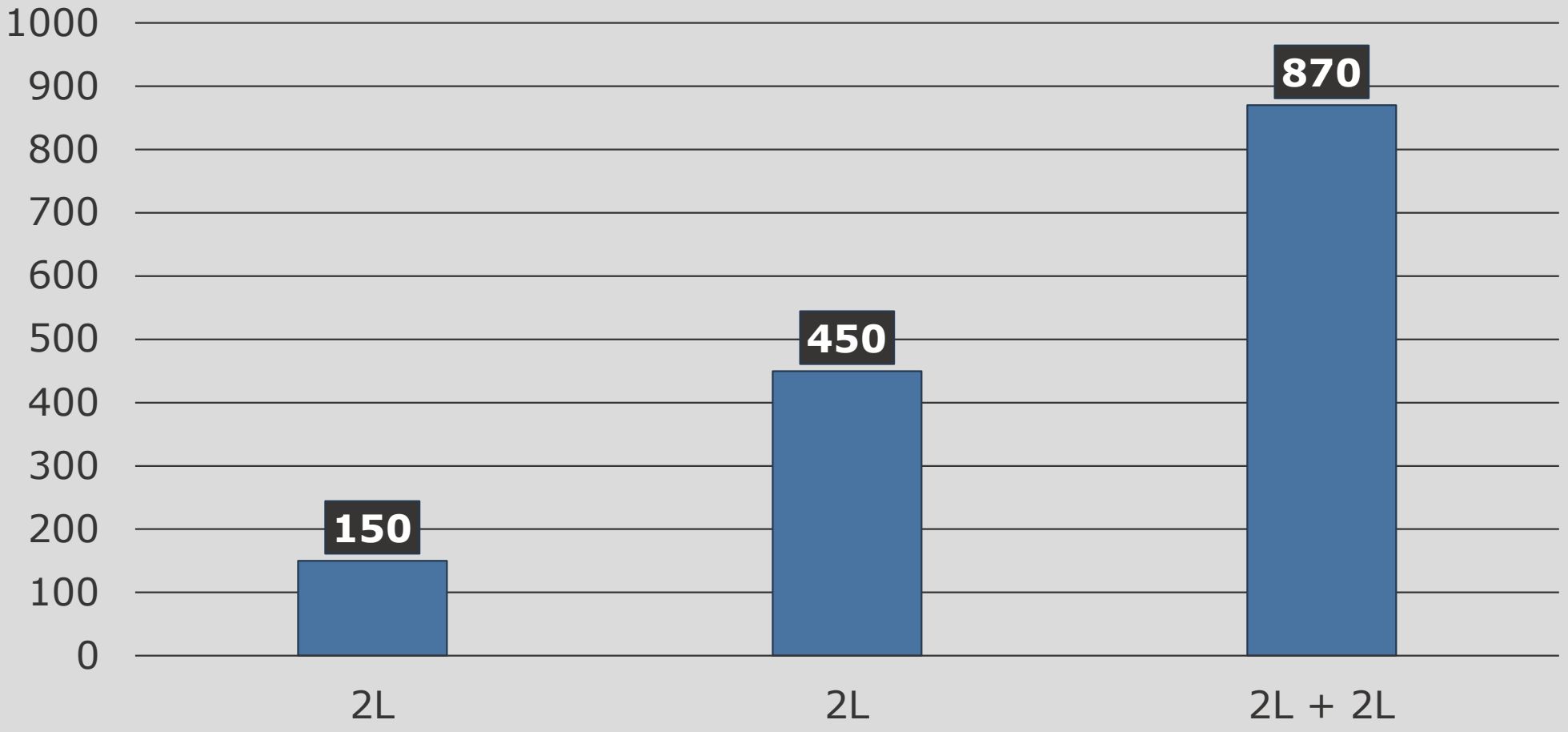
Other Options for the APD Prescription



Other Options for the APD Prescription- 2



Ultrafiltration in APD: Effect of Mid-day Exchange



Time	15 hrs	6 hrs	7.5 hrs + 7.5 hrs

Sodium Removal in PD- Effect of PD Modality

Rodriguez- Carmona and Fontan. Perit Dial Int 22:705, 2002

Peritoneal Na Removal (mmol/ day)

	CAPD	APD	p value
Cross- sectional study	173	53	0.001
Cross- over study	143	76	0.04

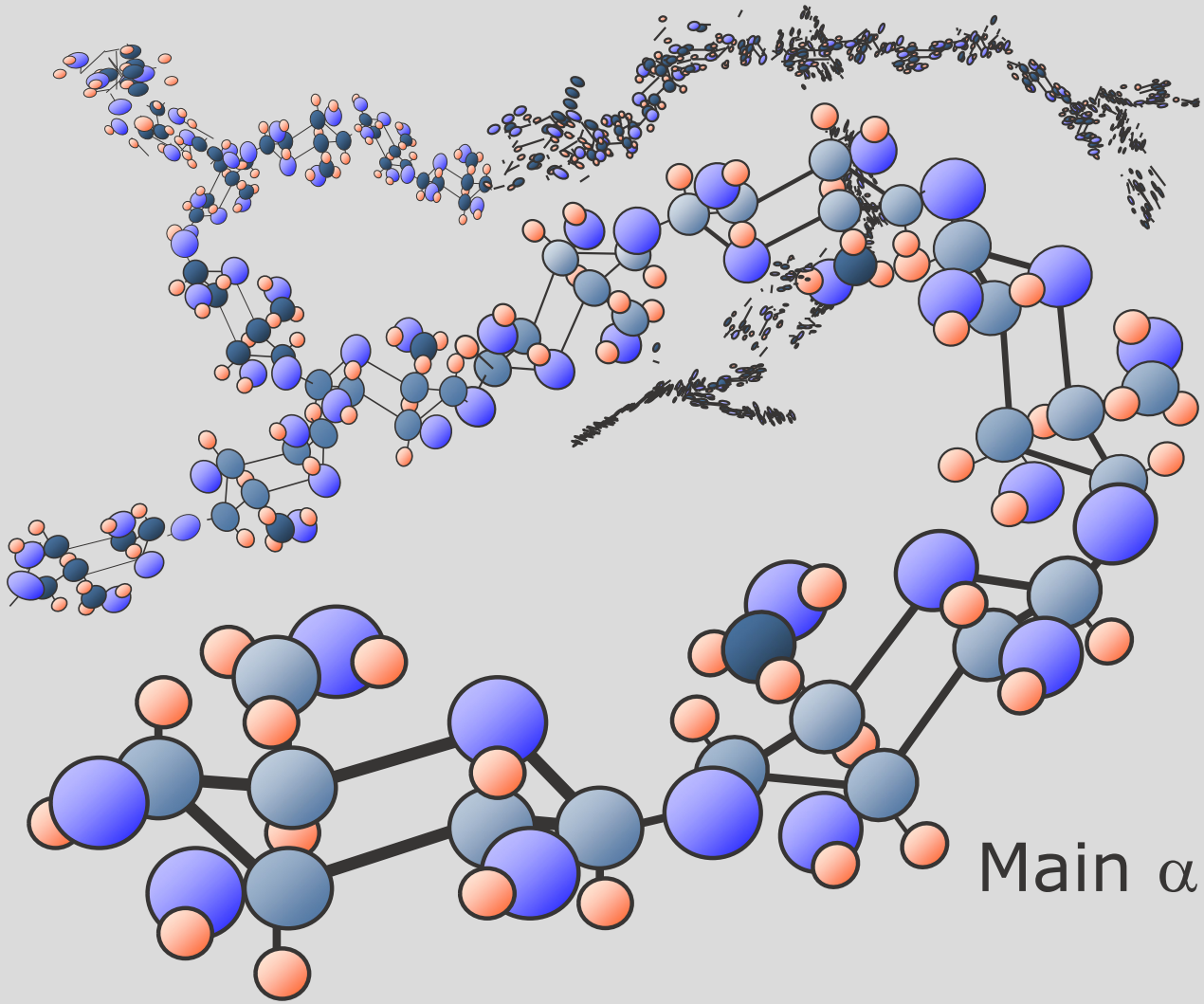
Summary of APD Prescription To Maximize Ultrafiltration

