Participant Guide

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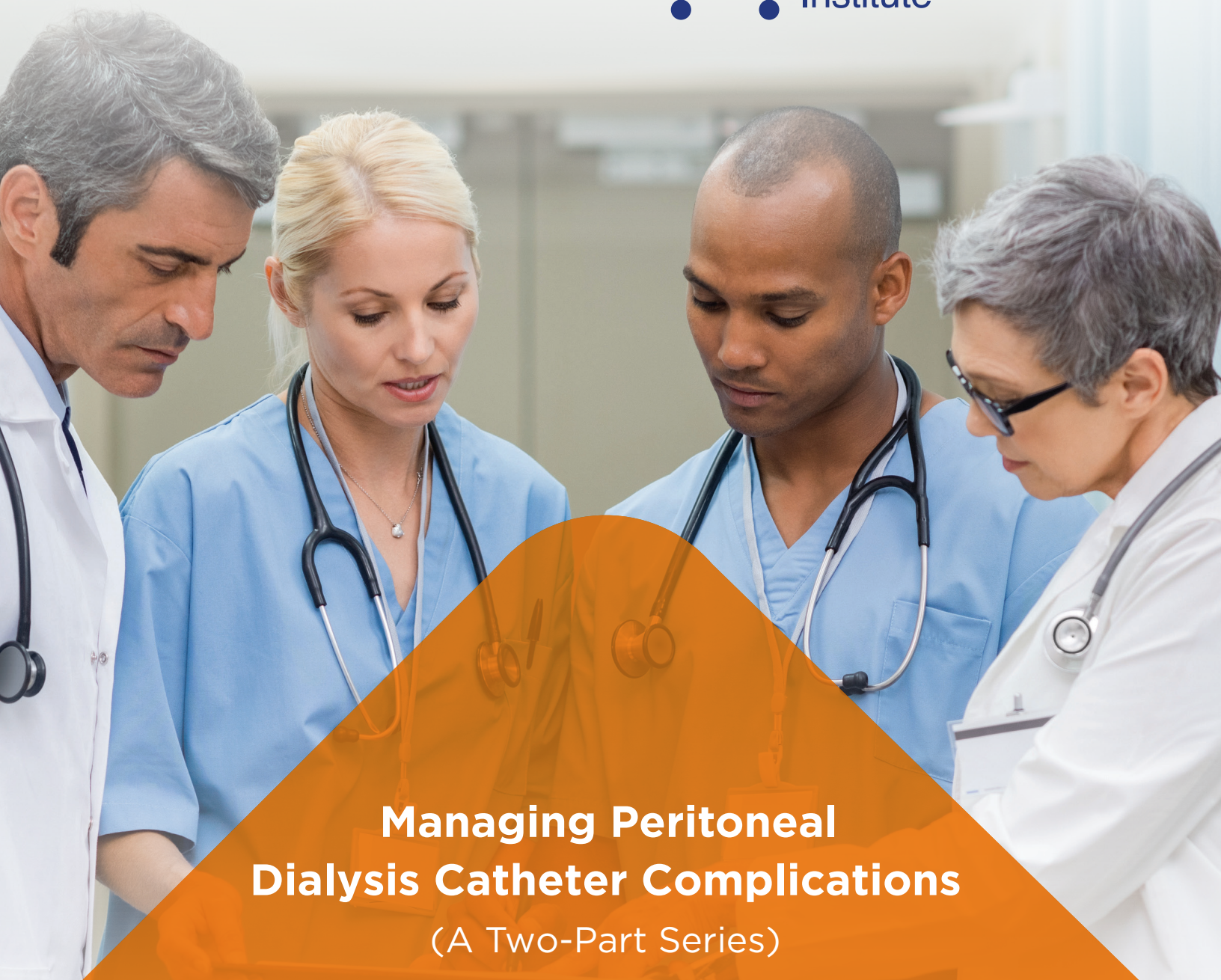

Managing Peritoneal Dialysis Catheter Complications

(A Two-Part Series)

Part 1: Mechanical Complications of Peritoneal Dialysis

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Torrance, California

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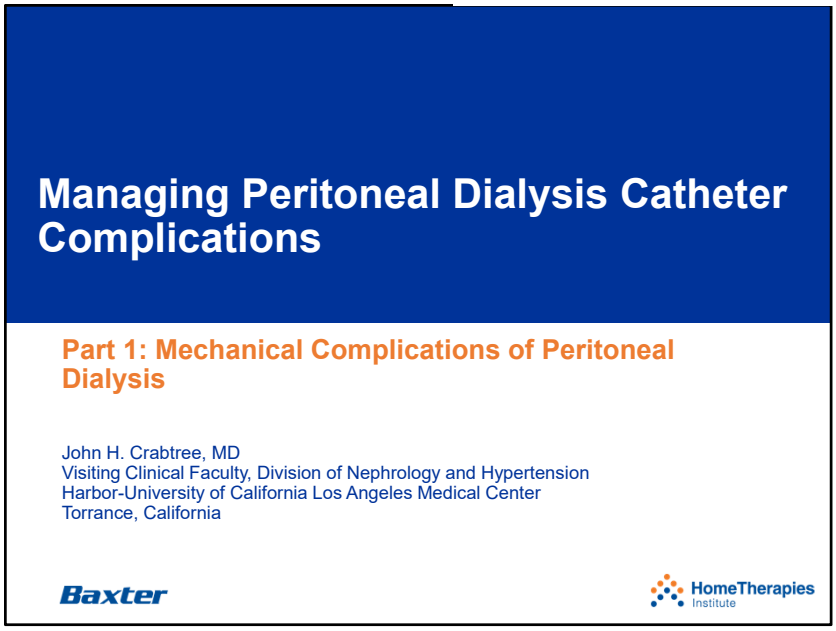
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Course Outline

- Mechanical catheter flow dysfunction
- Peritoneal boundary defects
- External catheter tubing damage



For informational purposes only. Health care providers should exercise their own judgment in determining whether any particular procedure or treatment is appropriate for their patients.

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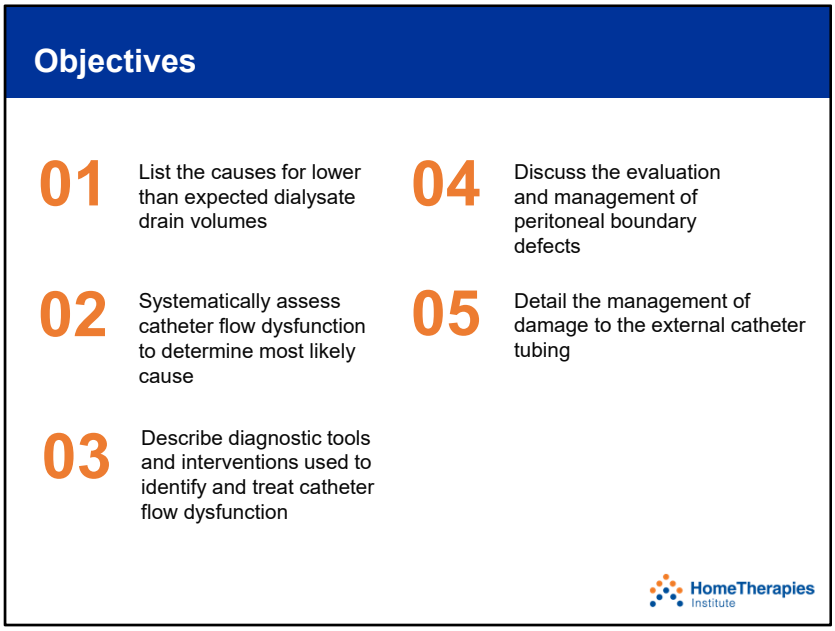
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 4

The success of a peritoneal dialysis program depends upon patients possessing a functional peritoneal dialysis access. After peritoneal dialysis-related infections, mechanical complications are the next most common cause for technique failure and patient transfer to hemodialysis. Familiarity with causes for mechanical complications, investigative studies, and corrective interventions can maintain technique survival and assure patient satisfaction with peritoneal dialysis as renal replacement therapy.

Upon completion of this session, you will be able to:

- List the causes for lower than expected dialysate drain volumes
- Systematically assess catheter flow dysfunction to determine most likely cause
- Describe diagnostic tools and interventions used to identify and treat catheter flow dysfunction
- Discuss the evaluation and management of peritoneal boundary defects including pericatheter leaks, hernias and pleuroperitoneal fistulae with hydrothorax
- Detail the management of damage to the external catheter tubing

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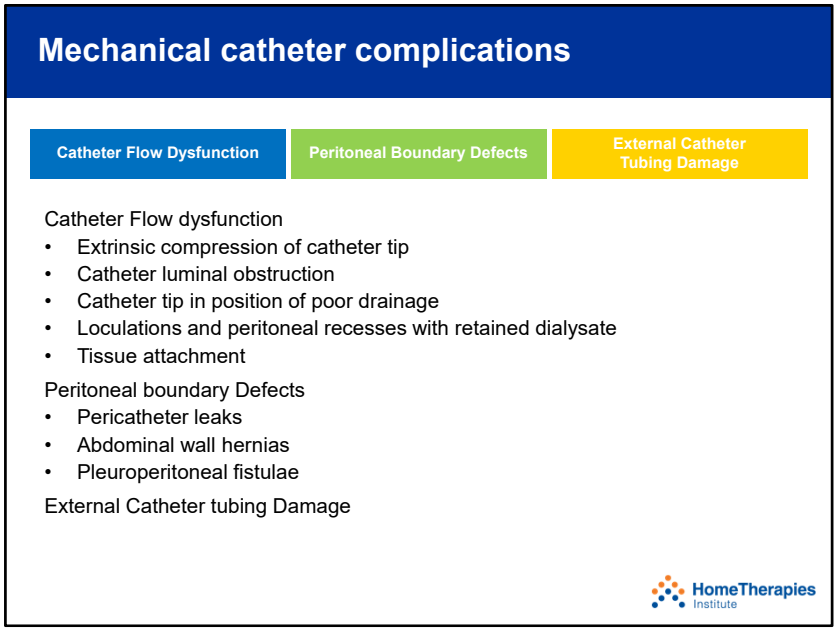
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 6

Causes for mechanical complications can be categorized as those due to:

Catheter Flow dysfunction[1]

- Extrinsic compression of catheter tip
- Catheter luminal obstruction[2]
- Catheter tip in position of poor drainage
- Loculations and peritoneal recesses with retained dialysate
- Tissue attachment

Peritoneal boundary Defects

- Pericatheter leaks
- Abdominal wall hernias
- Pleuroperitoneal fistulae

External Catheter tubing Damage

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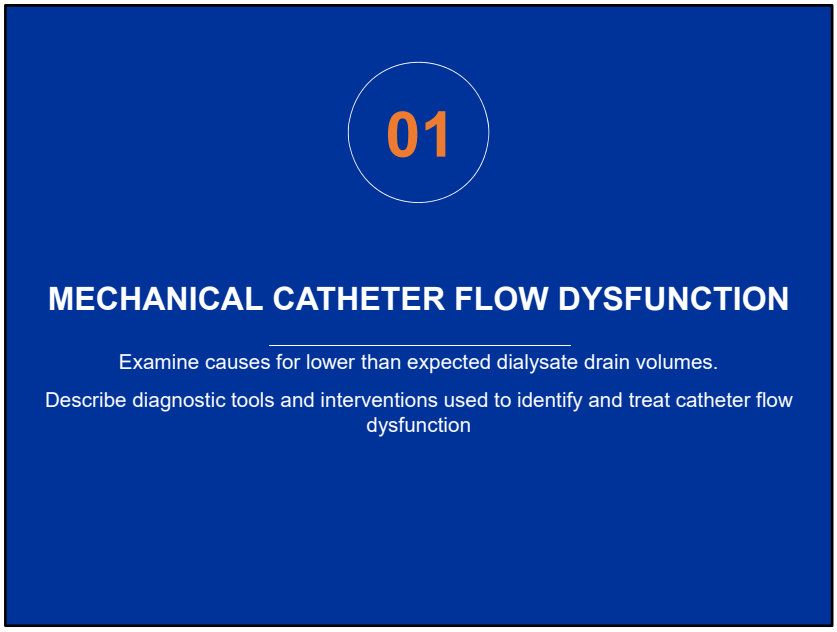

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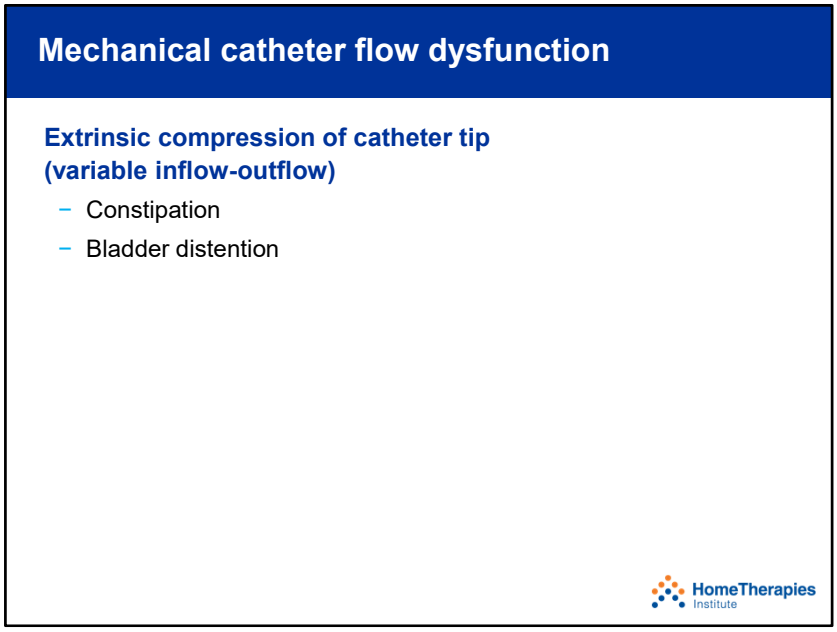
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 8

Catheter flow dysfunction from extrinsic pressure of organs on the side holes of the catheter tip is typically caused by:

- Constipation[2]
- Bladder distention[1]

Distension of the rectosigmoid colon and bladder crowds the pelvis and impinges on the catheter tip producing variable inflow-outflow dysfunction depending on the changes in degree of expansion.

