The Ever-Changing Landscape of Medical Devices Found in the Abdomen and Pelvis: What the Radiologist Can Tell the Clinician

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Disclosure

The authors have no conflicts to disclose.
Target Audience / Learning Objectives

Target Audience:

• Radiologists-in-training at any level
• Those interested in the imaging appearance of medical devices

After viewing this exhibit, participants should:

• Be familiar with common medical devices and gain exposure to newer or more uncommon medical devices found in the abdomen and pelvis.
• Appreciate the physical appearance of a spectrum of medical devices as portrayed in photographs, and be comfortable recognizing these devices on plain radiographs and CT.
• Understand how to properly evaluate various medical devices, including appropriate positioning and possible complications.
Types of Medical Devices

A broad list of medical devices, categorized by type:

**Gastrointestinal**
- Feeding tubes
- Nasogastric tubes
- Sengstaken-Blakemore tubes
- Gastrostomy tubes
- Adjustable gastric bands
- Esophageal stents
- Duodenal stents
- Colonic stents
- Endoclips
- Over-the-scope clips
- Colonic transit markers
- Capsule endoscopy

**Hepatobiliary**
- Cholecystostomy tubes
- Biliary drainage catheters
- Biliary stents
- TIPS
- Pancreatic duct stents
- Cystogastrostomy stents

**Genitourinary**
- Intrauterine devices
- Vaginal pessaries
- Percutaneous nephrostomy tubes
- Ureteral stents
- Penile prostheses
- Artificial urinary sphincters
- Prostate brachytherapy seeds
- Bioabsorbable sponges

**Vascular**
- Stents
- Endografts
- Embolization coils
- Vascular catheters
- Endovascular cooling catheters
- Bioabsorbable sponges

**Body Wall**
- Spinal cord stimulators
- Insulin pumps
- Baclofen pumps
Nasogastric Tubes

Key Facts / Considerations

- Nasogastric tubes are traditionally stiff large-bore tubes used for gastric or small bowel decompression
- Can also be used for nutrition and medication administration

Complications

- Malposition
  - Inadvertent placement into the airways is a common complication
  - May lead to pulmonary contusion or pneumothorax
- Gastric perforation
  - Rare
  - Likely due to aggressive advancement of tube
  - May lead to gastrointestinal hemorrhage or peritonitis

A. Photograph of a nasogastric tube. Usually at least one sidehole (blue arrow) interrupts the white radiopaque marker (red arrow).
B. Plain radiograph to confirm tube placement demonstrates a nasogastric tube, visualized as a single radiopaque line, coursing down the right mainstem bronchus (yellow arrow), which is a common complication.
Sengstaken-Blakemore Tubes

Key Facts / Considerations

- Used for emergency treatment of acutely bleeding esophageal and gastric varices
- Inflation of the esophageal and gastric balloons after placement tamponades the bleeding varices

Complications

- Esophageal rupture
  - Usually due to iatrogenic misplacement of the tube, with inflation of the larger gastric balloon while in the esophagus
  - Less commonly due to prolonged tube placement, resulting in pressure ischemia of the esophagus

A. Photograph of a Sengstaken-Blakemore tube. © 2015 C. R. Bard, Inc. Used with permission. Esophageal balloon (black arrow) and gastric balloon (red arrow).

B. Plain radiograph shows the tube in place (yellow arrow), with the esophageal balloon appropriately inflated in the esophagus (black arrows) and the gastric balloon appropriately inflated in the stomach (red arrow).

Esophageal Stents

Key Facts / Considerations

- Esophageal stents have traditionally been used for palliation of dysphagia secondary to malignancy
- Uncovered metallic stents were initially used, but occasionally occluded due to tumor ingrowth
- Covered metallic stents were developed to prevent tumor ingrowth, but have higher risk of migration
- Covered metallic stents are now also used for perforations, leaks, fistulae, or strictures

Complications

- Perforation: early iatrogenic complication
- Migration: change in position after placement
- Occlusion: tumor ingrowth or bolus obstruction
- Esophageal fistulae: persistent pressure from stent placement leads to erosion and fistula formation

A. Photograph of a covered metallic stent. Used with permission from Cook Medical.
B. 61-year-old female with metastatic esophageal adenocarcinoma, presenting with dysphagia, which was treated with an uncovered esophageal stent (arrow).
C. Patient presented with recurrent dysphagia. Sagittal CT image shows contrast opacification of the esophageal stent (yellow arrow), with irregular soft tissue within the distal stent lumen (red arrow).
D. Esophagram shows an eccentric irregular contour within the distal stent (red arrow), consistent with tumor ingrowth.
Adjustable Gastric Bands