- Limit number of overnight cycles- avoids hypernatremia
- Shorten long dwell duration:
  - Partially dry day
  - Mid-day exchange
- Use icodextrin rather than glucose-based dialysate for the long-day dwell

Icodextrin

- Glucose polymer- manufactured from corn starch- with average MW around 16,000 Daltons.
- Acts oncotically rather than osmotically
- Effects ultrafiltration through the numerous small intercellular pores (reflection coefficient = 1.0).
- Removed from the peritoneal cavity via lymphatics

Structure of Icodextrin

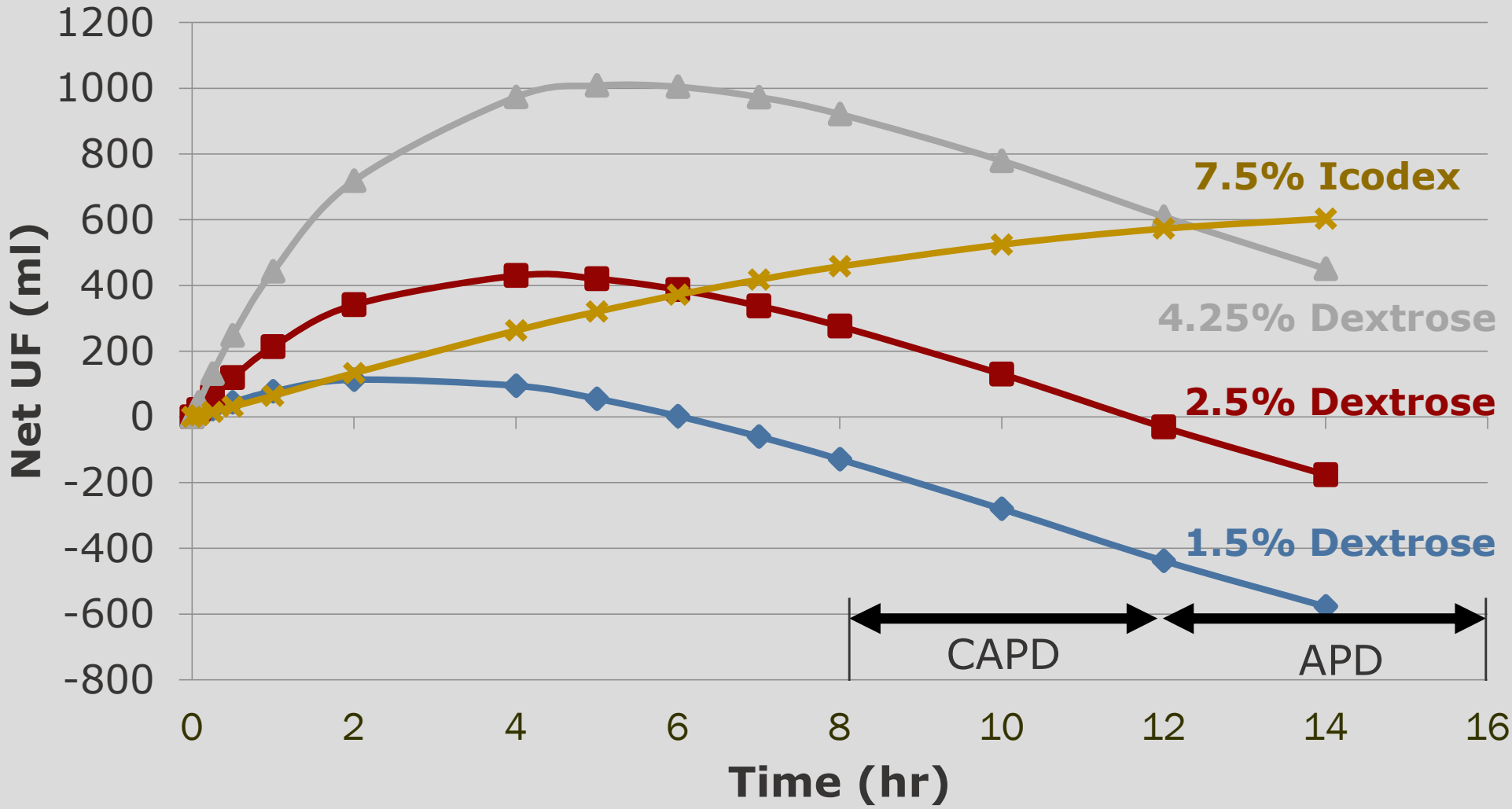


α (1→6) branch

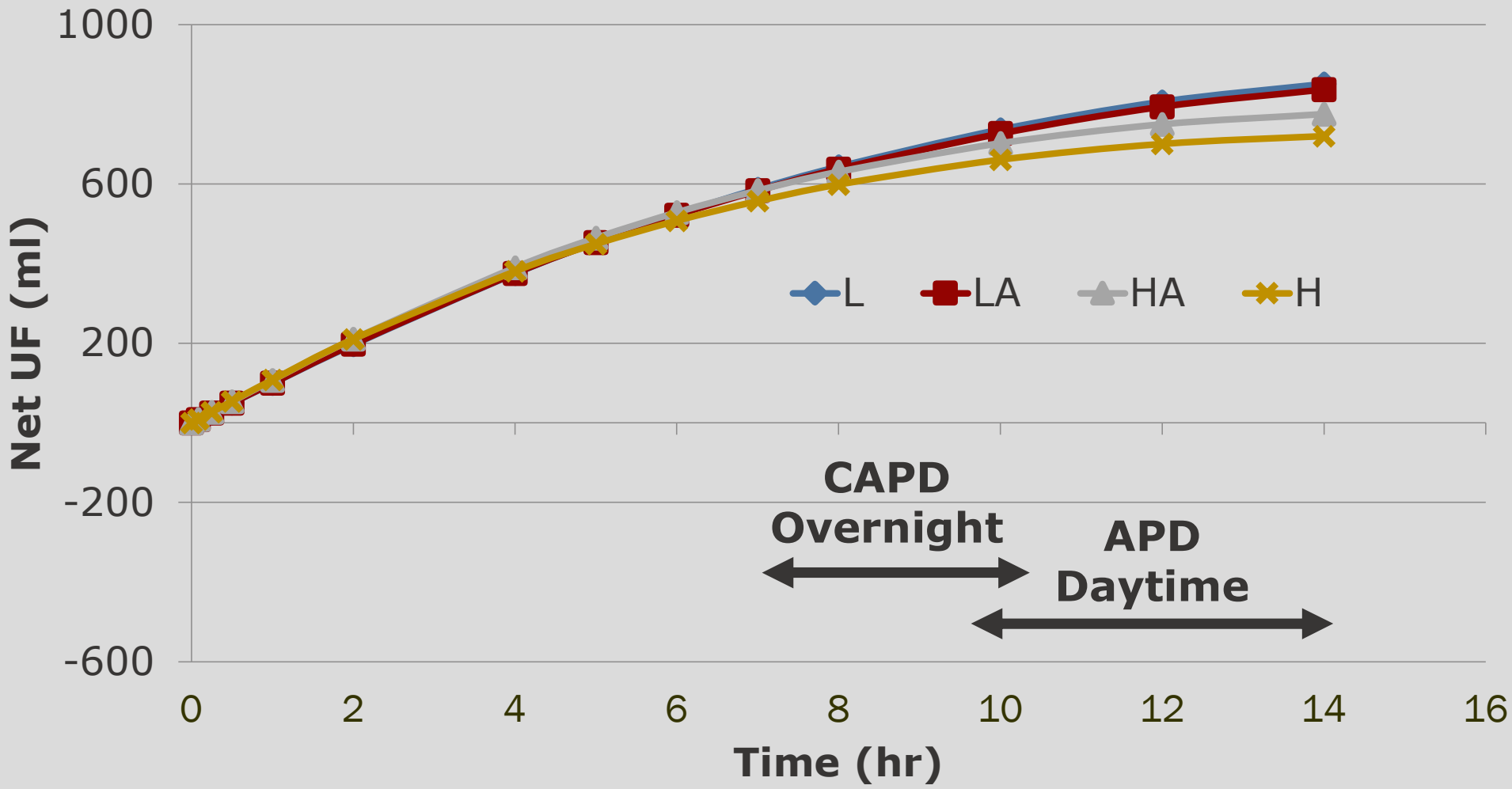
Main α (1→4) chain

Dextrose vs. Icodextrin Net UF

Ho Dac Pannekeet et al. Kid Int 50:979, 1996; Douma et al. Kid Int 53:1014, 1998