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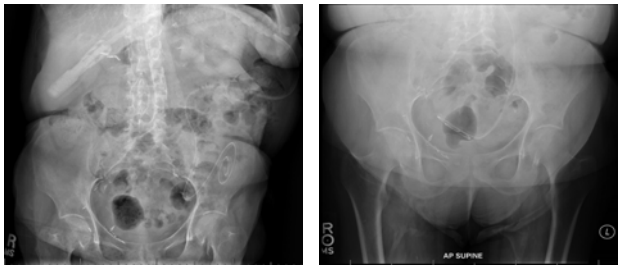
Part 1: Mechanical Complications of Peritoneal Dialysis

Mechanical catheter flow dysfunction from stool-filled bowel

Extrinsic compression of catheter tip (variable inflow-outflow)

- Constipation with catheter displacement and extrinsic compression resolved with cathartics



Before After

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My Notes:

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Constipation can both displace and extrinsically compress the catheter tip. Relief of constipation with cathartics can restore catheter function.[2]

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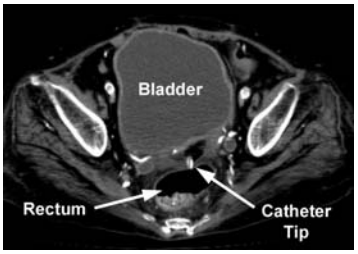
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

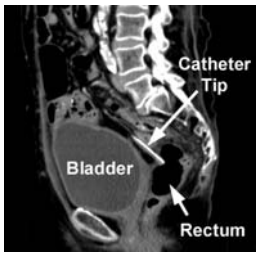
Mechanical catheter flow dysfunction from bladder distention

Extrinsic compression of catheter tip (variable inflow-outflow)

- CT scan showing bladder distention with extrinsic compression of catheter tip



Transverse View



Sagittal View

Uchiyama et al. Importance of neurogenic bladder as cause of drainage failure. Perit Dial Int 2016; 36:232-3.

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My Notes:

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Bladder distention can compress the catheter tip and interfere with flow function. Common causes of urinary retention are neurogenic bladder and prostatic enlargement.[1,3]

The CT scan shows compression of the catheter tip between the bladder and the rectum.

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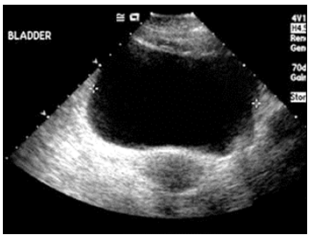
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Mechanical catheter flow dysfunction from distended bladder

Consider bladder distention as cause of drainage malfunction if post-void residual urine volume ≥ 50-300 ml

Assessment of post-void urinary volume:

- Bladder ultrasound
- Catheterization



Bladder ultrasound showing post-void urine volume of 450 ml.

Selius et al. Urinary retention in adults: diagnosis and initial management. Am Fam Physician 2008;77:643-50.

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My Notes:

Slide 11

The volume of residual urine considered to be significant varies in the literature, ranging from 50 to 300 ml. Consider bladder distension as cause of drainage malfunction if post-void residual urine volume is greater than 50-300 ml.[3]

Assessment of post-void urinary volume can be performed by:

- Bladder ultrasound
- Catheterization

This bladder scan image shows a post-void urine volume of 450 ml.

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Part 1: Mechanical Complications of Peritoneal Dialysis

Assessment and management sequence for catheter flow dysfunction and low drain volumes

Assess for extrinsic catheter tip compression

- Review bowel and urinary habits with patient
  - Treat constipation symptoms
  - Bladder scan or post-void catheterization for symptoms of urinary retention; urological referral for positive findings
- KUB x-ray may be obtained to check for stool pattern and rechecked to evaluate response to therapy if flow dysfunction still an issue

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My Notes:

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Assessment for extrinsic catheter tip compression:

- Review bowel and urinary habits with patient
  - Treat constipation symptoms[2]
  - Bladder scan or post-void catheterization for symptoms of urinary retention; urological referral for positive findings[3]
- KUB x-ray may be obtained to check for stool pattern and rechecked to evaluate response to therapy if flow dysfunction still an issue[2]
- The KUB x-ray also allows simultaneous evaluation for flow dysfunction due to catheter malposition and tubing kinks (include lateral x-ray if high suspicion of tubing kink)[2]

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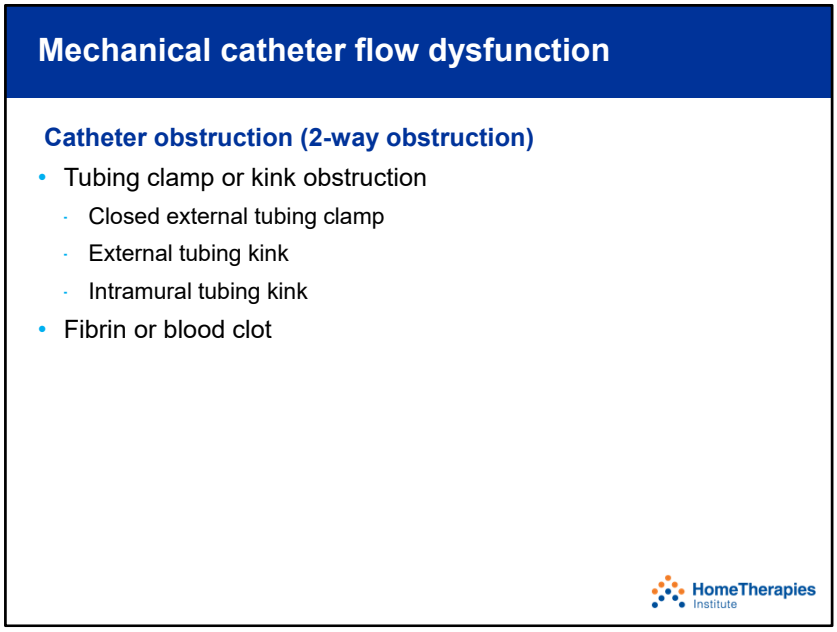
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 13

Two-way or complete catheter obstruction to inflow and outflow may be due to:[2]

- Tubing clamp or kink obstruction
  - Closed external tubing clamp
  - External tubing kink
  - Intramural tubing kink
- Fibrin or blood clot

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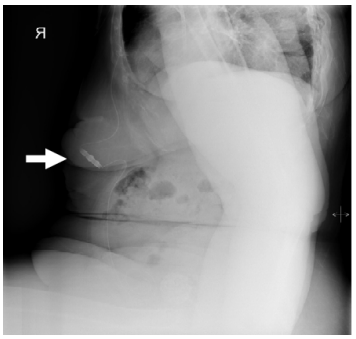
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Mechanical catheter flow obstruction by closed clamp or tubing kink

Assessment and management of tubing kinks

- Trace external tubing to check for closed clamps
- Examine under dressings for external catheter tubing kinks
- Radiologic imaging to search for intramural tubing kinks



Lateral chest x-ray showing tubing kink at titanium connector of presternal catheter

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My Notes:

Slide 14

Assessment and management of tubing kinks[2]

- Trace external tubing to check for closed clamps
- Examine under dressings for external catheter tubing kinks
- Radiologic imaging (including lateral x-rays) to search for intramural tubing kinks
- Obstructions by external clamps and kinks are easily relieved. Intramural kinks will require surgical referral for revision or catheter replacement

Pictured is a lateral chest X-ray showing a tubing kink at the titanium connector of a presternal catheter. An intramural kink such as this will require surgical revision.

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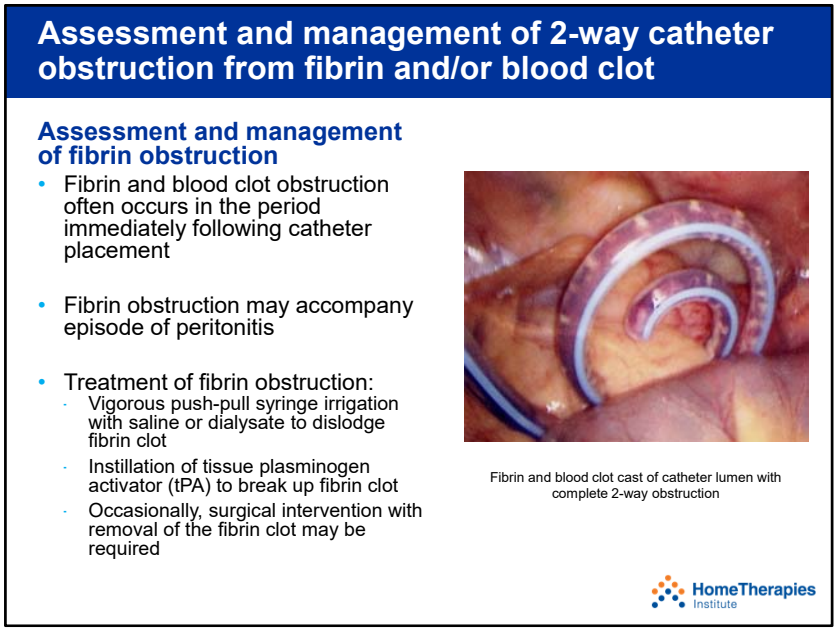
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 15

Assessment and management of fibrin obstruction:

- Fibrin and blood clot obstruction often occurs in the period immediately following catheter placement
- Fibrin obstruction may accompany episode of peritonitis[4]
- Treatment of fibrin obstruction:[2]
  - Vigorous push-pull syringe irrigation with saline or dialysate to dislodge fibrin clot
  - Instillation of tissue plasminogen activator (tPA) to break up fibrin clot
  - Occasionally, surgical intervention with removal of the fibrin clot may be required

This laparoscopic image shows a fibrin cast of the catheter coil that could not be dislodged except by surgical intervention.

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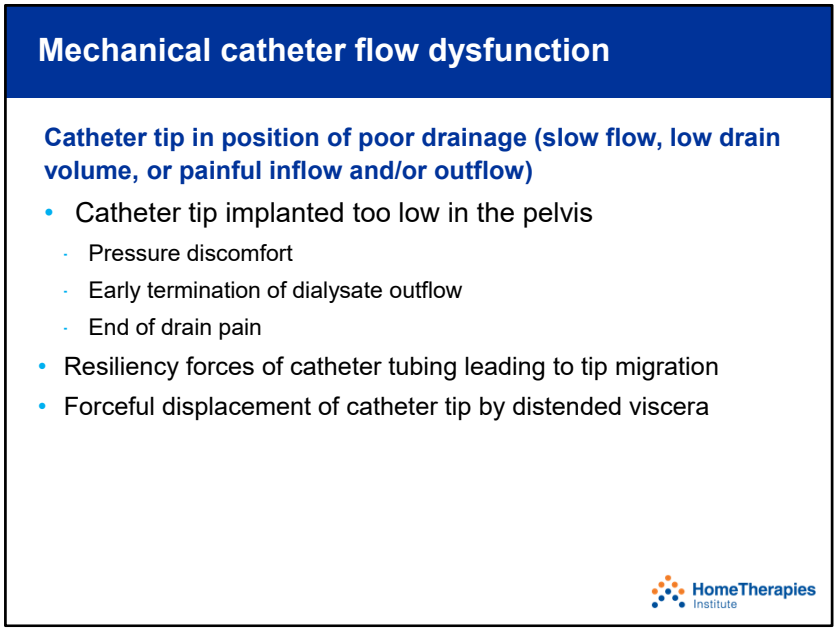
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 16

The catheter tip can be in a position of poor drainage function. This may manifest as slow flow, low drain volume, or painful inflow and/or outflow. Causes include:

- Catheter tip implanted too low in the pelvis[5]
  - Pressure discomfort
  - Early termination of dialysate outflow
  - End of drain pain
- Resiliency forces of catheter tubing leading to tip migration
- Forceful displacement of catheter tip by distended viscera

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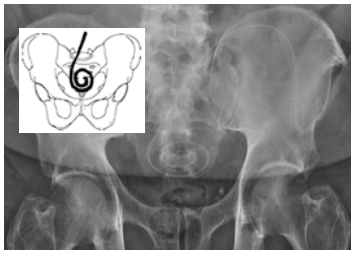
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

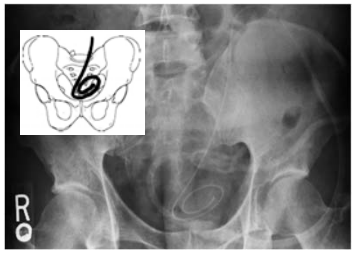
Management of flow dysfunction from catheter implanted too low in pelvis

Key activities

- Trial of tidal PD or conversion from APD to CAPD may resolve symptoms and permit adequate dialysis exchanges
- Too often, a symptomatic catheter tip implanted too low in pelvis can only be remedied by catheter replacement



Normal Coiled-Tip Configuration in Pelvis



Coiled-Tip Configuration Compressed in Pelvis

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My Notes:

Slide 17

Sometimes a KUB x-ray can give a clue of the catheter tip being positioned too low in the pelvis with deformity of the coiled tip.

