NON-INFECTIOUS COMPLICATIONS OF PD AND HD

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Fundamentals of Dialysis in Children
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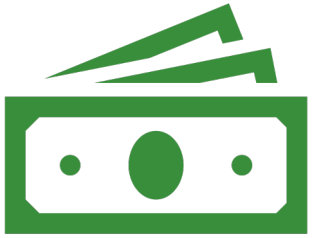
DISCLOSURES

NONE RELEVANT FOR THIS TALK



- Research Funding

DICERNA (Novo Nordisk)

- Consultant Fees, Speaker Fees and/or Travel Grants

ALNYLAM Pharmaceuticals

ARBOR Biotechnologies

DISCLOSURES

Clinical photos used with patient permission for educational purposes

OBJECTIVES

By the end of this session the learner will:

- Learn a framework for classifying some of the non-infectious complications of Peritoneal Dialysis (PD) and Hemodialysis (HD)
- Be able to recognize, investigate and/or treat some of the non-infectious complications of PD and HD in children

➢COMPLICATIONS CHOSEN

- ➢Major impact on patient themselves
- ➢Major impact on treatment success (or failure)
- ➢Less likely to be seen with small patient numbers but important for physicians to recognize when they occur

PERITONEAL DIALYSIS

CLASSIFICATION OF COMPLICATIONS OF PD

Infectious	Catheter related	Mechanical	Technique Related
Peritonitis	Catheter failure: one way and two way	Hernias	Ultrafiltration and membrane failure
Exit site infection	Catheter migration	Fluid leaks	Icodextrin allergy
Tunnel Infection	Omental grab	Hydrothorax	Sclerosing peritonitis
	Distal cuff erosion	Hemoperitoneum	Eosinophilic peritonitis
		Chyloperitoneum	Inadequate dialysis Electrolyte disturbances
	Peritoneal irritation	Abnormal fluid color	Hypervolemia/hypovolemia (Hyper- and hypo- tension
	Intra-abdominal trauma	Increased intra-peritoneal pressure	Iodine toxicity

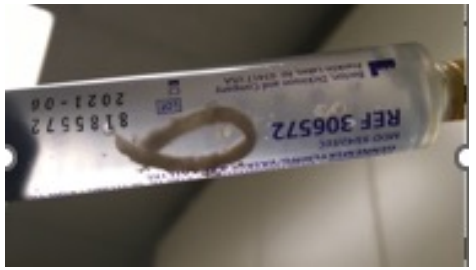
SickKids®

CATHETER RELATED

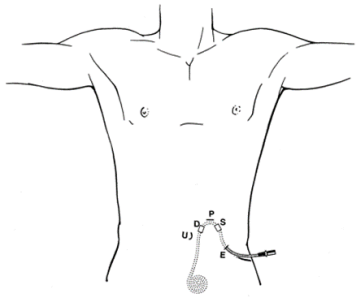
ONE WAY FAILURE

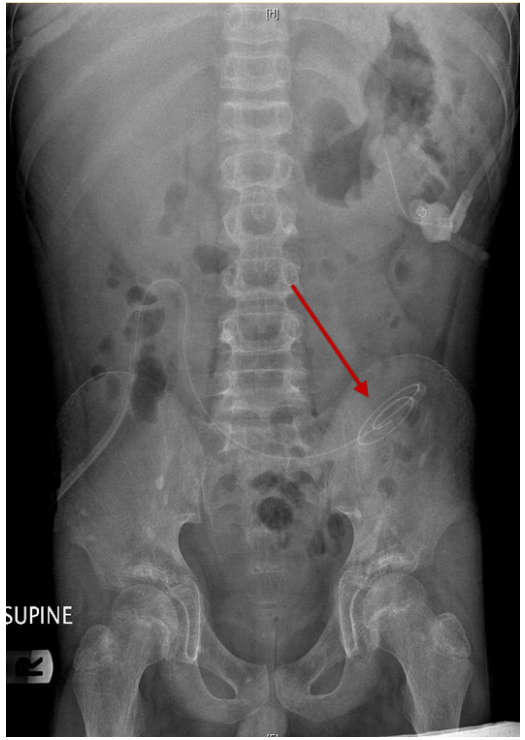
Defined as unidirectional flow only in the catheter

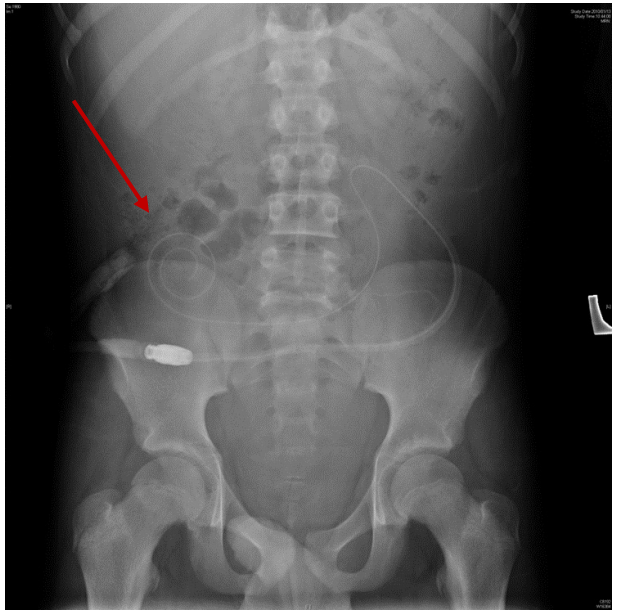
- Usually OUTFLOW failure with initially preserved inflow
- Often caused by omental projections in the catheter or clots/fibrins which compress and occlude the lumen during outflow
- Often progresses to bidirectional (two-way) failure
- Inflow failure
  - Check for clamps or kinking of catheter
  - Happens with Dialynate™ setup with high infusion volumes
  - Described with accordian clots/fibrins in the catheter

