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CAPD

Introduction

CAPD introduction in Asia

➢ Popovich & Moncrief	1975
➢ Iran (Ghods & Abdi)	1978
➢ Singapore	1979
➢ Malaysia	1980
➢ Hong Kong	1980
➢ Korea	1980
➢ Thailand	1982
➢ Taiwan	1984
➢ Japan	1984
➢ Philippine	1984
➢ Iran	1995

DIVISION OF NEPHROLOGY 1976-1977

University of Missouri Medical Center

And

Harry S. Truman Memorial Veterans Hospital

Columbia, Missouri

Karl D. Nolph, M.D.
Director,
Division of Nephrology

John C. Van Stone, M.D.
Assistant Professor
of Medicine

John H. Bauer, M.D.
Assistant Professor
of Medicine

C. Stephen Brooks, M.D.
Assistant Professor
of Medicine

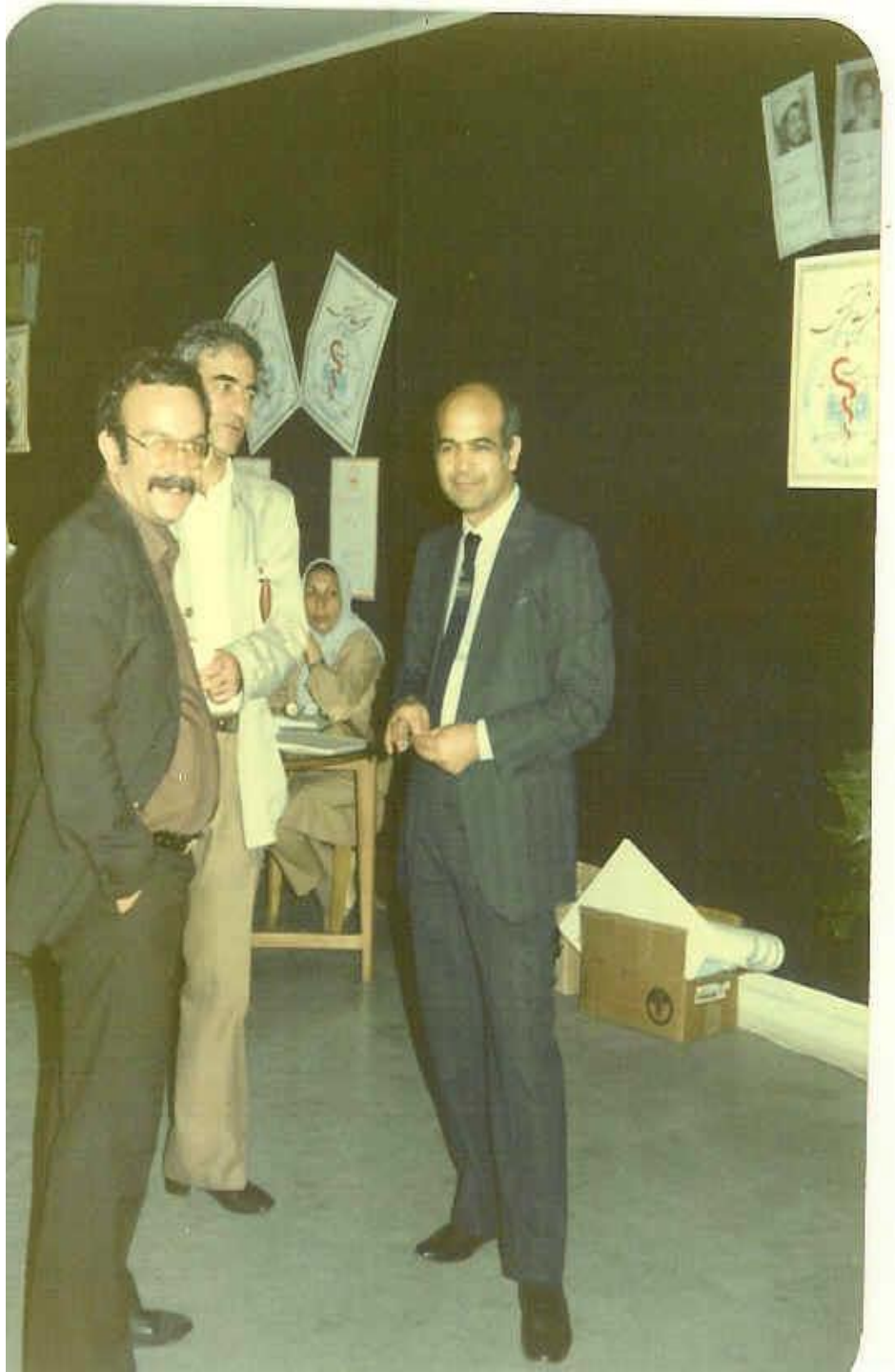
Michael I. Sorkin, M.D.
Assistant Professor
of Medicine

Wallace Gauntner, M.D.
Nephrology Fellow

Ahad Ghods, M.D.
Nephrology Fellow

Zbylut Twardowski, M.D.
Nephrology Fellow

Pilar Noya, M.D.
Post-Doctoral Student



1978

1979

1980

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Pilar Noya, M.D.
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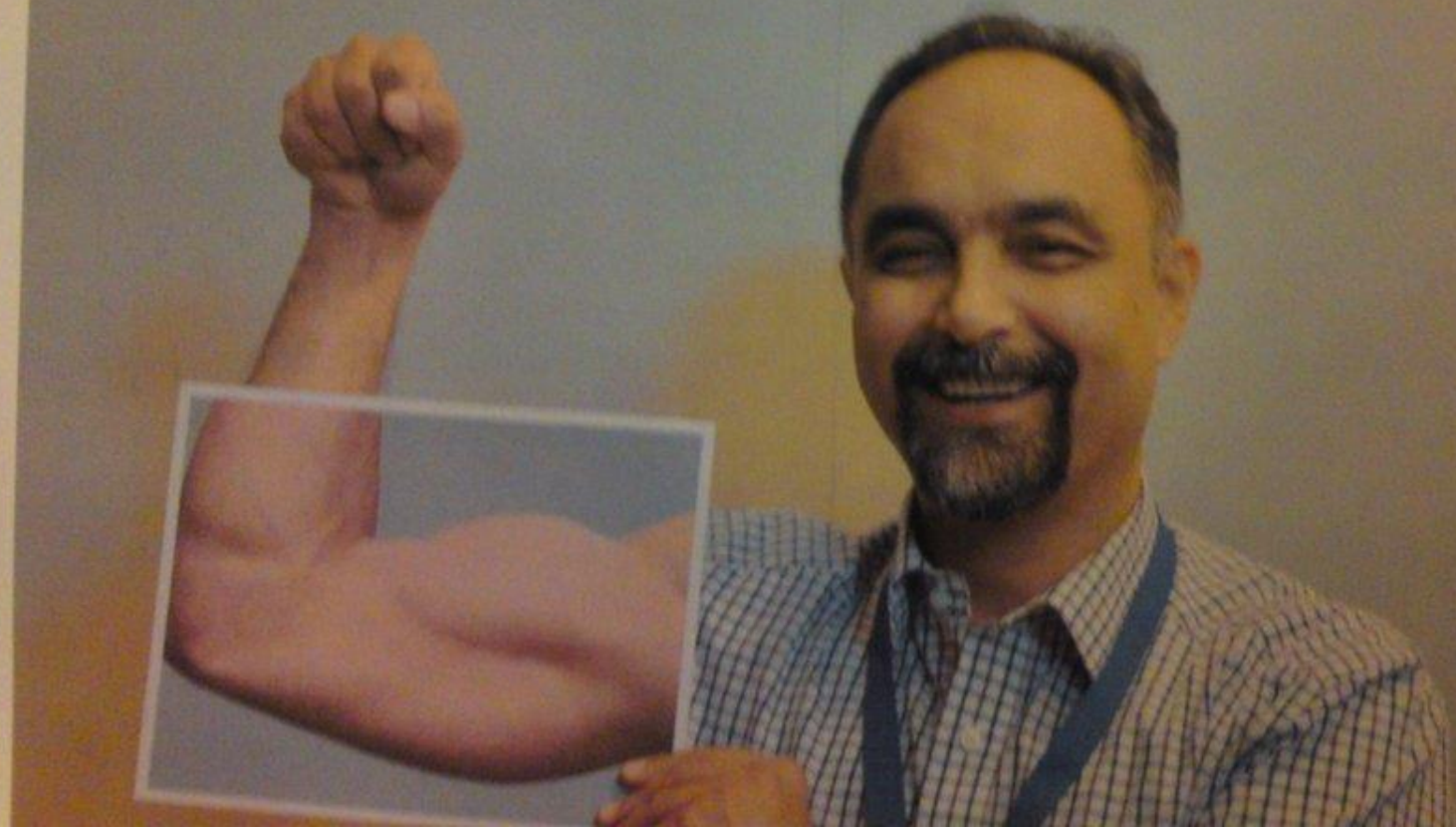
PD Start Strong

Peritoneal dialysis (PD) is associated with clinical benefits that can set up end stage renal disease (ESRD) patients for future success compared to conventional haemodialysis:

- Patients starting on PD have better short-term survival[1-3]
- PD better preserves residual renal function[3]
- PD is a strong bridge to transplant[4-5]

By starting your patients on PD, you will be preparing them for whatever ESRD sends their way.

PD. Stronger than you think.



PD The Most Healthy Start

دیالیز صفاقی سالمترین روش درمانی برای شروع

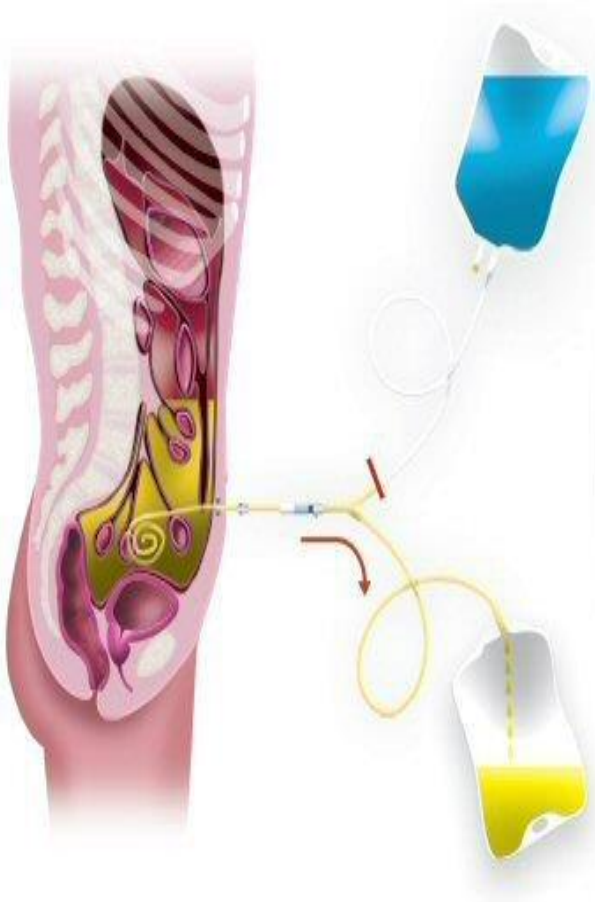
PD a bridge to kidney transplantation

دیالیز صفاقی پلی برای پیوند کلیه

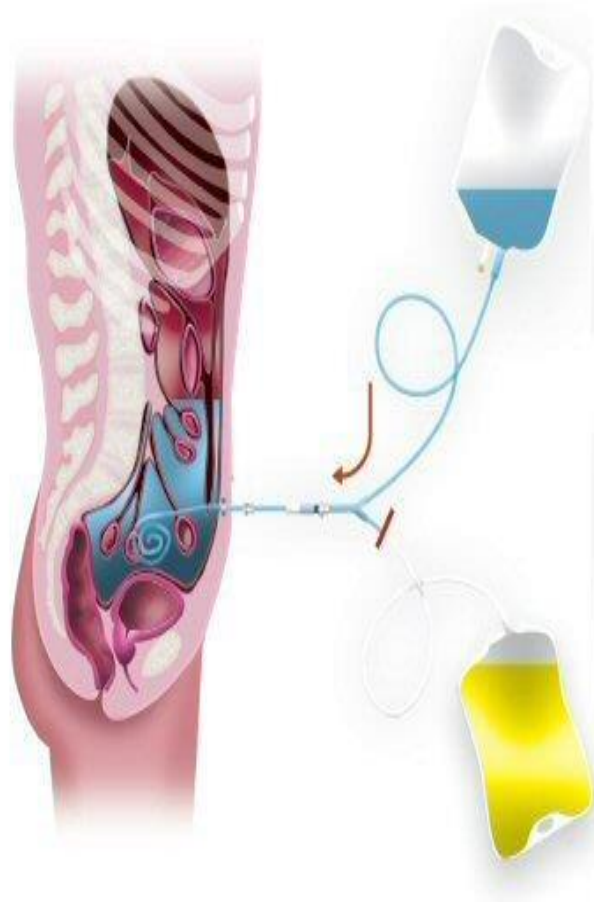
Iraj Najafi
PD congress Kish
Jan 2015

دیالیز صفاقی پلی مطمئن بسوی پیوند

PD Exchange



DRAIN



FILL

Does not require the use of blood to leave your body

DWELL

حين زمان dwell چه اتفاقي مي‌افتد؟

- کلیرانس سموم

دیالیز

- کلیرانس مایعات

Figure 5
Toxin Removal by Dialysate Flow

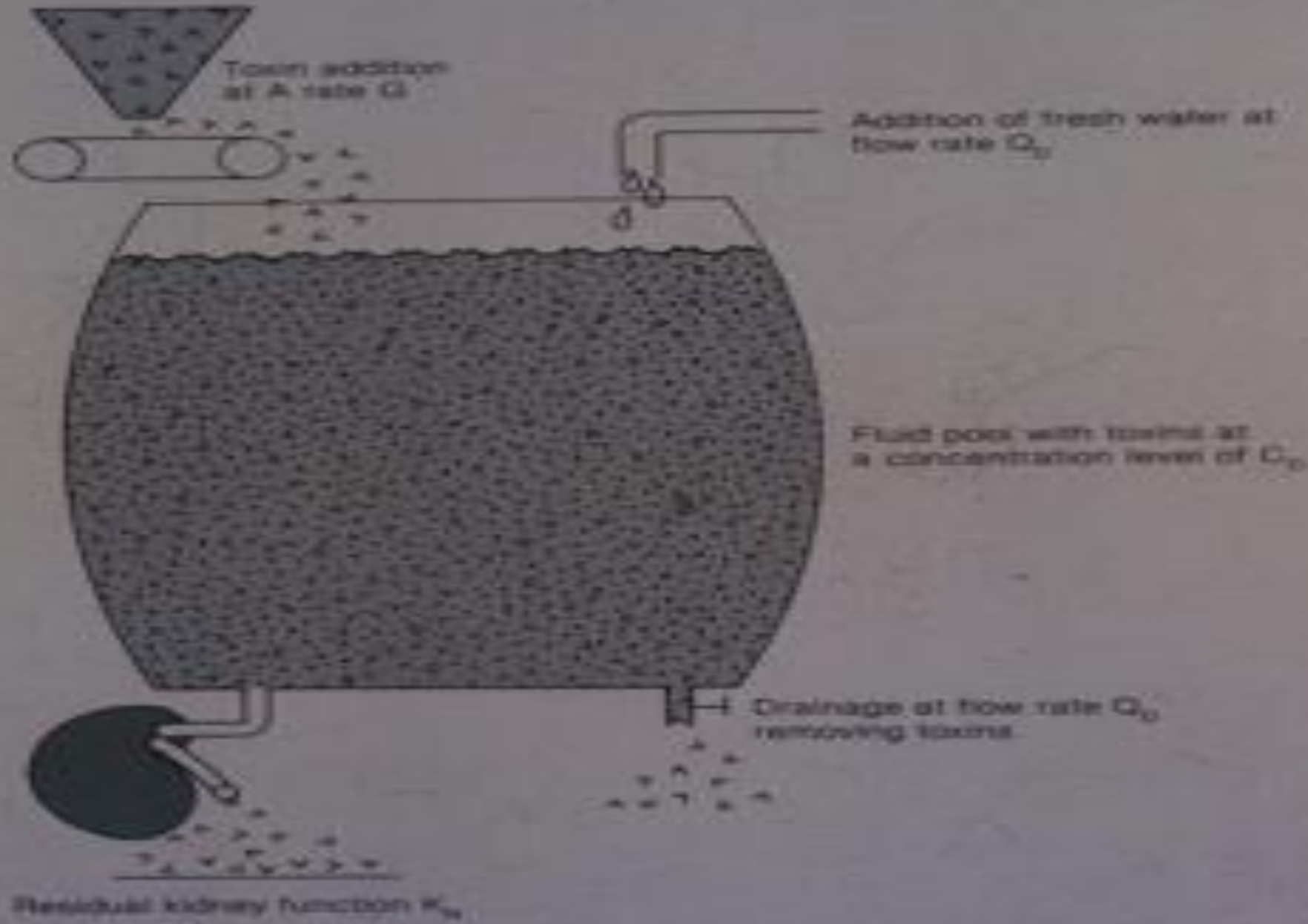


Figure 4
Schematic Characterization of the Patient-Peritoneal Dialysis System

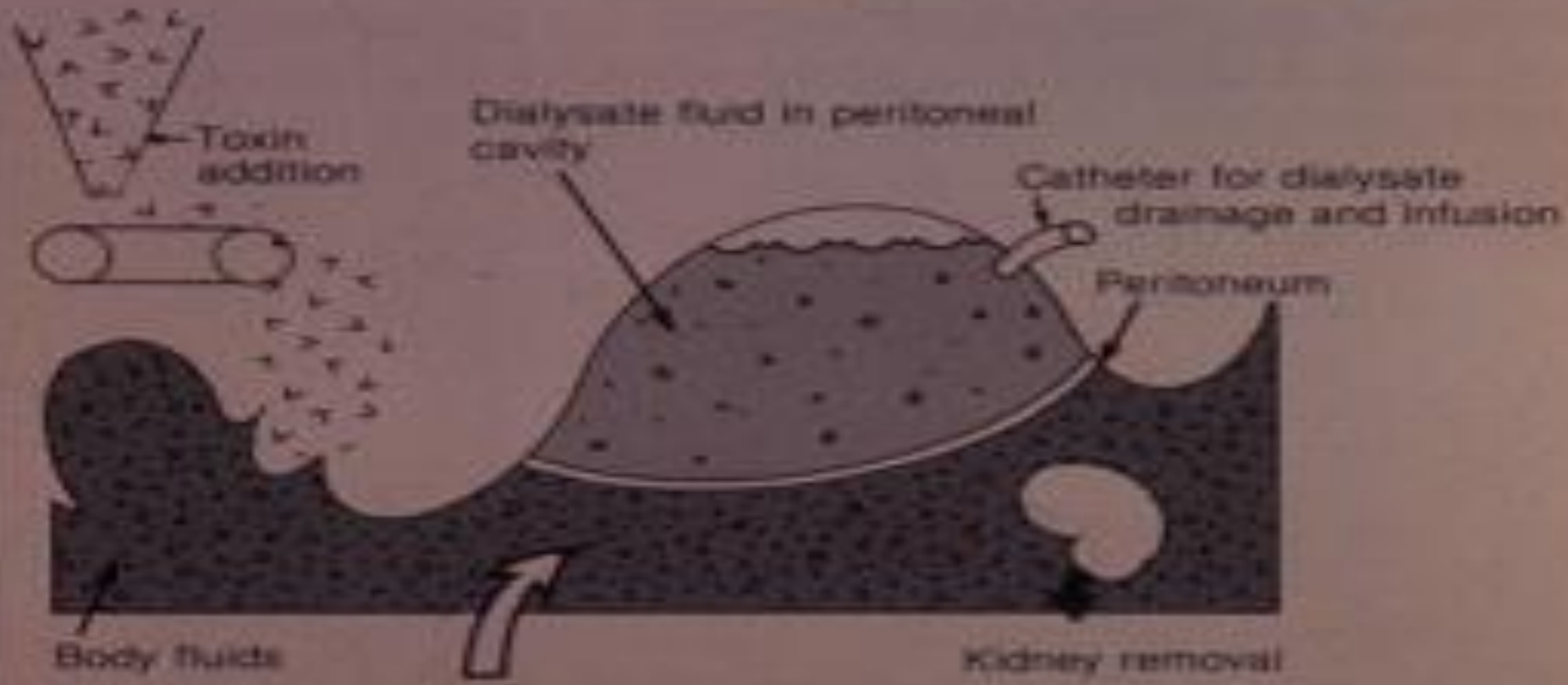


Figure 1
Diffusion of Molecules Through a Porous Membrane

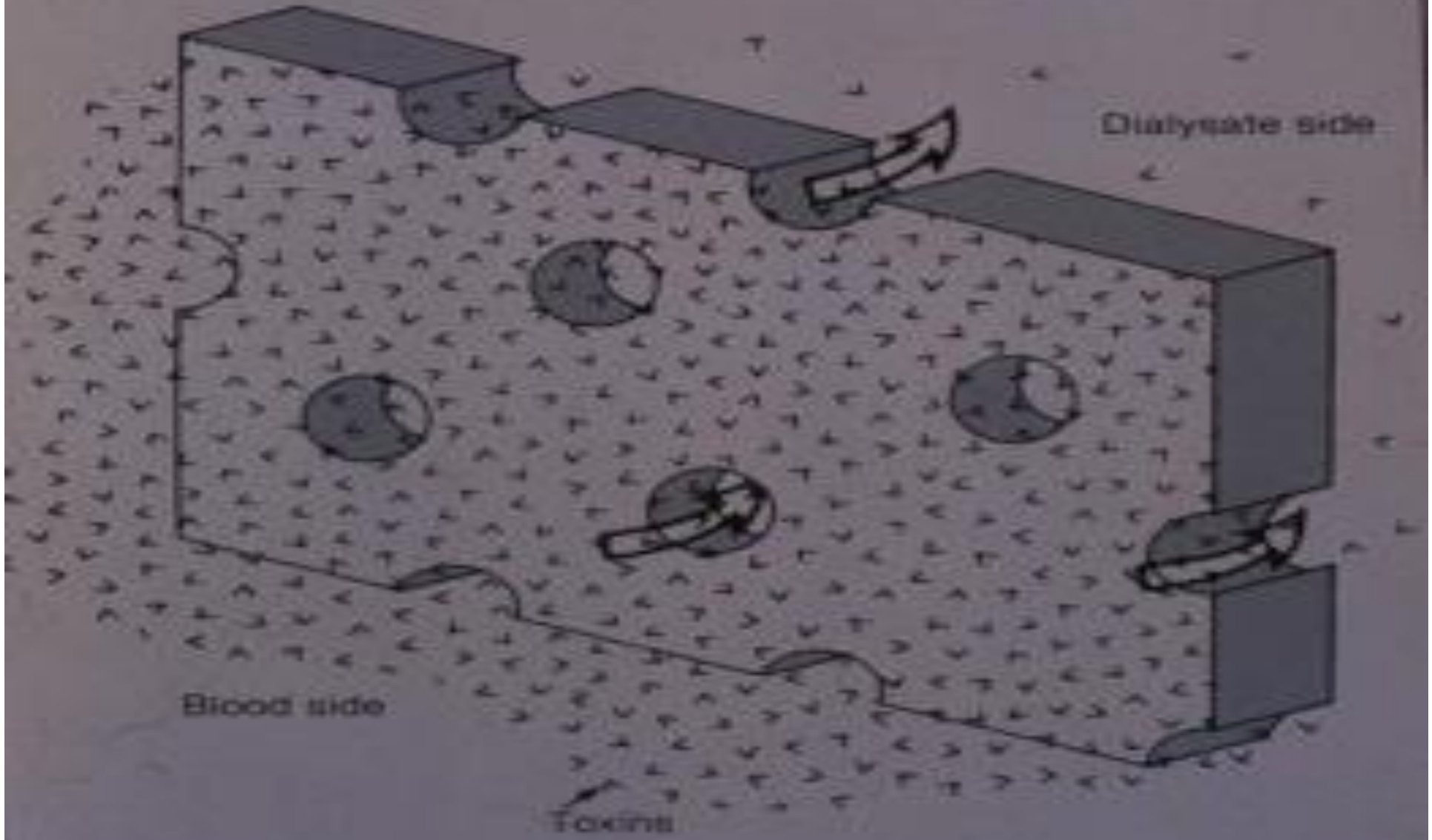


Figure 2
Microscopic View of Blood and Dialysate Toxin Levels Shortly After Infusion

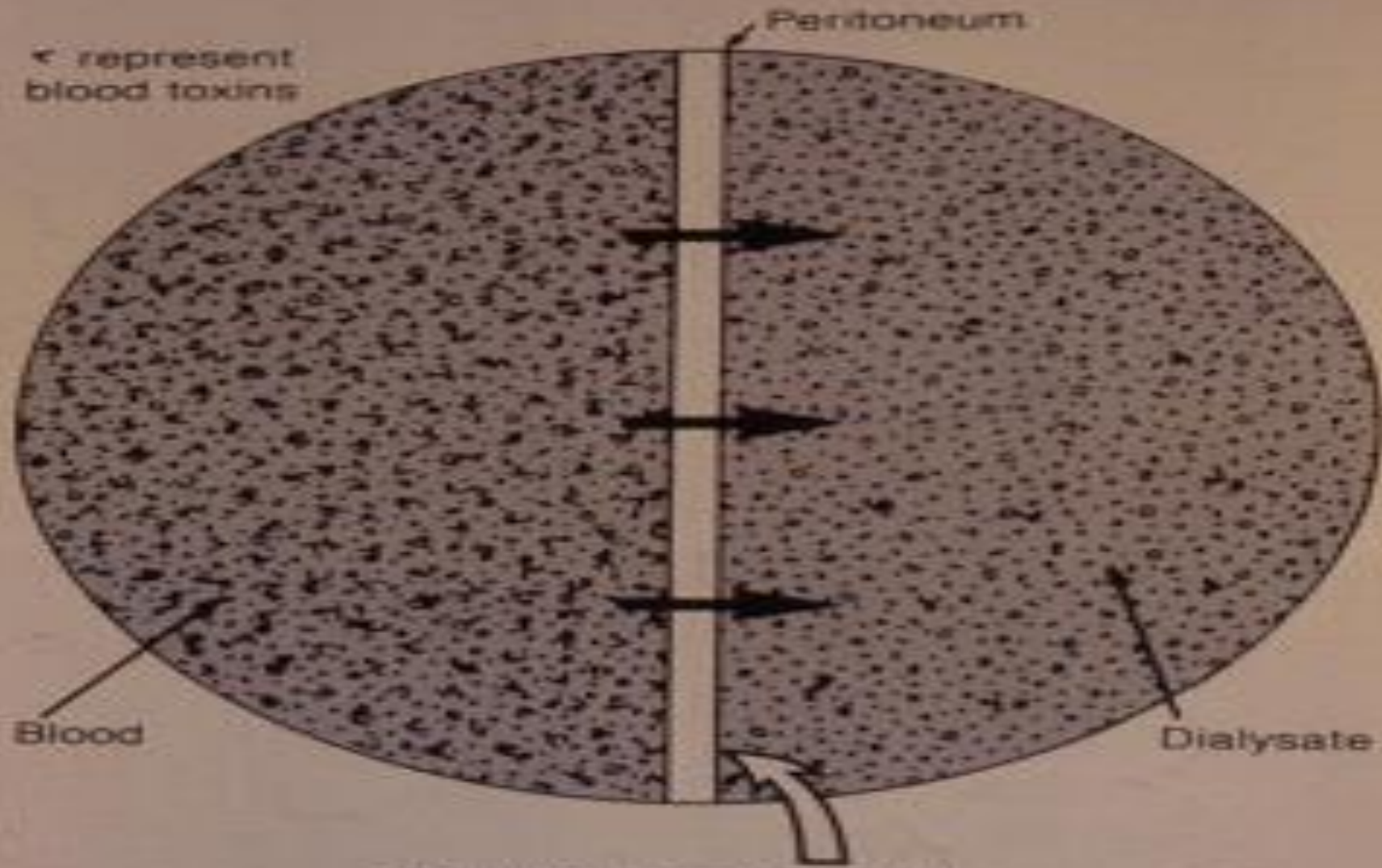
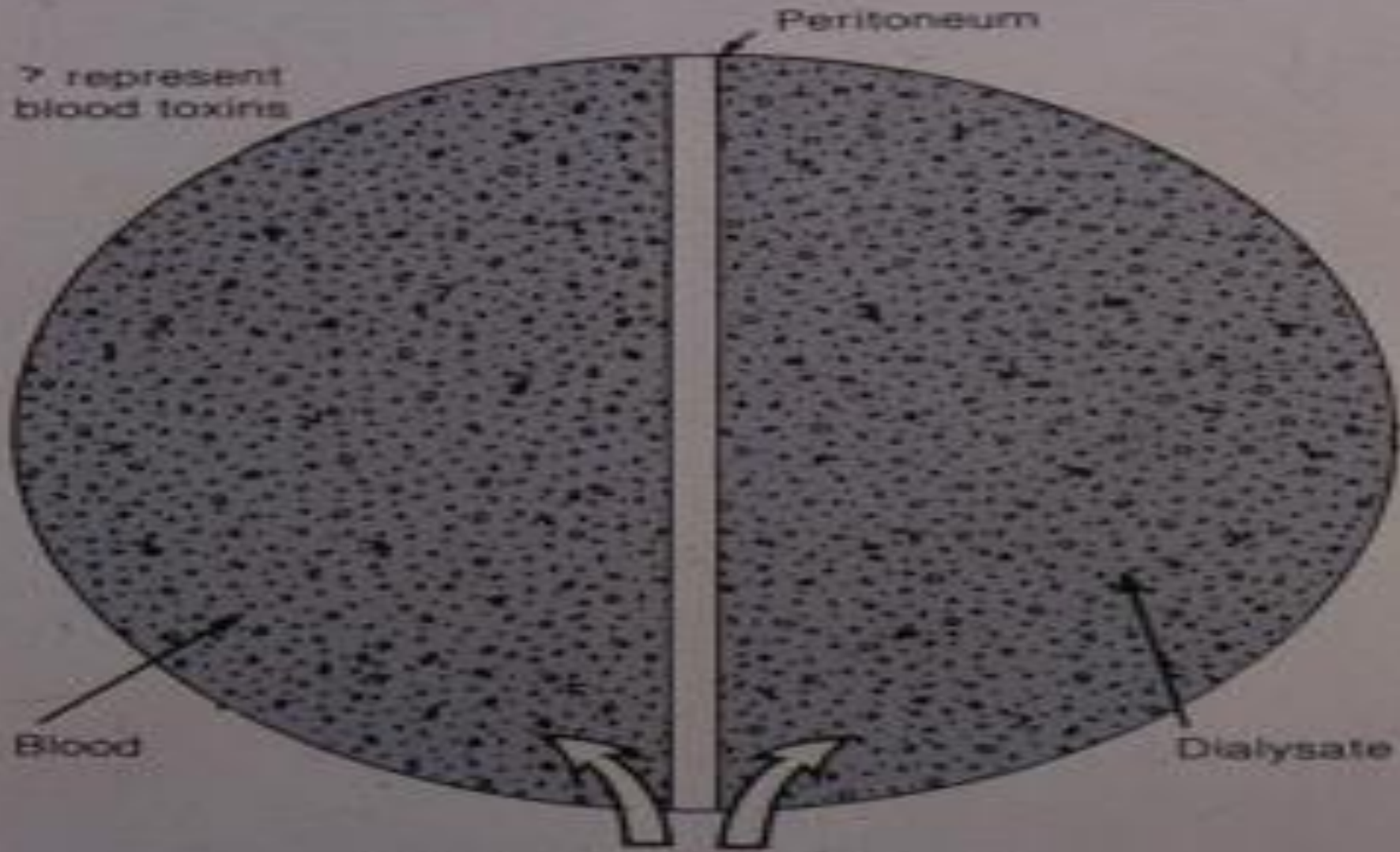
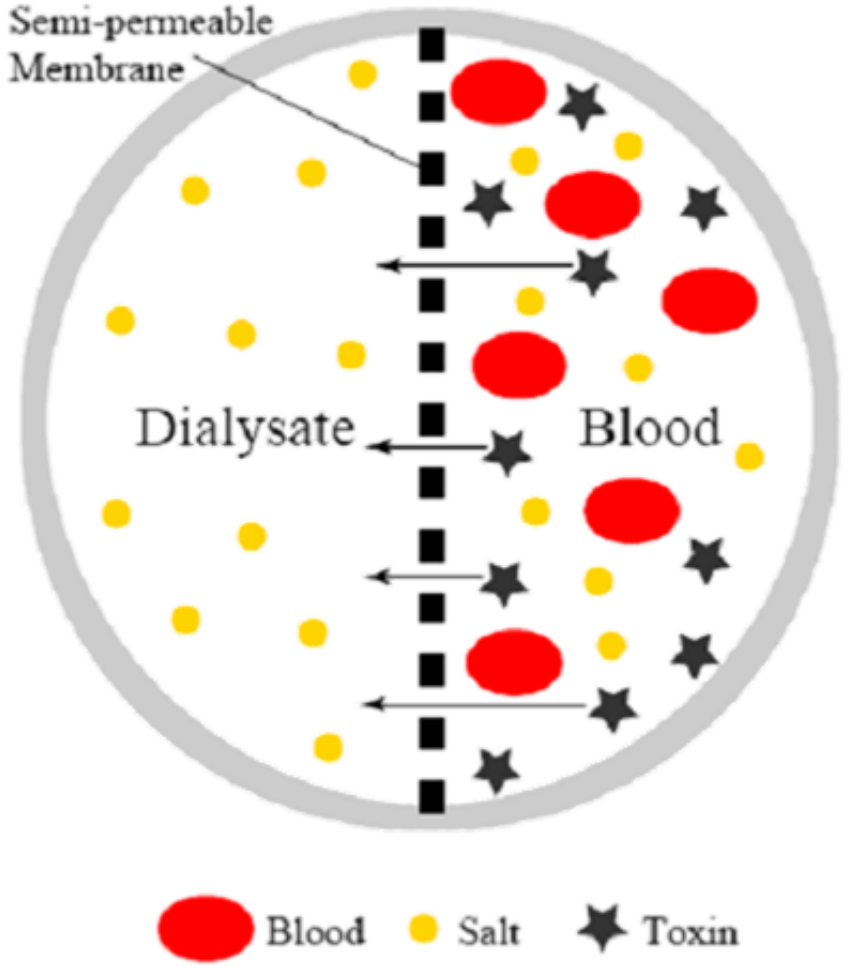


Figure 3
Microscopic View of Blood and Dialysate Toxin Levels Following a Prolonged Dwell Period (Equilibration)

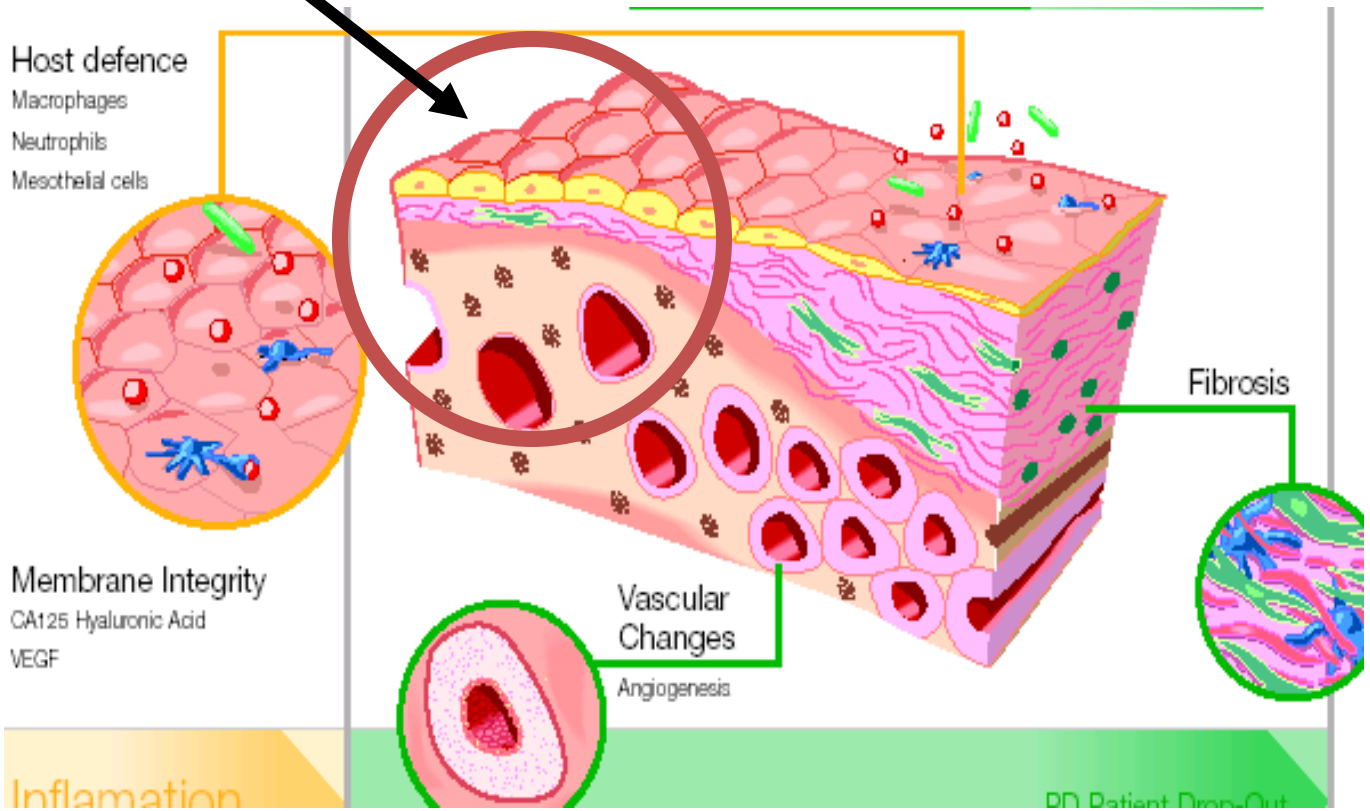


دیالیز صفاقي : چگونه کار مي‌کند؟

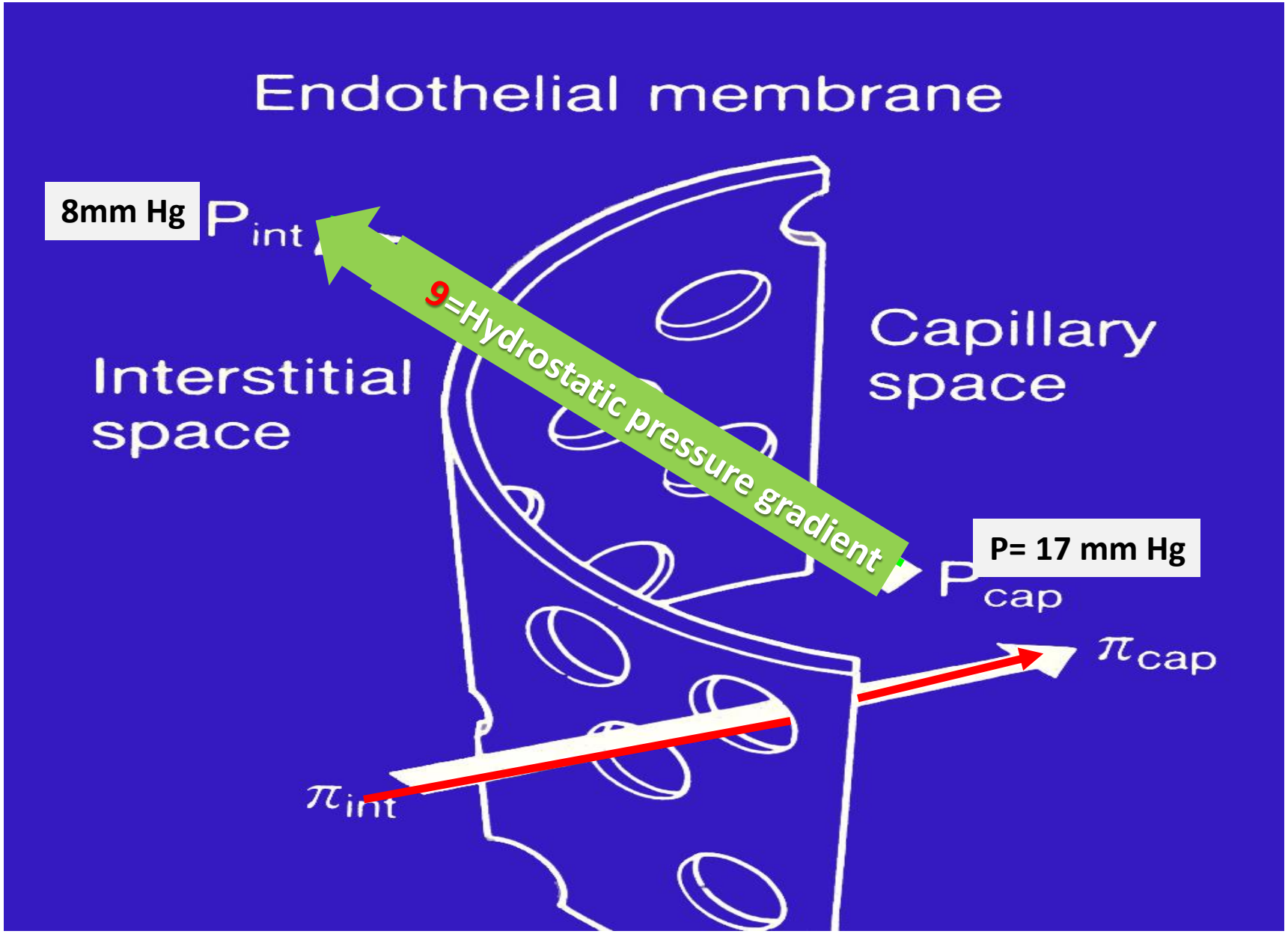


انتشار

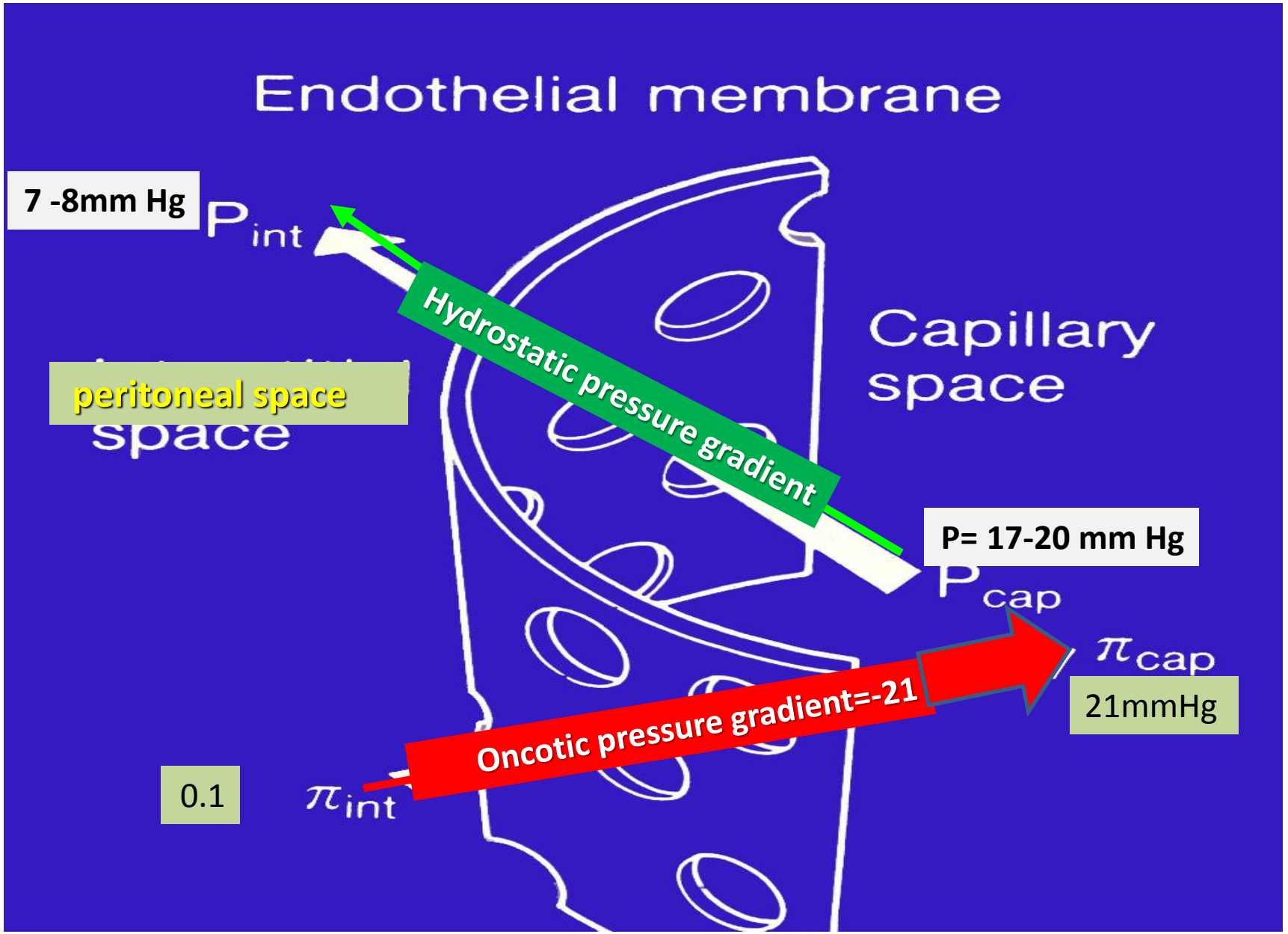
The Normal Peritoneal Membrane



Starling forces in peritoneal capillaries in PD



Starling forces in peritoneal capillaries in PD



Pressure Gradients

	Pressure in peritoneal capillaries	Pressure in the filled peritoneal cavity	Pressure gradient
Hydrostatic pressure (mmHg)	17	8 (recumbent)	9
Colloid osmotic pressure (mmHg)	21	0.1	−21
Osmolarity (mosmol/kg H_2O)	305	347 (1.36% glucose)	
		486 (3.86% glucose)	
Max. crystalloid osmotic pressure gradient (mmHg)		1.36% glucose	(347 − 305) × 0.03 × 19.3 = 2
		3.86% glucose	(486 − 305) × 0.03 × 19.3 = 1
Max. net pressure gradient (mmHg)			12[a] (1.36% glucose)
			93[a] (3.86% glucose)

The reflection coefficient for glucose is 0.03.