Management of flow dysfunction from catheter implanted too low in pelvis:[5]

- Trial of tidal PD or conversion from APD to CAPD may resolve symptoms and permit adequate dialysis exchanges
- Too often, a symptomatic catheter tip implanted too low in pelvis can only be remedied by catheter replacement

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Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Mechanical catheter flow dysfunction from catheter tip migration

Catheter tip in position of poor drainage (slow flow, low drain volume, or painful inflow and/or outflow)

- Shape-memory resiliency forces of catheter tubing can lead to tip migration
  - Occurs with catheters having a straight intercuff segment
  - Excessive bending of straight segment
  - Poor fixation of deep cuff (midline or above fascial layer)
  - Inadequate immobilization of intramural segment

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My Notes:

Slide 18

Shape-memory resiliency forces of catheter tubing can lead to tip migration manifesting as slow flow, low drain volume, or painful inflow and/or outflow. A KUB x-ray is diagnostic of catheter tip malposition.[5,6]

- Occurs with catheters having a straight intercuff segment
- Excessive bending of straight segment
- Poor fixation of deep cuff (midline or above fascial layer)
- Inadequate immobilization of intramural segment

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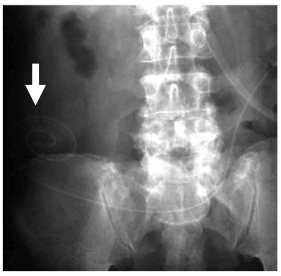
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Mechanical catheter flow dysfunction from catheter tip migration

Catheter tip in position of poor drainage (slow flow, low drain volume, or painful inflow and/or outflow)

- Shape-memory resiliency forces can lead to migration of the catheter tip into a position of poor drainage function, produce flow pain, or result in omental entrapment



Tube straightening with migration of catheter tip out of the pelvis

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Slide 19

As shown on this KUB, shape memory resiliency forces have led to tube straightening with migration of the catheter tip out of the pelvis.[5]

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Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Fluoroscopic guidewire repositioning for catheter tip migration

Fluoroscopic procedure for catheter manipulation

Migration of straight-tip catheter out of the pelvis into upper abdomen (arrows)

Guidewire passed through catheter with tip of wire manipulated into pelvis (arrows)

End result of guidewire manipulation of the catheter tip back into pelvis (arrows)

Kwon et al. Fluoroscopic guide wire manipulation of malfunctioning peritoneal dialysis catheters initially placed by interventional radiologists. J Vasc Interv Radiol 2014;25:904-10.

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My Notes:

Slide 20

Fluoroscopic guidewire manipulation can be used to return the catheter tip to a pelvic position.

The fluoroscopic images here show the migration of a straight-tip catheter out of the pelvis into the upper abdomen.

A guidewire is passed through the catheter with the tip of the wire manipulated into the pelvis.

Finally, the guidewire is used to reposition the catheter tip back into the pelvis.

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Part 1: Mechanical Complications of Peritoneal Dialysis

Complications of fluoroscopic guidewire manipulation

Fluoroscopic interventions

- Multiple procedures often required
- Published clinical failure rates for fluoroscopic manipulation vary from 25–75%
- Recurrence following fluoroscopic manipulation is due to not addressing the underlying problem
- When laparoscopic backup not available, technical failures are often managed by catheter replacement
- Patients often become frustrated with interruption of therapy and multiple interventions and elect to transfer permanently to hemodialysis

Kwon et al. Fluoroscopic guide wire manipulation of malfunctioning peritoneal dialysis catheters initially placed by interventional radiologists. J Vasc Interv Radiol 2014;25:904-10.

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My Notes:

Slide 21

Outcomes of fluoroscopic guidewire interventions:

- Multiple procedures often required due to failure to reposition or the recurrence of migration[5]
- Published clinical failure rates for fluoroscopic manipulation vary from 25–75%[5,7]
- Recurrence following fluoroscopic manipulation is due to not addressing the underlying problem of shape-memory resiliency forces produced by the original catheter implantation procedure
- When laparoscopic backup not available, technical failures are often managed by catheter replacement with frequent recurrence of the same problem[2]
- Patients often become frustrated with interruption of therapy and multiple interventions and elect to transfer permanently to hemodialysis

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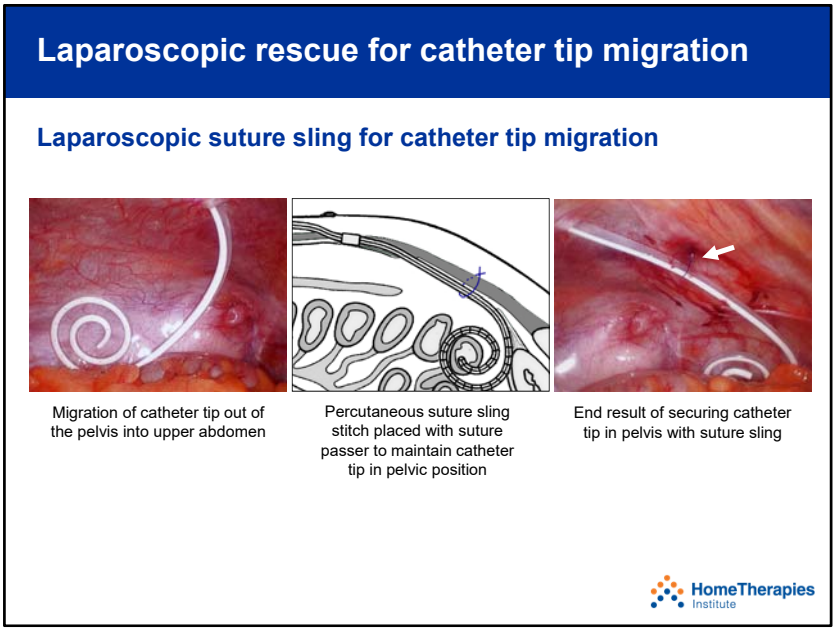

My Notes:

Slide 22

Laparoscopic intervention for catheter tip migration is best managed with placement of a suture sling to maintain the catheter in a pelvic orientation.

A suture sling as shown is preferable to stitching the catheter tip to a pelvic structure such as the bladder, uterus, or pelvic wall. These sutures tend to erode out with recurrence of catheter tip migration. A firm suture may impede subsequent removal of the catheter.[5]

A suture sling though the entire thickness of the abdominal wall will neither erode through or impede catheter removal.

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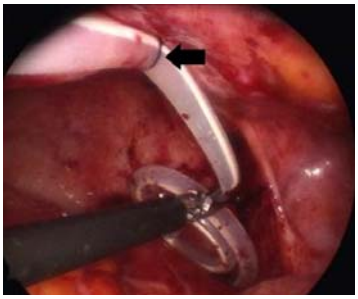
Part 1: Mechanical Complications of Peritoneal Dialysis

Potential complications of laparoscopic suture sling

- Suture sling too tight and crimps tubing with flow obstruction
- Patient may experience persistent pinching pain at sling site if suture tied too tight
- Possibility of dialysate leaks at fascial puncture site



Obstruction of catheter by suture sling tied too tight

Harissis et al. A new simplified one port laparoscopic technique of peritoneal dialysis catheter placement with intra-abdominal fixation. Am J Surg 2006; 192:125-9

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My Notes:

Slide 23

The surgeon does need to be familiar with potential complications of a suture sling and the techniques to prevent crimping of the catheter with an excessively tight stitch.

- Suture sling too tight and crimps tubing with flow obstruction
- Patient may experience persistent pinching pain at sling site if suture tied too tight
- Possibility of dialysate leaks at fascial puncture site[8]

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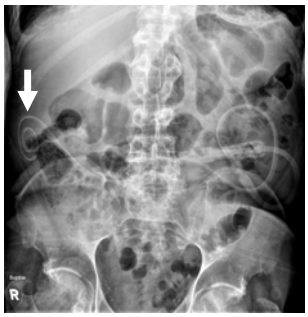
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Mechanical catheter flow dysfunction by forceful catheter tip displacement

Catheter tip in position of poor drainage (slow flow, low drain volume, or painful inflow and/or outflow)

- Forceful displacement of catheter tip from pelvis into position of poor drainage function



Catheter tip forced from pelvis by gas and stool-distended bowel

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My Notes:

Slide 24

While catheter tip malposition can result from tubing shape memory resiliency forces, the catheter tip can also be physically displaced by gas and stool-distended bowel. As with catheter tip migration, forceful displacement into a position of poor function is manifested by slow flow, low drain volume, or painful inflow and/or outflow.[5]

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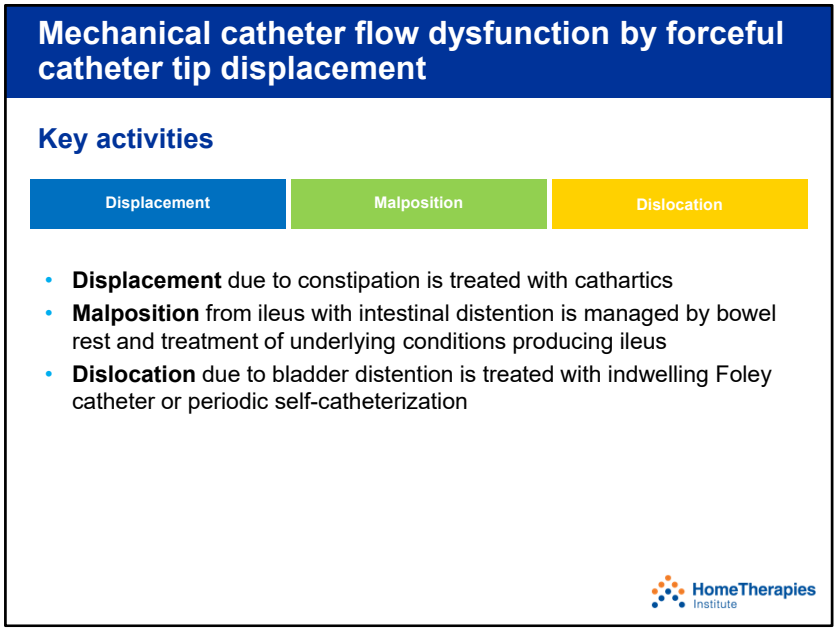

My Notes:

Slide 25

Management of flow dysfunction due to forceful catheter tip displacement:

- Displacement due to constipation is treated with cathartics, e.g., lactulose or polyethylene glycol solution[5]
- Malposition from ileus with intestinal distention is managed by bowel rest and treatment of underlying conditions producing ileus, e.g., infection, hypokalemia, or use of narcotic analgesics[9,10]
- Dislocation due to bladder distention is treated with indwelling Foley catheter or periodic self-catheterization; urological referral[3]

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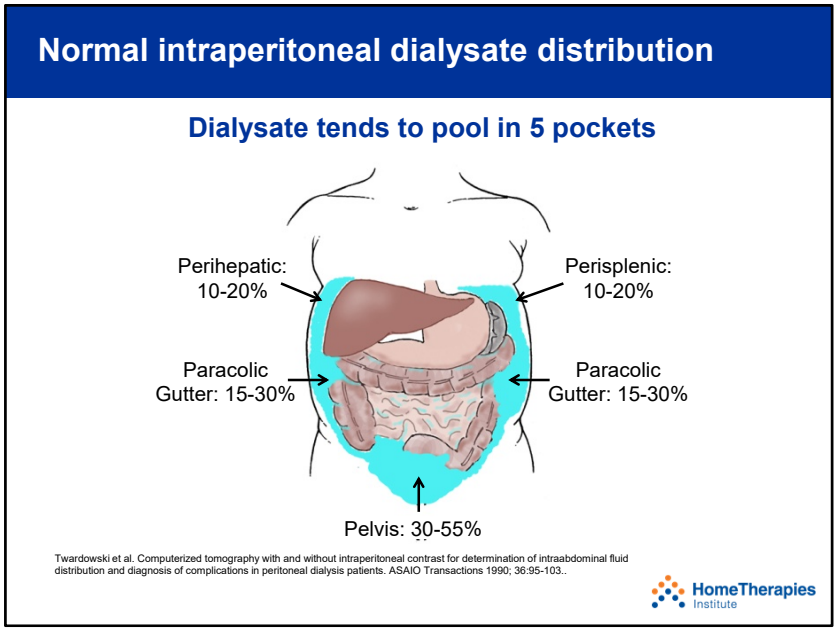

My Notes:

Slide 26

Let's examine conditions associated with intraperitoneal dialysate distribution.

- The dialysate does not distribute equally throughout the peritoneal cavity.
- 30 to 55% pools in the pelvis, 15 to 30% in the paracolic gutters, and 10 to 20% in the subdiaphragmatic spaces.[11]
- Variably, there may be narrow channels connecting these 5 pools so that filling and draining may be asymmetric or incomplete.
- Previous surgery and peritonitis with adhesions may alter pooling sites and drainage patterns.[11]

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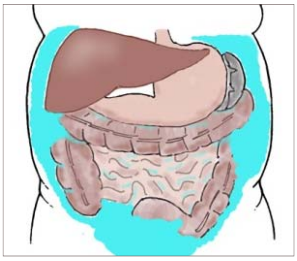
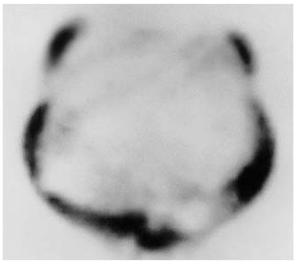
Peritoneal scintigraphy

Radioisotope (^{99m}technetium sulfur colloid) added to 2 liters of dialysis solution and infused



Normal distribution of dialysate within peritoneal cavity



Peritoneal scintigraphy showing normal distribution of dialysate

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The normal distribution of dialysate into 5 recesses in the recumbent patient is demonstrated with peritoneal scintigraphy where radioisotope has been added to 2 liters of dialysate and infused.