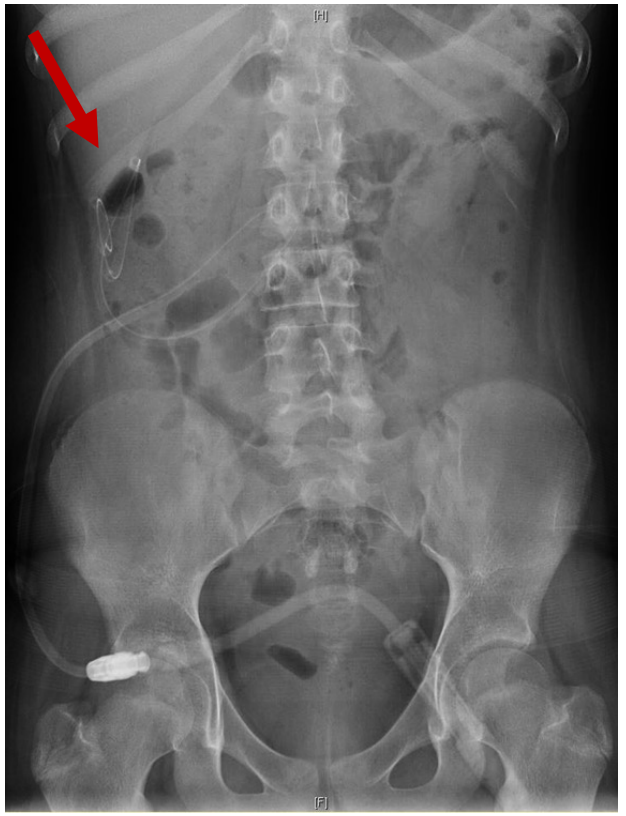


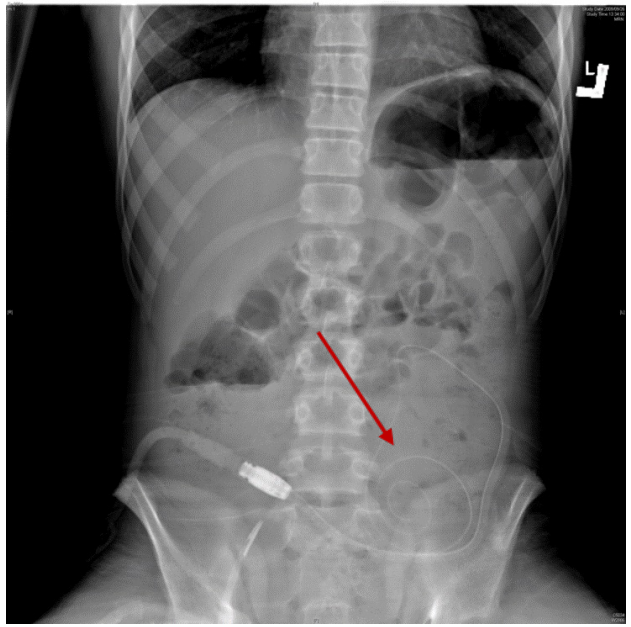
CATHETER MIGRATION





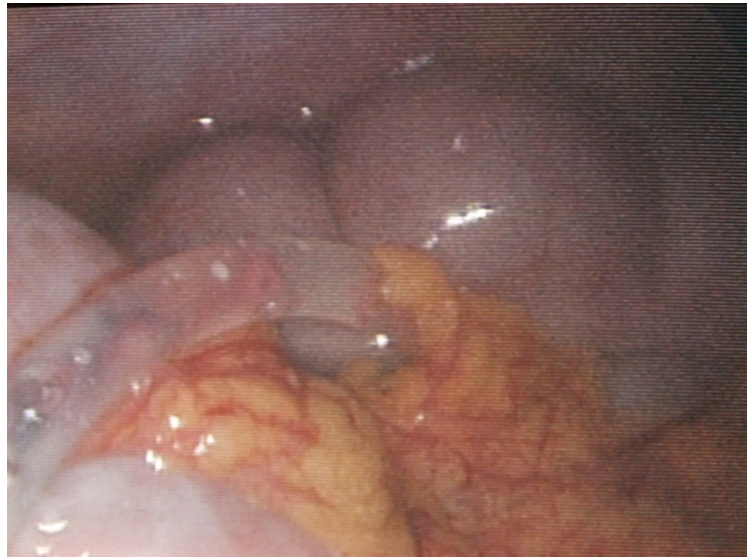


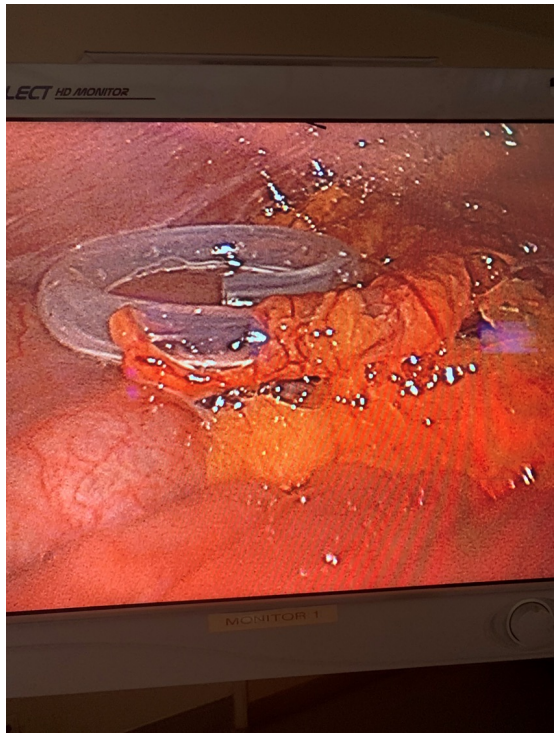


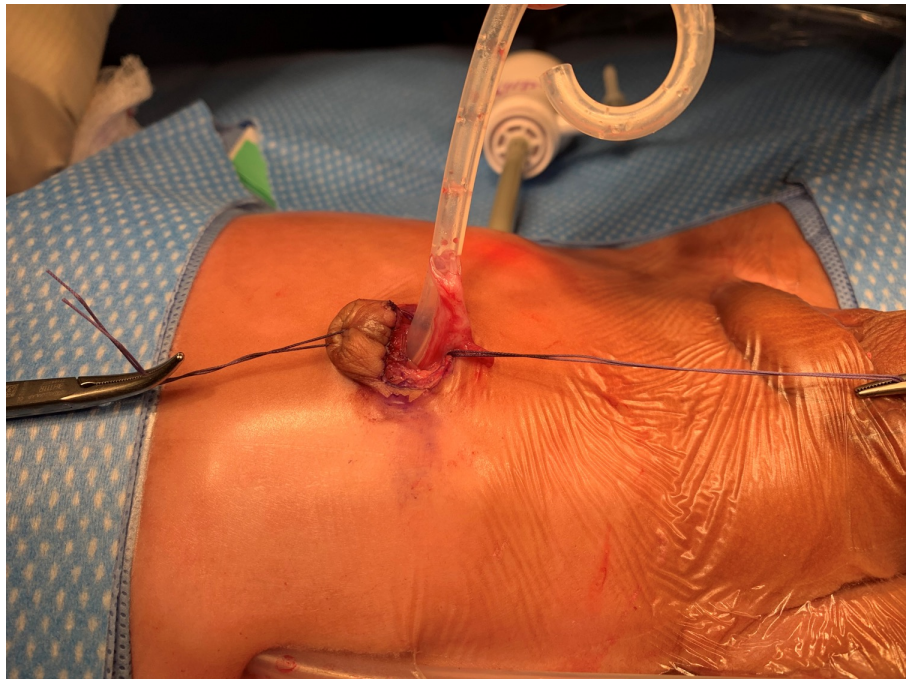


- Catheter migration does NOT equal dysfunction
- Catheters may move within the lower abdomen or pelvis
- Catheters may be displaced out of the pelvis with constipation or overdistended bladders

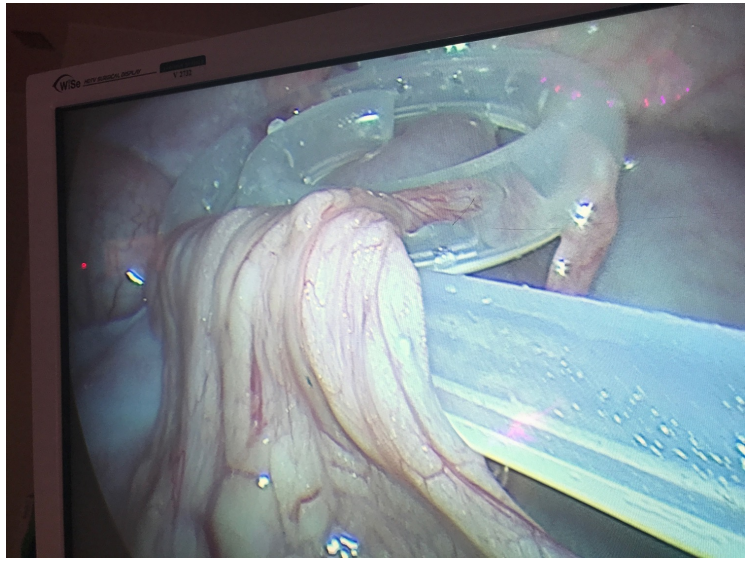
OMENTAL GRAB







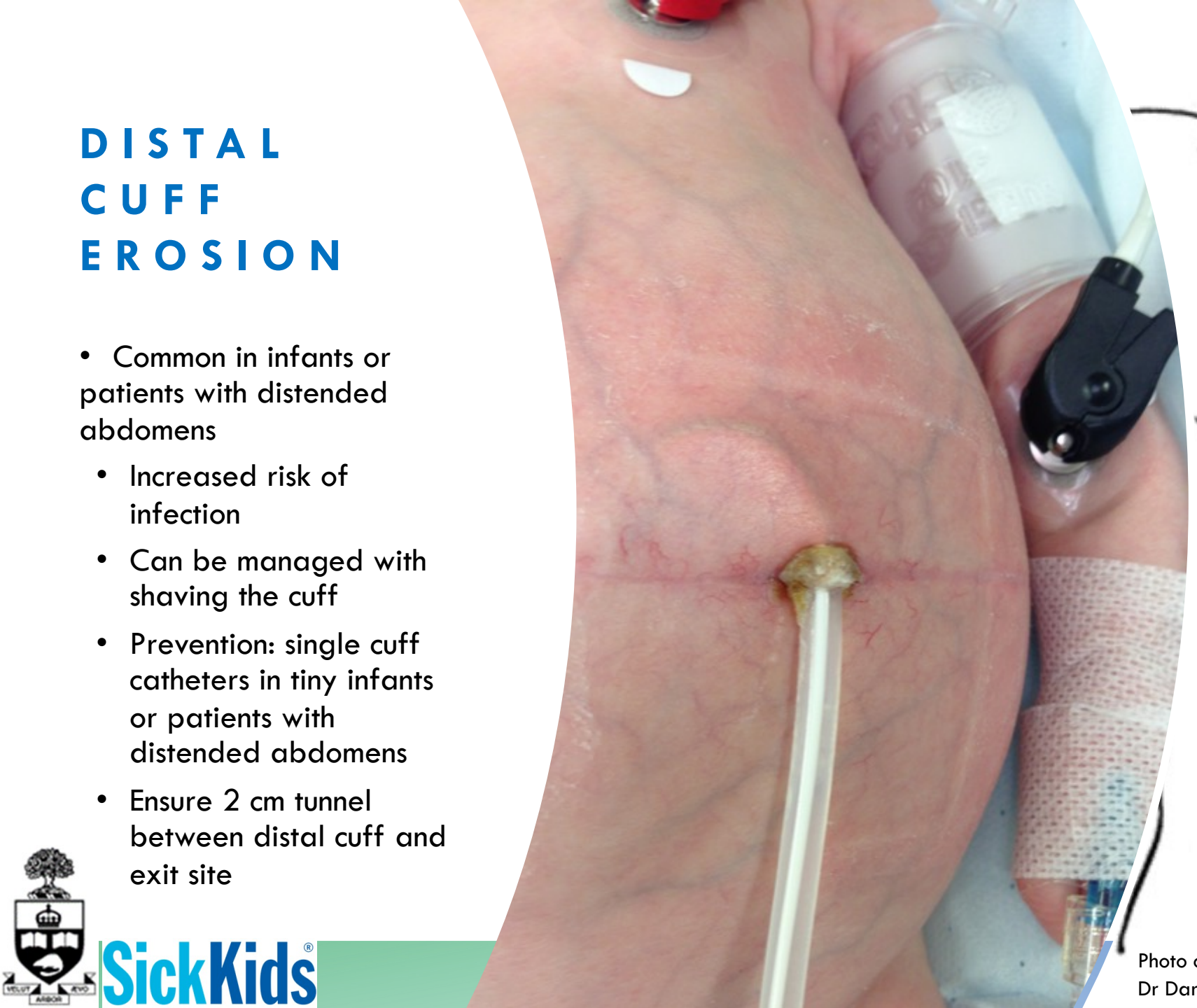
Operative photos courtesy of
Dr Armando Lorenzo, SickKids



- Partial omentectomy reduces the incidence of catheter malfunction in children
- Most often the omentum pulls the catheter up into the RUQ
- Omental dysfunction can occur without catheter displacement

DISTAL CUFF EROSION

- Common in infants or patients with distended abdomens
  - Increased risk of infection
  - Can be managed with shaving the cuff
  - Prevention: single cuff catheters in tiny infants or patients with distended abdomens
  - Ensure 2 cm tunnel between distal cuff and exit site