Key Facts / Considerations

- The band should be placed around the proximal stomach
- Phi (φ) angle
  - Angle formed by spinal column and longitudinal axis through the gastric band
  - Should be between 4° and 58°
- Proximal pouch should have maximal diameter less than 4 cm

Complications

- Initial malposition or subsequent slippage
  - Evaluate position and phi angle
- Pouch dilatation
  - Occurs when the band is too tight, leading to obstruction
- Intragastric erosion
  - Occurs when the band is too tight, leading to pressure ischemia

A. Plain radiograph shows the gastric band (yellow arrow), connection tubing (blue arrow), and access port (red arrow). B. Upper GI series centered on the gastric band, shows a φ angle measuring 70°, suggestive of slippage. C. D. Axial CT images show the gastric band (yellow arrow) around the proximal stomach and the access port in the subcutaneous tissues (blue arrow).
Over-the-Scope Clips ("Bear Claw")

Key Facts / Considerations

• Special type of endoclip
• Relatively new device used for endoscopic closure of large gastrointestinal defects, including sites of gastrointestinal bleeding, perforations, or fistulas

Complications

• Complications are not well established given that this is a relatively new procedure
• Most studies report very few perioperative or postoperative complications
• Migration and visceral perforation are theoretical complications to consider during imaging evaluation

51-year-old female who was previously dependent on a gastrostomy tube, which was removed, but complicated by a chronic gastrocutaneous fistula. This was successfully closed endoscopically with an over-the-scope clip. A. Photograph of a few over-the-scope clips. Used with permission from Ovesco Endoscopy AG. B. Plain radiograph shows the clip (arrow) projecting over the epigastric region. C. Sagittal CT image demonstrates the clip (arrow) embedded in the gastric wall at the site of the fistula.
Colonic Transit Markers

Key Facts / Considerations

- Used for colonic transit studies, which evaluate disorders of colonic motility
- Either 20 or 24 markers are ingested
- Delayed transit is defined as retention of >20% of the markers at 5 days

Complications

- Very few complications and no significant complications that can be evaluated by imaging

A. Photograph of a capsule containing 24 Sitzmarks radiopaque markers. B. Photograph of the markers outside of the capsule. C. Plain radiograph shows numerous metallic circular radiodensities projecting over the ascending and descending colon, consistent with colonic transit markers (arrows). D. CT demonstrates a few of these colonic transit markers within the ascending colon (arrows).

Capsule Endoscopy

Key Facts / Considerations

- Capsule endoscopy is a relatively new tool that allows for endoscopic imaging of the small bowel
- The primary indication is for evaluation of GI bleeding after negative workup by conventional endoscopy

Complications

- Very few complications
- Retained capsule
  - Rate reported to be 0.75%
  - Usually occurs in fibrostenosing Crohn’s disease
  - Other reported causes include diverticula, postoperative changes with blind ending loops of bowel, and malignant obstruction

71-year-old female with history of multiple small bowel resections for obstruction, now with iron deficiency anemia. Patient underwent capsule endoscopy, and after 8 hours, the study terminated with the capsule remaining at an ileoileostomy anastomosis. A. Photograph of the PillCam endoscopy capsule. B. Follow-up plain radiograph shows an endoscopy capsule projecting over the right lower quadrant several days after the procedure (arrow). C. Axial CT image demonstrates narrowing at the ileoileostomy anastomosis (arrow), with mild upstream dilatation. D. Sagittal CT image demonstrates the retained capsule in an upstream loop of small bowel (arrow).
**Internal Biliary Stents**

**Key Facts / Considerations**

- Biliary stents (plastic or metallic) are used to treat biliary obstruction

**Complications**

- **Occlusion**
  - Plastic stents: more commonly occlude due to bile encrustation
  - Metallic stents: usually occlude due to tumor progression

- **Migration**
  - Plastic stents: reported rates of migration is between 4-8%
  - Metallic stents: rarely reported to migrate after placement

- **Duodenal Ulceration / Perforation**
  - If a metallic stent protrudes too far into the duodenum, this may result in ulceration or perforation of the duodenal wall opposite the ampulla of Vater

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Liver Transplant with Saline Breast Implants

Key Facts / Considerations

• A small size of the donor’s liver in relation to the recipient’s abdominal cavity may lead to hypermobility of the graft and kinking of the vascular anastomoses.

• Classically, this has been addressed in two ways:
  1. Hepatopexy: anchoring the liver to the abdominal wall or diaphragm.
  2. Sengstaken-Blakemore tubes: temporarily inflating the gastric/esophageal balloons to support the liver in position during the postoperative period.

• Placement of breast implants as permanent support has been proposed, but rarely performed.