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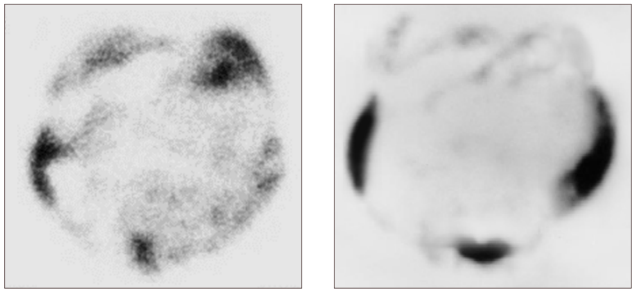
Part 1: Mechanical Complications of Peritoneal Dialysis

Incomplete dialysate drainage



Incomplete drainage due to compartmentalizing adhesions

Incomplete drainage due to retained fluid in bulging flank recesses

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My Notes:

Slide 28

Peritoneal scintigraphy can be of value in assessing causes of incomplete dialysate drainage.[12]

The image on the left shows scattered pockets of radioisotope-labeled dialysate due to compartmentalizing adhesions. These adhesions with loculation of the peritoneal cavity can be due to previous peritonitis or surgery.

The image on the right reveals dialysate pooled in the paracolic gutters which tends to occur in obese patients with bulging flanks.

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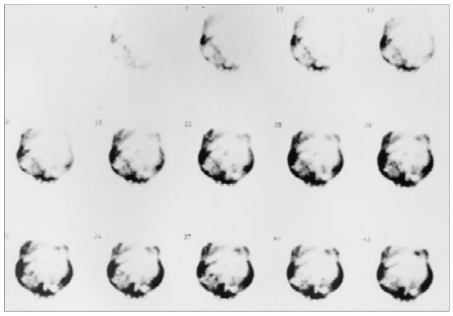
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Dynamic peritoneal scintigraphy

Normal peritoneal scintigraphy scan during dialysate inflow



Dialysate inflow phase images

Juergensen et al. Value of scintigraphy in chronic peritoneal dialysis patients. Kidney Int 1999; 55:1111-9.

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My Notes:

Slide 29

One of the attributes of imaging with peritoneal scintigraphy is the ability to perform dynamic studies capturing sequential images during dialysate inflow and outflow.

Shown here is a normal scan during dialysate inflow. The final image shows normal accumulation of the dialysate in the 5 recesses.

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Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Dynamic peritoneal scintigraphy

Abnormal peritoneal scintigraphy scan during dialysate inflow

Maldistribution of dialysate due to peritoneal loculation from adhesions

Dialysate inflow phase images

Juergensen et al. Value of scintigraphy in chronic peritoneal dialysis patients. Kidney Int 1999; 55:1111-9.

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My Notes:

Slide 30

This dynamic peritoneal scintigraphy shows abnormal distribution of dialysate during inflow. There is absence of radioisotope-labeled dialysate on the right side of the abdomen due to adhesions.

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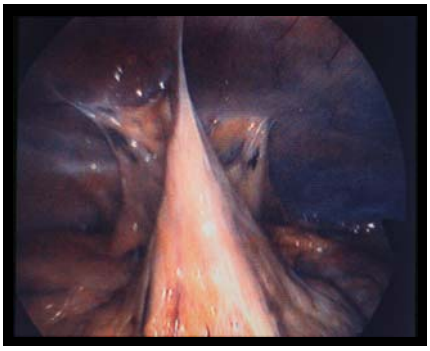
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Incomplete dialysate drainage caused by compartmentalizing adhesions



Adhesions can create poorly draining pockets within the peritoneal cavity

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My Notes:

Slide 31

This laparoscopic image of compartmentalizing adhesions can affect dialysate distribution during infusion or create pockets trapping fluid during drainage.

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Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

My Notes:

Slide 32

Laparoscopy can be used to take down adhesions.

- Instruments are inserted through laparoscopic ports
- Adhesions can be divided with a variety of surgical instruments. Shown in this video is the use of ultrasonic shears to take down the adhesions, utilizing ultrasonic energy to coagulate and divide the tissues.

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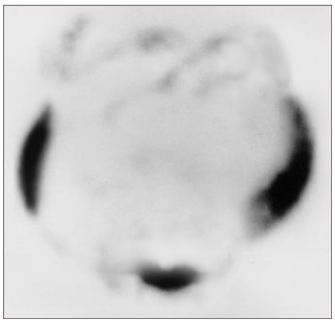
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Low drain volume due to retained dialysate in peritoneal recesses

Key activities

- Utilize tidal PD regimen with reserve volume adjusted above estimated residual volume
- Alternatively, dialysis performed as CAPD with patient assuming an upright posture (sitting, standing) to allow shifting of pooled dialysate to pelvis



Incomplete drainage due to retained fluid in bulging flank recesses

Katopodis et al. Estimation of residual peritoneal volume using technetium-99m sulfur colloid scintigraphy. ASAIO J 2015; 61:459-62

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My Notes:

Slide 33

Low drain volumes can be due to retained dialysate in peritoneal recesses as shown in this peritoneal scintigraphy image with residual fluid volume pooled in the paracolic gutters.[13]

Management:

- Utilize tidal PD regimen with reserve volume adjusted above estimated residual volume
- Alternatively, dialysis performed as CAPD with patient assuming an upright posture (sitting, standing) to allow shifting of pooled dialysate to pelvis

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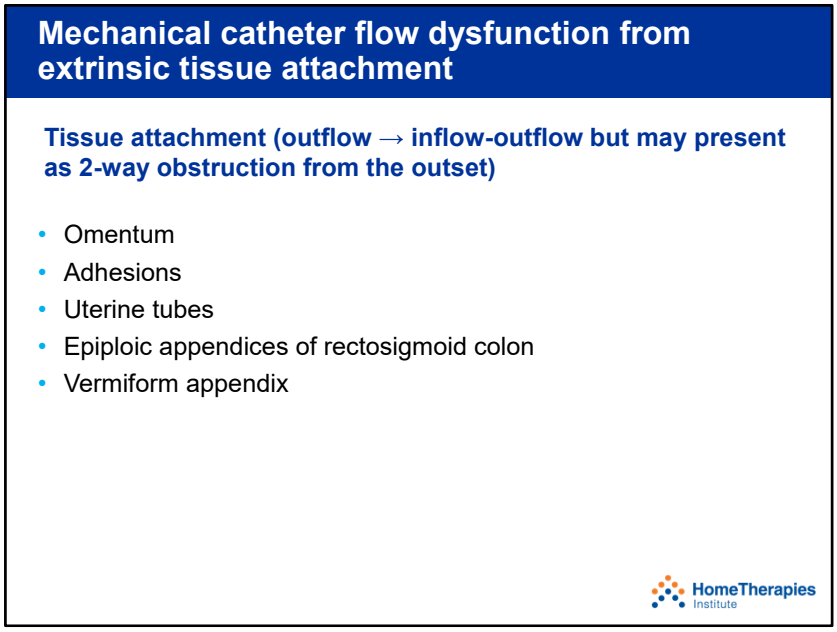
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 34

Catheter flow dysfunction can result from attachment of intraperitoneal tissues to the catheter.[14]

Common obstructing tissues include:

- Omentum
- Adhesions
- Uterine tubes
- Epiploic appendices of rectosigmoid colon
- Vermiform appendix

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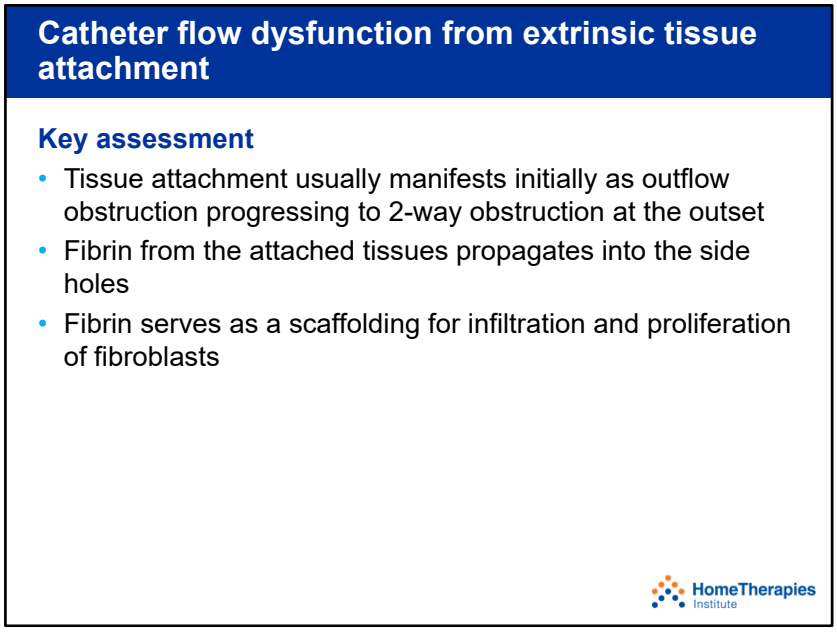
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 35

- Tissue attachment usually manifests initially as outflow obstruction from tissues acting as a flap-valve effect on catheter tip side drainage holes but may also present as 2-way obstruction at the outset
- Fibrin from the attached tissues propagates into the side holes and lumen of the catheter eventually producing 2-way obstruction.[10]
- Fibrin serves as a scaffolding for infiltration and proliferation of fibroblasts and endothelial cells leading to the formation of granulation tissue and firm adhesive attachment of the obstructing tissues.

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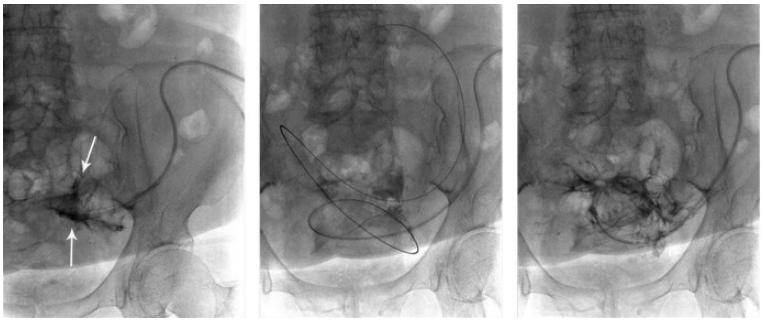
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Fluoroscopic guidewire manipulation to disrupt extraluminal obstruction

Fluoroscopic rescue procedure for tissue attachment



Contrast study shows contrast material stasis (arrows) around catheter tip

Guidewire manipulation performed to disrupt extraluminal obstruction

Final contrast study shows improved flow of contrast along intestinal outlines.

Kwon et al. Fluoroscopic guide wire manipulation of malfunctioning peritoneal dialysis catheters initially placed by interventional radiologists. J Vasc Interv Radiol 2014;25:904-10.

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My Notes:

Slide 36

Fluoroscopic guidewire manipulation has been used in attempts to disrupt extraluminal tissue obstruction of the catheter.[7]

- Diagnosis of tissue attachment by contrast studies under fluoroscopy show contrast material stasis around the catheter tip.
- Insertion of a guidewire through the catheter is used in an attempt to disrupt the extraluminal obstruction.
- If successful, final contrast study shows improved flow of contrast around the bowel loops.

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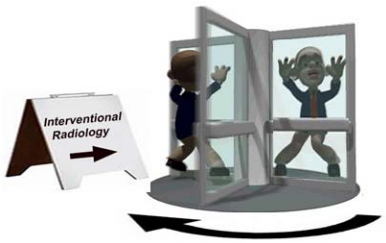
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Fluoroscopic interventions for extraluminal obstructions

Fluoroscopic interventions

- Similar to fluoroscopic manipulation for tip migration, multiple interventions are often required
- High clinical failure rate (as much as 90% if patient had previous abdominopelvic surgery or peritonitis)
- Difficult or impossible to perform with swan neck or presternal catheters
- Does not permit diagnosis-specific treatment of underlying problem

Revolving door of procedures



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My Notes:

Slide 37

- Similar to fluoroscopic manipulation for tip migration, multiple interventions are often required[15]
- High clinical failure rate (as much as 90% if patient had previous abdominopelvic surgery or peritonitis)[5]
- Difficult or impossible to perform with swan neck or presternal catheters
- Does not permit diagnosis-specific treatment of underlying problem[5]
- With multiple interventions and high failure rates, patients often feel trapped in revolving door of procedures and opt out to hemodialysis

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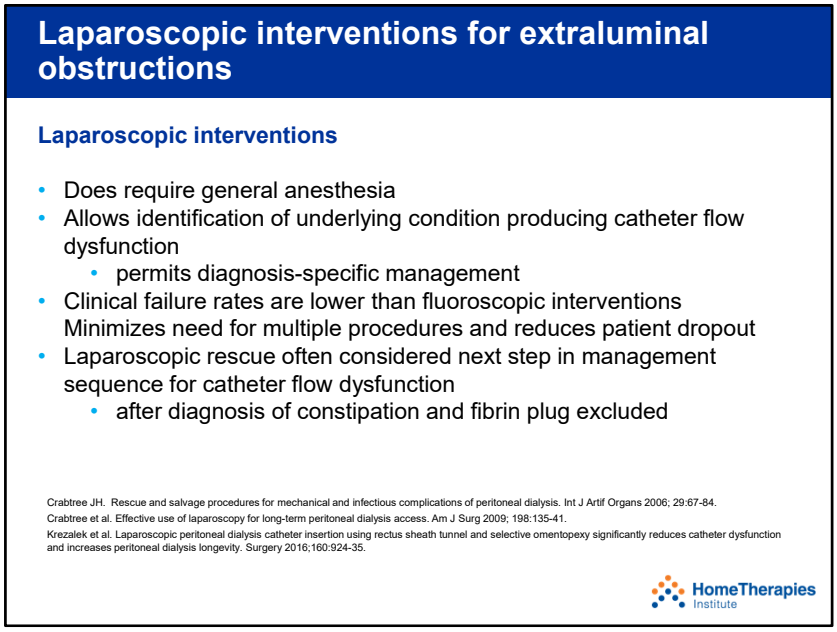
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 38

Laparoscopic interventions for extraluminal obstruction:

- Although minimally invasive procedure, does require general anesthesia[16]
- Allows identification of underlying condition producing catheter flow dysfunction and permits diagnosis-specific management[14]
- Clinical failure rates are lower than fluoroscopic interventions. High success rate minimizes need for multiple procedures and reduces patient dropout[14,17]
- Laparoscopic rescue often considered next step in management sequence for catheter flow dysfunction after diagnosis of constipation, bladder distention, and fibrin plug excluded[16]

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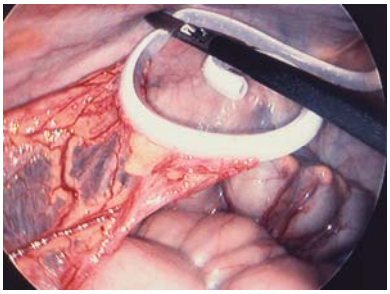
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Flow obstruction from omental entrapment

Omental apron



Catheter obstruction by omentum

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My Notes:

Slide 39

Let's take a look at examples of extraluminal tissue obstruction and their management beginning with the omentum.

