Peritoneal Dialysis

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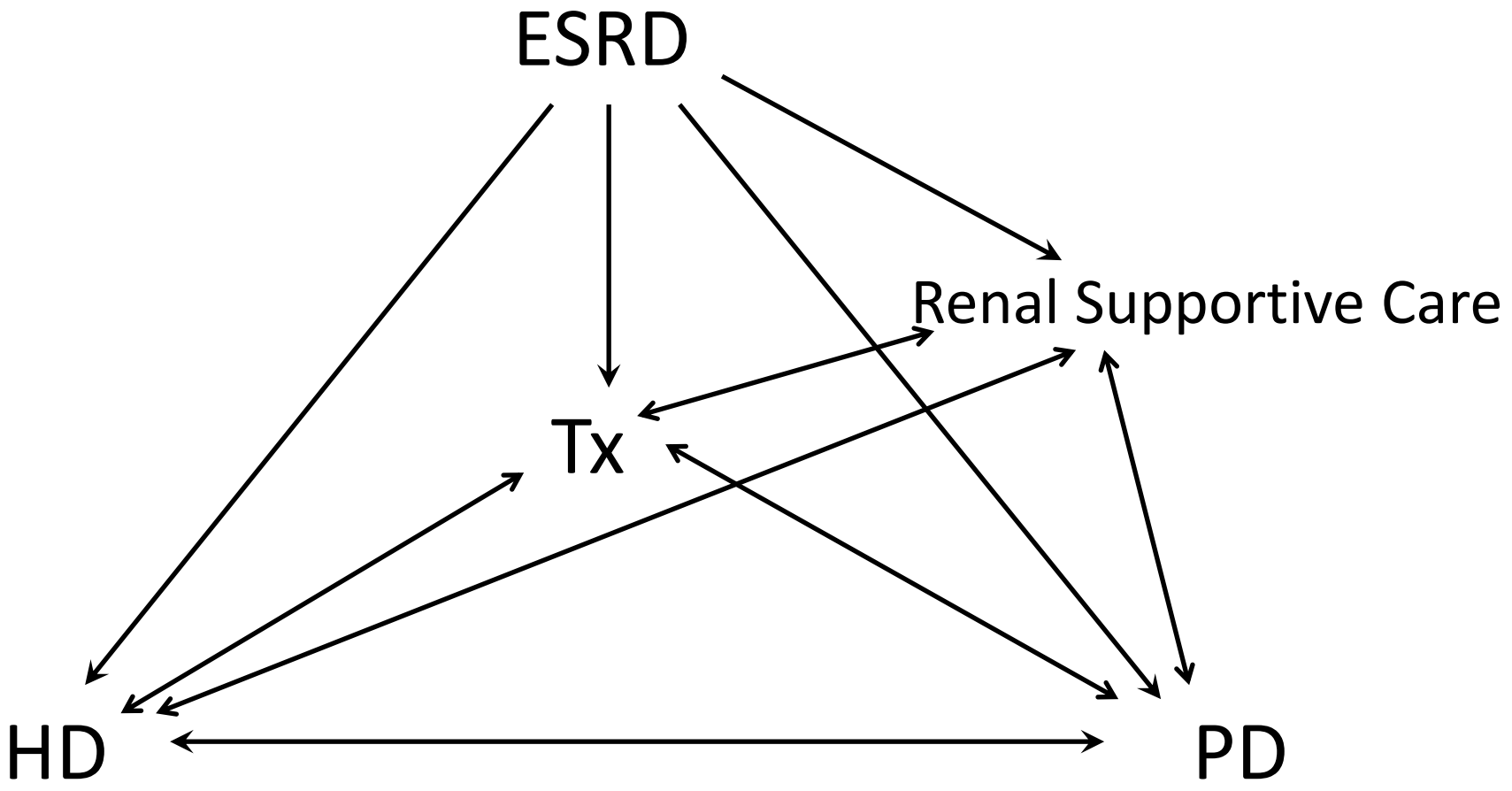
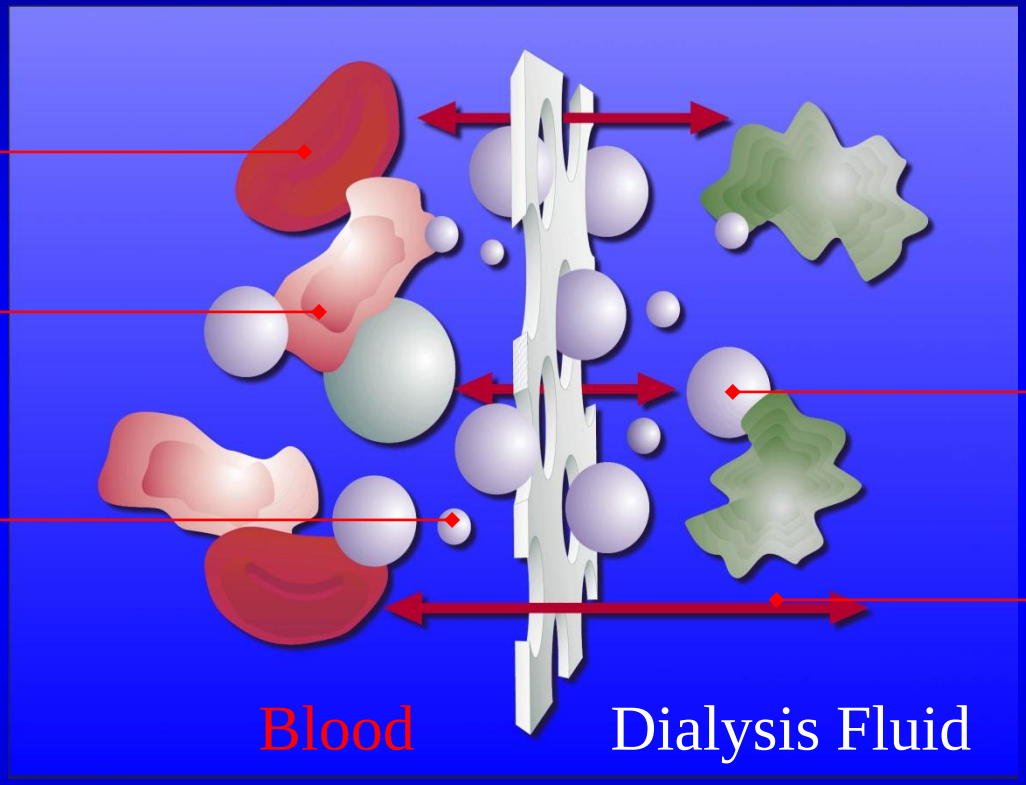
ESRD – Integrated Care and Options

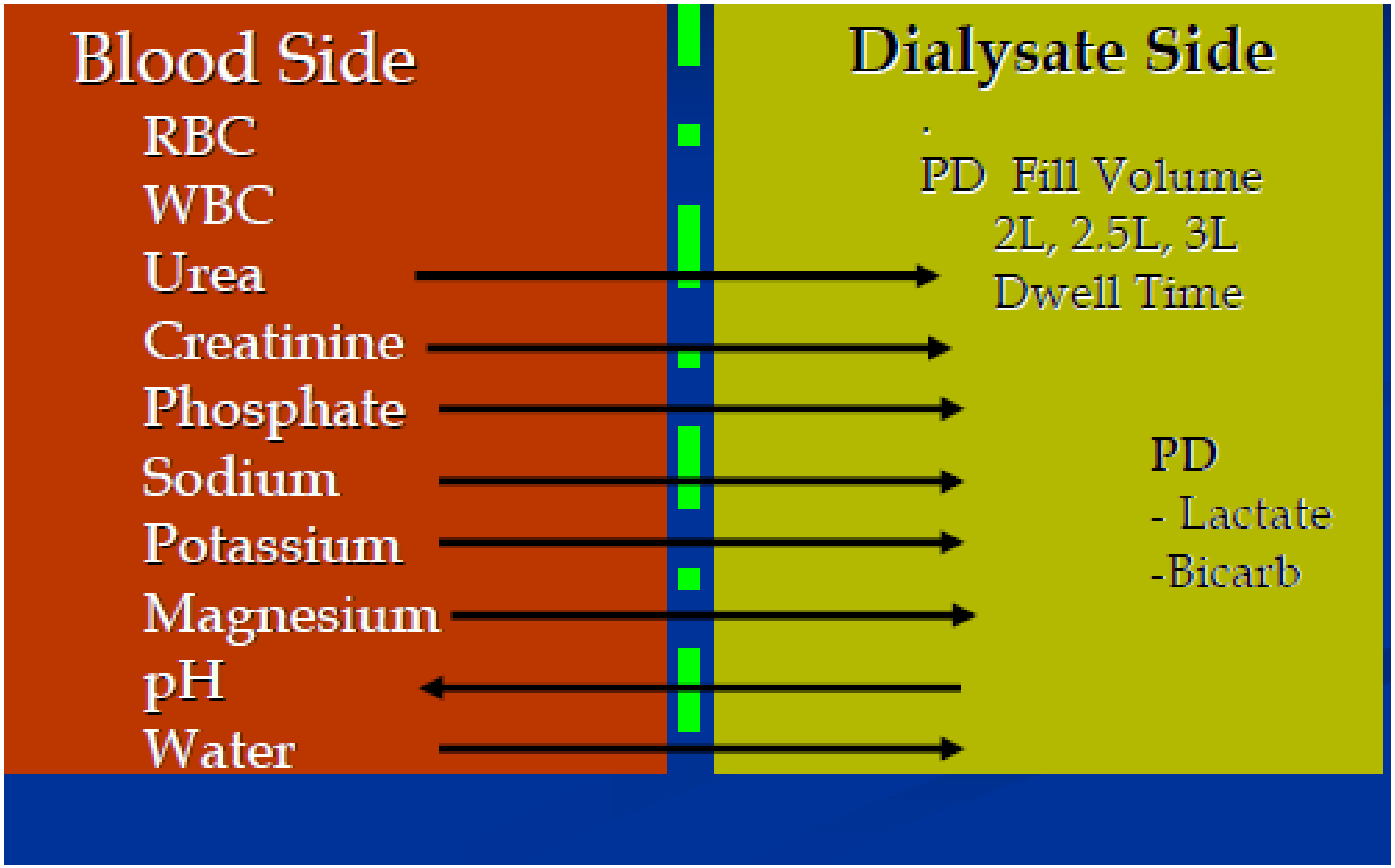


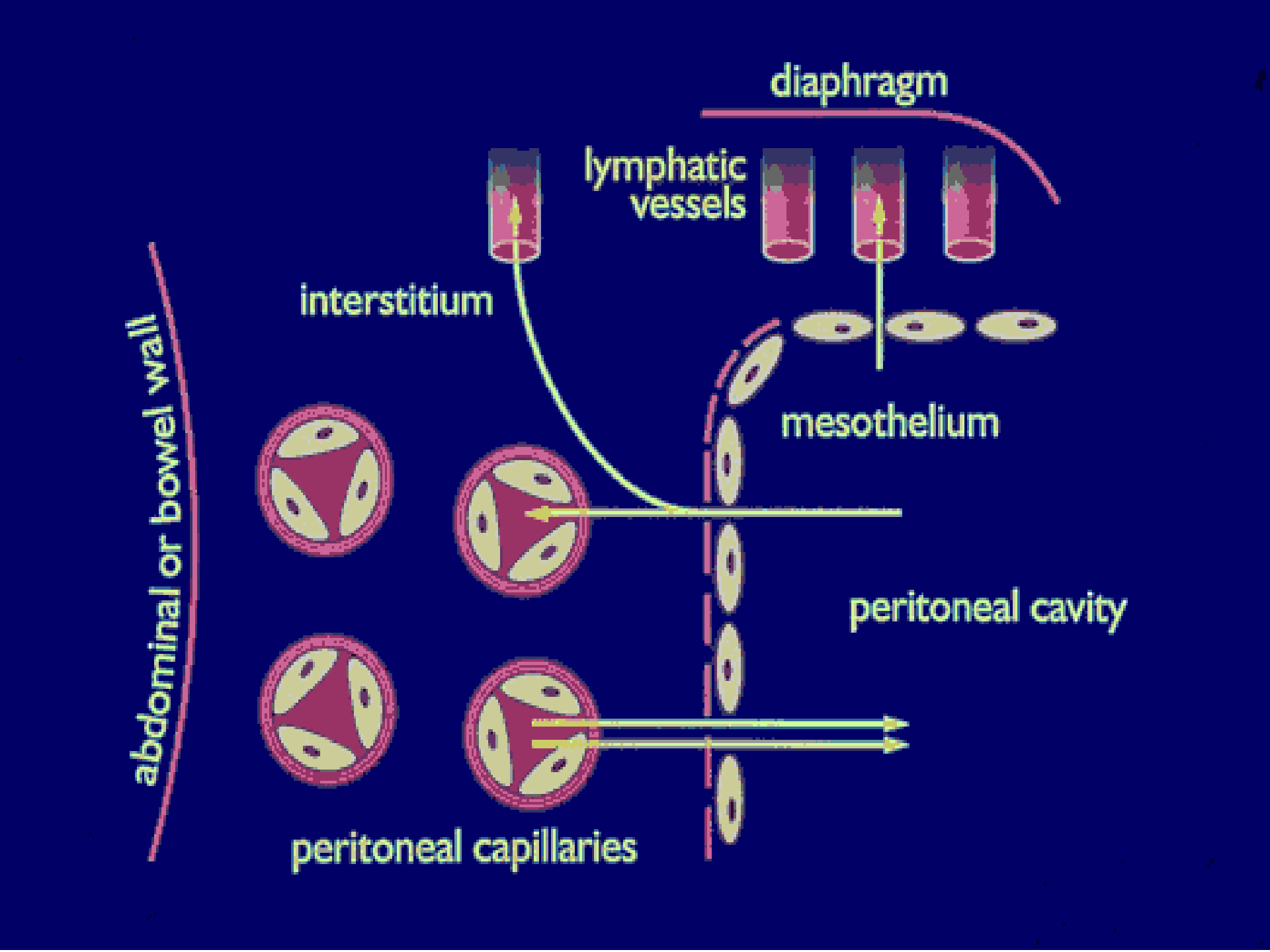
Principles of Dialysis: Diffusion and Ultrafiltration across a Semipermeable Membrane



The semi permeable membrane functions similar to a fine sieve, only molecules that are small enough can pass.