Icodextrin: Temporal Profile by Transport Status



Composition of Icodextrin

	Standard	Icodextrin
Dextrose (g/dL)	1.5, 2.5, 4.25	--
Icodextrin (g/dL)	--	7.5
Sodium (mEq/L)	132.0	132.0
Chloride (mEq/L)	96.0	96.0
Calcium (mEq/L)	3.5	3.5
Magnesium (mEq/L)	0.5	0.5
Lactate (mEq/L)	40.0	40.0
Osmolality (mOsm/kg)	346-485	282
pH	5.2	5.2

Metabolism of Icodextrin

Absorbed from peritoneal cavity via lymphatics

Icodextrin —**Intravascular**, ***amylase***→ **Oligosaccharides (maltose, maltotriose, etc. metabolized or removed by dialysis)**

Maltose —**Intracellular**, ***maltase***→ **Glucose**

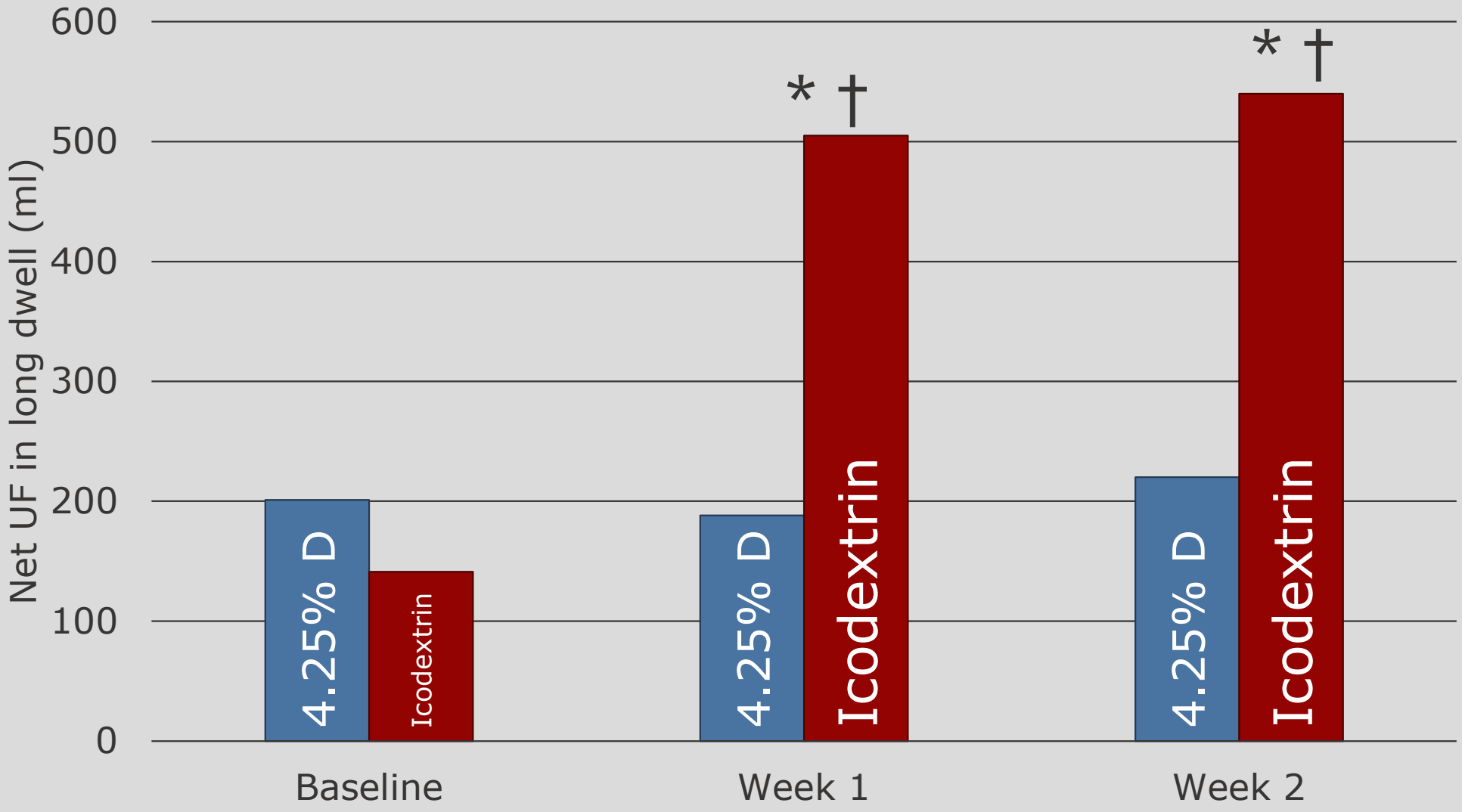
Icodextrin Metabolism

- No evidence for “maltose storage disorder”

- Further removal of metabolites by dialysis
  - Especially during other dextrose containing dwells