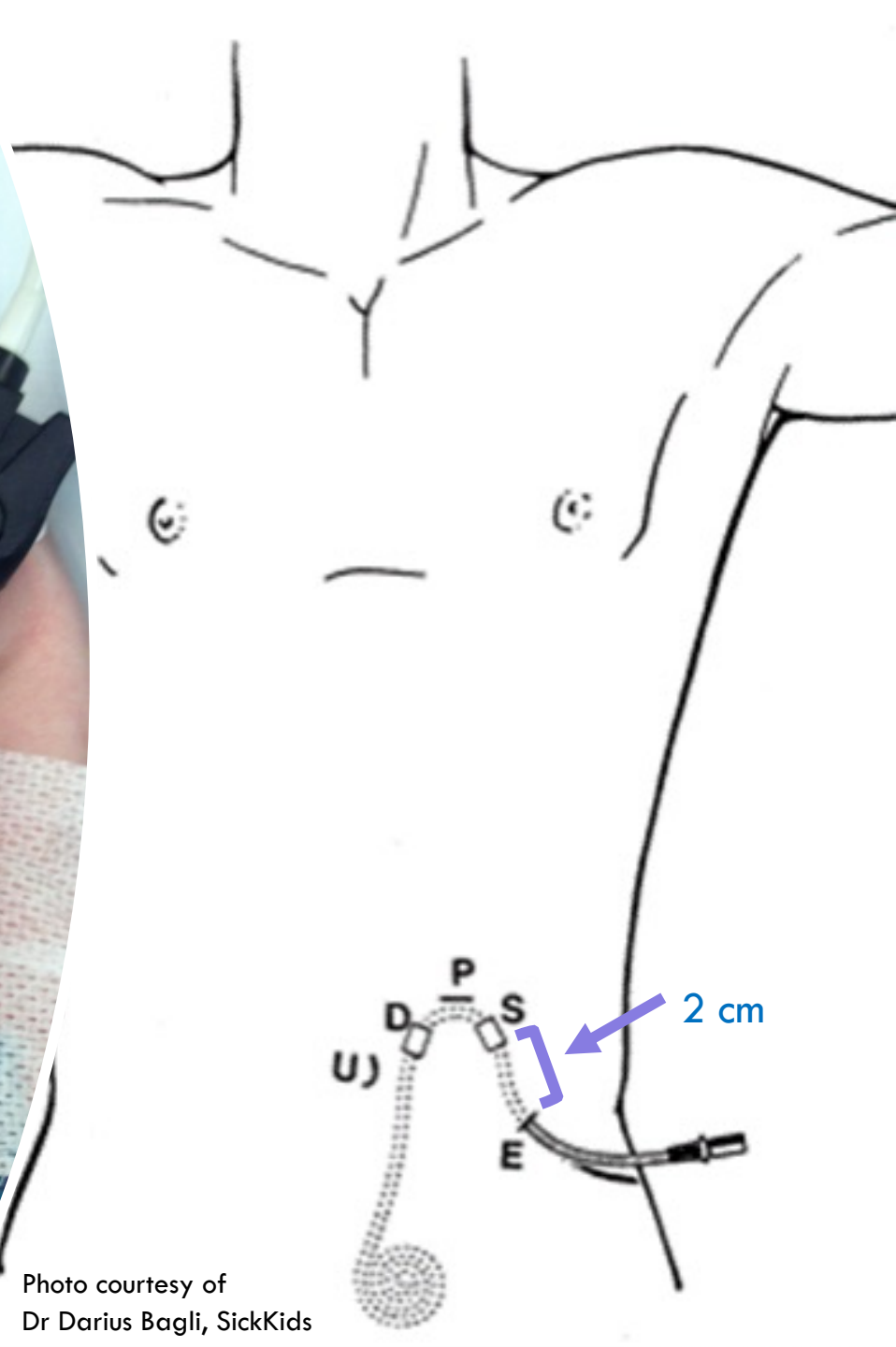
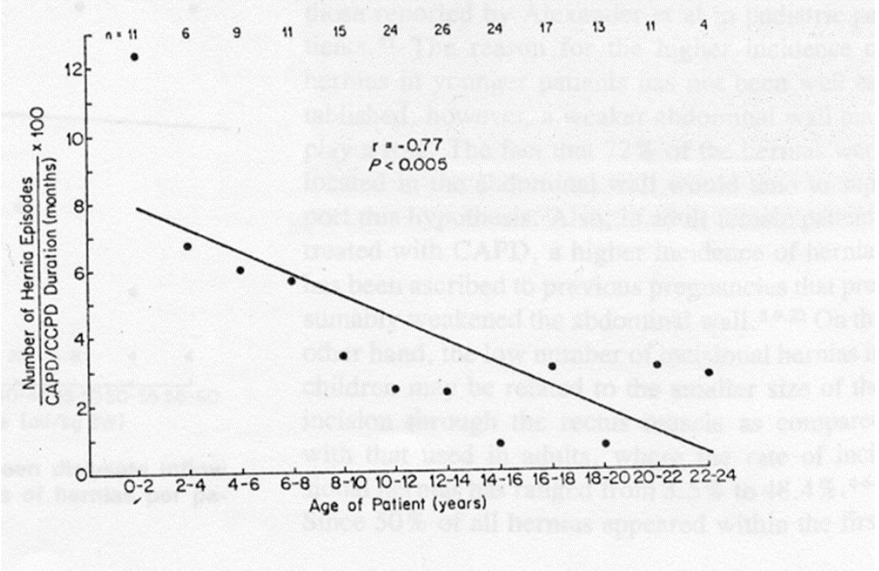


Photo courtesy of
Dr Darius Bagli, SickKids

MECHANICAL

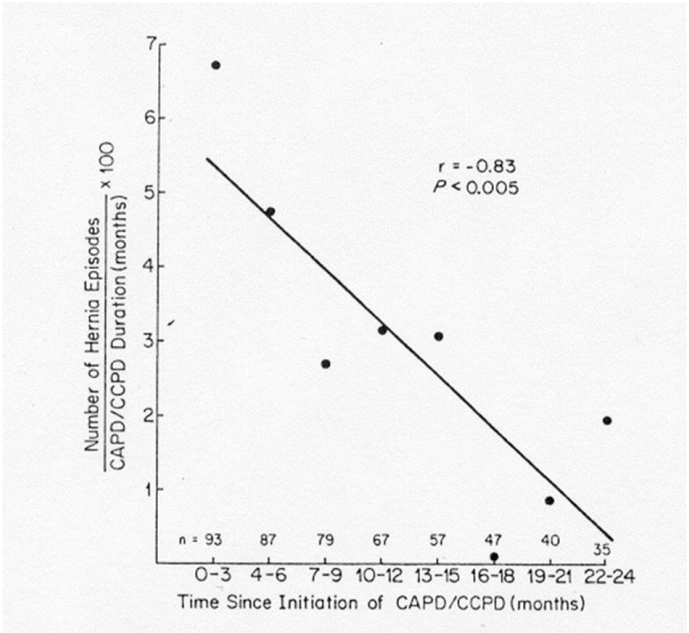
HERNIAS

- Incisional, umbilical or inguinal
- Decreased incidence of incisional hernias with paramedian catheter insertion
- Higher incidence of hernias in children than adults
  - 12-53% vs 10-31%
  - Incidence inversely proportional with age and time on dialysis



Hernias vs Age in PD

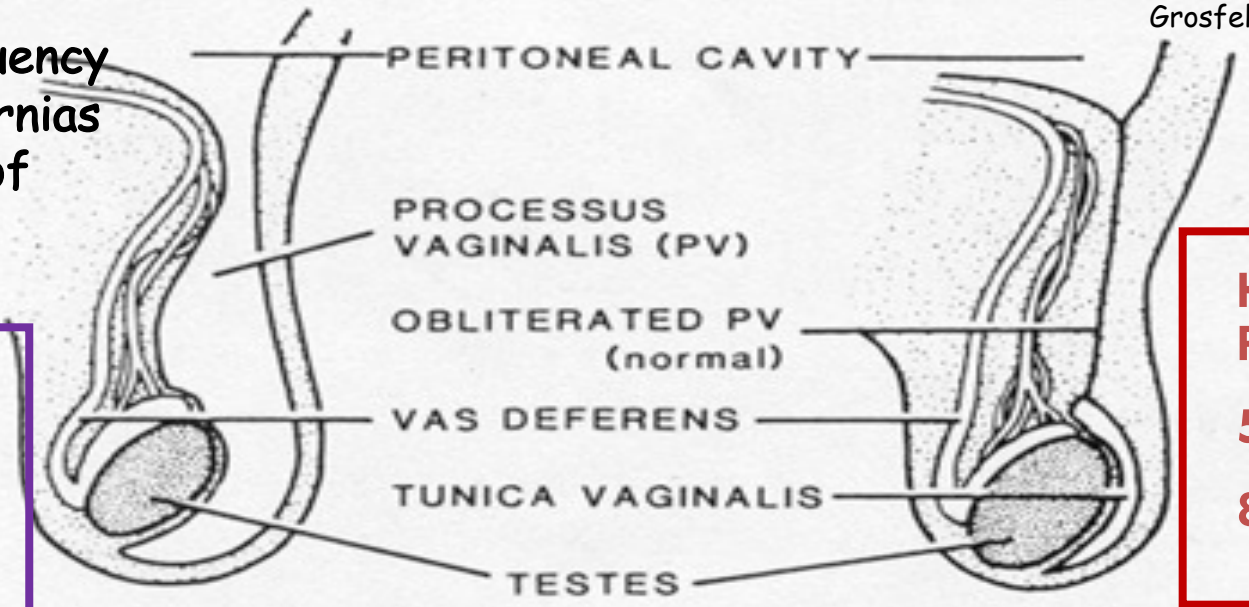
Hernia frequency vs time on dialysis



Von Lilien, AJKD X(5), 1987; 356-360

Grosfeld: World J Surgery 13, 506-15, 1989

Highest frequency of inguinal hernias in first year of life



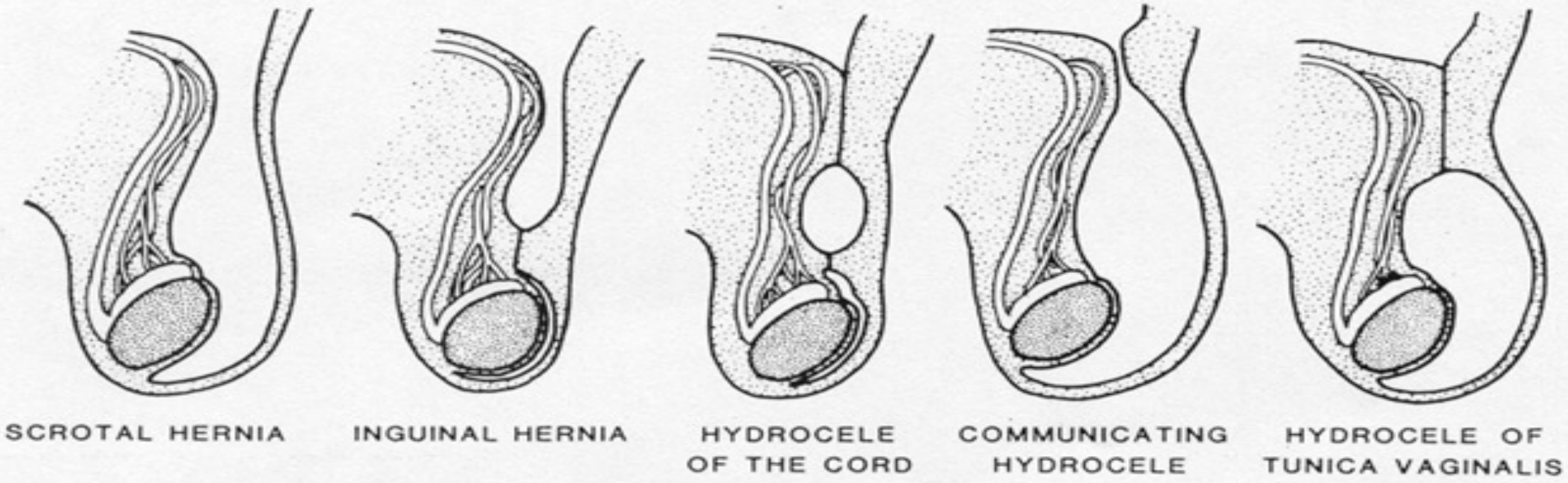
Patent processus vaginalis

- 80-90% newborns
- 70% 3 months
- 50% 1 yr
- 20% adulthood

Hernias develop early in PD patients:

56% by 3 months

88% by 6 months



INGUINAL HERNIAS

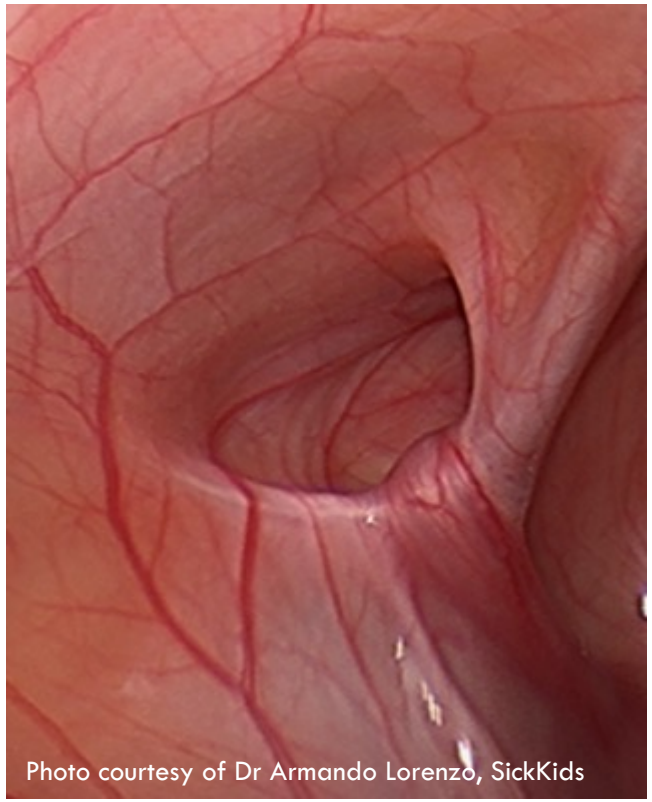


Photo courtesy of Dr Armando Lorenzo, SickKids

- More common in boys
- Frequently bilateral
- Tendency to increase in size over time
- 75% of hernias require surgical repair
- Repair second side electively with unilateral inguinal hernia
- Consider prophylactic hernia repair in male infants at onset of PD.
  - Temporizing measures until surgical repair
    - Low volume nocturnal cyclic PD
    - Empty daytime abdomen

INTRA-PERITONEAL PRESSURE

IPP measurement

Ped Neph 2003: Vol 18 (10)

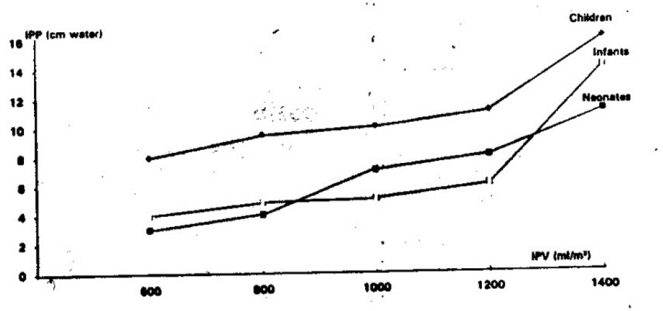
- Children have lower IPP than adults
- Infants have lowest IPP
- IPP relatively constant over dwell volumes 600-1200 ml/m2
- Usual IPP for dwells of 1000-1100 ml/m2 = 8.2 +/- 3.8

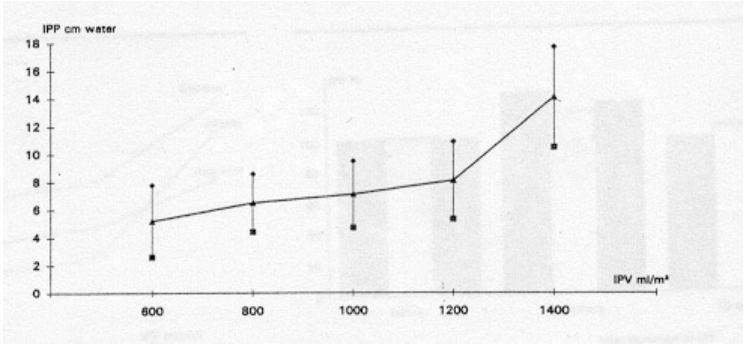
- Target dwell volumes
  - > 2 yrs 1100-1400 ml/m2
  - < 2 yrs 800 ml/m2

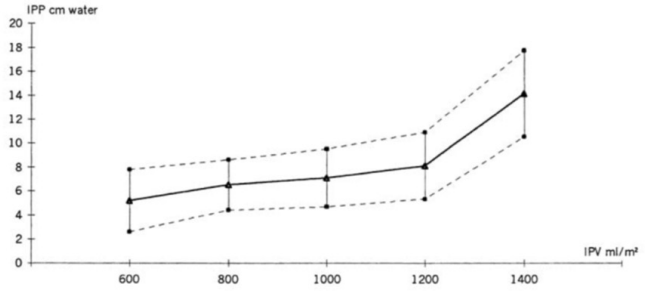
- 1500 ml/m^2 (2.66 L/1.73m^2) = peak mass transfer area coefficient
- Adult volumes 1400-1600 ml/m^2 (Keshaviah JASN 1994)

IPP is influenced by:
- PD volume
- Position
  - Lowest supine
  - Highest sitting

Fischbach et al. Adv in PD, Vol 12, P 330-4, 1996







17 patients (1mo-15 yrs); 255 measurements
Fischbach et al Ped Neph 2003

INTRAPERITONEAL PRESSURE

Consequences of too large dwell volumes

- Symptoms
  - pain/discomfort
  - Respiratory compromise
  - Increased vomiting
  - Lower limb edema
  - ? Hernias – higher IPP in children with hernias than without; optimal dwell volume to minimize hernias but maximize clearance is unknown
- Reduced ultrafiltration
  - Fluid absorption of 31-36 ml/hr/cm H_2O increase in IPP (lymphatics)
  - Higher glucose to achieve UF with high IPP
- Reduced phosphate removal

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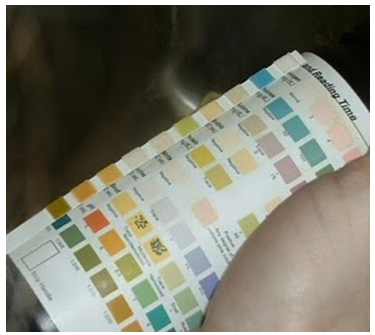
FLUID LEAKS

Early

< 30 days post catheter insertion

- Usually exit site leaks
- Diagnosed by high ES fluid glucose content

Photo courtesy of ZJ Twardowski



Late

> 30 days post catheter insertion

- Usually abdominal, often associated with hernias
- CT and nuclear imaging to diagnose

FLUID LEAKS - PRESENTATION

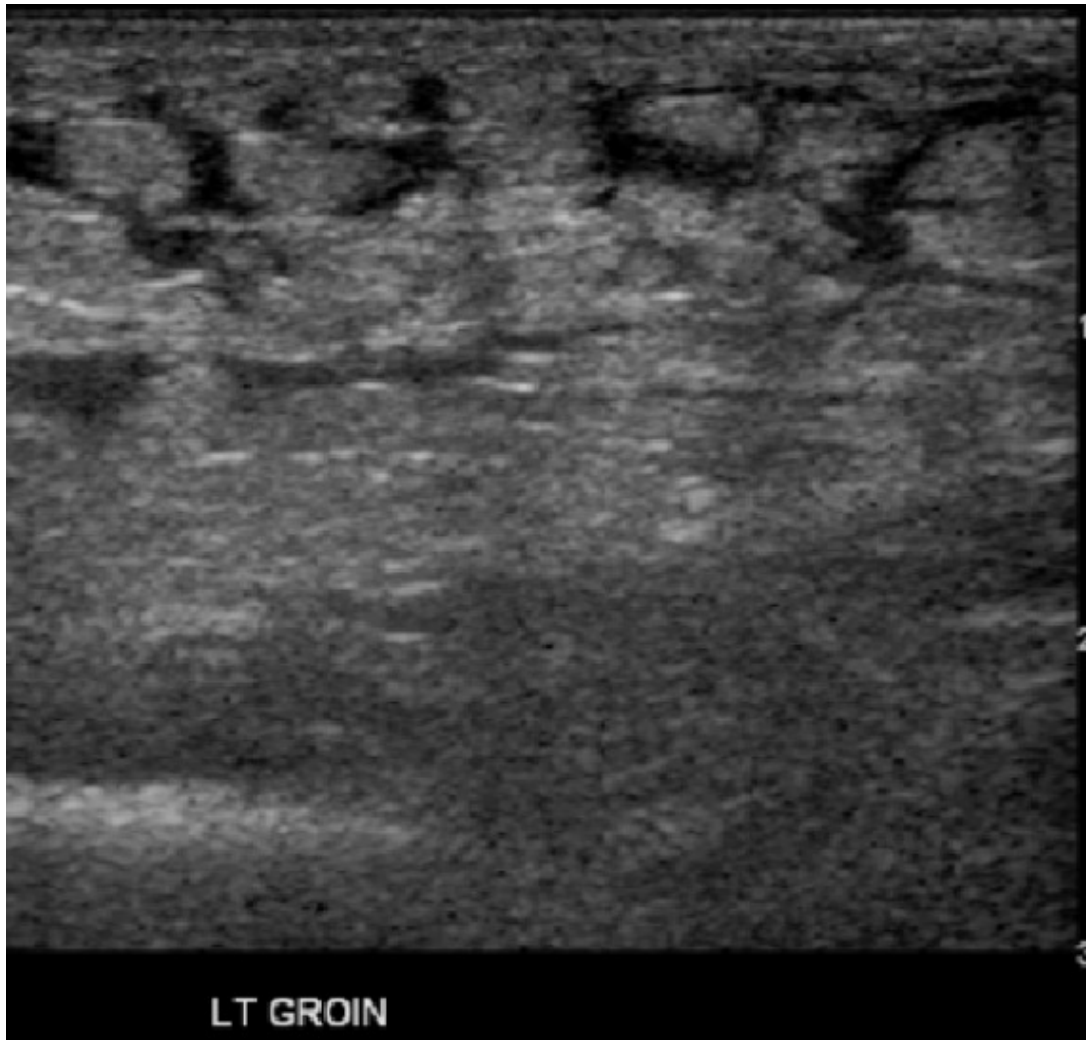
- Exit site leakage
- Abdominal wall edema
- Genital edema
- Decreased effluent drainage
- Respiratory distress

Males
- Hydroceles
- Dissection through tunica vaginalis with scrotal swelling
- Tracking down abdominal wall with scrotal and penile swelling