[a]These pressure gradients decrease during the dwell due to glucose absorption (61% per 4 h on avera

Composition of standard peritoneal dialysis solution

Na	**132 mmol/l**	
Ca	**1,25mmol/l**	
Mg	**0,5 mmol/l**	
Cl	**100 mmol/l**	
lactate	**35 mmol/l**	**ev. lactate/bicarbonate**
glucose	**1,36-4,25 g/dl**	
osmolarity	**347-486**	
pH	**5,2**	

GDP (degradation products of glucose)

Ramesh Khanna & Karl D. Nolph

Physiology of Ultrafiltration: Crystalloid Osmosis

- Normal serum osmolarity = 270 mOsm/L[1]

Dextrose Dialysate	mOsm/L
1.36%	345
2.27%	395
3.86%	484

Daugirdas et al: Handbook of Dialysis, Third Edition, p 299, 2000

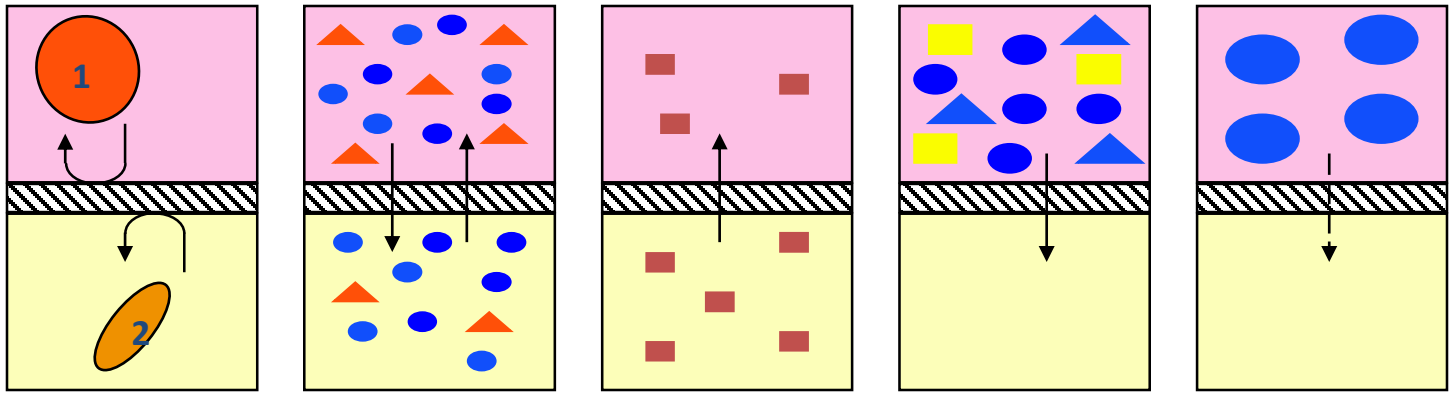
Pressure Gradients Across the Peritoneal Membrane During Peritoneal Dialysis

	Pressure in peritoneal capillaries	Pressure in dialysate-filled peritoneal cavity	Pressure gradient
Hydrostatic pressure (mmHg)	17	8 Recumbent	9
Colloid osmotic pressure (mmHg)	21	0.1	-21
Osmolality (mOsm/kg H_2O)	305	347 (Glucose 1.36%)	
		486 (Glucose 3.86%)	
Maximal crystalloid osmotic pressure gradient (mmHg)		Glucose 1.36%	(347-305)x0.03x19.3=24
		Glucose 3.86%	(486-305)x0.03x19.3=105
Net maximal pressure gradient (mmHg)		Glucose 1.36%	12
		Glucose 3.86%	93

The reflection coefficient of low molecular weight solutes is set at 0.03.

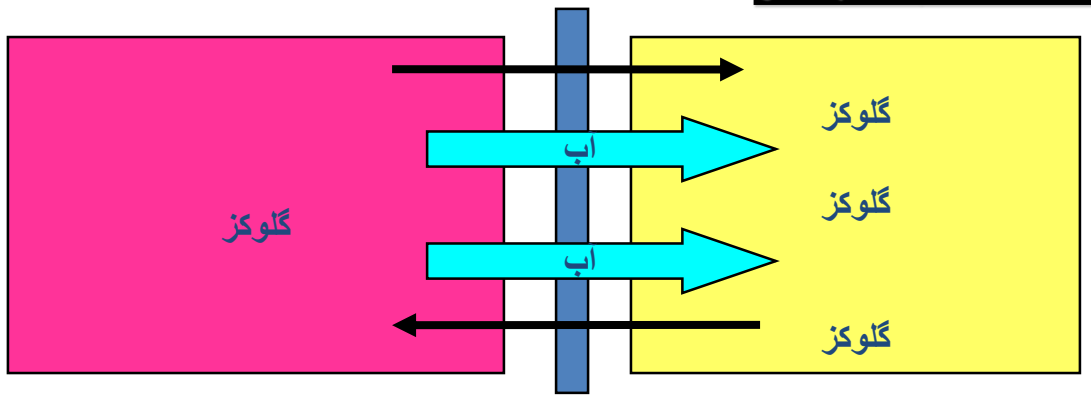
کلیرانس مواد و کلیرانس آب

با حرکت مواد از محیط با غلظت بیشتر به محیط با غلظت کمتر



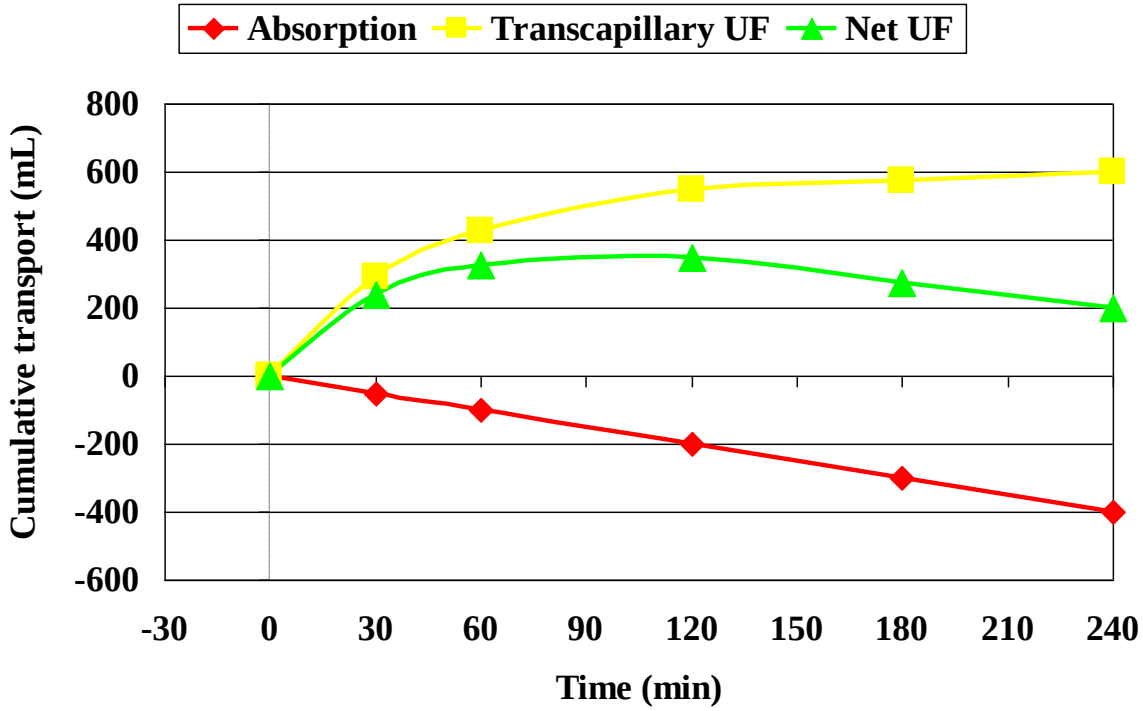
کلیرانس
با
انتشار

با حرکت مایعات از محیط با غلظت کمتر به جای غلیظ تر



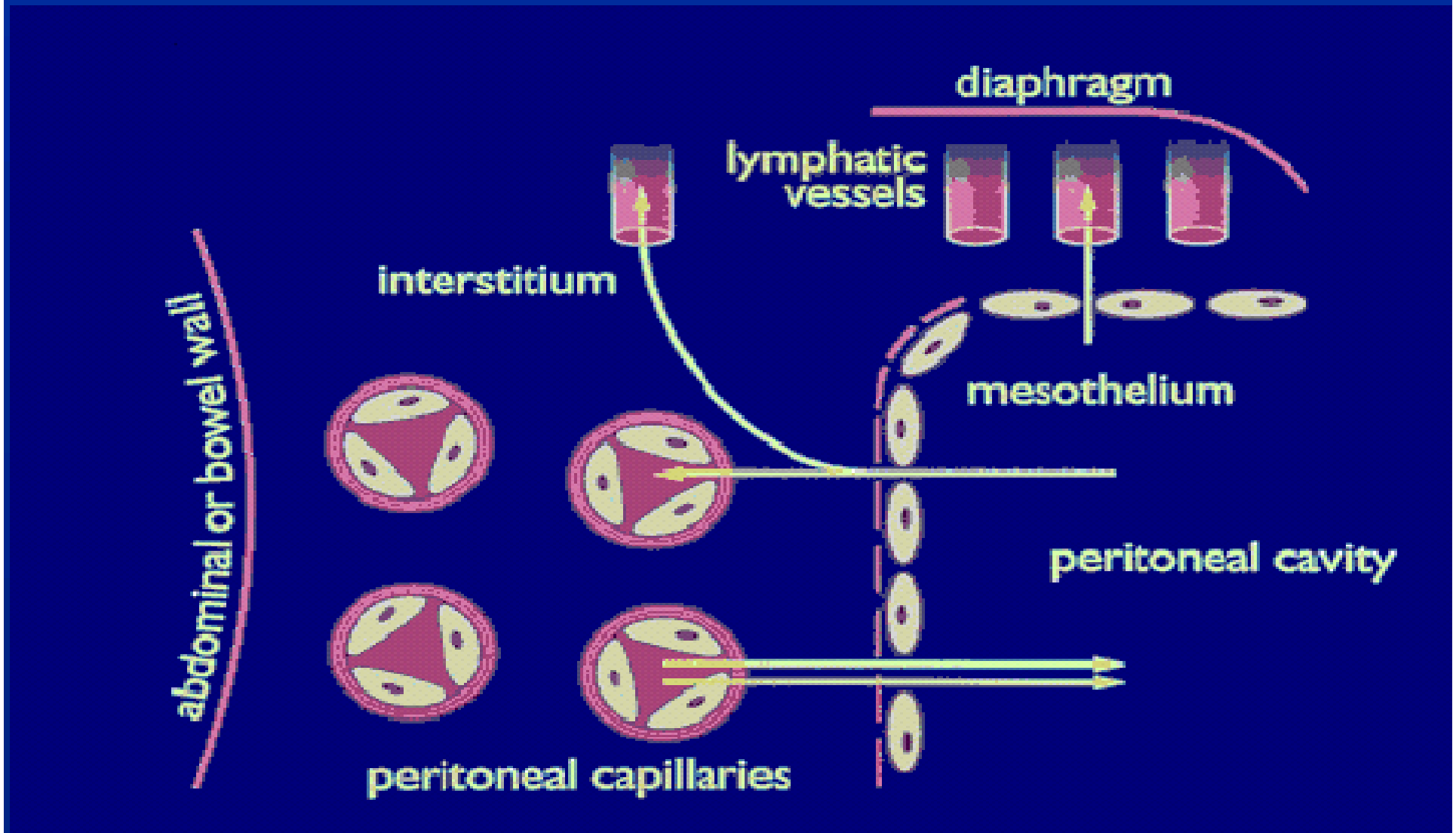
دفع مایعات
با
اسمز و فشار هیدروستاتیك

Physiology of Ultrafiltration: Net Ultrafiltration

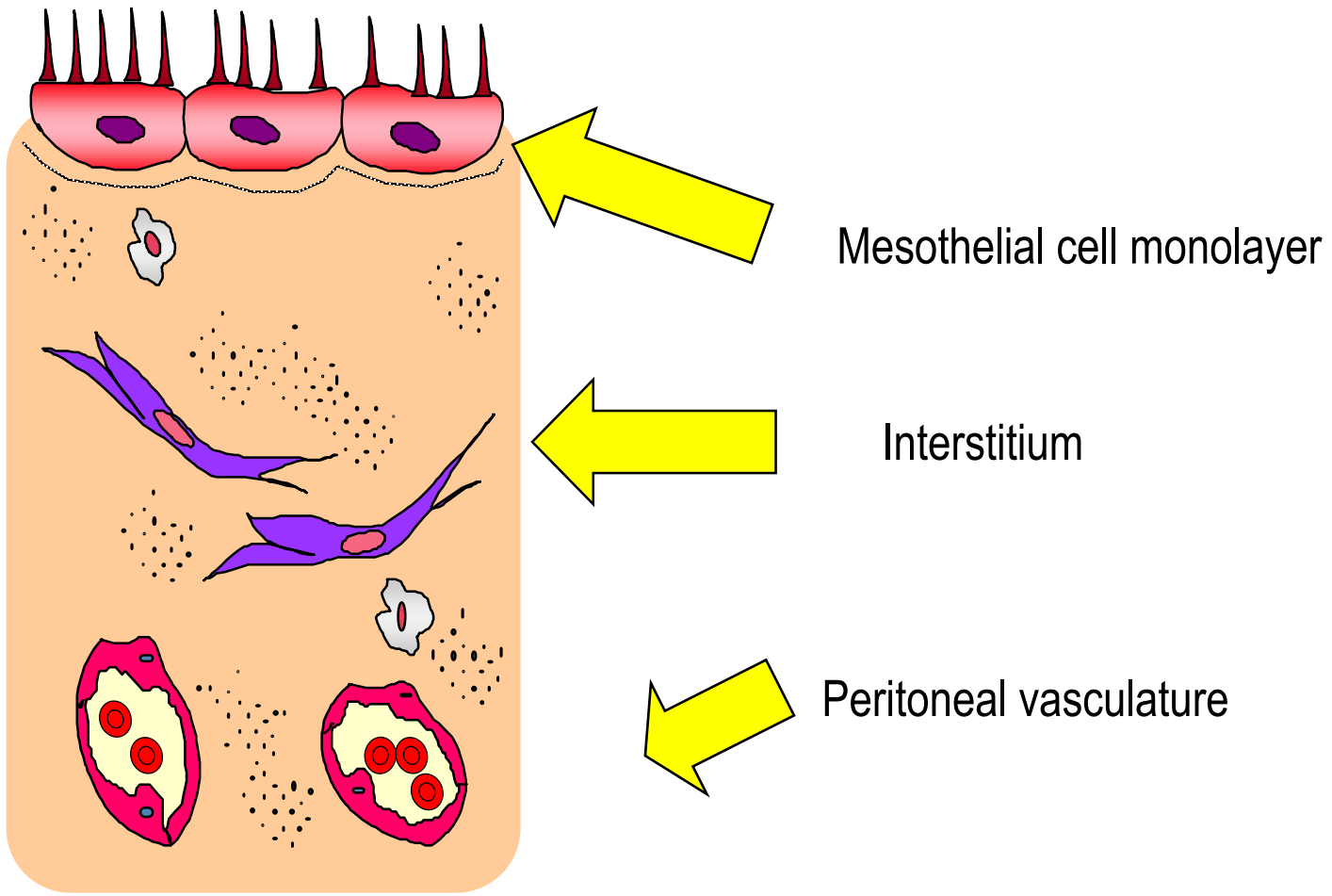


Mactier RA, et al. *J Clin Invest.* 1987;80:1311-1316.

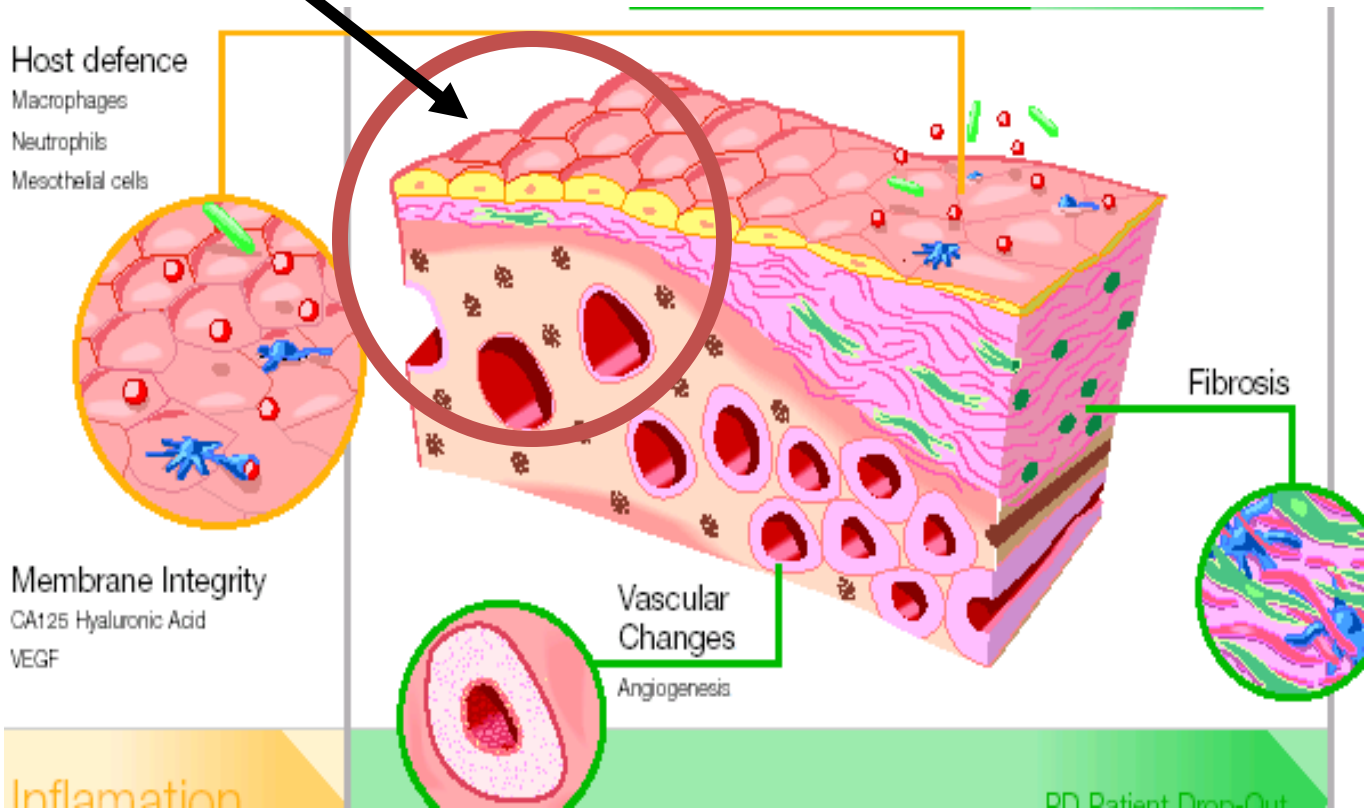
Physiology of Ultrafiltration: Structure of the Peritoneal Membrane



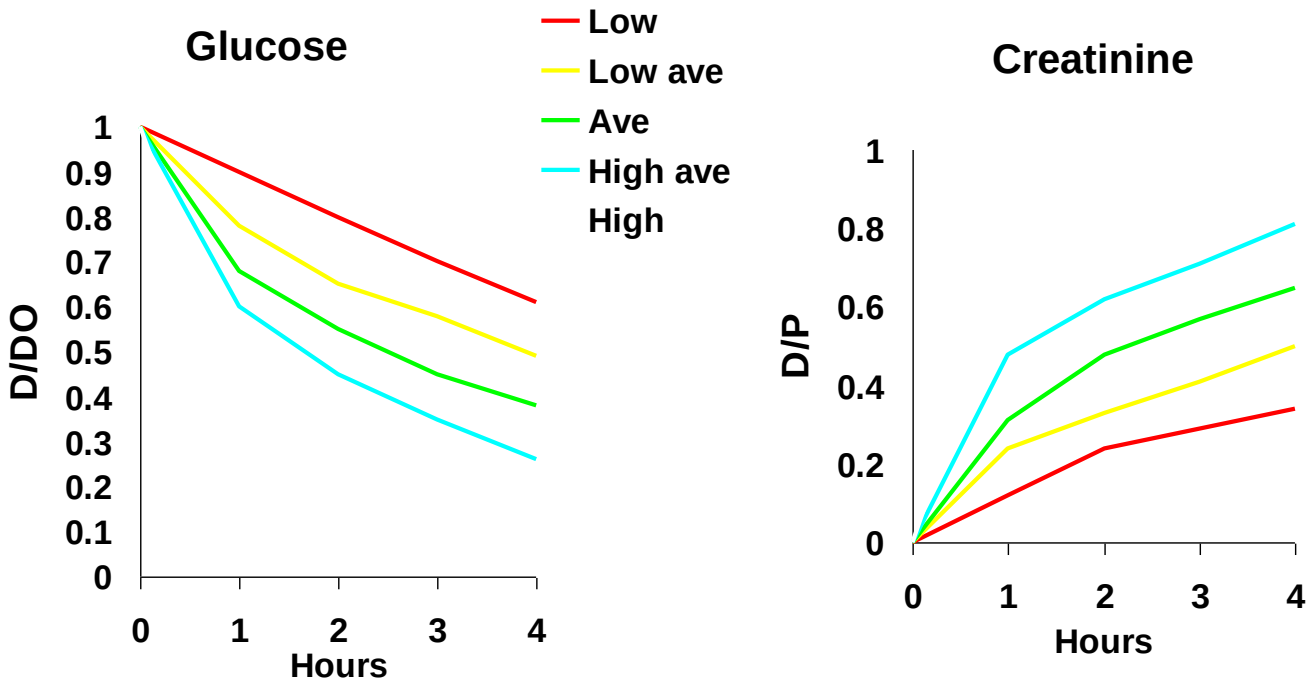
The Normal Peritoneal Membrane



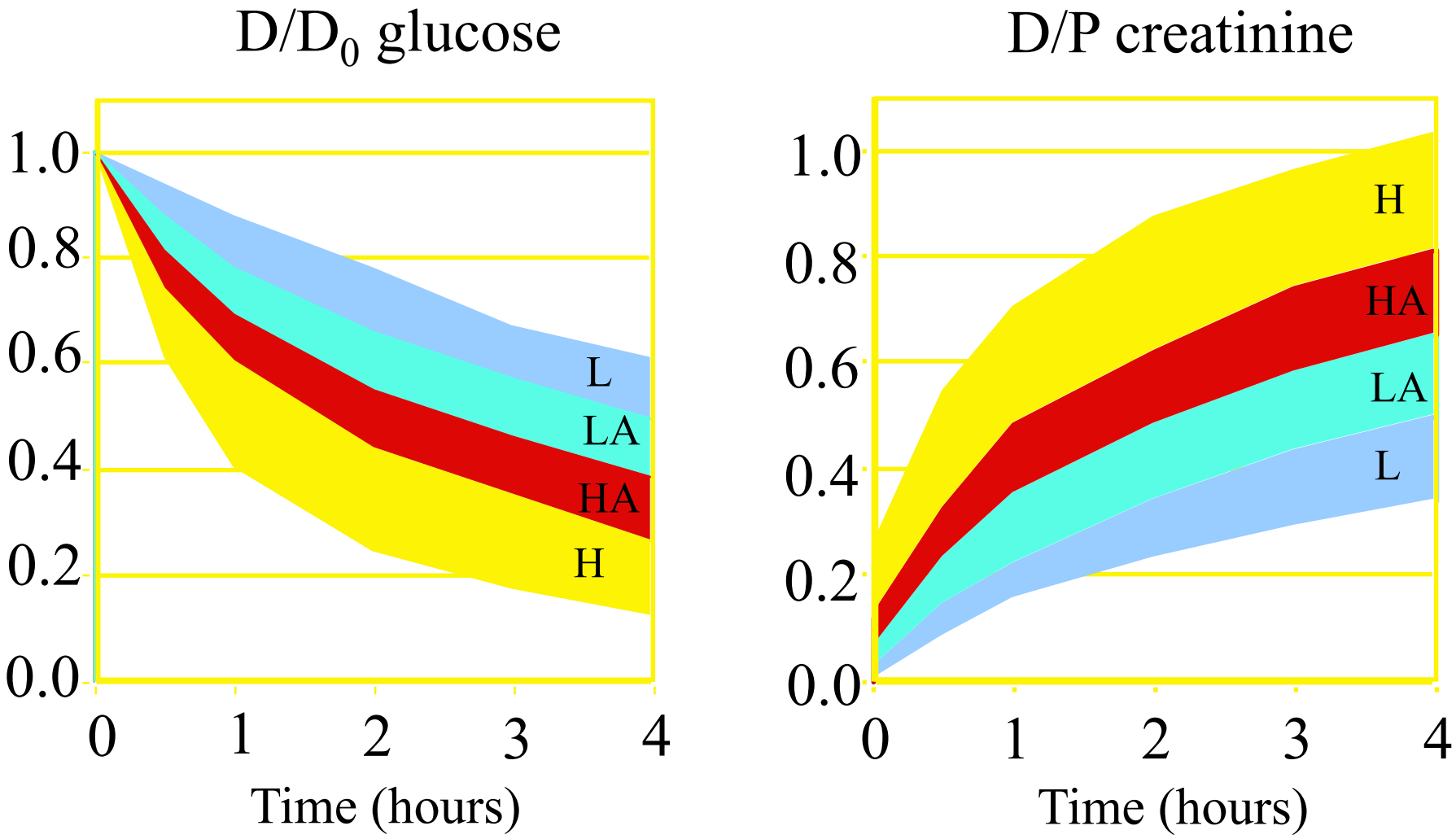
The Normal Peritoneal Membrane



Peritoneal Equilibration Test

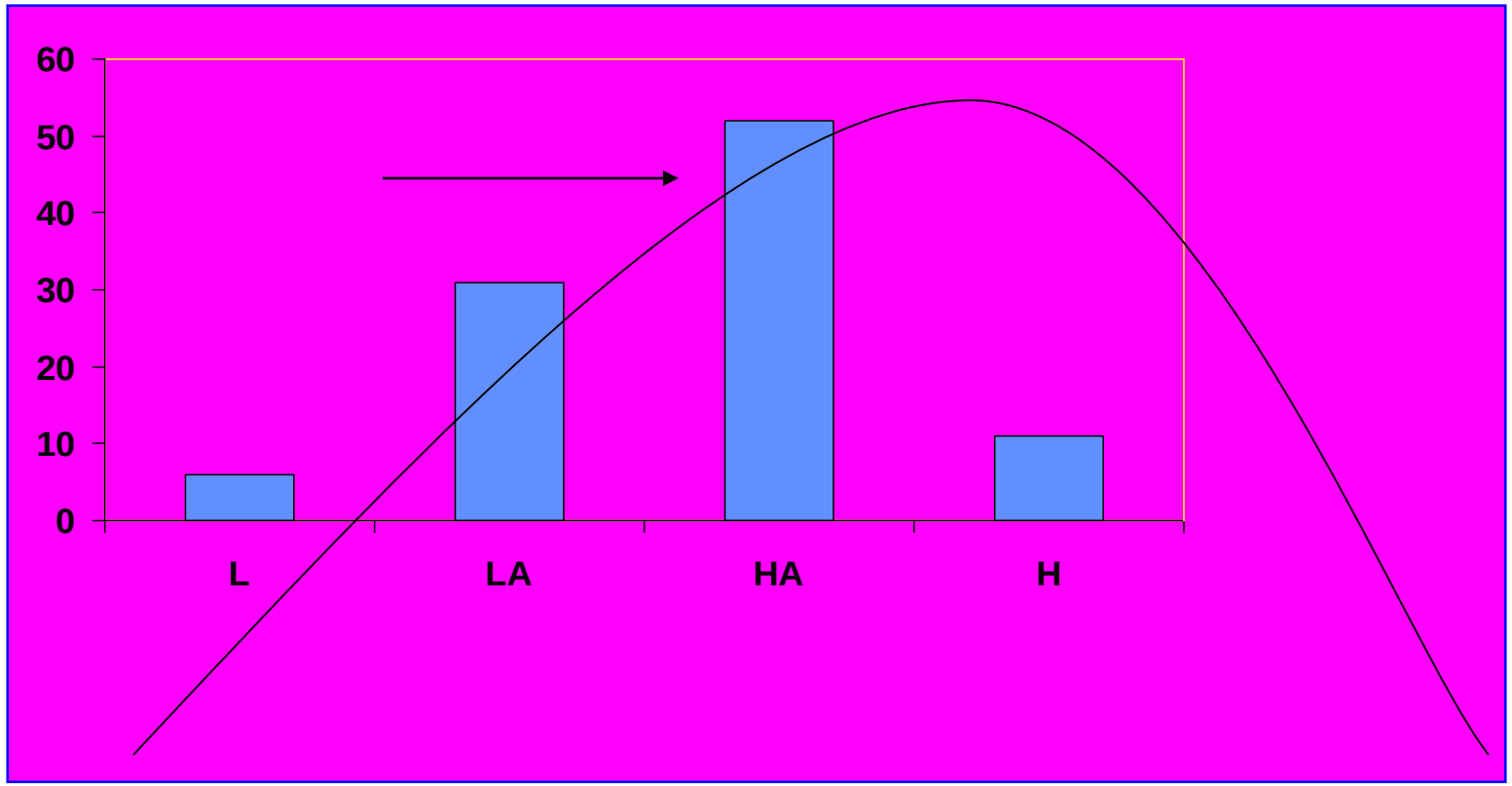


PET



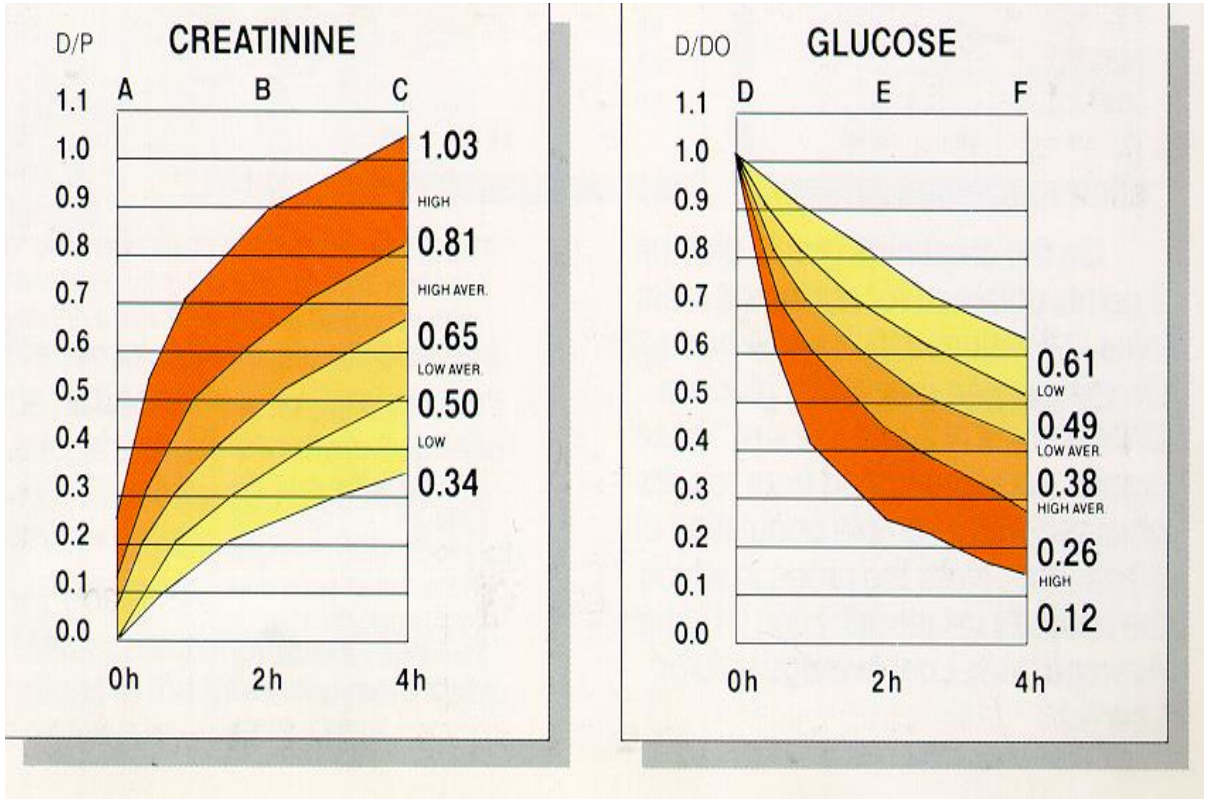
[Twardowski et al: PDI 7: 138-147, 1987]

Membrane transport type.



Peritoneal Equilibration Test

- Fast transporters
- Average transporters
- Slow transporters



High & Low Vs Fast & Slow

Appendix 4: the concept of fast, average and slow transport status

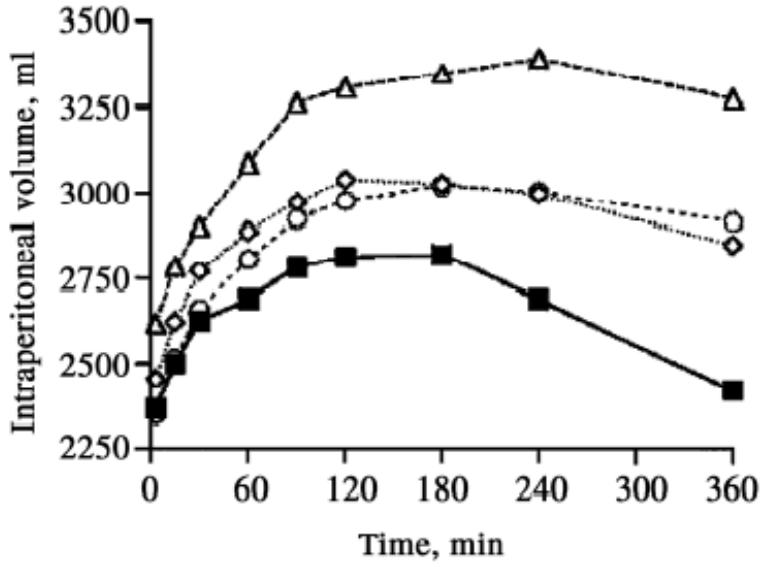


Fig. 1. Intraperitoneal dialysate volume vs dwell time. ■, high transport group (n=7) ◇, high-average transport group (n=20); ○, low-average transport (n=13); △, low transport group (n=6).