Icodextrin vs. 4.25% Dextrose in High/High Average Transporters

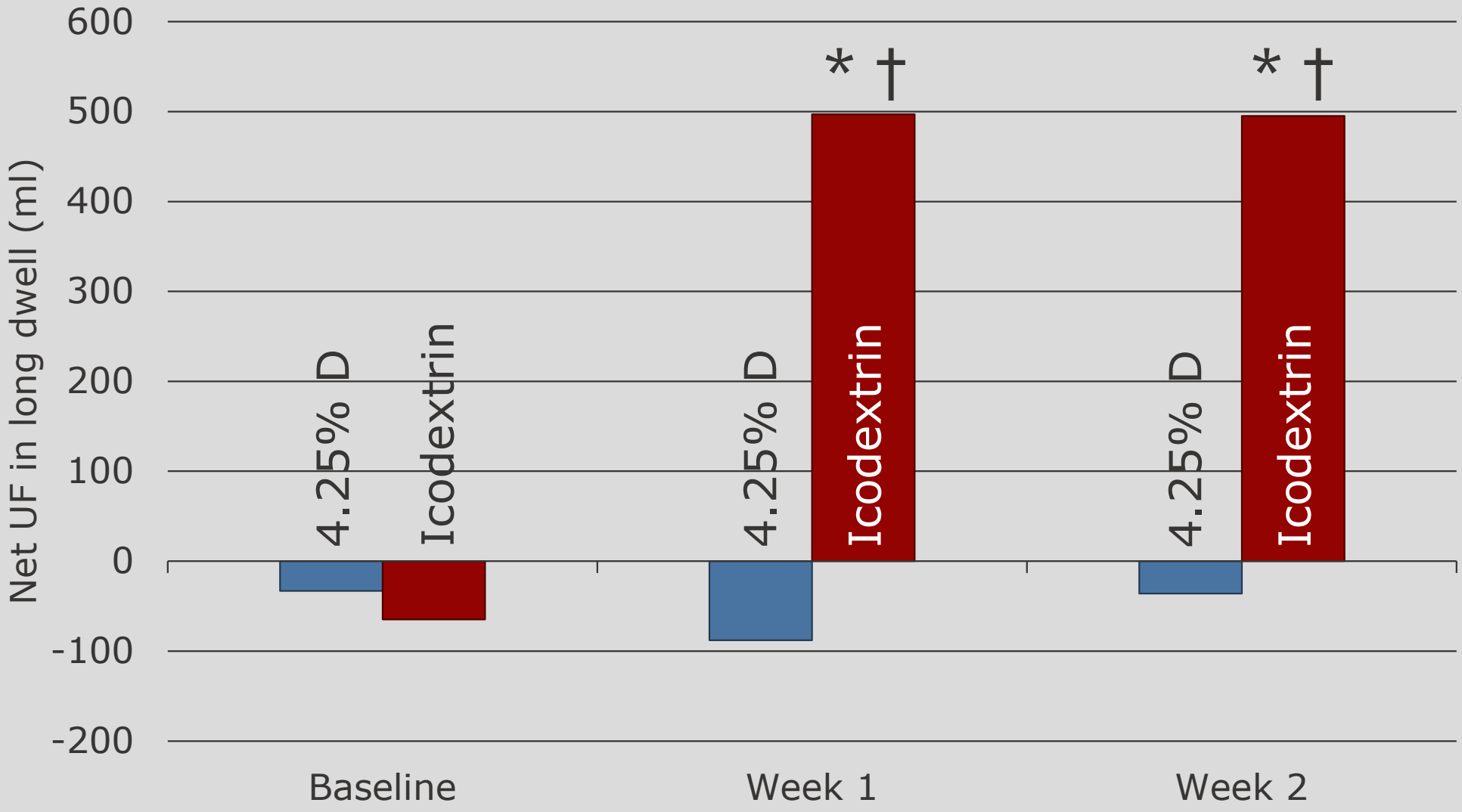
Finkelstein et al. J Am Soc Nephrol 16: 546, 2005



* p < 0.001 vs. baseline
† p < 0.001 vs. 4.25% D

Icodextrin vs. 4.25% Dextrose in High Transporters

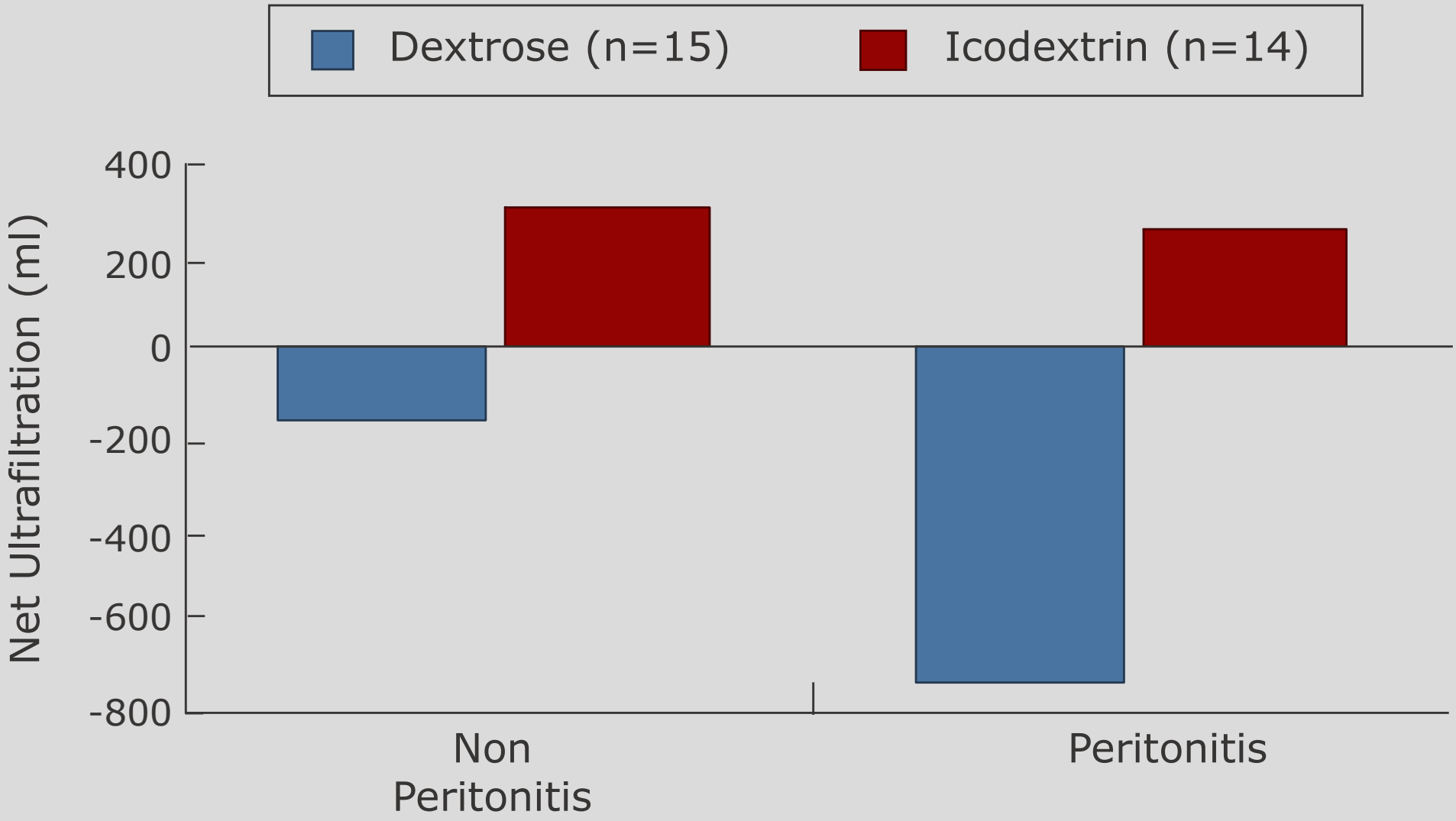
Finkelstein et al. J Am Soc Nephrol 16: 546, 2005



* p < 0.001 vs. baseline
† p < 0.001 vs. 4.25% D

UF with 2.5% Dextrose or Icodextrin (CCPD Long Dwell) During Peritonitis

Adapted from Posthuma et al. Nephrol Dial Transpl 13: 2341, 1998



Sodium Removal in PD- Effect of Icodextrin

Rodriguez- Carmona and Fontan. Perit Dial Int 22:705, 2002

Sixteen patients (10 CAPD/ 6 APD) converted from dextrose to icodextrin for the long dwell