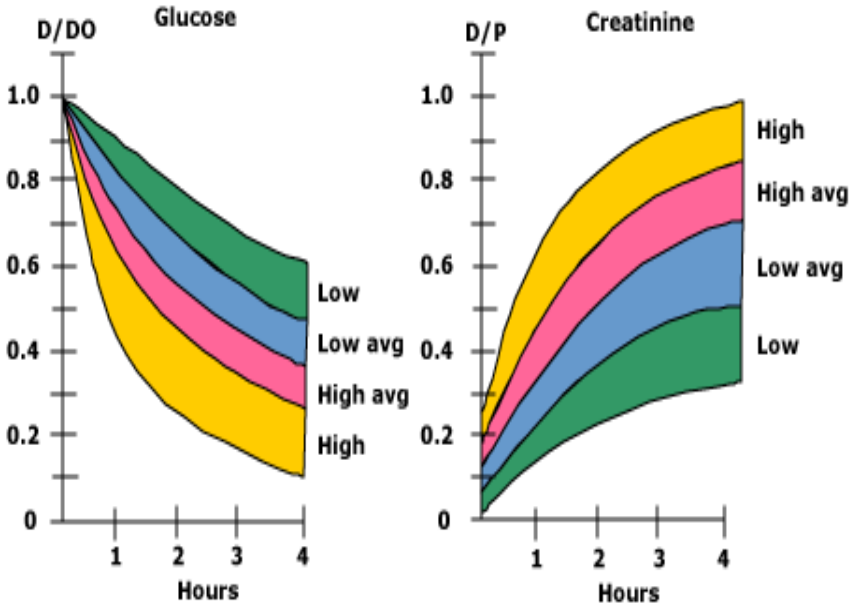
Peritoneal dialysis




diaphragm
lymphatic vessels
interstitium
abdominal or bowel wall
mesothelium
peritoneal cavity
peritoneal capillaries

PERITONEAL EQUILIBRATION TEST

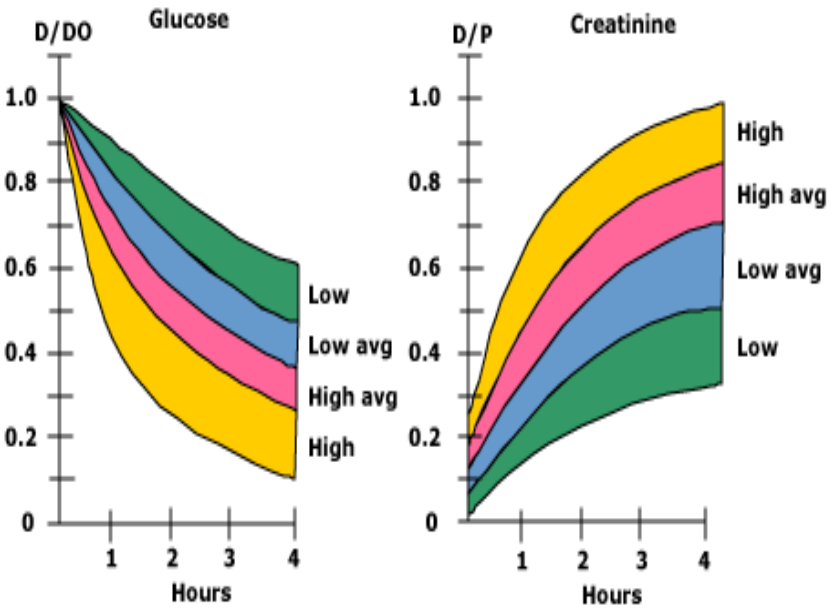
- Gives us an idea of the transport characteristics of an individual's peritoneal membrane.
- Assessed by using equilibration ratios between dialysate and plasma for urea (D/P urea), creatinine (D/P creatinine) …
- By waiting for equilibration, this test *measures the combined effect of diffusion and ultrafiltration.*

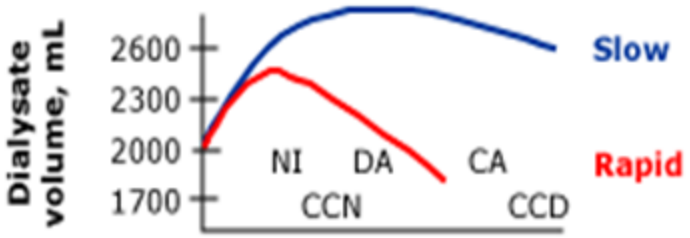


UF volumes are inversely proportional to peritoneal transport characteristics for solutes

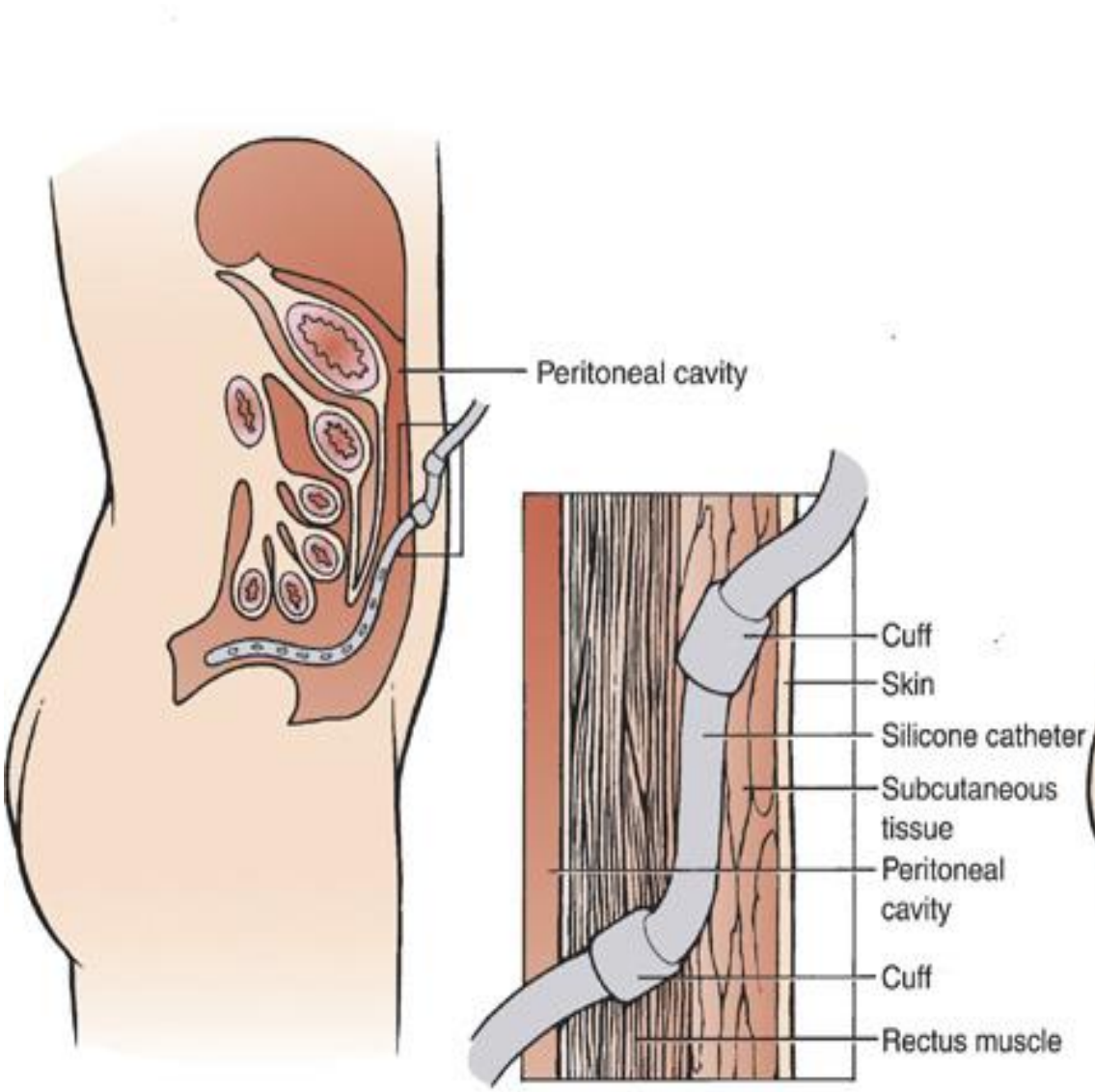
High transporters rapidly absorb the osmotic agent into peritoneal capillaries, diminishing stimulus for ultrafiltration within a few hours of dwell. After equilibration is achieved, because of reabsorption of fluid through the lymphatics, the UF volume comes down with time.

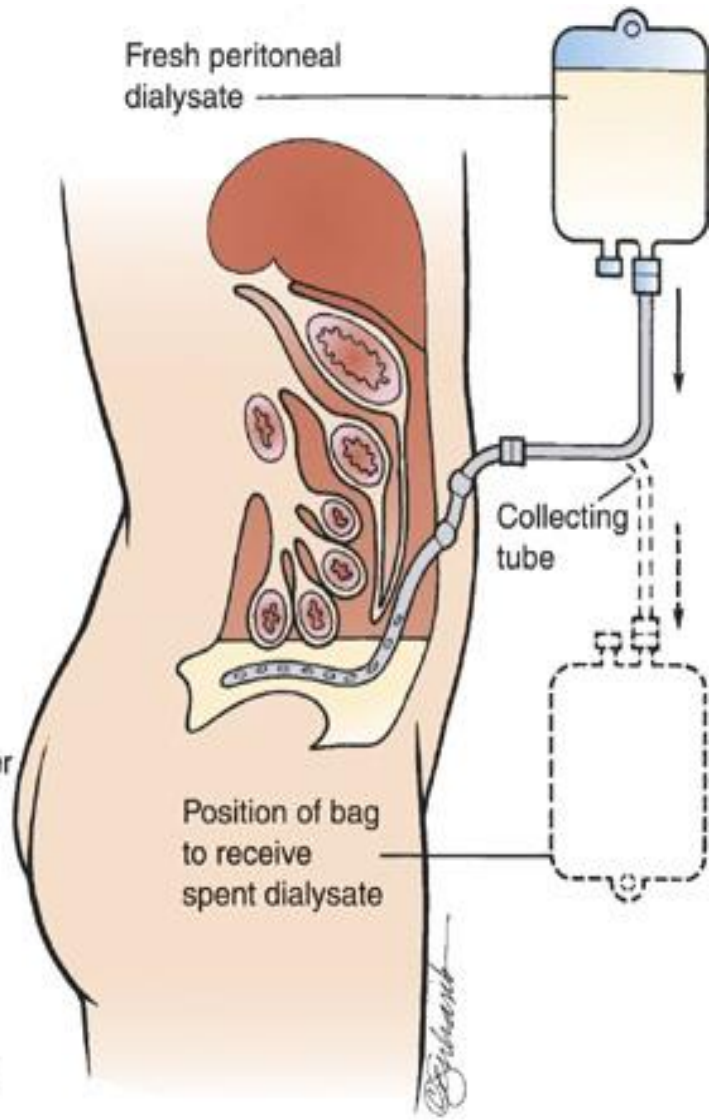
Low transporters have good ultrafiltration, because the osmotic gradient is maintained throughout the entire dwell.