Nephrol Dial Transpalnt (2010): Editorial Comments

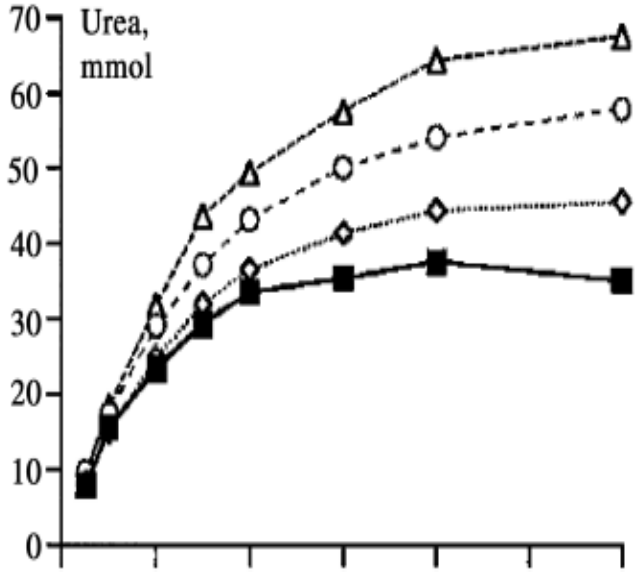
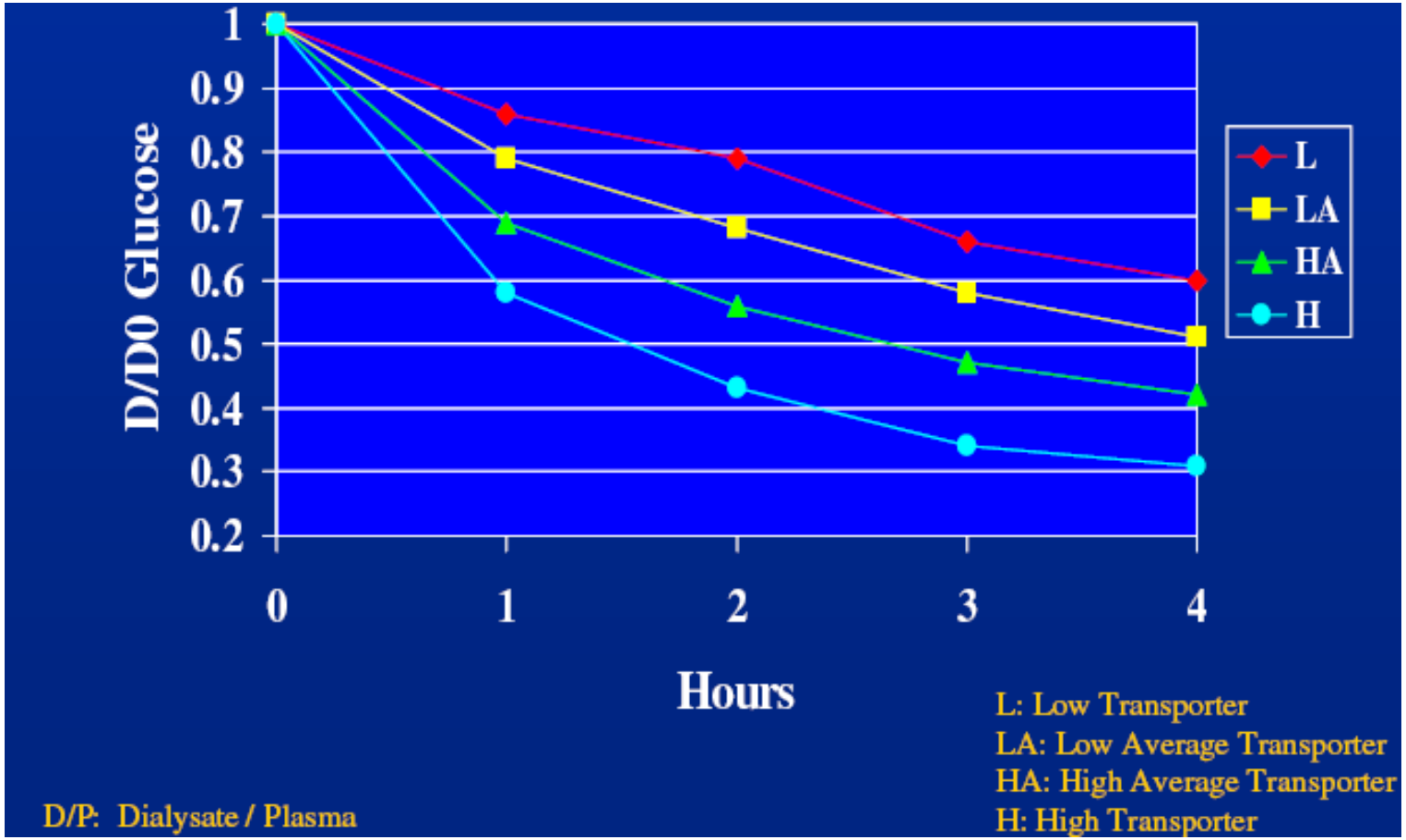


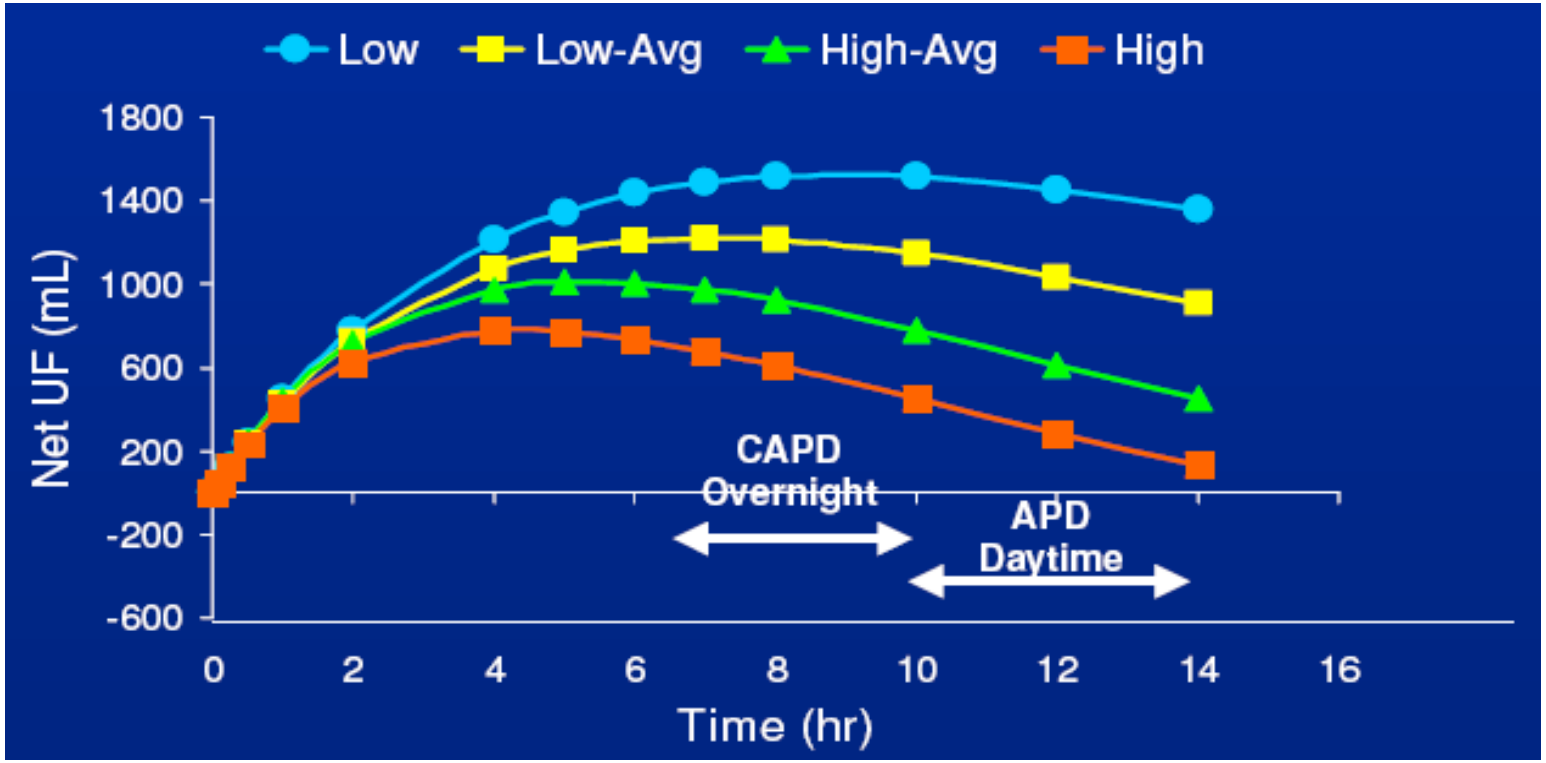
Fig. 2.

Solute clearance = volume x D/P

Physiology of Ultrafiltration:
Glucose Kinetics by Transport Status

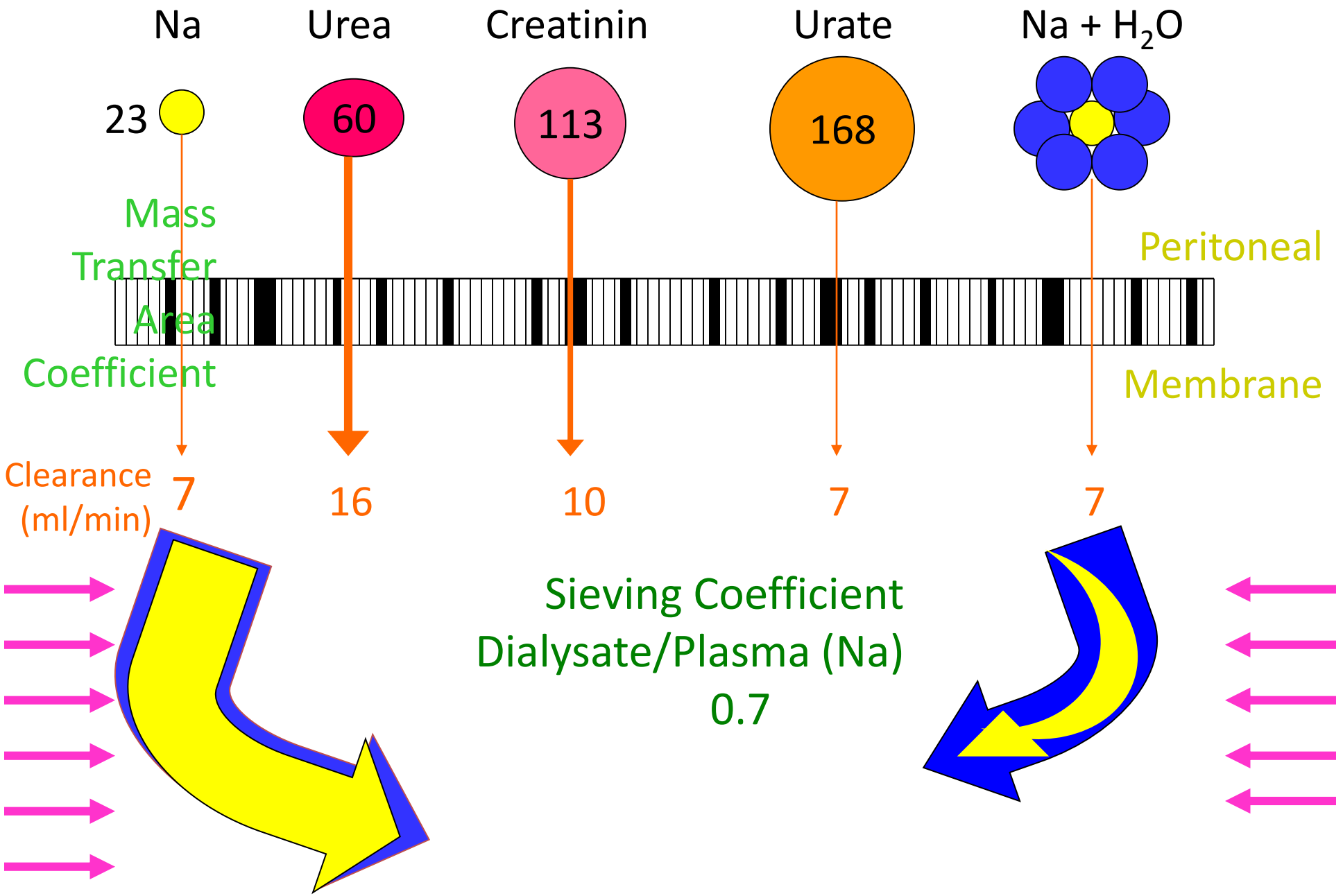


Physiology of Ultrafiltration:
Net Ultrafiltration: 3.86% Dextrose Dialysate

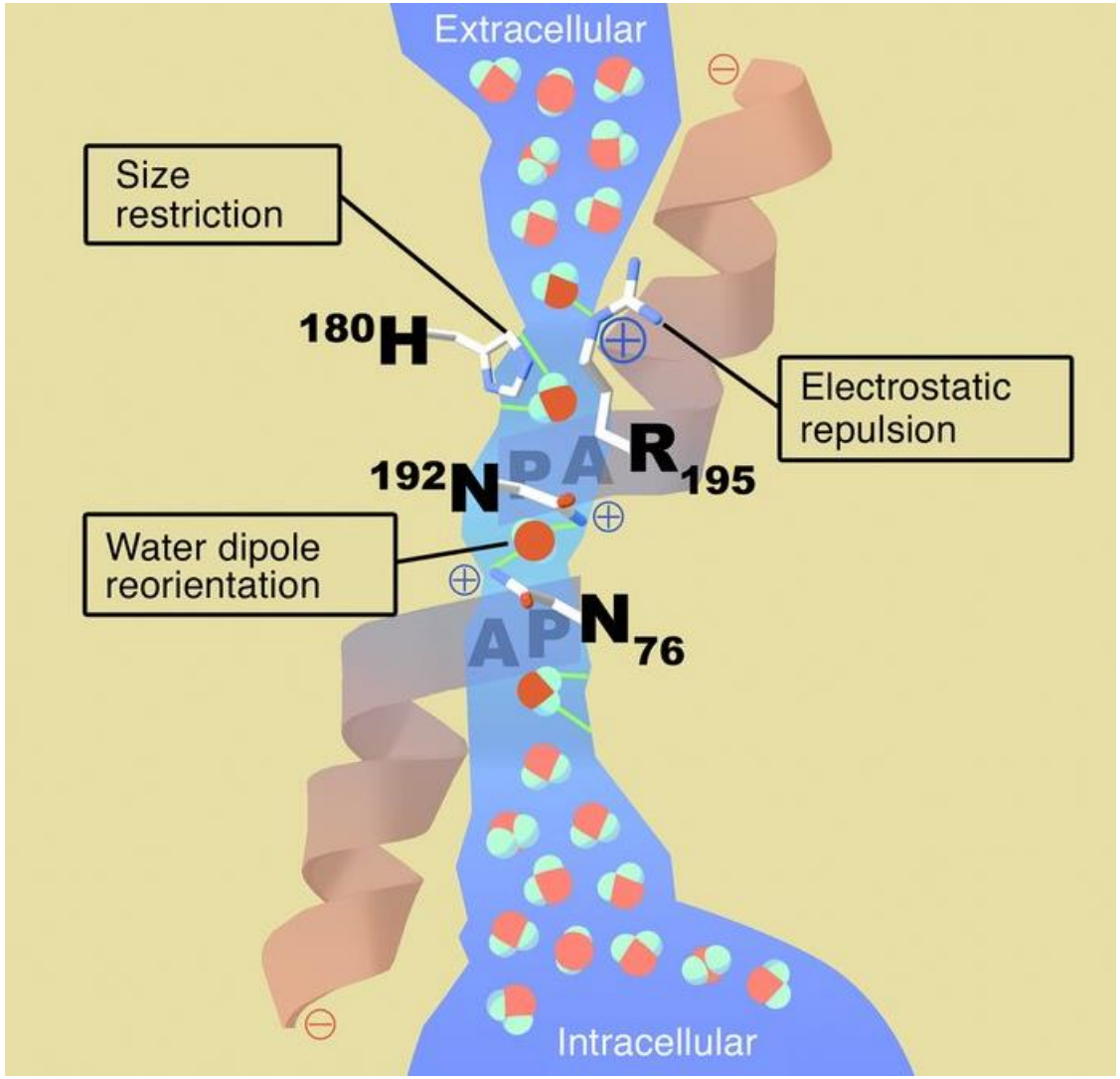


Mujais S, Vonesh E. *Kidney Int*. 2002;62 (suppl 81):S17-S22.

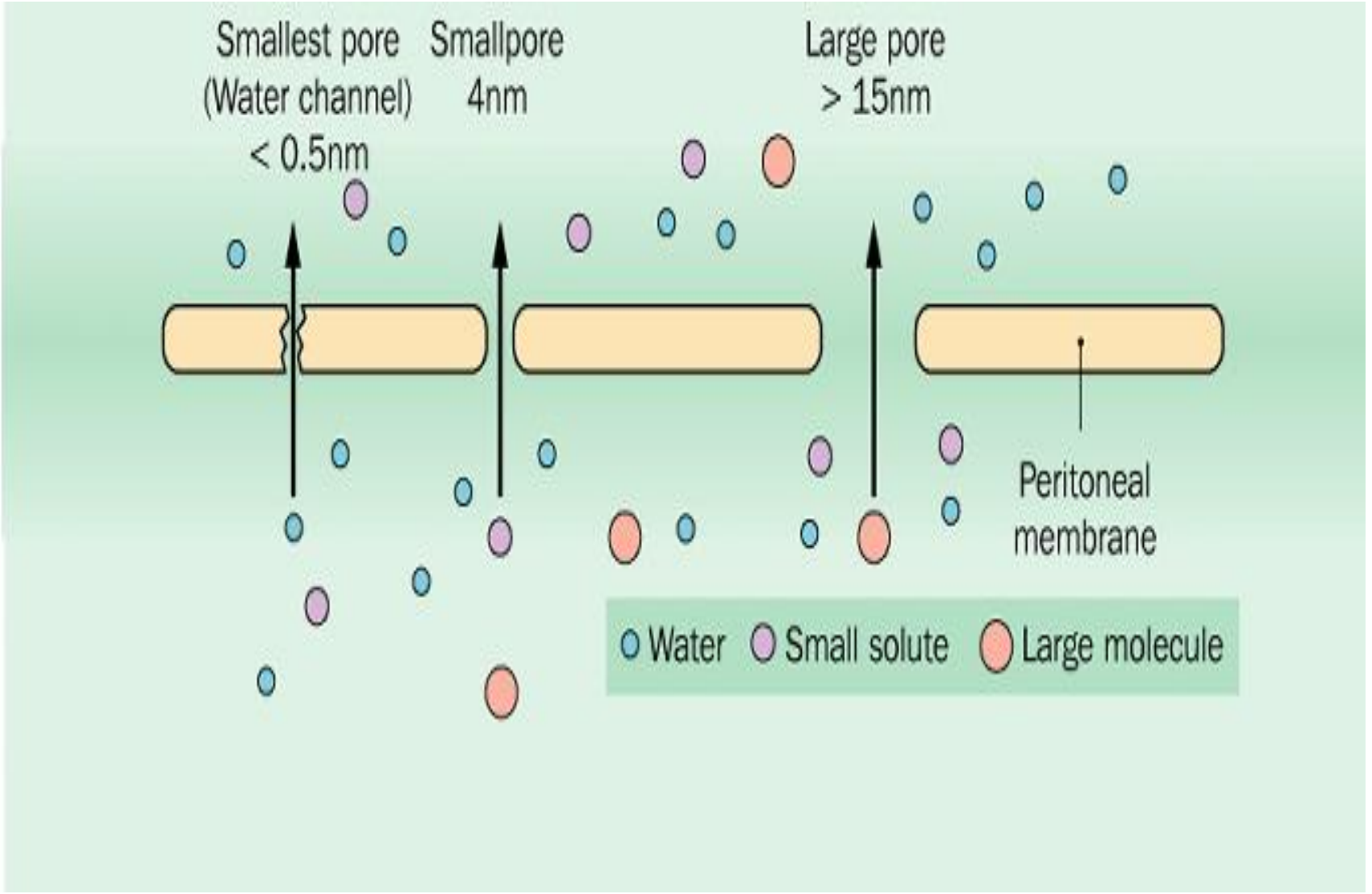
Na Balance in APD



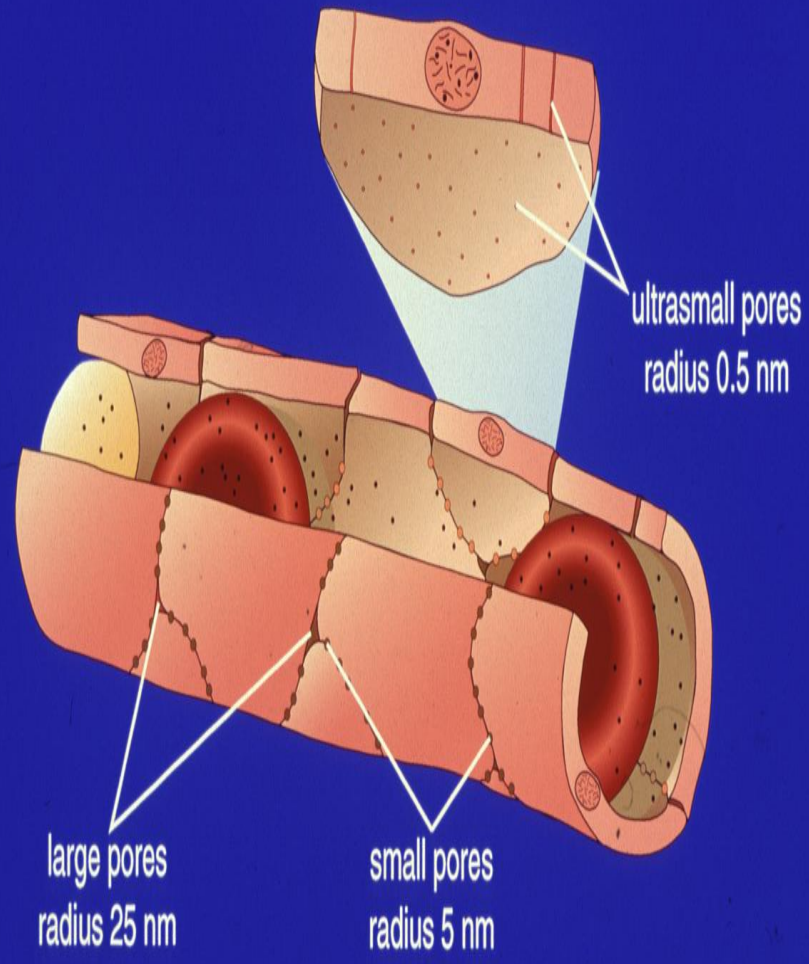
Aquaporin-1


Extracellular
Size restriction
180H
Electrostatic repulsion
192N
R195
Water dipole reorientation
N76
Intracellular

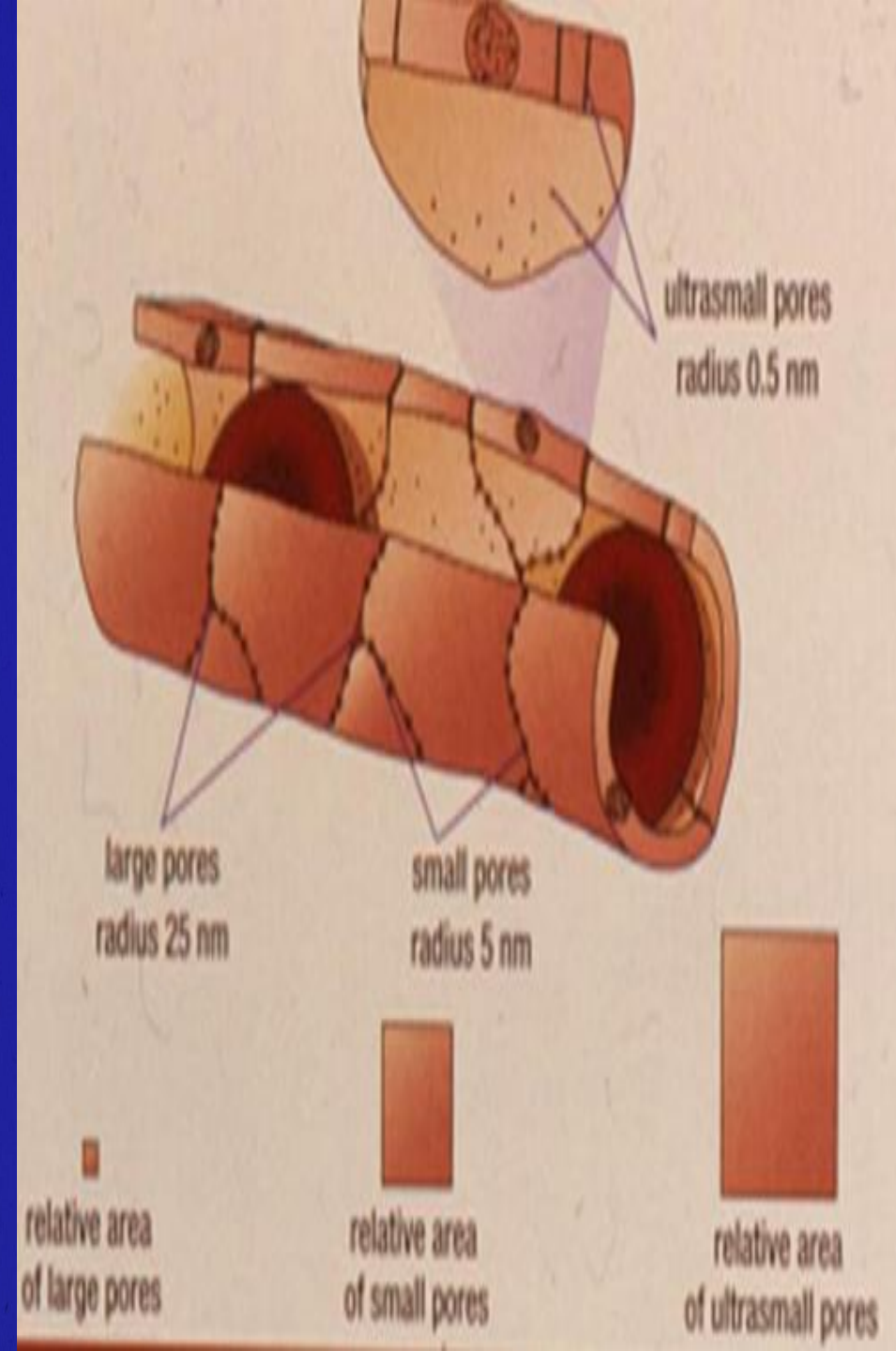
Model of transport - 3 sorts of pores



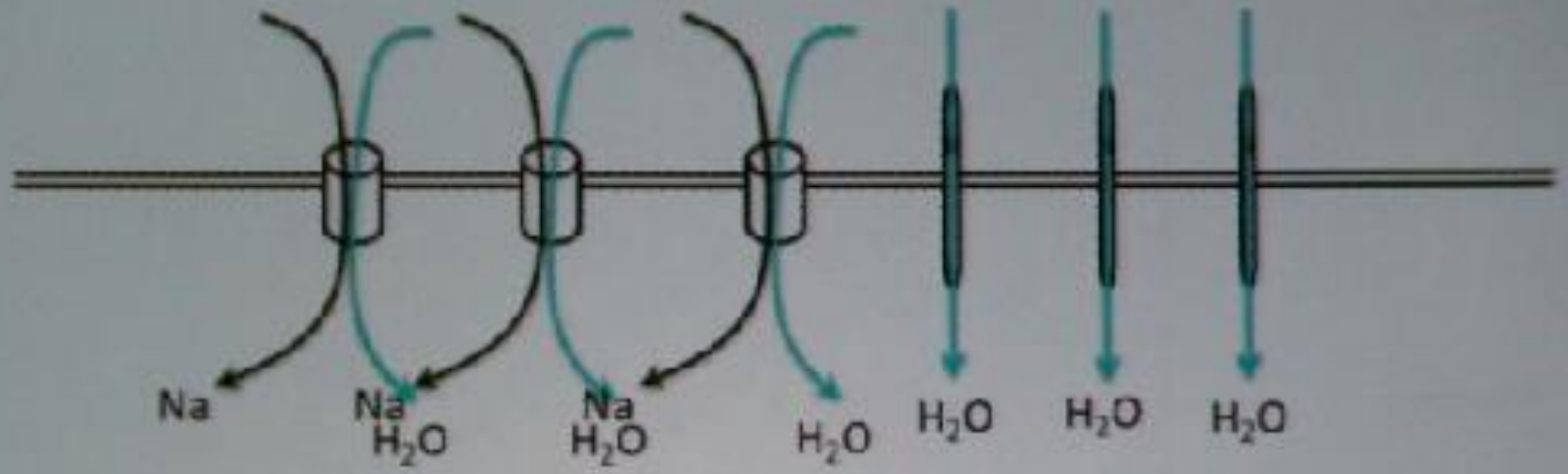
The three pores



Gambro PD/PDC:7

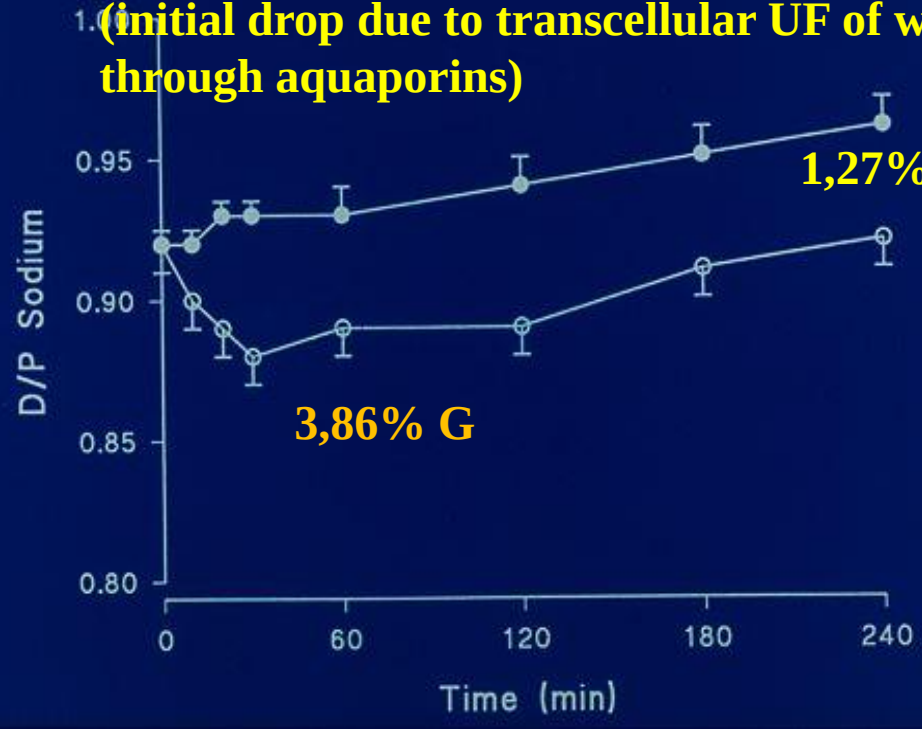


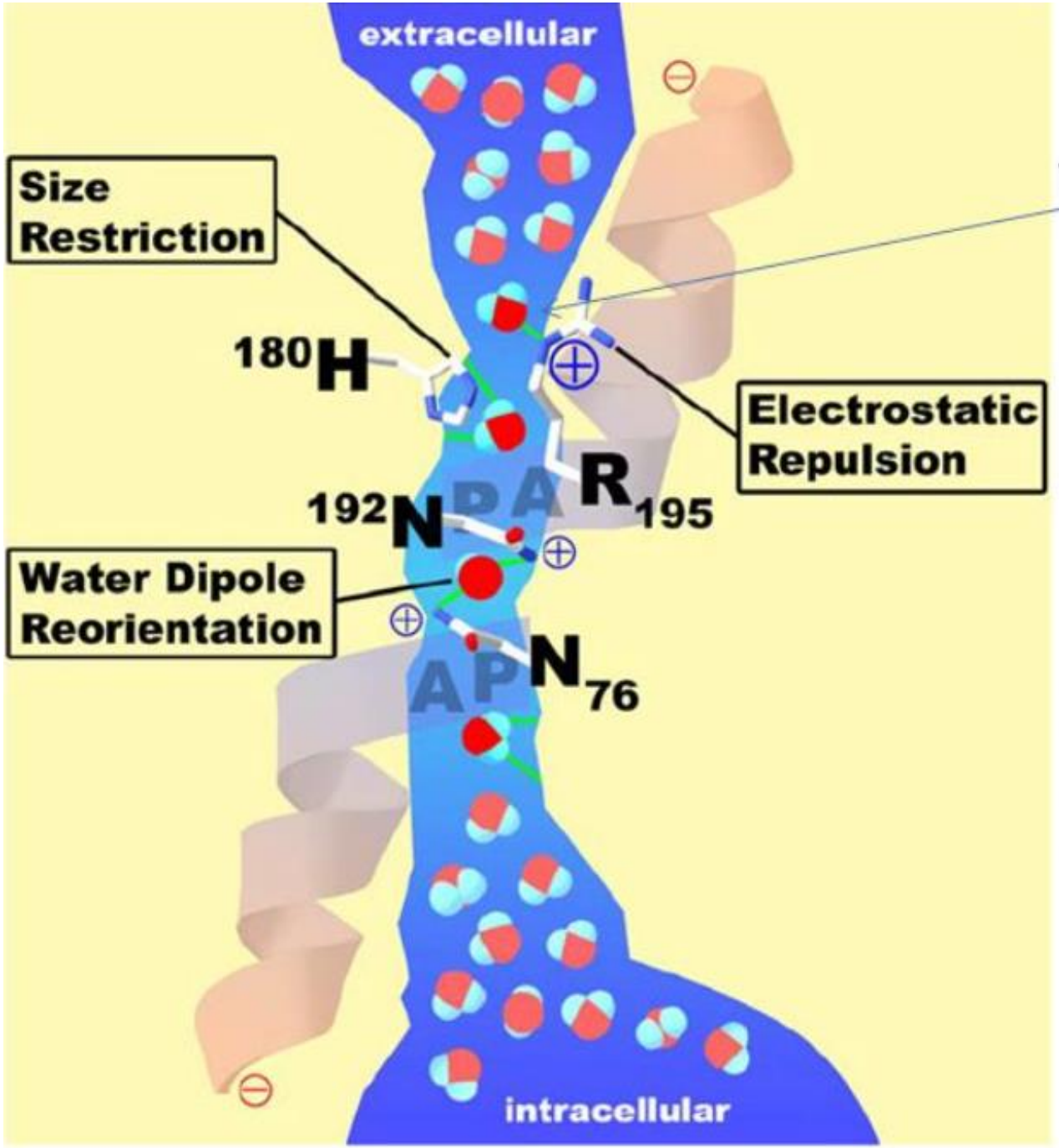
Na Seiving



- Initially, more H_20 can cross through Aquaporin
- Dilution effect causes drop in Na concentration
- Diffusion of Na to equilibrate Na concentration

(initial drop due to transcellular UF of water through aquaporins)





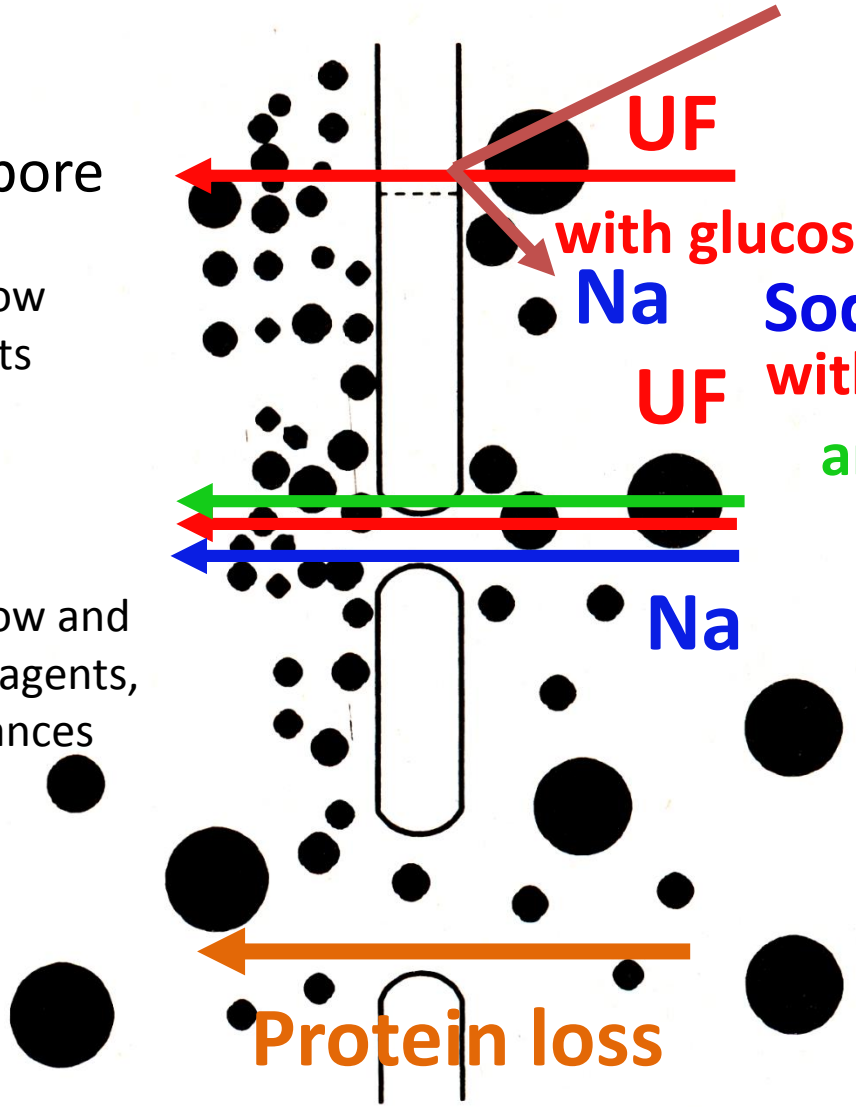
water transits the pore in single file

Figure 3. Functional schematic for water passage through AQP1. The extracellular vestibule and the intracellular vestibule of the channel contain water in bulk solution. They are connected by a 20-Å span where water molecules pass in single file. Barriers to the passage of protons are visible. Arginine-195 (R195) and histidine-180 (H180) provide fixed positive charges to repel proton passage. A single water molecule forms hydrogen bonds with the side chains of highly conserved asparagines-76 and -192 (N76 and N192). Partial positive charges are provided by the orientation of the two α helices that enter but do not entirely span the bilayer. Reprinted by permission from Kozono D, Yasui M, King LS, Agre P. Aquaporin water channels: atomic structure molecular dynamics meet clinical medicine. *J Clin Invest* 2002;109:1395–1399.

