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# Peritoneal Dialysis in ICU

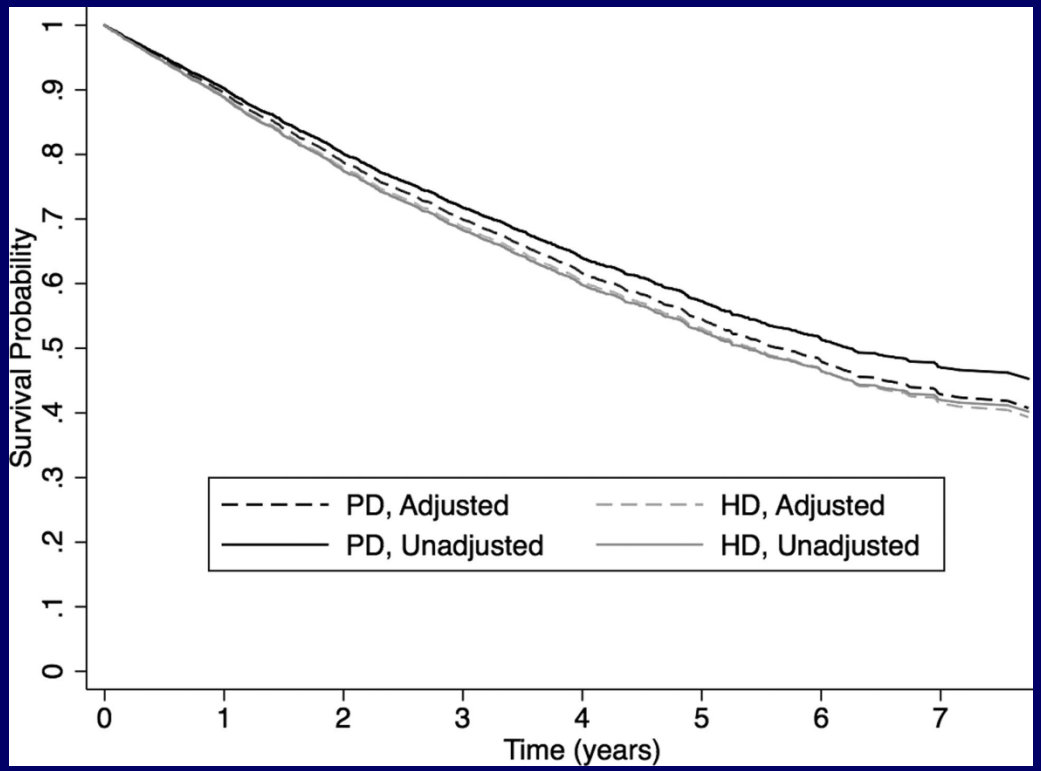
Iraj Najafi MD.

**Fouman**

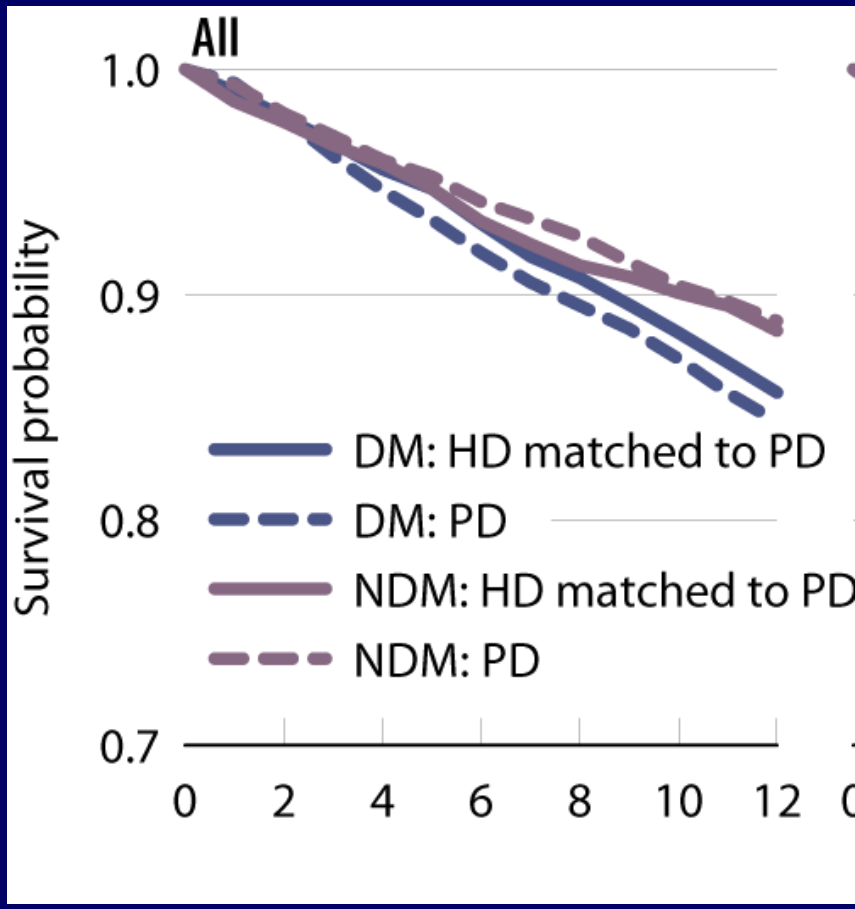
11/2/1397

# No Real Difference in Outcomes of PD and HD Patients with ESRD: US, Canada, Holland

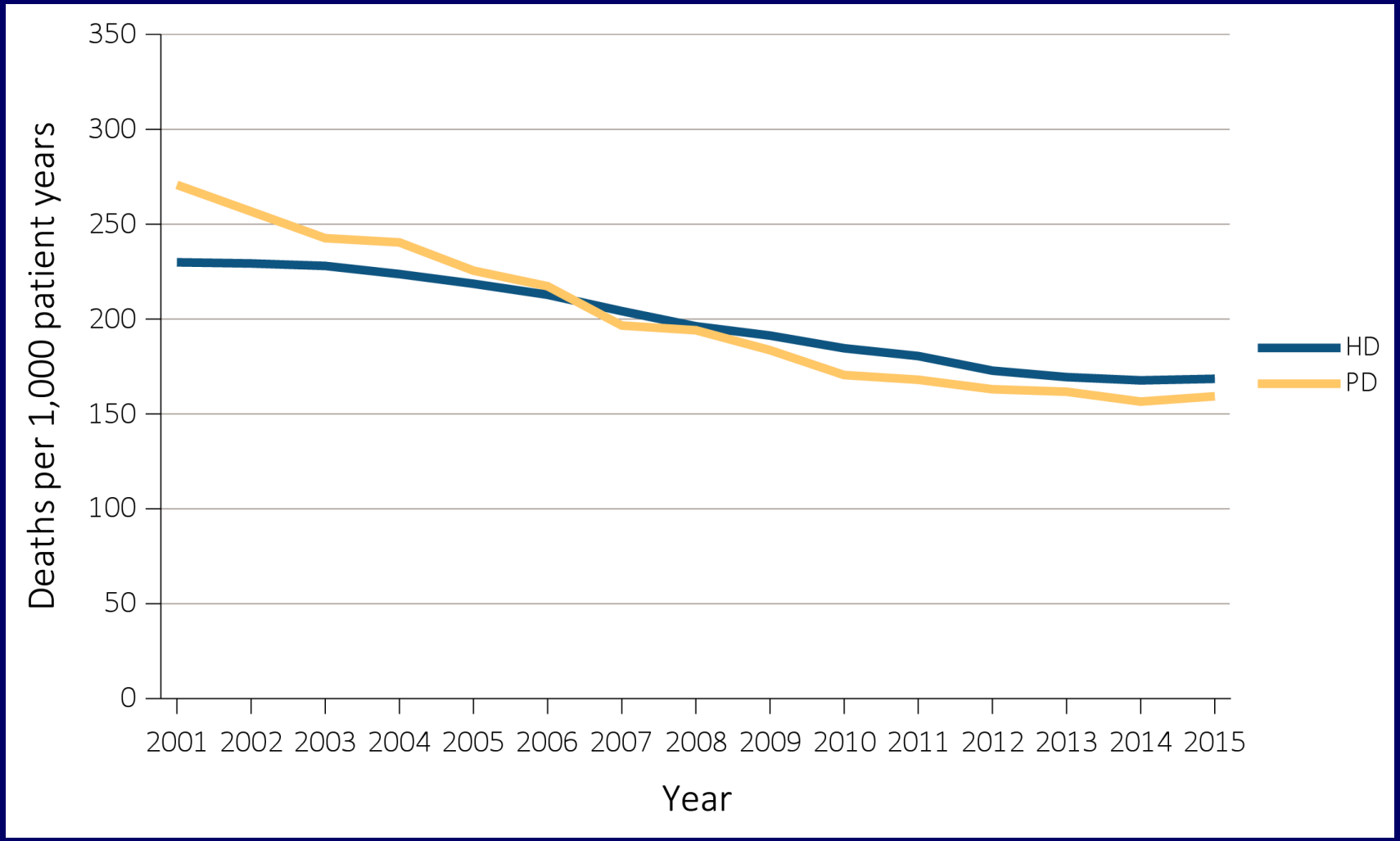
Selection Bias: Survival in Ontario Registry for PD and HD pts who had received at least 4 mths of predialysis care & started dialysis electively, as outpatients. (Quinn et al: J Am Soc Nephrol. 2011 22:1534



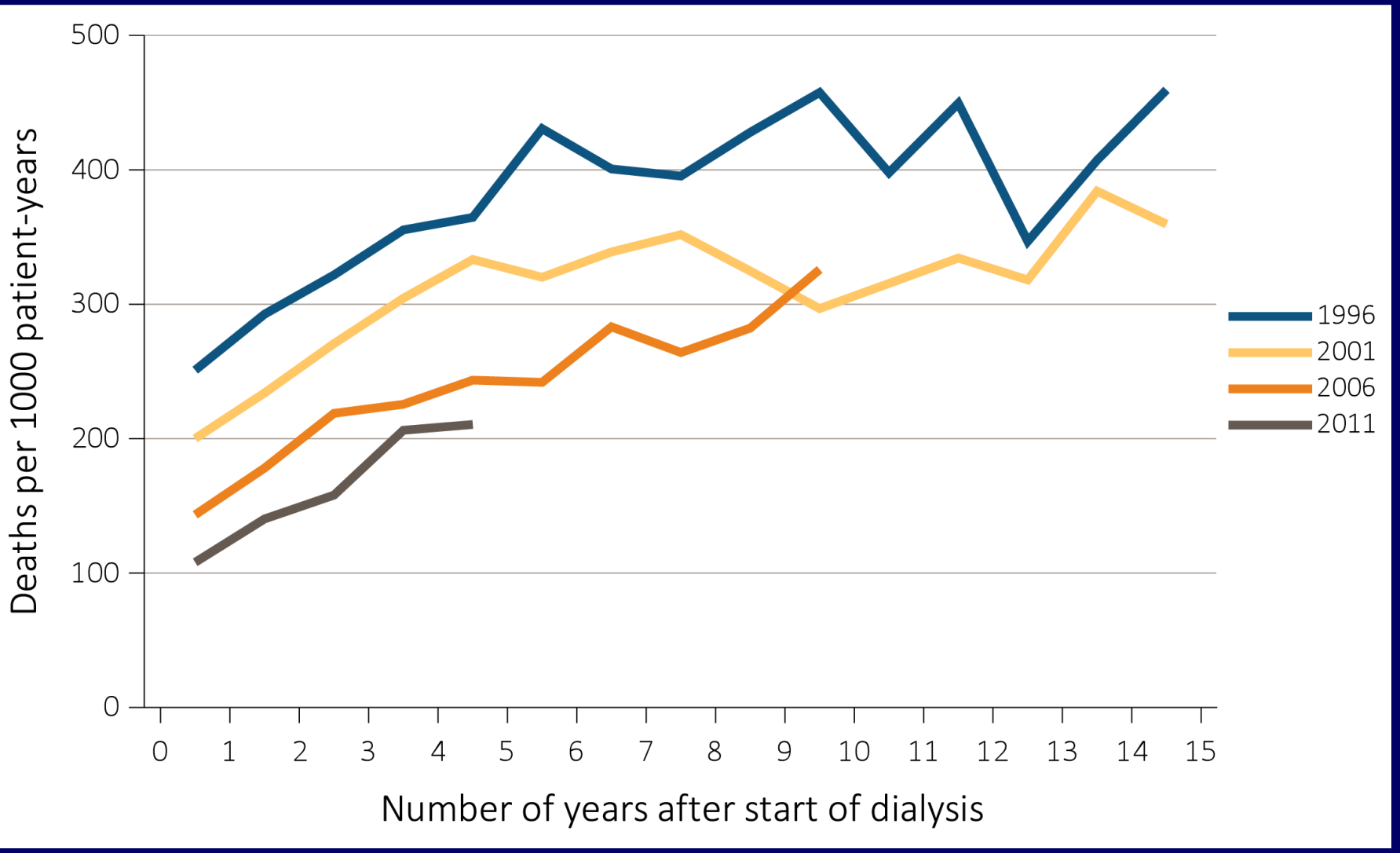

USRDS 2012: survival using propensity-matched modality data by race & diabetic status



# Decline in Mortality Over Time: USRDS 2017



# PD Mortality By Time of Start USRDS 2017

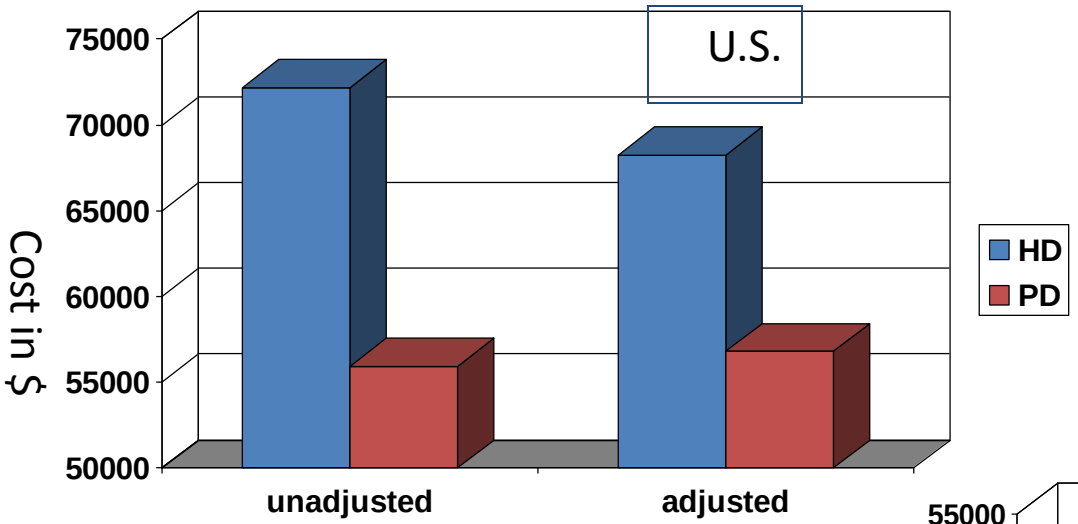


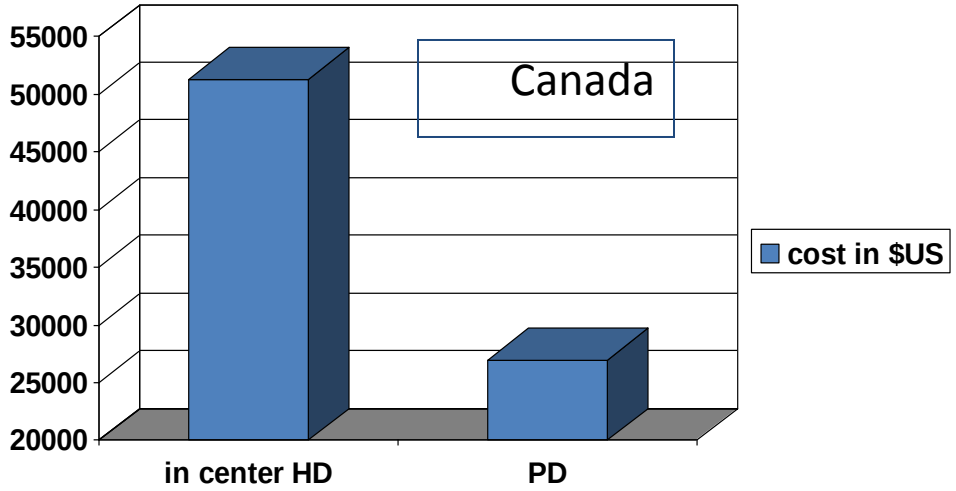
# What Drives the Improvements in PD Outcomes?

- Decrease in peritonitis rates
- Decrease in exit site infections
- Better management of infections
- Improvements in catheter placement
- Better understanding of the “dose” of dialysis
- Better management of ultrafiltration (icodextrin, understanding U/F failure, etc)

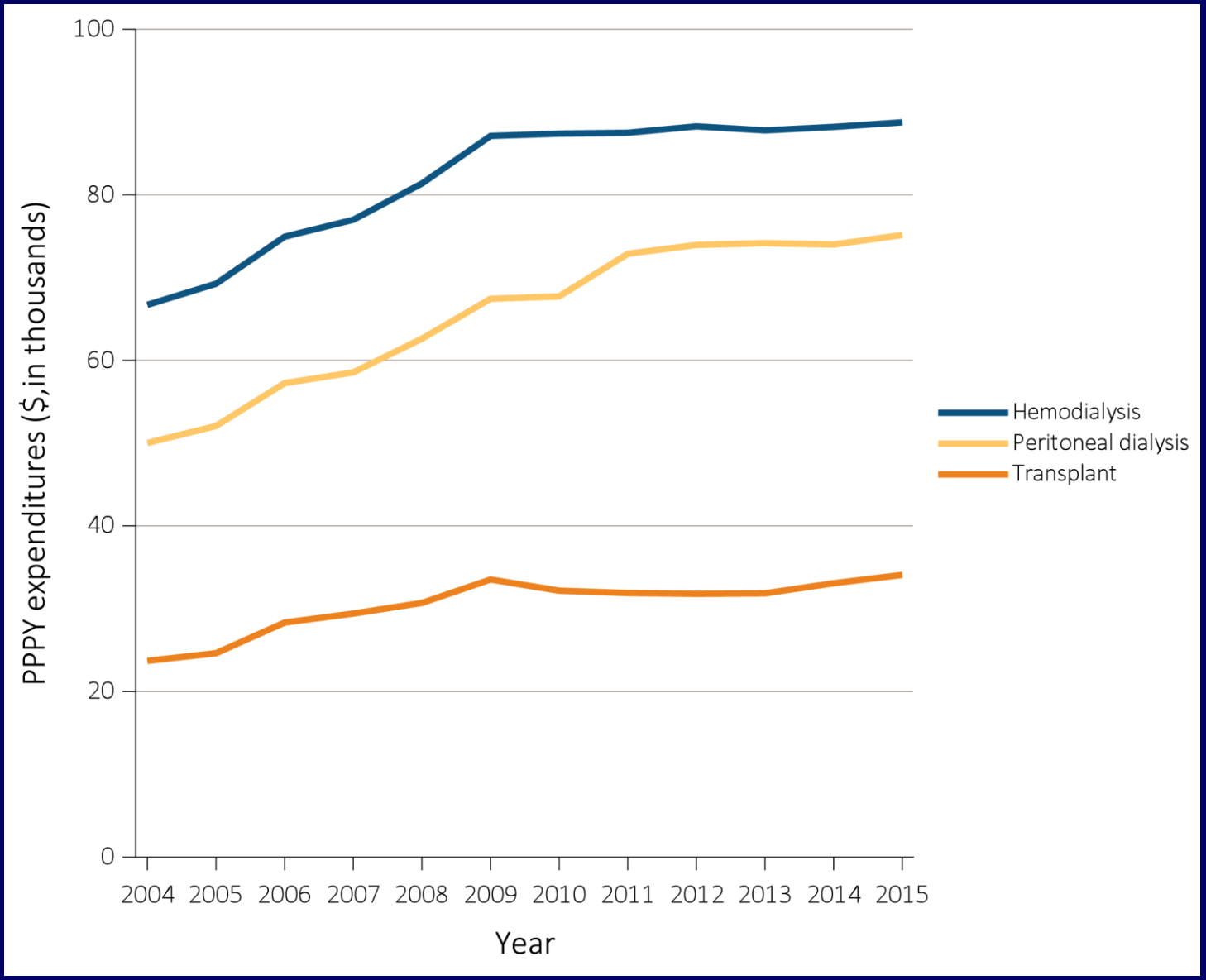
# GLOBAL COSTS: PD vs HD

(Lee: AJKD 40,611,2002; Shih: KI 68:319, 2005)



# *USRDS 2017:* Total Medicare ESRD expenditures per person per year 2004-2015



# PD in AKI

Iraj Najafi MD.

Fouman

11.2.1397

# Urgent Start PD

Iraj Najafi MD

Kish Nephrology Urology congress

۱۶ آذر ۱۳۹۶

# Urgent-start PD:

## *Definition*

- Initiation of peritoneal dialysis in patients with unplanned incident end-stage renal disease (ESRD) who are not yet on dialysis and who require dialysis initiation before the traditional waiting period of 2 or more weeks after PD catheter placement, but do not require emergent dialysis.

# *Protocol for*

# Urgent-start PD

Dr. Mohamed Alamin

# Catheter Insertion

- Who should place the PD catheter?