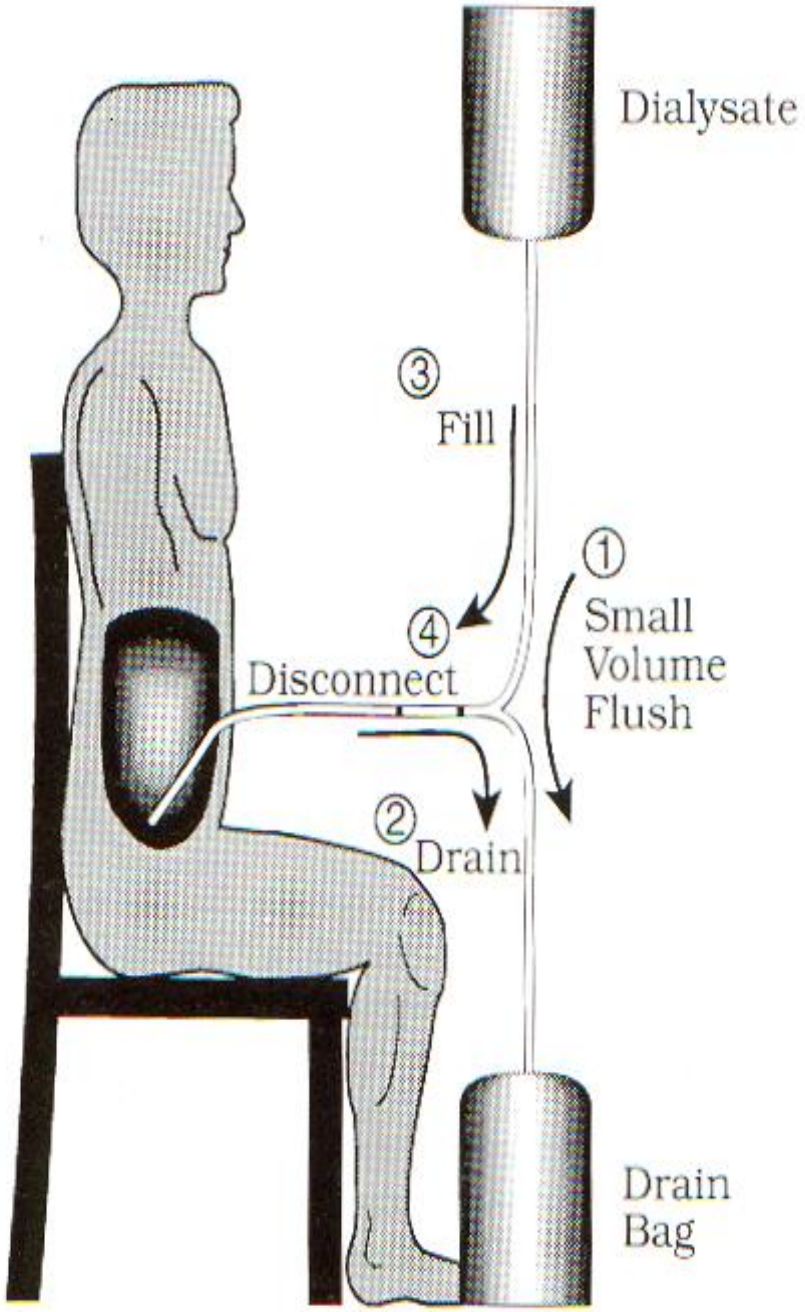




Peritoneal Dialysis Access







- 4 times per day

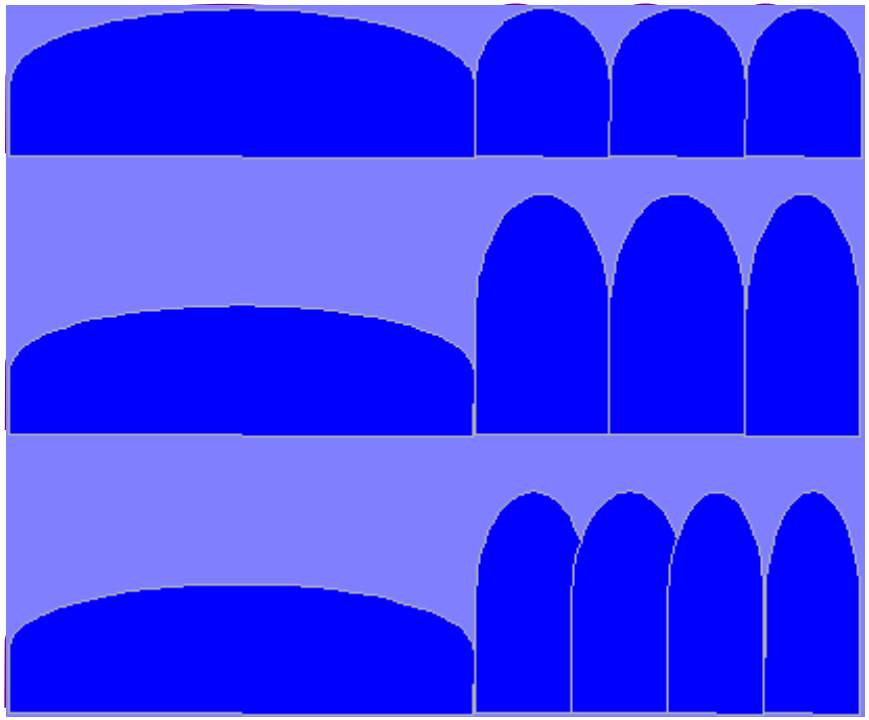
(2-3L exchanges

20-30 minutes out

5-10 minutes in)

- 7 days a week

CAPD-Continuous Ambulatory Peritoneal Dialysis

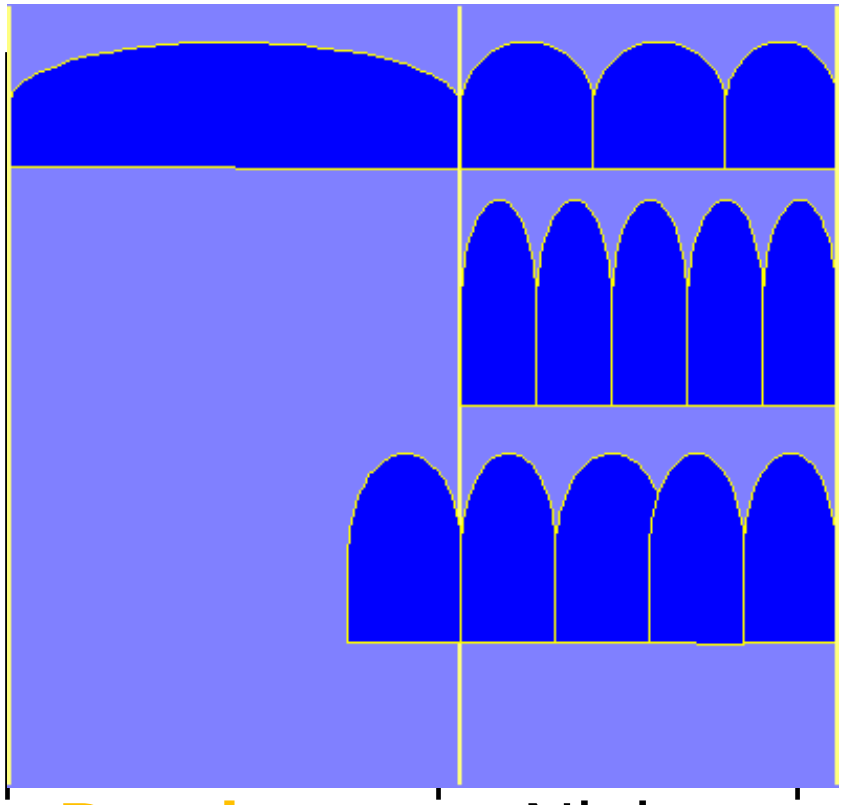


Standard CAPD

Night ***Day***

(9 hours) ***(15 hours)***

Continuous Cyclic PD and Nocturnal Intermittent PD



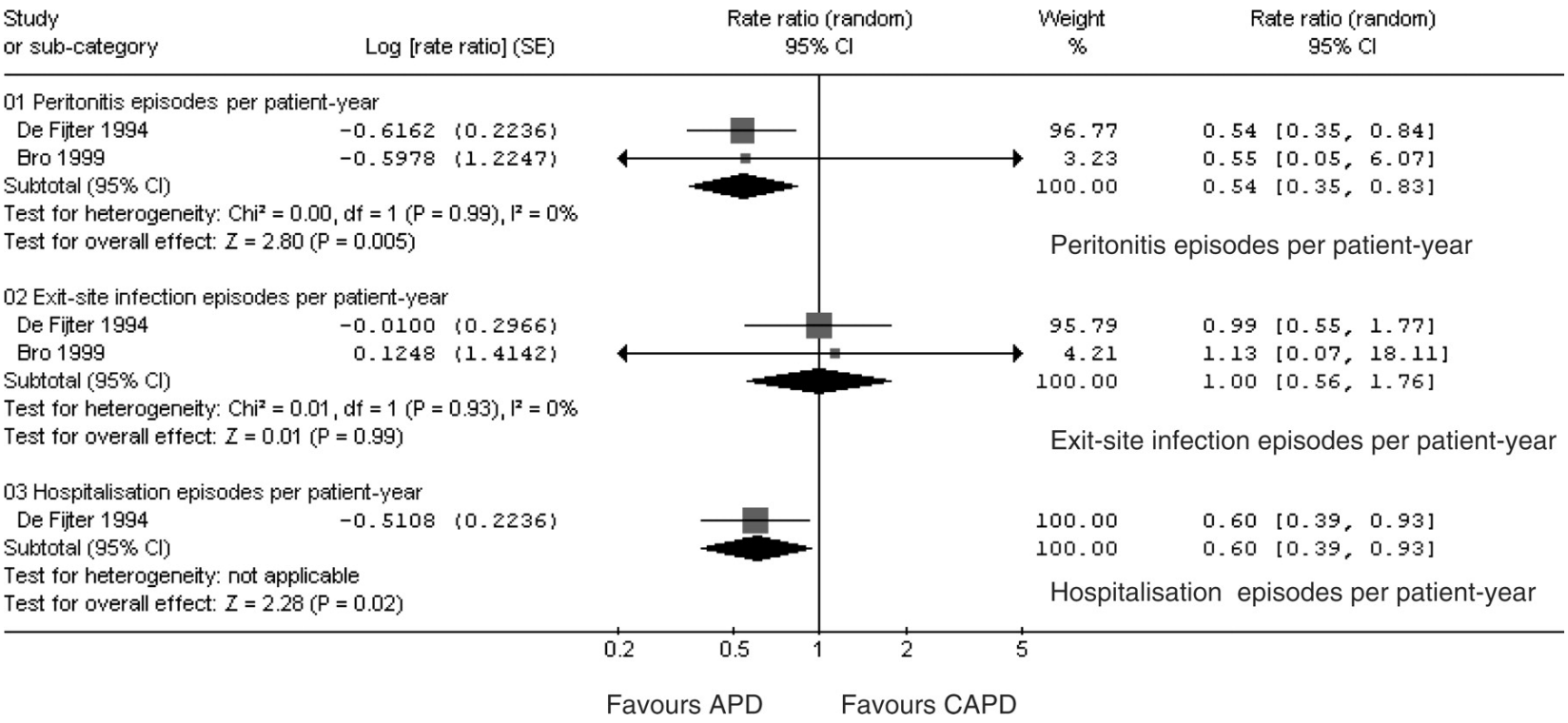
Standard CCPD

NIPD

NIPD with an increased time on cycler (or manual exchange, or prolonged night PD)

CAPD vs APD

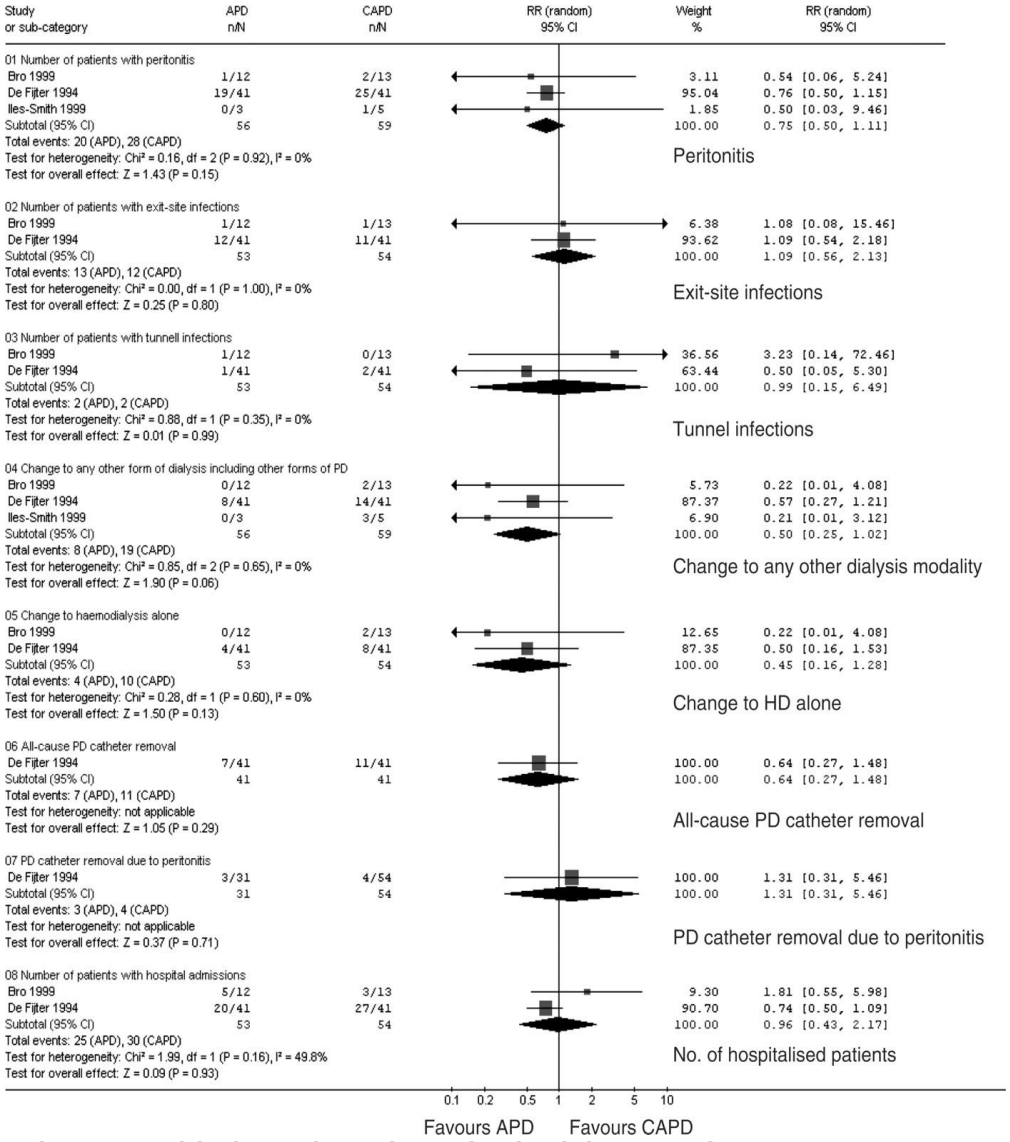
Complications expressed as episodes per patient-year.