Transcellular pore
r < 0.8 nm
Osmotic UF with low MW osmotic agents

Small pore
r = 4-6 nm
Osmotic UF with low and high MW osmotic agents,
Small solute clearances

Large pore
r > 20 nm
Protein loss



Π dominates
Sodium sieving
with glucose
and icodextrin

P dominates

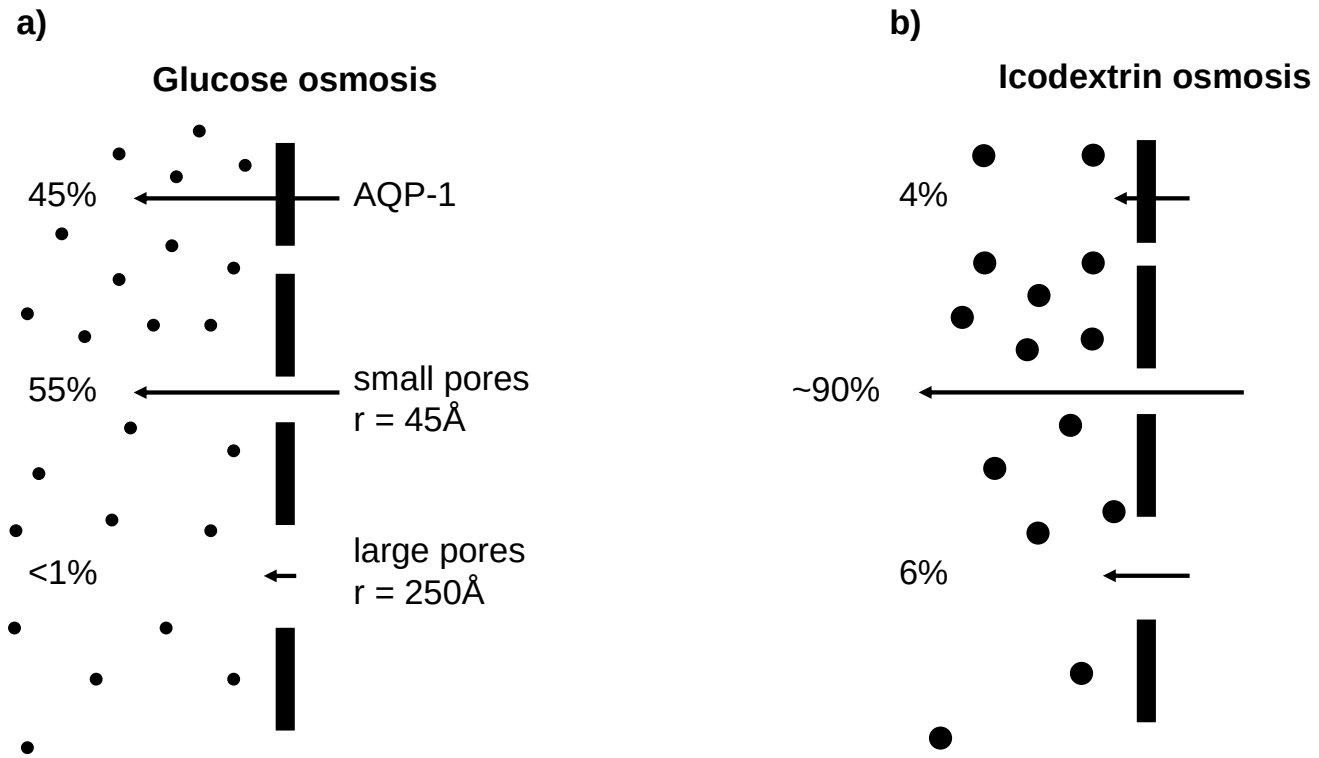
ENDOTHELIUM

Ultrasmall VS Small Channel

- The resistance in the aquaporins is much higher than in the small pores due to the difference between the two in radius.
- Water channels require very high osmotic pressure gradients
- The crystalloid osmotic pressure gradient across the water channels is:

- ***(347 – 305) × 19.3 = 811 mmHg for a 1.5% glucose solution***
- ***(486 – 305) × 19.3 = 3493 mmHg for a 4.25% glucose solution***

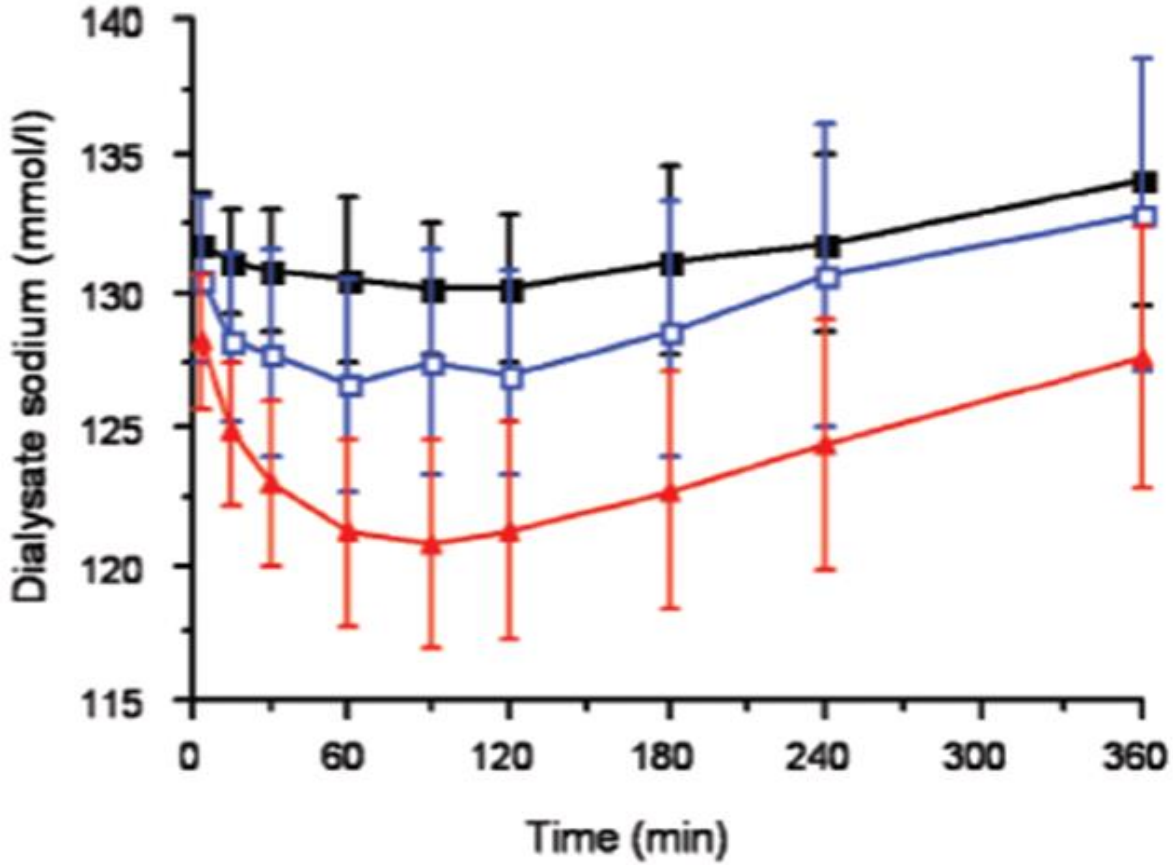
Partitioning of fluid flows in the TPM for glucose osmosis *vs.* ICO osmosis



Assessement of peritoneal function

1. PET- peritoneal equilibration test (type of transport and ultrafiltration after 4 hours)
2. weekly clearance of creatinine and urea
3. daily UF
4. dicrease of Na in dialysis fluid after 60 minutes using 3,8% G (test of aquaporines)

Na Dip



Black: 1.36%; blue: 2.27%; red: 3.86% glucose solution

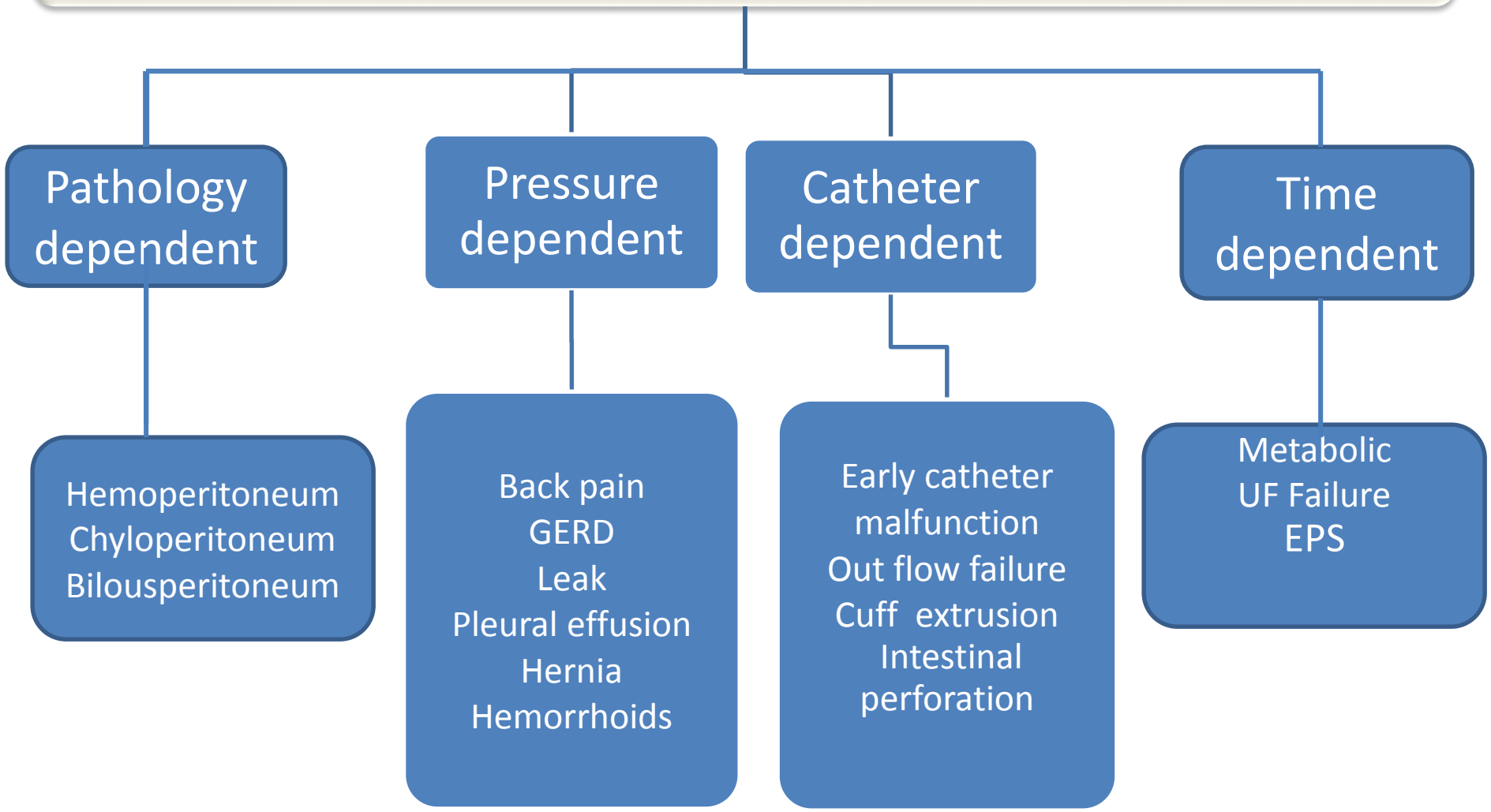
Peritoneal Dialysis Complications

Non-Infectious

Iraj Najafi MD.

22 . 4 . 1402

Non-Infectious complications



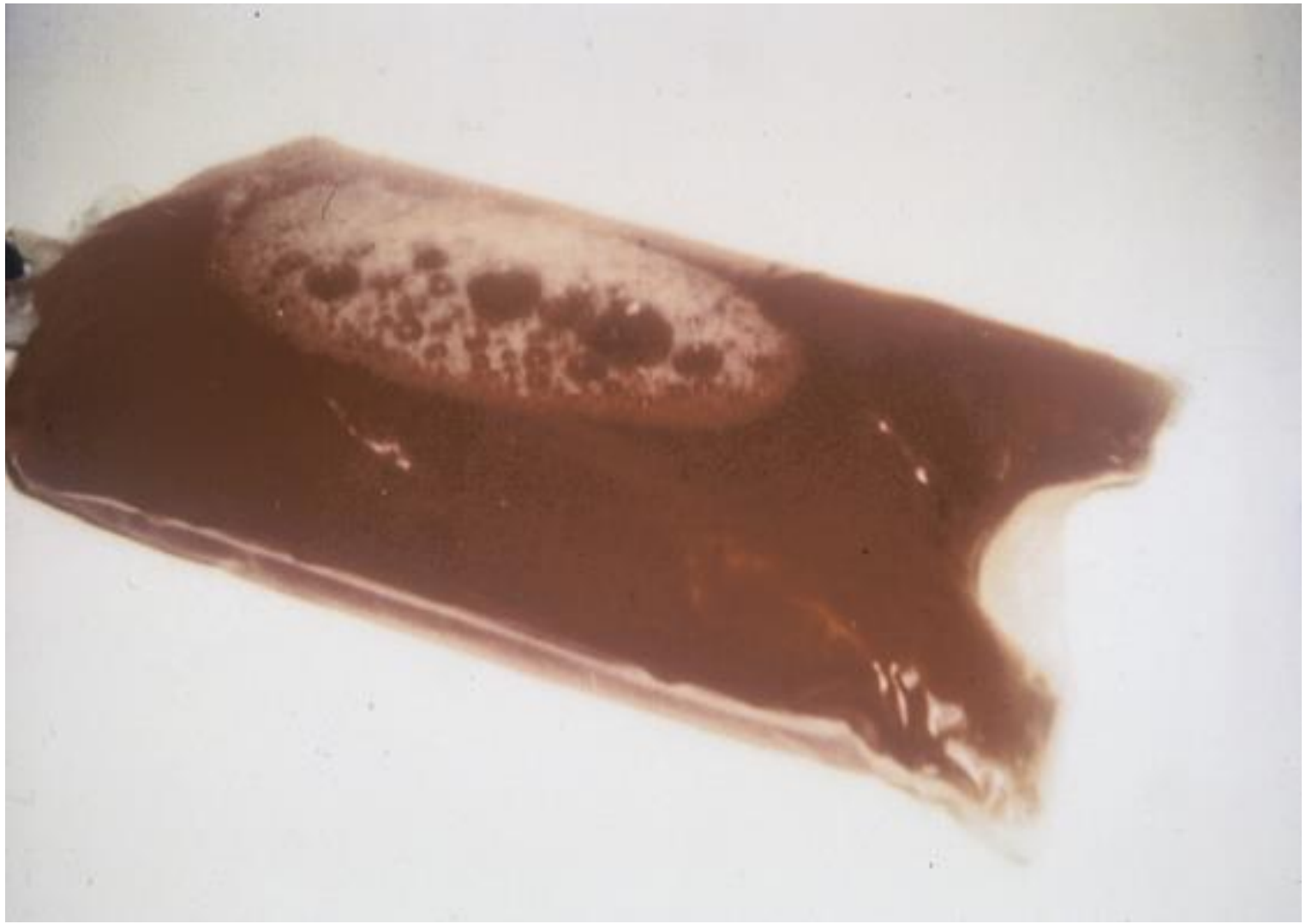
Causes of abdominal pain in PD except peritonitis

- Ischemic bowel
- Pancreatitis
- Cholecystitis
- Pyelonephritis
- Nephrolithiasis
- Constipation
- Incarcerated hernia
- Appendicitis
- Diverticulitis
- Ruptured viscous

Different colors : Different etiologies

Bloody Drainage

"Benign" and "Serious"



Bloody Drainage

Benign Causes:

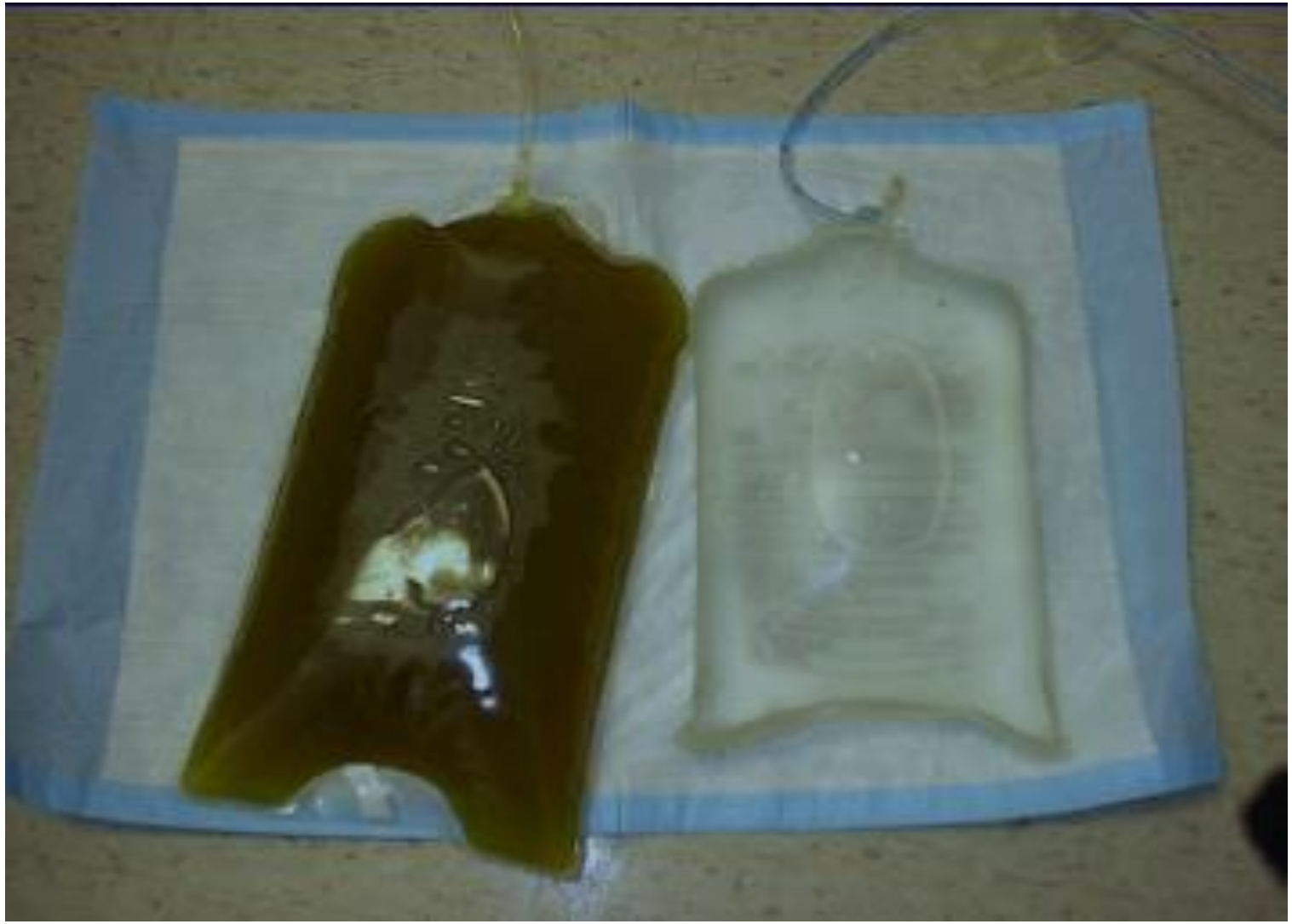
- menstruation
- ovulation
- trauma
- coagulopathy
- ruptured renal or ovarian cysts

Serious Causes:

- ischemic bowel
- colon cancer
- pancreatitis
- urologic cancer
- encapsulating peritoneal sclerosis

Bilious Drainage

Can rarely be seen after laparoscopic cholecystectomy



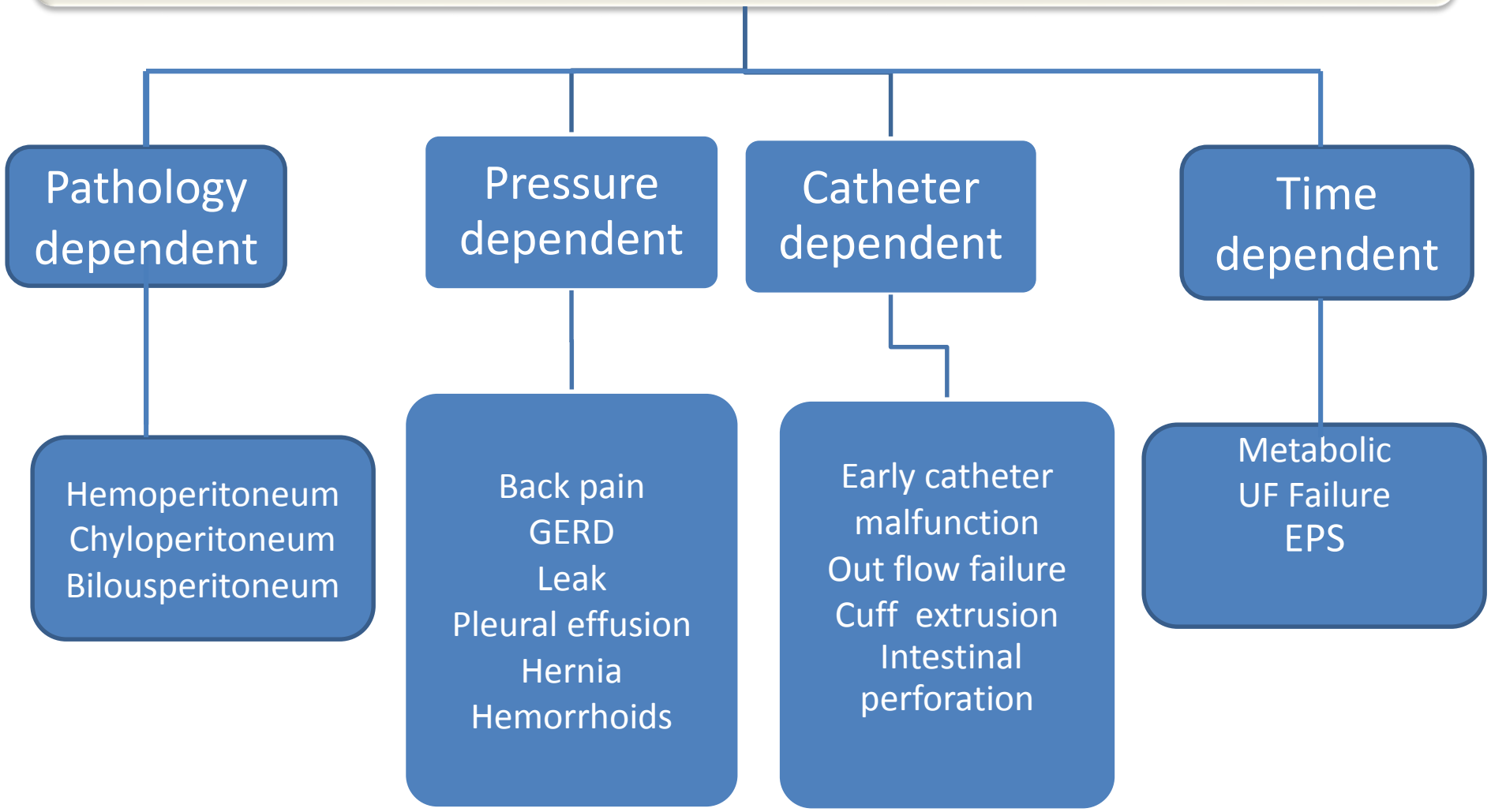
Chylous Drainage

Effluent cell count is normal but triglycerides are high

Chylous Drainage

- Patients should be investigated for underlying intra-abdominal pathology
- Can rarely be seen in lymphoma and tuberculosis
- Comes and goes depending on dietary fat intake
- **Treatment** should include diet of small and medium chain fatty acids

Non-Infectious complications



Catheter related problems

1. Catheter Malfunction
   - Catheter malposition
   - Omental wrap
   - Blood clot
2. Kink
3. Hematoma
4. Leak
5. Hernia
6. Exit site malposition
7. Catheter Extrusion
8. Short & malshape tunnel
9. Cuff Extrusion
10. Exit site infection
11. Tunnel infection

Prevention of early catheter malfunction

- Appropriate catheter
- Optimal surgical technique
- Good postoperative care
- Nephrologist & Surgeon or radiologist communication

Prevention of early catheter malfunction

- Swan neck catheter with appropriate length
- Laparoscopic insertion technique
- Liberal use of laxatives
- No way for insertion of catheter by unsupervised trainees

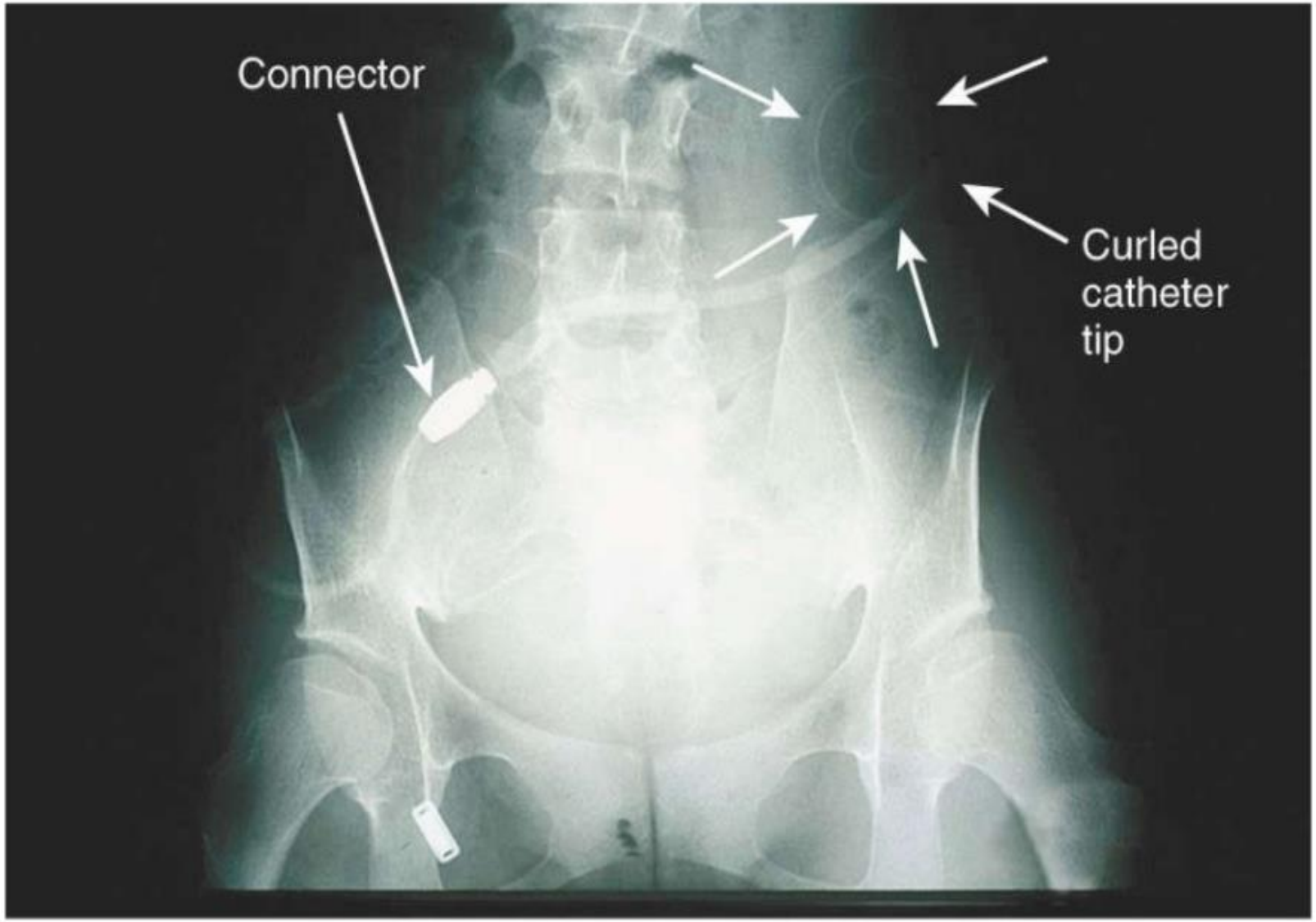
To achieve good long-term results, implantation must be performed by a

competent and experienced catheter insertion team

Outflow failure

- **Incidence: 5-20%**
- **Causes:**
- Constipation (anytime)
- Catheter malposition (days)
- Intraluminal catheter occlusion by thrombus
- Extraluminal catheter occlusion by omentum or adhesions (weeks)
- Kinking (soon after placement, positional)
- Loss of dialysate from peritoneal cavity

Malposition of the catheter



Treatment of outflow failure

Depends upon the cause of obstruction

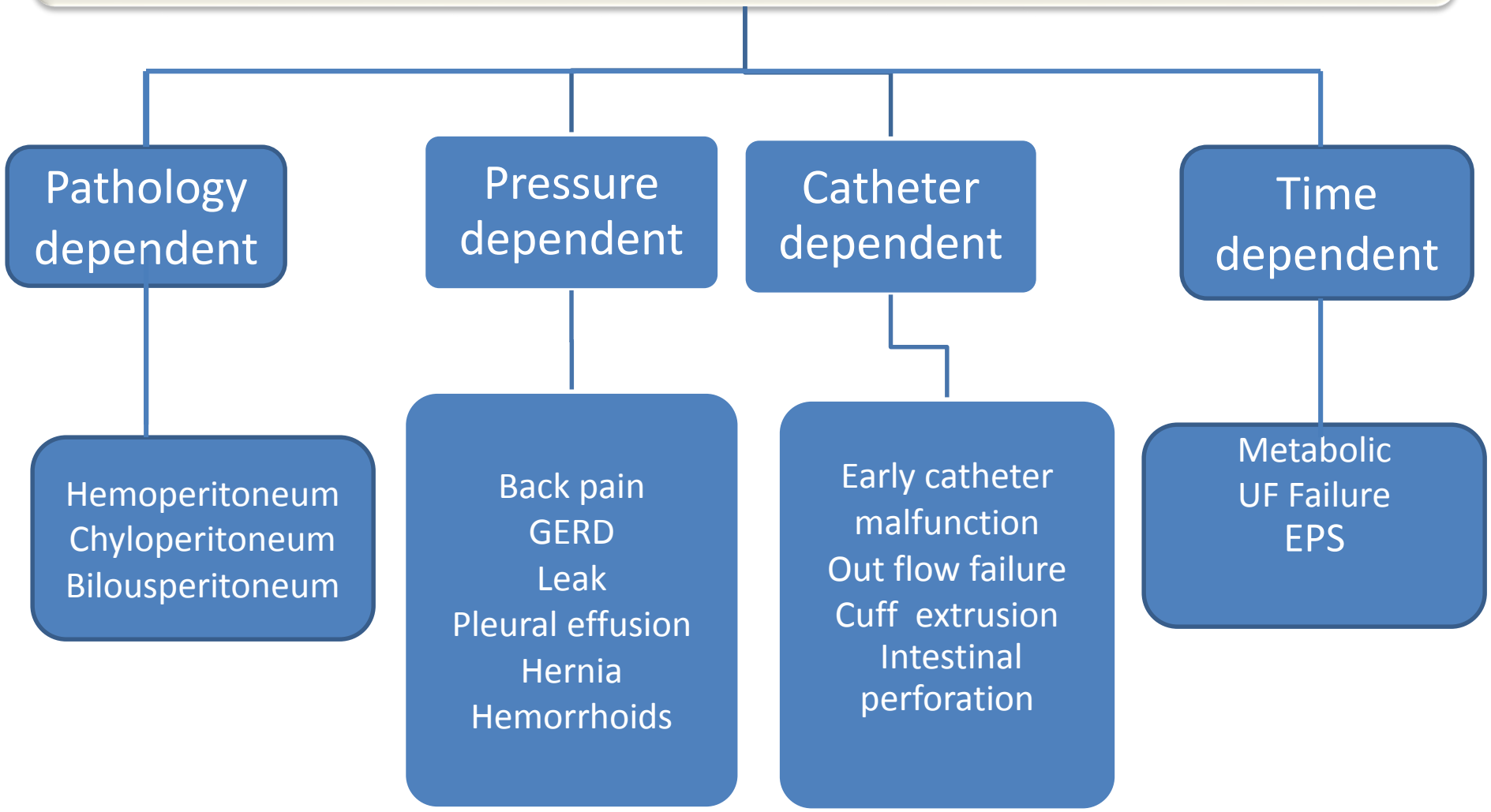
- **Conservative**

- **Surgical intervention and/or catheter replacement**

Treatment

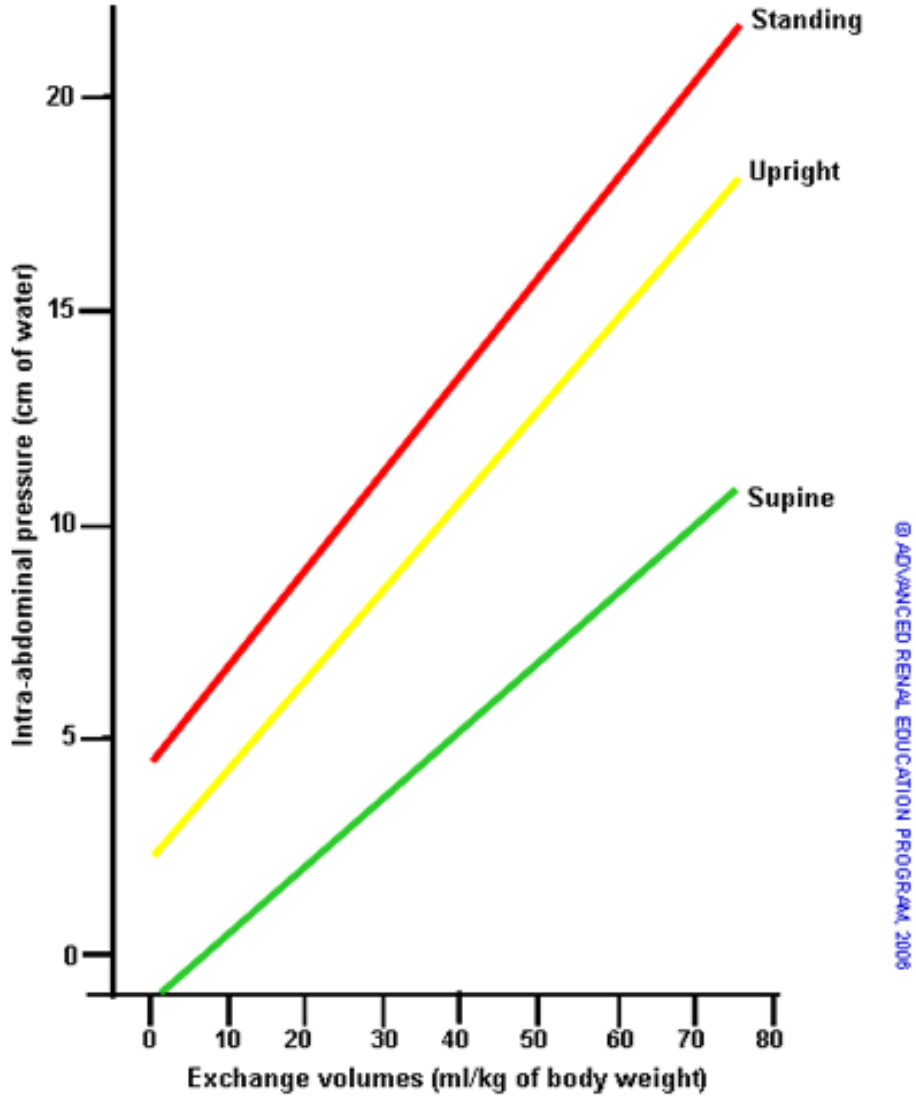
- **Constipation**
  - More than half of the cases are cured with releif of constipation
  - Laxatives, stool softeners, suppositories or enema
- **Fibrin clot**
  - Heparin 500 units/L of dialysate for lysis
  - Urokinase – instilled in catheter for 1 hour and then removed
  - Recombinant tPA – used if obstruction is refractory

Non-Infectious complications



Effect of dialysate volume and patient position on intra-abdominal pressure

Modified from Diaz-Buxo Kidney Int 28 (Suppl 17): S26, 1985



Intra Peritoneal Volume VS Intra Peritoneal Pressure

IPV (1 Liter) → IPP (2.2 cmH2O)

2 lit → 3 lit

Decubitus → Upright

MTAC ↑ 40%

UF ↓

MTAC ↓ 24%

UF ↓

Drain Volume ↑

UF Volume ↑

Surface Area ↑

Capillary Compression ↑

Vascularization ↓

Surface Area ↓

1.36% Glc ↓ UF

2.27% Glc → UF

3.86 Glc ↑ UF

Lymphatic Absorption ↑

Extralymph. Abs. ↑

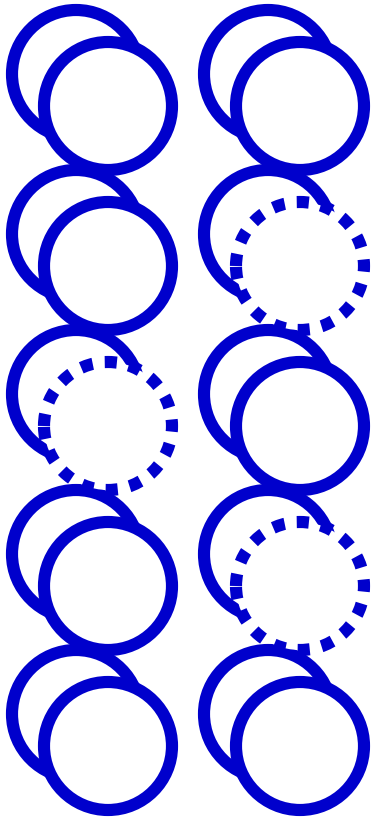
Transcapil. Ultrafilt. ↓

2 lit at rest decub= 5mmHg,
at rest upright = 20mmHg,

rest lat. Decub = 15mmHg,
active upright = 200mmHg

in PD

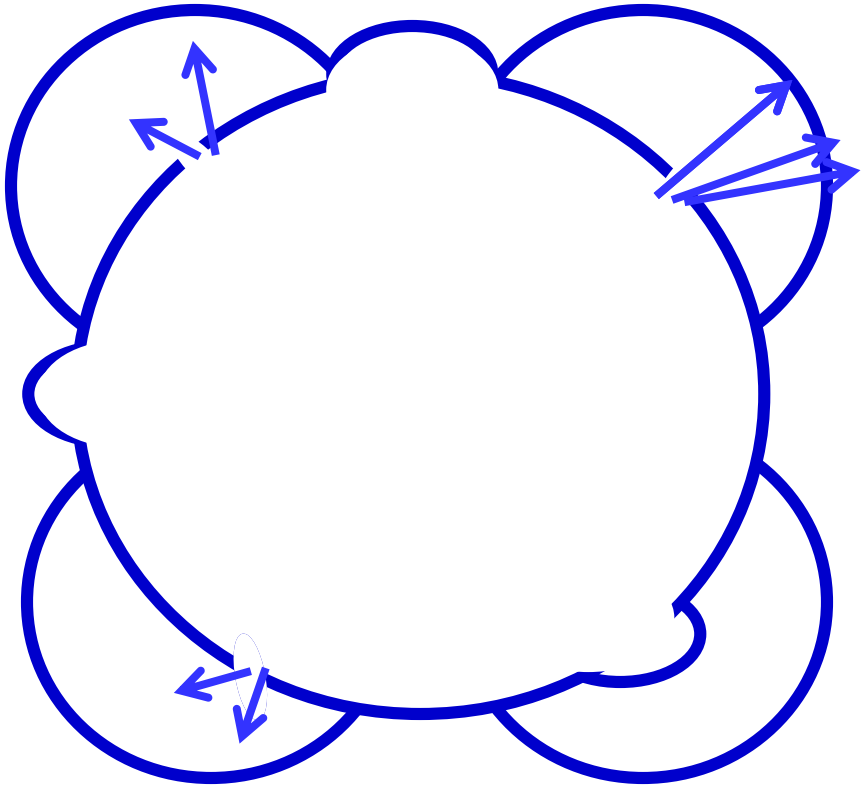
Adequate level of solute clearance for normal size anephric patients can be achieved only by:



Inordinate number of exchanges

Poor Compliance

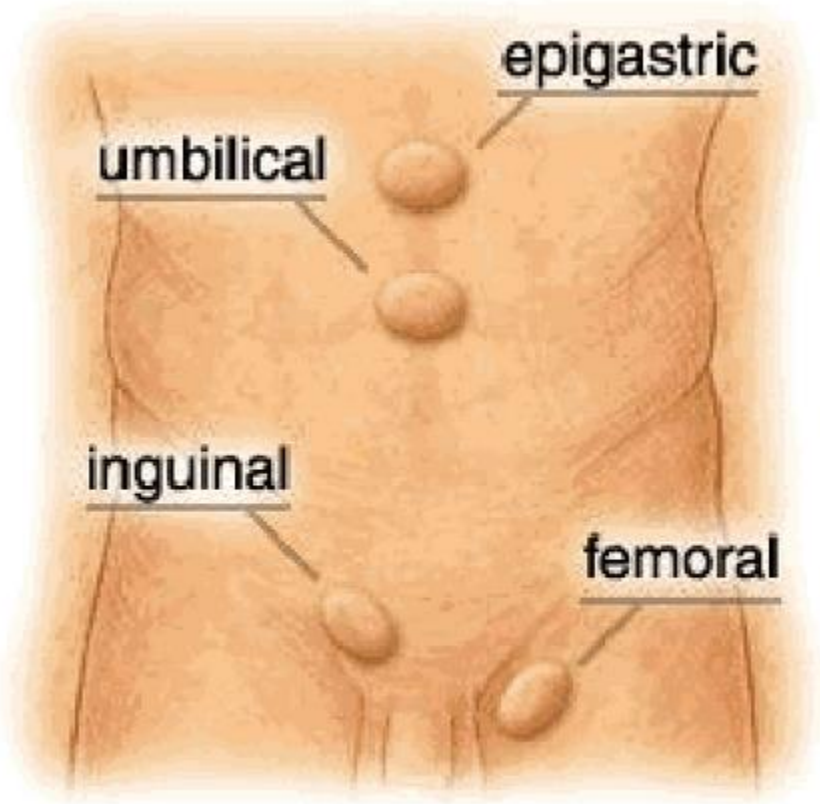
OR



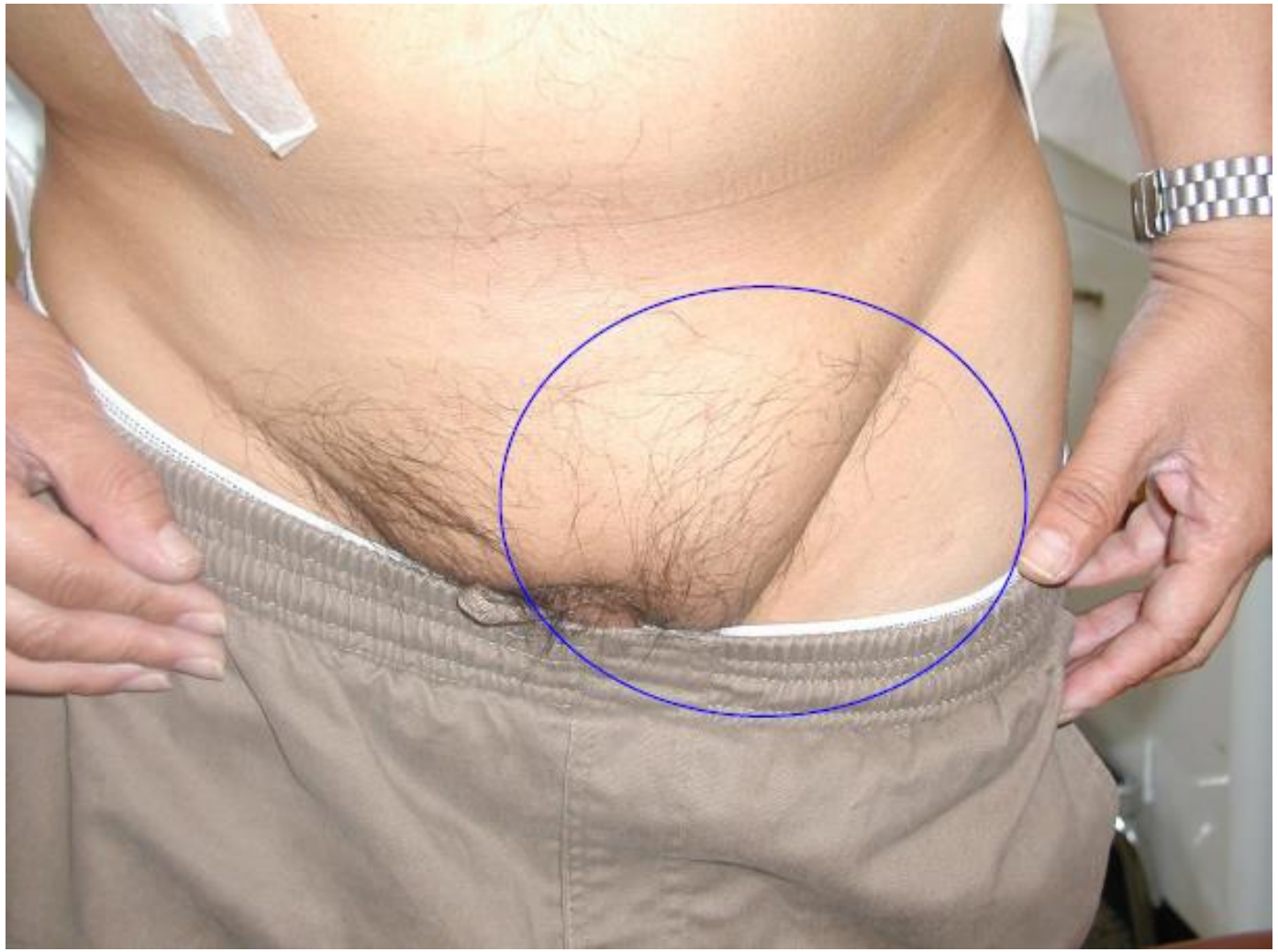
Hernia provoking intraperitoneal volume

Increase Volume

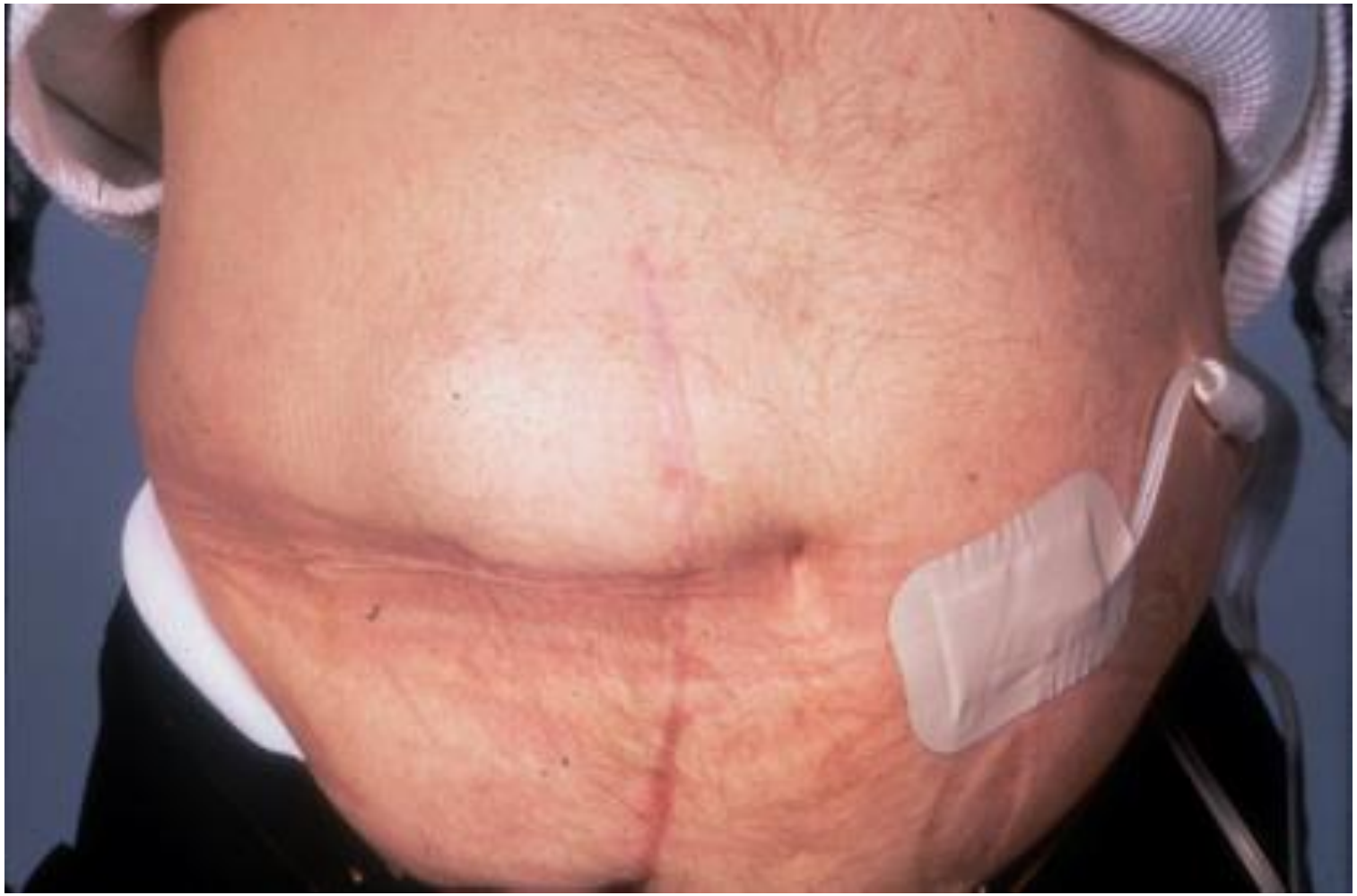
Hernias



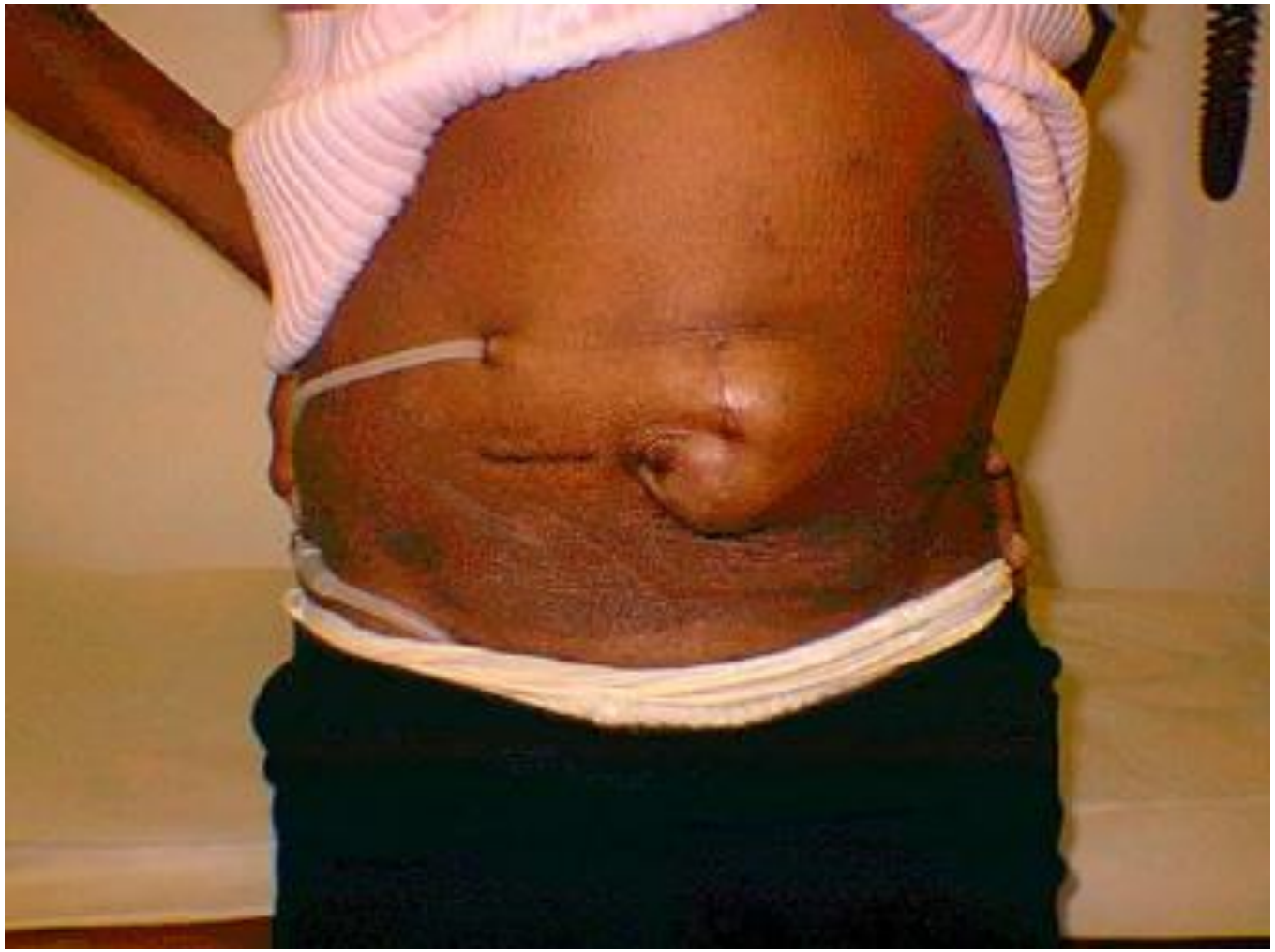
Hernias



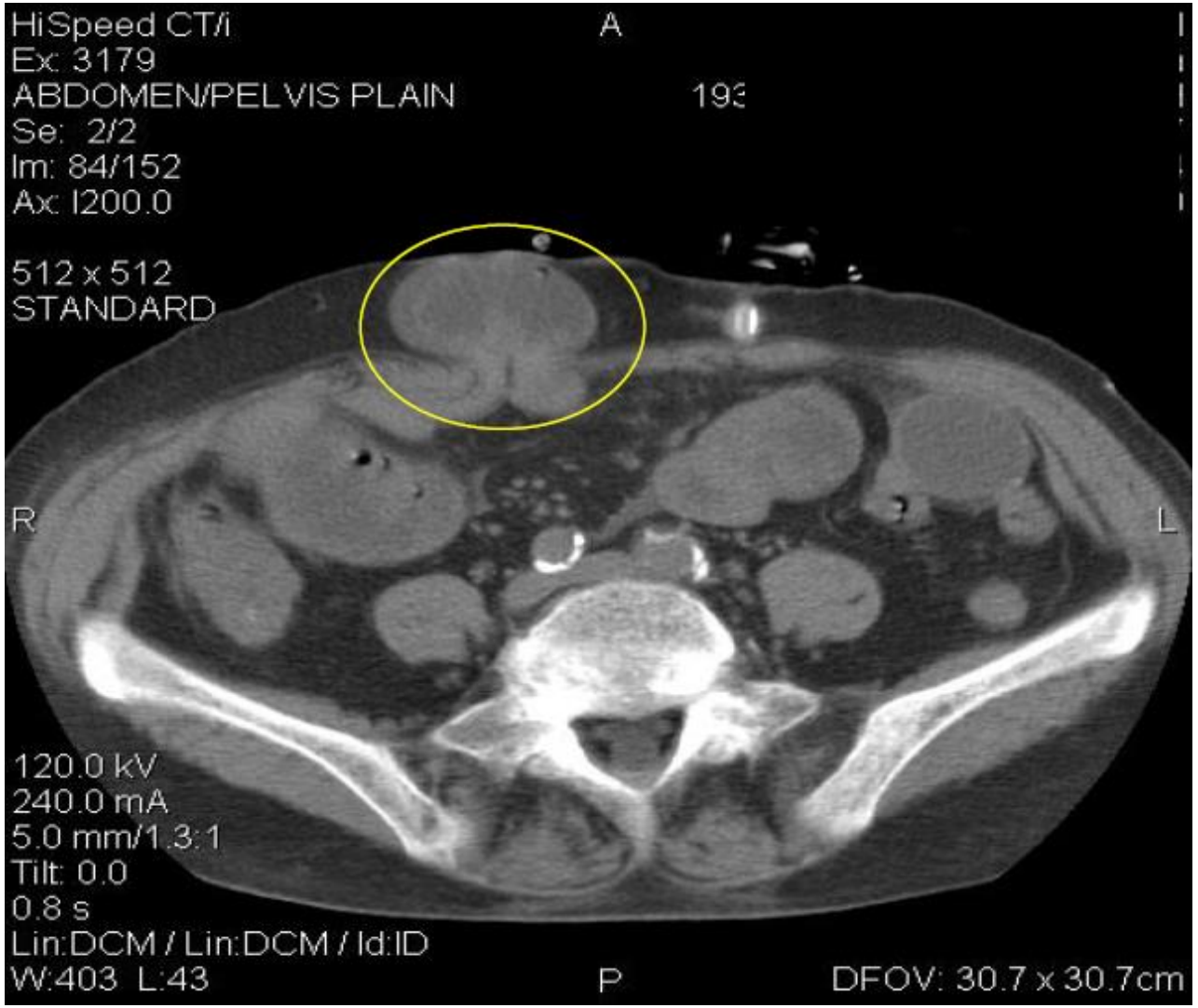
Hernia



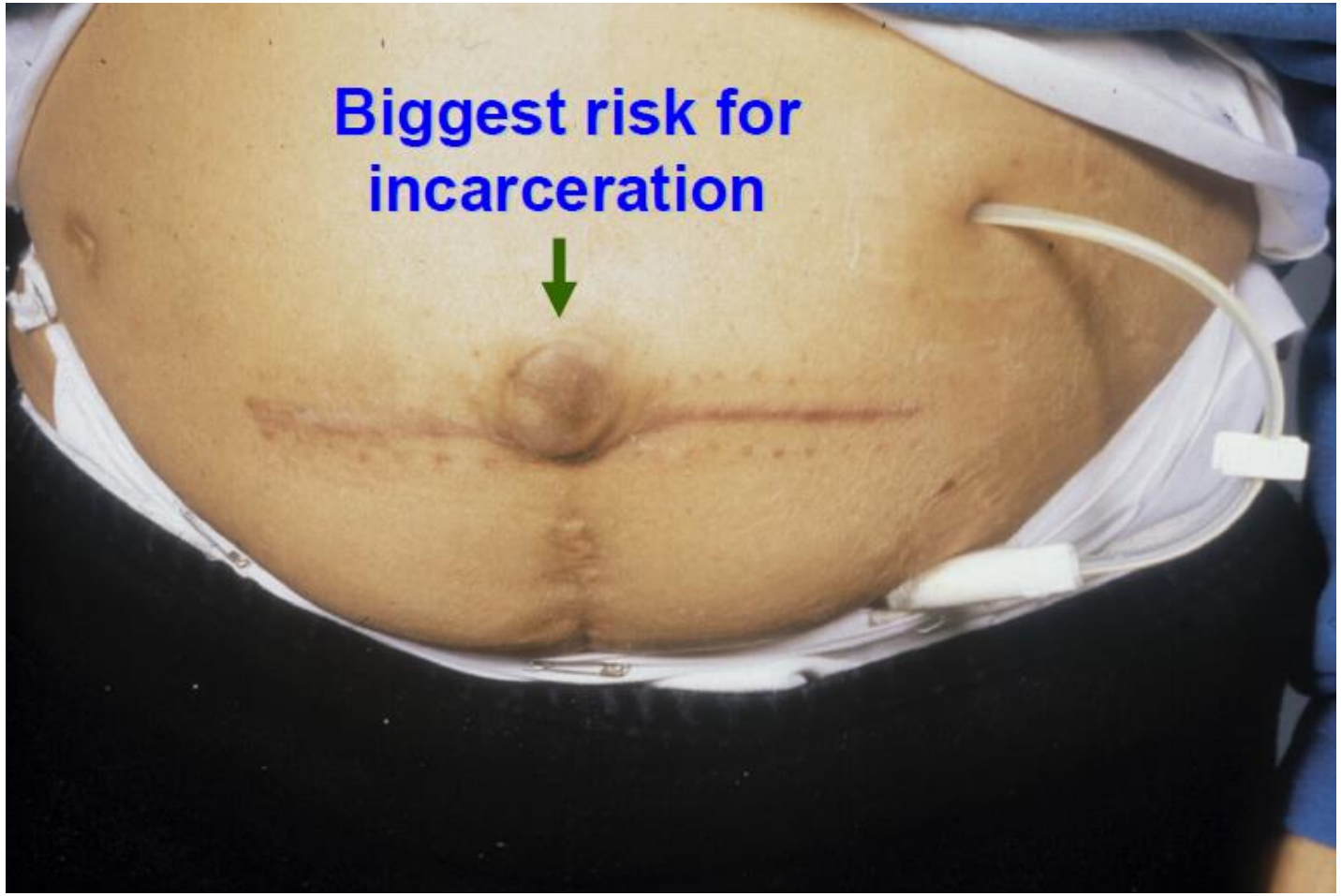
Ventral Hernia



Ct Scan of abdominal wall hernia



Umbilical Hernia



Hernias

How can a hernia lead to peritonitis?

Hernia

↓

Bowel Incarceration and Strangulation

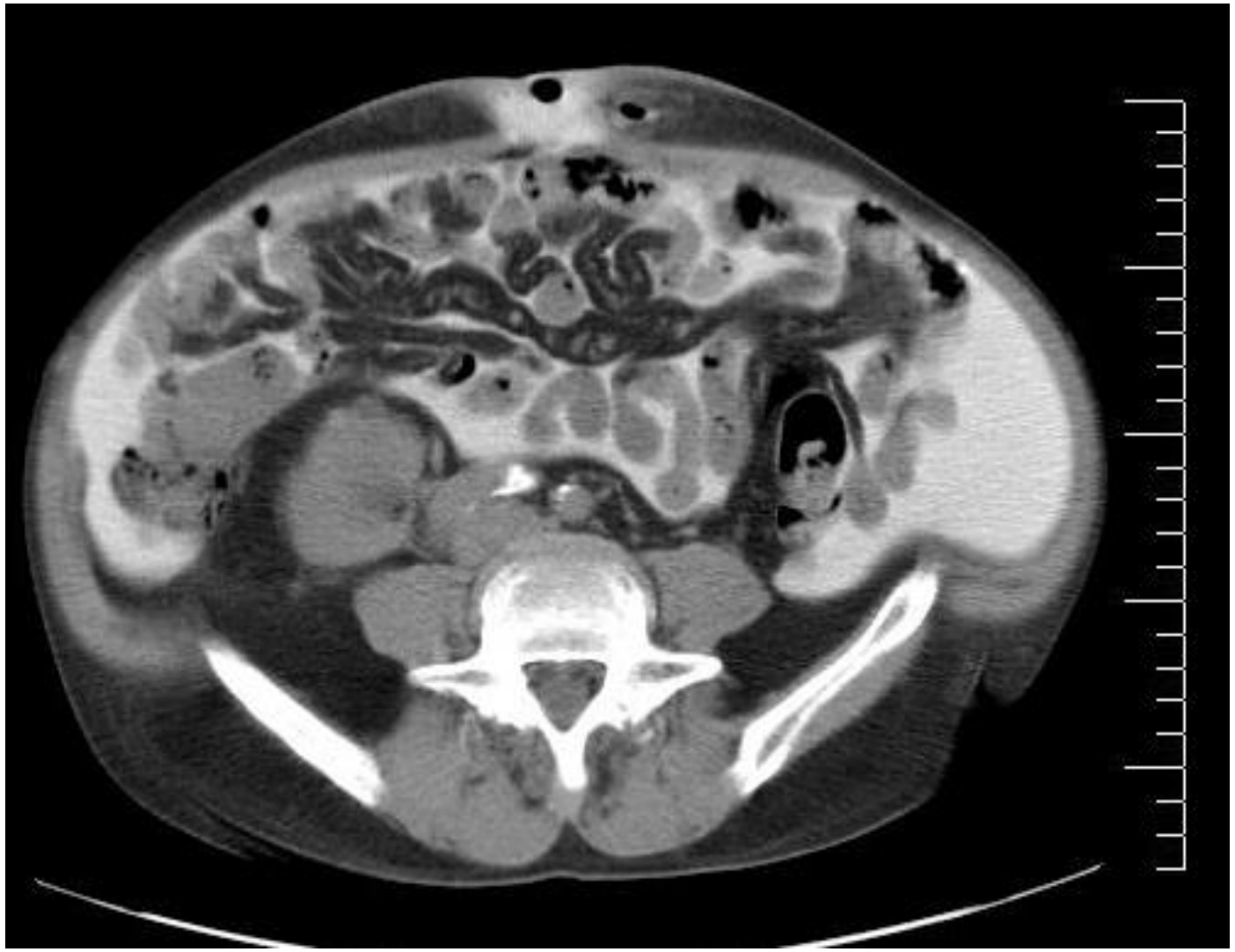
↓

Transmural Leakage of Bacteria

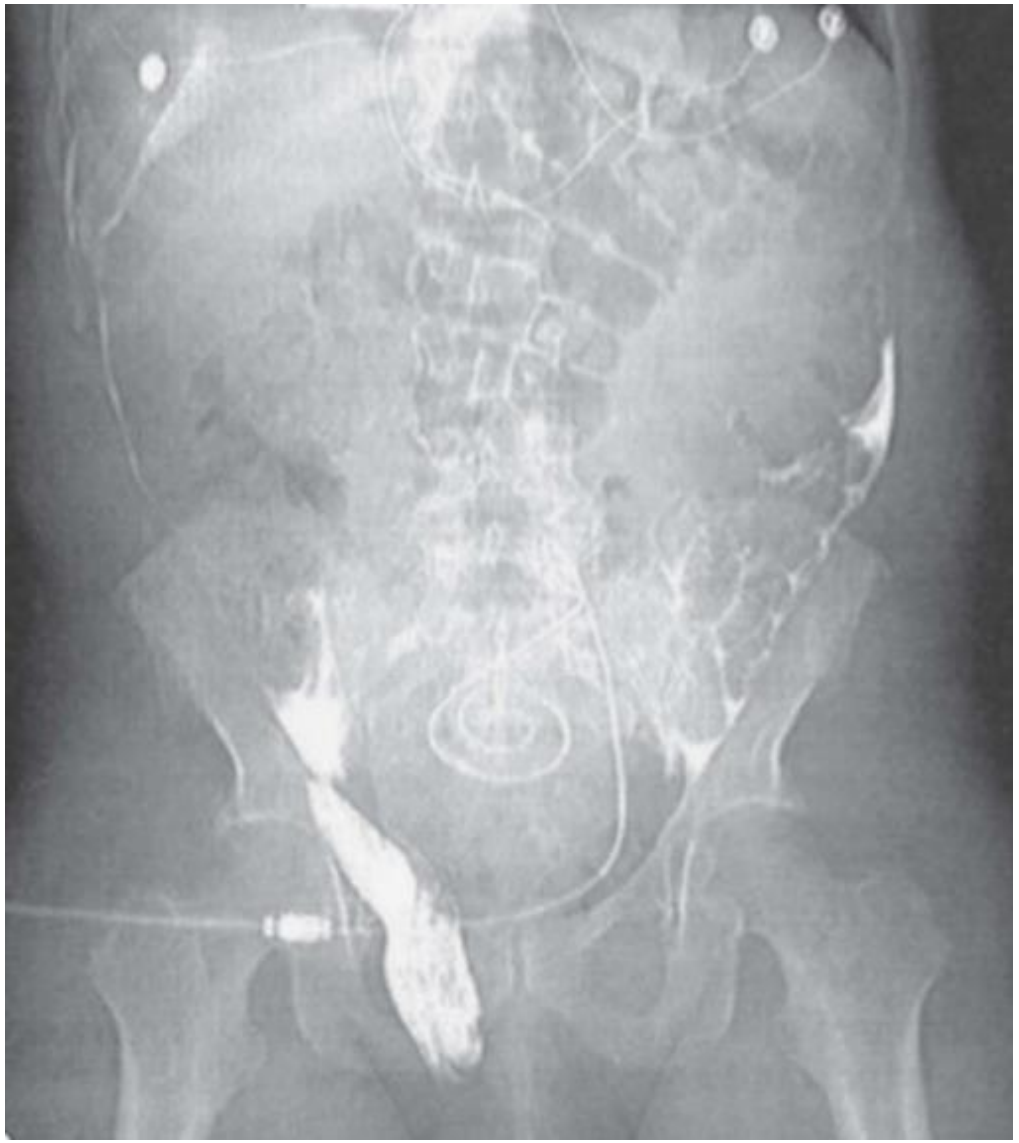
↓

Peritonitis

Hernia and Leak (CT Scan with IP Dye)



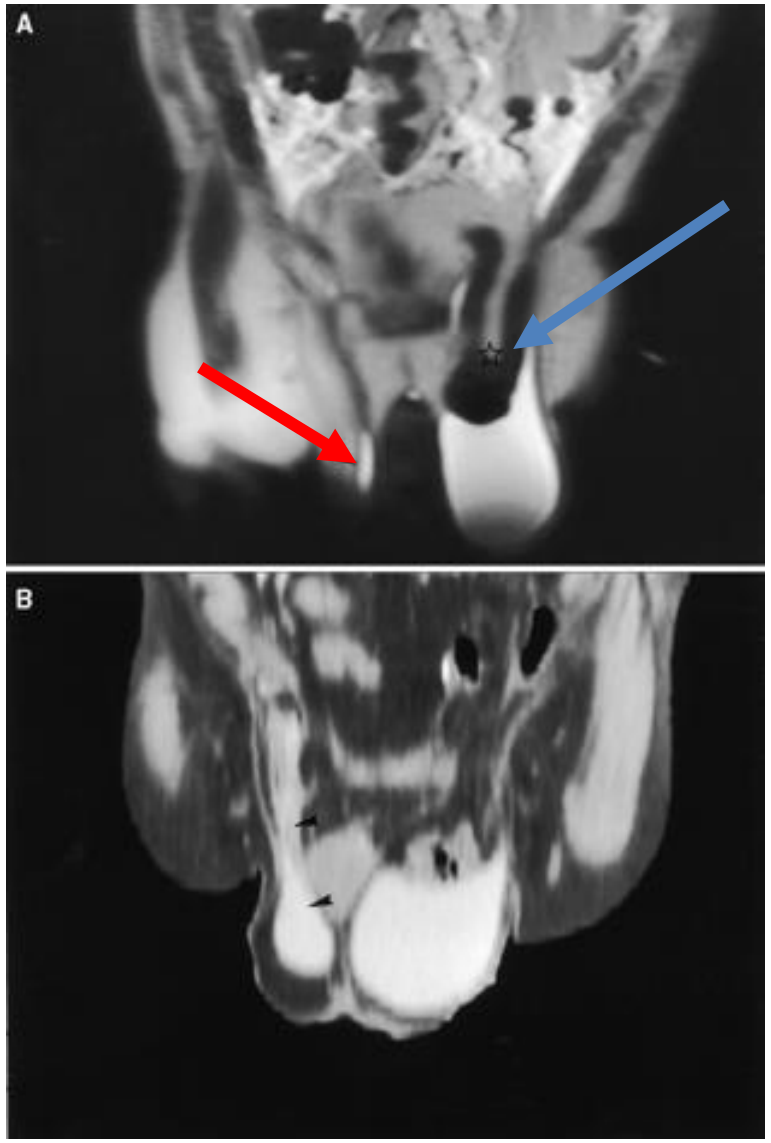
Hernia peritoneography



Genital Edema *(cont'd)*

MRI Scanning

61-yr-old man with bilateral scrotal herniation. On the right side, a small hernia partially filled with dialysate (red arrow). On the left side, a large hernia contains hyperintense dialysate at the bottom and a loop of the sigmoid colon (green arrow)



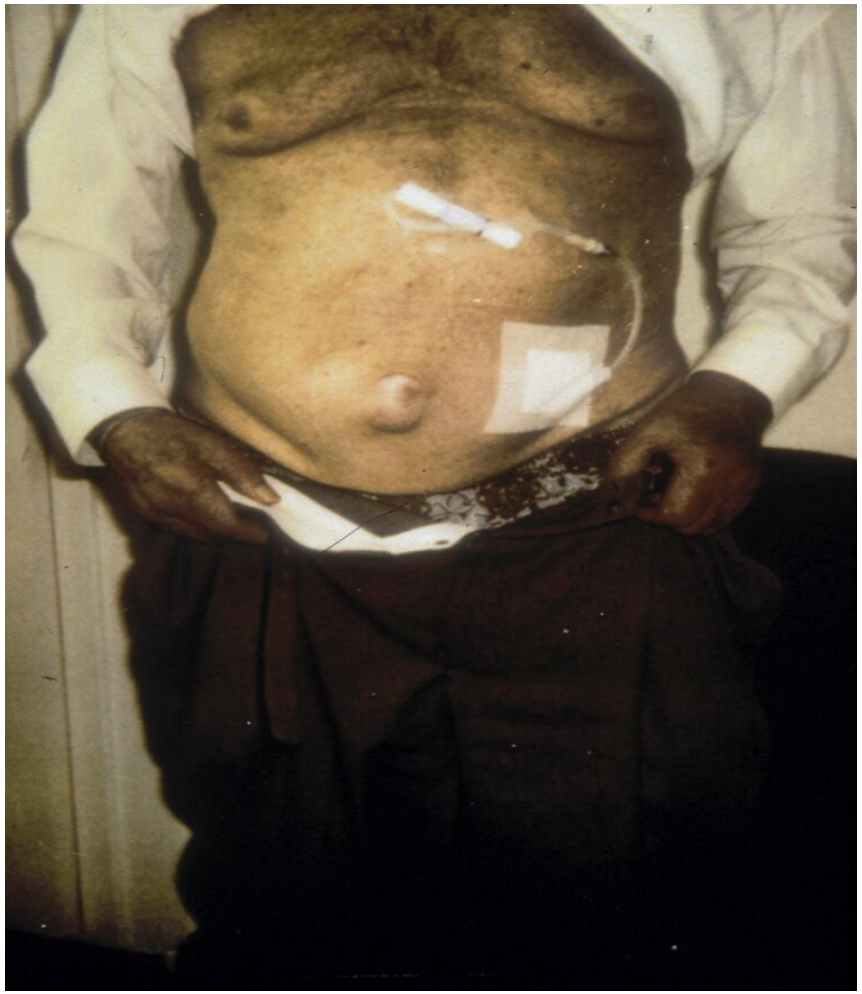
Prischl et al. MRI in PD JASN

Pericatheter leakage

❖Clinical manifestations:

- ❖ Fluid in the area surrounding the catheter
- ❖ Subtle subcutaneous swelling
- ❖Diminished outflow volumes may precede frank leakage
- ❖ Genital and abdominal wall edema may also indicate the presence of a leak

Abdominal Edema with Right Flank Bulging



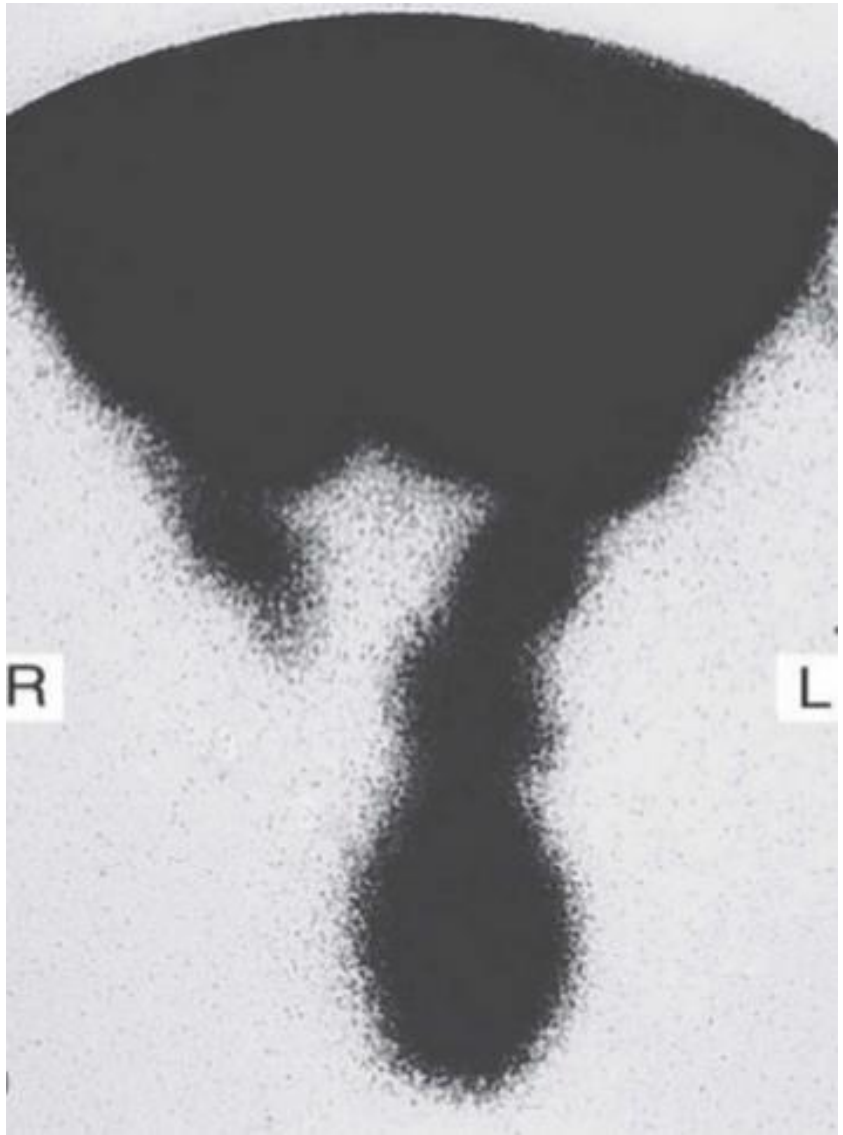
Diagnosis of Leak

To help confirm the diagnosis and delineate the anatomy of the leak

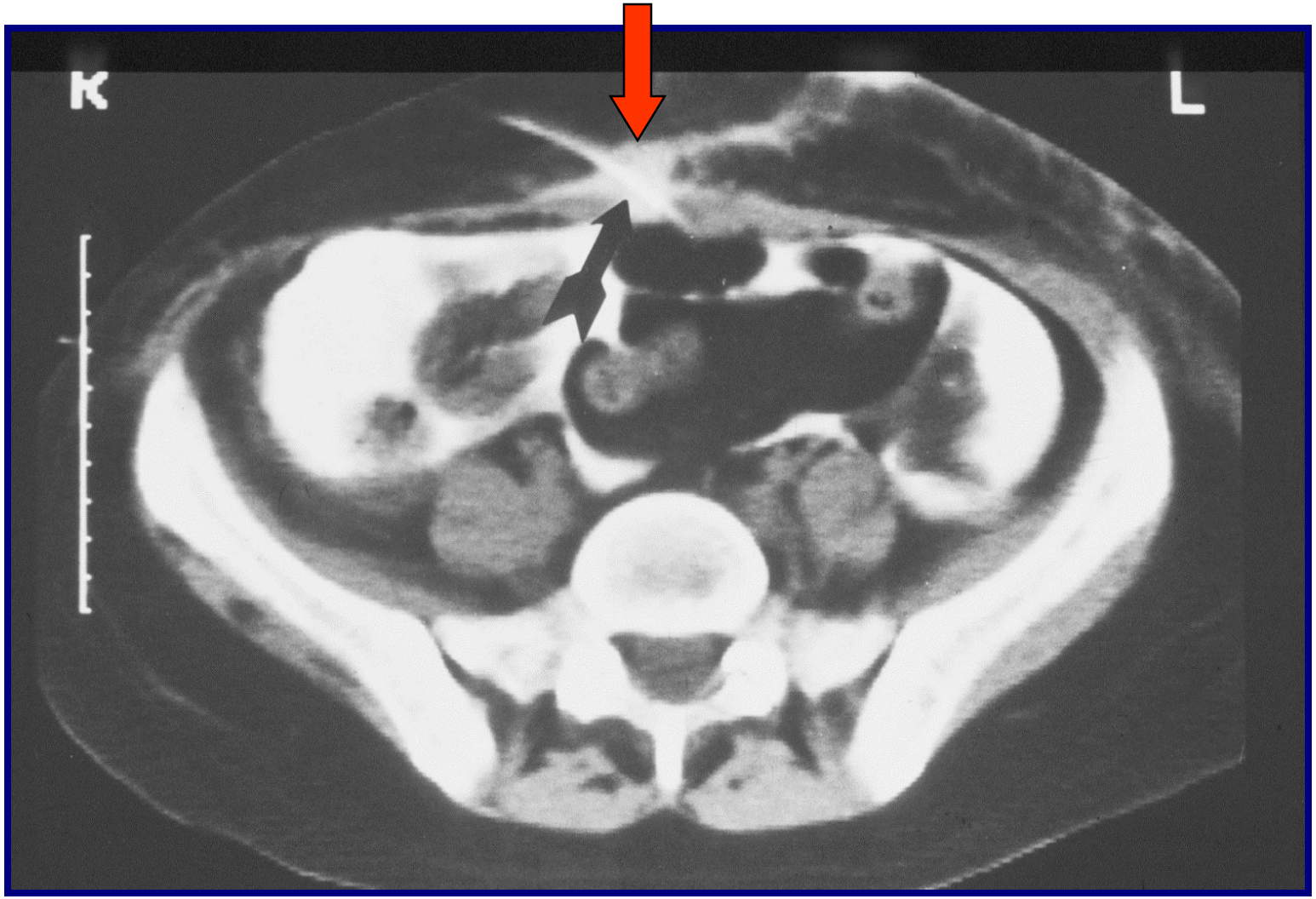
- **Peritoneal scintigraphy**
- **CT scanning after infusion of dialysate containing contrast material**
- **Magnetic resonance imaging using dialysate as the contrast material may also be useful.**

One-third of leaks occurring late after catheter placement required imaging for diagnosis.