**Expert personnel**

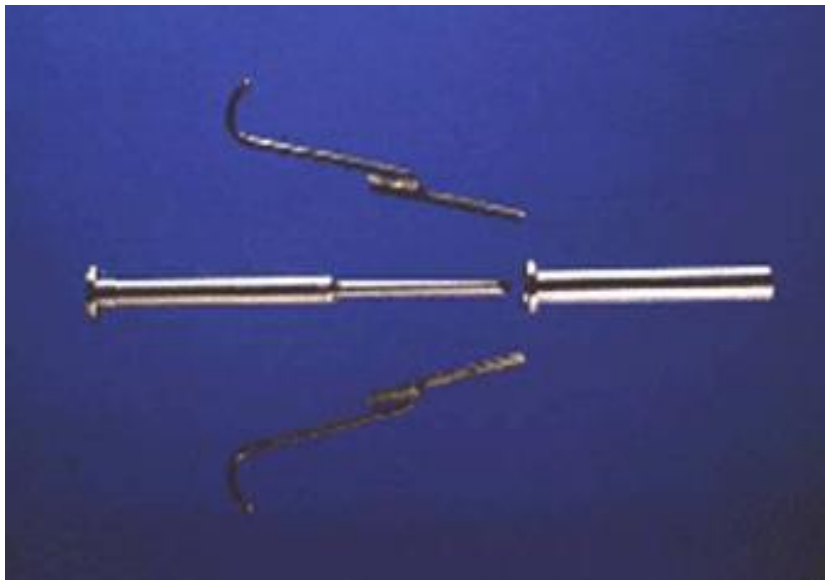
**Gold finger!!**

**Surgeon**
**Invasive Radiologist**
**Nephrologist**
**GP**
**Nurse**

# Different methods of catheter insertion

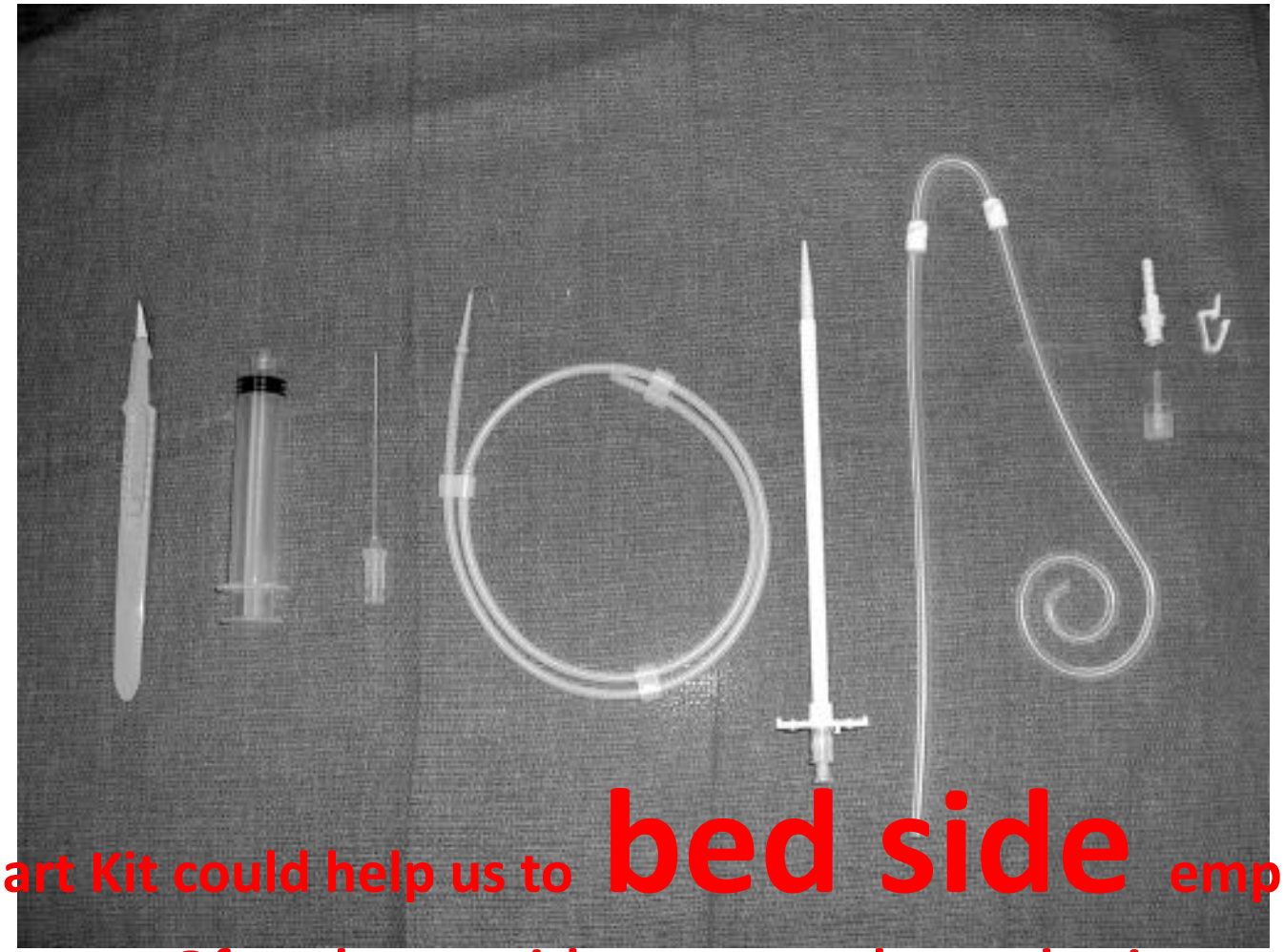
**Surgical**
**Laparoscopic**
**percutaneous**

# Using not a rigid instrument



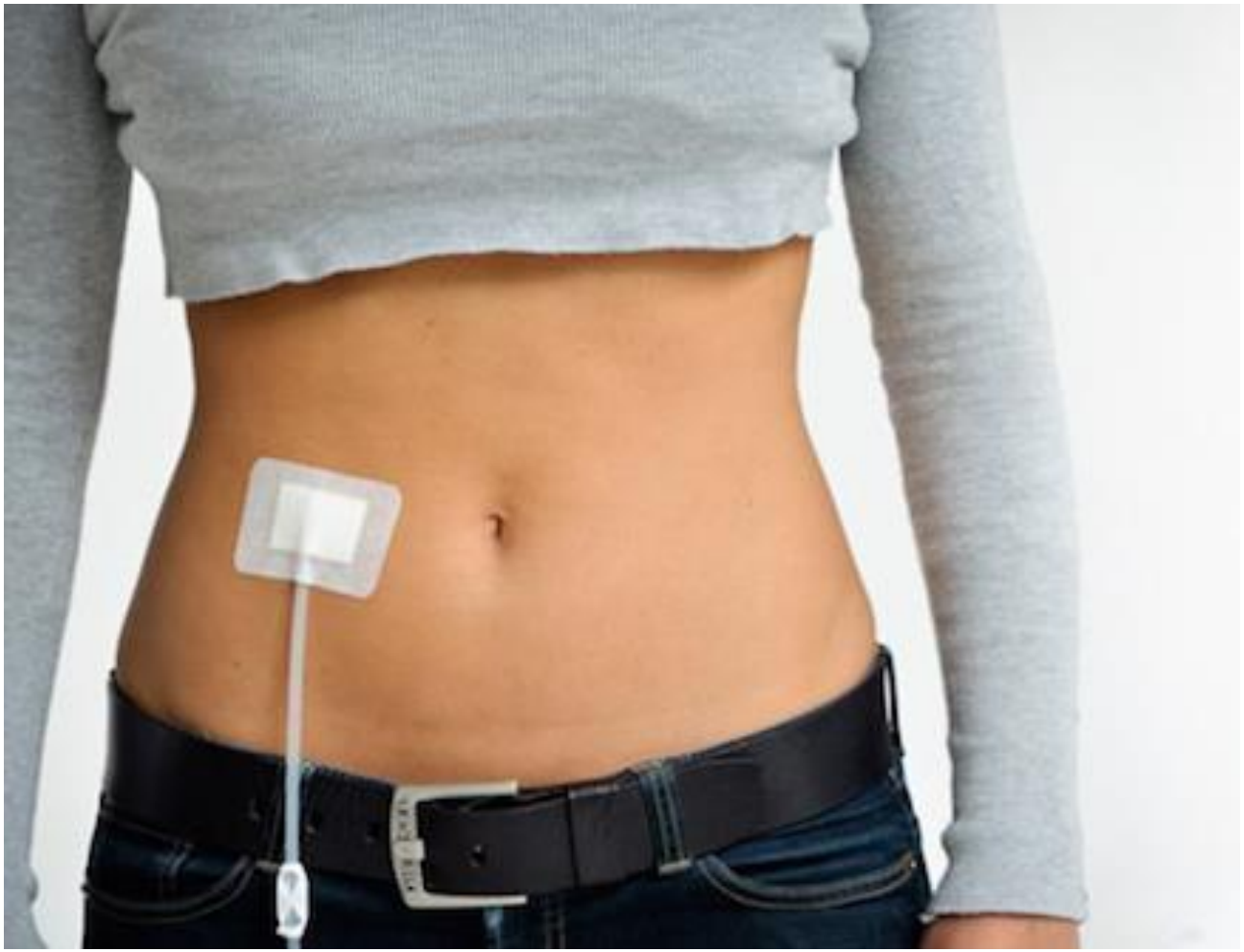
# It would be the consequences leak & …

Contents of the Quinton insertion kit: #11 scalpel, 10-cc syringe, 18-gauge introducer needle and 10-cc syringe, J/straight guidewire, 16-French **Pull-Apart introducer**, Swan neck curl cath, double-cuffed PD catheter, beta-cap adapter, cap, clamp

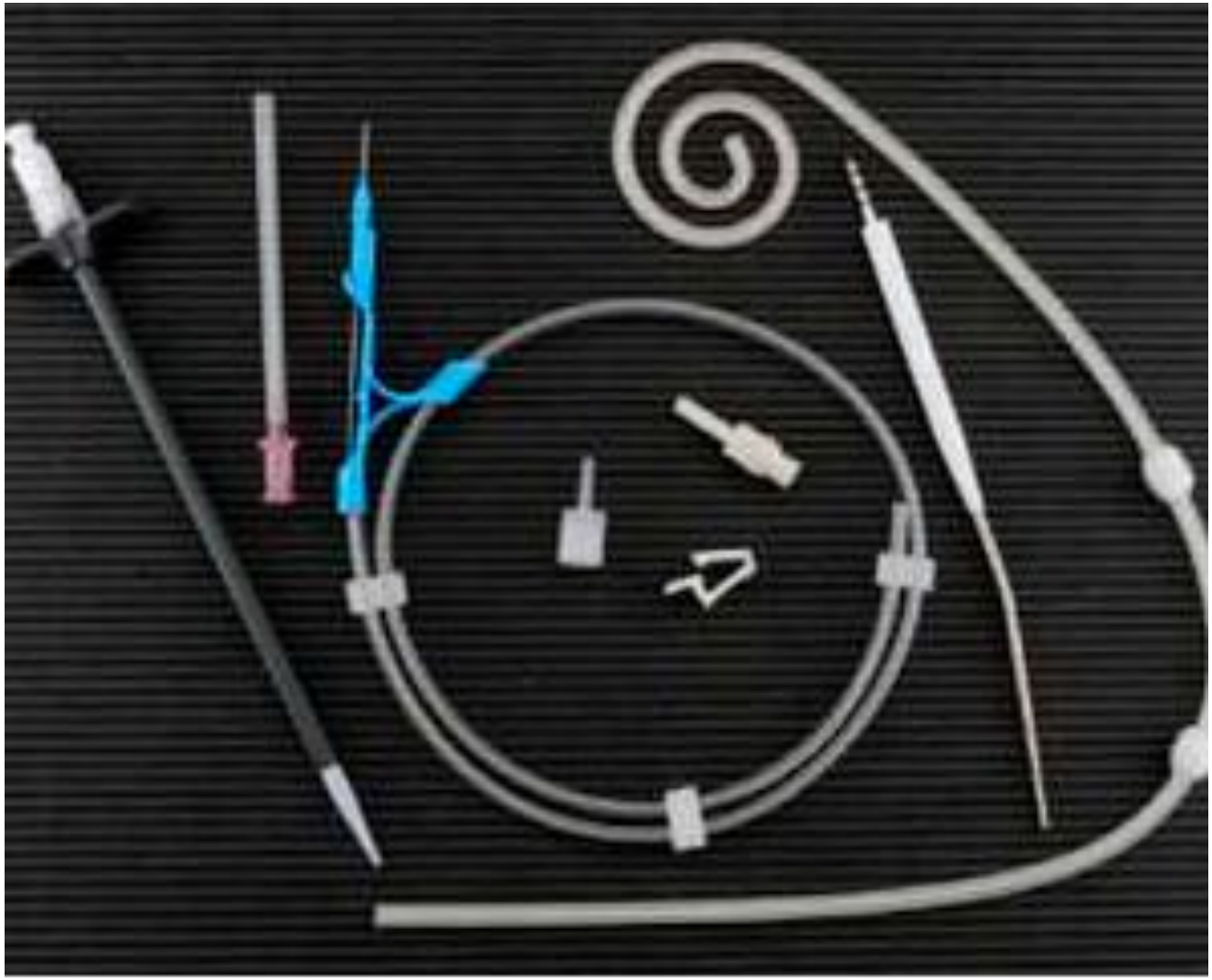


**Pull Apart Kit could help us to bed side emplacement Of catheter without general anesthesia**

# Gentle Insertion



# Gentle instrumentation




Recumbent
Low Volume
Intermitttent

# Urgent-start PD

# *Prescription*

3. PD modality: the U-s PD can be implemented through CAPD or APD but it is preferred to be in-center APD.
4. Fill volume: according to BSA of the patient
   - 500 ml if BSA < 1.65.
   - 750 ml if BSA 1.65-1.8.
   - 1000 ml if BSA > 1.8.
5. PD solution:
   - 1.5% dextrose if no peripheral edema or shortness of breath.
   - 2.5% dextrose if edema or shortness of breath.
   - 4.25% if prescribed by treating physician.

# Infectious and Mechanical Complications

| Complications | Urgent-Start PD (n=18) | Non-Urgent-Start PD (n=19) |
|---|---|---|
| No. of peritonitis episodes | 1 | 1 |
| Peritonitis rate (/patient-month) | 1/110 | 1/42 |
| No. of exit-site infections | 2 | 1 |
| Exit-site infection (/patient-month) | 1/55 | 1/42 |
| Minor leaks | 4 (22.2) | 1 (11.1) |
| Major leaks | 2 (11.1) | 0 (0) |
| Poor initial drain | 0 (0) | 1 (11.1) |
| Primary nonfunction | 2 (11.2) | 2 (22.2) |
| Hematoma | 1 (5.6) | 0 (0) |
| Bowel perforation | 0 (0) | 0 (0) |

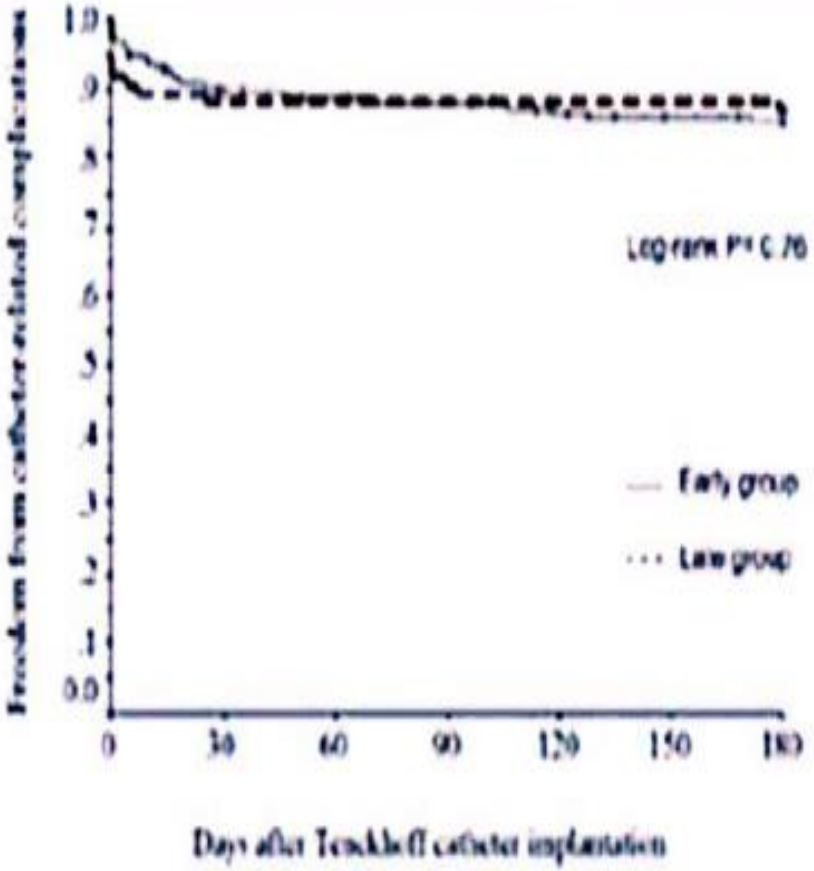



Figure 2 — Actuarial freedom from catheter-related complications is displayed using the Kaplan-Meier method. The early and late groups show no statistical difference with respect to overall catheter-related complications up to 6 months after starting CAPD (log rank $p = 0.76$). Early = break-in period ≤14 days; late = break-in period >14 days.

TABLE 2

Catheter-Related Complications Within Six Months

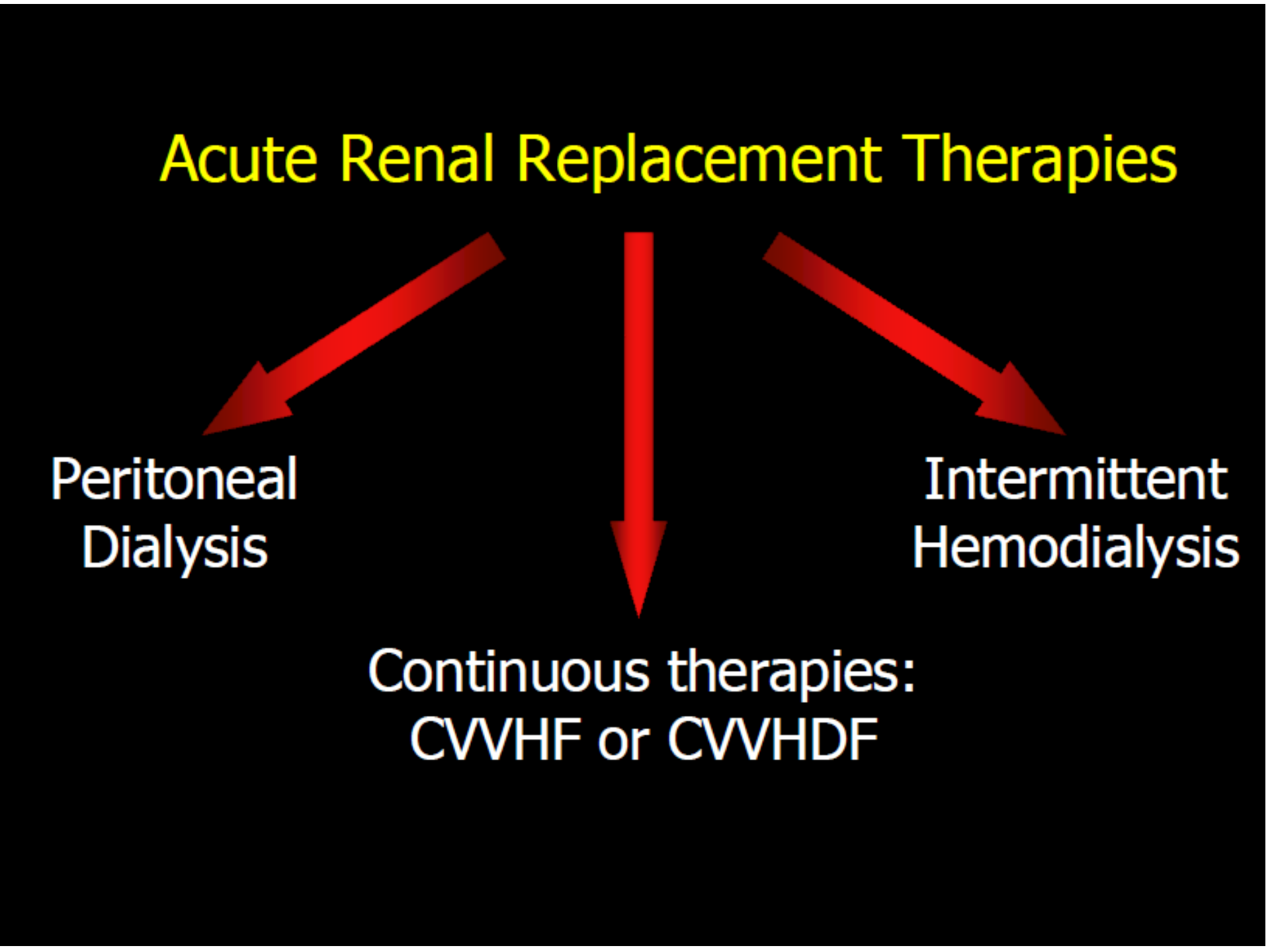
| | Early ($n$=226) | Late ($n$=84) | $p$ Value |
|---|---|---|---|
| Complication cases ($n$) | 33 (14.6%) | 11 (13.1%) | 0.74 |
| Mechanical complications | | | |
| Leakage | 5 (2.2%) | 2 (2.4%) | |
| Diminished outflow volume | 7 (3.1%) | 5 (6.0%) | |
| Migration | 7 (3.1%) | 2 (2.4%) | |
| Pericatheter hernia | 1 (0.4%) | 0 (0%) | |
| Hemoperitoneum | 1 (0.4%) | 0 (0%) | |
| Infectious complications | | | |
| Pericatheter infection | 3 (1.3%) | 0 (0%) | |
| Peritonitis | 9 (4.0%) | 2 (2.4%) | |

Early = break-in period ≤14 days; late = break-in period >14 days.