Kannaiyan S. Rabindranath et al. Nephrol. Dial. Transplant. 2007;22:2991-2998

NDT Nephrology Dialysis Transplantation

CAPD vs APD



Impact of PD modality on various clinically important outcomes.

No differences in number of patients with exit site infections, tunnel infections.

No difference in technique survival

Kannaiyan S. Rabindranath et al. Nephrol. Dial. Transplant. 2007;22:2991-2998

NDT Nephrology Dialysis Transplantation

Currently available PD solutions

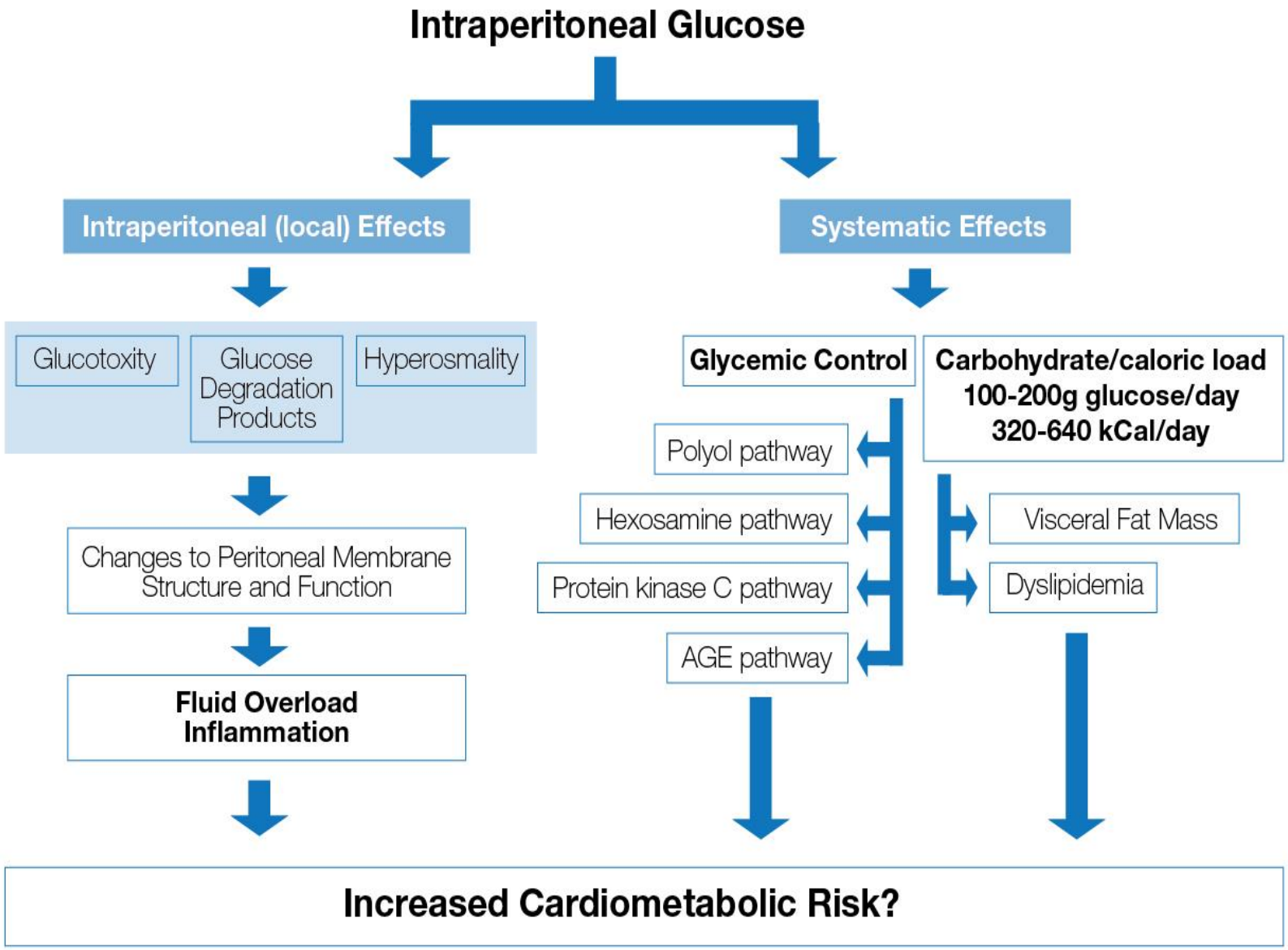
Table 1 | Selected peritoneal dialysis solutions currently available in Europe

Solution (manufacturer)	pH	Chambers	Buffer	Osmotic agent	GDPs	Advantages	Disadvantages
Dianeal® (Baxter*)	5.2	Single	Lactate	Glucose	High	Easy to manufacture; low cost	Low pH; poor peritoneal membrane biocompatibility; infusion pain; contains lactate
Extraneal® (Baxter*)	5.6	Single	Lactate	Icodextrin	Low	Sustained ultrafiltration; reduced hyperglycemia; improved metabolic profile and body composition	Contains lactate; low pH; single daily use only; hypersensitivity
Nutrineal® (Baxter*)	5.5	Single	Lactate	Amino acids	No	Avoids glucose exposure; peritoneal membrane protection; enhanced nutrition	Contains lactate; low pH; single daily use only
Physioneal® (Baxter*)	7.4	Double	Lactate/ bicarbonate	Glucose	Low	Improved biocompatibility; preserved membrane defense; reduced infusion pain	Local and systemic glucose exposure; reduced peritoneal lactate exposure
Stay-safe® (Fresenius‡)	5.5	Single	Lactate	Glucose	High	Ease of manufacture; low cost	Low pH; poor peritoneal membrane biocompatibility; infusion pain; contains lactate
Balance® (Fresenius‡)	7.0	Double	Lactate	Glucose	Low	Improved biocompatibility; preserved membrane defense; reduced risk of peritonitis?	Higher but not neutral pH; local and systemic glucose exposure; contains lactate
BicaVera® (Fresenius‡)	7.4	Double	Bicarbonate	Glucose	Low	Improved biocompatibility; preserved membrane defense; improved correction of acidosis	Local and systemic glucose exposure
Gambrosol® Trio (Fresenius‡)	6.5	Triple	Lactate	Glucose	Low	Improved biocompatibility; preserved membrane defense	Higher but not neutral pH; local and systemic glucose exposure; contains lactate

*Deerfield, IL, USA. ‡Bad Homburg, Germany. Abbreviation: GDPs, glucose degradation products.

García-López, E. *et al.* (2012) An update on peritoneal dialysis solutions
Nat. Rev. Nephrol. doi:10.1038/nrneph.2012.13

nature REVIEWS NEPHROLOGY



CJ Holmes, 2009

7.5% Icodextrin

Relatively inert high molecular weight polymaltose glucose polymer

Less permeable than dextrose - ultrafiltration occurs for a longer period of time.

Equivalent UF volume as a 4.25% dextrose

Best used in a long dwell

Reduced carbohydrate load

Potential advantage of reducing the long term metabolic complications associated with hypertonic dextrose

Icodextrin

Some glucometers measure non-glucose sugars (e.g. icodextrin metabolite - Maltose): Falsely elevated readings.

Glucometers based on glucose dehydrogenase pyrroloquinolone quinone OR glucose dehydrogenase flavin-adenine dinucleotide cannot distinguish between glucose vs. maltose

www.glucosesafety.com

Maltose metabolites with icodextrin do not return to baseline until 2 weeks after cessation.

GLUCOSE MONITORS

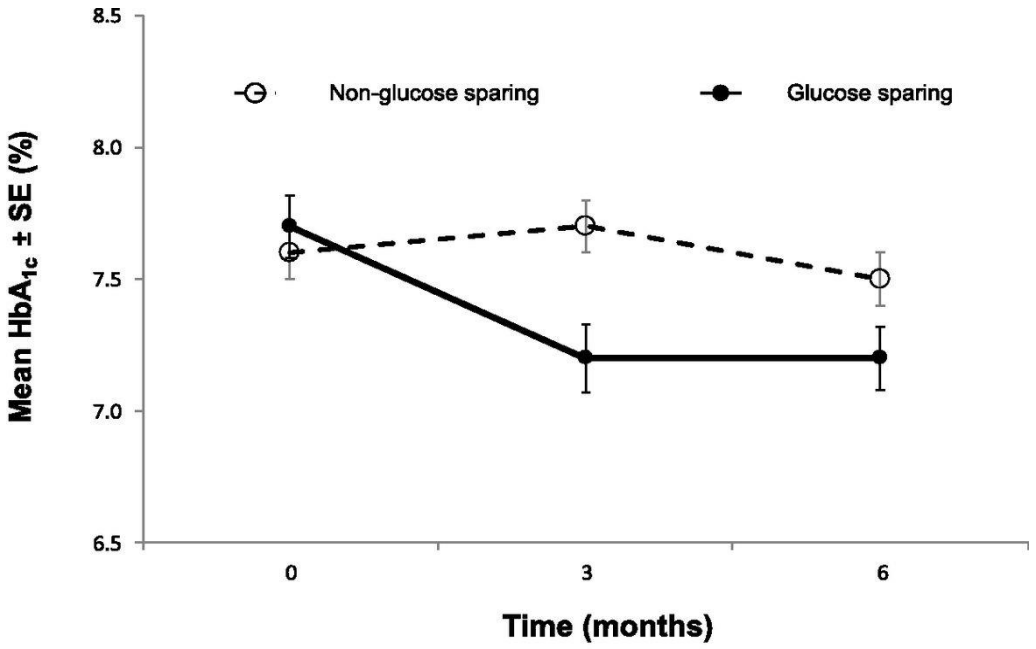
Updated 6th Nov, 2019

Glucose Monitor Brand	Compatible with Extraneal (Icodextrin) PD solution (Glucose-specific)	Test Type*	Manufacturer
FreeStyle Freedom	Yes	GDH-FAD	
FreeStyle Freedom Lite	Yes	GDH-FAD	Abbott Diabetes Care
FreeStyle Lite	Yes	GDH-FAD	www.abbottdiabetescare.com
FreeStyle Libre[1]	Not recommended	GO	Phone: 1800 801 478
FreeStyle Libre Pro[1]	Not recommended	GO	
FreeStyle Optium Neo	Yes	GDH-NAD	
FreeStyle Optium Neo H	Yes	GDH-NAD	
FreeStyle Papillon Vision	Yes	GDH-FAD	
FreeStyle Precision Neo	Yes	GDH-NAD	
FreeStyle Precision Pro	Yes	GDH-NAD	
Optium Xido Neo	Yes	GDH-NAD	
Precision Xceed Pro	Yes	GDH-NAD	
Assure Platinum	Yes	GO	

Under estimation of Serum amylase level

PD Fluids with Low Glucose exposure

Mean HbA1c (±SEM) at baseline, month 3, and end of study by treatment group in the intention-to-treat population.