Peritoneal Na Removal (mmol/ day)

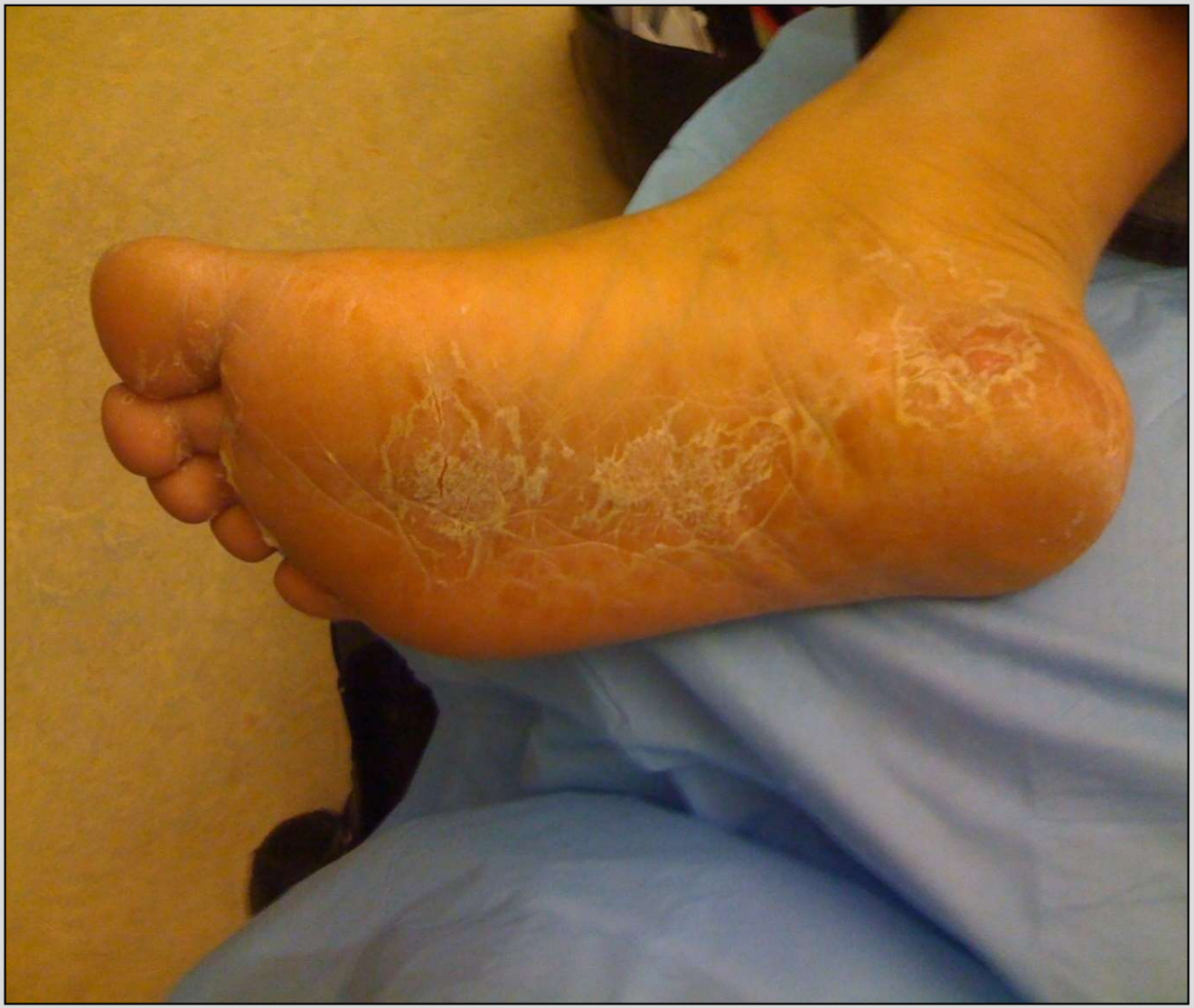
With Dextrose	With Icodextrin	p value
98	148	0.04

When Using Icodextrin Be Aware Of:

- Falsely elevated glucose measurements when using glucose monitors that utilize glucose dehydrogenase pyrroloquinolinequinone (GDH PQQ)
- Mild hyponatremia due to the dilutional (osmotic) effect of icodextrin metabolites (similar to the effect of hyperglycemia)
- Spuriously low amylase measurements due to an interference by maltose and/or icodextrin metabolites on the amylase assay

Icodextrin Skin Allergy

Teitelbaum, I. unpublished



Sterile Peritonitis with Icodextrin

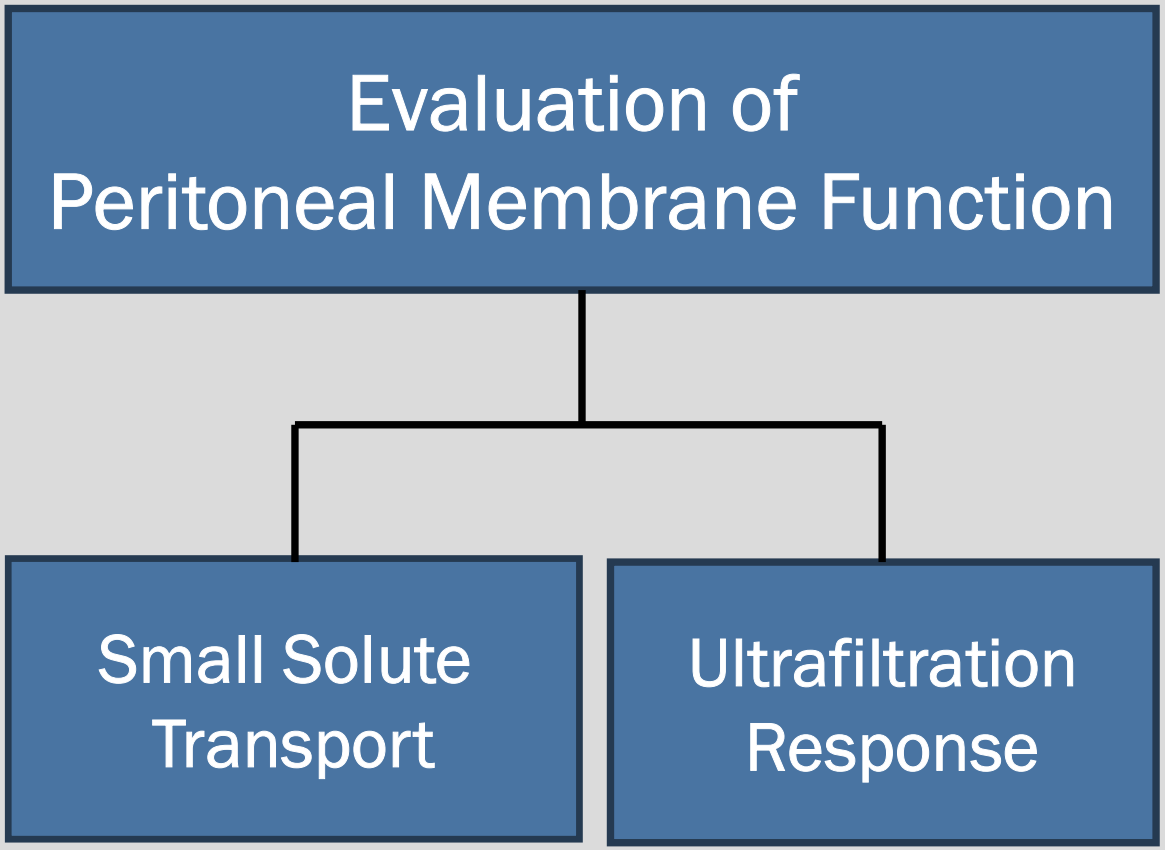
- Numerous cases of "sterile peritonitis" characterized by monocytosis reported, with a peak in the spring of 2002
- Determined to be due to a peptidoglycan produced by *Alicyclobacillus acidocaldarius* contaminating raw material from one of the two suppliers thereof
- Cases ceased once problem rectified