# AKI

❖ **The most important question in the management of ARF probably relate to:**

- Modality selection
- Dialysis dose
- Adequate start and stop
- Consequence on residual renal function


Acute Renal Replacement Therapies
Peritoneal Dialysis
Intermittent Hemodialysis
Continuous therapies:
CVVHF or CVVHDF

JAMA. 1959;170(8):917-924

# PERITONEAL DIALYSIS

## 1. TECHNIQUE AND APPLICATIONS

1. Morton H. Maxwell, M.D.;
2. Robert E. Rockney, M.D.;
3. Charles R. Kleeman, M.D.;
4. Mary R. Twiss, R.N.

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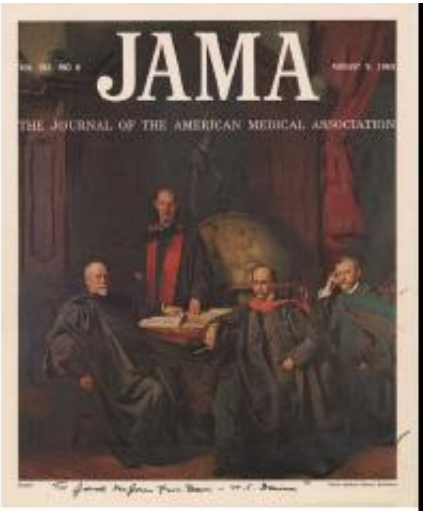



**PD ... the modality first used for the treatment of AKI**

eliminated by a new technique of intermittent dialysis utilizing commercially prepared electrolyte solutions, special catheters, and a "closed system" of infusion and drainage. This was mechanically successful in 76 instances. Conditions treated satisfactorily included acute renal failure, barbiturate poisoning, intractable edema, hepatic coma, hypercalcemia, and chronic uremia. Although less efficient than the artificial kidney on an hourly basis, peritoneal lavage is easier to use over extended periods of time.

# What Nephrologists do is not that they think!!!

In 2009 a survey by George

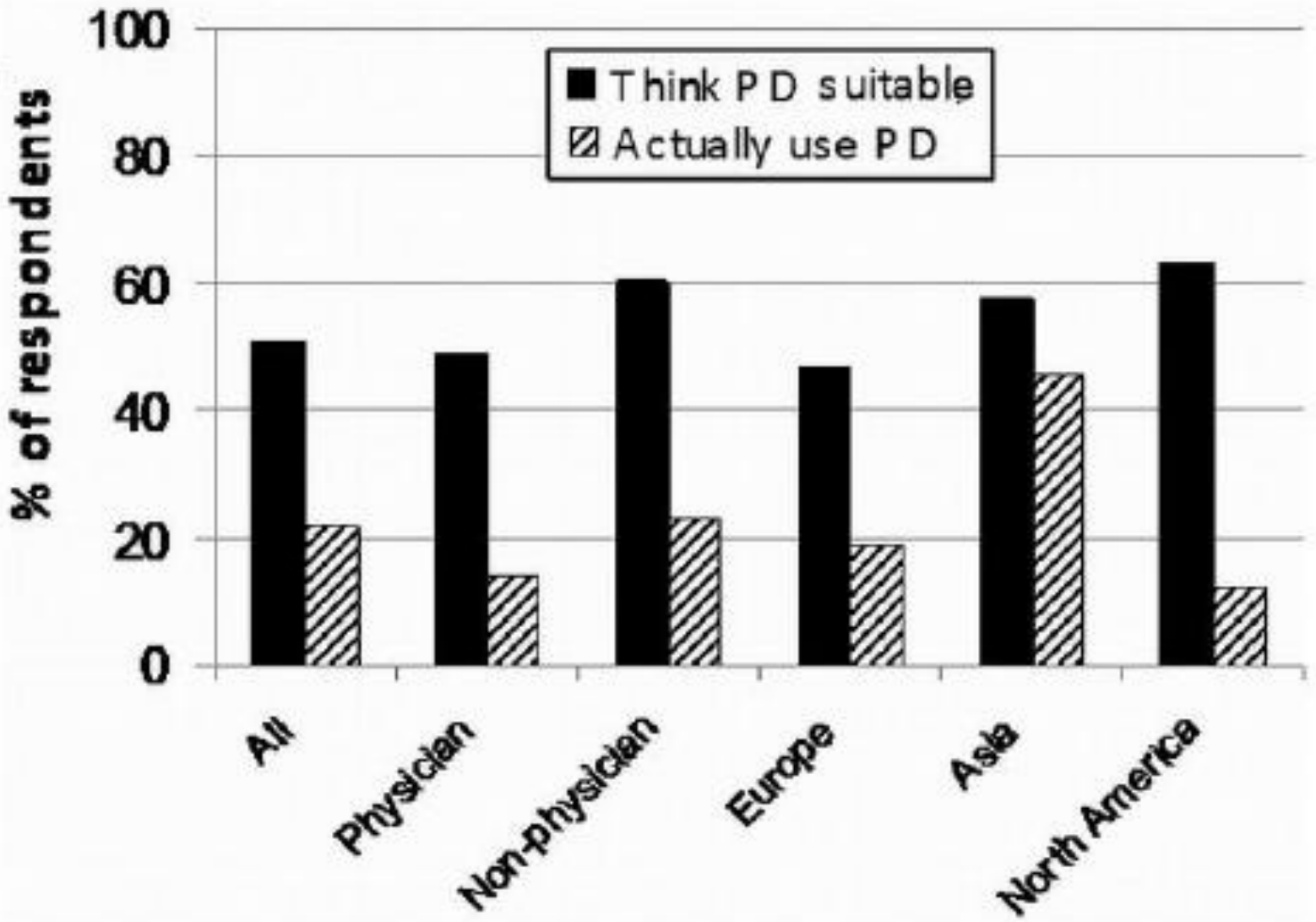
**55%** of the Nephrologists felt that PD was a suitable modality for AKI patients , but only **22%** were actually using the modality.!!!!1

PD was used in ~**46%** in Asia-Pacific/Australia regions and lesser in Europe**18.9** and North America, **12.2%**, respectively.

# Gaiao *et al.'s survey*

- Amongst delegates at 3 major dialysis congresses, found that
- **36%** felt PD was suitable for AKI in the intensive care unit **(ICU);** however, only
- **15%** actually practiced it

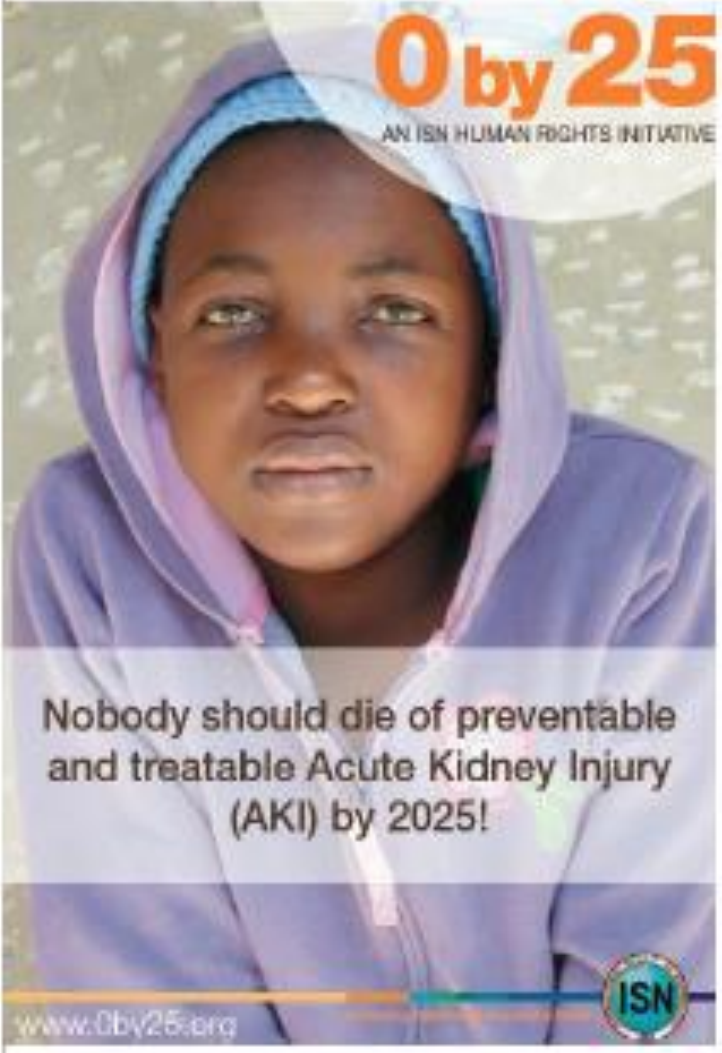
- When it came to treating AKI in the **wards,** more than **50%** felt it was suitable .




Gaiao S Perit Dial Int 2012

# EBP Vs PD in AKI

- Acute PD is practiced by **physicians from Asia** compared to those from Europe and North America
- **Cost** and available resources are major issues
- PD does not require **electricity** nor does it use **expensive machinery** or consumables
- George et al. noted that acute PD costs half that of hemofiltration




# Saving Young Lives

## IN AFRICA AND ASIA

*A partnership to deliver care for acute kidney injury in the developing world*

IPNA ISN SKCF

# Uchino *et al*

❖ **In a study involving 54 nephrology centers distributed over five countries.**

- **CVVH** were the major methods used in patients with ARF in almost **80%** of services, while **PD** was used in **3.2%** of these centers and intermittent **HD** in **16.8%** .

- In **Latin America**, particularly in Brazil, PD was used in **23%** of patients with ARF and in **Europe** in **21%** .

- **Peritoneal dialysis** for ARF still constitutes the mainstay of therapy in many **developing countries** .

# EBP Vs PD in AKI

- Furthermore, PD use to treat AKI is limited to small children in many countries, especially in **Western countries.**

- Contributing factors include the development of efficient and easy-to-place **central venous catheters**

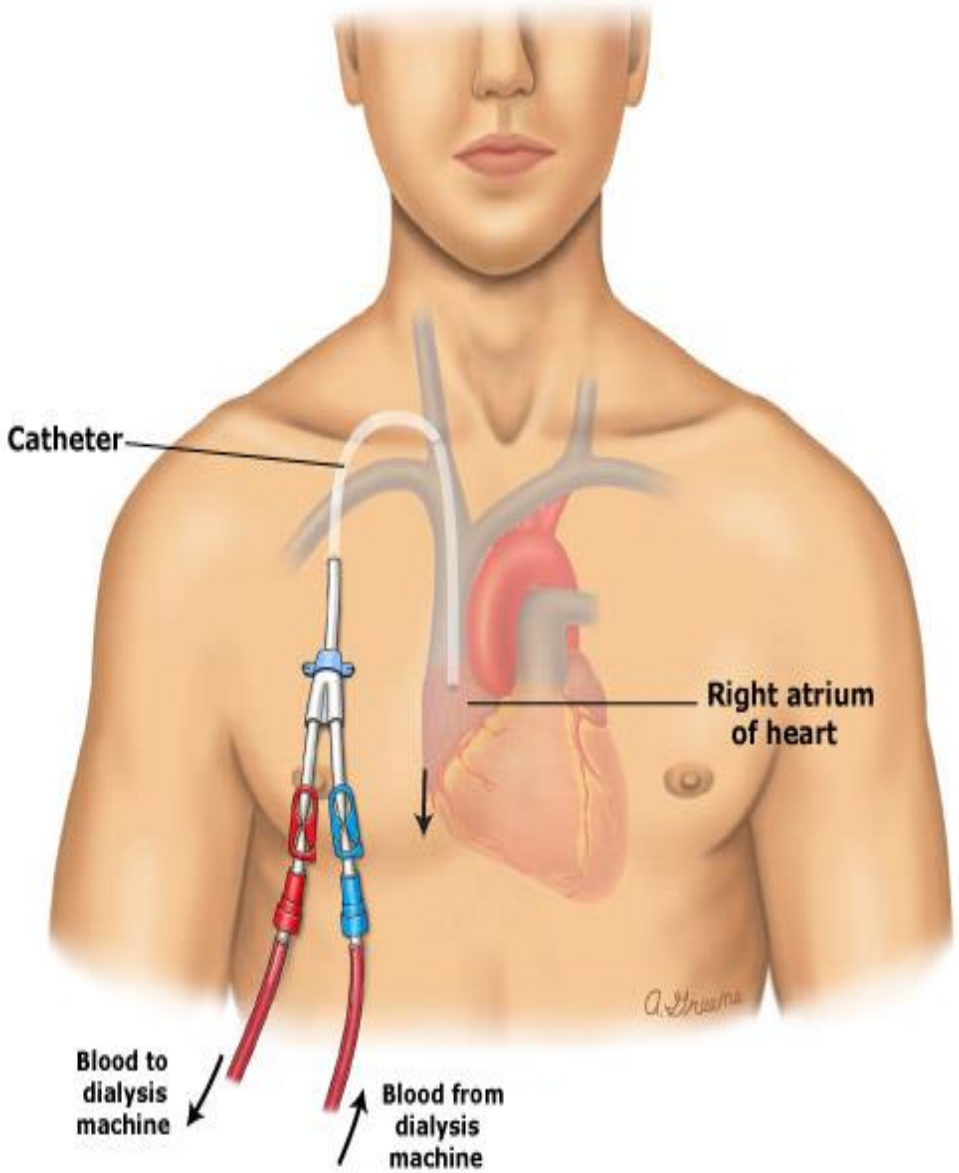
- The expanded use of **CRRTs** and slow extended daily dialysis in these countries

- The perception that PD offers **inferior care**

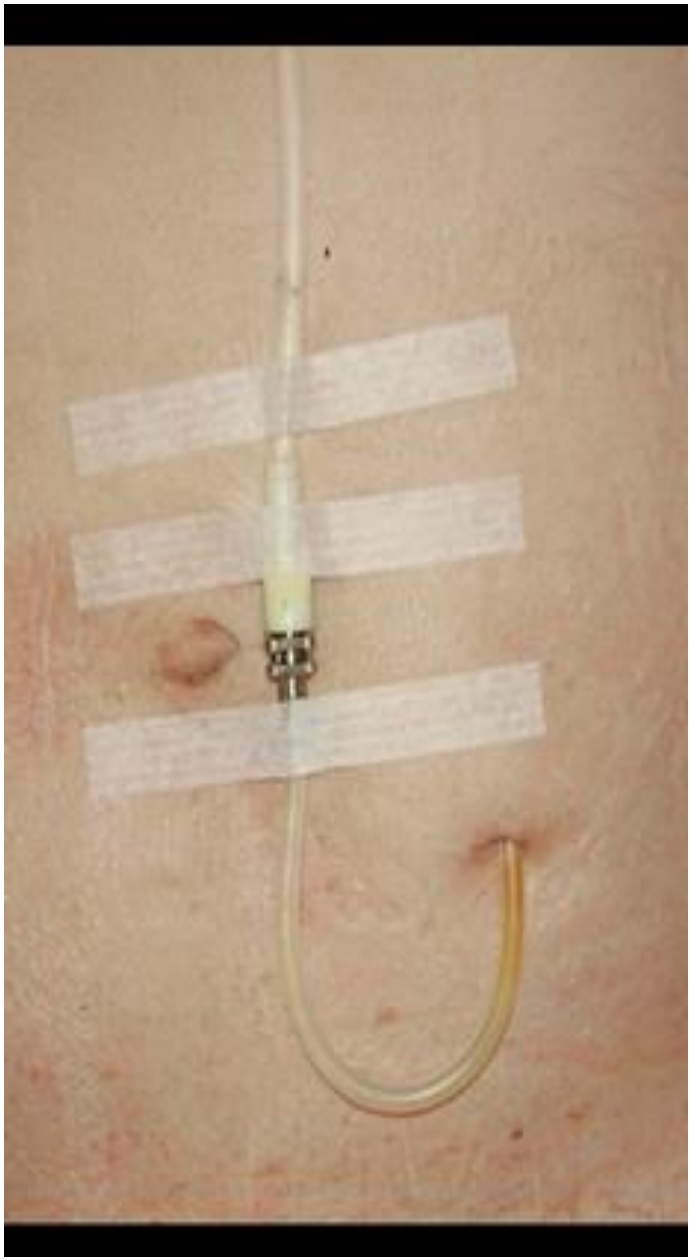

A-V SHUNT (LEFT ARM)

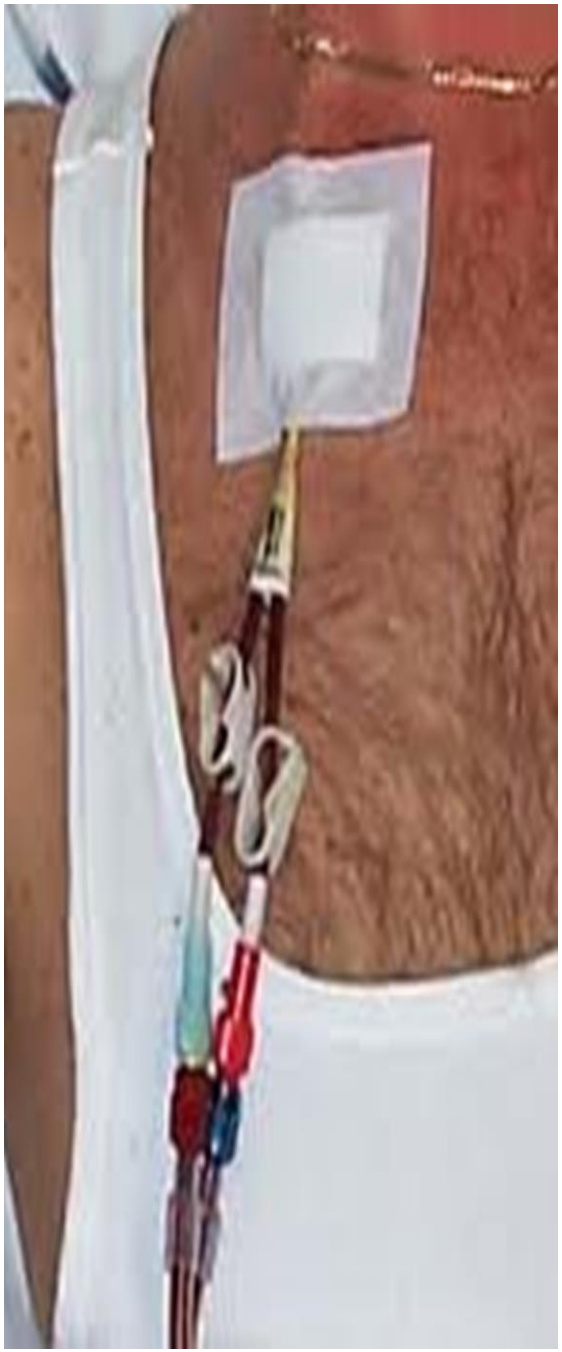
**Figure 3. An AV shunt in the ankle, a popular procedure with the PMH team.**

**Figure 2. An infected AV shunt.**



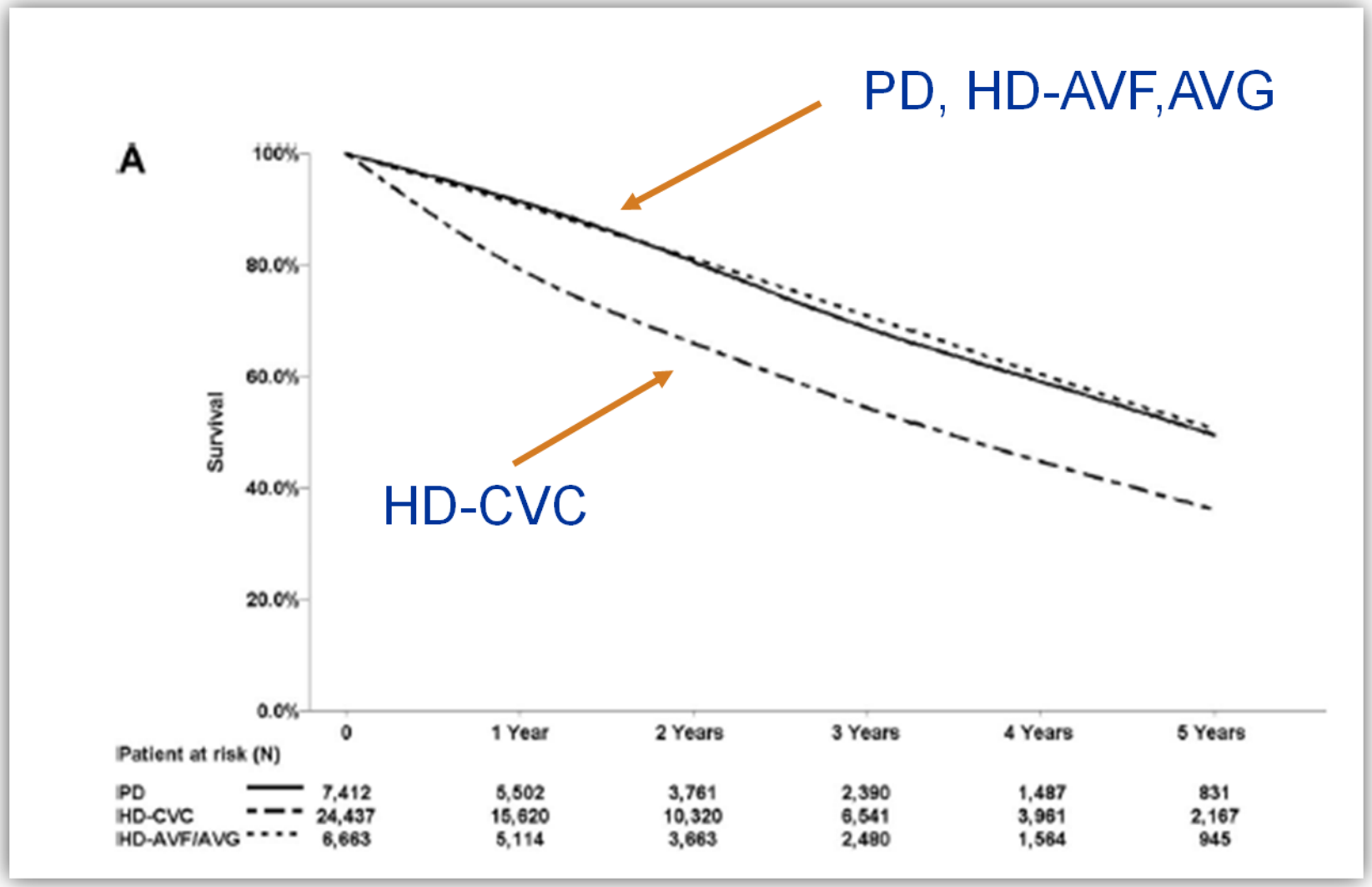

**But when this came to market PD lost its patients and loose the game to HD**





# Survival Curves by Modality and Access Type

Perl J et al. J Am Soc Nephrol 2011;22:1113-1121.