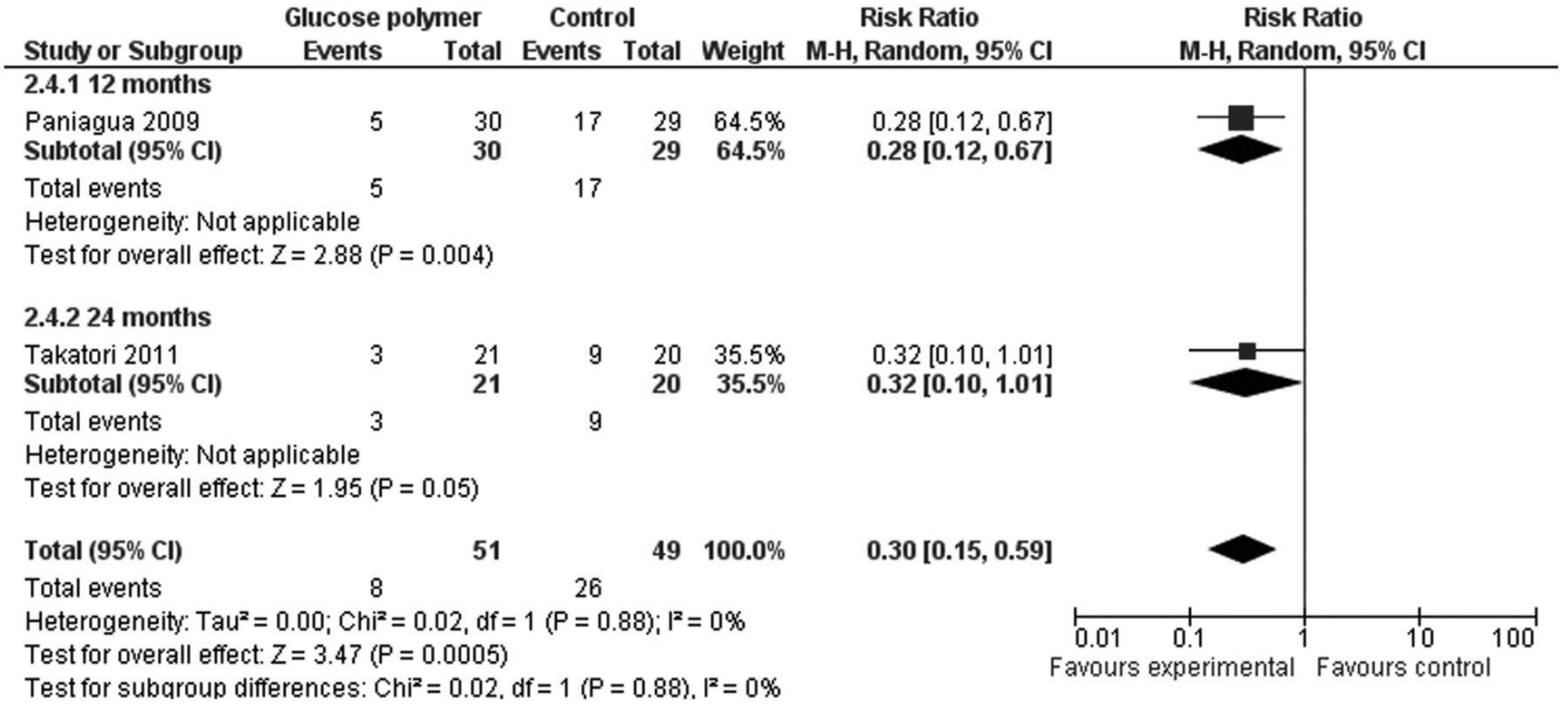
Subjects			
Non-glucose sparing	125	107	118
Glucose sparing	119	86	99

Serum triglyceride, very-low-density lipoprotein, and apolipoprotein B levels improved in the intervention group.
Deaths and serious adverse events, including several related to extracellular fluid volume expansion were significantly high in the intervention group.

Philip K.T. Li et al. JASN 2013;24:1889-1900

JASN

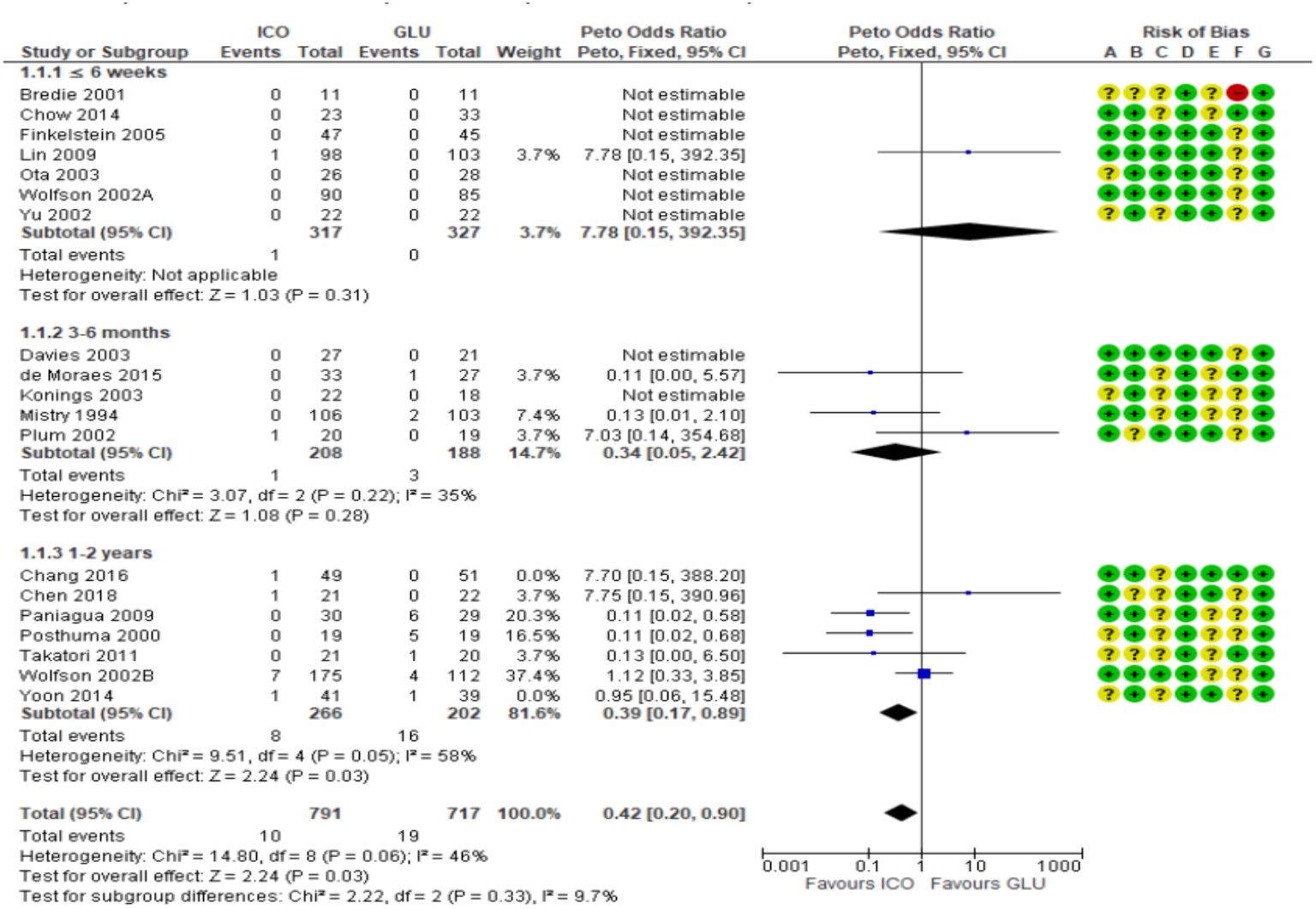
Effect of icodextrin on uncontrolled fluid overload episodes.



Yeoungjee Cho et al. Nephrol. Dial. Transplant. 2013;28:1899-1907

NDT
Nephrology Dialysis Transplantation

Icodextrin vs Glucose: Effect on Mortality



AJKD 2020: doi: 10.1053/j.ajkd.2019.10.004

Icodextrin use on other clinical outcomes

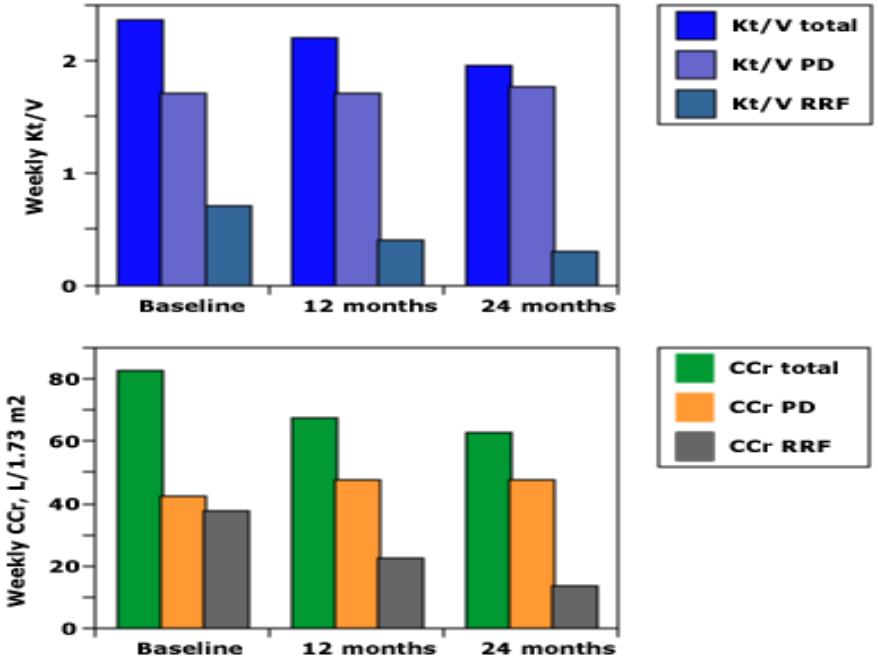
- No impact on
  - Technique survival
  - Residual renal function
  - Urine output
  - Incidence of peritonitis

Yeoungjee Cho et al. Nephrol. Dial. Transplant. 2013;28:1899-1907

AJKD 2010: doi: 10.1053/j.ajkd.2019.10.004

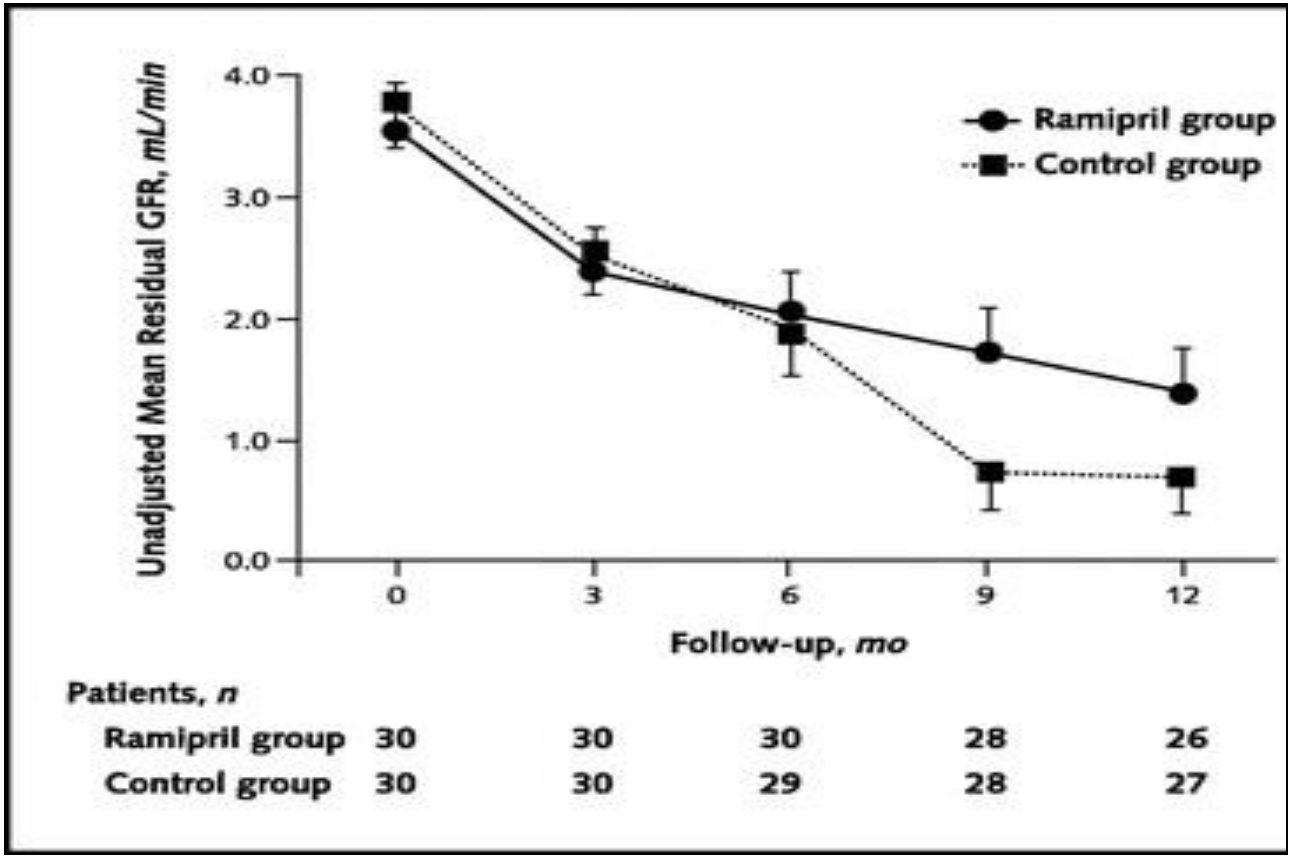
Importance of RRF

- Solute clearance
- Benefits of maintaining RRF
  - Anaemia
  - Fluid management
  - BP and LVH
  - Patient survival



Increasing urine output with diuretics increases free water excretion, without increasing solute excretion

Effects of an Angiotensin-Converting Enzyme Inhibitor on Residual Renal Function in Patients Receiving Peritoneal Dialysis: A Randomized, Controlled Study



Unadjusted mean residual glomerular filtration rate (GFR) at baseline and follow-up in the ramipril group and the control group.