The omentum is a fat laden sheet of peritoneum that hangs down from the greater curvature of the stomach and transverse colon. When the omentum is redundant and extends to the pelvis, it may siphon up to the catheter tip producing obstruction.[15,16]

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Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Management of flow obstruction from omental entrapment

Laparoscopic omentolysis

Omental entrapment of catheter coil

Omentum stripped from catheter coil

Cleaned catheter tip repositioned in pelvis

Crabtree et al. Laparoscopic epiplopexy of the greater omentum and epiploic appendices in the salvaging of dysfunctional peritoneal dialysis catheters. Surg Laparosc Endosc 1996 6:176-80.

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My Notes:

Slide 40

Laparoscopy allows simultaneous diagnosis and treatment of catheter obstruction by omentum.

The omentum is stripped from the catheter tubing and the catheter tip repositioned in the pelvis.

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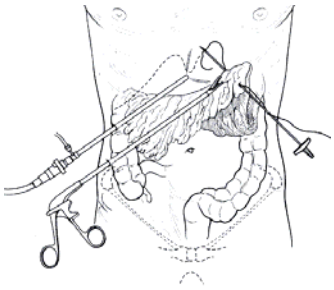
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Laparoscopic management of omental obstruction



Omentum sutured to upper abdominal wall to keep it free of pelvis

Laparoscopic omentopexy to upper abdominal wall

Crabtree JH. Rescue and salvage procedures for mechanical and infectious complications of peritoneal dialysis. Int J Artif Organs 2006; 29:67-84.

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My Notes:

Slide 41

To prevent recurrence of the omental obstruction, the omentum is sutured to the upper abdominal wall remote from the pelvis. This procedure is referred to as an omentopexy. It is quick and easy to perform and with minimal risk of complications.[16]

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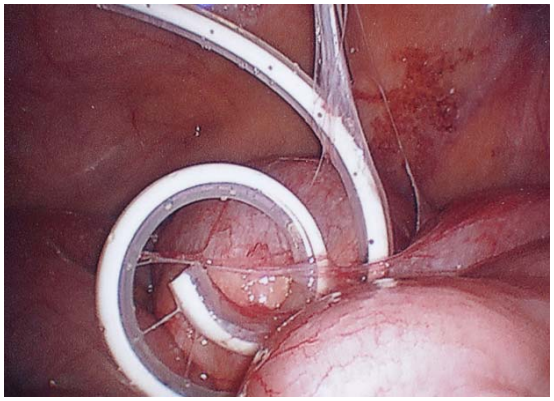
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Flow obstruction from adhesions



Catheter entrapped between loops of bowel by adhesions

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My Notes:

Slide 42

Adhesions are a form of scar tissue that may result from inflammation and irritation of the intraperitoneal tissue surfaces. Peritonitis and surgical operations are the usual causes of adhesions. Adhesions can produce obstruction of the catheter or create pockets within the peritoneal cavity resulting in poor distribution and drainage of dialysate solution.

Often, adhesions can be divided with laparoscopic instruments to rescue obstructed catheters or to eliminate compartmentalization within the peritoneal cavity that interferes with catheter flow function.[5,18]

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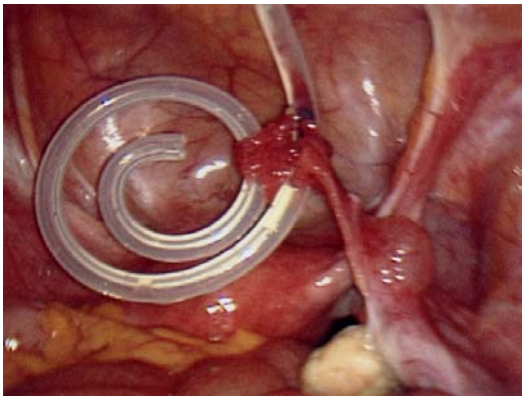
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Flow obstruction from uterine tube



Uterine tube obstructing proximal side holes of catheter

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My Notes:

Slide 43

The fimbria of the uterine tubes is another tissue structure that can siphon up to the catheter producing obstruction.[5]

In this laparoscopic photograph, the fimbria are attached to the proximal side holes of the catheter tip. Blood and granulation tissue can be seen within the lumen of the catheter adjacent to the adherent uterine tube.

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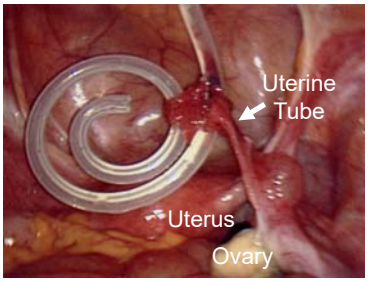
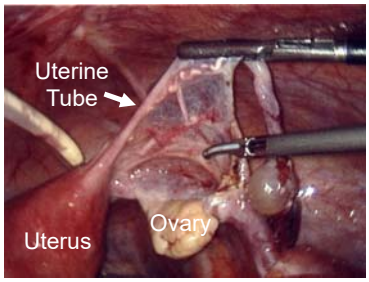
Part 1: Mechanical Complications of Peritoneal Dialysis

Management of flow obstruction from uterine tube

Laparoscopic salpingectomy



Uterine tube obstruction of catheter tip



Laparoscopic resection of uterine tube

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Slide 44

Laparoscopically, the fimbria of the uterine tube can be stripped from the catheter. To prevent recurrence, the uterine tube may be resected.

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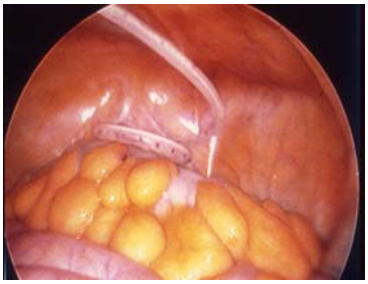
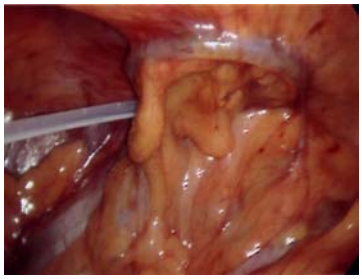
Part 1: Mechanical Complications of Peritoneal Dialysis

Flow obstruction from epiploic appendices of colon



Epiploic appendices of sigmoid colon



Catheter obstruction from epiploic appendices of sigmoid colon

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My Notes:

Slide 45

The epiploic appendices are fat-filled tabs or pendants of peritoneum that project
from the serous coat of the colon. They are particularly predominant in the rectosigmoid region where the PD catheter tip usually comes to rest. Normally the are short and stubby and cause no problems. When they are redundant finger-like projections, they can siphon up to the catheter and cause obstruction.[18]

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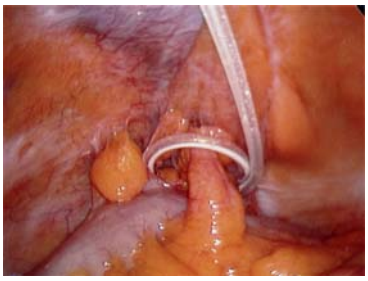
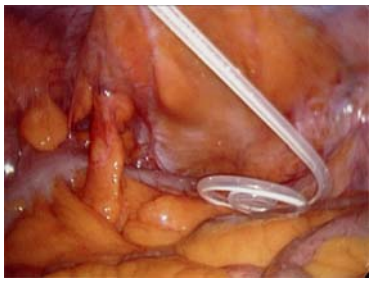
Part 1: Mechanical Complications of Peritoneal Dialysis

Management of epiploic appendix obstruction



Obstruction of catheter tip by epiploic appendix of sigmoid colon



Catheter pulled free of obstruction leaving epiploic appendix adherent to abdominal wall

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My Notes:

Slide 46

This is an example of obstruction of the catheter tip by an epiploic appendix of the sigmoid colon. Sometimes, this can be remedied by simply pulling the catheter free of the attachment leaving the epiploic appendix adherent to the abdominal wall to prevent recurrence.[18]

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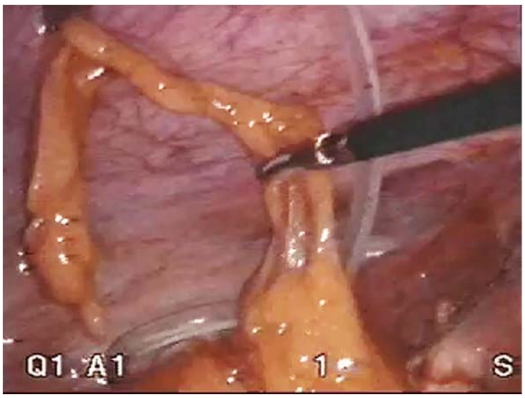
Part 1: Mechanical Complications of Peritoneal Dialysis

Alternatively, epiploic appendices can be resected



Laparoscopic resection of epiploic appendix

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My Notes:

Slide 47

Other times, if the epiploic appendix is free to siphon up to the catheter again, it makes sense to resect it to prevent recurrence.

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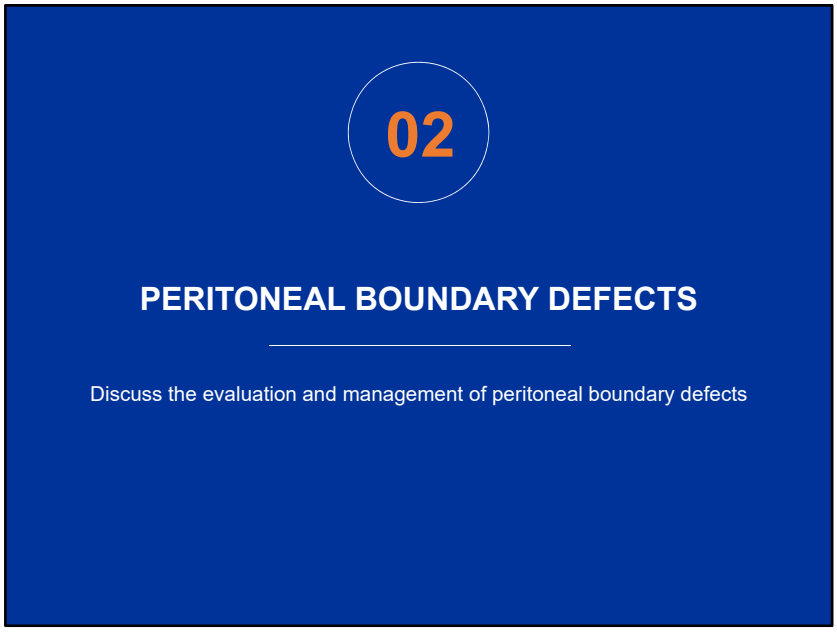
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Course Outline

- Mechanical catheter flow dysfunction
- Peritoneal boundary defects
- External catheter tubing damage



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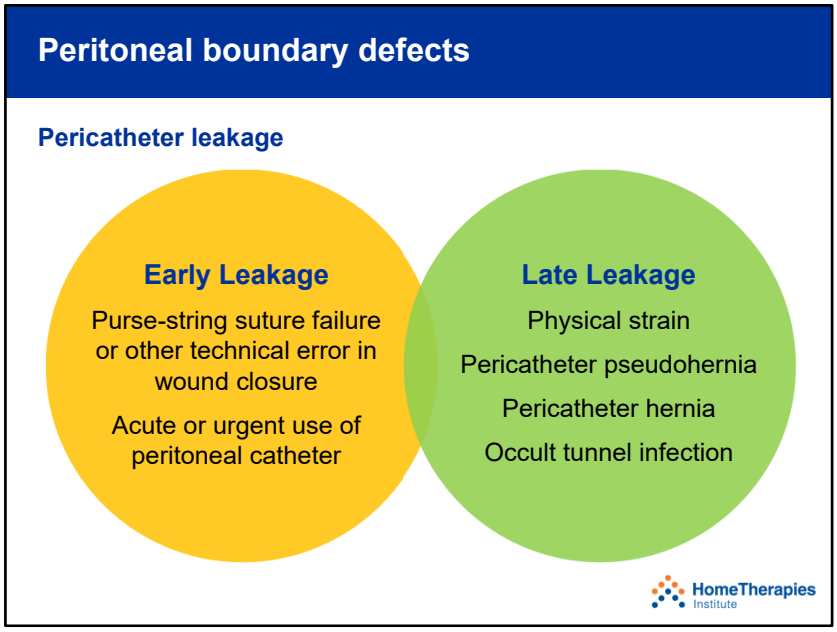
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 49

Defects in the lining of the peritoneal cavity can result in dialysate leakage. Leakage around the catheter as it passes through the abdominal wall is a common cause of peritoneal boundary defects.