# EBP Vs PD in AKI

- When comparing the **overall risk of each type** of therapy for ARF, there are marked differences between CVVH, CVVHD, HD and PD.

- The **blood treatment** therapies have a significant risk of septicemia, low flow from blood access, hypotension, membrane clothing and bleeding.

- **PD** therapy includes risk of PD catheter outflow failure, leak, hyperglycemia and asymptomatic peritonitis.

# Developing vs Developed countries

The etiology of AKI varies in developed and emerging economies

**Much more Hypercatabolic**

**In western countries**

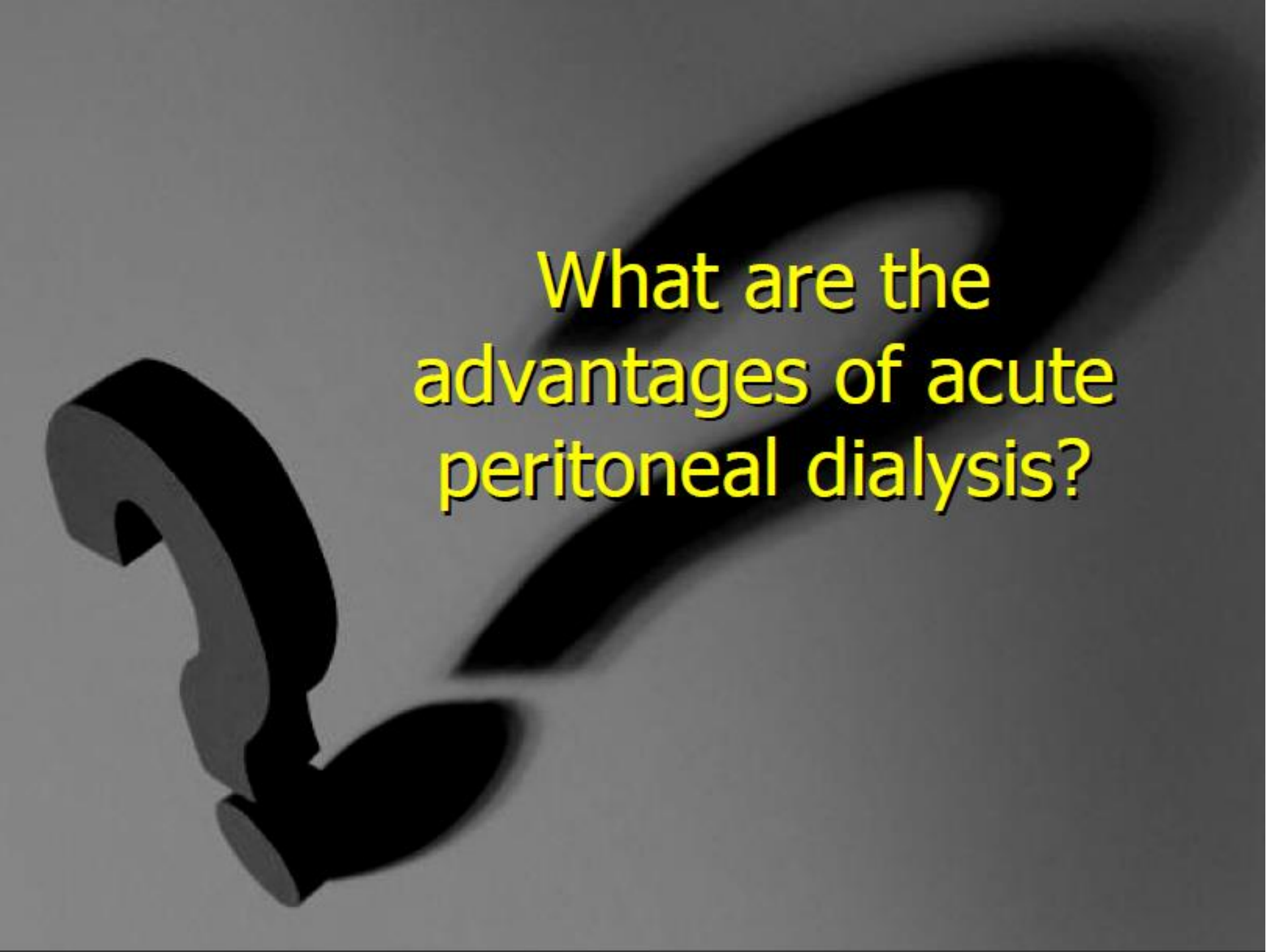
# Comparison of AKI

| 'Developing' Countries | 'Developed' Countries |
| --- | --- |
| • Infections and poisoning | • Sepsis (primary/secondary) |
| • Underlying HIV | • Underlying Diabetes |
| • Younger | • Older |
| • Pre-existing normal function | • Often Acute on Chronic |
| • Single organ failure | • Multimorbidity |
| • Logistics favour PD | • Logistics favour HD/CVVHD |
| • Recovery good | • Recovery limited |
| • CKD later | • Remain dialysis dependent |

# PD for ARF

**Table 1.** Indications and relative contraindications for peritoneal dialysis in patients with acute renal failure

| Indications for acute peritoneal dialysis | Relative contraindication for acute peritoneal dialysis |
|---|---|
| Hemodynamically unstable patients | Recent abdominal or cardiothoracic surgery |
| Bleeding diathesis or active hemorrhage | Diaphragmatic pleuroperitoneal connections |
| Problem with vascular access | Fecal or fungal peritonitis |
| Pediatric ICU | Severe respiratory failure |
| Atheroembolic renal disease? | Abdominal wall celulitis |
| ARF due to malignant hypertension? | Severe reflux disease |
| Unavailability of other continuous therapies | Extremely high catabolic status with hyperK |
| Special circumstances (disasters) | Pulmonary edema |
| | Peritoneal adhesions |


What are the advantages of acute peritoneal dialysis?

# Why PD for AKI?

- Simple technology – no requirement for continuous external power, complex monitoring systems
- Cost effective – life saved ~ $350
- Effective (metabolic acidosis, electrolytes, UF – including high volume regimes for hyper-catabolic)
- Preferred method: infants, children, head injuries, encephalopathy, post-cardiac surgery, cardiac failure (e.g. CHF with acute reversible decompensation), anti-coagulation difficulties, ascites

Next slide

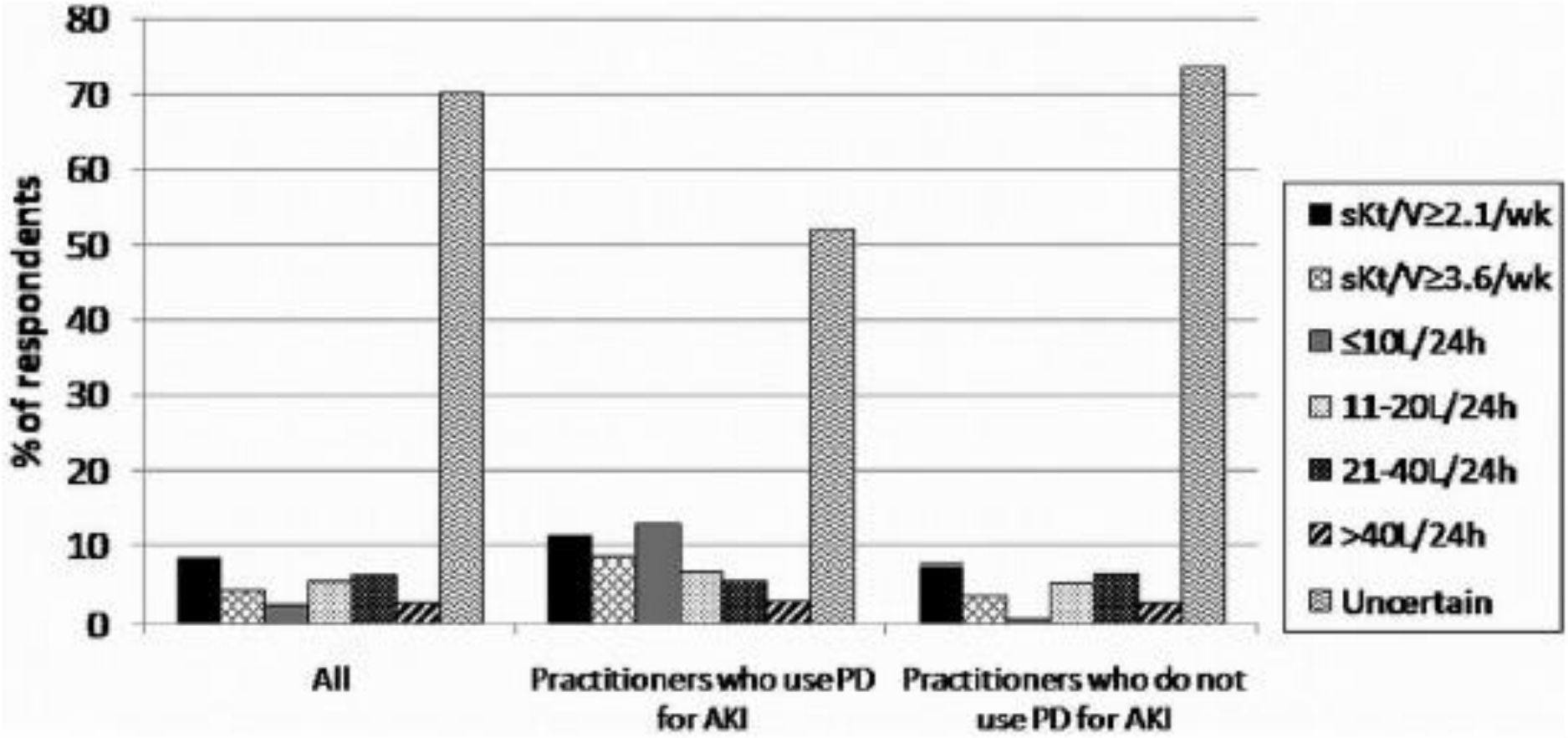
# Gaiao *et al.'s survey*
# PD dose

- Indeed, **66 – 70%** of practitioners professed uncertainty regarding the appropriate PD dose.

- Even among those who did use PD for AKI, **37 – 52%** were uncertain of the appropriate dose

- In published studies, weekly Kt/V's have ranged between **1.8** and **5.6** and fluid volumes have varied from **13 – 70 L** per day

- This is likely related, at least in part, to a lack of definitive data and/or consensus guidelines.




Gaiao S Perit Dial Int 2012

# Dose of PD in ARF

- We know that hyperkalemia, acidosis, and massive fluid overload need to be treated first.

- Then the dose and importance of removal of small molecules or larger molecule clearances should be addressed.

# Dose of PD in ARF

- **Weekly urea clearances**
  - Kt/V of 2.1 ‘minimum’ dose
  - Kt/V of 3.43 ‘maximum’ dose
  - Kt/V of 4.13 no extra benefit

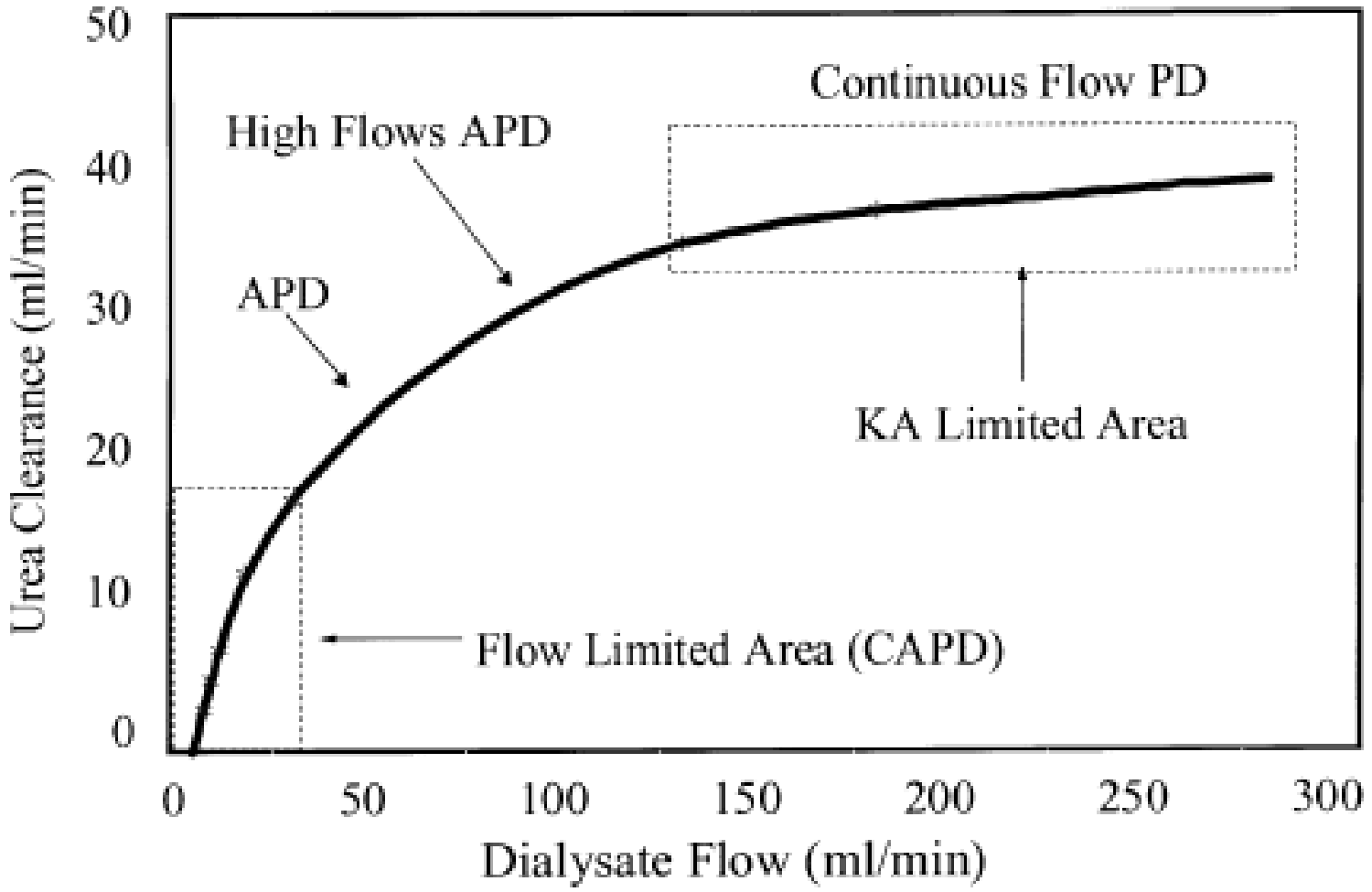
  - Higher small-solute clearances may be necessary for those patients with more complex septic and catabolic illnesses

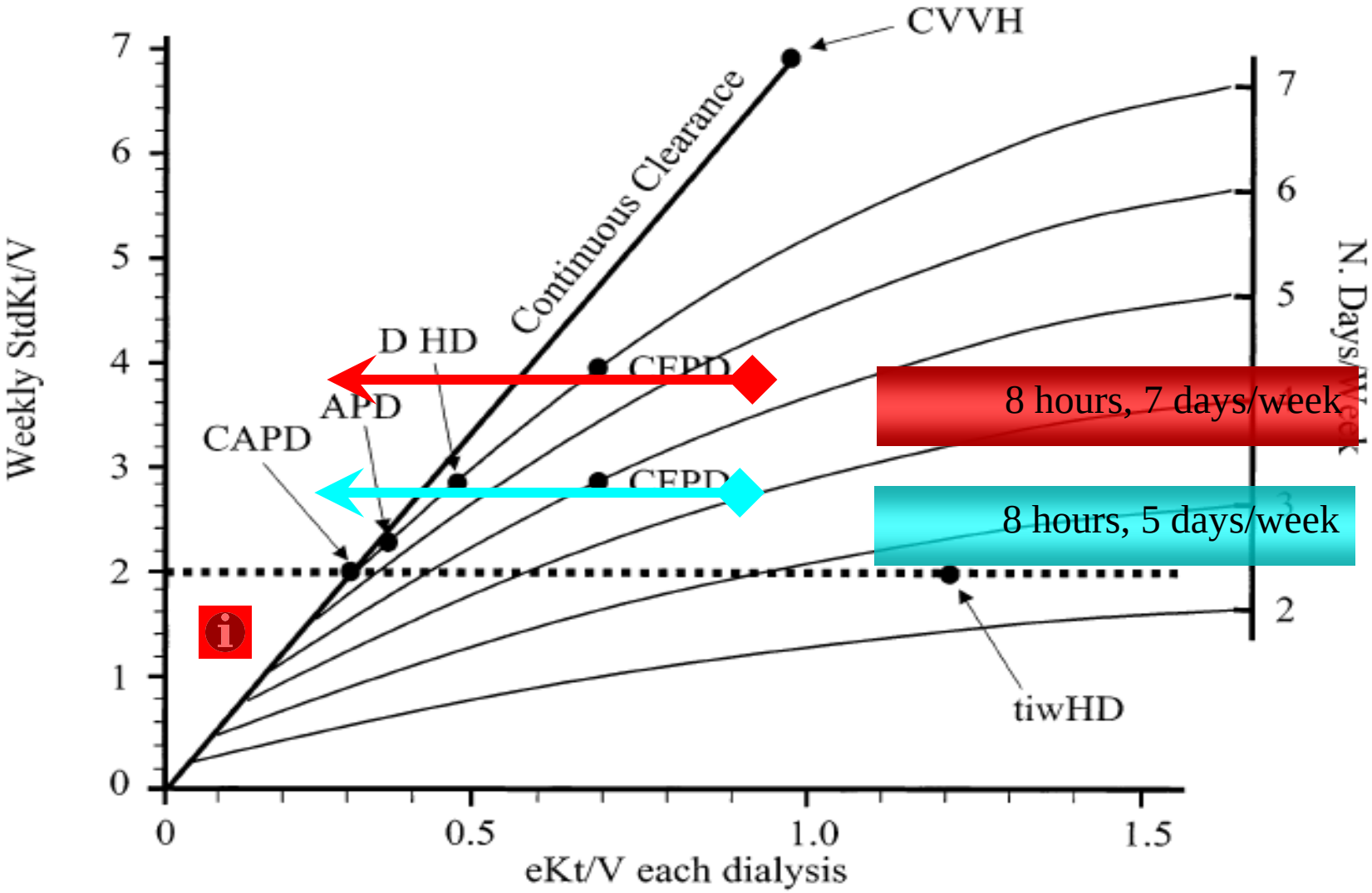
# Different PD regimen in ARF

**Table 2.** Techniques of peritoneal dialysis for ARF treatment

| Technique | Description |
|---|---|
| Acute Intermittent Peritoneal Dialysis (AIPD) | Most often used in the past. Frequent and short exchanges with volumes 1-2 liters and dialysate flows of 2-6 liters/h. Each session lasts 16-20 h, usually tri session per week. The solute clearance is likely inadequate due to its intermittent nature |
| Chronic Equilibrated Peritoneal Dialysis (CEPD) | Long dwells of 2-6 h with up to 2 liters of dialysate each (similar to CAPD). The clearance of small molecules may be also inadequate but clearance of middle molecules is possibly higher due to the long dwells |
| Tidal Peritoneal Dialysis (TPD) | Typically involves an initial infusion of 3 liters of dialysate into the peritoneal cavity. A portion of dialysate, tidal drain volume (usually 1-1.5 liters) is drained and replaced with fresh dialysate (tidal fill volume)The reserve volume always remains in the peritoneal cavity throughout the tidal cycle |
| High Volume Peritoneal Dialysis (HVPD) | Continuous therapy proposed to increase high small solute clearances. Frequent exchanges, usually with cycler (18-48 exchanges per 24 h, 2 liters per exchange). The total dialysate volume range from 36-70 liters a day |
| Continuous Flow Peritoneal Dialysis (CFPD) | In-flow and out-flow of dialysate occurs simultaneously through two access routes. By inflow of 300 ml/min it is possible to achieve a high peritoneal urea clearance |

# PD CLEARANCE VERSUS DIALYSATE FLOW




CVVH
Continuous Clearance
D HD
CEPD
APD
CAPD
CEPD
8 hours, 7 days/week
8 hours, 5 days/week
tiwHD
Weekly StdKt/V
eKt/V each dialysis
N. Days/Week
0
1
2
3
4
5
6
7
0
0.5
1.0
1.5

# The dose of dialysis in AKI



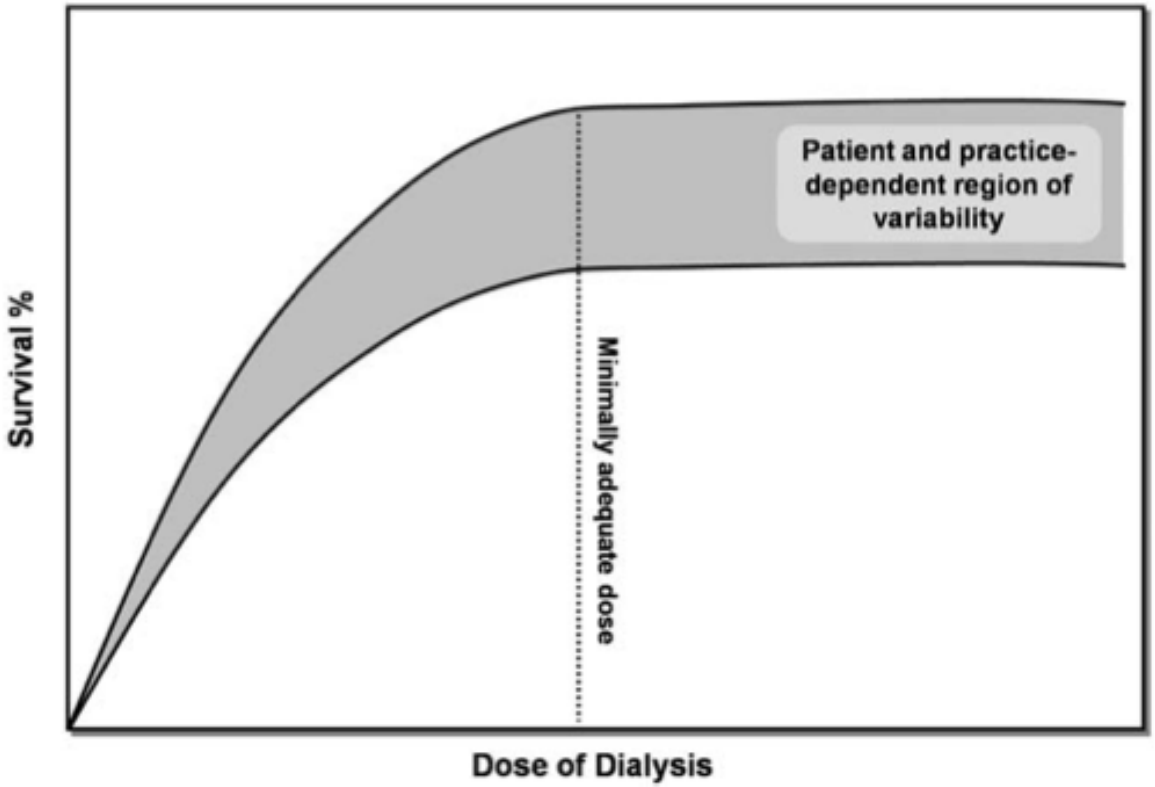



**Fig. 1.** The putative dose–response relationship between dialysis dose and survival (adapted from Ricci [26]). In uraemic patients who receive no dialysis, mortality is close to 100%. The probability of survival improves with dialysis. At low doses of dialysis, increasing the dosage improves survival, but this effect eventually tapers off. Beyond a certain threshold, further increments in dialysis dose will not reap further survival benefits.