Annals of Internal Medicine. 139(2):105-112, July 15, 2003

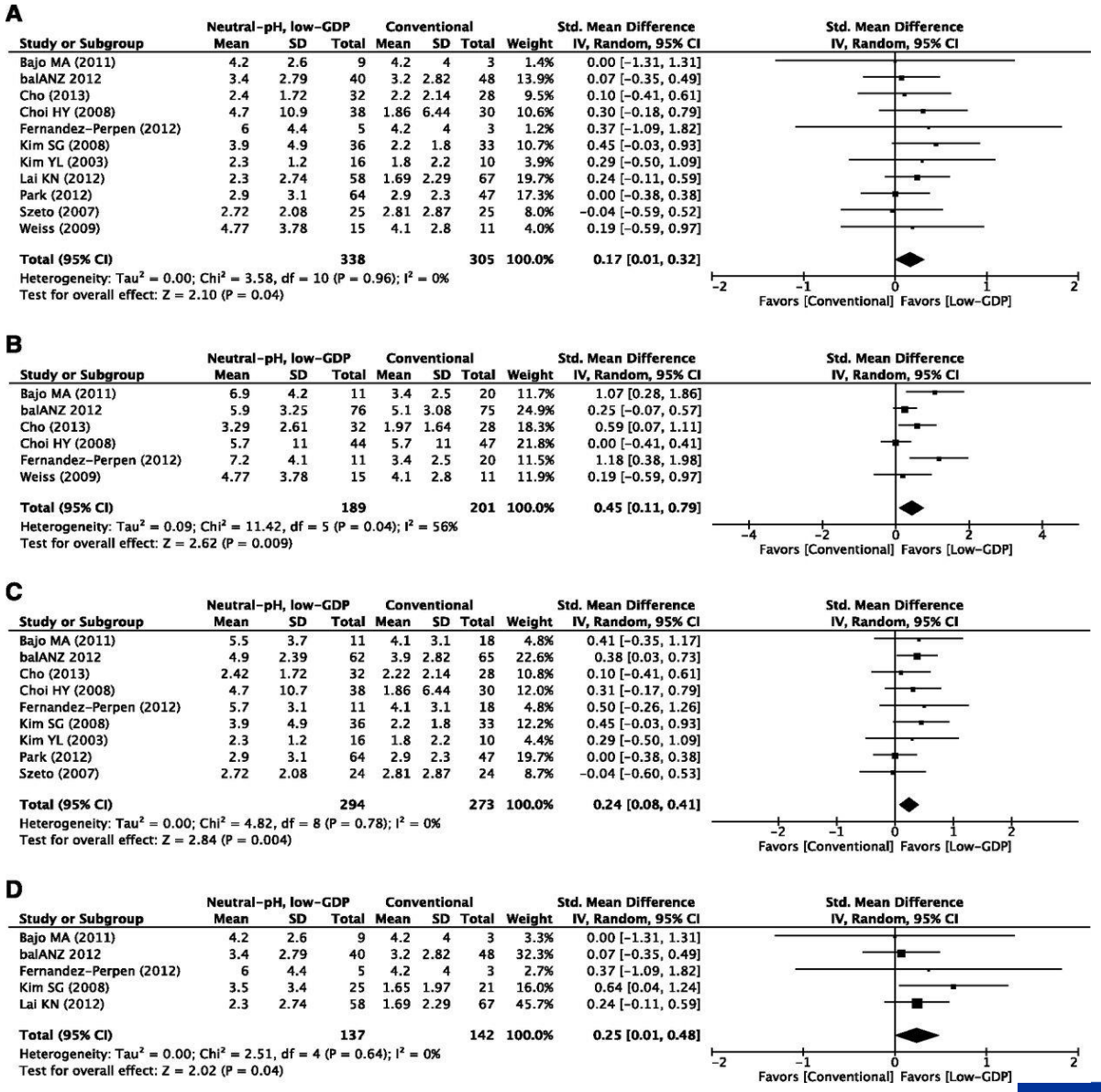
Preservation of RRF

Use of ACEi/ARBs for treatment of hypertension
Low GDP, neutral pH PD solutions

Avoid

- Prolonged use of Aminoglycosides
- NSAIDS
- Contrast agents

Effect of neutral-pH, low–GDP PD solutions on RRF



Seychelle Yohanna et al. CJASN 2015;10:1380-1388

CJASN

Low GDP, neutral pH solutions on other outcomes

- Preserve urine output
- Less inflow pain
- No effect on:
  - Ultrafiltration volume
  - Peritoneal clearances
  - Peritonitis episodes
  - Technique failure
  - Mortality

PD ‘ADEQUACY’

Guidelines

PERITONEAL DIALYSIS INTERNATIONAL

Peritoneal Dialysis International
2020, Vol. 40(3) 244–253

DOI: 10.1177/0896860819895364
journals.sagepub.com/home/ptd
SAGE

International Society for Peritoneal Dialysis practice recommendations: Prescribing high-quality goal-directed peritoneal dialysis

Edwina A Brown[1], Peter G Blake[2], Neil Boudville[3], Simon Davies[4,5], Javier de Arteaga[6], Jie Dong[7], Fred Finkelstein[8], Marjorie Foo[9], Helen Hurst[10], David W Johnson[11], Mark Johnson[12], Adrian Liew[13], Thyago Moraes[14], Jeff Perl[15], Rukshana Shroff[16], Isaac Teitelbaum[17], Angela Yee-Moon Wang[18] and Bradley Warady[19]

Prescribing ‘high quality goal-directed’ PD

- To promote the provision of high-quality dialysis care by the dialysis team:
  - PROMs
  - Maintenance of fluid status
  - Maintenance of Nutritional Status
  - Removal of Toxins
- Shared decision making to allow the person doing PD to achieve his/her own life goals

Peritoneal Dialysis Adequacy

Solute clearance:

Small solute clearances can be measured by 'Adequest Test'

'Target': weekly KT/V 1.7 (urea);

In anuric patients, additional target of creatinine clearance of 45 L/week/1.73 m2.

Ultrafiltration:

PD Fluid volume drained – infused

Target: 1 Litre/day

'Goal Directed PD Prescription': Shared Decision making

https://doi.org/10.1177/0896860819895364

PD- Complications

Infective

- Peritonitis
- Exit site infection
- Tunnel Infection

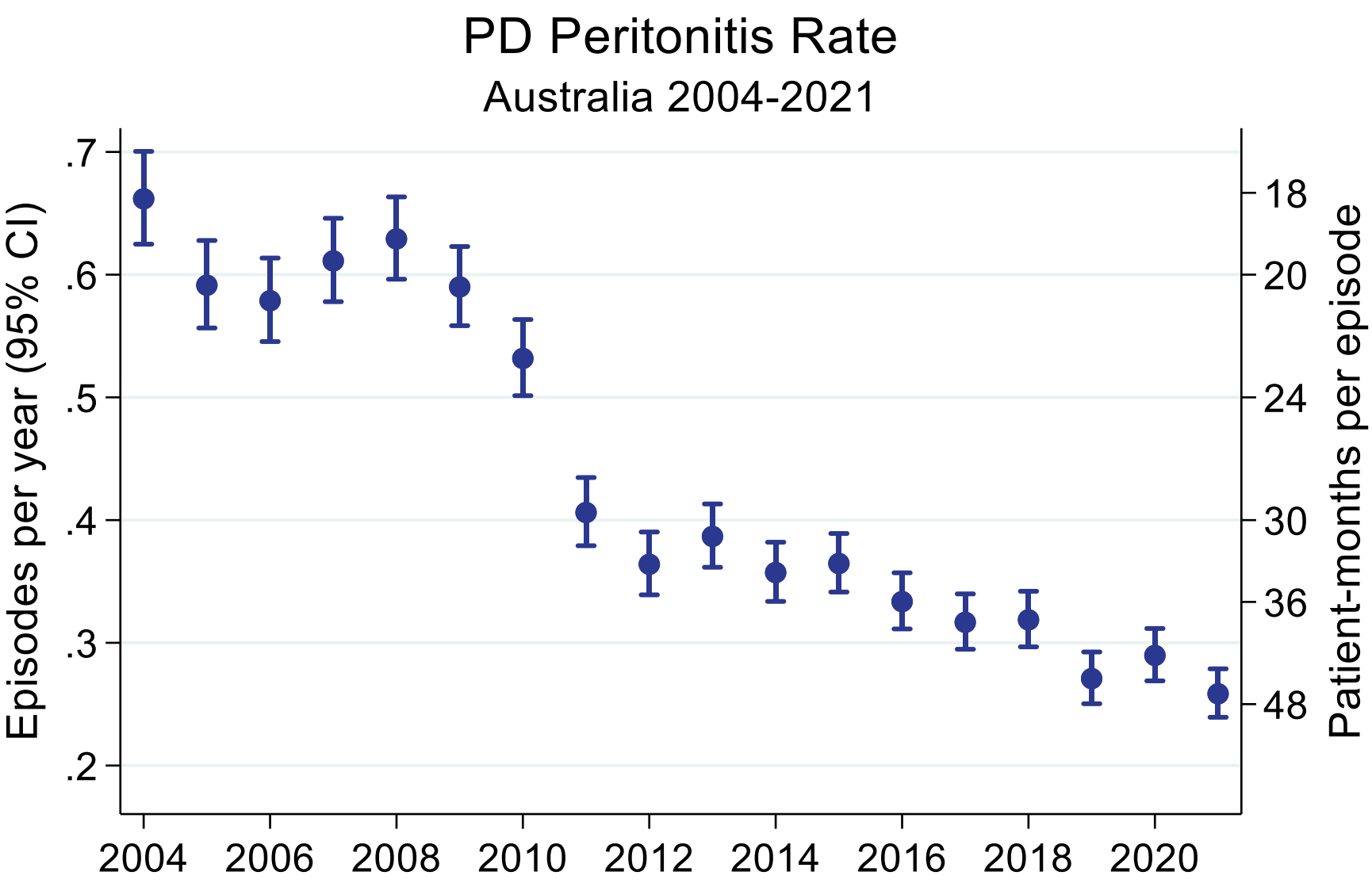
*Pressure related:

- Hernias
- Dialysate leaks
  - Pericatheter
  - Abd. wall
  - Genitalia
  - Pleural

Non-infective

- Access Related:
  - Catheter obstruction
  - Omental entrapment
  - Tip migration
  - Cuff extrusion
- Ultrafiltration failure
- Technique failure

*Intra-abdominal Pressure lowest when supine, greatest while sitting



2022 ANZDATA Annual Report, Figure 5.22

ISPD 2022 Guidelines

Prevention of PD peritonitis

We recommend that systemic prophylactic antibiotics should be administered immediately prior to catheter insertion **(1A)**

- We recommend daily topical application of antibiotic (mupirocin or gentamicin) cream or ointment to the catheter exit-site **(1B)**.