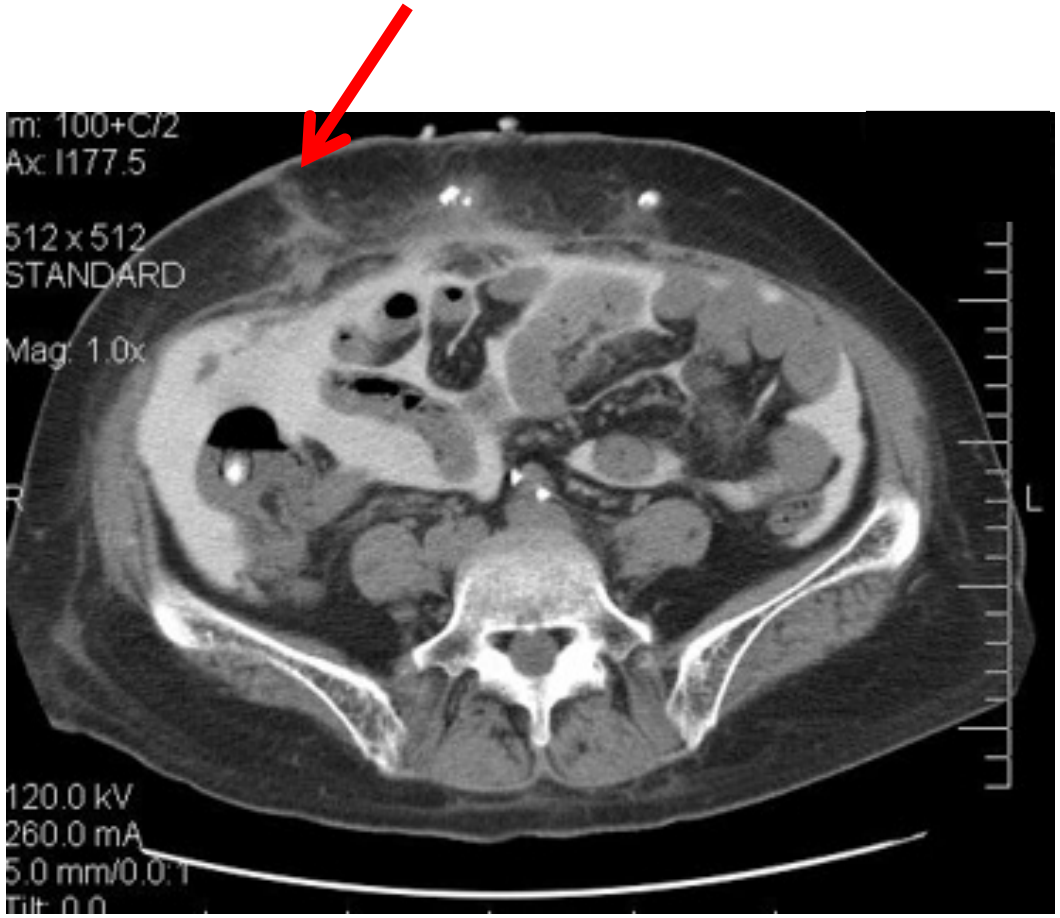
Females
- Labial edema from fluid tracking down abdominal wall
- Vaginal leaks
  - leakage via fallopian tubes
  - Tracking through fascial planes into vaginal vault

FLUID LEAKS – ULTRASOUND IMAGING

- **Laparoscopic port leak**
- Abdominal wall, suprapubic and labial edema



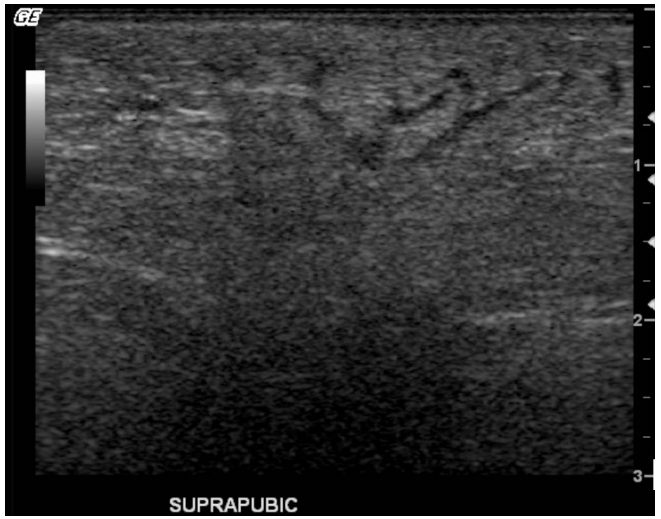
FLUID LEAKS – DIAGNOSIS WITH CT

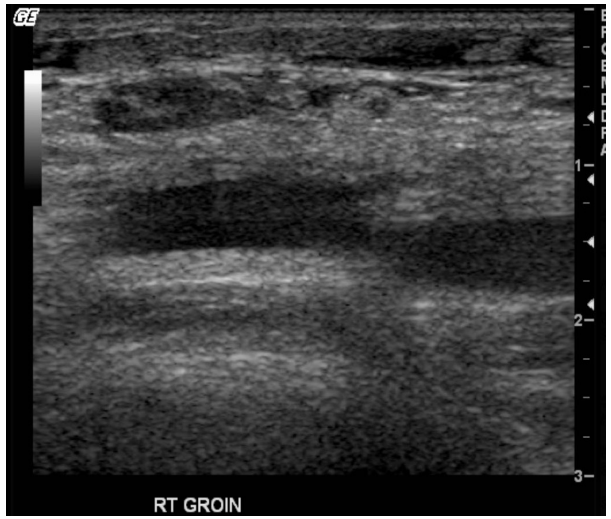


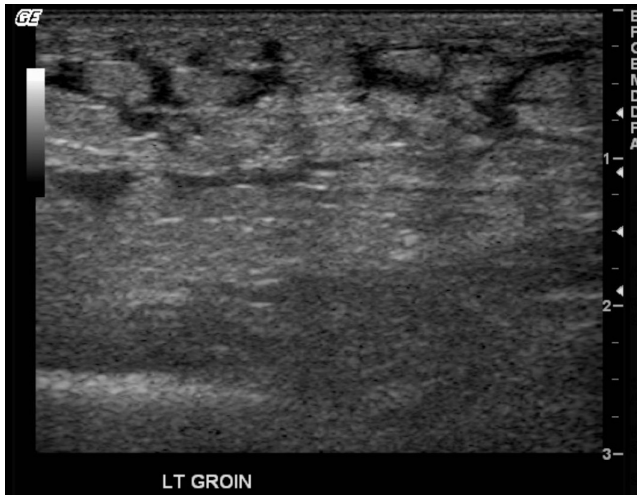
CT with IP contrast

Courtesy of Dr Joanne Bargman

Genital Swelling : Female







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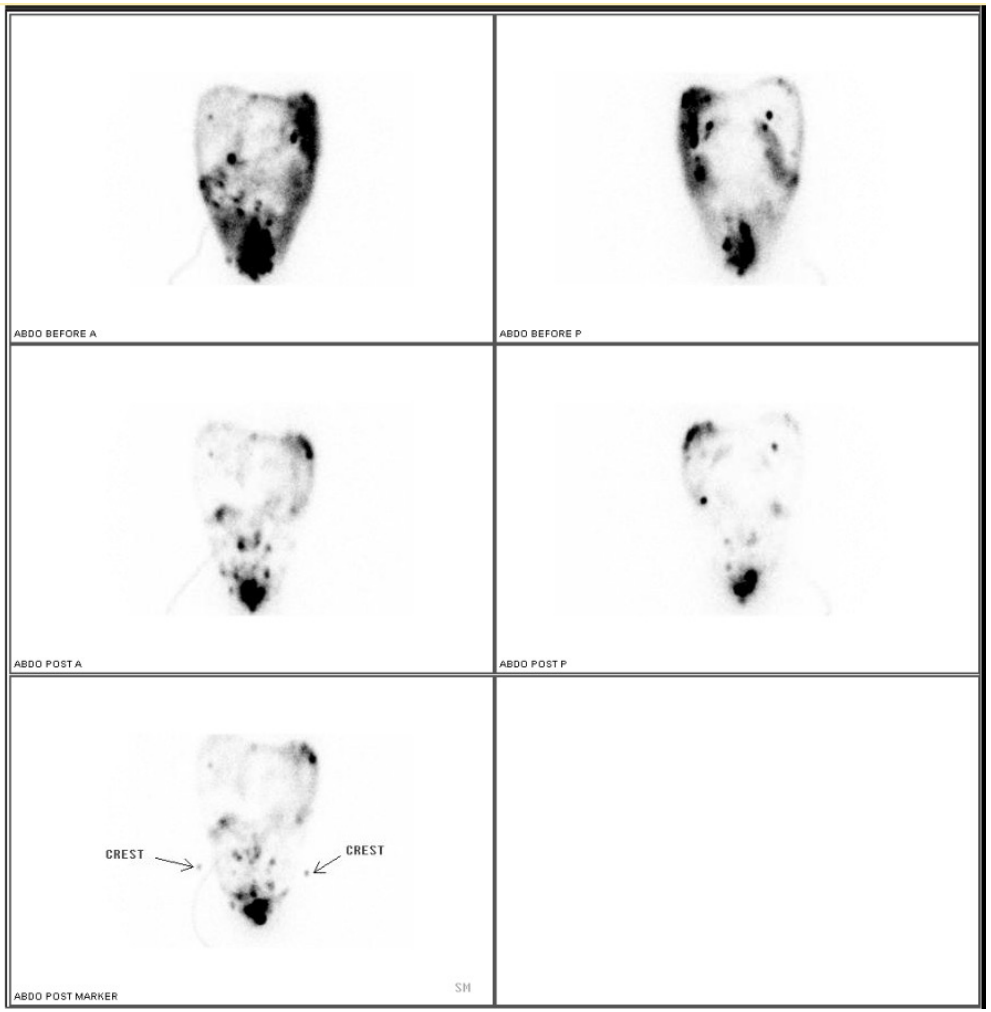


(a-c) Superficial US images of the suprapubic area showed "Marbled fat" appearance of the subcutaneous tissue, consistent with mild suprapubic edema and possible anterior abdominal wall leakage. d) Peritoneal scintigraphy with technecium sulphur colloid showed focal retention of the tracer within the suprapubic region persisting on post-drainage images suggestive of dialysate abdominal wall leakage.

LEAKS IN KIDS

Under-reporting is likely an issue

- Higher incidence in younger children
- 31-87% at exit site
- 50% leaks occur within 5 days of catheter implantation
- 50% managed successfully conservatively
- Late leaks require surgical correction in 80% (unless related to laparoscopic port insertion)