Indications for Icodextrin

- Use during a long dwell ≥ 8 hours
  - At night in CAPD
  - During day in CCPD
- Once a day only- so far
- Moderate cost differential, so best candidates are:
  - High and high average transporters
  - CCPD pts who cannot perform a midday exchange
    - Will increase small solute clearance

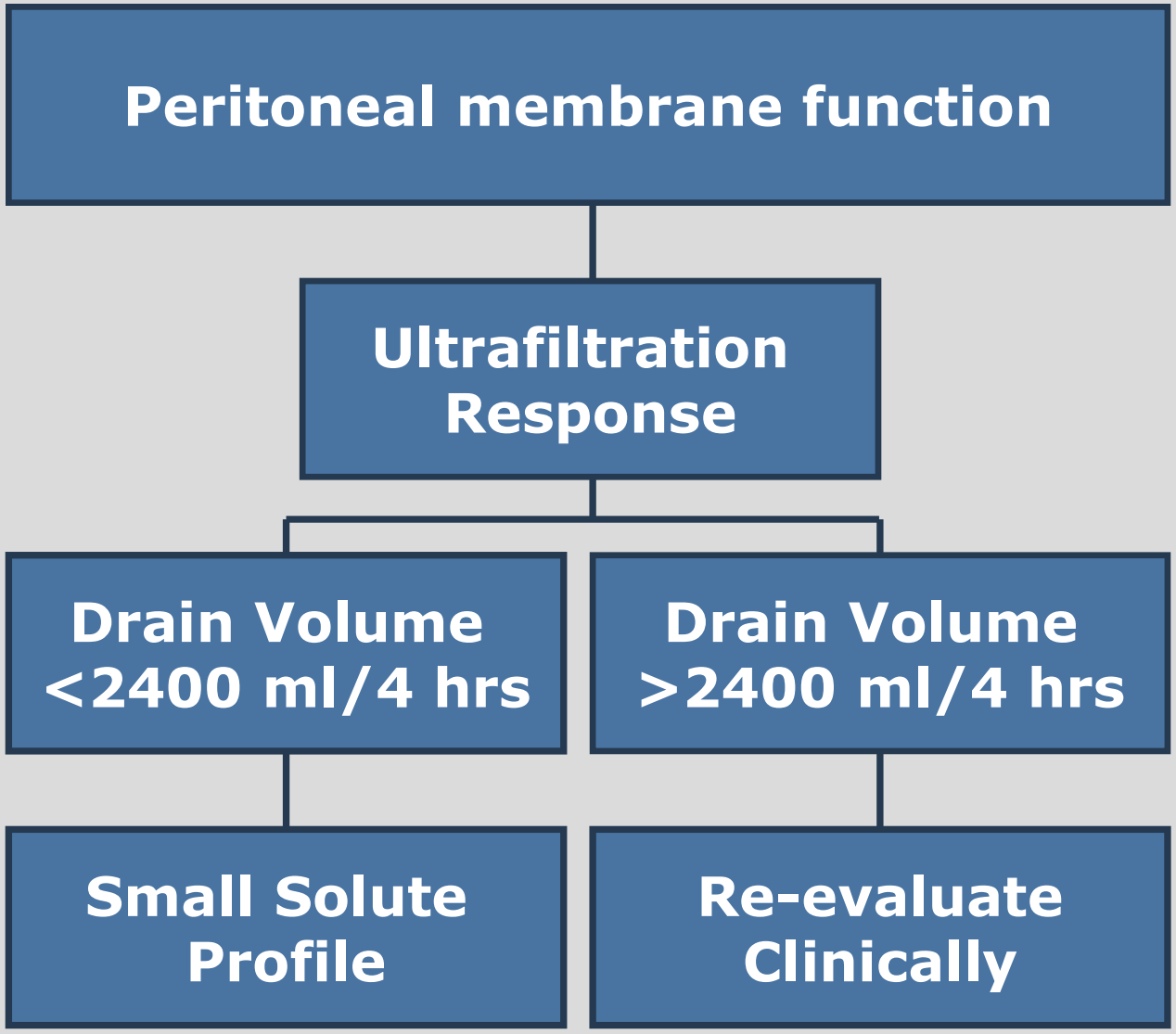
Approach to the Patient with Volume Overload- 2

Mujais et al. Perit Dial Int 20: S5, 2000



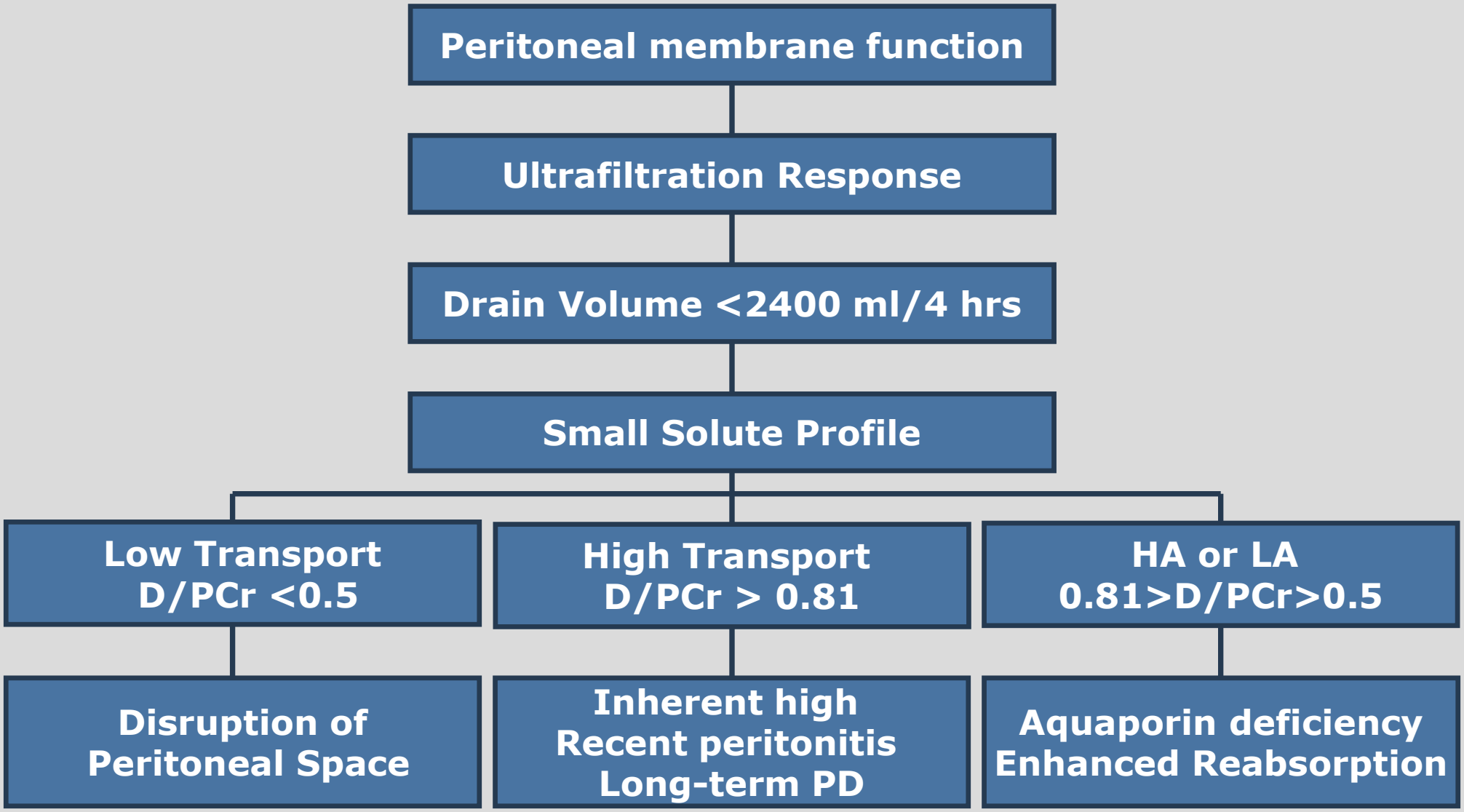
Approach to the Patient with Volume Overload- 3