Peritoneal Dialysis International 2022, Vol. 42(2) 110–153

ISPD 2022 Guidelines: Diagnosis

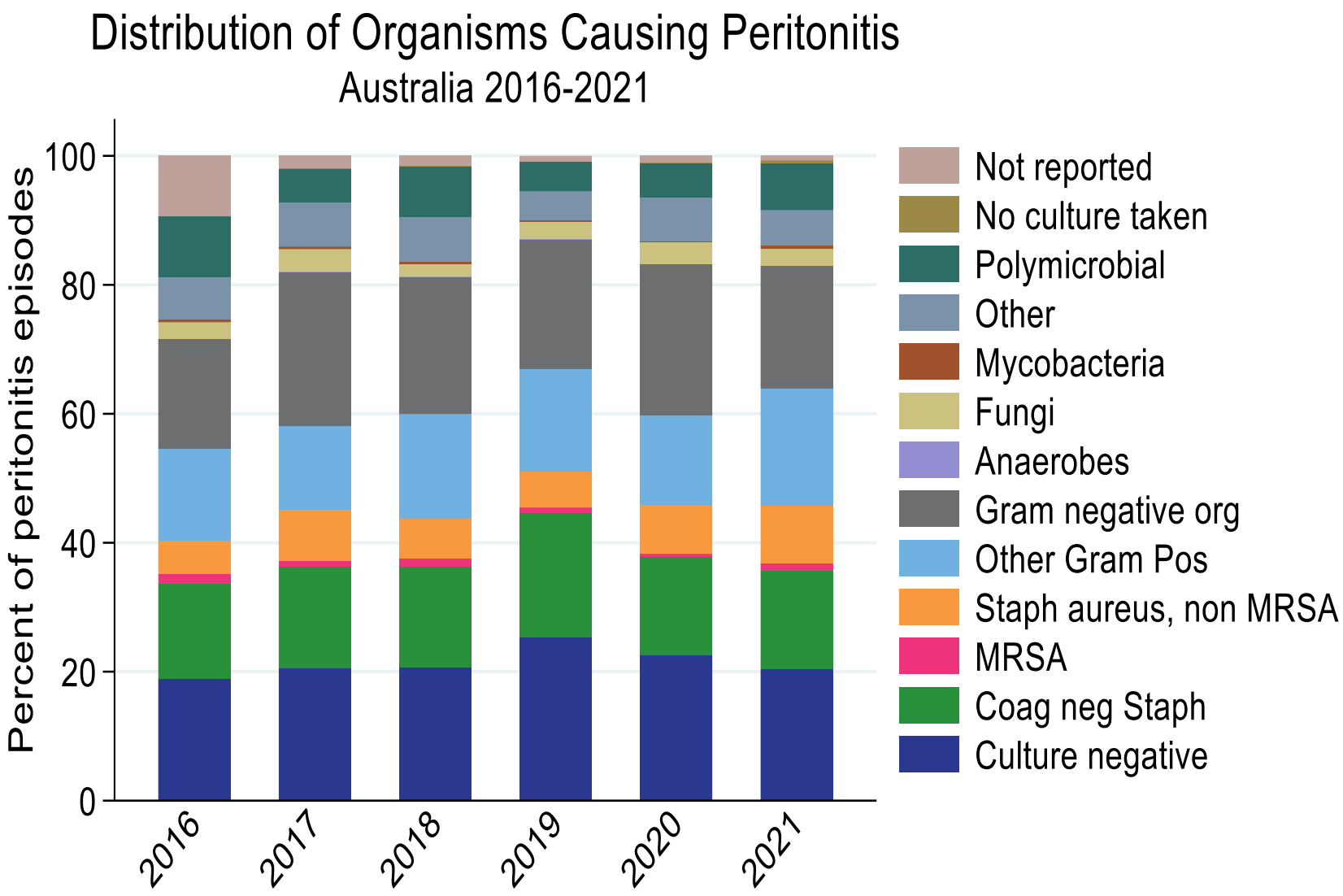
- We recommend that peritonitis should always be diagnosed when at least 2 of the following are present:
  - clinical features consistent with peritonitis, i.e. abdominal pain and/or cloudy dialysis effluent;
  - dialysis effluent white cell count >100/μL or >0.1 x 10^9/L (after a dwell time of at least 2 hours), with >50% PMN; and
  - positive dialysis effluent culture **(1C)**.
- We recommend that PD patients presenting with cloudy effluent should be presumed to have peritonitis and treated as such until the diagnosis can be confirmed or excluded **(1C)**.

Peritoneal Dialysis International 2022, Vol. 42(2) 110–153

Differential Diagnosis of Cloudy Effluent

- Culture-positive infectious peritonitis
- Infectious peritonitis with sterile cultures

- Chemical peritonitis - Eosinophilia of the effluent
- Hemoperitoneum
- Malignancy (rare)
- Chylous effluent (rare)
- Specimen taken from “dry” abdomen



2022 ANZDATA Annual Report, Figure 5.27

Treatment of PD related Peritonitis

- Every hour of delay in administering antibacterial therapy from time of presentation to hospital increased the risk of PD failure or death by 6.8%
- Start empirical antibiotics ASAP
- IP administration of antibiotics better than IV
- Intermittent IP administration of antibiotics has similar response rates as continuous IP administration

Cochrane review: Treatment for peritoneal dialysis-associated peritonitis (April 2014)
DOI: 10.1002/14651858.CD005284.pub
KI Reports (2016) 1, 65–72; http://dx.doi.org/10.1016/j.ekir.2016.05.003

Antibiotics and duration of treatment

Staph epi –	IP Cephalosporin x 2 wks
Stept/Enterococcus:	IP Ampicillin ± Gentamicin (1 week) x 2 wks
Staph aureus:	MSSA: IP Cephalosprin x 3 wks
	MRSA: IP Vanc x 3 wks
Gram Negative:	IP Aminoglycoside 2 wks
Pseudomonas:	2 antibiotics, 3 wks
	(High rate for recurrence and relapse)
Culture negative:	IP Cephalosporin 2 wks

Catheter removal: Indications

- Peritonitis with exit site/tunnel infection
- Refractory peritonitis: No improvement after 5 days of antibiotics
- Relapsing peritonitis: Peritonitis with same organism within 4 weeks of stopping antibiotics.
- Peritonitis with intra-abdominal pathology
- Fungal / Mycobacterial peritonitis

PERITONEAL DIALYSIS INTERNATIONAL

Special Series/Guidelines

Peritoneal Dialysis International
2022, Vol. 42(2) 110–153

DOI: 10.1177/08968608221080586
journals.sagepub.com/home/ptd
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ISPD peritonitis guideline recommendations: 2022 update on prevention and treatment

Philip Kam-Tao Li[1,2], Kai Ming Chow[1,2], Yeoungjee Cho[3,4], Stanley Fan[5], Ana E Figueiredo[6], Tess Harris[7], Talerngsak Kanjanabuch[8,9], Yong-Lim Kim[10], Magdalena Madero[11], Jolanta Malyszko[12], Rajnish Mehrotra[13], Ikechi G Okpechi[14], Jeff Perl[15], Beth Piraino[16], Naomi Runnegar[17], Isaac Teitelbaum[18], Jennifer Ka-Wah Wong[19], Xueqing Yu[20,21] and David W Johnson[3,4]

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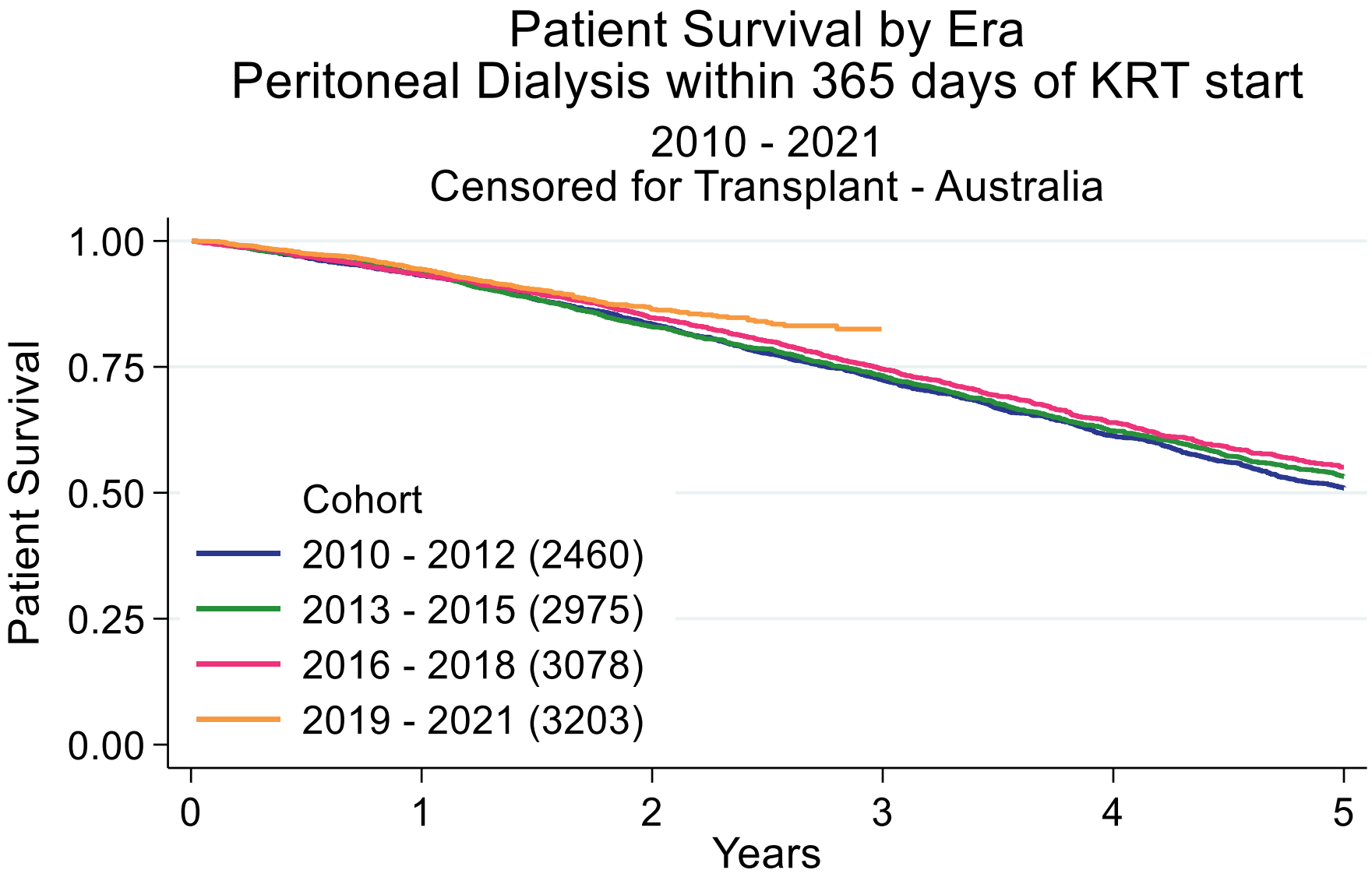
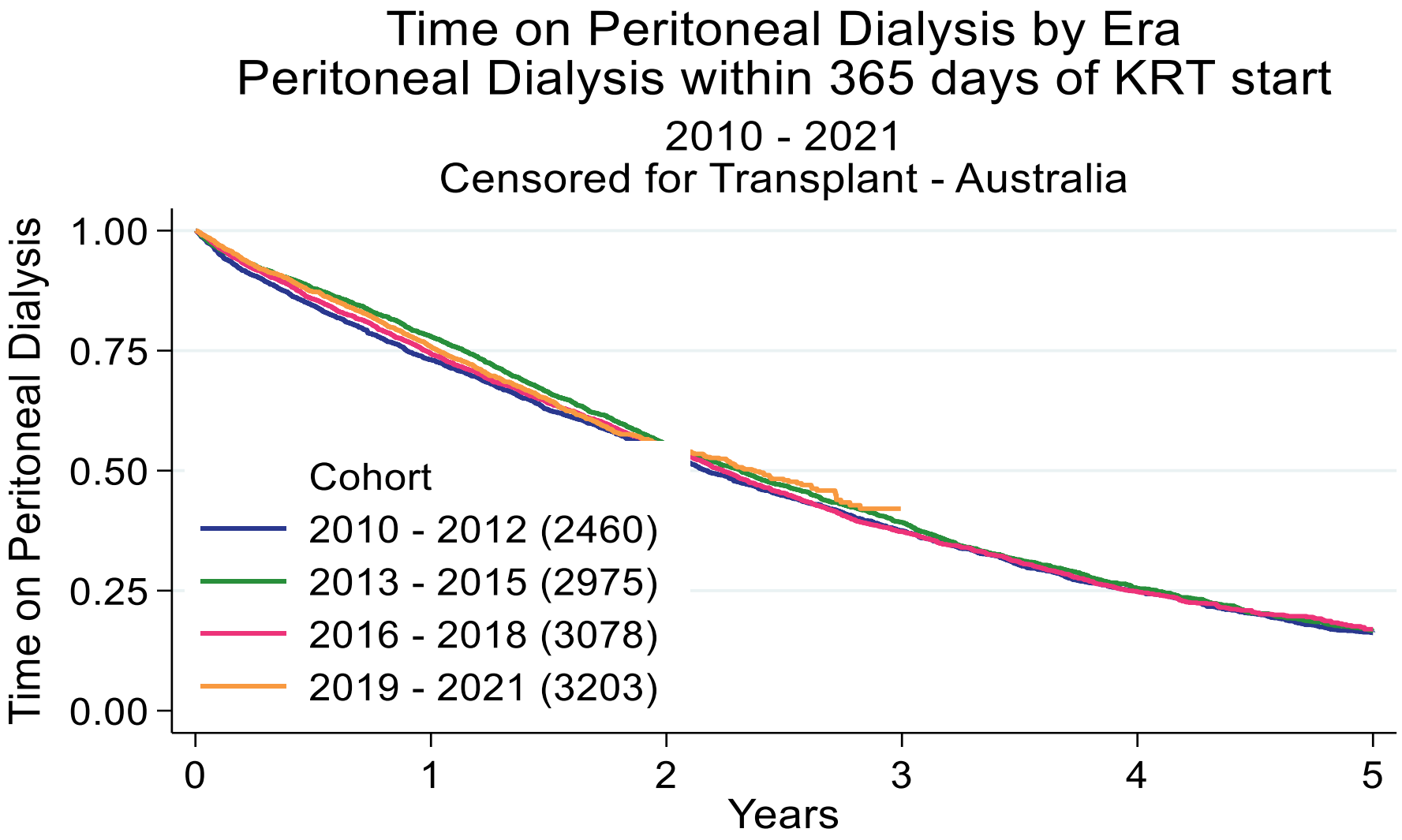