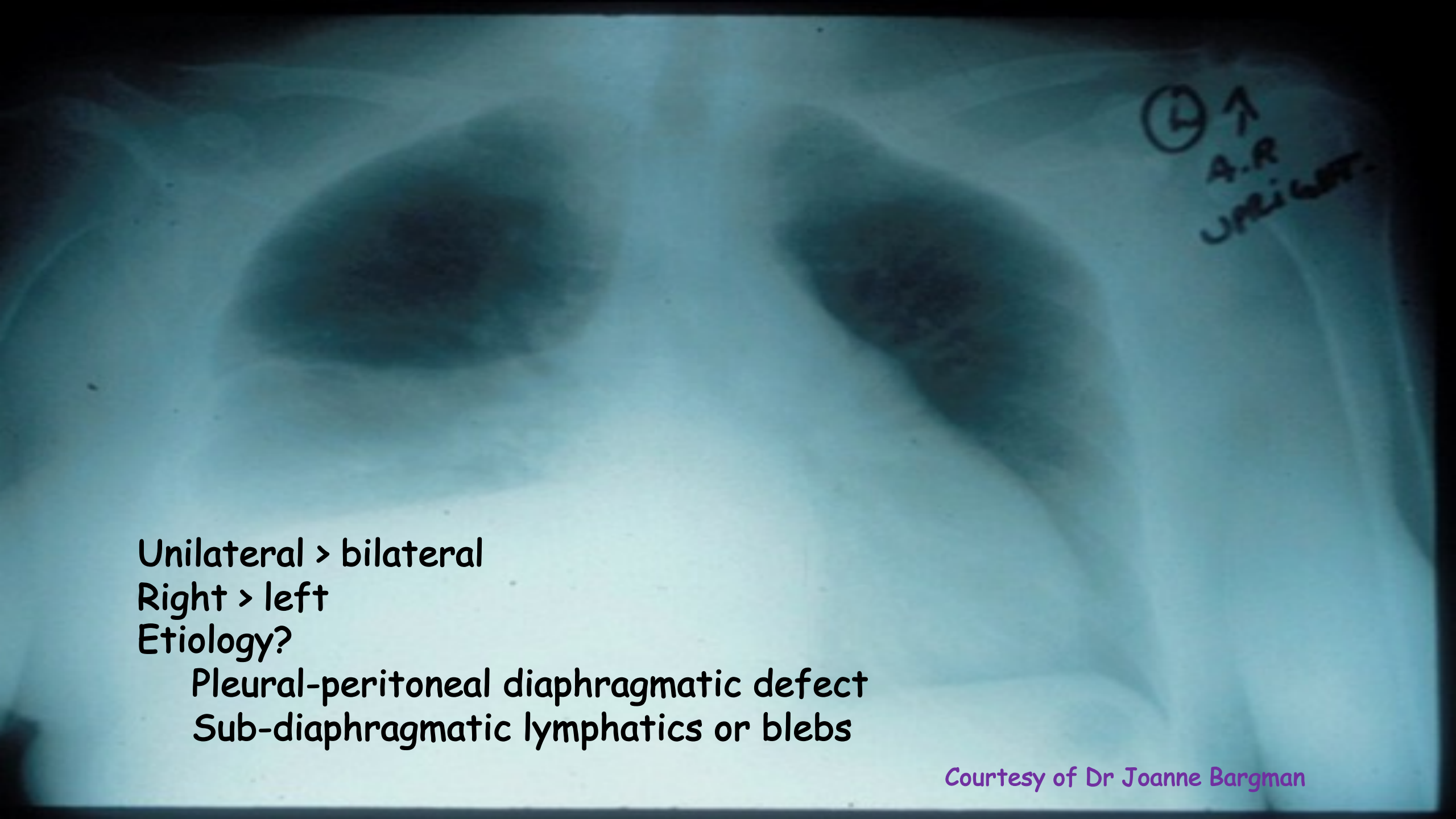
Management

- Spontaneous resolution may occur
  - Small volume, nocturnal cycling, dry daytime abdomen
  - Temporary cessation of dialysis
- Temporary switch to hemodialysis
- Surgical correction if persistent

HYDROTHORAX

- Uncommon but potentially serious
- Spectrum of presentation
  - Clinically silent
  - Dramatic respiratory distress
  - Decreased ultrafiltration
  - Acute PD
    - glucose in chest tube fluid
    - increased drainage from chest tube

- 40-50% occur within 2-4 weeks of initiation of PD
- Incidence:
  - 1.6-6.5% adults
  - 2% children
- Confirmation of Diagnosis
  - Peritoneal scintigraphy with technetium sulfur colloid in dialysate
  - MRI
  - CT with contrast



Unilateral > bilateral
Right > left
Etiology?
- Pleural-peritoneal diaphragmatic defect
- Sub-diaphragmatic lymphatics or blebs

Courtesy of Dr Joanne Bargman

HYDROTHORAX

- Treatment
  - Reduced dialysate volumes
  - Temporary cessation of dialysis
  - Surgical repair of diaphragmatic defect
  - (Pleurodesis with talc or tetracycline- uncommon practice now)

May result in transfer to hemodialysis

HEMOPERITONEUM

- 6-57% adults
- Females > males
- 50% menstruating females
- Incidence in children?
  - Italian registry 1.7%
  - ? Under-reporting
- Generally mild, but can be life-threatening, depending on etiology

Courtesy of Dr Joanne Bargman

HEMOPERITONEUM

- 3 Patterns in reproductive females

  - 2-3 days before onset of menses
  - Mild, recurrent, painless
  - Retrograde menstruation vs endometriosis

  - mid-cyclic bleeding due to ovulation

  - Severe bleeding with significant abdominal pain
    - Rupture of corpus luteum cyst

Suppression of ovulation results in resolution of ovulation or corpus luteum cyst related bleeding

Causes of Hemoperitoneum

- Post-catheter insertion
- Trauma
- Menstrual related
- Coagulopathy
- Malignancy
- Physical activity
- Pancreatitis
- Cholecystitis
- Ulcer
- Peritoneal calcifications
- Sclerosing peritonitis

Treatment of Hemoperitoneum

- Treat underlying cause
- Heparin 500 U/L dialysate fluid
- Cold dialysis solution
- Suppression of ovulation

SickKids®

ABNORMAL COLOR DIALYSATE

Semin Dial. 2019;32:72–79

CHYLOPERITONEUM

- Rare complication of PD
- Often confused with peritonitis
- Characteristic milky appearance of PD fluid

CAUSES OF CHYLOPERITONEUM

- Congenital anomalies of the lymphatic system
- Abdominal trauma or surgery inc PD catheter insertion
- Malignancy
- Disruption/obstruction of thoracic duct
- IVC clot

DIAGNOSIS:
Elevated PD fluid lymphocyte count
Elevated PD fluid triglyceride levels > 110 mg/L
Chylomicrons in PD fluid

ABNORMAL COLOR DIALYSATE

- Rifampin

Fluorescine

Bilirubin

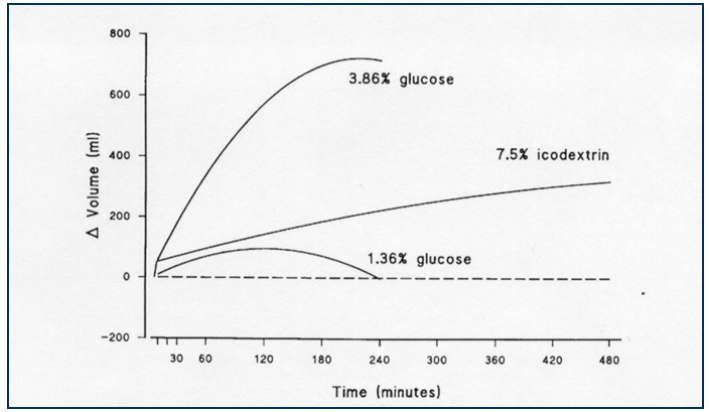
Rhabdomyolysis

Dossin T, Goffin E.
When the color of peritoneal dialysis effluent can be used as a diagnostic tool.
Semin Dial. 2019;32:72–79

TECHNIQUE RELATED

ICODEXTRIN ALLERGY

- Icodextrin is a glucose polymer PD solution which exerts UF through colloid osmosis
- Used for day dwell in APD and night dwell in CAPD
- Skin reactions occur in up to 15% of patients on icodextrin



- Occurs soon after commencing treatment (8-14 days)
- Resolves with cessation of treatment (takes up to 14 days)
- May recur on re-challenge
- Therapy
  - Supportive/symptomatic
  - Cessation of icodextrin
  - Re-challenge not encouraged with severe reactions

Practical Considerations When Prescribing Icodextrin: A Narrative Review
Samuel A. Silver Ziv Harel Jeffrey Perl
Am J Nephrol 2014;39:515–527

ICODEXTRIN ALLERGY

Figure 2. *Case 2. Acute generalized exanthematous pustulosis with nonfollicular pustules.*

ARCH DERMATOL/VOL 137, MAR 2001

- **Rash**
  - Generalized
  - Limited to palms and soles
  - May be mistaken for Kawasaki disease

Figure 1. *Case 1. Exfoliative eruption of the hands and onycholysis of the fingernails.*

EOSINOPHILIC PERITONITIS

Peritoneal eosinophilia

- ≥ 100 cells in PD fluid with > 10% eosinophils

May be accompanied by peripheral eosinophilia

Presentation

- Cloudy fluid
- May be asymptomatic

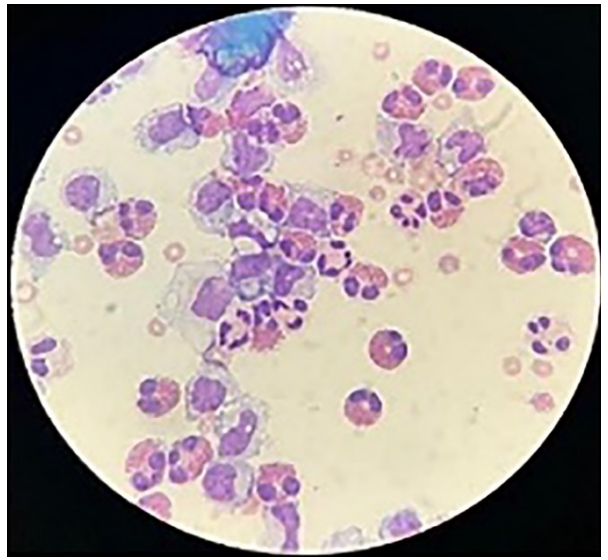
Idiopathic

- Hypersensitivity response to PD materials or IP drugs
- Usually occurs within first 3 months of PD onset

Infection related

- Occurs after resolution of a culture positive peritonitis

Generally benign



Semin Dial. 2022;35:548–555.

Treatment

- Eliminate infection
- Time – may resolve spontaneously
- Antihistamines – cetirizine, ketotifen
- Steroids
- Montelukast

SCLEROSING PERITONITIS

- Rare but devastating complication of long-term PD

- Risk factors:
  - Prolonged duration of dialysis > 5 yrs
  - Recurrent bacterial peritonitis
  - Acetate dialysate
  - Prolonged exposure to hypertonic solutions
  - Chlorhexidine in alcohol
  - Plasticizers
  - Beta-blockers

Time (yrs)	Rigby	Kawanishi	Hoshii
Overall incidence		2.5-2.8%	2.5%
<2-3	1.9%	0%	
5	6.4%	0.7%	6.6%
6	10.8%	-	
8	19.4%	2.7%	
10		5.9%	22%
15		5.8%	
>15		17.2%	
mortality	56%	23-27%	12%

Honda and Warady
Ped Neph 2010; 25: 75-81

SCLEROSING PERITONITIS

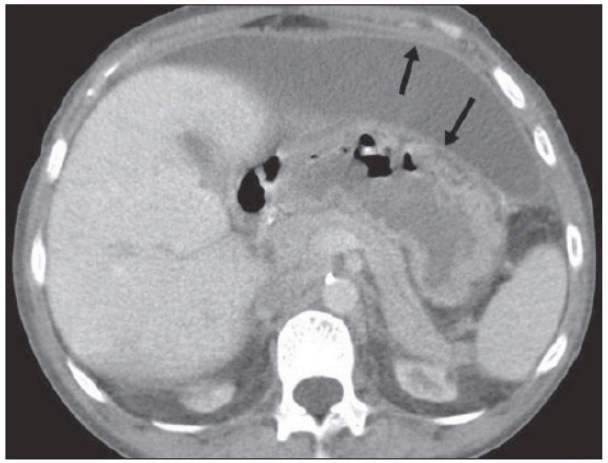
Clinical Presentation

- Loss of UF
- Increased peritoneal transport
- High D/P creatinine ratio
- High CRP
- Bloody effluent
- Intermittent bowel obstruction symptoms
- Abdominal pain/nausea/vomiting
- Weight loss
- Low grade fever
- Progressive inanition and death