Mujais et al. Perit Dial Int 20: S5, 2000



Approach to the Patient with Volume Overload- 4

Mujais et al. Perit Dial Int 20: S5, 2000



Effect of Peritoneal Resting on MTCurea, MTCcreat, and Ultrafiltration

De Alvaro et al. Adv in Perit Dial 9:56, 1993

	Before	After	P value
MTC_{urea}	25.7 ± 6.9	20.6 ± 6.2	< 0.05
MTC_{creat}	16.7 ± 6.0	13.6 ± 4.1	< 0.05
UF (mL)	493.8 ± 278.0	881.3 ± 388.1	<0.001

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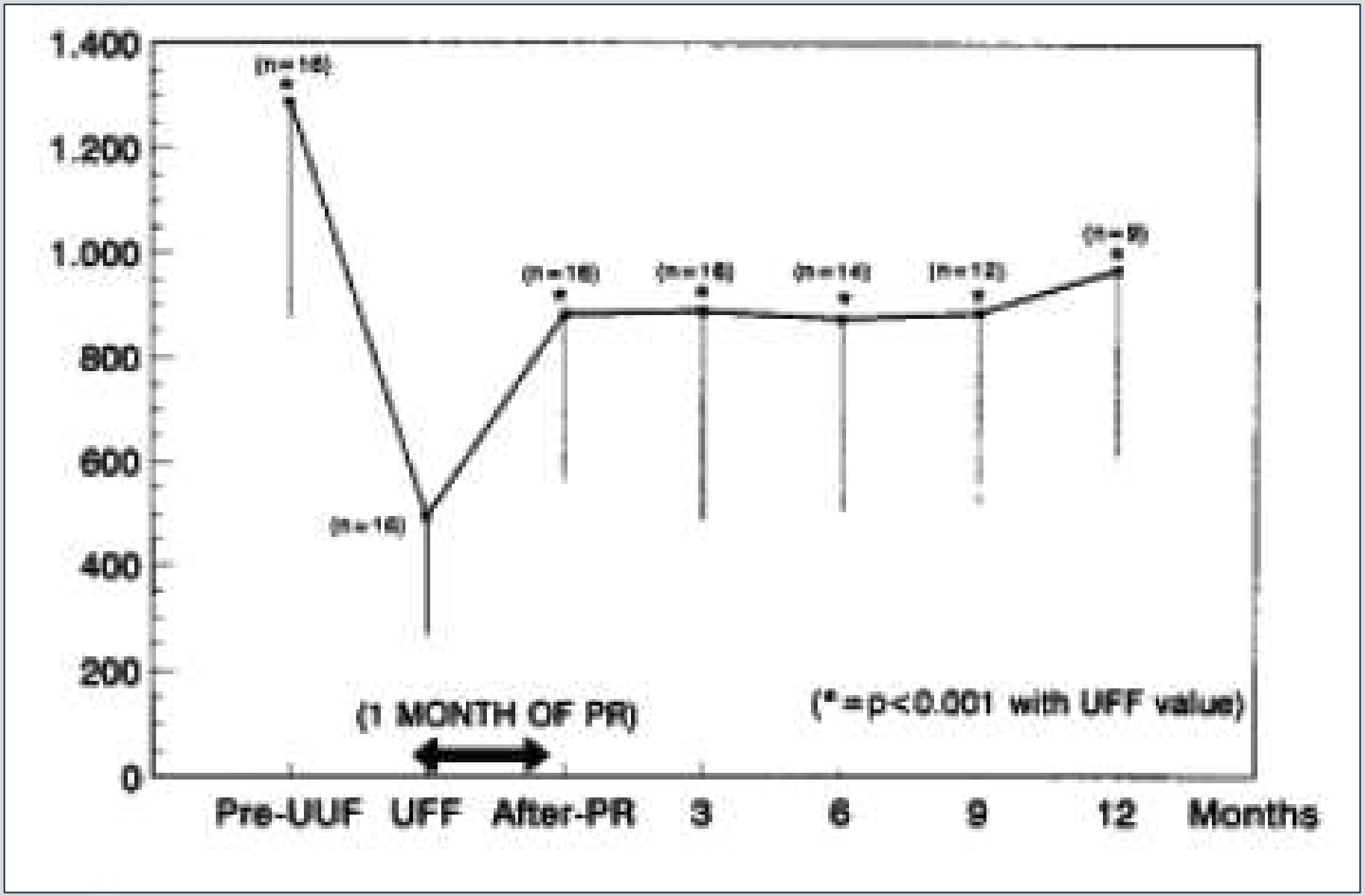
Effect of Peritoneal Resting on UF Is Sustained for at Least One Year

De Alvaro et al. Adv in Perit Dial 9:56, 1993



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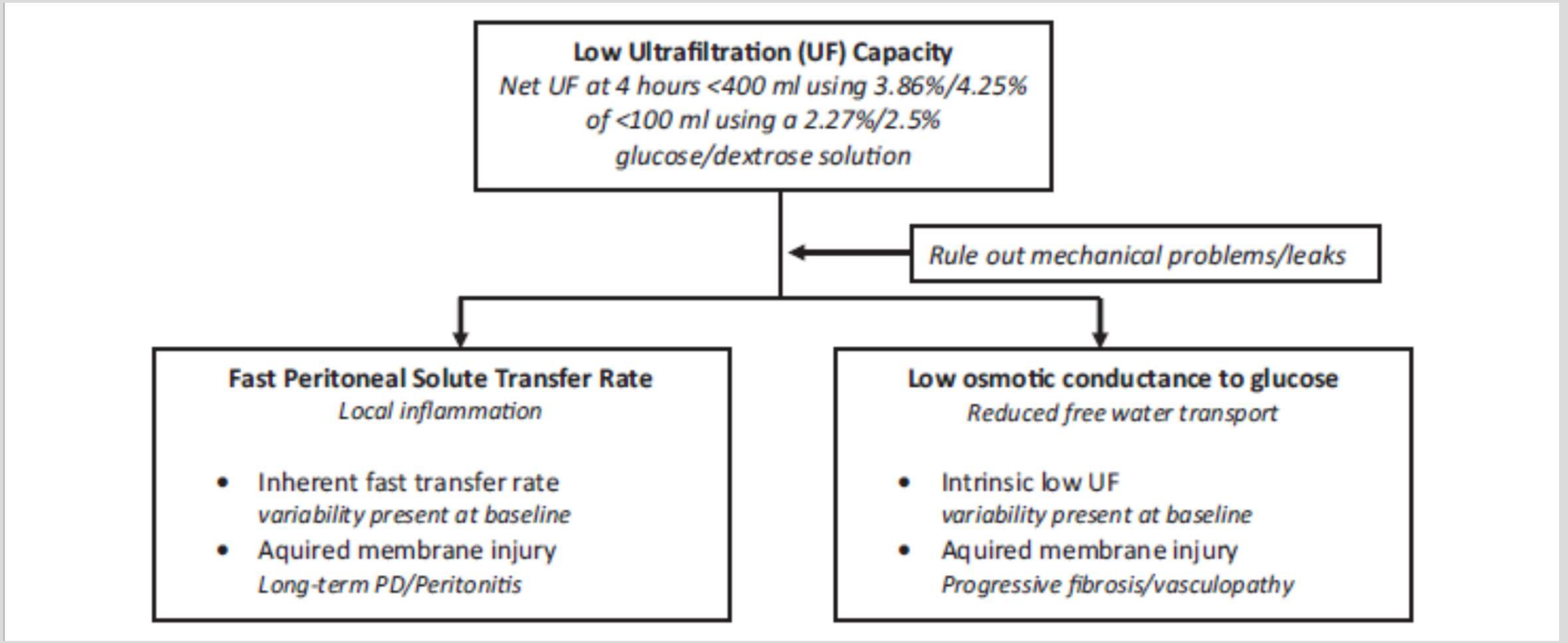
Classification of the Causes of Membrane Dysfunction