- Early leakage[16]
  - Purse-string suture failure or other technical error in wound closure
  - Acute or urgent use of peritoneal catheter
- Late leakage[2,16]
  - Physical strain
  - Pericatheter pseudohernia
  - Pericatheter hernia
  - Occult tunnel infection

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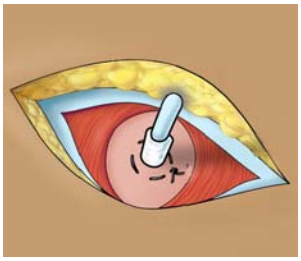
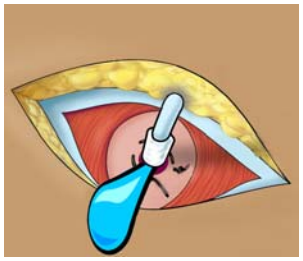
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Dramatic early pericatheter leaks warrant immediate surgical exploration

Technical error with suture failure



Intact purse-string suture



Purse-string suture failure with dramatic pericatheter leak

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My Notes:

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Dramatic early pericatheter leaks warrant immediate surgical exploration. They are usually caused by a technical error made during catheter placement, e.g., failure of the purse string suture.[16]

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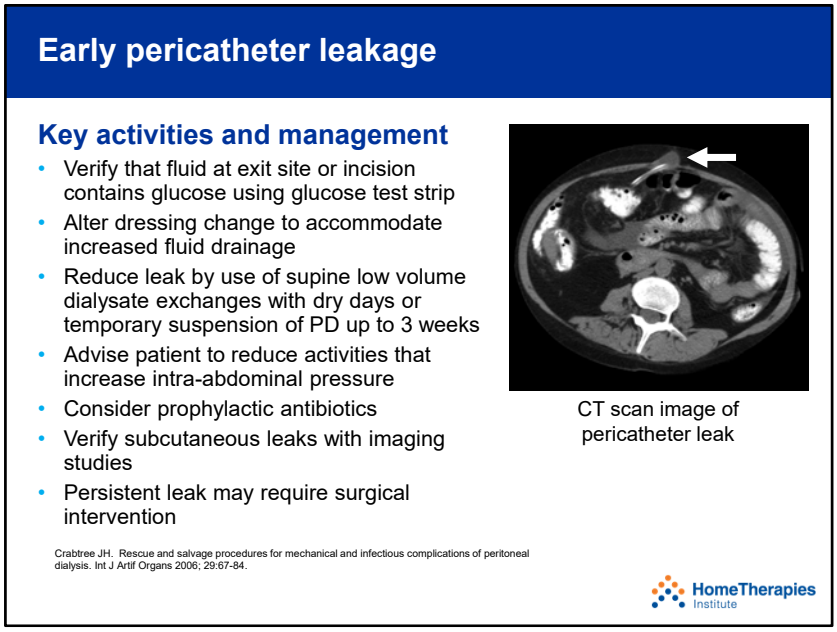
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 51

Key activities and management of early pericatheter leakage include:[2,16]

- Verify that fluid at exit site or incision contains glucose using glucose test strip
- Alter dressing change to accommodate increased fluid drainage
- Reduce leak by use of supine low volume dialysate exchanges with dry days or temporary suspension of PD up to 3 weeks
- Advise patient to reduce activities that increase intra-abdominal pressure (lifting, coughing, straining)
- Consider prophylactic antibiotics
- Verify subcutaneous leaks with imaging studies (CT, scintigraphy, US, or MRI)
- Persistent leak may require surgical intervention

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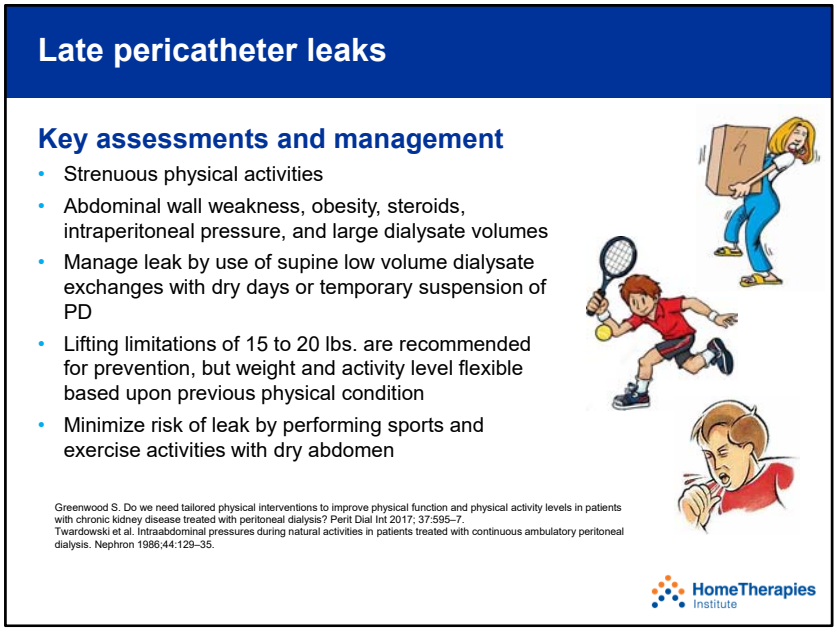
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 52

Late pericatheter leaks can result from strenuous physical activities.[2,19,20,21]

- Strenuous physical activities, e.g., sports, heavy lifting, forceful coughing, may cause acute late pericatheter leaks
- Abdominal wall weakness, obesity, steroids, intraperitoneal pressure, and large dialysate volume are among factors that increase susceptibility to acute leaks from physical forces
- Manage leak by use of supine low volume dialysate exchanges with dry days or temporary suspension of PD
- Lifting limitations of 15 to 20 lbs. are recommended for prevention, but weight and activity level flexible based upon previous physical condition
- Minimize risk of leak by performing sports and exercise activities with dry abdomen

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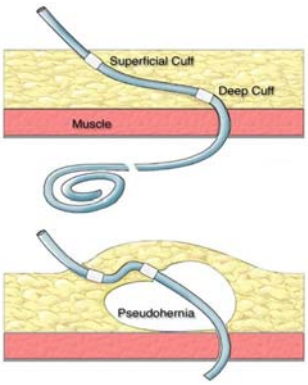
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Late pericatheter leak and catheter extrusion from pseudohernia

Key assessments and activities

- Risk for pseudohernia occurs when single or deepest catheter Dacron cuff is positioned in the subcutaneous tissue instead of within the muscle
- Contributing factors include increased intraabdominal pressure from dialysate and a weak abdominal wall
- Complications include leakage and extrusion of the catheter
- Catheter replacement is required



Diaz-Buxo, et al. Single cuff versus double cuff Tenckhoff catheter. Perit Dial Bull 1984; 4:S100-2.

Crabtree JH. Rescue and salvage procedures for mechanical and infectious complications of peritoneal dialysis. Int J Artif Organs 2006; 29:67-84.

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My Notes:

Slide 53

Late pericatheter leak can occur as a consequence of a pseudohernia. Large pseudohernias can lead to complete extrusion of the catheter.[16,22]

- Risk for pseudohernia occurs when single or deepest catheter Dacron cuff is positioned in the subcutaneous tissue instead of within the muscle
- Continuously increased intraabdominal pressure from the presence of dialysate in combination with a weak abdominal wall are contributing factors for formation of a pseudohernia
- Late pericatheter leakage is a complication of pseudohernia
- Catheter replacement is required, preferably inserting new catheter at paramedian site with deep cuff within muscle tissue for firm tissue ingrowth and fixation

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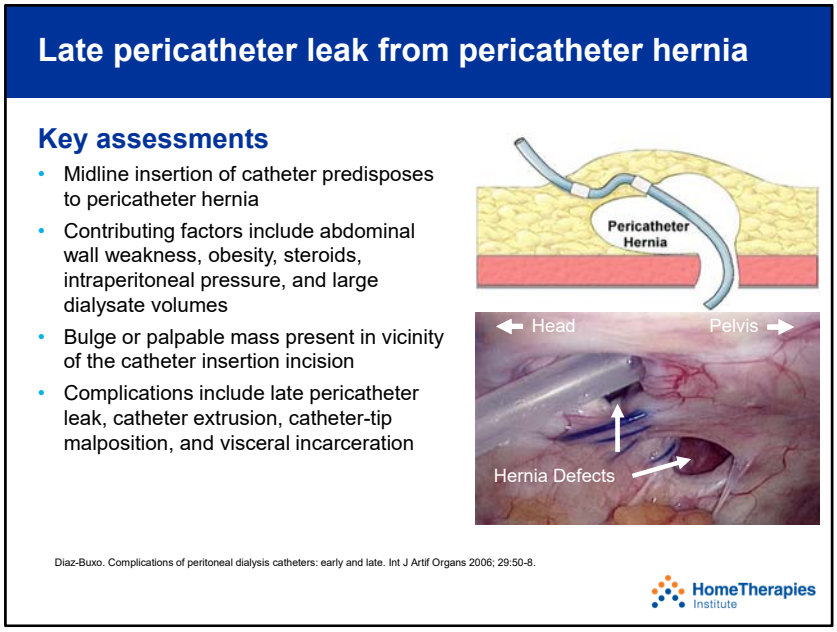
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 54

Late pericatheter leaks can occur from a pericatheter hernia.[2,16,20,22]

- Midline insertion of catheter predisposes to pericatheter hernia because of thinness of tissue at linea alba
- Abdominal wall weakness, obesity, steroids, intraperitoneal pressure, and large dialysate volume are among factors that increase susceptibility to herniation around catheter
- Bulge or palpable mass present in vicinity of the catheter insertion incision
- Late pericatheter leak, catheter extrusion, catheter-tip malposition, and visceral incarceration are potential complications of pericatheter hernia

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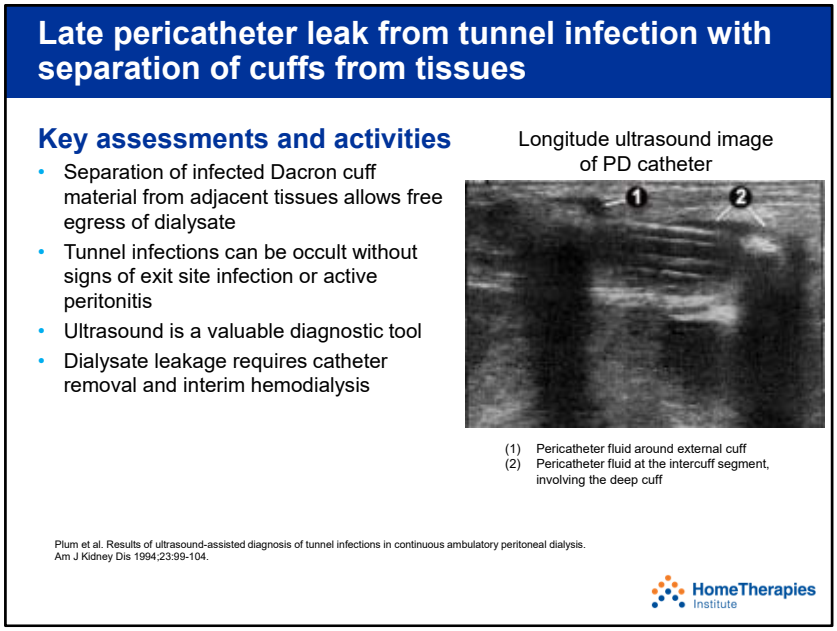
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 55

Late pericatheter leaks can occur in association with tunnel infections with separation of the Dacron cuffs from the tissues.[2,23]

- Separation of infected Dacron cuff material from adjacent tissues allows free egress of dialysate along the catheter tunnel
- Tunnel infections can be occult without signs of exit site infection or active peritonitis
- Ultrasound may be of value in showing presence of fluid and separation of cuffs from adjacent tissues
- Dialysate leakage from tunnel infection requires catheter removal and interim hemodialysis

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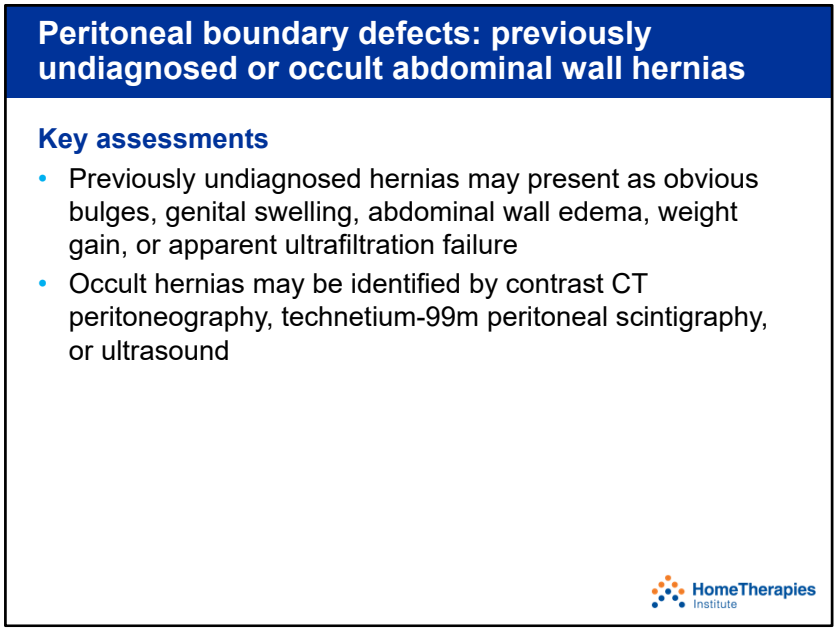
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 56

All identified hernias should be repaired at the time of catheter insertion; however, small or occult defects may go undetected, becoming manifest only after the force of increased intraabdominal pressure with peritoneal dialysis.[16]

- Previously undiagnosed hernias may present as obvious bulges, genital swelling, abdominal wall edema, weight gain, or apparent ultrafiltration failure
- Occult hernias may be identified by contrast CT peritoneography, Tc-99m peritoneal scintigraphy, or ultrasound

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Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Umbilical hernia

Key assessments

- Most common hernia encountered in peritoneal dialysis patients
- Although hernia sac may be large, fascial defect usually small
- Occasionally presents as occult abdominal wall leak or drainage from umbilicus

Crabtree JH. Rescue and salvage procedures for mechanical and infectious complications of peritoneal dialysis. Int J Artif Organs 2006; 29:67-84.