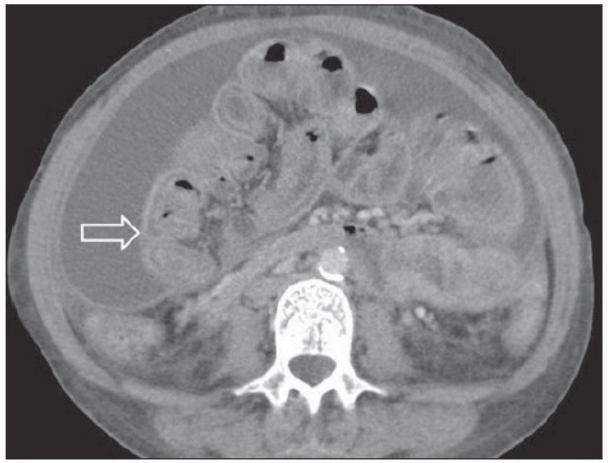
U/S appearance

- Increased small bowel peristalsis
- Tethering of bowel to posterior abdominal wall
- Intraperitoneal echogenic strands
- Bowel wall thickening
- Late finding: membrane encasing tethered matted loops of bowel

CT - SCLEROSING PERITONITIS

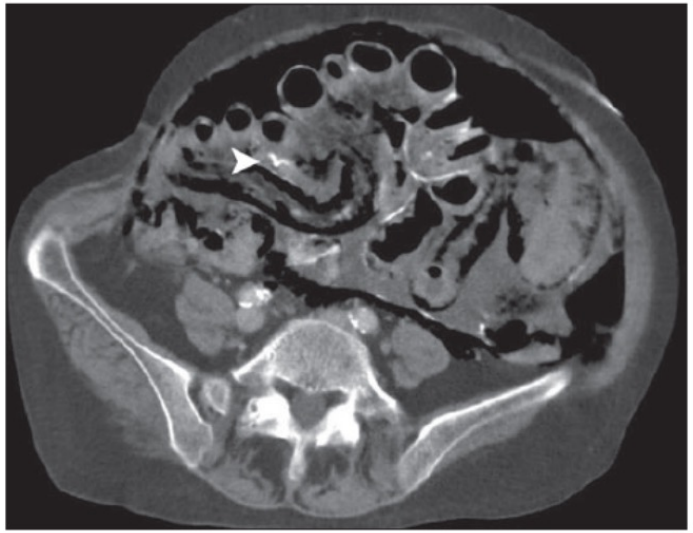


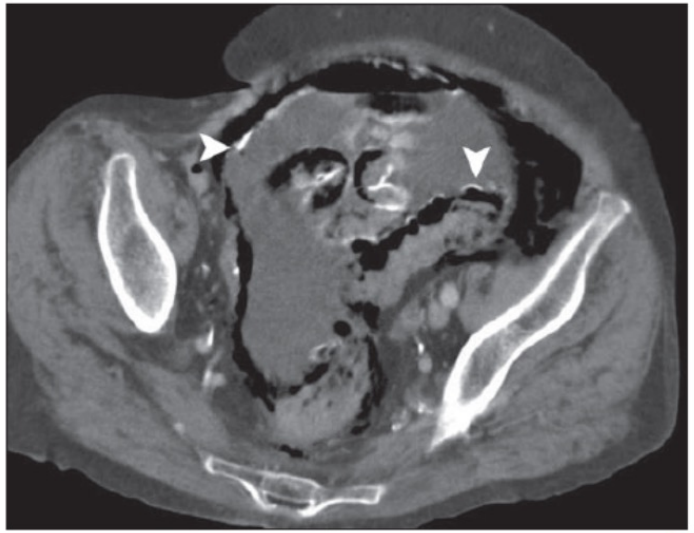
Peritoneal thickening



Bowel wall thickening

Tethered small bowel – “cocooning





Visceral and Parietal Peritoneal Calcification

AJR:195, July 2010

SCLEROSING PERITONITIS

- **Treatment:**
  - **Prevention**

- **Detection/Prevention**
  - **Screen for peritoneal calcifications in patients on PD > 5 yrs**
  - **Peritoneal biopsy:**
    - **patients on PD > 8 yrs**
    - **Loss of UF and on PD > 5 yrs**
    - **Calcification on CT and on PD > 5 yrs**
    - **Ensure your pathologist understands the question being asked and how to process the biopsy specimen**

Recommendations for pathological diagnosis on biopsy samples from peritoneal dialysis patients
Kunio Kawanishi, Kazuho Honda, and Chieko Hamada
Pleura Peritoneum. 2017 Mar 1; 2(1): 3–15

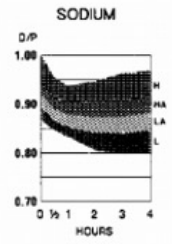
ULTRAFILTRATION FAILURE

- UF failure is common with long term PD
- UF failure with symptomatic volume overload may result in technique failure
- Symptomatic fluid retention may manifest as:
  - ankle, facial or genital edema
  - Dyspnea, pulmonary edema, pleural effusions
  - Hypertension

Fluid retention may also be caused by:

- Non-adherence to dietary Na and fluid restrictions
- Peritonitis
- Fluid leaks
- Catheter occlusion
- Non-adherence to dialysis prescription
- Loss of residual renal function

CAUSES OF ULTRAFILTRATION FAILURE

Type 1	Type 2	Type 3	Aquaporin deficiency
High peritoneal transport Loss of UF gradient	Low peritoneal solute transport	High lymphatic drainage	Low number of ultra-small pores
Intrinsic Peritonitis Iatrogenic – small volume dwells	Sclerosing peritonitis Adhesions	Increased intra-peritoneal pressure	Suboptimal drop in dialysate Na at 1 hour of PET Small solute transport normal or increased
Fluid restriction Diuretics Dialysis with short dwells Change to HD	Transfer to HD	Transfer to HD	 Twardowski et al PDI 1987

HEMODIALYSIS

CLASSIFICATION OF COMPLICATIONS OF HD

Access Related	Mechanical	Technique Related
CVL Thrombosis	Dialyzer/Membrane reactions	Dialysis disequilibrium
CVL malfunction/ malposition	Blood leaks	Hypotension
CVL infection (exit site, blood)	Air embolism and microbubbles	Hypertension
Fistula/Graft 1° non-function	Hemolysis	Loss of Residual renal function
Stenosis Thrombosis	Electrolyte disturbances	Sudden death
Infection	Clotting/Bleeding	Inadequate dialysis

DIALYZER & MEMBRANE REACTIONS

DIALYZER REACTIONS

- **Type A - Hypersensitivity reaction**
  - Anaphylactic signs and symptoms
  - Antigen-Antibody mediated
  - Incidence: ~ 3-7 reactions per 1000 patients per year

- **Type B – non-specific**
  - Chest and back pain
  - Fever
  - Incidence: ~ 3-5 reactions per 1000 patients per year

- **Patients may react to multiple components of the circuit:**
  - Membrane
  - Sterilizing agent eg ethylene oxide
  - Heparin
  - Potting compound
  - Housing
  - Reuse agents

Potential allergens	Timing/Manifestations/Comments
Sterilizing agent – Ethylene oxide	**Shortly after initiation of dialysis:** -Anaphylaxis -non-specific malaise, fever

Bactericidal gas used as sterilizing agent in dialyzers and tubing
IgE specific anti-ETO Ab associated with higher rate of reactions
Prevention:
- **Alternate sterilization agent**
- **Careful flushing of the circuit**
- **Reuse**

Potential allergens	Timing/Manifestations/Comments
Sterilizing agent – Ethylene oxide	**Shortly after initiation of dialysis:** -Anaphylaxis -non-specific malaise, fever
Anticoagulant – Heparin	**Allergic reaction - rare** **Heparin induced thrombocytopenia (HIT)**

Potential allergens	Timing/Manifestations/Comments
Sterilizing agent – Ethylene oxide	**Shortly after initiation of dialysis:** -Anaphylaxis -non-specific malaise, fever
Anticoagulant – Heparin	**Allergic reaction - rare** **Heparin induced thrombocytopenia (HIT)**
Dialyzer Membrane - AN69	**Minutes after blood-membrane contact:** -Hypotension, anaphylaxis Risk factors: -blood prime, metabolic acidosis, patients on ACE inhibitors
Dialyzer membrane – eg polysulfone	**Minutes-hours after blood-membrane contact:** -pruritis common -worsens with progressive treatments and may progress to anaphylaxis -all polysulfone membranes are not the same; can try another polysulfone membrane from another manufacturer

Potential allergens	Timing/Manifestations/Comments
Sterilizing agent – Ethylene oxide	**Shortly after initiation of dialysis:** -Anaphylaxis -non-specific malaise, fever
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Dialyzer Membrane especially AN69 membrane	**Minutes after blood-membrane contact:** -Hypotension, anaphylaxis Risk factors: -blood prime, metabolic acidosis, patients on ACE inhibitors
Dialyzer membrane – eg polysulfone	**Minutes-hours after blood-membrane contact:** -pruritis common -worsens with progressive treatments and may progress to anaphylaxis -all polysulfone membranes are not the same; can try another polysulfone membrane from another manufacturer
Micro-contamination from back leak	**Fevers, chills, malaise** **Risk factors:** -high flux membranes, water quality

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TREATMENT OF ANAPHYLAXIS

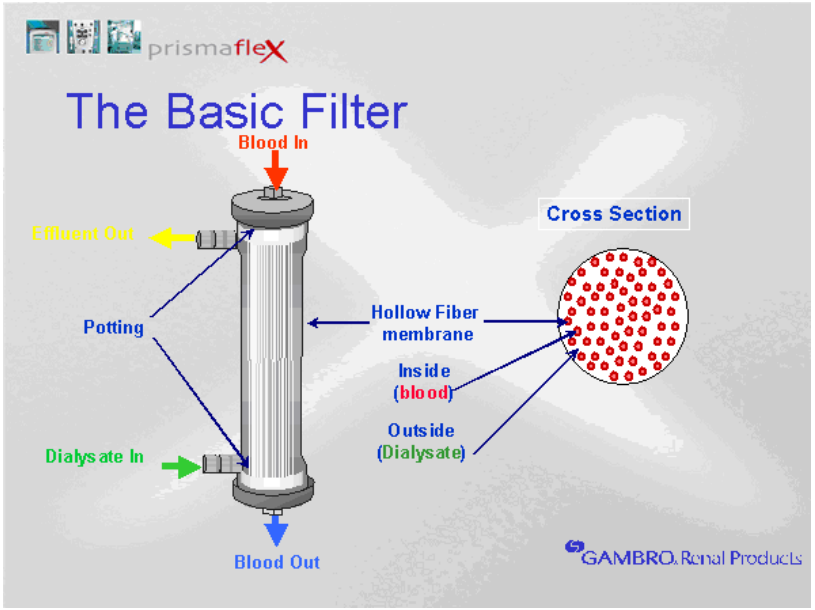
- Immediate cessation of dialysis **without re-transfusion**
  - Prevent further antigen exposure
- Save the dialysis circuit for examination
- Supportive care
  - IV antihistamines and steroids
  - Oxygen
  - Inhaled B-agonists for bronchospasm
  - Epinephrine for anaphylaxis
- Attempt to identify the allergen
  - Stepwise removal of potential offending agents
- Ensure alternate dialyzers are available for presumptive membrane allergy