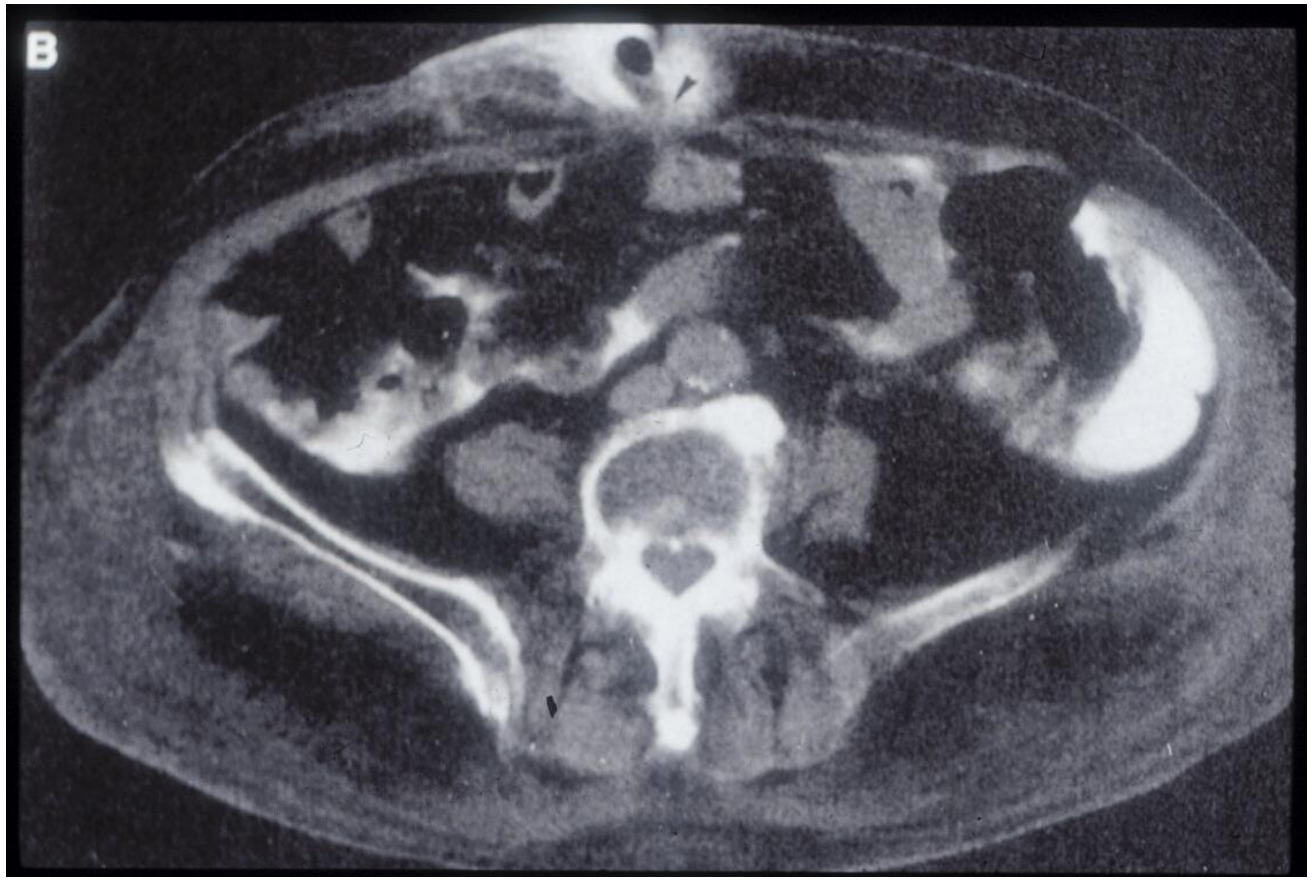
Isotopic scan of peritoneum



Pericatheter Leak - CT Cannulogram



CT Scan with IP Dye Demonstrating Leak through Catheter Insertion Site *(Prischl)*



Retroperitoneal Leak (UF Failure)

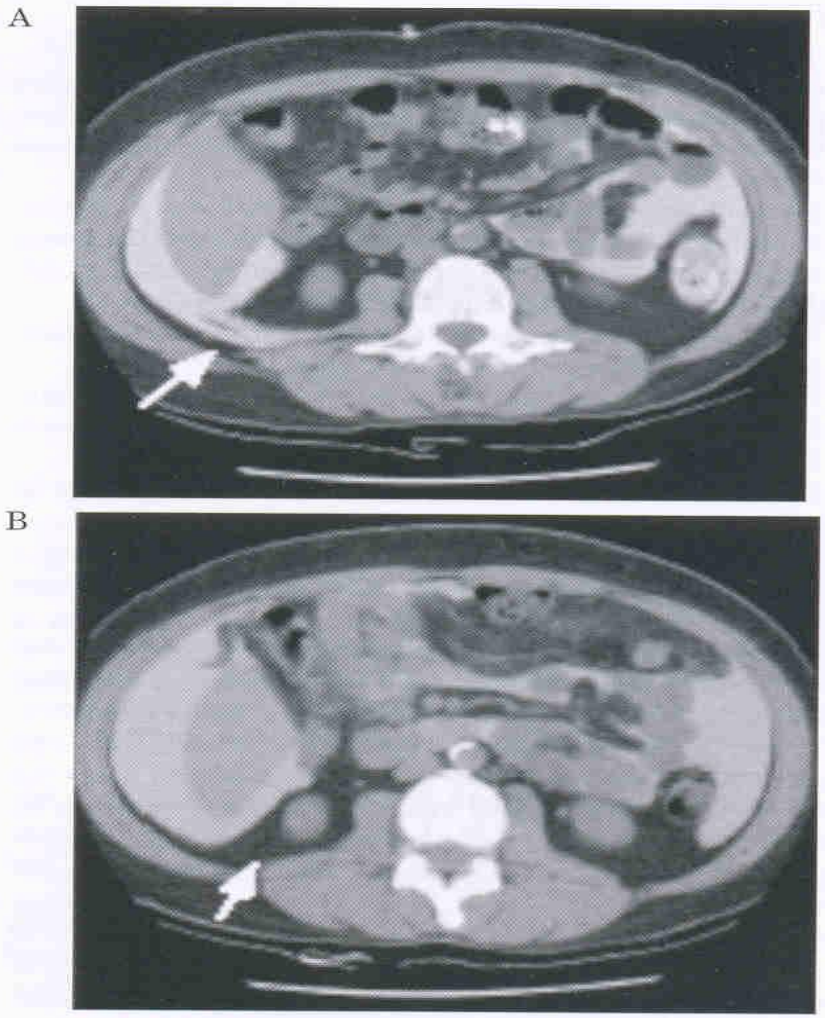


Figure 3 — Computed tomographic (CT) peritoneography for Case 3. Retroperitoneal leakage is marked with an arrow (A). Repeat CT peritoneography shows disappearance of the leakage (B).

Management of Leak, Hernia

- Decreasing exertional activity
- Decreasing dialysate volume
- Occasionally, APD
- Temporary conversion to hemodialysis

- Leaks and Hernias that do not respond to conservative management may require surgical repair

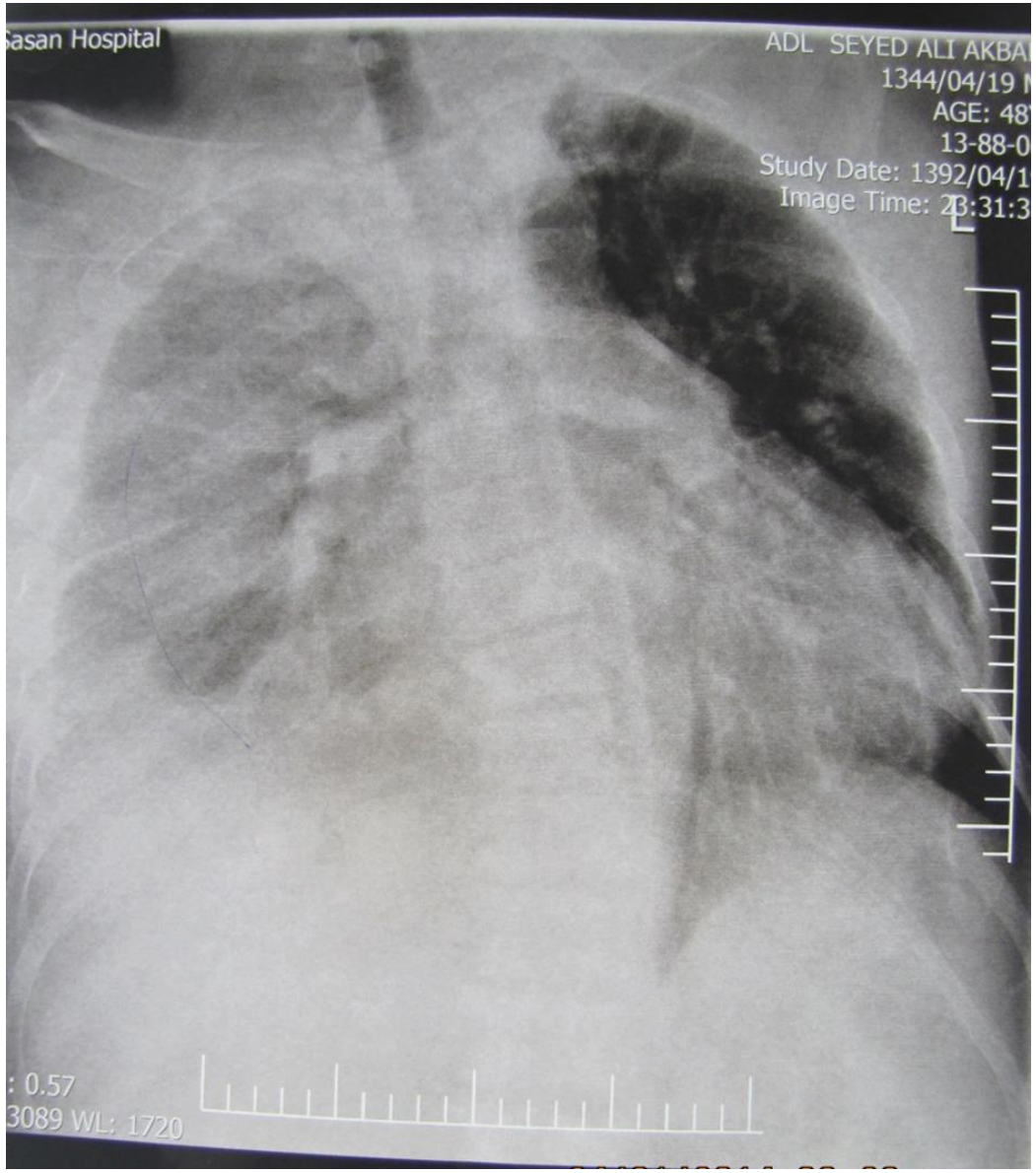
Pleural effusion

- **Possible aetiologies:**
- Volume overload, CHF
- Local pleural process
- Peritoneal dialysate leak

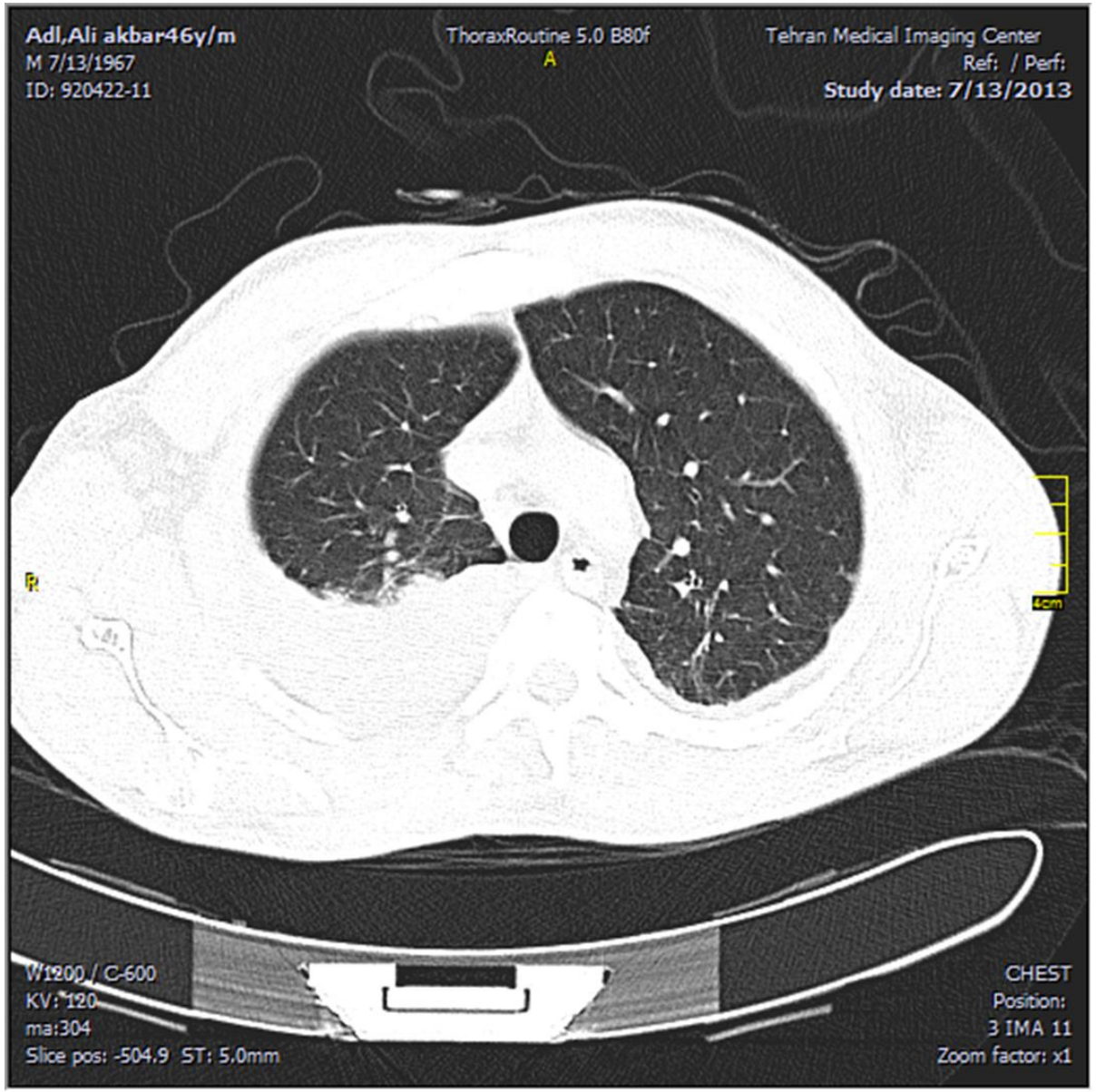
- **Suspicion of peritoneal dialysate leak:**
  in a non edematous pt with inadequate UF

- Incidence: 1.6%, more common in females
- ADPKD patients prone to have due to decreased abdominal capacity

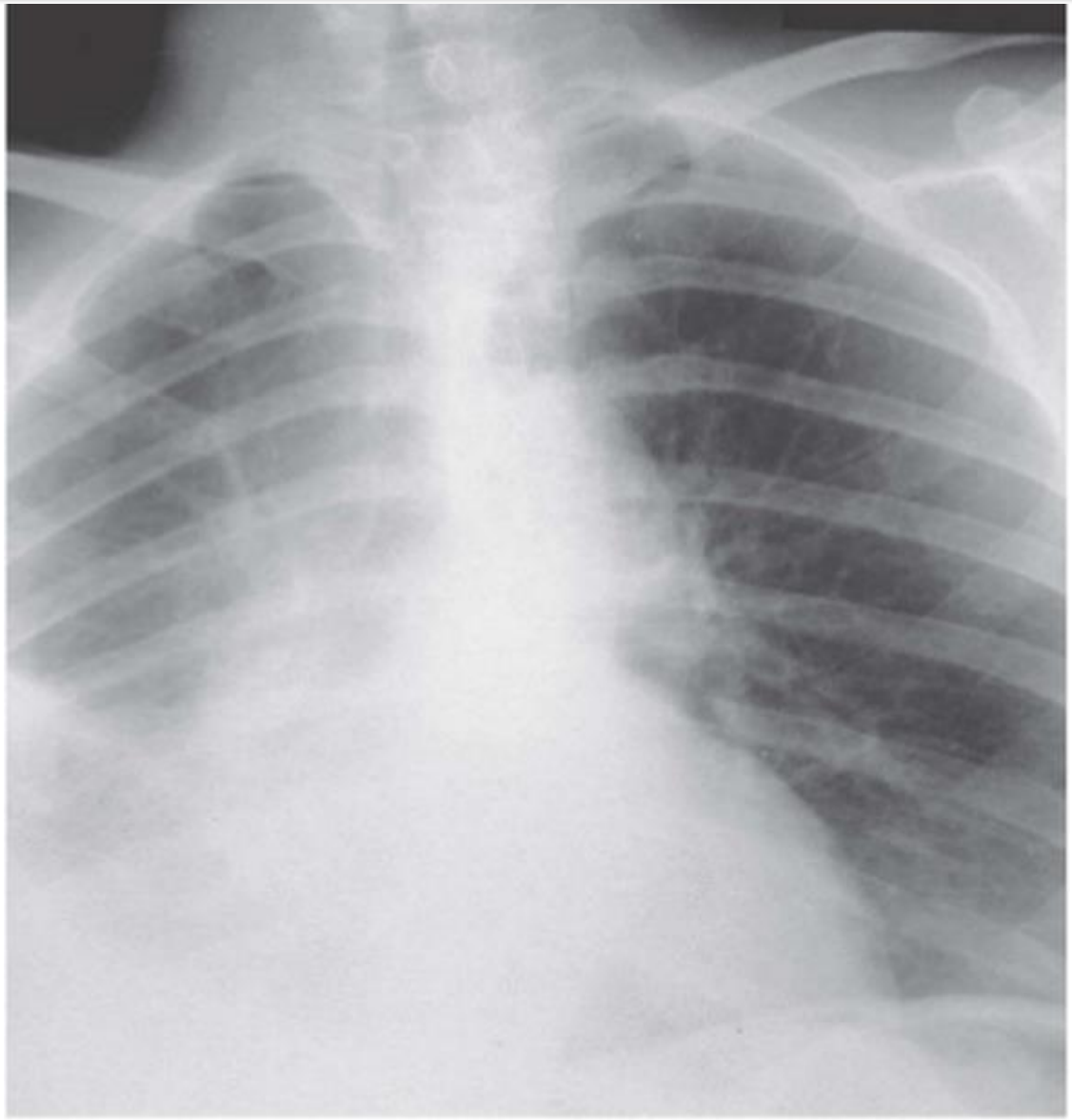
Chest X-Ray, Haziness of right lung



Chest CT, Pleural effusion and normal lung



Pleural leak



Pleural leak

- Usually occurs early after starting PD
- Unrelated to dialysate volumes

Hypotheses:

- Congenital communication between pleura and peritoneum
- Combination of increased intra-abdominal pressure and negative intra-thoracic

Defect in the Hemidiaphragm
(Lieberman et al)

Pleural leak

- **Clinical features**
  - Can be asymptomatic
  - Shortness of breath on exertion
  - Inadequate Ultrafiltration
  - Usually on right side
  - Occurs early after PD initiation, 50% of cases within 1 st month

- **Diagnosis: Glucose concentration in pleural fluid is high**

Non-Infectious complications

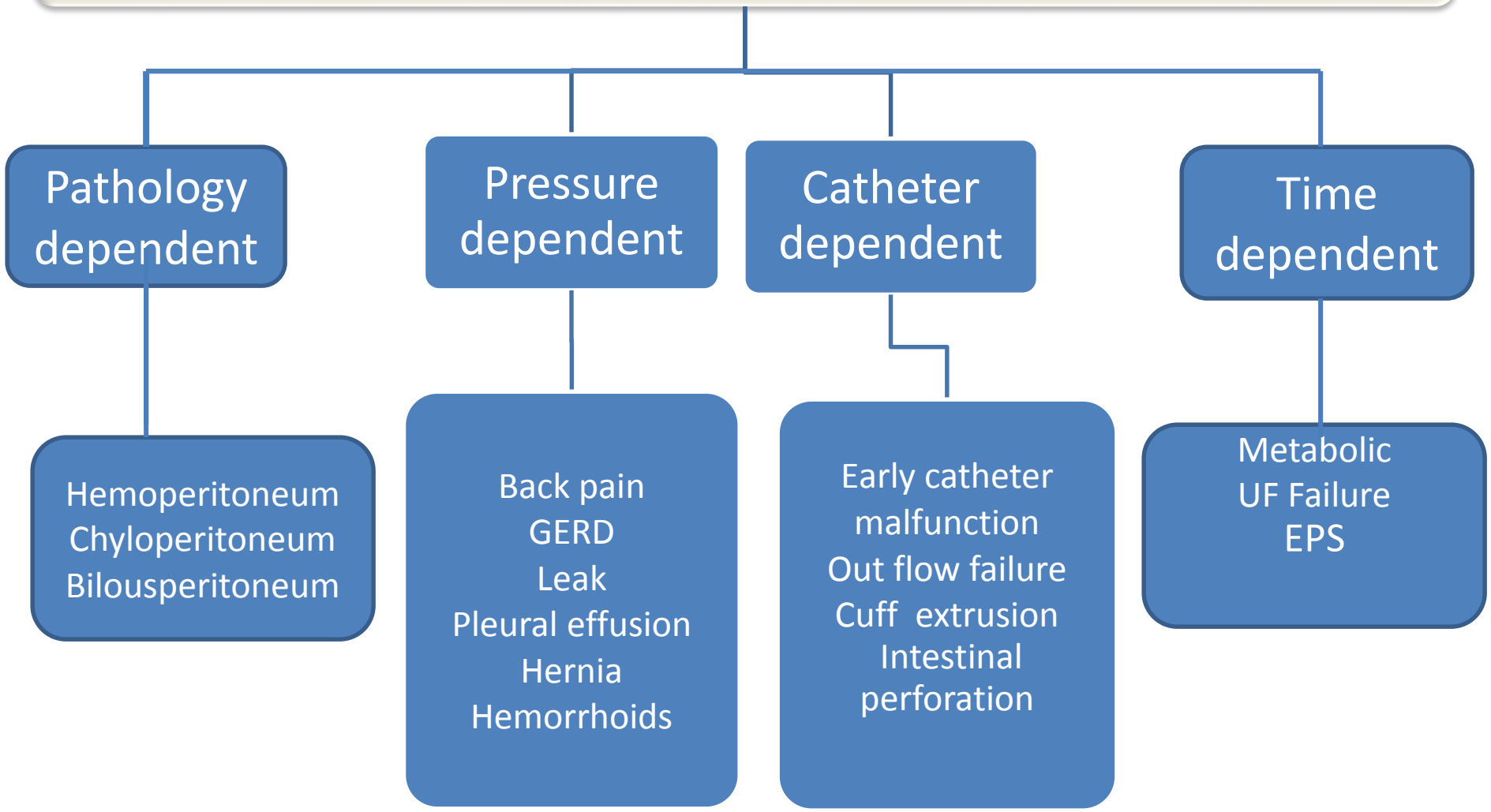
latest report of two centers in Tehran

Complication	Centers		
	Shariati 138 pt	Shafa 360 pt	Other Studies
Catheter Malfunction	20.2%	9.7%	5-20%
Hernia	5.7%	5.27%	10-15%
Hemoperitoneum	6.5%	4.72%	2.2%
Leak	15.2%	10.5%	11%
EPS	2.9%	2.22%	0.7-7.3%

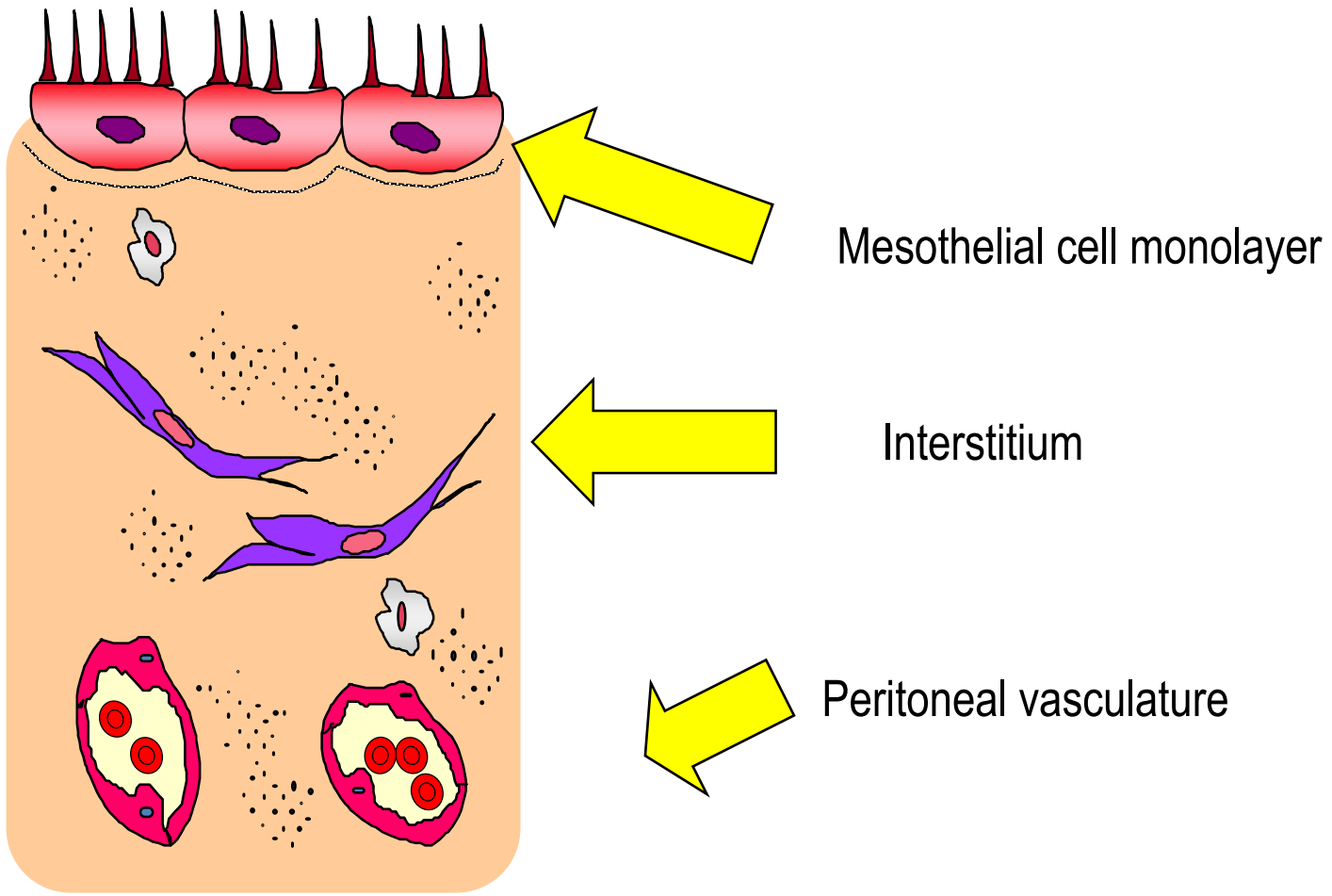
Indian J Nephrol. 2011 Apr-Jun; 21(2): 112–115.

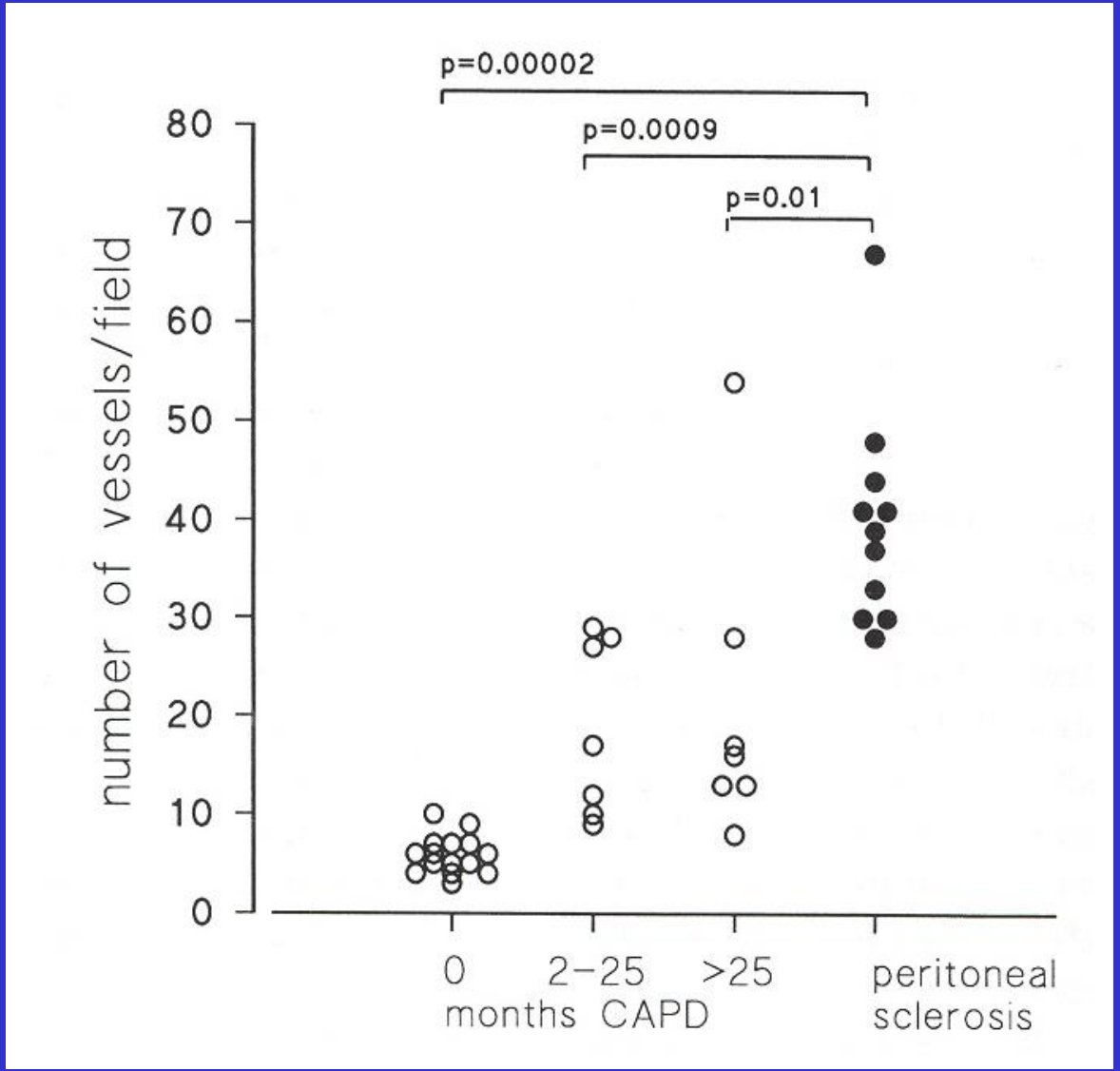
Unpublished Data Shafa PD research center 2014 Dec

Non-Infectious complications



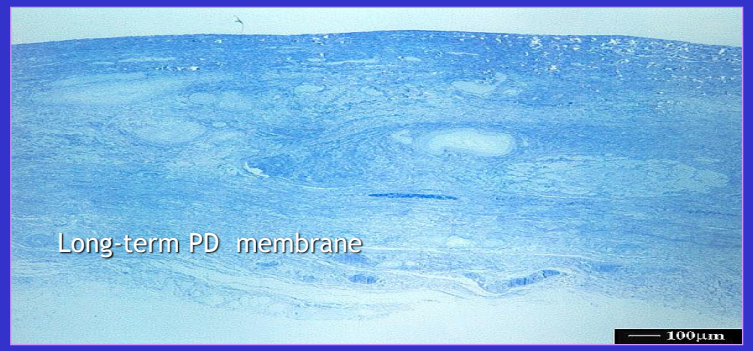
The Normal Peritoneal Membrane

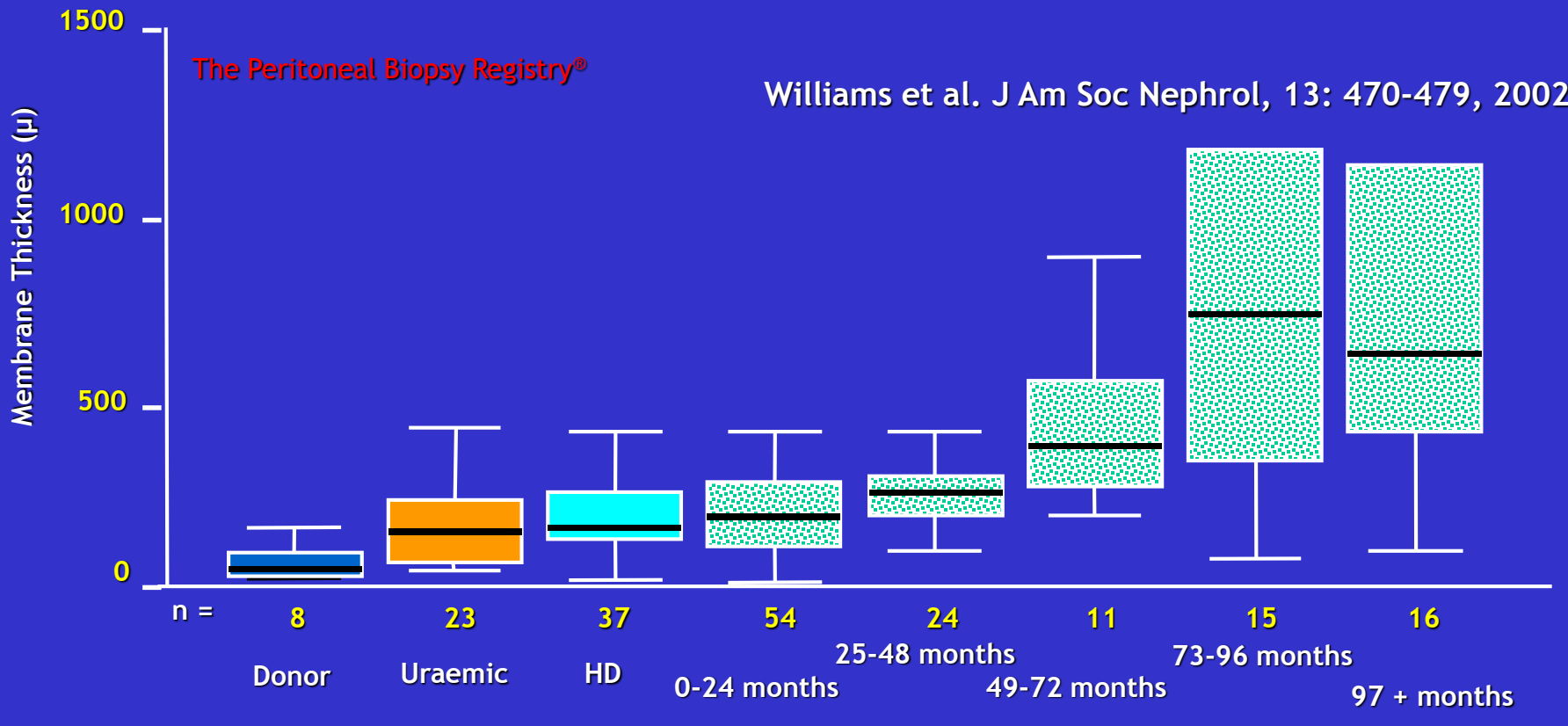


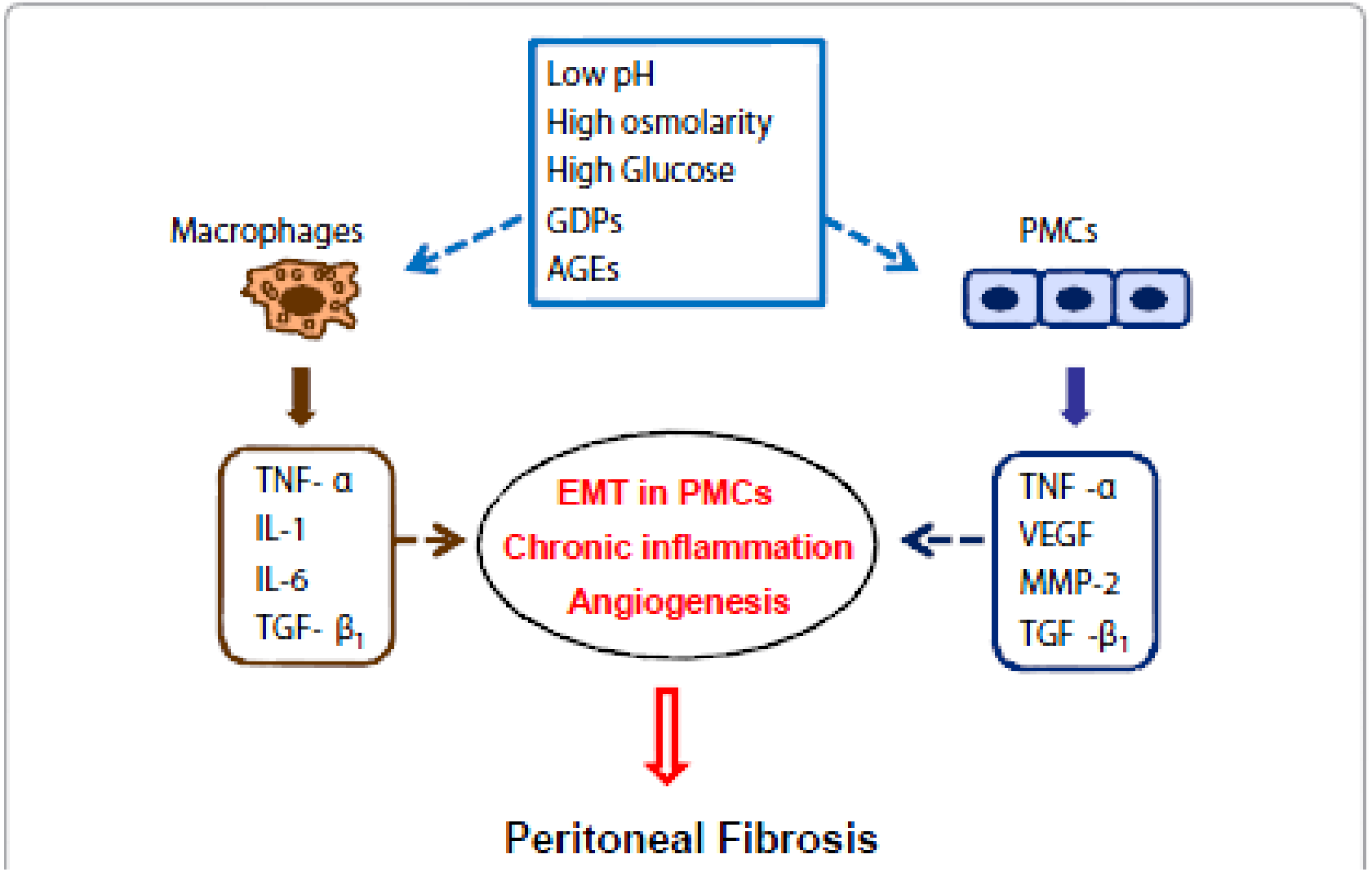


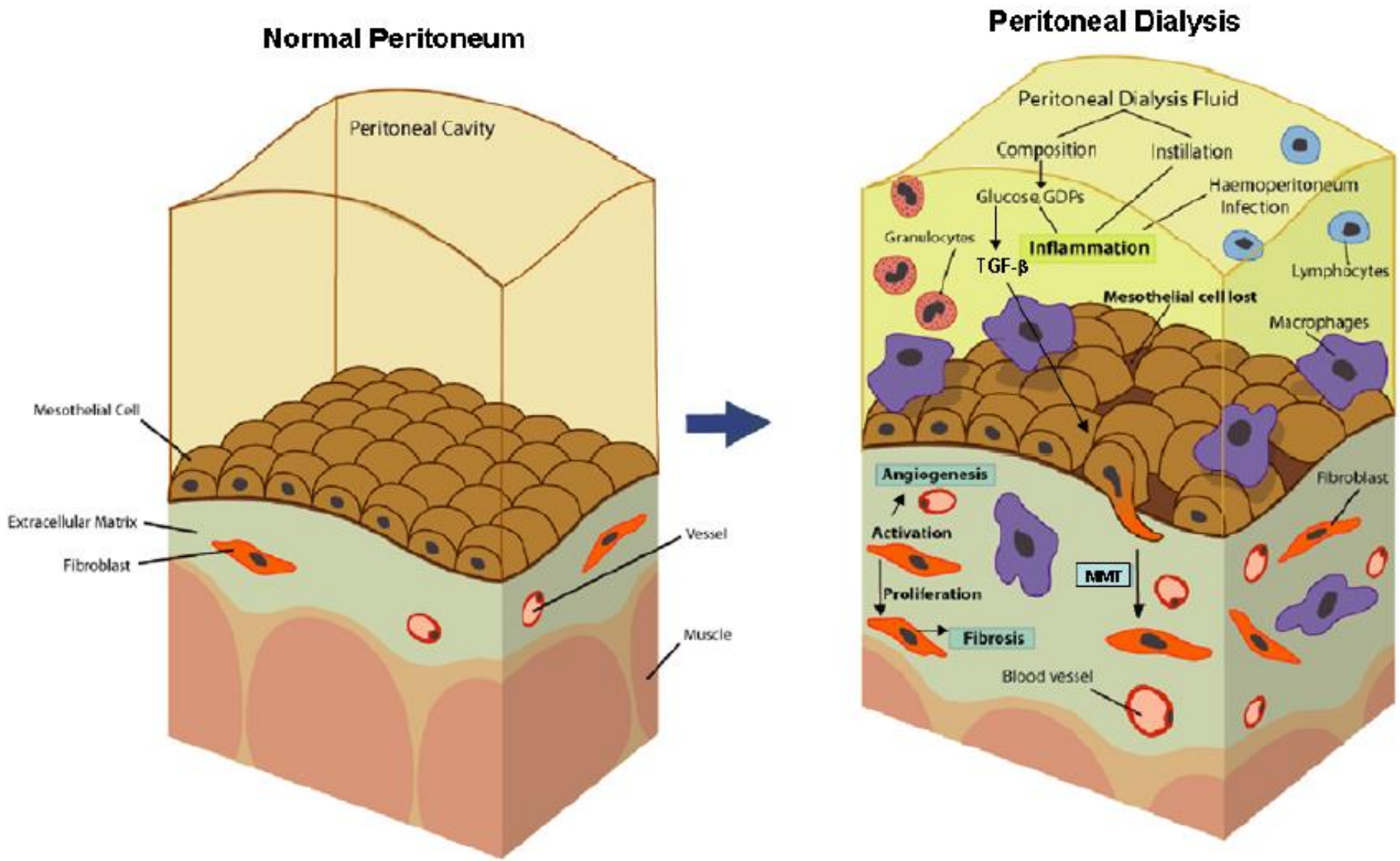
Mateijsen M et al, PDI 1999;19:517-525

Morphological changes in the peritoneal membrane





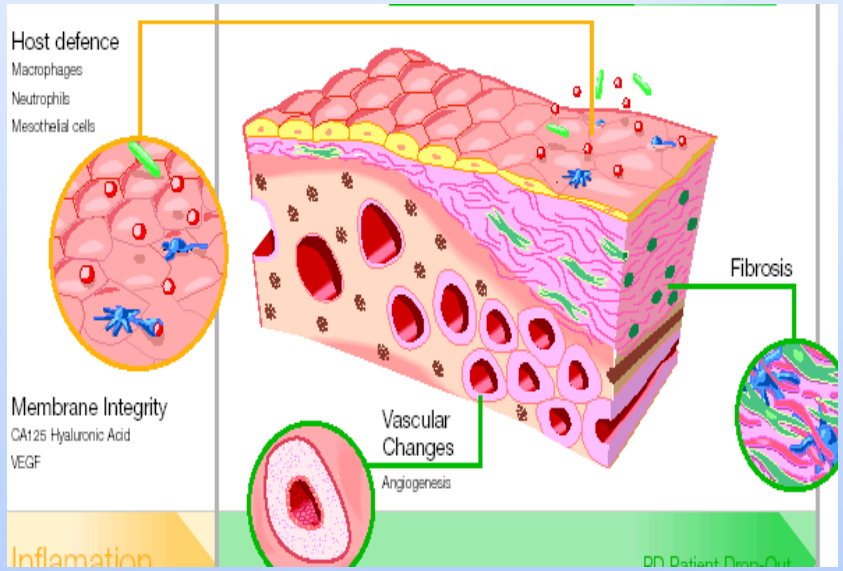

Low pH
High osmolarity
High Glucose
GDPs
AGEs
Macrophages
PMCs
TNF- α
IL-1
IL-6
TGF- β1
EMT in PMCs
Chronic inflammation
Angiogenesis
TNF -α
VEGF
MMP-2
TGF -β1
Peritoneal Fibrosis


Normal Peritoneum
Peritoneal Cavity
Mesothelial Cell
Extracellular Matrix
Fibroblast
Vessel
Muscle
Peritoneal Dialysis
Peritoneal Dialysis Fluid
Composition
Instillation
Glucose GDPs
Haemoperitoneum
Infection
Granulocytes
Inflammation
TGF-β
Lymphocytes
Mesothelial cell lost
Macrophages
Angiogenesis
Fibroblast
Activation
MMT
Proliferation
Fibrosis
Blood vessel

Membrane characteristics change

- Membrane characteristics change **with time on therapy**.