Morelle J et al. Perit Dial Int 41:352, 2021

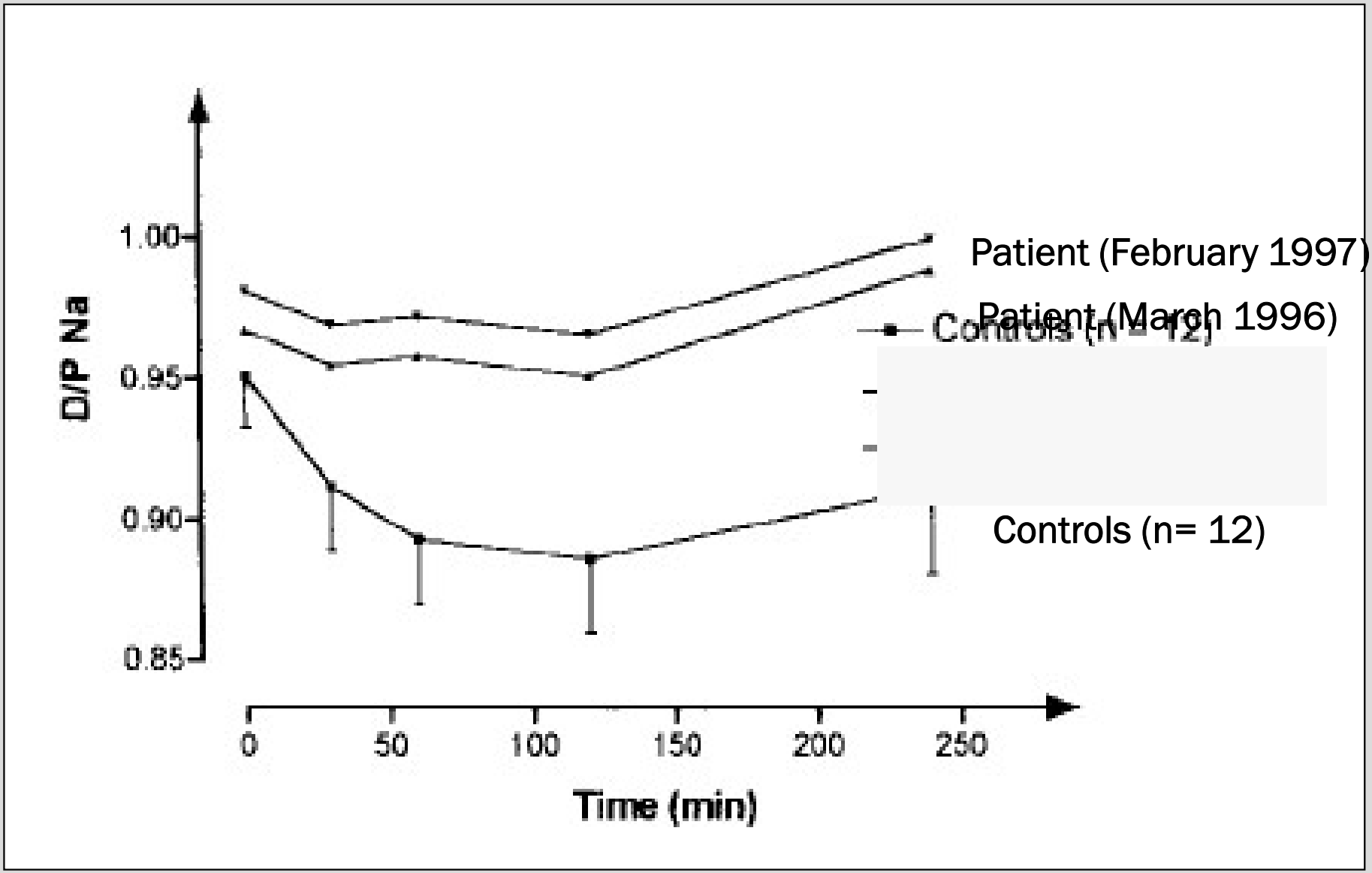


Workup for Volume Overload

- Perform careful history and physical exam
- Assess residual kidney function
- Review with patient understanding of, and compliance with, dietary prescription
- Review with patient understanding of, and compliance with, dialysis prescription
- Perform 2L “fill and drain” to assess flow
- Assess membrane characteristics with modified PET (4.25% x 4 hours)

A Case of Impaired AQP Function

Goffin et al. Am J Kid Dis 33:383, 1999



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Evaluation of Aquaporin-Mediated Water Flow
La Milia et al. Kid Int 68:840, 2005

- During a **one** hour 4.25% dwell, most of the ultrafiltrate will come across the ultrasmall pore (AQP-1).
- During this period Na transport across the small pore is due almost entirely to convection.
- The degree of AQP- mediated water transport may be assessed by evaluating UF across the small pore (UFSP).

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Calculation of UFSP

La Milia et al. Kid Int 68:840, 2005

Sodium removal (NaR; mmol) =

$$[\text{Volume}_{\text{dialysate out}}\ (\text{L}) \cdot \text{Na}_{\text{dialysate out}}\ (\text{mmol/L})] -$$

$$[\text{Volume}_{\text{dialysate in}}\ (\text{L}) \cdot \text{Na}_{\text{dialysate in}}\ (\text{mmol/L})]$$

$$\text{UFSP (mL)} = [\text{NaR (mmol)} \cdot 1000] / \text{Na}_p$$

AQP- mediated free water transport is equal to UF- UFSP

Average free H_2O transport = 46% of total UF; ≤ 26% of total UF suggests AQP-1 deficiency or failure

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journals.sagepub.com/home/ptd

ISPD recommendations for the evaluation of peritoneal membrane dysfunction in adults: Classification, measurement, interpretation and rationale for intervention

Johann Morelle[1], Joanna Stachowska-Pietka[2], Carl Öberg[3], Liliana Gadola[4], Vincenzo La Milia[5], Zanzhe Yu[6], Mark Lambie[7], Rajnish Mehrotra[8], Javier de Arteaga[9] and Simon Davies[7]

Available under "Guidelines" at www.ispd.org

THANK YOU

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