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My Notes:

Slide 57

Umbilical hernias are the most common hernias encountered in peritoneal dialysis patients.[16]

Although hernia sac may be large, the fascial defect is usually small; otherwise it should have been noticed prior to catheter placement.[24]

Occasionally, umbilical hernias present as occult abdominal wall leakage or drainage from the umbilicus.[2]

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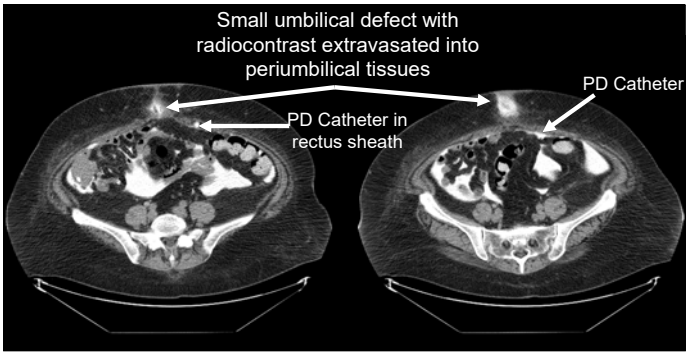
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

CT Peritoneography for occult umbilical hernia



Note radiocontrast visible between loops of bowel within the peritoneal cavity. Catheter clearly demonstrated apart from abdominal wall leak.

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My Notes:

Slide 58

CT peritoneography can be helpful in distinguishing between an occult umbilical hernia or pericatheter leakage.[16]

Radiocontrast is visible between loops of bowel within the peritoneal cavity. A small umbilical defect is visible with radiocontrast extravasated into the periumbilical tissues.

The peritoneal dialysis catheter is clearly demonstrated apart from the abdominal wall leak.

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Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Genital edema on peritoneal dialysis

Key assessment

- Scrotal edema can prevent accurate determination of presence and side of inguinal hernia
- Imaging studies often required to identify side of hernia
- Low volume low dialysate exchanges with dry days may allow patient to continue on PD with reduction of swelling in preparation for surgical repair

Crabtree JH. Hernia repair without delay in initiating or continuing peritoneal dialysis. Perit Dial Int 2006; 26:178-82.

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My Notes:

Slide 59

The onset of genital edema is not an infrequent complication following initiation of peritoneal dialysis.[24]

- Scrotal edema can prevent accurate determination of the presence and side of a hernia.
- The edema may be due to an inguinal hernia, Spigelian hernia, pericatheter leakage, or even an occult umbilical hernia with settling of fluid by gravity into the soft tissues of the scrotum.
- Imaging studies often required to identify side of hernia
- Low volume low dialysate exchanges with dry days may allow patient to continue on PD with reduction of swelling in preparation for surgical repair

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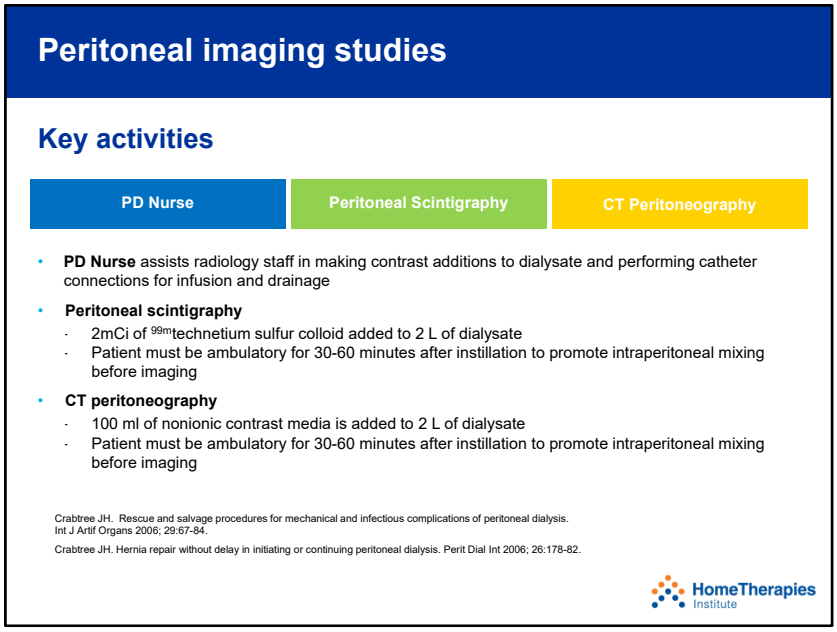
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 60

Imaging studies can be useful in identifying the site of an occult peritoneal boundary defect.[16,24]

- Advisable that PD Nurse assist radiology staff in making contrast additions to dialysate and performing catheter connections for infusion and drainage
- Peritoneal scintigraphy
  - 2mCi of ^{99m}technetium sulfur colloid added to 2 L of dialysate
  - Patient must be ambulatory for 30-60 minutes after instillation to promote intraperitoneal mixing before imaging
- CT peritoneography
  - 100 ml of nonionic contrast media is added to 2 L of dialysate
  - Patient must be ambulatory for 30-60 minutes after instillation to promote intraperitoneal mixing before imaging

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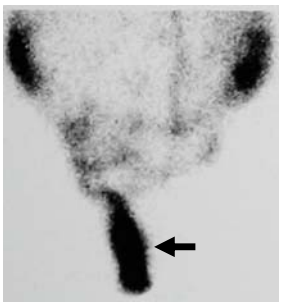
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Diagnostic imaging for genital edema to detect side of hernia and leak

CT Peritoneography showing right indirect inguinal hernia



Tc-99 Peritoneal Scintigraphy showing right indirect inguinal hernia

Crabtree JH. Rescue and salvage procedures for mechanical and infectious complications of peritoneal dialysis. Int J Artif Organs 2006; 29:67-84.

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My Notes:

Slide 61

Shown here are examples of CT peritoneography and peritoneal scintigraphy showing right inguinal hernias with contrast filling the hernia sacs.

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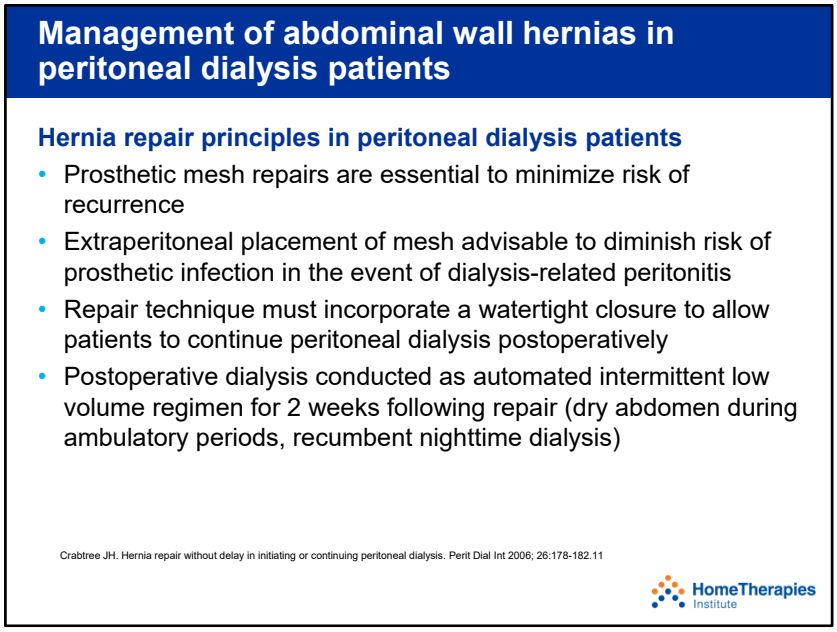
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 62

Repair of hernias in patients on peritoneal dialysis should follow some basic principles. This will enable a successful repair and allow the patient to continue uninterrupted peritoneal dialysis therapy.

Hernia repair principles in peritoneal dialysis patients:

- Prosthetic mesh repairs are essential to minimize risk of recurrence from high intraperitoneal pressures[24]
- Extraperitoneal placement of mesh advisable to diminish risk of prosthetic infection in the event of dialysis-related peritonitis[10,24]
- Repair technique must incorporate a watertight closure to allow patients to continue peritoneal dialysis postoperatively[24]
- Postoperative dialysis conducted as automated intermittent low volume regimen for 2 weeks following repair (dry abdomen during ambulatory periods, recumbent nighttime dialysis)[24]

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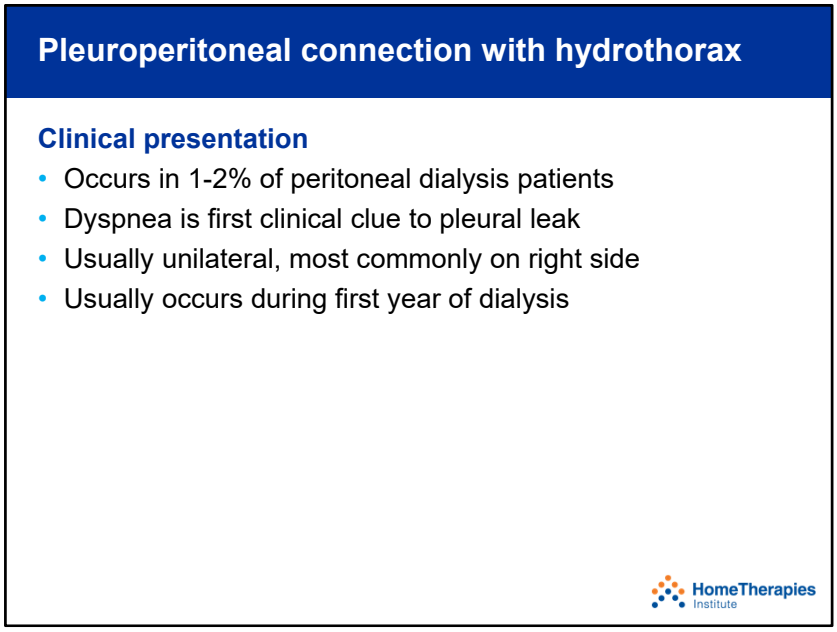
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 63

A pleuroperitoneal connection permits a leak of dialysate into the pleural space through some sort of defect in the diaphragm, usually microscopic in size.[25]

- Occurs in 1-2% of peritoneal dialysis patients.
- Dyspnea is 1st clinical clue to pleural leak.
- Usually unilateral, most commonly on right side.
- Usually occurs during 1st year of dialysis.

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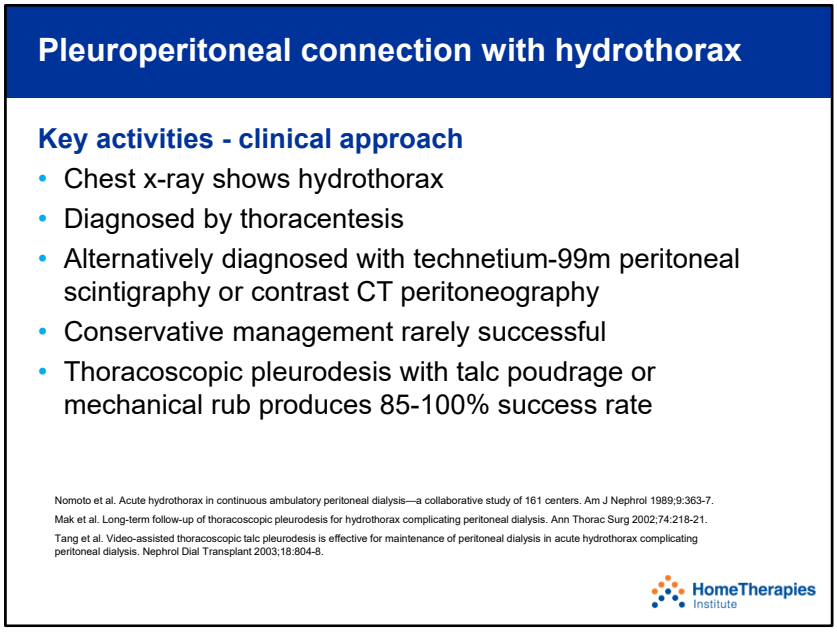
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 64

- Diagnosis is confirmed by thoracentesis with recovery of fluid low in protein and high in glucose concentration.[26]
- Alternatively, the diagnosis can be established by contrast CT peritoneography or Tc-99m peritoneal scintigraphy.[27]
- Conservative management (peritoneal rest, low volume dialysis) is rarely successful.[28,29]
- Thoracoscopic pleurodesis with talc poudrage or mechanical rub produces 85-100% success rate.[29,30]

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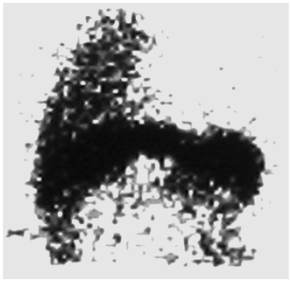
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Hydrothorax complicating peritoneal dialysis

Key activities

- Imaging studies to confirm diagnosis of hydrothorax from pleuroperitoneal fistula

PA Chest X-Ray



Peritoneal Scintigraphy

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My Notes:

Slide 65

The chest x-ray shows a right hydrothorax.