# Dialysis Dosage & pts survival

By no dialysis, mortality is close to 100%.

Increasing dosage improves survival

Beyond a certain threshold, increments in dialysis dose will not improve patients survival



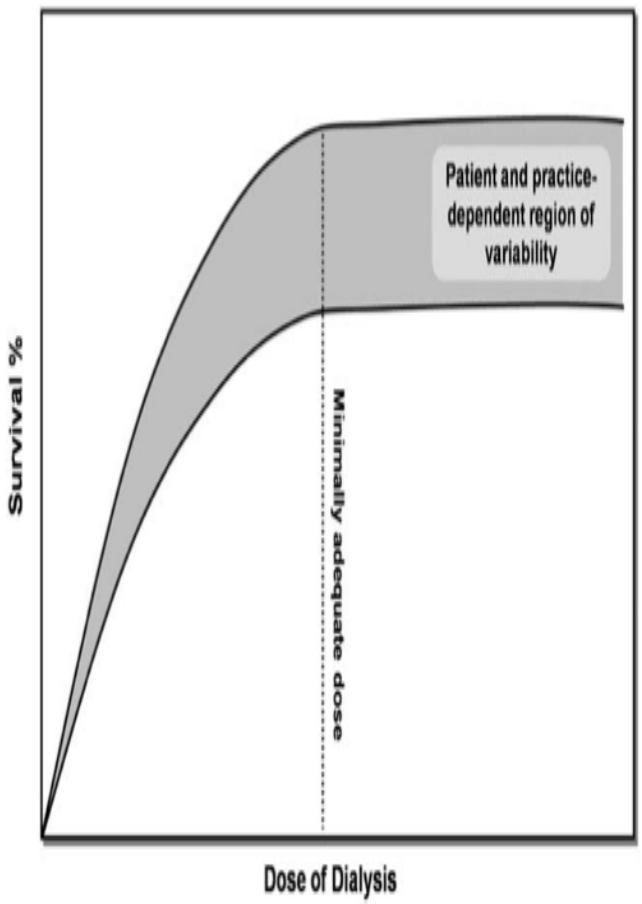



**Fig. 1.** The putative dose–response relationship between dialysis dose and survival (adapted from Ricci [26]). In uraemic patients who receive no dialysis, mortality is close to 100%. The probability of survival improves with dialysis. At low doses of dialysis, increasing the dosage improves survival, but this effect eventually tapers off. Beyond a certain threshold, further increments in dialysis dose will not reap further survival benefits.

# Is PD adequate in acutely ill ARF patients

- Most of the studies that have evaluated PD in hypercatabolic ARF reported **PD** as having **adequate** and satisfactory **control of fluid and metabolic derangements.**

- **However, they have major limitations**
  - small sample sizes,
  - inadequate measurement of catabolic status,
  - lack of apropriate measurements of dialysis adequacy

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*Kidney International, Vol. 61 (2002), pp. 747–757*

# Is peritoneal dialysis adequate for hypercatabolic acute renal failure in developing countries?

**VIPUL CHIMANLAL CHITALIA, ALAN FERNANDES ALMEIDA, HARINAKSHI RAI, MANSI BAPAT, KINNARI VIPUL CHITALIA, VIDYA N. ACHARYA, and RAMESH KHANNA**

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**Conclusion：**

**TPD** produced higher solute clearances in less time with greater protein loss.

**CEPD** just fell short to meet dialysis adequacy standard.

However, both **TPD** and **CEPD** are reasonable options for mild-moderate hypercatabolic ARF.

**Kt/V** appropriately estimates solute removal in PD.

# Hypercathatabolic renal failure

- Patients were **grouped into mild, moderate and severe hypercatabolic** according to the severity of catabolism as estimated by the excess urea appearance rate (UNA) (vide infra)

- **Patients with mild-moderate hypercatabolic ARF** (excess UNA, above the dietary nitrogen intake up to 12 g/day) **were randomized in the trial.**

# Hypercathatabolic renal failure

- **Patients with any of the following conditions were excluded:**
- Inadequate instability (systolic blood pressure < 80 mm Hg)
- Pulmonary edema
- Severe metabolic acidosis (blood pH <7.2 and plasma bicarbonate <14)
- Excess UNA more than 12 g/day (severe hypercatabolic renal failure)

# Criteria for effectiveness!

## Weekly Kt/V > 2 and Creatinine clearances > 60



**Table 4.** Pre- and post-dialysis BUN and creatinine, solute clearances (Kt/V, normalized creatinine clearances and solute removal indices) and ultrafiltrate in TPD and CEPD

| | TPD | | CEPD | | |
|---|---|---|---|---|---|
| Variables | Mean ± SD | Range | Mean ± SD | Range | *P* value |
| Pre-dialysis BUN *mg/dL* | 78.80 ± 8.30 | 68–125 | 77.96 ± 22.10 | 63–118 | 0.67 |
| Post-dialysis BUN *mg/dL* | 50.84 ± 11.30 | 42–68 | 64.71 ± 12.4 | 59–82 | 0.04 |
| Pre-dialysis creatinine *mg/dL* | 8.16 ± 2.73 | 4.9–10.30 | 7.79 ± 2.49 | 4–9.70 | 0.62 |
| Post-dialysis creatinine *mg/dL* | 5.01 ± 1.9 | 4.2–7.90 | 6.52 ± 1.61 | 4.60–8 | 0.02 |
| $C_{cl}$ *mL/min* | 9.94 ± 2.93 | 7.14–20.92 | 6.74 ± 1.63 | 3.94–9.34 | 0.01 |
| *L/session/1.73 m²* | 9.79 ± 1.13 | 6.94–11.34 | 7.40 ± 1.21[a] | 5.53–9.79 | 0.031 |
| *L/week/1.73 m²* | 68.5 ± 4.43 | 49.60–73.36 | 58.85 ± 2.57 | 43.73–68.49 | 0.035 |
| $C_{ur}$ *mL/min* | 19.85 ± 1.95 | 15.67–23.01 | 10.63 ± 2.62 | 8.38–12.52 | 0.001 |
| Kt/V (session) | 0.34 ± 0.14 | 0.18–0.50 | 0.26 ± 0.07[a] | 0.12–0.39 | 0.001 |
| Kt/V (week) | 2.43 ± 0.87 | 1.11–3.49 | 1.80 ± 0.32 | 1.47–2.75 | 0.001 |
| $SRI_{Dialysate}$ | 28.46 ± 4.6% | 41–57.9% | 20.64 ± 5.93% | 14–36.45% | 0.02 |
| $SRI_{Kt/V}$ | 21.06 ± 4.03% | 15.62–30.48% | 15.53 ± 5.45% | 9.5–21.47% | 0.02 |
| UF *ml/min* | 4.28 ± 0.70 | 3.01–5.8 | 1.82 ± 0.13 | 0.80–2 | 0.04 |
| *L/session* | 2.88 ± 0.71 | 1.89–4.14 | 2.01 ± 0.28[a] | 0.38–2.44 | 0.03 |

The difference was considered statistically significant by paired *t* test for $P < 0.05$ for $N = 87$. $C_{ur}$ is dialysate urea.

[a] Values of CEPD tabulated for 24 hours for comparison

# Comparing PD with dHD

- Observational comparative cohort study:
- 120 patients with ATN assigned to PD or dHD
- Age 63, men 75%, sepsis 45%, shock 62%
- Similar metabolic control
- Survival: PD 58%, dHD 52%
- Recovery of renal function: PD 28%, dHD 22%

*Gabriel DP et al. Perit Dial Int. 2009 Feb;29 Suppl 2:S62-71*

http://www.kidney-international.org



# High volume peritoneal dialysis vs daily hemodialysis: A randomized, controlled trial in patients with acute kidney injury

DP Gabriel[1], JT Caramori[1], LC Martim[1], P Barretti[1] and AL Balbi[1]

[1]*Department of Internal Medicine, University Hospital, Botucatu School of Medicine, São Paulo State University (UNESP), Botucatu, SP, Brazil*

Objective:

to compare the effect of High Volume PD and Daily HD on survival in patients with ARF

# High volume peritoneal dialysis vs daily hemodialysis: A randomized, controlled trial in patients with acute kidney injury

DP Gabriel[1], JT Caramori[1], LC Martim[1], P Barretti[1] and AL Balbi[1]

## Results

36-44 litres of PD fluid per day

18-22 Cycles (35-50 minute dwell time)

***KT/V***

per session:

| | |
|---|---|
| prescribed | 0.65 |
| delivered | 0.53 |

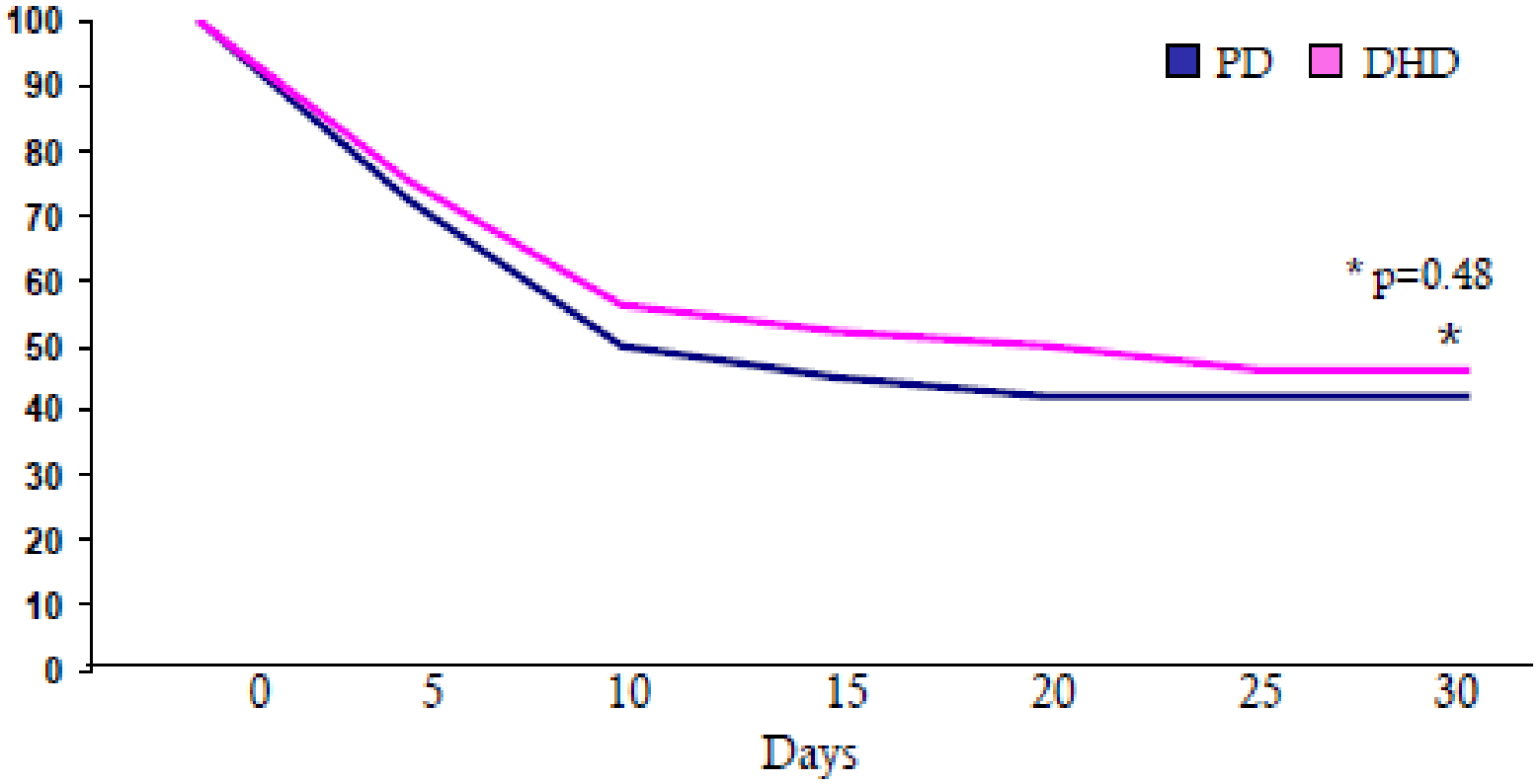
weekly:

| | |
|---|---|
| prescribed | 4.5 |
| delivered | 3.51 |

Survival

# High volume peritoneal dialysis vs daily hemodialysis: A randomized, controlled trial in patients with acute kidney injury

DP Gabriel[1], JT Caramori[1], LC Martim[1], P Barretti[1] and AL Balbi[1]




Gabriel DP, KI 2008;73:587-593

# Comparing PD with CVVHDF

open-labeled, randomized trial compared PD with CVVHDF

Urea and creatinine clearance was higher with CVVHDF than PD.

PD showed better control of acid-base

Fluid correction was faster with CVVHDF.

Similar result for hyperkalemia and hemodynamic instability.

PD was cost-effective as compared with CVVHDF

Mortality 84% in CVVHDF versus 72% in PD ($P = 0.49$).

George J, Varma S, Kumar S et al. Comparing CVVHDF and PD in Critically ill patients with acute kidney injury: a pilot study.

Perit Dial Int 2011; 31: 422–429

# Comparing PD with CRRT

- RCT comparing two therapies in the ICU setting
- 50 patients randomised, 1:1, mean age 45
- Equally efficient in achieving metabolic and acid-base control
- Similar outcomes (high mortality);
  CRRT 80%, PD 70%)
- Cost of disposable: CRRT: INR 7184 ±1436 vs. PD INR 3009 ± 1643, $p < 0.001$ (US$1=INR 47)

*George V. et al. Perit Dial Int. 2011 Jul-Aug;31(4):422-9*

# A randomized clinical trial of high volume peritoneal dialysis versus extended daily hemodialysis for acute kidney injury patients

- 2 centres, RCT, 407 patients, 143 analysed
- Primary endpoint: in hospital mortality
- Secondary endpoints: recovery RRF, efficacy
- Difficulties with randomisation (unbalanced)
- Many exclusions – so generalisability not clear
- Metabolic control quicker with edHD
- RR of death using PD was 1.4 (CI 0.7-2.4, p = 0.19)

*Ponce D, Int Urol Nephrol. 2012*

# High-volume peritoneal dialysis in acute kidney injury: indications and limitations

- Prospective analysis of 204 treated patients (analysis in 150)
- 63.8±15.8 years, 70% ICU setting
- Sepsis main cause
- 57.3% dies, 20% recovered RRF
- Age, sepsis predicted death

*Ponce D. Clin J Am Soc Nephrol. 2012 Jun;7(6):887-94*

*Clin J Am Soc Nephrol 7: 887–894, 2012*

# High-Volume Peritoneal Dialysis in Acute Kidney Injury: Indications and Limitations

*Daniela Ponce, Marina Nogueira Berbel, Cassiana Regina de Goes, Cibele Taís Puato Almeida, and André Luís Balbi*

## Summary

**Background and objectives** Peritoneal dialysis is still used for AKI in developing countries despite concerns about its limitations. The objective of this study was to explore the role of high-volume peritoneal dialysis in AKI patients in relation to metabolic and fluid control, outcome, and risk factors associated with death.

**Design, setting, participants, & measurements** A prospective study was performed on 204 AKI patients who were assigned to high-volume peritoneal dialysis (prescribed Kt/V=0.60/session) by flexible catheter and cycler; 150 patients (80.2%) were included in the final analysis.

**Results** Mean age was 63.8±15.8 years, 70% of patients were in the intensive care unit, and sepsis was the main etiology of AKI (54.7%). BUN and creatinine levels stabilized after four sessions at around 50 and 4 mg/dl, respectively. Fluid removal and nitrogen balance increased progressively and stabilized around 1200 ml and −1 g/d after four sessions, respectively. Weekly delivered Kt/V was 3.5±0.68. Regarding AKI outcome, 23% of patients presented renal function recovery, 6.6% of patients remained on dialysis after 30 days, and 57.3% of patients died. Age and sepsis were identified as risk factors for death. In urine output, increase of 1 g in nitrogen balance and increase of 500 ml in ultrafiltration after three sessions were identified as protective factors.

*Clin J Am Soc Nephrol 7: 887–894, 2012*

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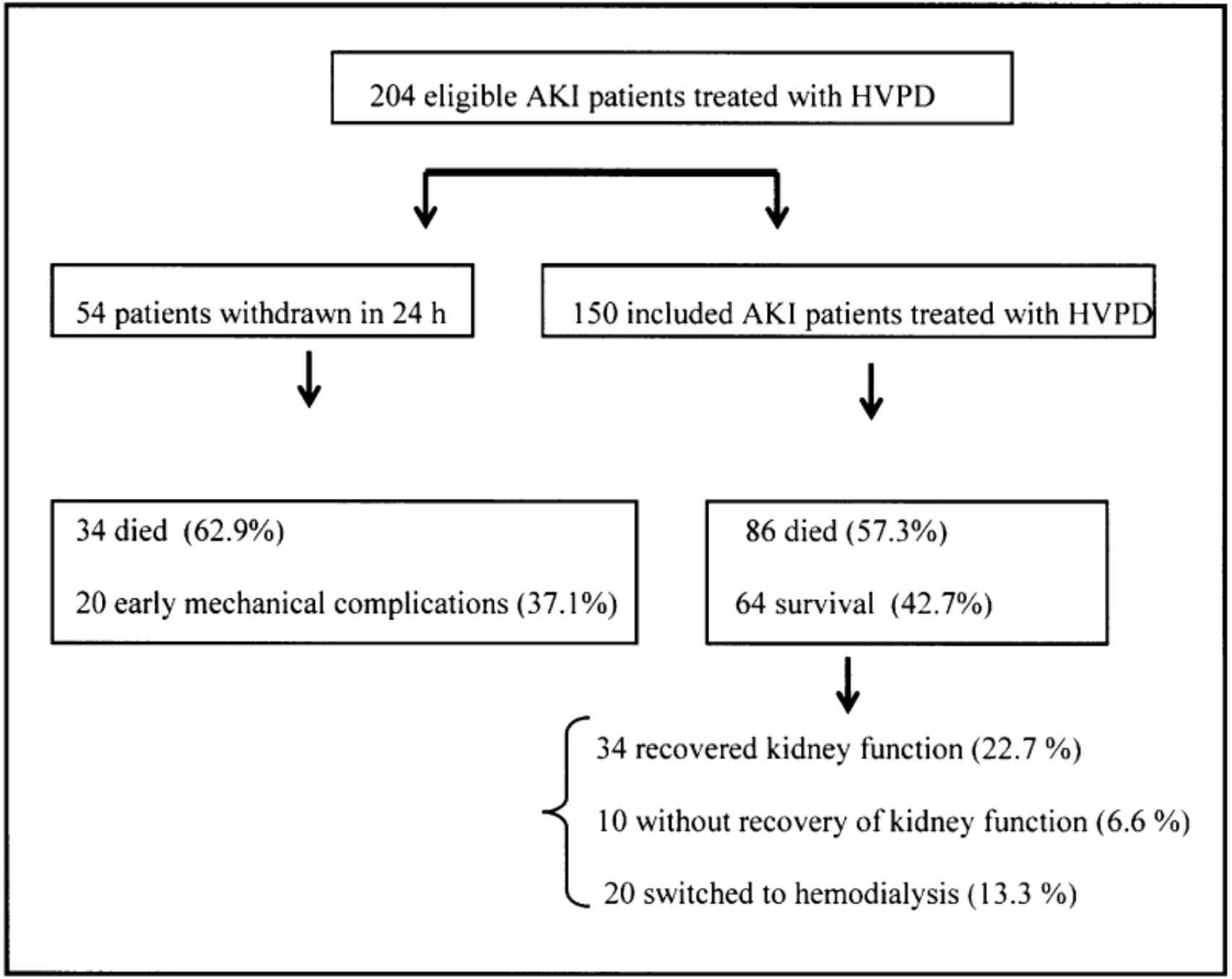

204 eligible AKI patients treated with HVPD
54 patients withdrawn in 24 h
150 included AKI patients treated with HVPD
34 died (62.9%)
20 early mechanical complications (37.1%)
86 died (57.3%)
64 survival (42.7%)
34 recovered kidney function (22.7 %)
10 without recovery of kidney function (6.6 %)
20 switched to hemodialysis (13.3 %)

# Limitations

- The limitation of this study was that the results were not presented according to **intention to treat**.