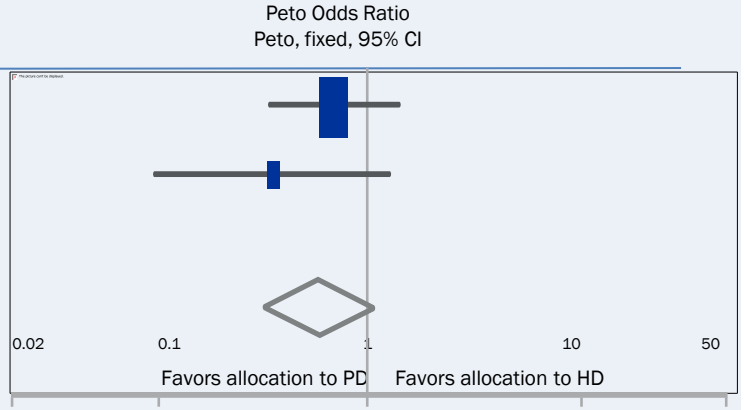
2022 ANZDATA Annual Report, Figure 5.10.1



2022 ANZDATA Annual Report, Figure 5.13.1

Survival advantage of PD over HD? Only 2 RCTs

Study or Subgroup	PD Events	PD Total	HD Events	HD Total	Weight	Peto Odds Ratio Peto, fixed, 95% CI
ChinaQ 2018	13	332	19	336	77.1%	**0.68 (0.34, 1.39)**
NECOSAD 2003	5	20	9	18	22.9%	**0.35 (0.10, 1.29)**
Total (95% CI)		352		354	100.0%	0.59 (0.31, 1.09)
Total events	18		28			
Heterogeneity: Chi² = 0.77, df = 1 (P = 0.38); I² = 0% Test for overall effect: Z = 1.68 (P = 0.09)						



ChinaQ: Deaths

HD: 19 / 336 | PD: 13 / 332

NECOSAD: Deaths

HD: 9 / 18 | PD: 5 / 20

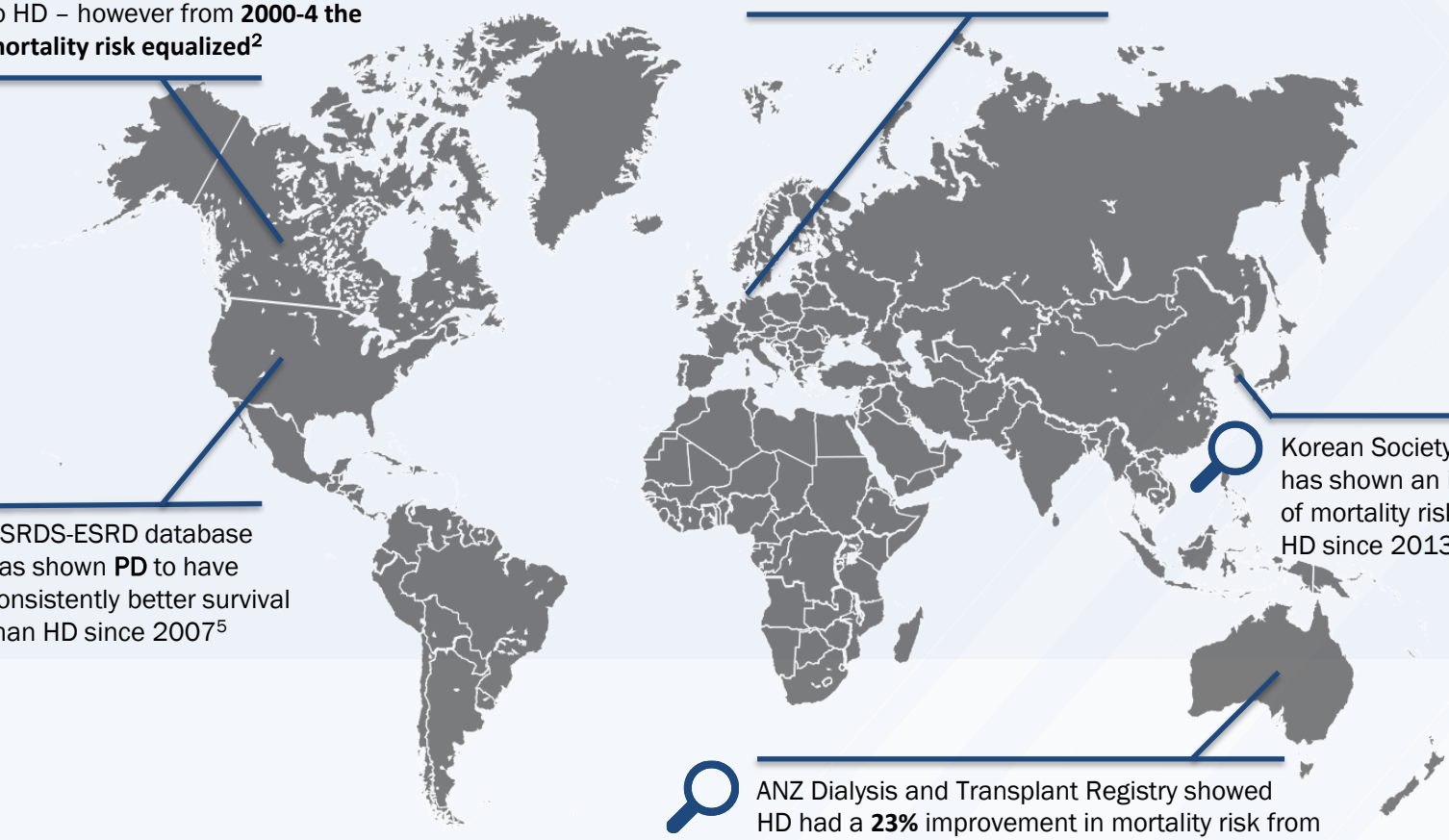
- Pooled data from two RCTs of 706 patients randomized equally to PD or HD
- There is an indication of 40% lower risk of death with PD
- This did not achieve statistical significance

1. Yu X, et al. 2018
2. Korevaar JC, et al. 2003

Multiple observational studies show PD survival rates outpacing HD

Canadian Organ Replacement Registry showed **PD** to historically have higher mortality risk compared to HD – however from **2000-4 the mortality risk equalized**[2]

Danish Society Of Nephrology Registry has shown a consistent trend in improving **PD** mortality risk from 1990-2010[3]

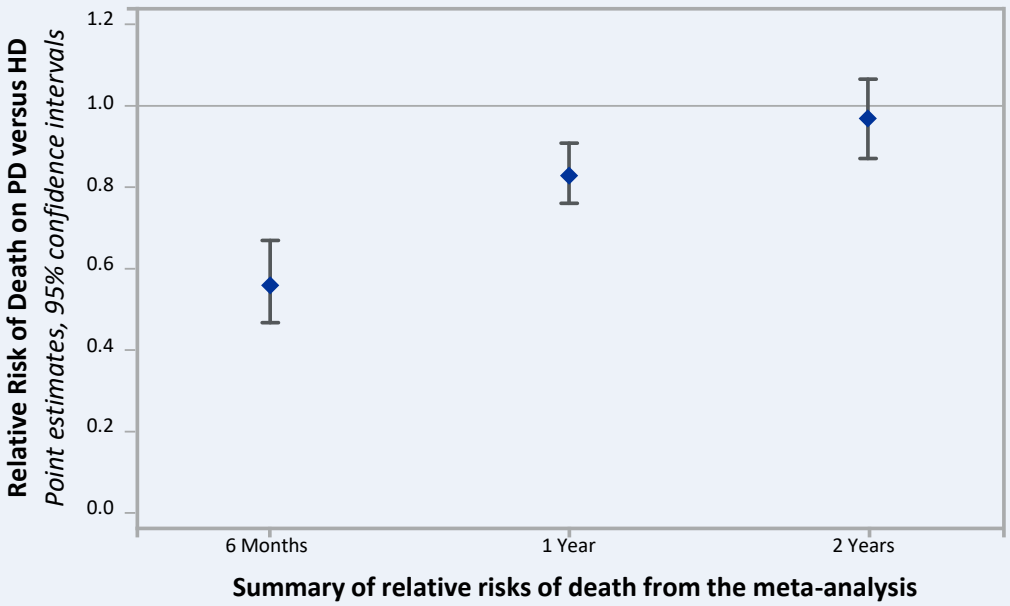


USRDS-ESRD database has shown **PD** to have consistently better survival than HD since 2007[5]

Korean Society of Nephrology has shown an improvement of mortality risk of **PD** over HD since 2013[4]

ANZ Dialysis and Transplant Registry showed HD had a **23%** improvement in mortality risk from 1998-2012 however **PD** showed a **29%** improvement in mortality from 1998-2012[6]

DURING YEAR 1 PATIENTS HAVE BETWEEN 17-44% LOWER DEATH RATE ON **PD** VS HD[35]



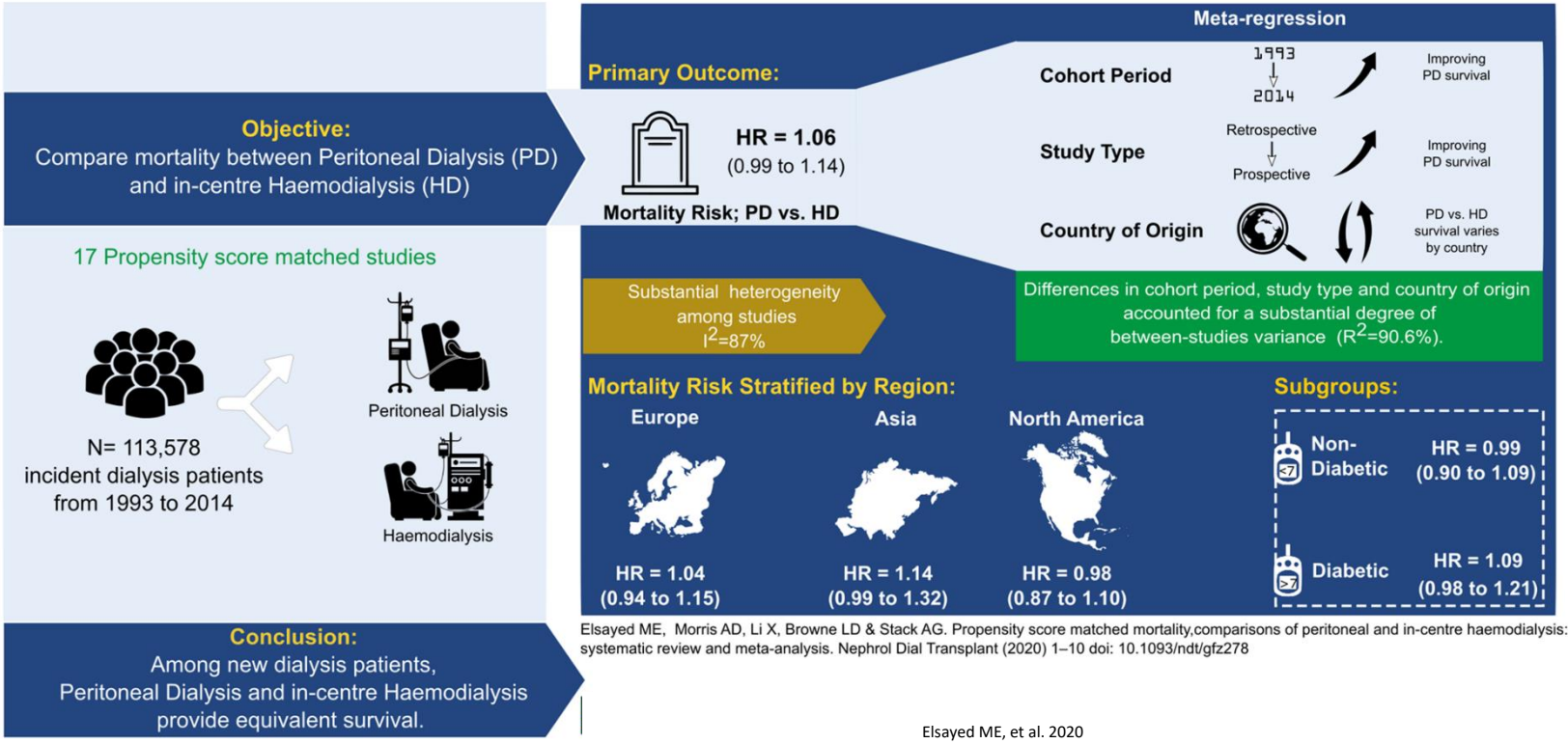
Summary of relative risks of death from the meta-analysis

Meta-analysis of 811,319 patients from 18 countries: those who start dialysis with **PD** have an early survival benefit vs their counterparts who start with **HD**

Mortality rates are significantly higher on HD than on PD through the first two years

Key: HD – hemodialysis; PD – peritoneal dialysis; RRF – residual renal function.

Mortality comparisons of peritoneal and in-centre hemodialysis



Elsayed ME, Morris AD, Li X, Browne LD & Stack AG. Propensity score matched mortality,comparisons of peritoneal and in-centre haemodialysis: systematic review and meta-analysis. Nephrol Dial Transplant (2020) 1–10 doi: 10.1093/ndt/gfz278

Elsayed ME, et al. 2020

Other ‘Special’ conditions favouring HD or PD

Condition	Favours PD	Favours HD	No Difference
CCF		X	?
Hypoalbuminemia		X	
Health related QOL	X		?
Survival from critical illness in ICU		X	
BP control	X		
Lower ESA dose	X		