Peritoneal scintigraphy confirms a pleuroperitoneal connection with accumulation of radiocontrast in the right hemithorax.

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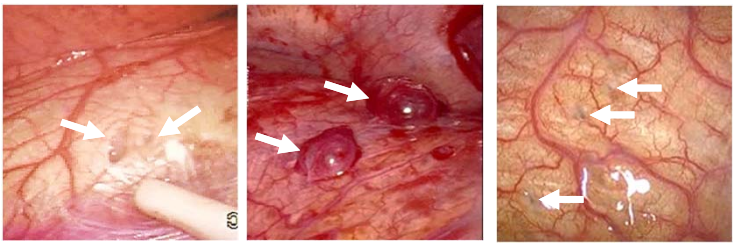
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Various appearances of pleuroperitoneal fistulae

Thoracoscopic exploration



Small diaphragmatic slit-like defects

Weeping pleural blebs overlying small diaphragmatic defects

Multiple small diaphragmatic punctate holes

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My Notes:

Slide 66

Shown here are thoracoscopic images of various appearances of pleuroperitoneal fistulae, including diaphragmatic slits, blebs, and punctate hole. Often, the site of the pleuroperitoneal connection cannot be identified.

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Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Thoracoscopic pleurodesis with talc poudrage

Key activities

- Interim hemodialysis will be required
- Thoracoscopic approach is minimally invasive
- Pleurodesis: roughing up the pleural lining of the chest cavity to produce scaring
- Poudrage: spraying sterile talc into the pleural cavity to promote sealing of the space
- Postoperatively, a chest tube is used to drain the pleural space for 2 to 3 days
- Peritoneal dialysis can usually be restarted after 3 weeks

Preoperative

3-weeks Postoperative

Tang et al. Video-assisted thoracoscopic talc pleurodesis is effective for maintenance of peritoneal dialysis in acute hydrothorax complicating peritoneal dialysis. Nephrol Dial Transplant 2003;18:804-8.

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My Notes:

Slide 67

Thoracoscopic pleurodesis with talc poudrage has a high rate of success in closing the leak, permitting the patient to return to peritoneal dialysis.[28,30]

- Interim hemodialysis will be required
- Thoracoscopic approach is minimally invasive but does require general anesthesia
- Pleurodesis is performed by roughing up the pleural lining of the chest cavity to produce scaring and obliteration of the pleural space
- Poudrage is accomplished by spraying sterile talc into the pleural space to promote adhesion and sealing of the space
- Postoperatively, a chest tube is used to drain the pleural space for 2 to 3 days
- Peritoneal dialysis can usually be restarted after 3 weeks if the chest x-ray shows resolution of the hydrothorax

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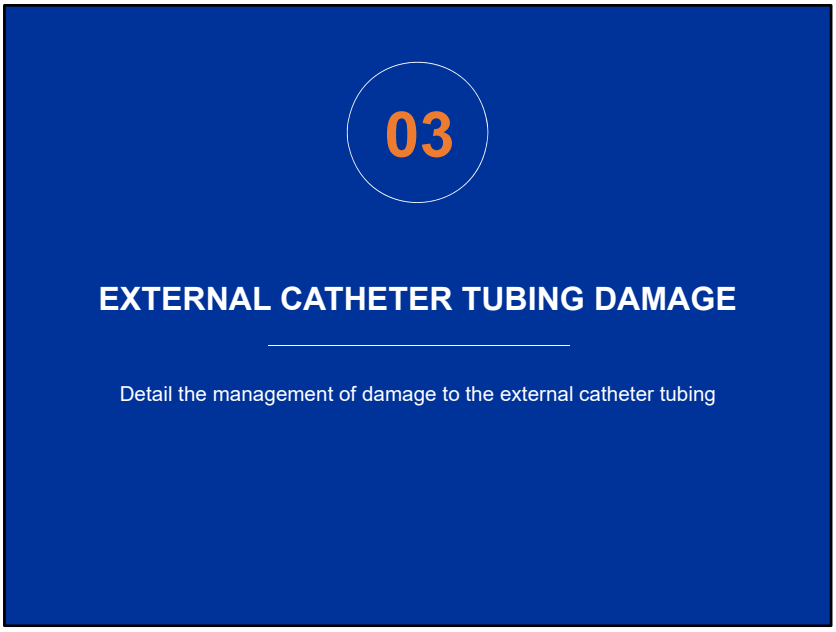
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Course Outline

- Mechanical catheter flow dysfunction
- Peritoneal boundary defects
- External catheter tubing damage



My Notes:

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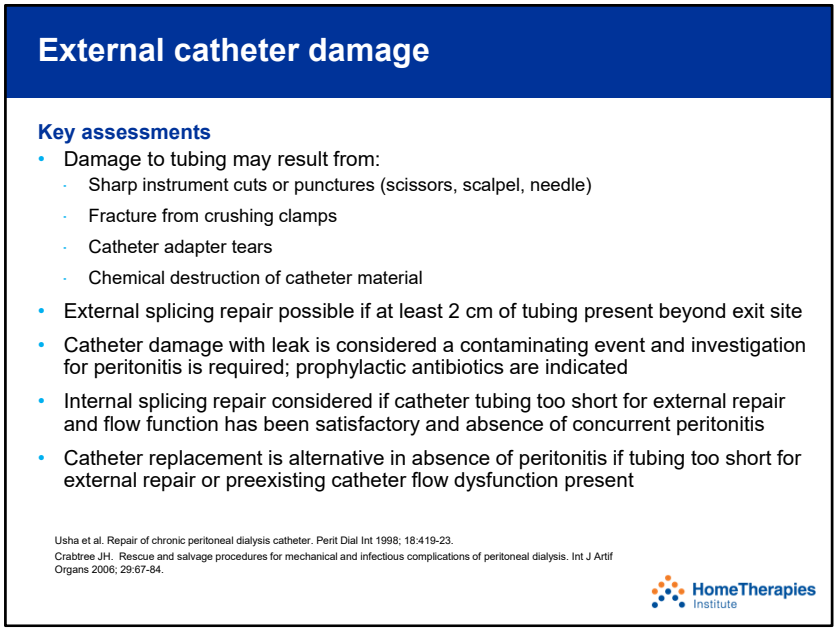
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 69

- External catheter damage to tubing may result from[31]:
  - Sharp instrument cuts or punctures (scissors, scalpel, needle)
  - Fracture from crushing clamps
  - Catheter adapter tears
  - Chemical destruction from contact with solvents, strong oxidants, or plasticizers present in some cleaning agents and topical antiseptics and antibiotics
- External splicing repair possible if at least 2 cm of tubing present beyond exit site[31]
- Catheter damage with leak is considered a contaminating event and investigation for peritonitis is required; prophylactic antibiotics are indicated[31]
- Internal splicing repair considered if catheter tubing too short for external repair and flow function has been satisfactory and absence of concurrent peritonitis[16]
- Catheter replacement is alternative in absence of peritonitis if tubing too short for external repair or preexisting catheter flow dysfunction present[16]

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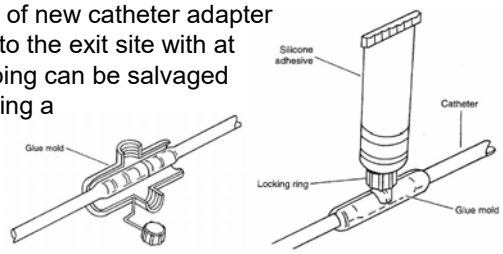
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

External repair of catheter tubing damage

Key activities

- Prophylactic antibiotics for 3 days
- Tubing damage remote from exit site with ample length of intact residual tubing can be managed with amputation of the affected segment and insertion of new catheter adapter
- Tubing damage close to the exit site with at least 2 cm of intact tubing can be salvaged by external splicing using a commercial repair kit



Usha et al. Repair of chronic peritoneal dialysis catheter. Perit Dial Int 1998; 18:419-23.

Yap et al. Risk factors and outcome of contamination in patients on peritoneal dialysis—a single-center experience of 15 years. Perit Dial Int 2012; 32:612-6.

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My Notes:

Slide 70

Often, external repair of the catheter tubing can be performed.[31,32]

- Prophylactic antibiotics for 3 days
- Tubing damage remote from exit site with ample length of intact residual tubing can be managed with amputation of the affected segment and insertion of new catheter adapter
- Tubing damage close to the exit site with at least 2 cm of intact tubing can be salvaged by external splicing using a commercial repair kit

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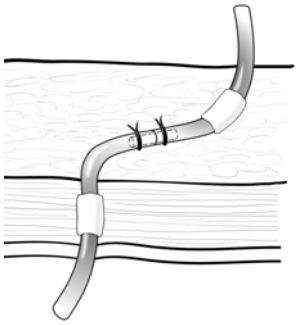
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Internal splicing when external tubing too short to repair

Key activities

- Prophylactic antibiotics for 3 days
- Internal segment of catheter exposed through the old insertion incision
- New catheter trimmed for appropriate fit and attached to stump of old catheter with double-barbed titanium connector
- New catheter tunneled to new exit site location
- Wound closed
- Remaining segment of damaged catheter removed at the exit site



Crabtree JH. Rescue and salvage procedures for mechanical and infectious complications of peritoneal dialysis. Int J Artif Organs 2006; 29:67-84.

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My Notes:

Slide 71

An internal splicing procedure can be performed when external tubing is too short for external repair.[16,32]

- Prophylactic antibiotics for 3 days
- Internal segment of catheter exposed through the old insertion incision
- New catheter trimmed for appropriate fit and attached to stump of old catheter with double-barbed titanium connector
- New catheter tunneled to new exit site location
- Wound closed
- Remaining segment of damaged catheter removed at the exit site

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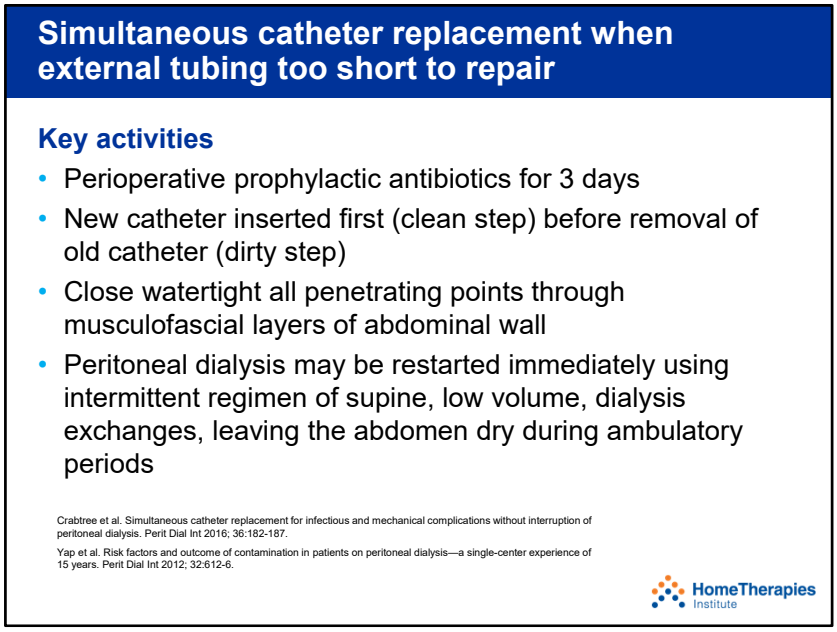
Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis



My Notes:

Slide 72

Simultaneous catheter replacement is an alternative procedure for external tubing damage too short to repair.[33]

- Perioperative prophylactic antibiotics for 3 days
- New catheter inserted first (clean step) before removal of old catheter (dirty step)
- Close watertight all penetrating points through musculofascial layers of abdominal wall
- Peritoneal dialysis may be restarted immediately using intermittent regimen of supine, low volume, dialysis exchanges during the interval of postoperative recovery, leaving the abdomen dry during ambulatory periods

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Managing PD Catheter Complications
Part 1: Mechanical Complications of Peritoneal Dialysis

Summary

- **Proper assessment** of catheter flow dysfunction is important
- **Imaging studies** are useful in identifying causes of flow dysfunction and sites of leak from peritoneal boundary defects
- **Laparoscopy** is an invaluable tool in the diagnosis and management of catheter flow obstruction
- **Hernias** acquired while on peritoneal dialysis can be repaired without interruption of therapy
- **Thoracoscopic pleurodesis with talc poudrage** is effective treatment for pleuroperitoneal fistulae with hydrothorax
- **Internal catheter splicing or simultaneous catheter replacement** can preserve peritoneal dialysis when external tubing damage is too short for external repair

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My Notes:

Summary:

- Proper assessment of catheter flow dysfunction is important in determining root cause and designing appropriate therapeutics
- Imaging studies (US, fluoroscopy, CT peritoneography, peritoneal scintigraphy) are useful in identifying causes of flow dysfunction and sites of leak from peritoneal boundary defects
- Laparoscopy is an invaluable tool in the diagnosis and management of catheter flow obstruction
- Hernias acquired while on peritoneal dialysis can be repaired without interruption of therapy
- Thoracoscopic pleurodesis with talc poudrage is effective treatment for pleuroperitoneal fistulae with hydrothorax
- Internal catheter splicing or simultaneous catheter replacement can preserve peritoneal dialysis when external tubing damage is too short for external repair

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