- Patients who changed the dialysis method (from HVPD to HD) were **excluded** to survival analysis.

# Conclusions

- High-volume peritoneal dialysis is effective for a selected AKI patient group, allowing adequate metabolic and fluid control.

- **Age, sepsis, and urine output** as well as **nitrogen balance and ultrafiltration** were associated significantly with death.

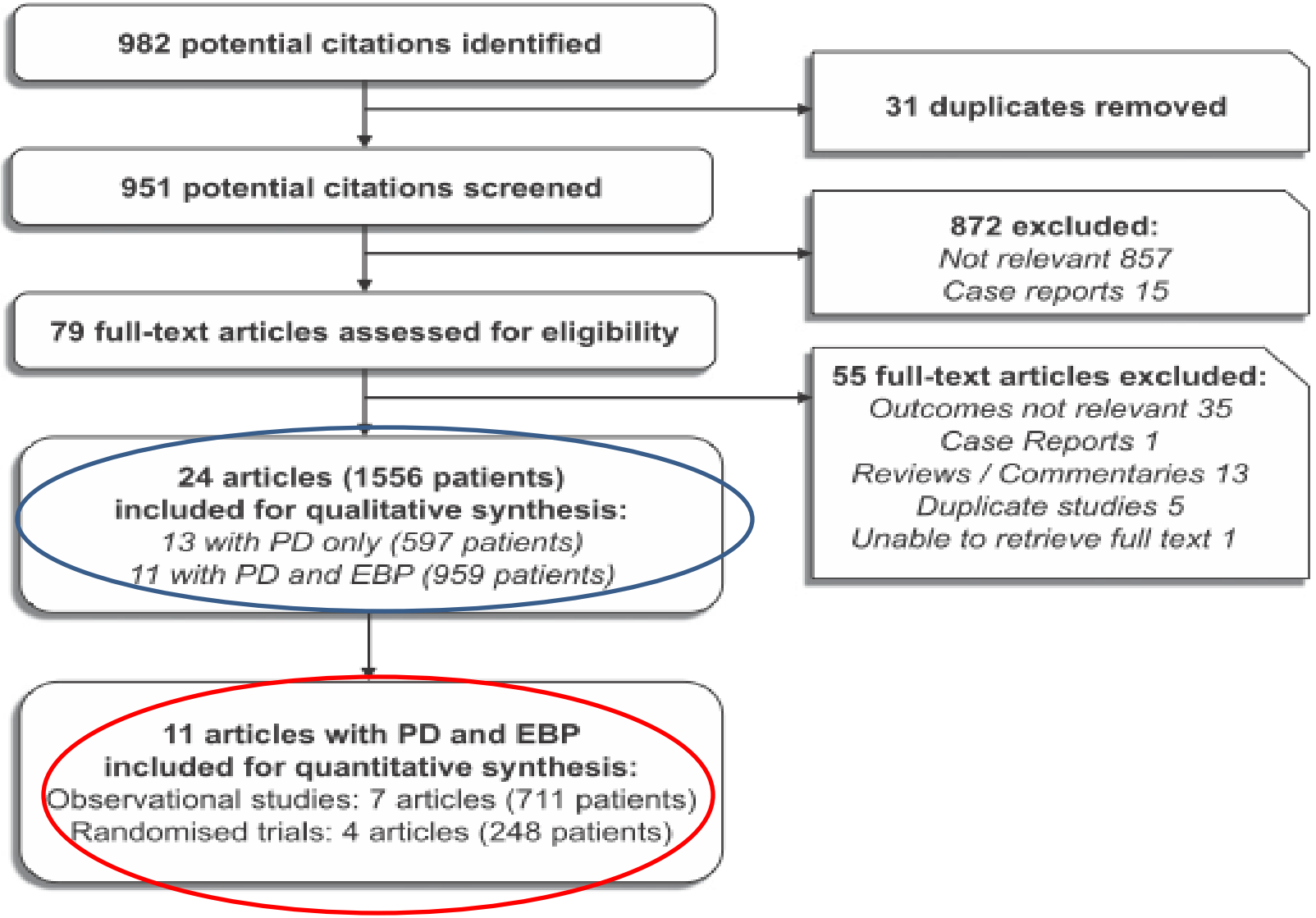
**Clin J Am Soc Nephrol 7: 887–894, 2012**

# Most important Review Article 2013

## Use of Peritoneal Dialysis in AKI: A Systematic Review


- Chang Yin Chionh,*† Sachin S. Soni,*‡ Fredric O. Finkelstein,§ Claudio Ronco,*| and Dinna N. Cruz|

# Study Selection



# Distribution of studies included for review



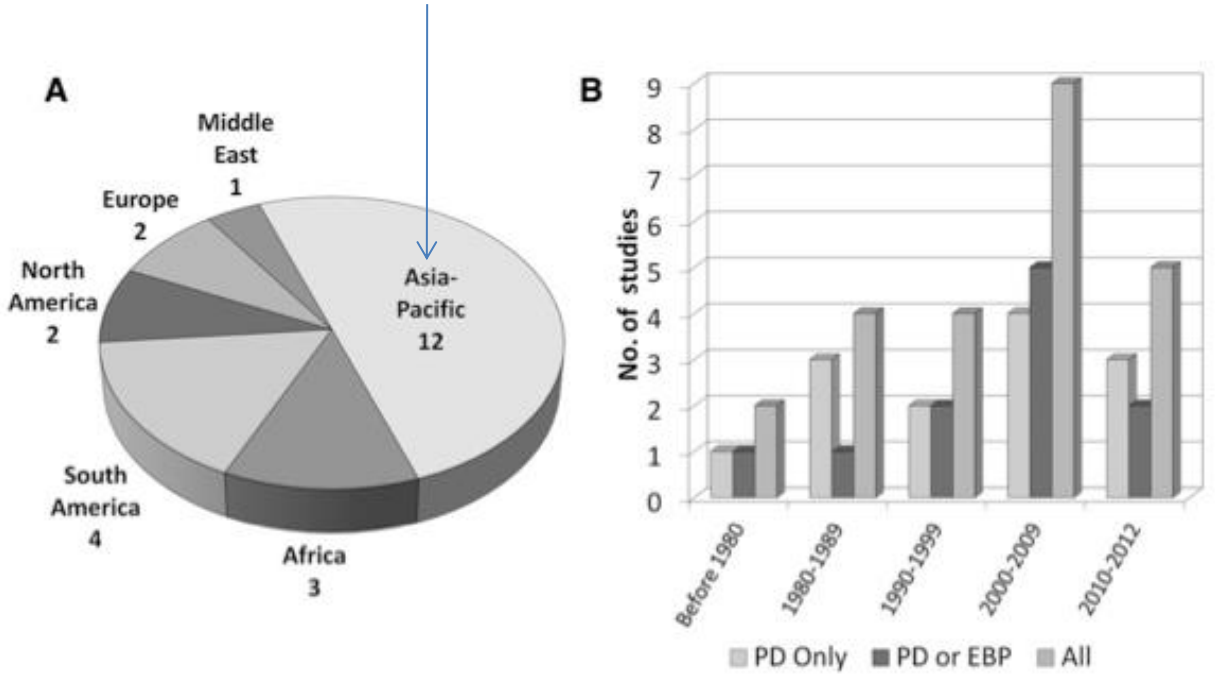
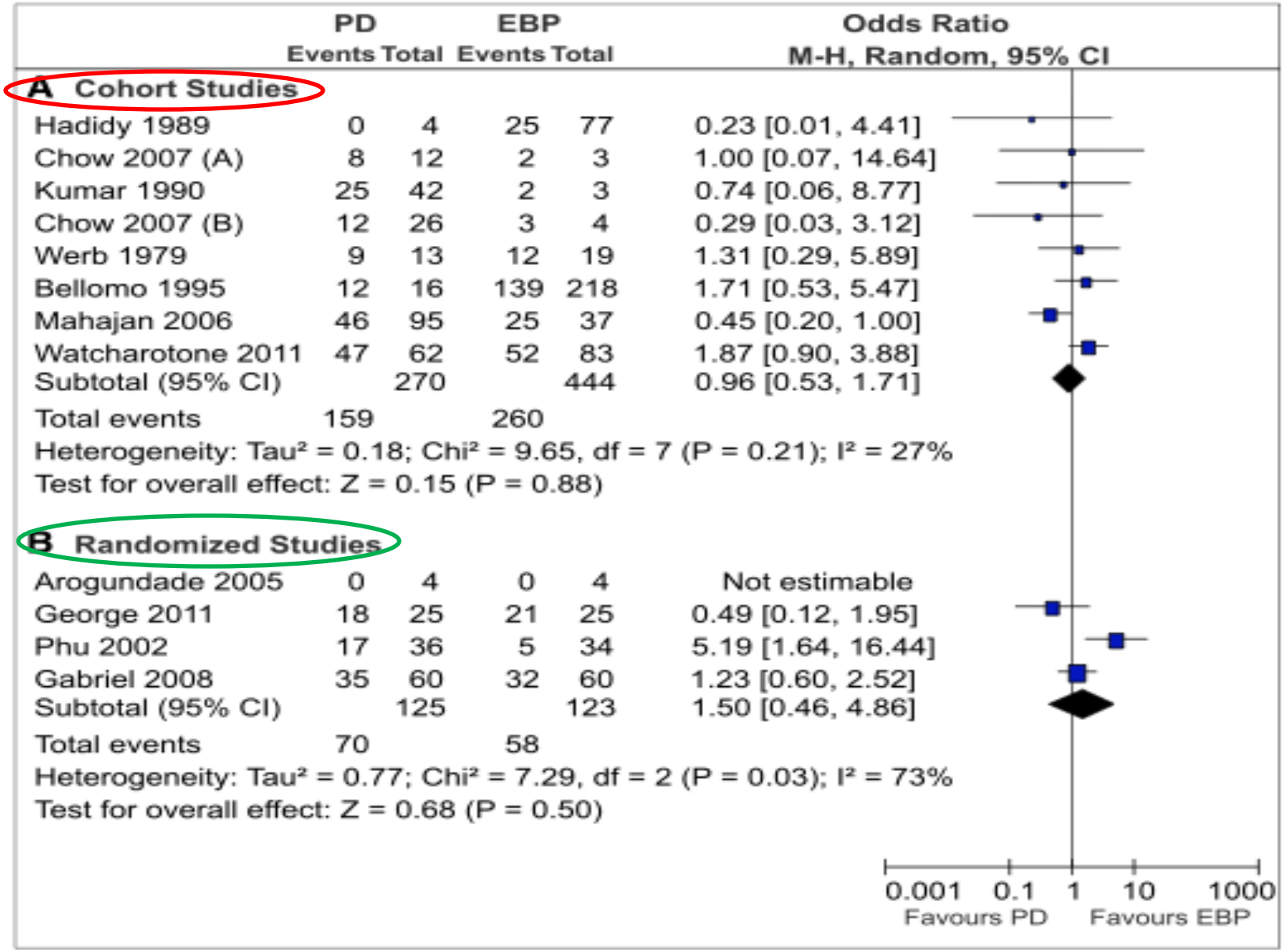



**Figure 2.** | Distribution of studies included for review. The number of studies is illustrated according to (A) geographical region of origin and (B) year of study publication. Australia is included under Asia–Pacific. EBP, extracorporeal blood purification; PD, peritoneal dialysis.

# Effect of renal replacement therapy modality on mortality in patients with AKI grouped by study design



# Conclusion & Discussion

❖**We had three main findings**.

- **First**, there is a paucity of good-quality data, with only four relatively small RCTs.
- **Second**, pooled analysis of 11 studies showed no difference in mortality between PD and EBP.
- **Third**, reporting was poor regarding PD dose and other important outcomes, such as renal recovery and PD-related complications.

# ISPD Guidelines: PD for Acute Kidney Injury

Brett Cullis
Nephrologist and Specialist Intensive Care Physician


Greys Hospital Kidney Unit

University of Exeter Medical School


Exeter Kidney Unit

Peritoneal Dialysis International

Peritoneal Dialysis International, Vol. 34, pp. 366–373
DOI: 10.3747/pdi.2013.00030



# ISPD GUIDELINES/RECOMMENDATIONS

## PERITONEAL DIALYSIS FOR ACUTE KIDNEY INJURY

Brett Cullis,[1,2] Mohamed Abdelraheem,[1] Georgi Abrahams,[3] Andre Balik,[3] Diana N. Cruz,[4] Yaacov Frishberg,[5] Vera Koch,[6] Mignon McCulloch,[7] Alp Namerogˇlu,[8] Peter Nourse,[9] Roberto Pecoits-Filho,[10] Daniela Ponce,[11] Bradley Warady,[12] Karen Yeates,[13] and Fredric O. Finkelstein[14]

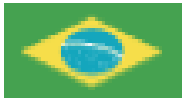
*Renal Unit,[1] Grays Hospital, Pietermaritzburg, South Africa; Renal and Intensive Care Units,[2] Royal Devon and Exeter Hospital, Exeter, United Kingdom; Pediatric Nephrology Unit,[3] Soba University Hospital, University of Khartoum, Sudan; Pondicherry Institute of Medical Sciences and Madras Medical Mission,[4] Chennai, India; Department of Medicine,[5] Botucatu School of Medicine, Sao Paulo, Brazil; Division of Nephrology-Hypertension,[6] University of California, San Diego, USA; Division of Pediatric Nephrology,[7] Shaare Zedek Medical Center, Jerusalem, Israel; Pediatric Nephrology Unit,[8] Instituto da Crianca of the Hospital das Clinicas of the University of Sao Paulo Medical School, Sao Paulo, Brazil; Pediatric Nephrology Department,[9] Red Cross War Memorial Children's Hospital, University of Cape Town, Cape Town, South Africa; Department of Surgery,[10] Red Cross War Memorial Children's Hospital, University of Cape Town, Cape Town, South Africa; School of Medicine,[11] Pontificia Universidade Catolica do Parana, Curitiba, Brazil; Division of Pediatric Nephrology,[12] University of Missouri-Kansas City School of Medicine, Kansas City, USA; Division of Nephrology,[13] Queen's University, Kingston, Canada; and Yale University,[14] New Haven, USA*

Fred Finkelstein

Brett Cullis (Co-chairs)

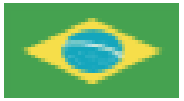
## Adult Section

Georgi Abraham 

Andre Balbi 

Dinna Cruz 

Roberto Pecoits-Filho 

Daniela Ponce 

Karen Yeates 

## Paediatric Section

Mohamed Abdelraheem 

Yaacov Frishberg 

Vera Koch 

Mignon McCulloch 

Peter Nourse 

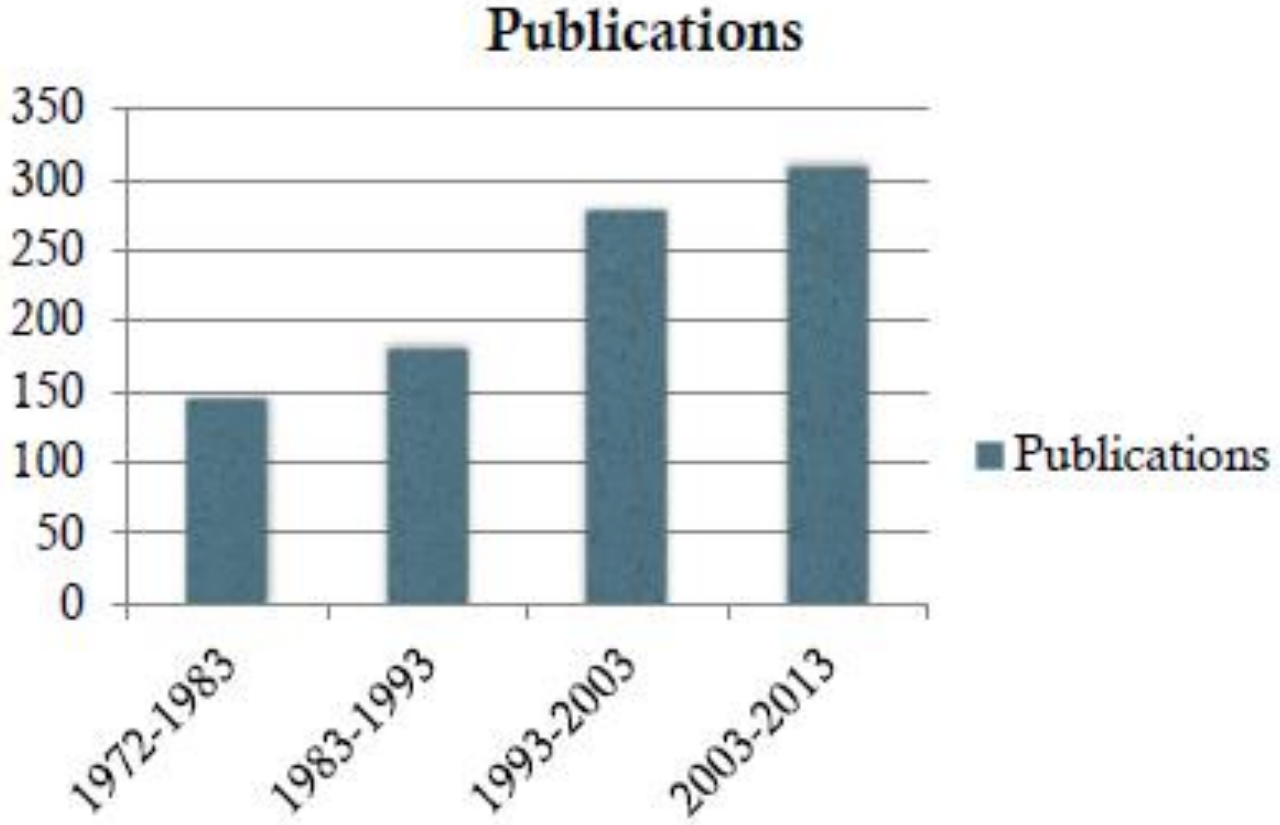
Alp Numanoglu 

Brad Warady
(Paediatrics Advisor) 

# Questions

- Is PD a suitable modality for treating AKI
- What is optimal access and fluid delivery for PD in AKI
- Which fluids should be used and what to do when not available
- How to dose PD for AKI
- Continuous flow PD

# Why do we need guidelines?



## ADULT GUIDELINES

### GUIDELINE A1: Suitability of peritoneal dialysis for AKI in adults

A1.1 Peritoneal dialysis should be considered as a suitable method of continuous renal replacement therapy in patients with acute kidney injury (1B).

### GUIDELINE P1: Suitability of PD for AKI in children

P1.1 Peritoneal dialysis is a suitable modality for RRT in AKI in children (1C).