SickKids®

BLOOD LEAKS

BLOOD LEAKS

- Separation of blood and dialysate compartments is essential for safety and efficacy of HD

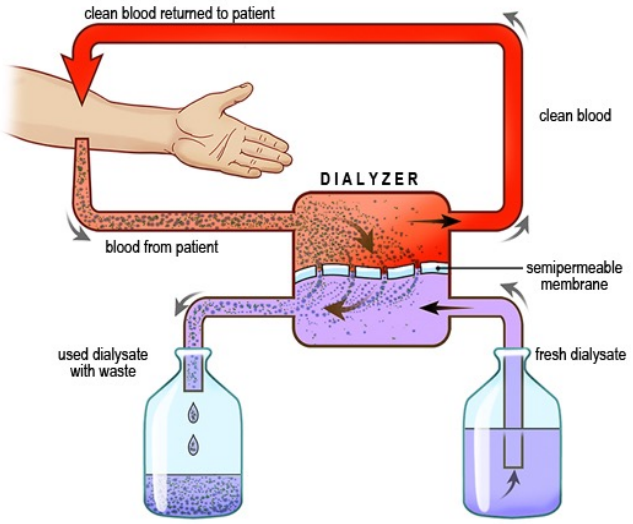


- Blood leaks occur when there is a disruption in dialyzer hollow fiber integrity
  - During manufacture
  - "Misadventure" during shipping, storage or handling
  - Excess trans-membrane pressure

BLOOD LEAKS

- Leak diagnosis
  - Red stained dialysate in the absence of hemolysis
  - Optical sensors on modern machines detect blood in dialysis compartment

- Treatment
  - Terminate dialysis session
  - Check Hb
  - Restart dialysis with a fresh circuit if indicated

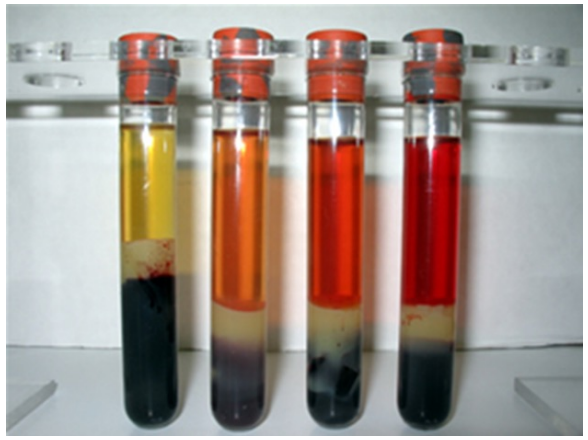


SAVE THE CIRCUIT

HEMOLYSIS

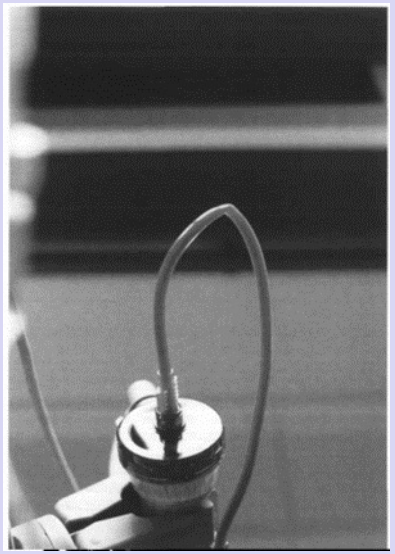
HEMOLYSIS

- Rare but potentially life threatening complication of HD
- Presentation may relate to the cause as well as the hemolysis itself
- Manifestations:
  - Non-specific malaise
  - Weakness
  - Nausea
  - Abdominal pain
  - Gross hematuria
  - Arrhythmia
  - Cardiac arrest



DIAGNOSIS

- Fall in Hb
- Pink plasma with elevated free plasma Hb
- Elevated LDH, low haptoglobin
- Increased bilirubin
- Hyperkalemia

Causes of Hemolysis	Treatment of Hemolysis
• High dialysate temperature • Inappropriate dialysate Na • **Kinking of tubing** • **Defect in tubing** • Dialysate contamination with copper or chlorites • Mechanical trauma from mismatch between blood flow and access (turbulence)	 Case Rep Nephrol Dial 2021;11:348–354 

Causes of Hemolysis	Treatment of Hemolysis
• High dialysate temperature • Inappropriate dialysate Na • Kinking of tubing • Defect in tubing • Dialysate contamination with copper or chlorites • Mechanical trauma from mismatch between blood flow and access (turbulence)	• Terminate dialysis immediately • Do not re-transfuse the circuit • Supportive therapy Control hyperkalemia Transfuse prn Oxygen prn SAVE THE DIALYSIS CIRCUIT to determine etiology if possible

AIR EMBOLISM

AIR EMBOLISM

- Rare but catastrophic complication
- Air infused into circulation
  - Inter-dialytic
    - Accidental disconnection or accessing of CVL
    - Removal of CVL
  - Intra-dialytic
    - Pre-arterial pump segment
    - Loose circuit connections
    - Cracks in tubing
    - Line disconnections
    - Drip chamber

Venous air embolism

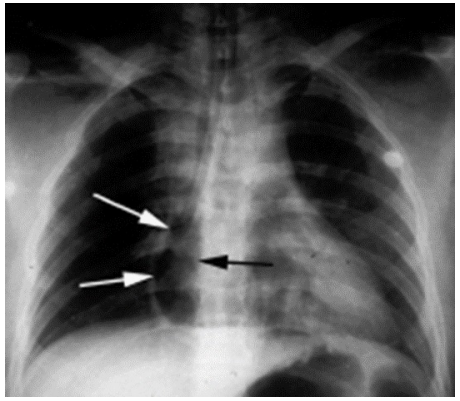
Clinically insignificant → Cardiovascular collapse/Death

SEVERITY DEPENDS ON
Volume of air
Rate of delivery
Position of patient

Worse in children than adults

SIGNS & SYMPTOMS
Cardiac
Pulmonary
Neurological

AIR EMBOLISM



Supine

- **Right ventricle foaming**
- **Mechanical obstruction of outflow tract**
- **Air in pulmonary circulation with micro-occlusion**

- **Air in left side of heart**
  - **AV shunts in lung**
  - **Right to left cardiac shunts**

Sitting

- Entry into cerebral venous system
- Cerebral venous obstruction
- Altered level of consciousness, seizures, death

- 3-5 ml/kg air in venous system necessary to cause death
- Tiny amounts of arterial air are lethal

Treatment:

- **Prevention**

- On dialysis: clamp venous lines, stop blood pump
- Lie patient on left side, head and chest down
- 100% O2
- Aspirate air through CVL if present
- Dexamethasone (decrease cerebral edema)
- Hyperbaric oxygen

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DIALYSIS DISEQUILIBRIUM

DIALYSIS DISEQUILIBRIUM

- Brain swelling from fluid shifts – multifactorial etiology
- More common with acute dialysis
- Can occur with chronic dialysis when urea is high
- Occurs usually at the end of dialysis

Figure 1.—An enhanced computed tomographic scan of the head shows diffuse cerebral edema.

TREATMENT

- **Prevention**
- Mannitol to reduce cerebral edema
- Hypertonic NaCl to reduce cerebral edema
- Lorazepam for prolonged seizure

Risk Factors	Signs & Symptoms	Preventative Measures
High pre-dialysis urea **Aggressive urea removal** **Neurological disease** **Malignant hypertension** **Hypo-natremia** **Severe metabolic acidosis** **Diabetics with poor glycemic control**	**Nausea, Vomiting** **Headache** **Blurred vision** **Muscle twitching, cramps** **Altered sensorium including disorientation** **Tremors, restlessness** **Seizures** **Coma** **Hypertension** **Papilledema**	**Gradual reduction of urea during initiation of dialysis:** -reduced dialysis time (2hrs) -slow blood flow (2-3mls/kg/min) -decreased dialysate flow -use of smaller surface area, less efficient dialyzers **Sequential dialysis/isolated UF for large UF requirements** **Sodium ramping** -reverse sodium profiling -regular Na ramping **Intradialytic mannitol** **Prophylactic phenytoin** **Change in dialysis regimen to** -short daily dialysis -nocturnal HD -hemodiafiltration -peritoneal dialysis

INTRADIALYTIC HYPOTENSION

INTRADIALYTIC HYPOTENSION

GENERAL	CONTRIBUTING FACTORS	SIGNS AND SYMPTOMS
Occurs in 20-30% pediatric HD patients Interferes with fluid removal and achievement of dry weight Contributes to patient discomfort	Large extracorporeal circuit Excess inter-dialytic weight gain Incorrect dry weight Dialyzer reactions Decline in ECF osmolality during dialysis Increase in core body temperature Low dialysate sodium Administration of anti-hypertensives Eating during dialysis Anuria vs polyuria	Restlessness Muscle cramps Hypotension Tachycardia Yawning Headache Altered sensorium

Consequences	Moderators

• Intradialytic symptoms
• Suspension of UF with resultant hypervolemia
 	
• Premature discontinuation of treatment and inadequate dialysis
 	
• Accelerated decline in residual renal function
 	
• Mesenteric ischemia
 	
• Cerebrovascular:
  • Transient ischemic attacks
  • Stroke
 	
• Cardiovascular:
  • regional LV dysfunction
  • ischemic cardiomyopathy progressing to heart failure
  • increased risk of arrhythmias	

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Pediatric Myocardial Stunning underscores the cardiac toxicity of conventional hemodialysis treatments

Hothi et al
CJASN 4; 790-97, 2009

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• Mesenteric ischemia
 	
• Cerebrovascular:
  • Transient ischemic attacks
  • Stroke
 	
• Cardiovascular:
  • regional LV dysfunction
  • ischemic cardiomyopathy progressing to heart failure
  • increased risk of arrhythmias
	• Withhold antihypertensive medications on dialysis days
	• Avoid food intake during dialysis
	• Dialysate
	  • bicarbonate buffer
	  • higher dialysate calcium
	  • sodium profiling
	• UF profiling
	• Periods of isolated UF
	• Cooled dialysate
	• Pre-dialysis or Intradialytic midodrine
	• RBV driven UF algorithms
	• Carnitine
	• Alternative dialysis regimens
	  • short daily dialysis
	  • hemodiafiltration
	  • prolonged/nocturnal HD

INTRADIALYTIC HYPOTENSION

- Prevention is primary goal
  - Avoidance of large intradialytic weight gain
  - Determination of accurate dry weight
  - Use of tools such as CRITLINE or RBV (relative blood volume) to detect excessive UF

SUMMARY

- Dialysis related complications are largely technique specific
- They account for significant morbidity and technique failure
- Incidence of many complications in children is unknown
- Future directions should seek to better characterize the incidence and outcome

The End