1. **neo-angiogenesis**
2. **Vasculopathy**
3. **interstitial fibrosis**

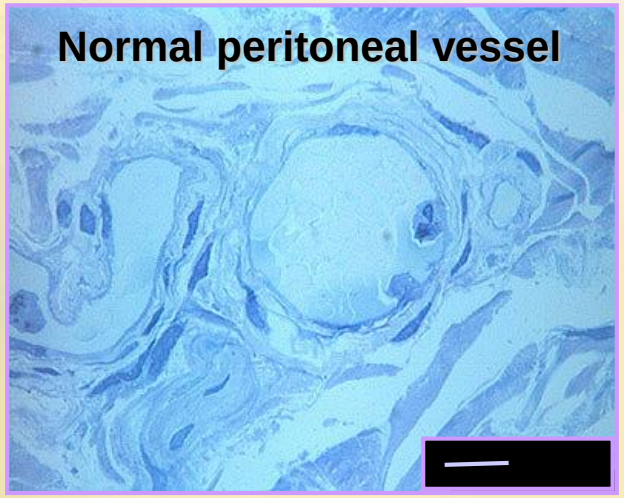


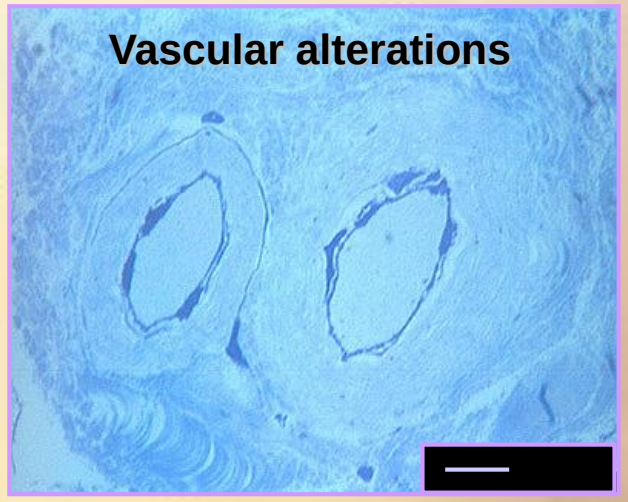
lead to ;

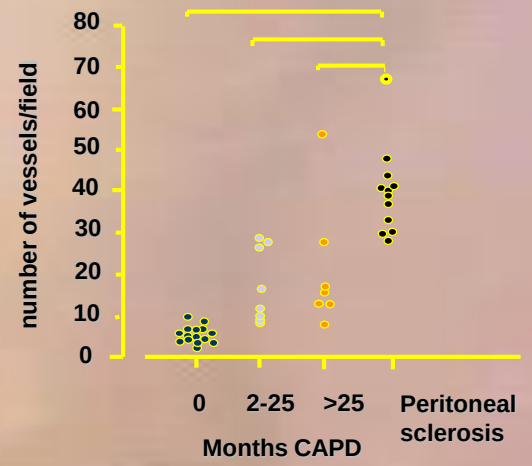
- **increase in the transport rate for small solutes**
- **Decreased ultrafiltration capacity**

The transport of solutes and fluid

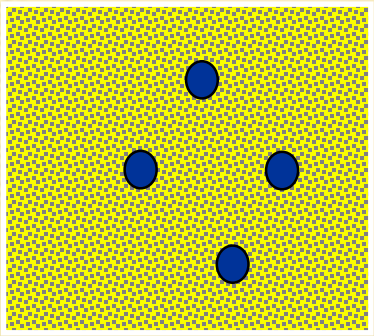
High transporters: An increase in surface area/permeability leading to greater glucose absorption and a more rapid dissolution of the osmotic gradient



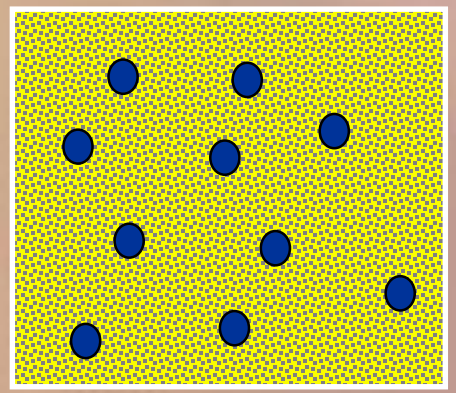




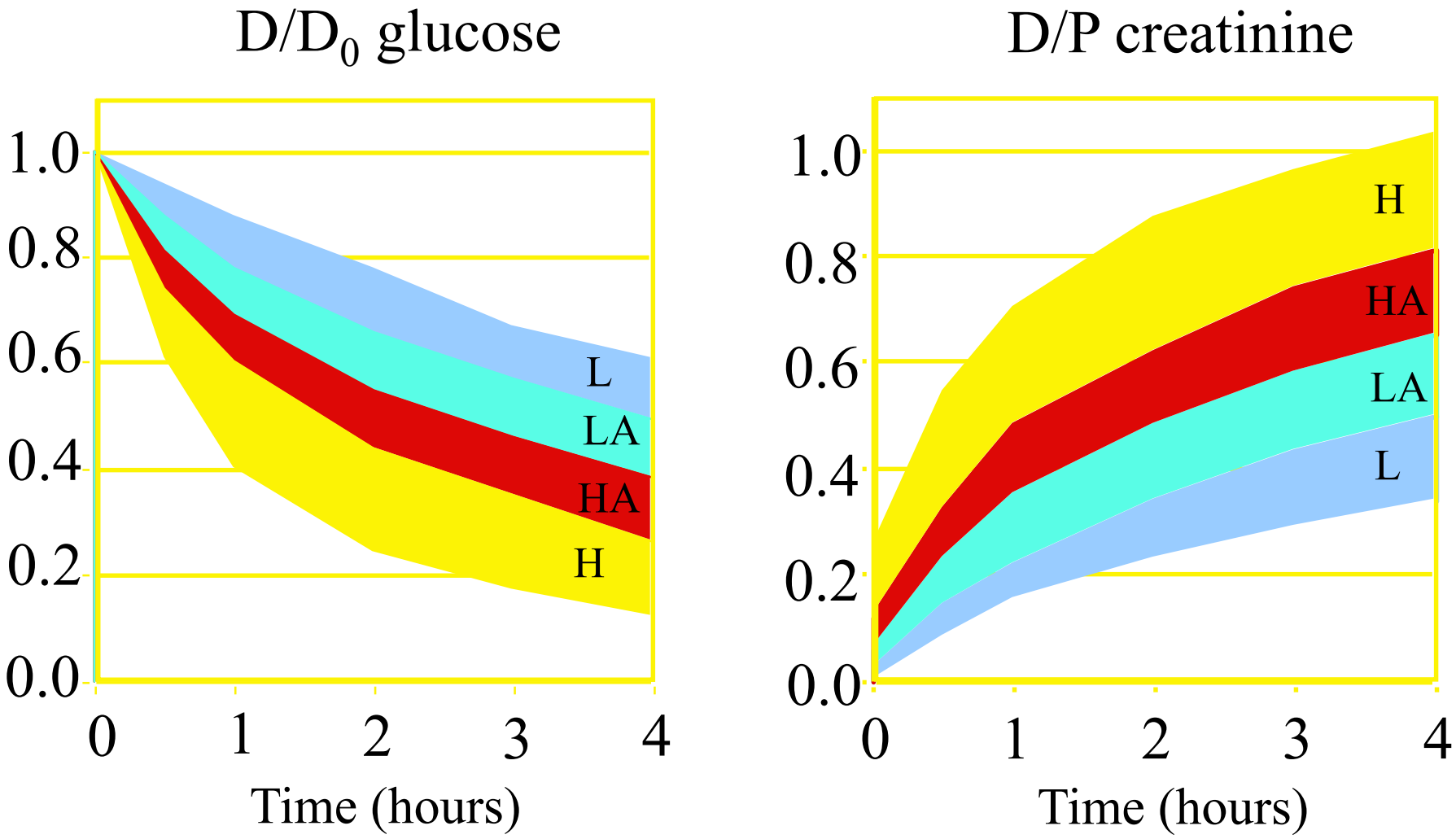
Mateijsen *et al.* PDI, 19: 517-525, 1999



Net result

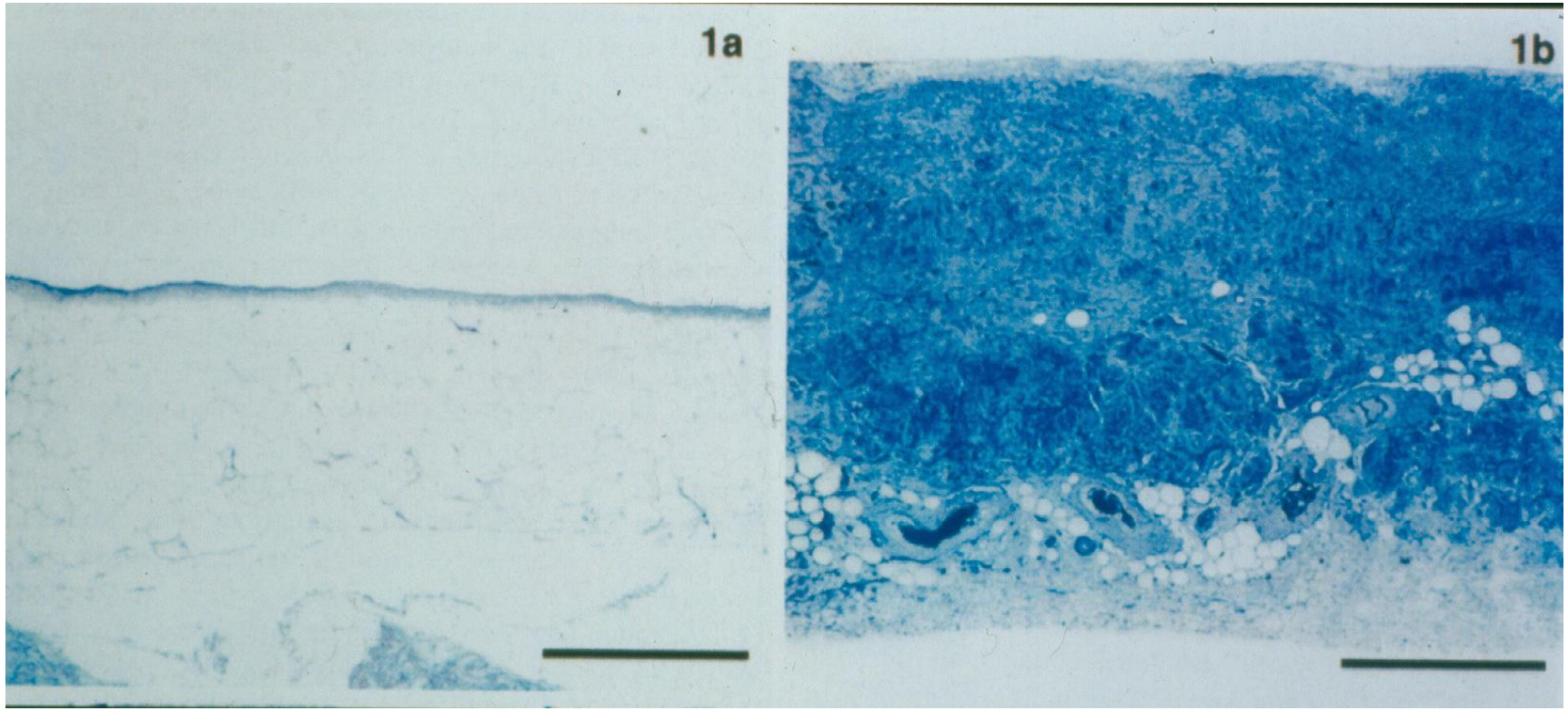


PET



[Twardowski et al: PDI 7: 138-147, 1987]

Submesothelial “scarring” in a long-term PD patient with marked UFF



Williams et al, J Am Soc Nephrol 2002;13:470-479

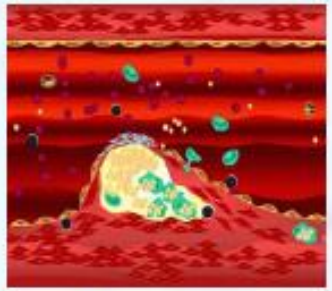
Clinical Consequences of high GLUCOSE concentrations in PD solutions

1.- MEMBRANE FAILURE

- High transporter
- UF loss
- Inadequate dialysis

AHT

Atherosclerosis



- Hiperglucemia
- Hiperinsulinemia
- Hiperlipemia

DM

2.- GENERAL METABOLIC PROBLEMS

MIA Syndrome

Metabolic Problems of the PD Patient

- Long time dextrose exposure
- A lot of dextrose absorption
- Weight gain
- Insulin resistance
- Metabolic syndrome
- Specific lipid related issues
- Like: leptin, adinoponectin, ghrelin
- Protein losses

UFF Classification

Type I

- High transport status
- Rapid loss of glucose osmotic gradient
- Commonest; increases with time

Type II

- Low transport status
- Loss of peritoneal surface area
- Not common

Type III

- High lymphatic flow rate
- By exclusion of other types only
- Prevalence unknown

Type IV

- Aquaporin dysfunction
- Rare

Overall, UFF occurs in <3% of patients in Year 1,
In 9.5% by 3 years and in 30% by 6 years

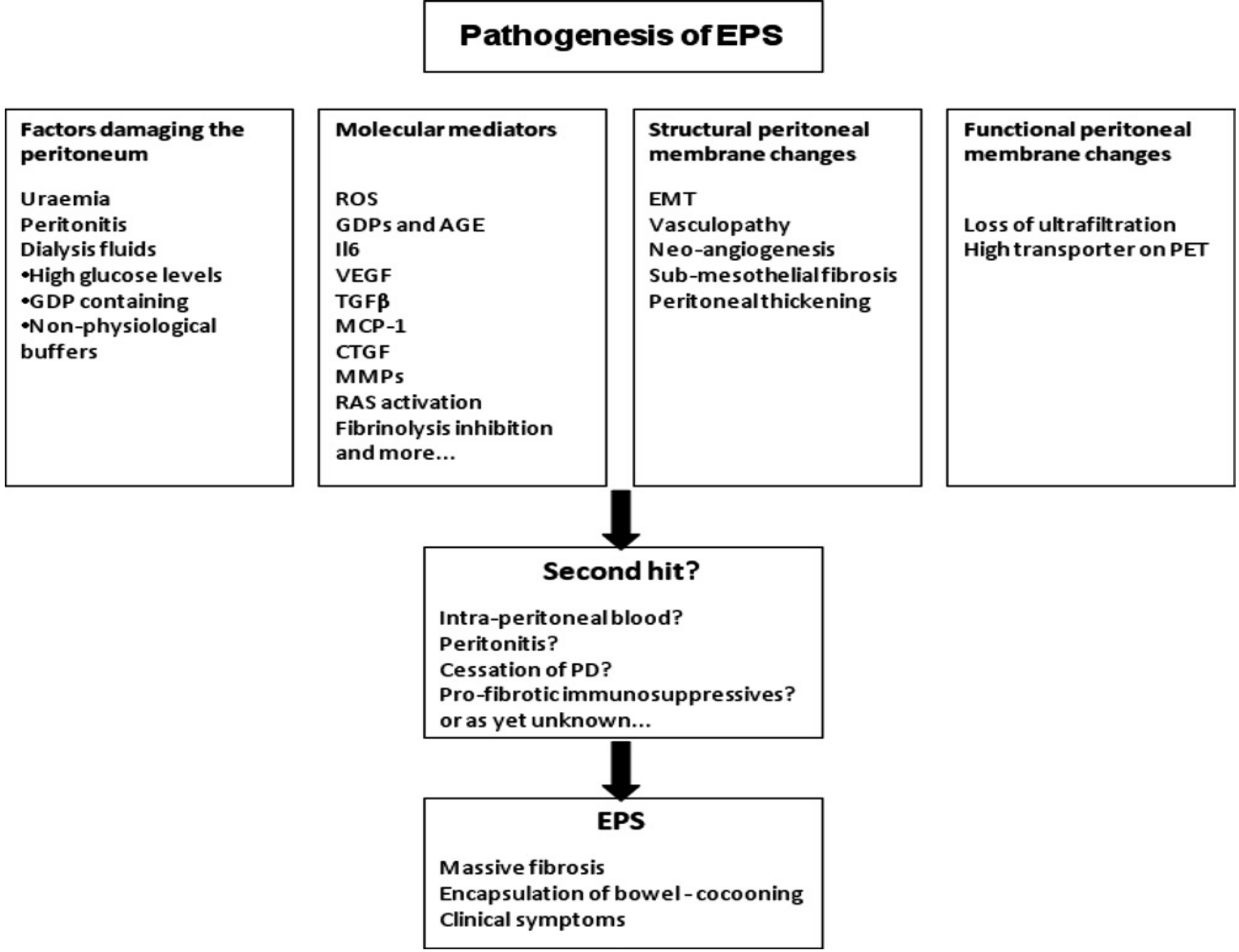
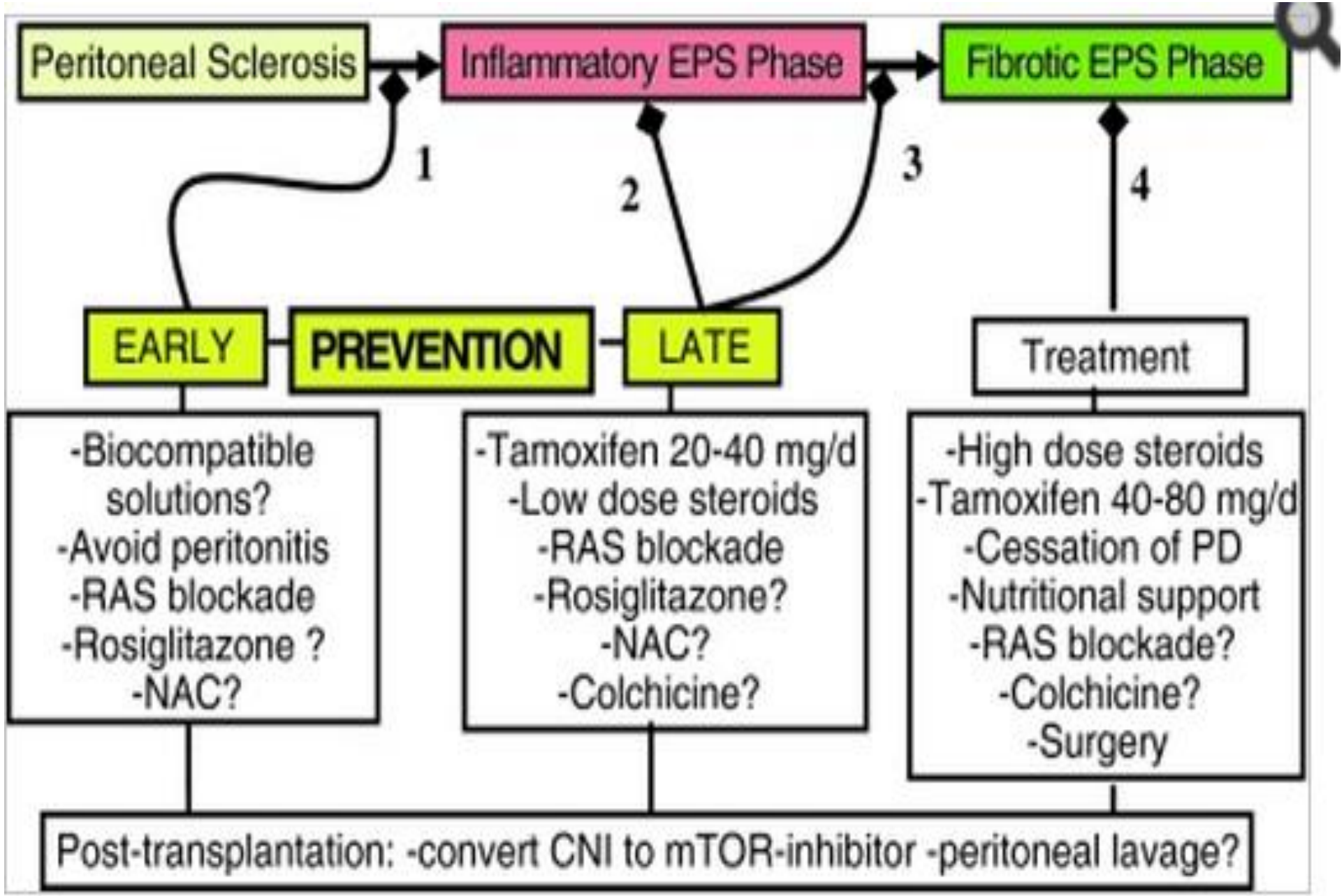

Pathogenesis of EPS
Factors damaging the peritoneum
Uraemia
Peritonitis
Dialysis fluids
•High glucose levels
•GDP containing
•Non-physiological buffers
Molecular mediators
ROS
GDPs and AGE
Il6
VEGF
TGFβ
MCP-1
CTGF
MMPs
RAS activation
Fibrinolysis inhibition
and more…
Structural peritoneal membrane changes
EMT
Vasculopathy
Neo-angiogenesis
Sub-mesothelial fibrosis
Peritoneal thickening
Functional peritoneal membrane changes
Loss of ultrafiltration
High transporter on PET
Second hit?
Intra-peritoneal blood?
Peritonitis?
Cessation of PD?
Pro-fibrotic immunosuppressives?
or as yet unknown…
EPS
Massive fibrosis
Encapsulation of bowel - cocooning
Clinical symptoms

Table 1. States of encapsulating peritoneal sclerosis and clinical manifestations

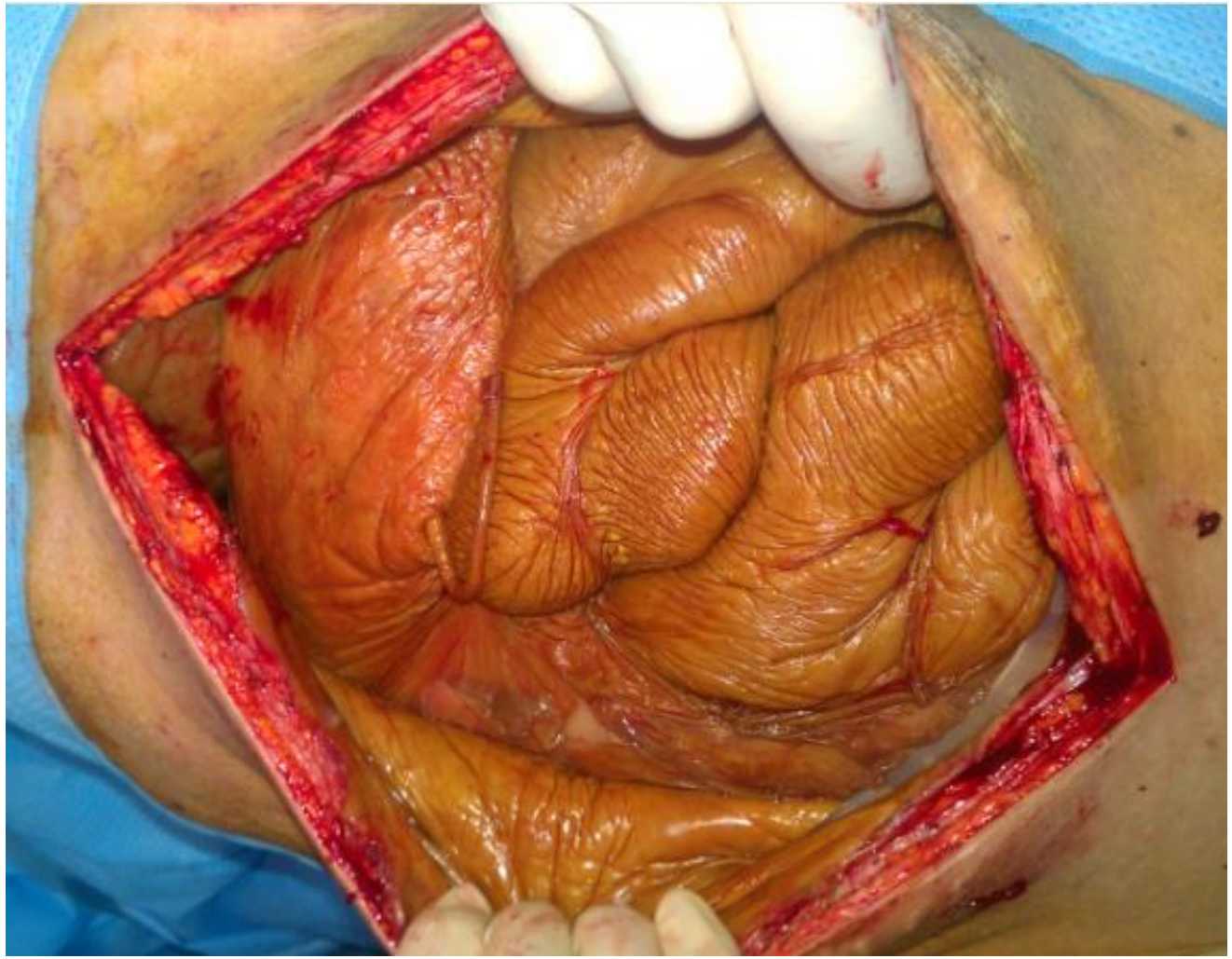
Stages	Findings
Stage 1. Asymptomatic (pre-EPS period)	Ultrafiltration failure, high transport, hypoproteinaemia, haemoperitoneum, ascites, and peritoneal calcifications.
Stage 2 (inflammatory period)	Haemoperitoneum, fever, ascites, weight loss, hyporexia, diarrhoea, increased concentrations of C-reactive protein.
Stage 3 (progressive or encapsulating period)	Signs and symptoms of ileus (nausea, vomiting, abdominal pain, constipation, abdominal mass, ascites).
Stage 4 (obstructive period)	Anorexia, complete intestinal obstruction, and abdominal mass.

EPS: encapsulating peritoneal sclerosis.
Modified from Nakamoto et al.[2]

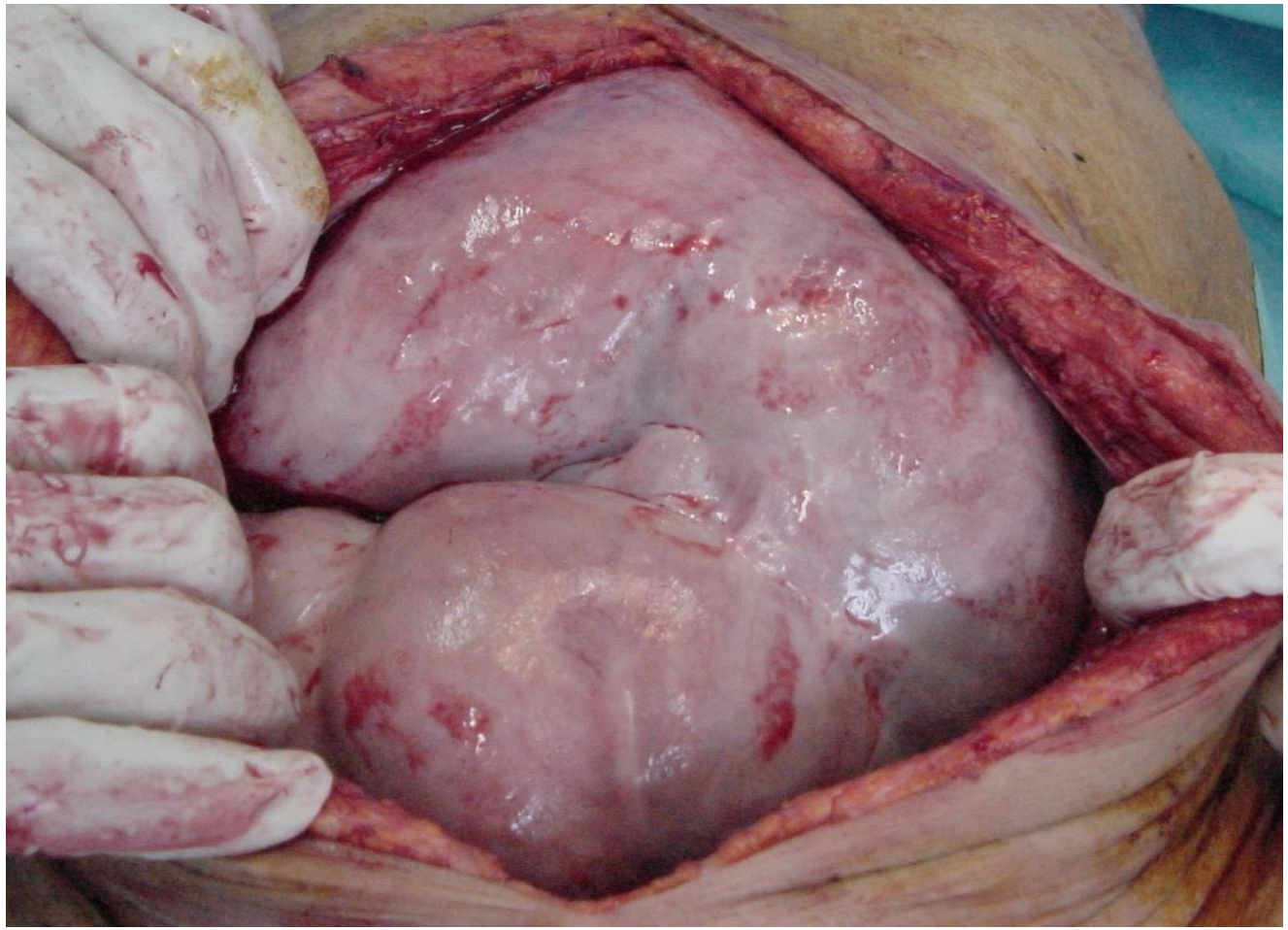


Int Urol Nephrol. 2011 March; 43(1): 147–156

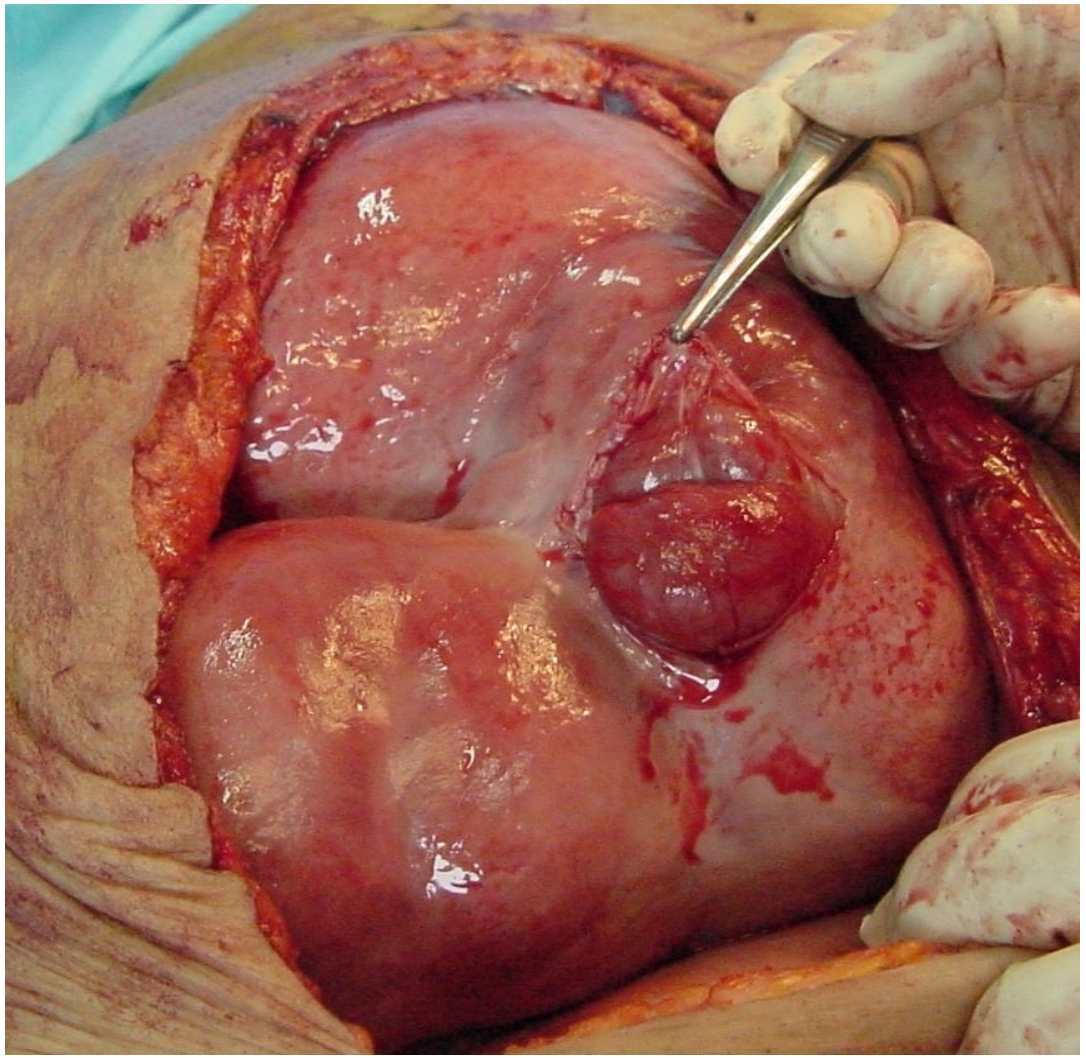
EPS Fibrous cocoon



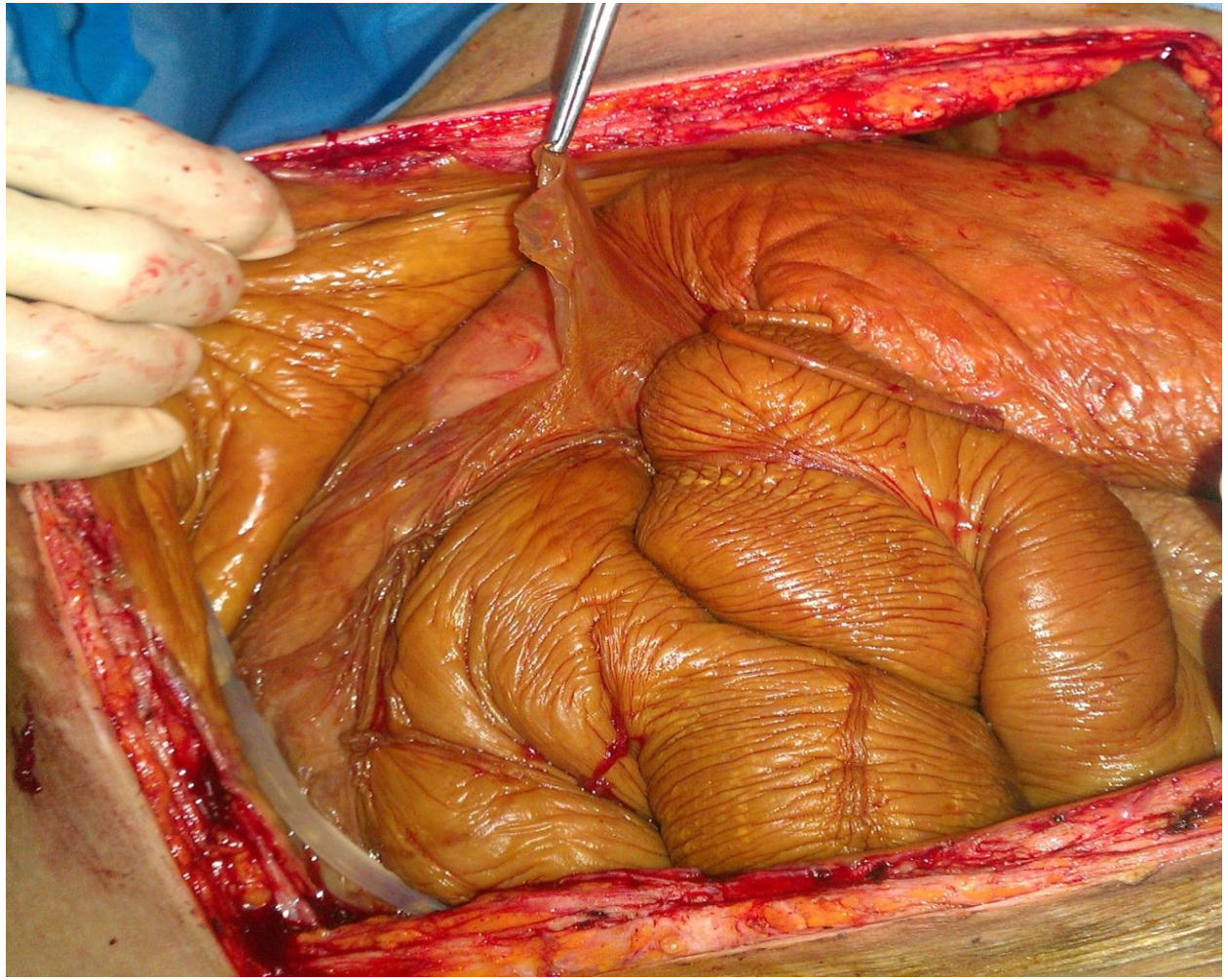
EPS



EPS

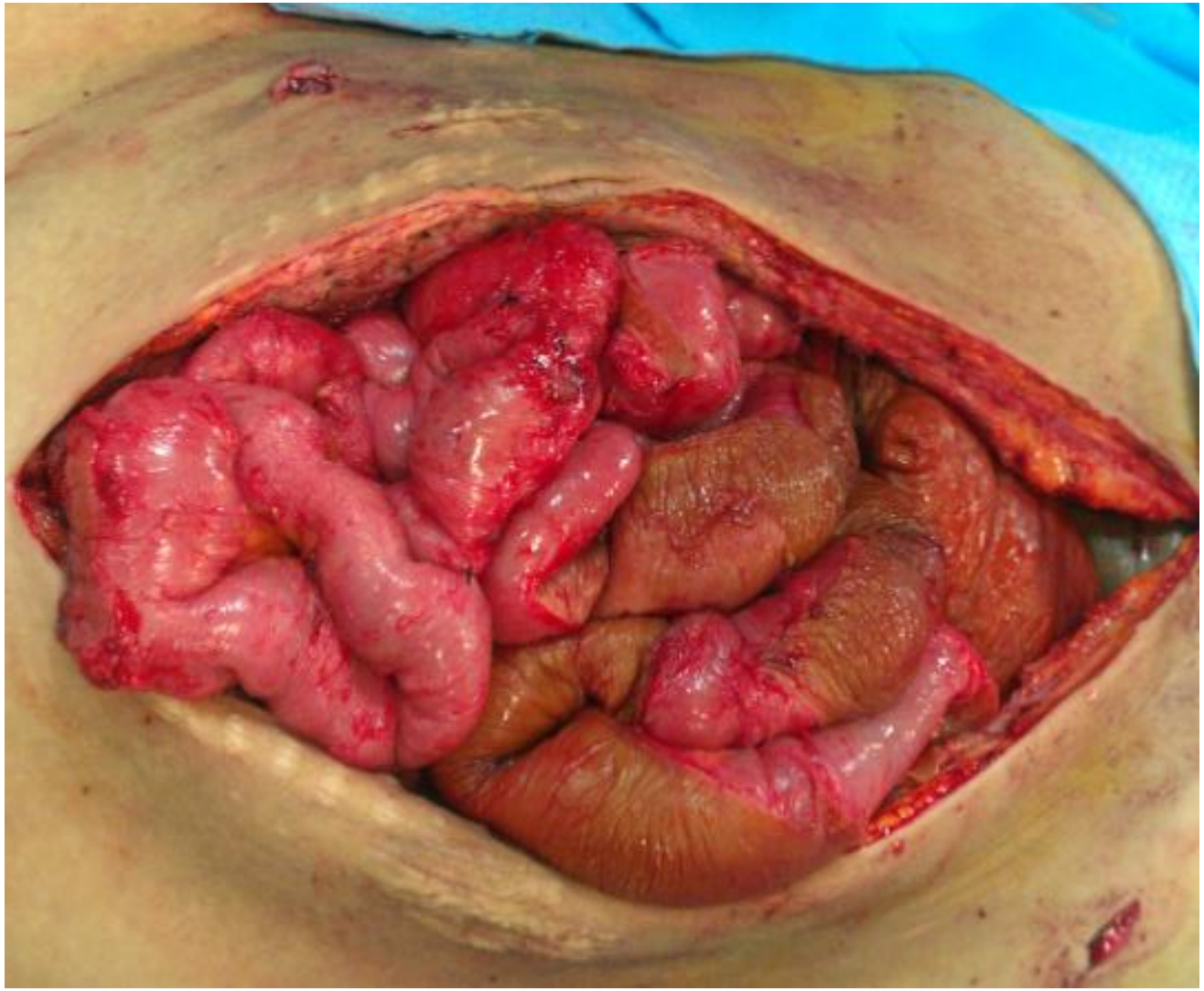


EPS Fibrous thick peritoneum

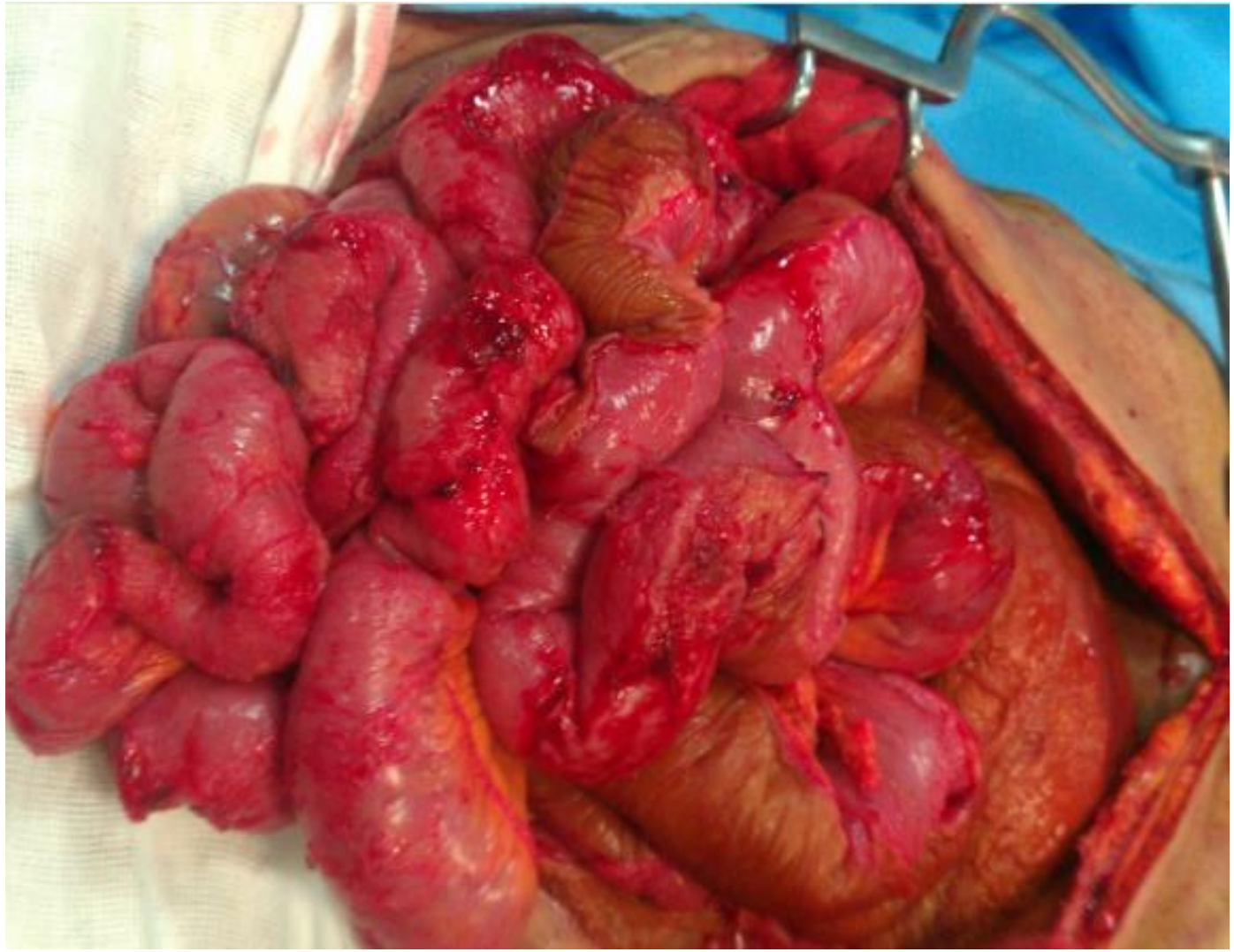


Small bowel entrapped in cocoon

EPS during Enterolysis surgery



EPS after Enterolysis surgery



برخورد با بیمار دچار Overload

- در اولین مرحله باید مسئله عدم رعایت رژیم غذایی و مصرف آب و نمک زیاد توسط بیمار مورد ارزیابی قرار گیرد. اگرچه شرح حال بسیار می تواند کمک کننده باشد ولی با اندازه گیری میزان توتال سدیم دفعی از طریق ادرار 24 ساعته و مجموعه دیالیزات خروجی بصورت دقیق میتوان آنرا رد یا اثبات کرد.
- در مرحله بعد باید میزان باقیمانده کار کلیه و حجم ادرار 24 ساعته چک گردد. بدیهی است در مواردی، با کاهش تدریجی و گریزناپذیر کار کلیه بیمار مبتلا به overload خواهد گردید.