Blood Purification

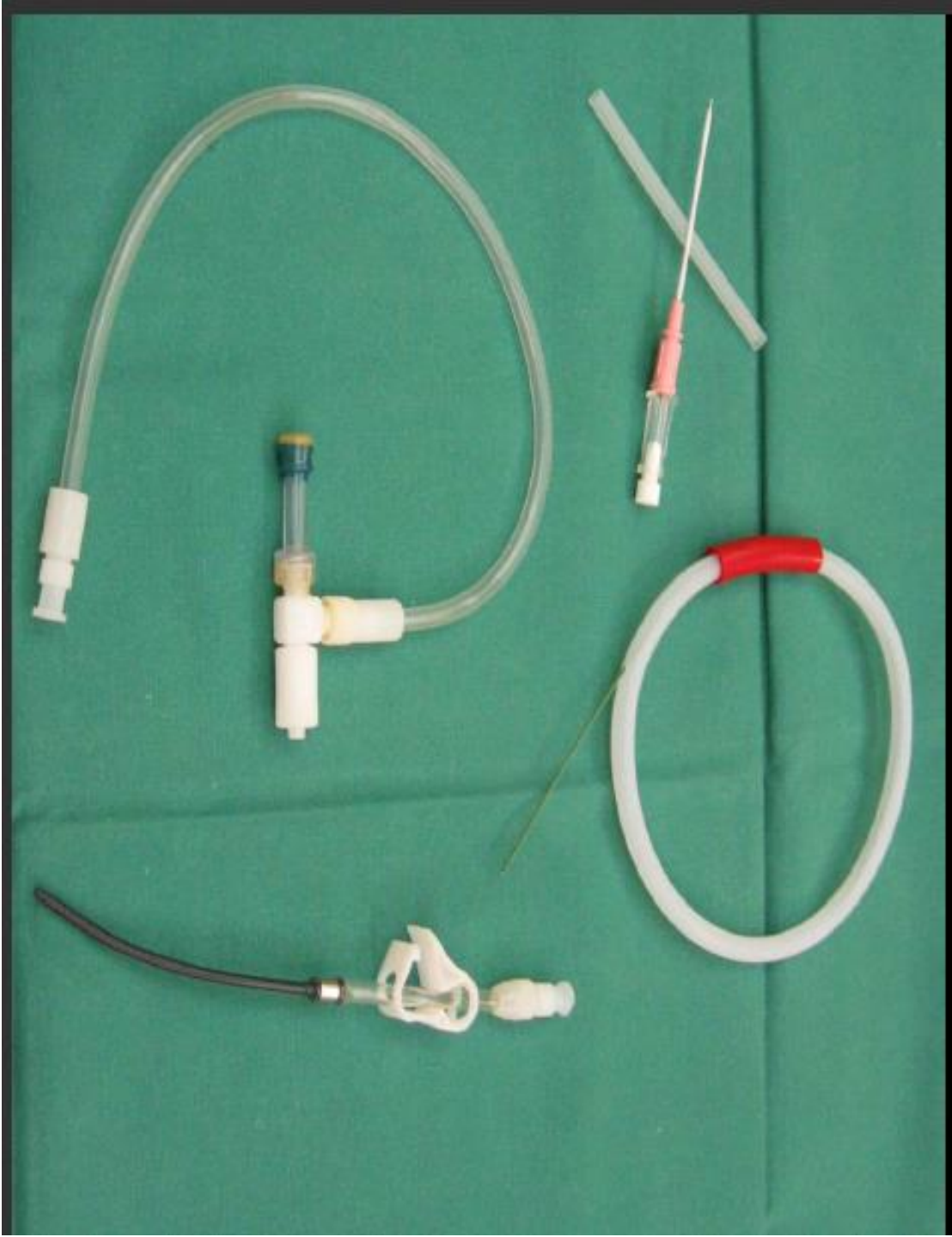
Blood Purif 2013;35:77–80
DOI: 10.1159/000345186

Published online: January 22, 2013

# Peritoneal Dialysis in the Pediatric Intensive Care Unit Setting: Techniques, Quantitations and Outcomes

Melvin Bonilla-Félix

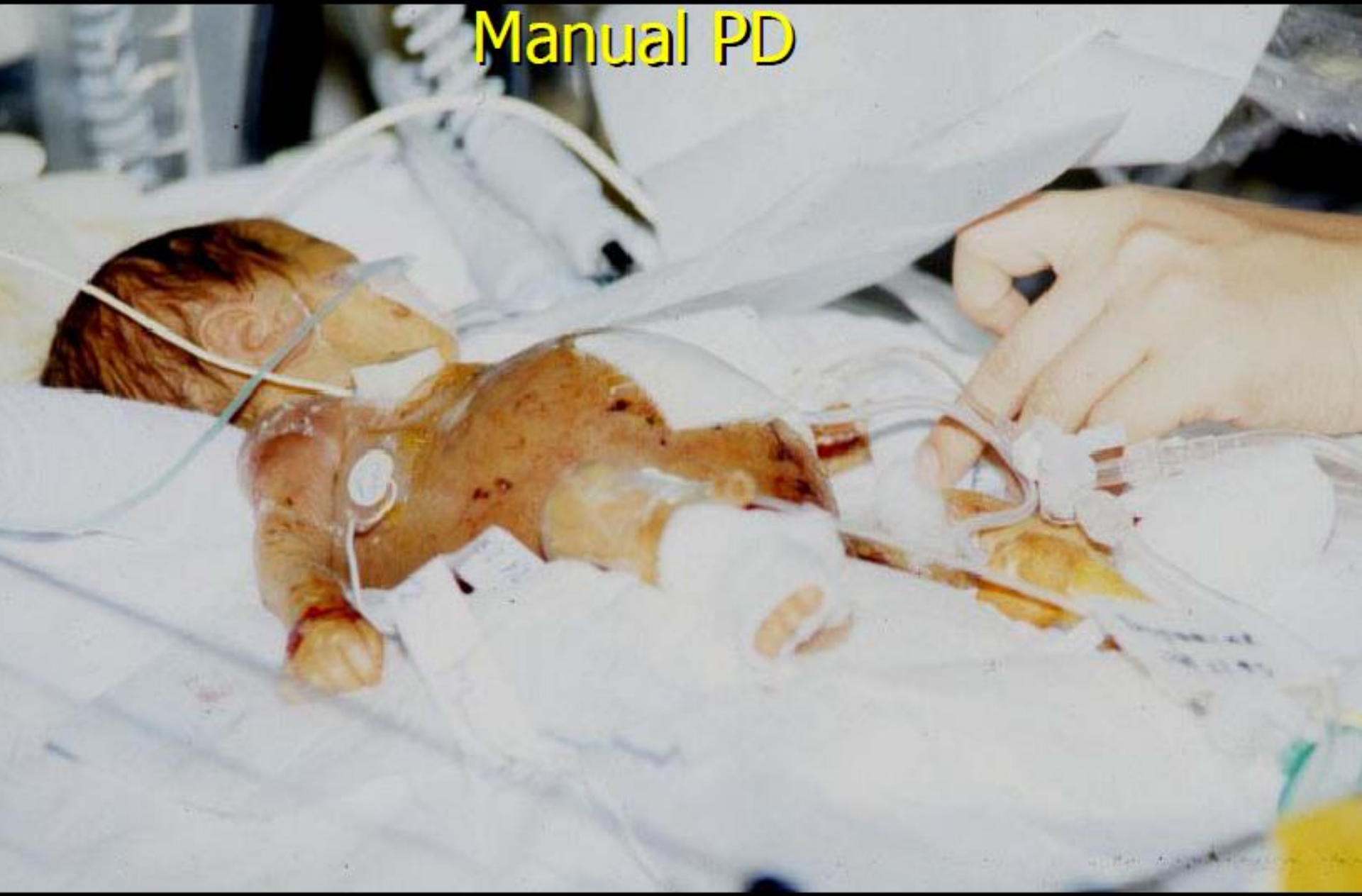
Department of Pediatrics, University of Puerto Rico – Medical Sciences Campus, San Juan, P.R., USA



# Acute PD catheter

- Stylet catheter (stiff catheter)
- Seldinger technique (soft catheter)
- Direct insertion surgically of single cuff straight Tenckhoff catheters

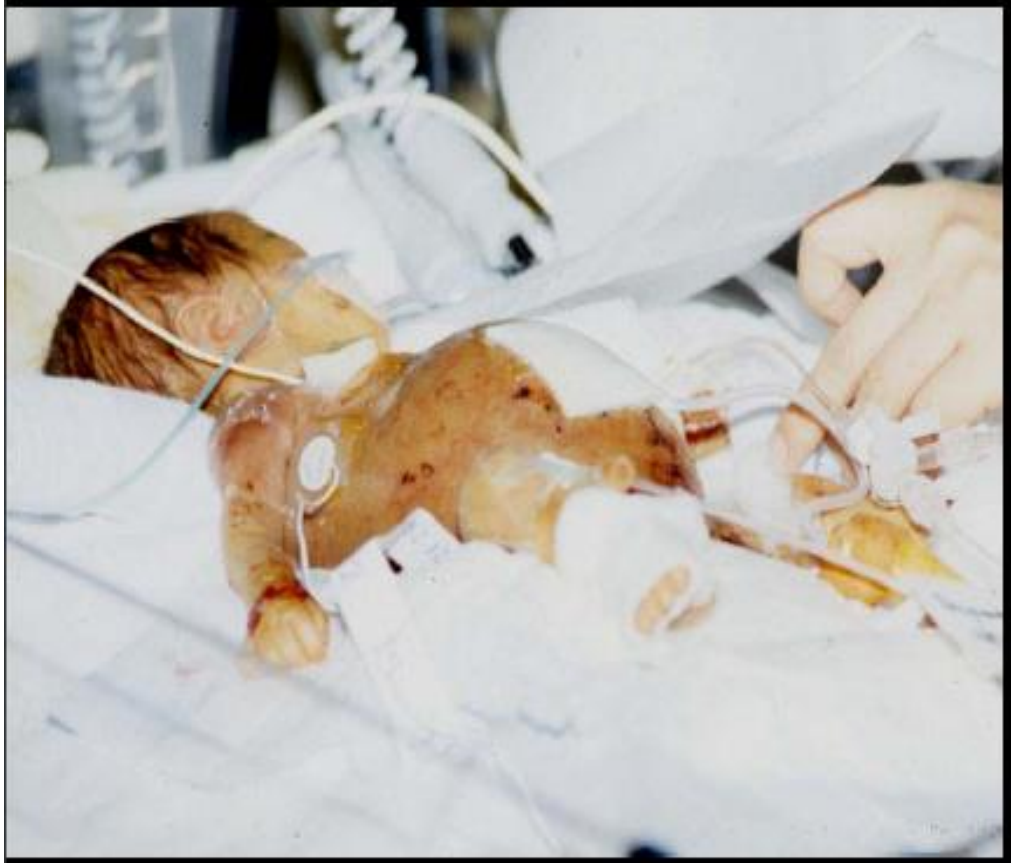
# Manual PD



# Problems of PD in the critically ill infant

- Catheter leakage
  - Subcutaneous tissue
  - Hernia sites especially inguinal
  - Congenital diaphragmatic "hole"
- Poor drainage
  - Catheter malposition
  - Kink
  - Omental wrapping
  - Fibrin clot

# Problems of PD in the critically ill infant



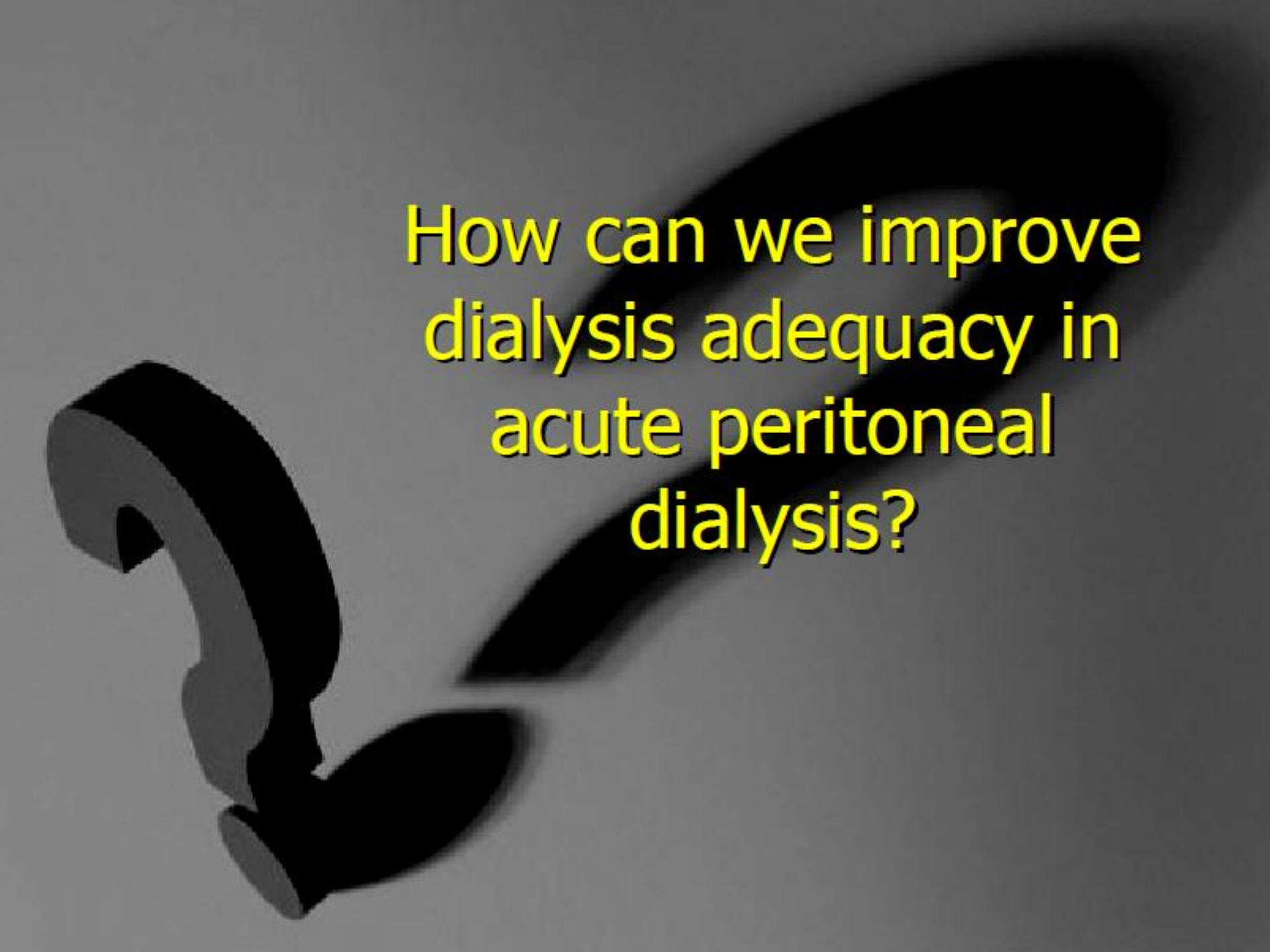
- Peritonitis
- Hyperglycemia
- Lactic acidosis
  - Lactate dialysis in hypoxic patients

# Problems of PD in the critically ill infant

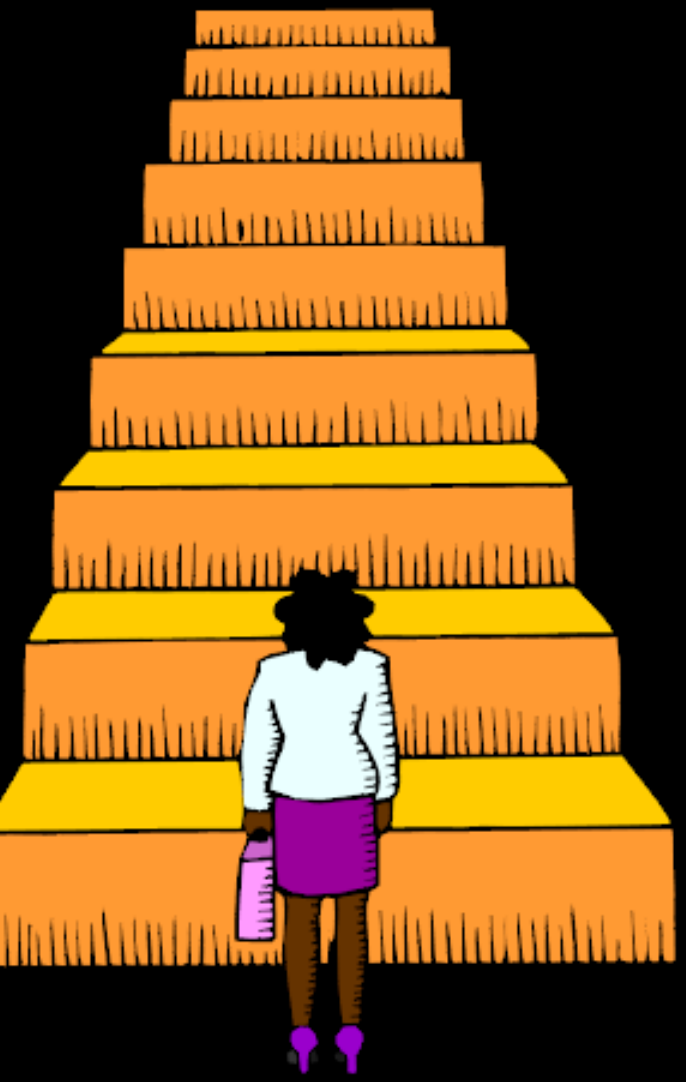
- Slow inefficient dialysis
  - Small volumes in neonates and preterms
  - Hypercatabolic state with severe hyperkalemia, hyperphosphatemia
    - Post-surgical
    - Multi-organ failure
  - Inborn errors with hyperammonemia or severe organic acidemia
  - Unpredictable ultrafiltration

# Predicted effects of treatment modalities during a 24-hour period in a 3-kg infant

| | HD | PD | CAVH | CAVHD |
|---|---|---|---|---|
| Urea clearance (L/24 hrs) | 2.1 | 2.4 | 1.6 | 3.6 |
| Ultrafiltration (L/24 hrs) | 0.2 | 0.6 | 1.6 | 1.0 |


How can we improve dialysis adequacy in acute peritoneal dialysis?

# Obstacles to achieving target



- Poor solute clearance
  - Dwell volume limited
  - Intermittent dwell technique
- Unpredictable UF rate
  - Technical problems with drainage
  - Hypotension on multiple inotropic support
  - Increased intra-abdominal pressure

# Tidal PD in mild/moderate hypercatabolic ARF

| Variables | Tidal PD | Continuous equilibrating PD | P value |
|---|---|---|---|
| $C_{Cr}$ (ml/min) | 9.94±2.93 | 6.74±1.63 | 0.01 |
| $C_{Cr}$ (L/wk/1.73m$^2$) | 68.50±4.43 | 58.85±2.57 | 0.035 |
| $C_{ur}$ (ml/min) | 19.85±1.95 | 10.63±2.62 | 0.001 |
| Kt/V (wk) | 2.43±0.87 | 1.80±0.32 | 0.001 |
| $SRI_{dialysate}$ | 28.46±4.60 | 20.64±5.93 | 0.02 |
| $SRI_{Kt/V}$ | 21.06±4.03 | 15.53±5.45 | 0.02 |
| UF (ml/min) | 4.28±0.70 | 1.82±0.13 | 0.04 |
| $C_K$ (ml/min) | 24.56±5.80 | 16.81±4.60 | 0.01 |
| $C_{Pi}$ (ml/min) | 14.23±5.40 | 9.60±3.90 | 0.04 |
| Dextrose abs (g/session) | 98.63±21.43 | 168.27±23.80 | 0.0001 |
| Protein loss (g/session) | 10.49±1.55 | 6.63±1.25 | 0.001 |

*(Chitalia VC et al, Kidney Int 2002)*

# CFPD: Dialysis characteristics

| | Dialysate flow rate (ml/min) | Peritoneal urea clearance (ml/min) | Peritoneal creatinine clearance (ml/min) | UF rate (ml/min) |
|---|---|---|---|---|
| Cruz et al, 2000: 2 separate catheters | 200 | 42 | 33 | 16 |
| Raj et al, 2000: single lumen catheter with single needle device | 141 | 26.5 | 24.1 | 3 |
| Mineshima et al, 2000: double lumen catheter | 100 | 14.1 | | 2.5 |
| Freida et al, 2003: 2 separate catheters | 100-150 | 21-36 | 13-33 | 2-8 |
| Amerling et al, 2003: 2 separate catheters | 200-300 | 25-75 | | 12-17 |

# PD cost in Iran

- Until recently, the **cost of healthcare in the Iran** consumed almost 6.4% of the GDP

- The cost of PD comparing HD now in Iran is **20% more expensive**.

- 430,000,000 as compared with 350,000,000 Rials **US$ 12,500 vs 10,150 for HD**

- **12 years ago it was reversed**

# Economy of RRT Modalities in Iran
## *(Hemodialysis vs. Peritoneal Dialysis)*

Authors: Farhang ZangnehH., Manbachi M., Najafi I., Mehran Nikoo H., Keyvani M.

## INTRODUCTION

Health care expenditure in European countries varies between 11% of Gross Domestic Product (GDP) (Germany) and 6% of GDP (Luxemburg) whereas in Iran, this figure sums up to about 4% of the GDP. On the other hand, dialysis costs (in comparison to the total health budget) vary between 36% in France and 19% in Germany, while not more than 0.04% of the general population (on the average) is under dialysis. In previous studies performed by the MOH in Iran, CAPD (with an annual cost of around 70 million Rials) was introduced more expensive than hemodialysis (with an annual cost of around 48 million Rials) in the governmental sector. As this report contradicts completely with the information from other regions of the world, where CAPD is at least 30% less expensive than hemodialysis, we decided to have a second thought on this issue in Iran.

## MATERIAL AND METHODS

According to the international guidelines, we have classified all the related expenses into six general categories, summarized as below:

7th EuroPD meeting; Prague, Oct 2005 poster presentation

# Economy of RRT Modalities in Iran

(Hemodialysis vs. Peritoneal Dialysis)

Authors: Farhang ZangnehH., Manbachi M., Najafi I., Mehran Nikoo H., Keyvani M.

| Annual Costs Per Patient (in Rials and US Dollar) | Hemodialysis | CAPD |
|---|---|---|
| Hardware & Services | 11,927,644 | 891,694 |
| Physicians & Nurses | 11,576,500 | 4,052,137 |
| Pharmaceuticals | 28,632,302 | 13,898,446 |
| Consumables | 32,189,820 | 71,892,493 |
| Complications | 1,190,000 | 1,173,699 |
| Others | 16,315,760 | 2,025,113 |
| **Total (Rials)** | **101,832,027** | **93,933,582** |
| **Total (US $)** | **11,572** | **10,674** |

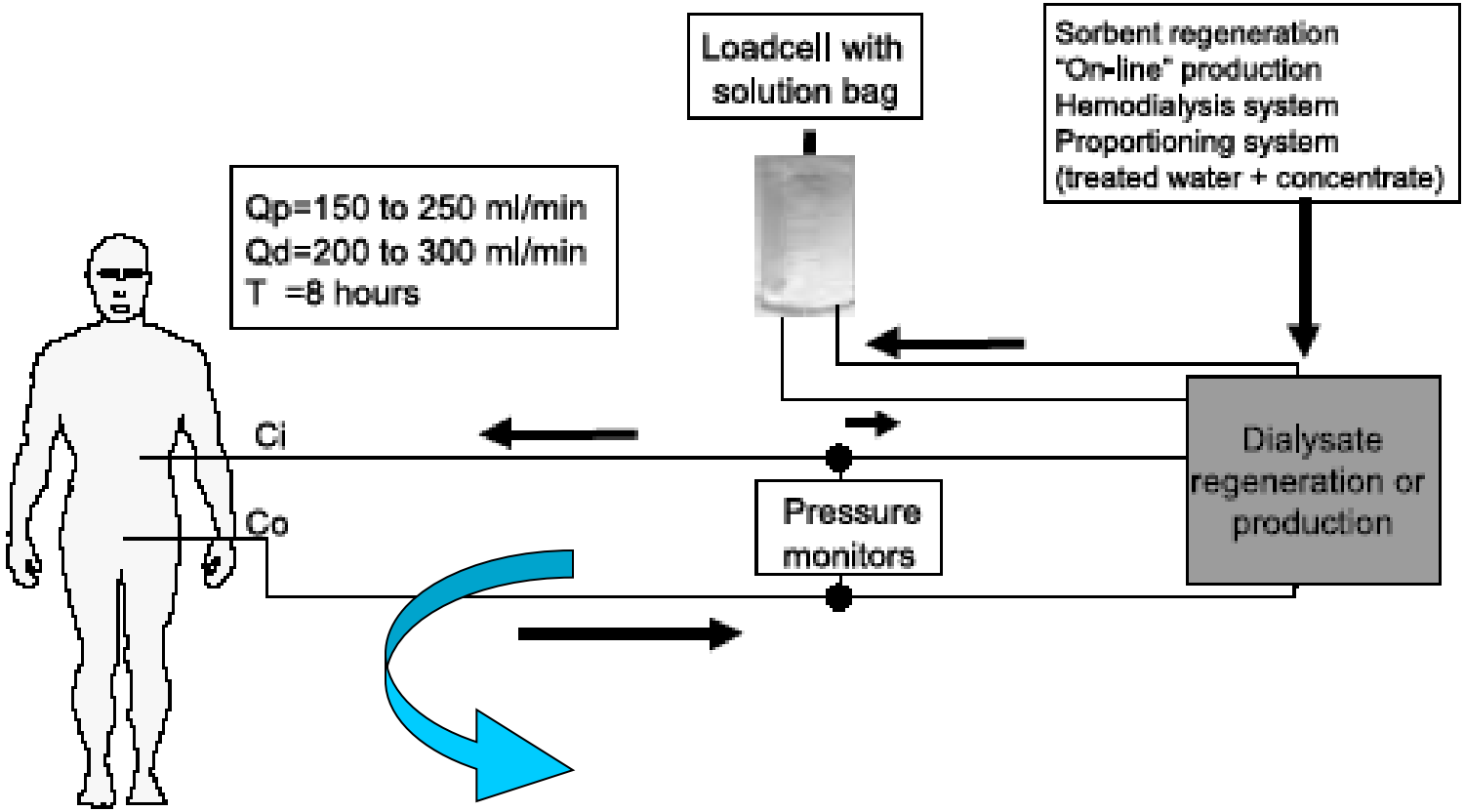
Comment: The extended calculations can be found *here*.

**Convince the Ministry**

# Weekly Price of PD in ICU IRAN

- 300 ml/min * 60 min = 18000 ml = 9 * 2L Bag
- 9 * 2L Bag/1h * 30000 Tuman = 270,000 / 1h
- 270,000 * 10h = 2,700,000 Tuman/ session
- 2,700,000 * 7 days = 18,900,000 Tuman/week

# Schematic representation of the CFPD system



# PD in ICU

Iraj Najafi MD.

Fouman

11.2.1397

# Limitation of acute PD to specific indications

"Uncomplicated" or medical causes of ARF

- Glomerular diseases
- Drug-induced acute tubular necrosis
- Ischemic acute tubular necrosis if hemodynamically stable
- Hemolytic-uremic syndrome
- Infections such as leptospirosis
- Snake bites

Toxins

- Limited used in those drugs with low MW, small Vd, minimal protein binding, water soluble
  - Alcohols
  - NaCl intoxication
  - salicylates


متشکرم
انشاء الله موفق باشید


Acute PD
Flexible, cuffed PD catheter
percutaneous/surgical insertion
Rigid catheter
Adequate resources
Yes
No
Shock or liver failure
Yes
No
Bicarbonate containing dialysate
Standard dialysate
Cycler: 36-44 litres with 2 litre fill volumes
Manual: <50kg – 1.5 litre 2 hourly cycles
50- 80kg – 2 litre 2 hourly cycles
>80kg – 2litre 1.5 hourly cycles
Consider change to 4 hourly cycles once acidosis, pulmonary oedema and hyperkalaemia resolved
Add Heparin 500u / litre dialysate
Standard dialysate
Target weekly Kt/V – 2.1
<40kg – 1 litre 2 hourly cycles
40-60Kg – 2 litre 3 hourly cycles
>60kg – 2 litre 2 hourly cycles
Change to 4 hourly cycles once acidosis, pulmonary oedema and hyperkalaemia resolved
Add Heparin 500u /litre dialysate

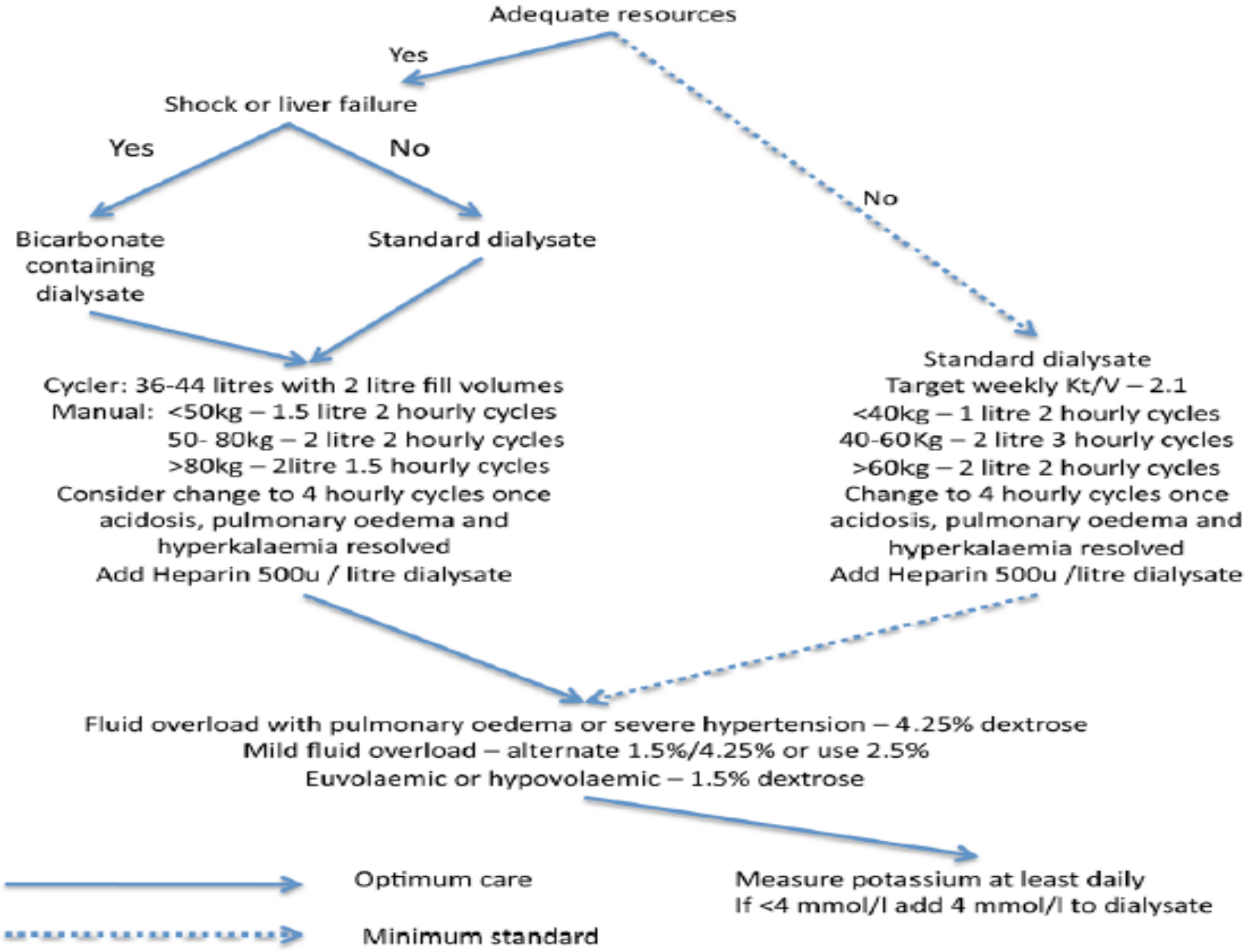
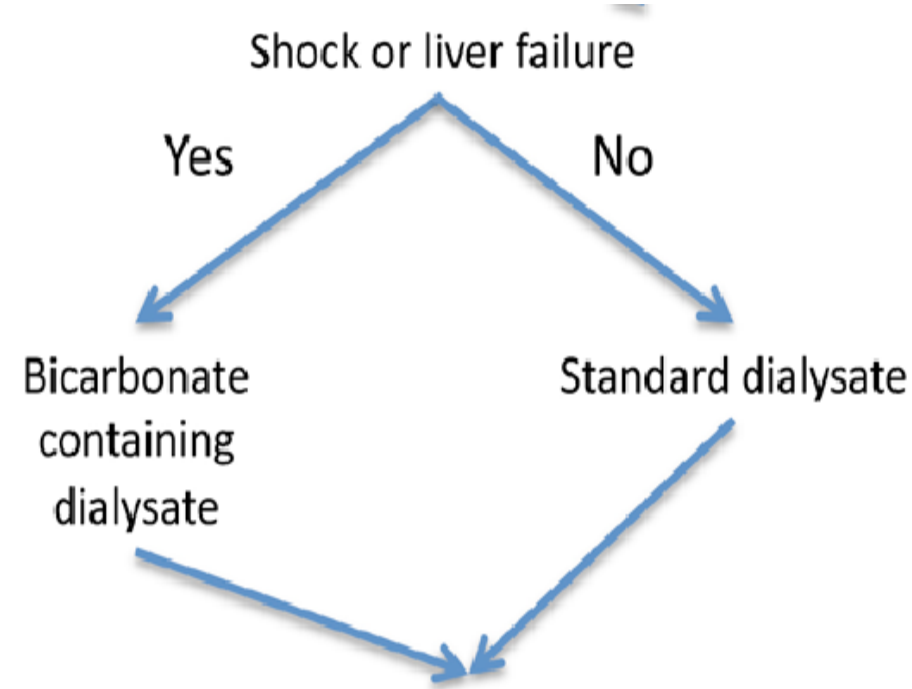



Figure 1 — Suggested dosing algorithm.

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Target weekly Kt/V – 2.1
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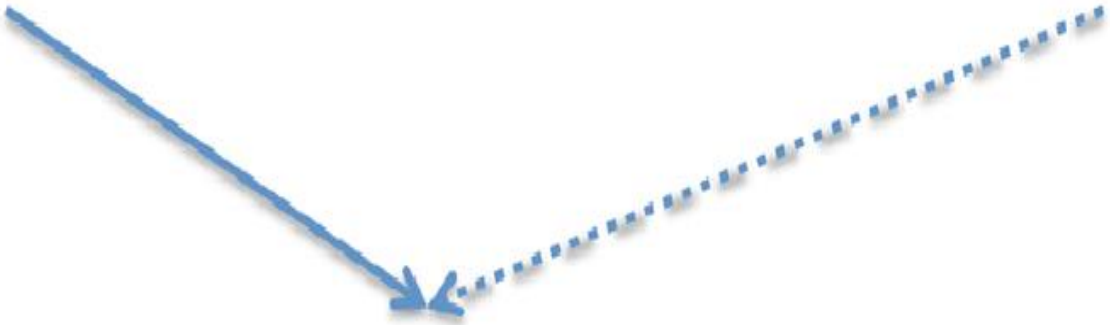


Fluid overload with pulmonary oedema or severe hypertension – 4.25% dextrose

Mild fluid overload – alternate 1.5%/4.25% or use 2.5%

Euvolaemic or hypovolaemic – 1.5% dextrose

Measure potassium at least daily

If <4 mmol/l add 4 mmol/l to dialysate

Optimum care

Minimum standard

# CONCLUSION

- PD to treat patients with AKI provides an acceptable form of treatment. While PD is not used commonly in the developed world to treat patients with AKI, recent studies have suggested that outcomes with PD are as good as with extracorporeal RRTs. Certainly, in the developing world, there are major advantages for PD to manage patients with AKI. While the guidelines presented above focus on optimal treatment algorithms, it is important to keep in mind that treatment patterns need to be developed in accordance with individual patient needs taking into account the available resources and hospital environment. In low-resource settings, flexibility and appropriate adjustments in treatment patterns may need to be made.

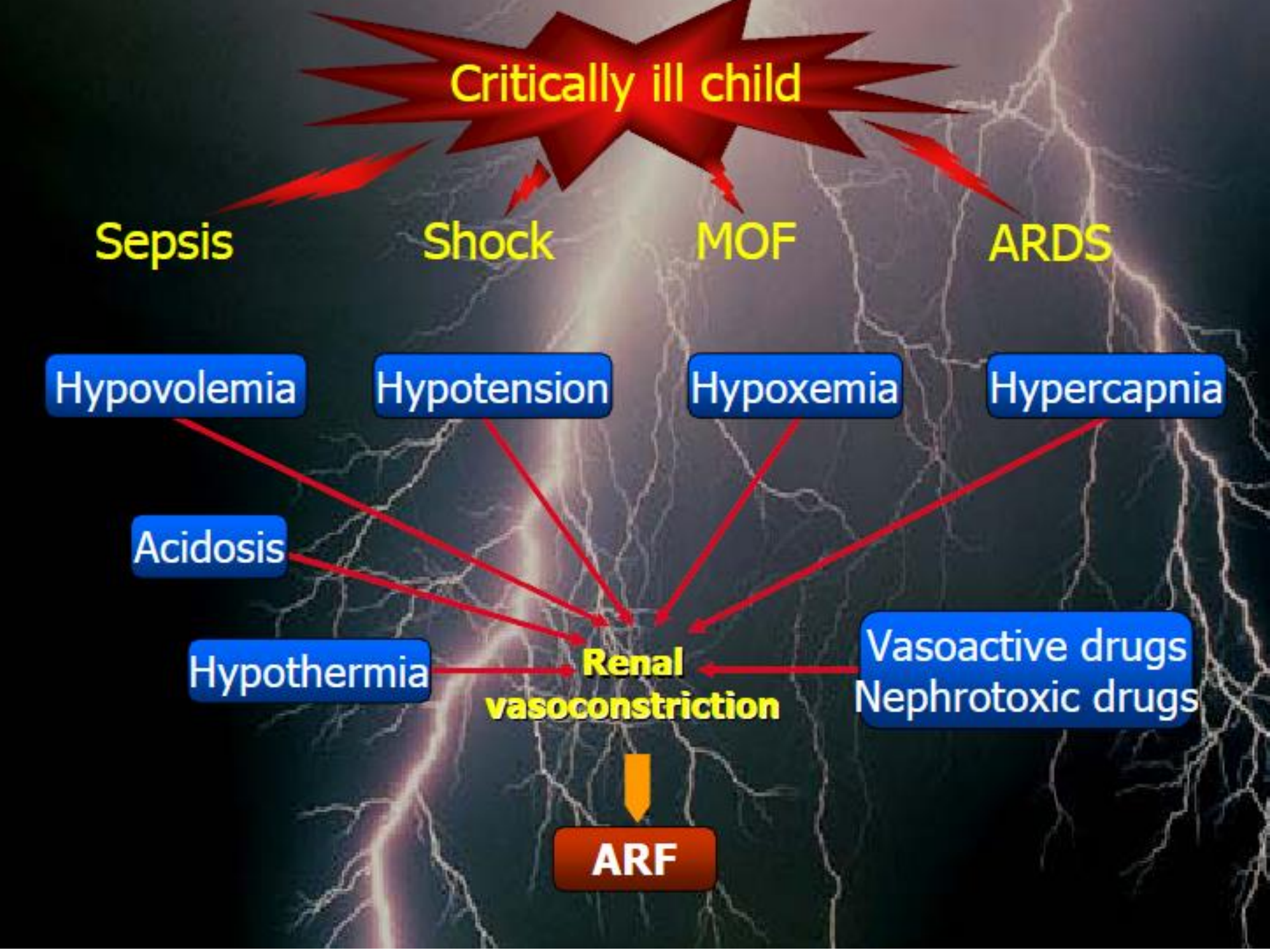
# conclusion

- In conclusion, while waiting for better, multicenter comparative studies, there are many patients with acute kidney injury that may benefit from continuous, gentle affordable and efficient peritoneal dialysis.

# Conclusions

- There is currently no evidence to suggest significant differences in mortality between peritoneal dialysis and extracorporeal blood purification in AKI.

- There is a need for good-quality evidence in this important area.


Critically ill child
Sepsis
Shock
MOF
ARDS
Hypovolemia
Hypotension
Hypoxemia
Hypercapnia
Acidosis
Hypothermia
Renal vasoconstriction
Vasoactive drugs
Nephrotoxic drugs
ARF

# Cost of Peritoneal Dialysis and Haemodialysis Across the World

Akash Nayak Karopadi, Giacomo Mason, Enrico Rettore, Claudio Ronco

Nephrol Dial Transplant. 2013;28(10):2553-2569.

[ CLOSE WINDOW ]

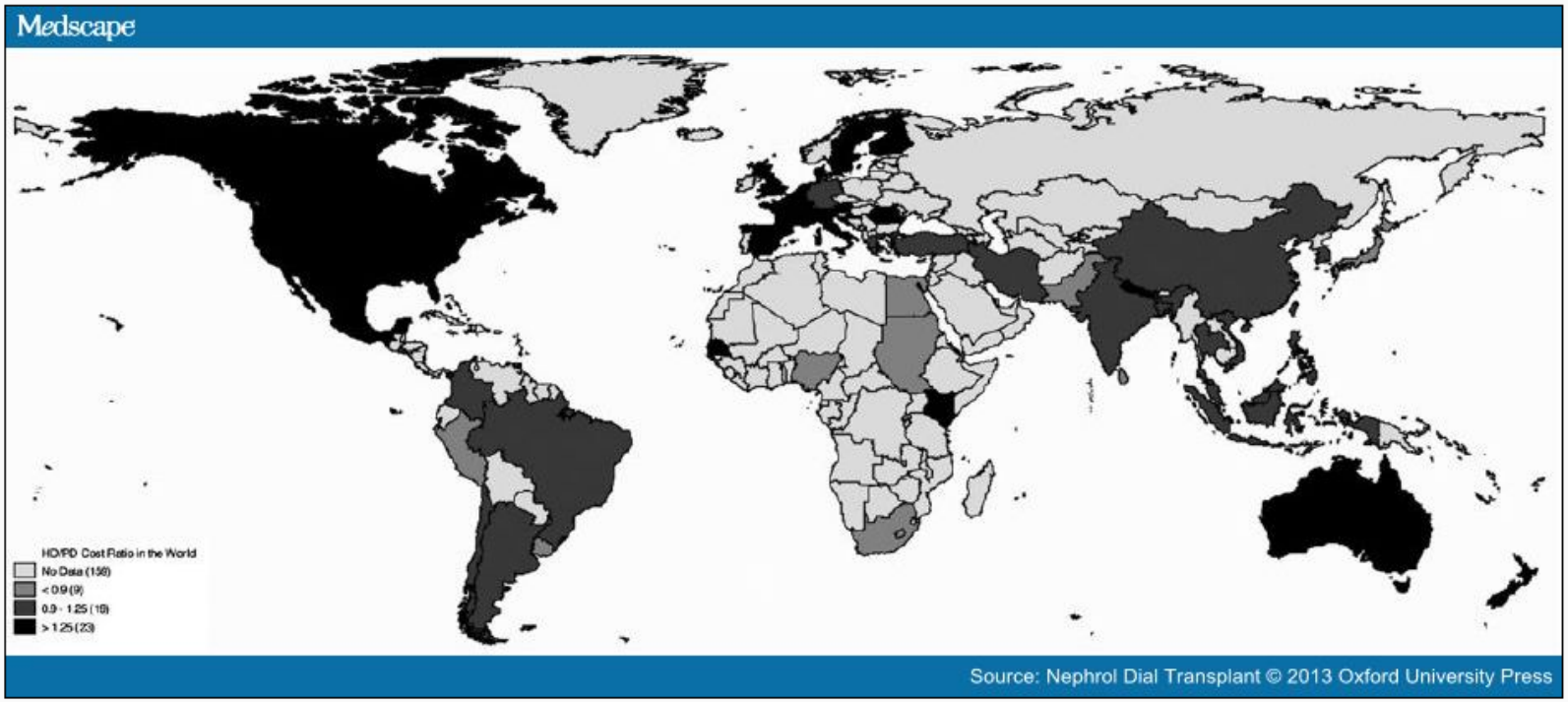



**Figure 1.**

Map summarizing the HD/PD ratios in 51 countries (survey data included). Countries are placed in three categories: (i) HD/PD ratio <0.90. (ii) HD/PD ratio between 0.90 and 1.25. (iii) HD/PD ratio >1.25. Map was generated using Stata 12 (StataCorp. 2011. Stata Statistical Software: Release 12. College Station, TX: StataCorp LP.)

**Table 1. Studies comparing HD and PD costs (arranged according to the country and year of publication)**

| Source | Country | Year of publication | HD/PD cost ratio | Methodological notes |
|---|---|---|---|---|
| Abraham *et al.* [80] | Sri Lanka | 2008 | 0.85 | B |
| Van Bui *et al.* [17] | Vietnam | 2008 | Similar cost | B |
| Naidas *et al.* [18] | Philippines | 1998 | 1.14 | CE |
| Prodjosudhadi *et al.* [10] | Indonesia | 2006 | 1.03 | B |
| Morad *et al.* [81] | Malaysia | 2005 | 1.08 | B |
| Hooi *et al.* [82] | Malaysia | 2005 | 1.06 | CE |
| Lim *et al.* [83] | Malaysia | 1999 | 0.81 | CE |
| Teerawattanon *et al.* [84] | Thailand | 2007 | 1.07 | CU |
| Neil *et al.* [16] | Thailand | 2009 | 1.13 | CB |
| Li and Chow [4] | Japan | 2001 | 1.09 | B |
| Fukuhara *et al.* [15] | Japan | 2007 | 0.85 | CB |
| Yu *et al.* [85] | Hong Kong | 2007 | 2.35 | B |
| Neil *et al.* [16] | Singapore | 2009 | 1.38 | CB |
| Utas *et al.* [12] | Turkey | 2008 | 1.16 | CB |
| Erek *et al.* [13] | Turkey | 2004 | 1.02 | CB |
| Najafi *et al.* [11] | Iran | 2010 | 1.08 | B |

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# Lessons from PD/AKI Data

- PD is as effective as HD or CVVH to treat critically ill AKI patients
- Nephrologists can place catheters in these patients at bedside successfully
- Catheters work well if used right after placement – even with large volume PD cycling

# Problems of PD in the critically ill infant

- Respiratory distress
  - Splinting of diaphragm
  - Poor ultrafiltration with fluid overload
- Poor ultrafiltration
  - Decreased gut perfusion
  - Loss of osmotic gradient (sepsis)