اشکالات مکانیکی

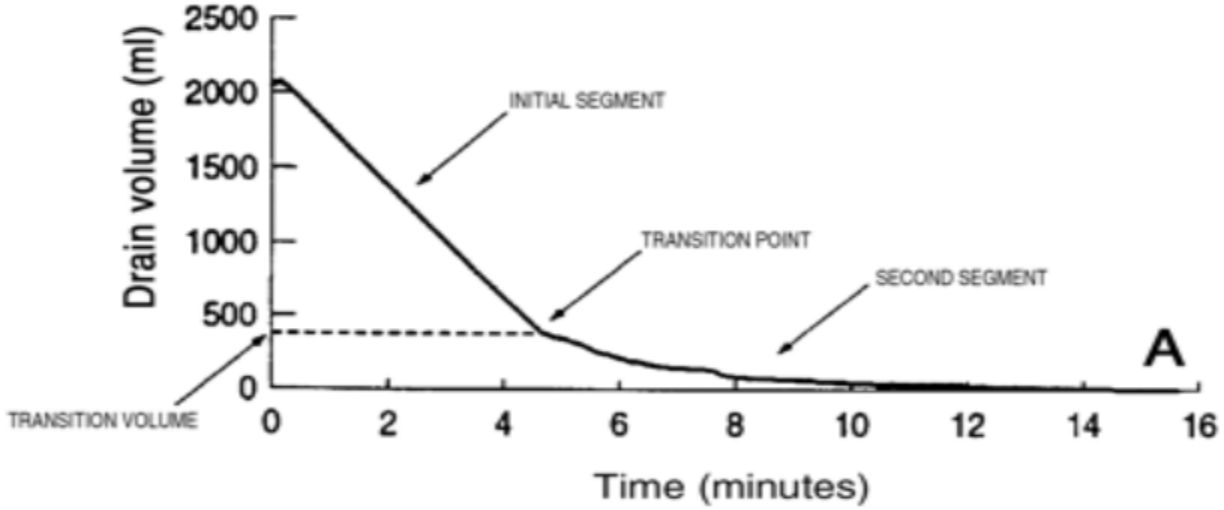
- مورد دیگری که میتواند با کاهش مایع برگشتی و overload همراه گردد اشکالات مکانیکی از قبیل leak مایع به فضای پلور یا رتروپریتوان یا عضلات قسمت قدامی شکم و اشکالات در کاتتر اعم از پیچ خوردگی ، تغییر جای نوک کاتتر و خارج شدن از لگن تشریحی، انسداد کاتتر از داخل بخاطر لخته فیبرینی یا لخته خونی یا انسداد سوراخهای کاتتر از خارج بخاطر یبوست شدید و چسبندگی به احشاء یا چسبندگی چادرینه بصورت Peritoneal cap یا Peritoneal Wrap میباشد.

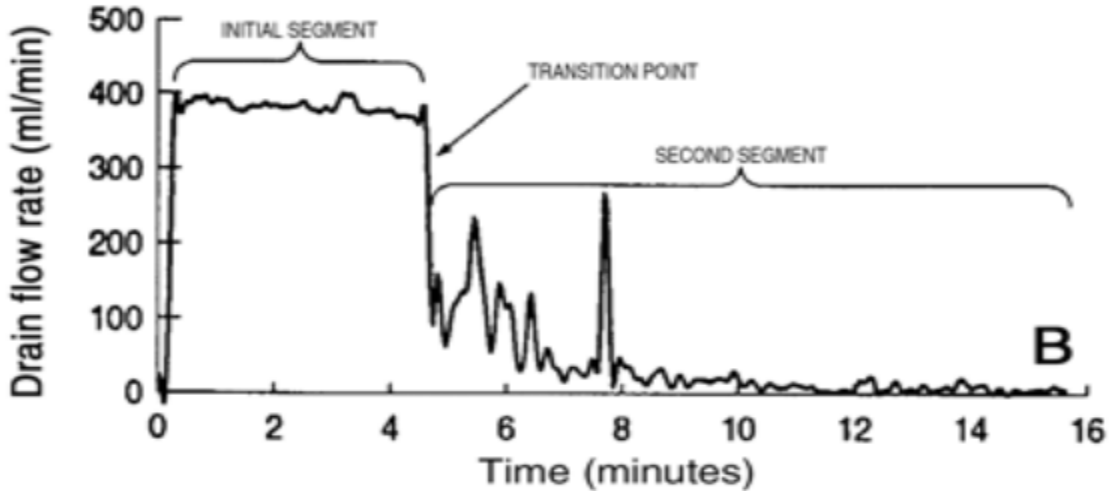
- **کلاً در مواردیکه اولترافیلتراسیون حتی علیرغم مصرف ایکودکسترین منفی باقی بماند، باید به این موارد مشکوک شد.**

اشکالات مکانیکی

- در برخورد عملی با این بیماران ابتدا یک Rapid exchange (ورود کامل مایع به حفره صفاق و خروج فوری آن) زیر دید مستقیم خودمان انجام می دهیم تا از نحوه ورود و سرعت ورود مایع، نحوه خروج و مشخص شدن زمان Break point و میزان UF در این حالت باخبر شویم. اگر در هر کدام از موارد فوق مشکلی وجود داشت پی به وجود اشکال مکانیکال خواهیم برد.

Peritoneal outflow curve





اشکالات مکانیکی(کاتتر)

- **اگر** در نحوه ورود و خروج اختلالی رؤیت شود اشکال در کارکرد کاتتر است.
- **اگر** با مسهل شدید مشکل مرتفع شود که معمولاً در 50% موارد میشود، مشکل جابجایی نوک کاتتر بخاطر یبوست یا فشار مواد فکالوئید روی سوراخهای کاتتر بوده است.
- **اگر** این مشکل با تزریق هپارین یا اوروکیناز به لومن کاتتر حل شود، اشکال تخلیه محلول در لخته فیبرین یا لخته خون در لومن کاتتر یا چسبندگی خفیف مزو به نوک کاتتر بوده است.
- **اگر** با این تزریقات هم مسئله حل نشد و در عکس ساده شکم نوک کاتتر در لگن تشریحی نباشد و نوک کاتتر به زیر دیافراگم یا جایی دیگر در شکم منتقل شده باشد اشکال در چسبندگی شدید چادرینه و جابجایی نوک کاتتر می باشد که از طریق Interventional Radiology یا لاپاراسکوپیک نوک کاتتر باید از مزو و چادرینه جدا شود. در موارد نادری عمل جراحی باز یا خارج کردن کاتتر ضرورت پیدا خواهد نمود.

اشکالات مکانیکی(نشط مایع)

- **اگر** در سرعت ورود مایع و جریان خروج مشکلی دیده نمی شود بجز اینکه مایع برگشتی مشخصاً کمتر از مایع ورودی است در اینجا leak تشخیص اصلی است که آنرا از طریق معاینه کلینیکال و دیدن غیر قرینگی شکم، ادم در ناحیه اسکروتوم یا Labia ، نمای پوست پرتقالی در ناحیه زیر شکم و وجود احتمالاً درد در ورود مایع مشخص می گردد.
- **بعضاً** فقط با CT اسکن شکم با ماده حاجب یا MRI (در آداپتورهای تیتانیومی امکانپذیر نخواهد بود) مسئله باثبات خواهد رسید.
- **Leak پلورال** با Tap مایع پلور و قند بسیار بالای آن باثبات میرسد.

عدم کمپلیانس (رژیم غذایی یا رژیم دیالیز)

- **اگر** علیرغم این اقدامات علت احتباس آب و نمک مشخص نبود باید در این مرحله اقدام به انجام یک Modified PET و اندازه گیری میزان UF چهار ساعته کرد.
- **اگر** میزان UF بیشتر از 400 cc است و D/P کراتی نین با اندازه گیریها در ماههای قبل فرقی ندارد، به احتمال زیاد مشکل ناشی از عدم کمپلیانس از نظر رژیم غذایی یا نوع و تعداد نامناسب مایع دیالیز مصرفی می باشد.
- **اگر** آنهم اشکال نداشت شاید مسئله کاهش باقیمانده کار کلیه باشد

(UFF)

- **ولی** اگر در انجام PET ، نارسایی اولترافیلتراسیون (UFF) با حجم زیر 400 cc در 4 ساعت باثبات رسید در گذشته از طریق نگاه به تغییرات در Small solute profile دامنه تشخیص را تنگتر می کردند.
- **اگر D/P کراتی نین نسبت به ماهها قبل کاهش پیدا کرده بود** و به زیر 6/0 رسیده بود. تشخیص تیپ II نارسایی مامبران (پریتوان اسکلروزه با چسبندگی های زیاد) باثبات می رسید که اگر با بالا بردن حجم مایع دیالیز مصرفی، کلیرانس به حد کفایت نمی رسید، بیمار باید از دیالیز خونی چه بصورت Hybrid و چه بصورت کامل استفاده بعمل می آورد.
- **اگر D/P کراتی نین افزایش پیدا کرده بود** و یا به بالای 8/0 رسیده بود، مسئله تیپ I نارسایی مامبران یا بصورت موقت بدنبال پریتونیت یا بصورت دائم، مطرح می شد. که در این حالت بیمار باید APD شود و در Dwell های طولانی ایکودکسترین مصرف نماید

(UFF)

- **و بالاخره اگر در D/P کراتی نین تغییری نسبت به قبل مشاهده نمی گردید و بین (8/0 تا 6/0) بود** تشخیص افتراقی بشرح زیر بود:
- 1) افزایش بازجذب لمفاتیک یعنی تیپ III نارسایی مامبران
- 2) مشکل در کانالهای بسیار کوچک (کانالهای آب) تیپ IV نارسایی مامبران
- 3) اشکال در (Hydraulic conductance of membrane) Glucose osmotic conductance
- 4) Occult leak or occult catheter dysfunction

- **در سالهای جدید برای افتراق موارد مشروحه فوق که به تنهایی با انجام PET حتی از نوع Modified قابل افتراق نبودند از روشهای جدید PET استفاده می کنند**

JNEPHROL 2010; 23(06): 633-647

www.sin-italy.org/jnonline – www.jnephrol.com

Peritoneal transport testing

Vincenzo La Milia

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Abstract

Different tests can be used to provide valuable information about the function of the peritoneal membrane. The data obtained can be useful for tailoring dialysis adequacy, for the analysis of clinical problems such as

the analysis of clinical problems such as ultrafiltration (UF) failure (UFF) (1) and to predict the development of severe peritoneal membrane damage.

The analysis of the anatomic changes of peritoneal tissue can be performed only during the placement or removal of a peritoneal catheter or during other surgical procedures.

Peritoneal Barrier Assessment: Clinical Functional Tests

- Peritoneal Equilibration Test (PET)
  - Standard PET, Fast PET
  - Modified or High Glucose 4.25%/3.86% PET
  - Mini-PET
  - Double Mini-PET
- Dialysis Adequacy and Transport Test (DATT)
- Accelerate Peritoneal Exchange Time (APEX)
- Peritoneal Dialysis Capacity (PDC)
- Standard Permeability Analysis (SPA)

Tests for evaluation of peritoneal membrane function

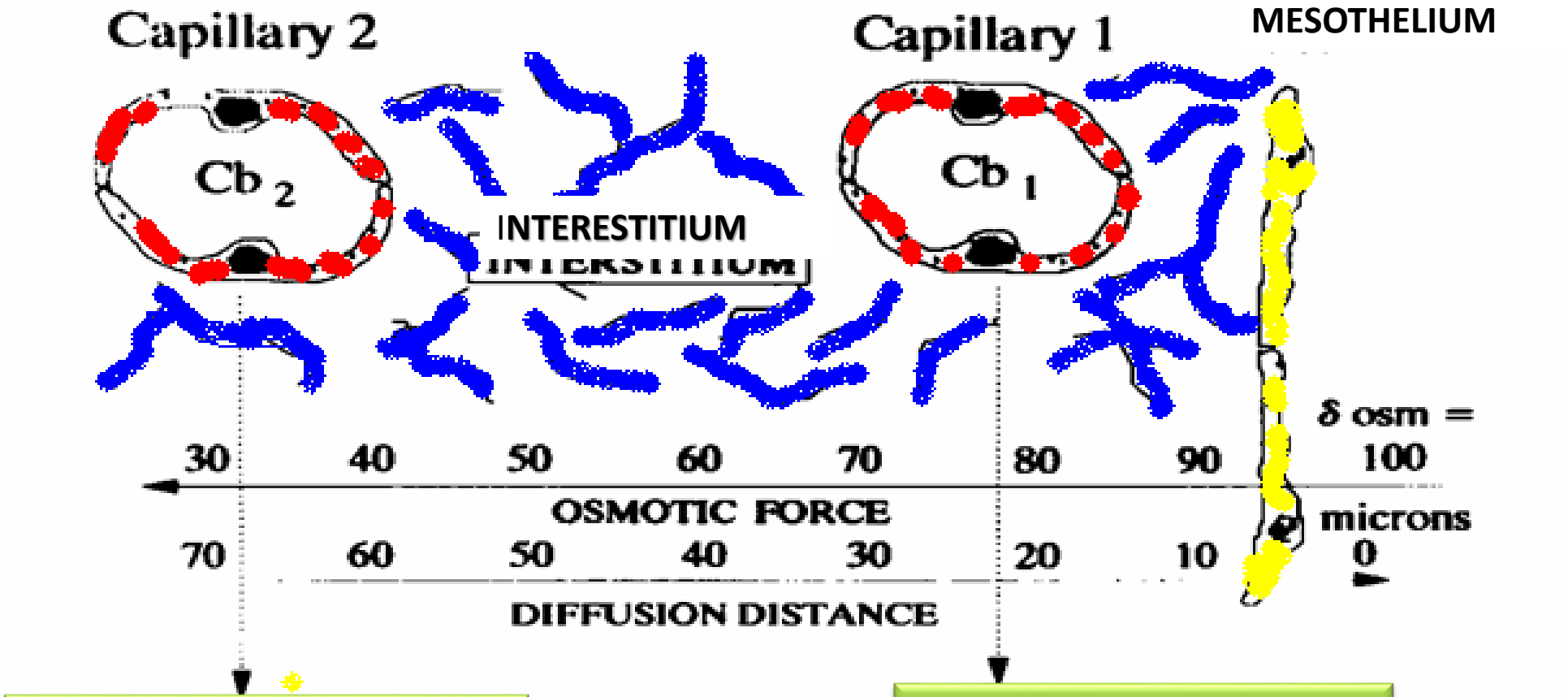
Mini-PET	1-hour test exchange 3.86% glucose solution	D/PCreat; Dt/D0 glucose after 1 hour	Maximal UF capacity after 1 hour Measures of Na sieving (all) FWT UFSP
Double Mini-PET	Two 1-hour test exchanges (performed consecutively) 1st exchange 1.36% 2nd exchange 3.86%	D/PCreat; Dt/D0 glucose after 1 hour	Minimal and maximal UF capacity after 1 hour Measures of Na sieving (all) FWT UFSP OCG
Combined 3.86%-PET	4-hour test exchange 3.86% glucose solution Temporary drainage of dialysate after 1 hour to assess the volume by weighing and taking a dialysate sample. Then reinfusion of dialysate (left in place for another 3 hours)	D/PCreat; Dt/D0 glucose	Maximal UF capacity after 1 and 4 hours Measures of Na sieving (all) FWT UFSP
Uni-PET	Two test exchanges (performed consecutively) 1st exchange 1.36% lasting 1 hour 2nd exchange 3.86% lasting 4 hours: Temporary drainage of dialysate after 1 hour to assess the volume by weighing and taking a dialysate sample. Then reinfusion of dialysate (left in place for another 3 hours)	D/PCreat; Dt/D0 glucose	Maximal UF capacity after 1 and 4 hours Measures of Na sieving (all) FWT UFSP OCG

Concept:

The Interstitium does matter as a barrier to small solute transport

Distributed Model (Compartmental model)

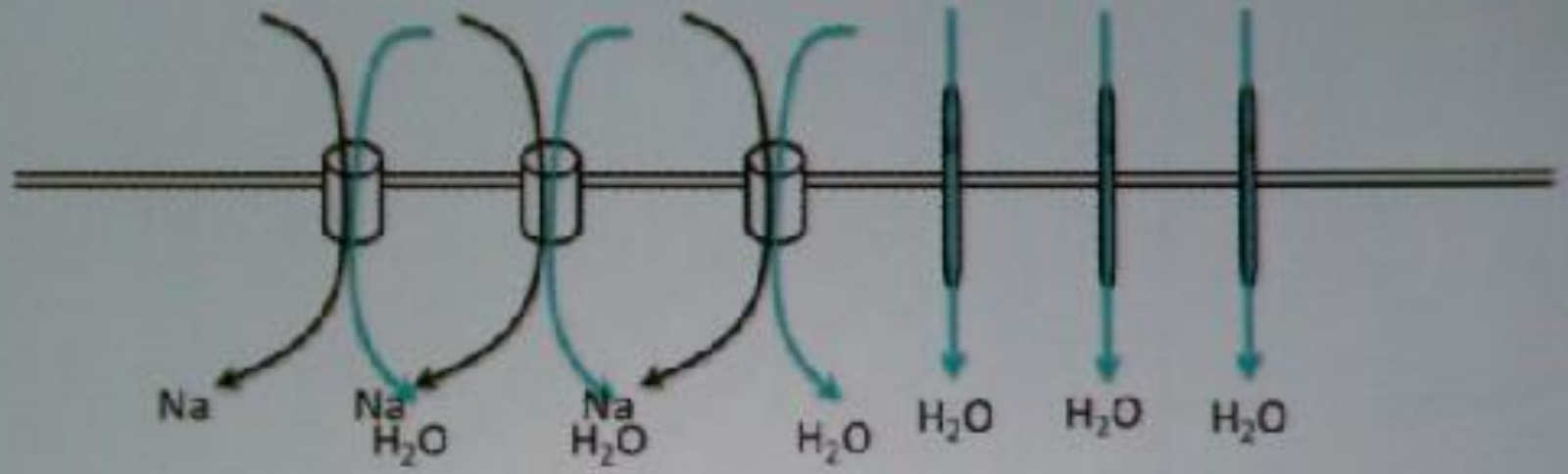
Distributed model and effective peritoneal surface area



Distal capillary:
Low Osmotic Gradient
Low filtration Fraction
Slow solute Diffusion

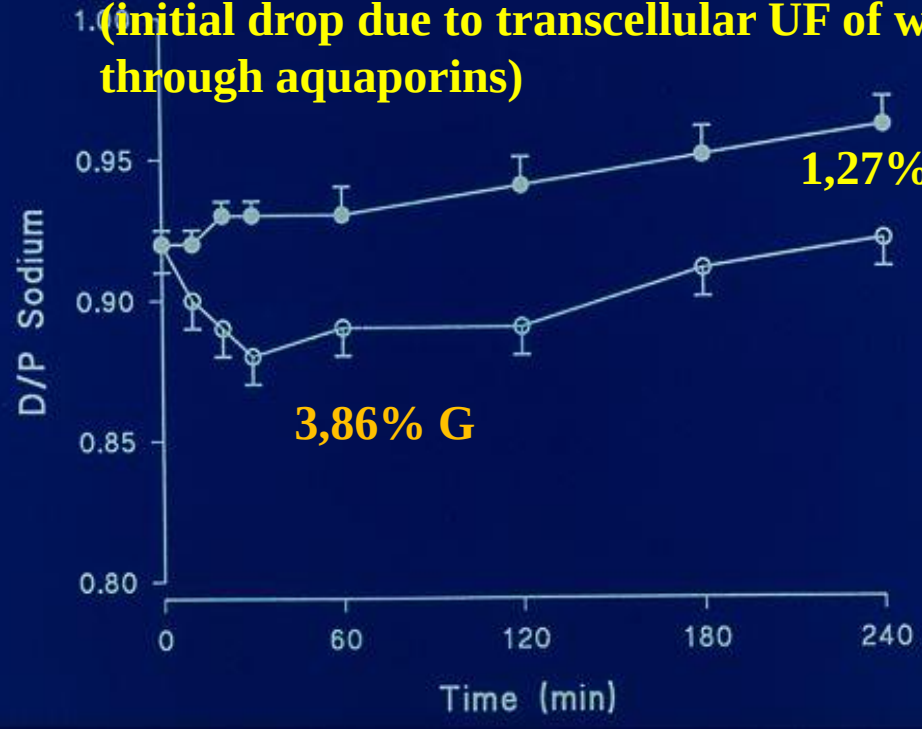
Nearest Capillary :
High Osmotic Gradient
High filtration Fraction
High solute Diffusion

Na Seiving

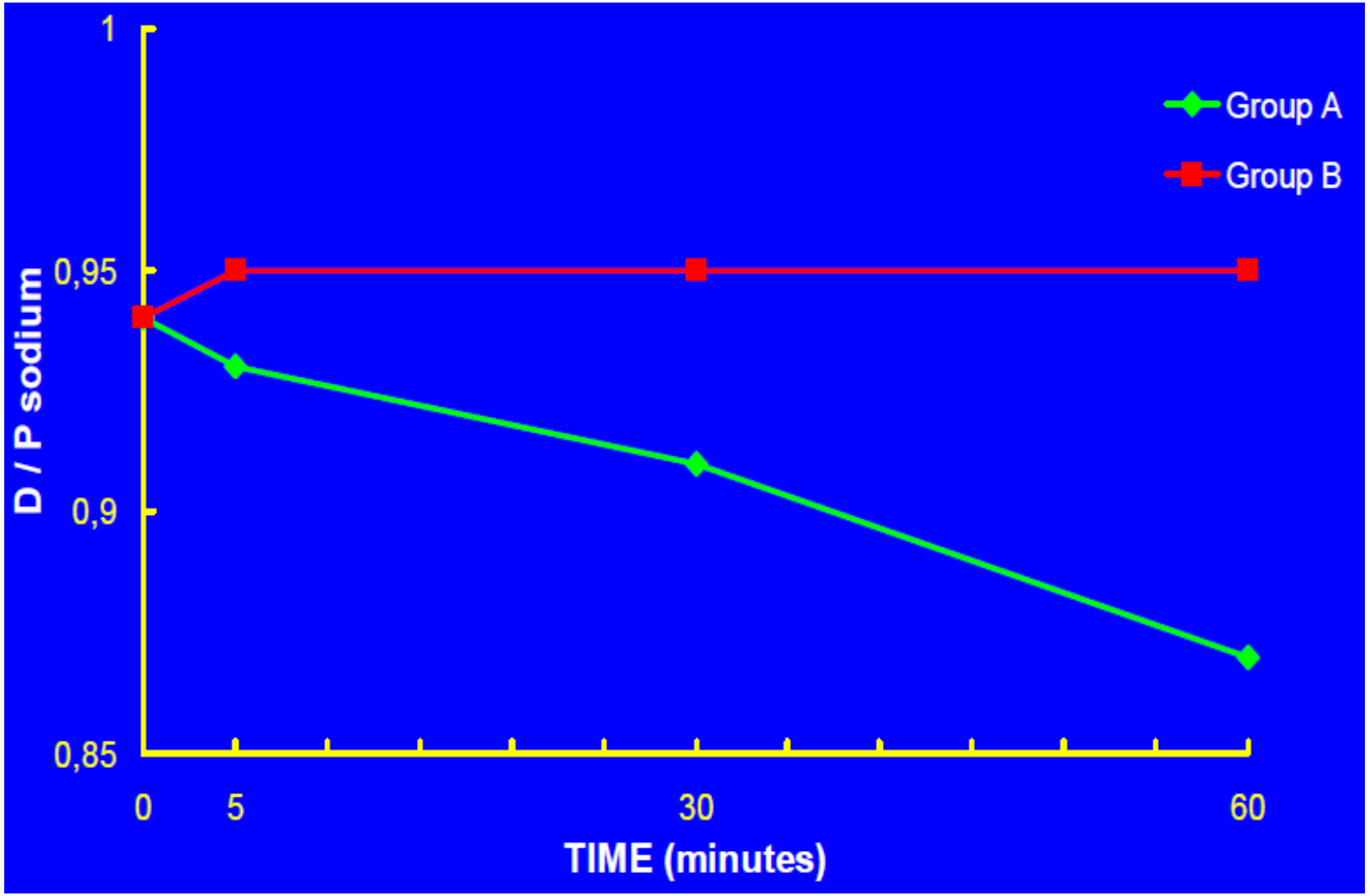


- Initially, more H_20 can cross through Aquaporin
- Dilution effect causes drop in Na concentration
- Diffusion of Na to equilibrate Na concentration

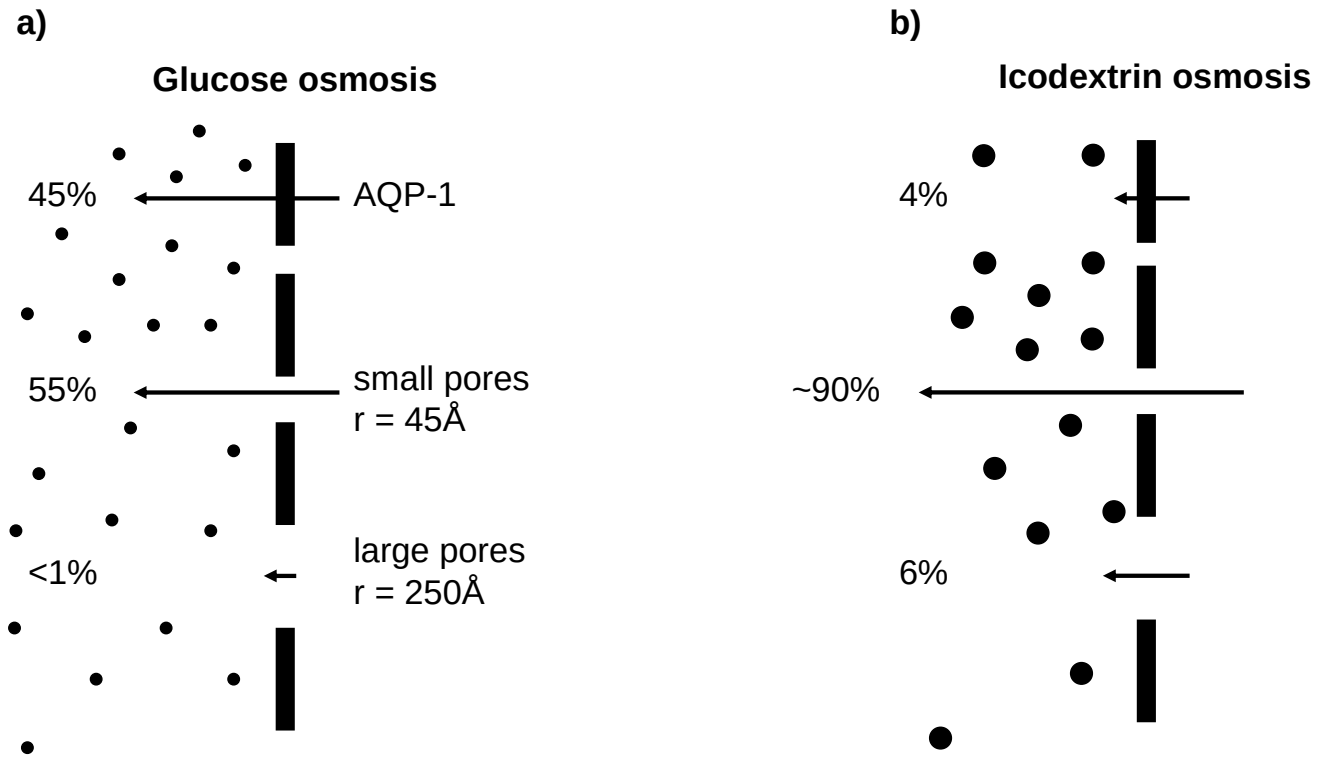
(initial drop due to transcellular UF of water through aquaporins)



Icodextrin Vs Glucose based Solutions



Partitioning of fluid flows in the TPM for glucose osmosis *vs.* ICO osmosis



Ultrasmall VS Small Channel

- The resistance in the aquaporins is much higher than in the small pores due to the difference between the two in radius.

- Water channels require very high osmotic pressure gradients

- The crystalloid osmotic pressure gradient across the water channels is

- ***(347 – 305) × 19.3 = 811 mmHg for a 1.5% glucose solution***
- ***(486 – 305) × 19.3 = 3493 mmHg for a 4.25% glucose solution***

Extraneal PD solution

Composition

Icodextrin (g/dl)	7.5
Sodium (mEq/L)	132
Chloride (mEq/L)	96
Calcium (mEq/L)	3.5
Magnesium (mEq/L)	0.5
Lactate (mEq/L)	40
Osmolality (mOsm/kg)	282
pH	5.2-5.6

Characteristics

- Isosmolar to serum (282 mOsm/kg)
- UF equivalent to 4.25% dextrose
- Sustained positive net UF for >14 hr
- "Gentle" ultrafiltration
- One bag per day (long dwell)

Icodextrin

Extraneal

How dose it help in evaluation of peritoneal membrane function

Glucose based solution Vs Icodextrin

- **The pressure gradients across the peritoneal membrane that can be expected using:**

- 1.5% glucose-based solution is **12 mmHg**
- 4.25% glucose- based solution is **93 mmHg**
- 7.5% icodextrin-based dialysis solution is **42 mmHg**
- However, because of its lower absorption, the gradient will remain stable for a much longer period of time

Reflection coefficient for the osmotic agent

- (i.e., glucose).
- This **measures :**
- **how effectively the osmotic agent diffuses out of the dialysis solution into the peritoneal capillaries**.
- =between 0 and 1;
- **the lower the value**, :

I. the **faster** the **osmotic gradient is lost**

II. the **less** sustained **ultrafiltration** is.

- *glucose low (~ 0.03),*

- **The polyglucose , Icodextrin, has a reflection coefficient close to 1.0.**

The role of Icodextrin in peritoneal function evaluation

اگر دسترسی به این تستها ندارید از ایکودکسترین برای تشخیص افتراقی این موارد میتوانید کمک بگیرید، برای مثال :

1. اگر بیماری برگشتی اش بتازگی کم شده وبا ایکودکسترین نیزاصلاح نمیشود و پایین می ماند احتمالا با مشکل مکانیکال مثل لیک و جابجایی نوک کاتتر روبرو هستیم .
2. اگر این احتمال را با عکس ساده و سیتی اسکن شکم رد کردید، بیمار مبتلا به بازجذ ب لمفاوی زیاد یا اشکال در کانالهای آب میباشد که برای افتراق ایندو از هم Modified PET testبا محلول شماره 3 انجام میدهیم .

The role of Icodextrin in peritoneal function evaluation

3. در Modified PET test اگر Na dip داشته باشیم مشکل بازجذب لمفاتیک هست. Type 3 UFF

4. و اگر Na dip نداشته باشیم اشکال از کانالهای آب میباشد. Type 4 UFF

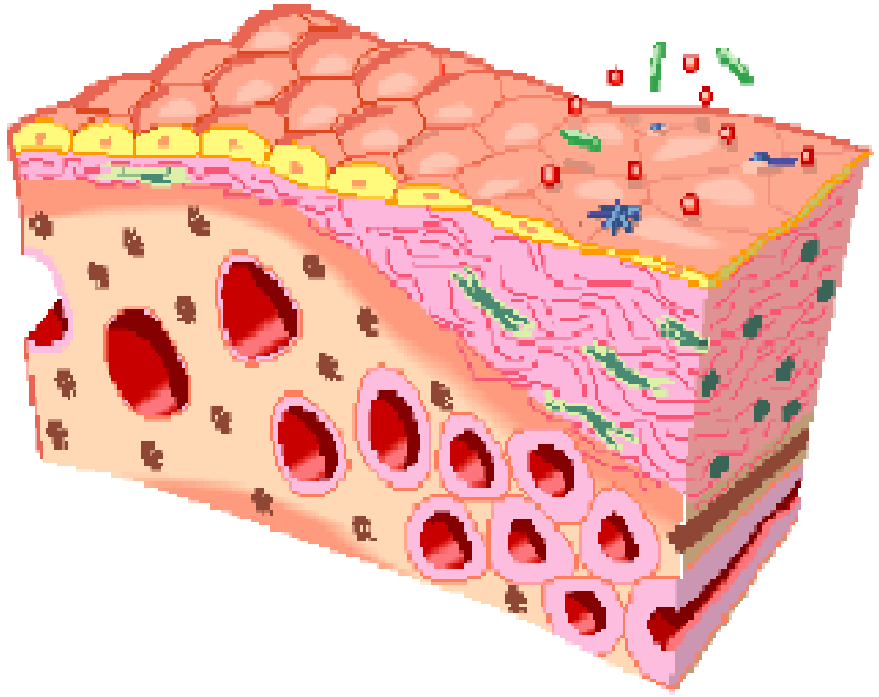
The role of Icodextrin in peritoneal function evaluation

- اگر بیماری Sodium dip مختلی دارد ممکن است به دو علت باشد .

1. Very Rapid transporter
2. Aouaporine deficiency

3. که در اولی میزان اولترافیلتراسیون در پاسخ به ایکودکسترین بشدت افزایش پیدا میکند در حالی که در نقص آکواپورین هیچ تغییری نمیکند.

Improving the quality of PD care



Changes to the peritoneal membrane over time

Extraneal and Nutrineal may preserve the membrane functionality for longer by:

- Reducing glucose exposure
- Reducing GDP

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Peritoneal Dialysis and Its Local and Systemic Complications: F
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REVIEW ARTICLE

Front. Physiol., 07 January 2019 | https://doi.org/10.3389/fphys.2018.01853

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Biocompatible Peritoneal Dialysis: The Target Is Still Way Off

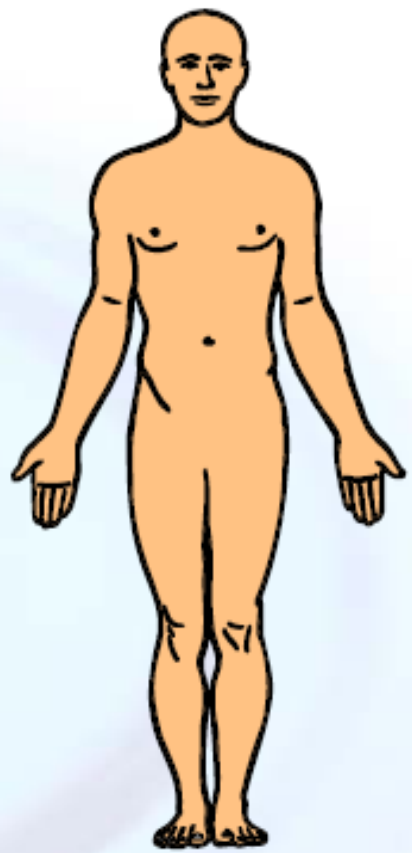
Maria Bartosova and Claus Peter Schmitt*

Center for Pediatric and Adolescent Medicine Heidelberg, University of Heidelberg, Heidelberg, Germany

Slowing down progression of co-morbidities

Advanced solutions in combination may help to slow down the progression of co-morbidities by:

- Minimising glucose load
- Optimising fluid balance
- Delivering 25% of daily protein needs
- Improving hyperlipidaemia
- Reducing hypertension
- Improving blood sugar control
- Preserving RRF




پیروز و سربلند
باشید