Complications

• Complications are not well established, but implant rupture or migration are theoretical possibilities to consider.

57-year-old male with hilar cholangiocarcinoma. Patient went for orthotopic liver transplant. During the operation, the surgeons noticed hepatic congestion with certain orientations of the transplant liver, at which point they decided to place two saline implants posterior to the right hepatic lobe. A. B. Axial and C. coronal CT images show the two saline implants in place (arrows), posterior to the right hepatic lobe.
Cystogastrostomy Stents

Key Facts / Considerations

- Endoscopic cystogastrostomy is a relatively new development for treatment of pancreatic pseudocysts as an alternative to surgical cystogastrostomy or percutaneous drainage.
- New dumbbell-shaped stents have been developed to reduce the risk of migration seen with straight tubular stents.

Complications

- Complications are not well established given that this is a relatively new procedure.
- Migration and occlusion are theoretical complications to consider during imaging evaluation.

A. Plain radiograph shows a straight covered metal stent projecting over the epigastric region (arrow).
B. CT appearance of the same stent (arrow).
C. Photograph of the AXIOS lumen-apposing stent. Image provided courtesy of Boston Scientific. © 2016 Boston Scientific Corporation or its affiliates. All rights reserved.

Ureteral Stents

Key Facts / Considerations

• Used to treat benign or malignant obstruction

Complications

• Malposition
  - Stiffer stents can penetrate the ureters, renal pelvis, or renal parenchyma after placement
  - Must evaluate proper formation of the pigtails curl

• Migration
  - If the stent is too short, reconstitution of the proximal pigtails can cause the distal stent to retract into the distal ureter
  - Ureteral peristalsis may also discharge a stent into the bladder

• Encrustation
  - Occurs with any stent and risk increases with longer indwelling times

• Stent fracture
  - Risk increases with longer indwelling times

A. One pigtail curl of a typical ureteral stent. Used with permission from Cook Medical.
B. Scout radiograph shows the presence of bilateral percutaneous nephrostomy tubes (blue arrows) and bilateral ureteral stents (yellow arrows). Both pigtails of the right stent are not formed (red arrows), suggesting that the stent is under tension.
C. Axial CT images show the proximal end of the right stent has perforated through the kidney with the tip in the perirenal space (red arrow).
D. The distal tip of the right stent has retracted into the right ureter (red arrow). The distal pigtails of the left stent is appropriately formed (yellow arrow).

Artificial Urinary Sphincters

Key Facts / Considerations

- Gold standard for treatment of post-prostatectomy urinary incontinence
- Complications listed below require surgical revision

Complications

- Mechanical failure
  - Kinking in the tubing
  - Tubing fracture or balloon rupture, leading to loss of fluid
- Infection
  - Imaging is insensitive, but may see an abscess
- Urethral erosion
  - Results when occlusive cuff is too tight, leading to pressure ischemia of the urethra
  - Evaluation primarily based on cystourethroscopy
  - Cannot reliably evaluate by imaging unless advanced

Urethral Bulking Agents

Key Facts / Considerations

- Minimally invasive procedure to treat stress urinary incontinence
- Various materials have been used:
  - cross-linked bovine collagen
  - silicone
  - microbeads
- Collagen and silicone based agents are not discernible on radiographs. In addition, they are similar in attenuation to soft tissues on CT and are best appreciated on contrast-enhanced studies.
- Microbeads can be identified on radiographs and are higher in attenuation than soft tissues on CT
- Can mimic pathology if unaware of patient’s history

Complications

- Few reported complications
- Transient urinary retention that usually resolves

79-year-old female with history of bladder cancer status post cystectomy with neobladder formation, now with stress urinary incontinence. A. Axial and B. coronal CT shows an apparent rim-enhancing lesion just inferior to the neobladder (arrows). C. D. Transvaginal ultrasound images show a hyperechoic shadowing lesion at the neobladder neck without color Doppler flow (arrows). Review of the medical record revealed that the patient underwent perirethral injection of Macroplastique urethral bulking agent.
Intrauterine Devices

Key Facts / Considerations

- Clinical history and exam raises the suspicion for IUD migration
- Ultrasound is initial test to identify if the IUD is within the endometrial cavity
- If not identified on ultrasound, plain radiographs used to determine if there has been expulsion
- If identified on plain radiographs, CT used for localization and evaluation for complications

Complications

- Expulsion: extrusion out of the body
  - Reported rate up to 10% of patients
- Displacement: non-ideal location within the endometrial cavity
  - Reported rate up to 25% of patients
- Uterine Perforation
  - Intraperitoneal location may lead to visceral perforation, abscess formation, or bowel obstruction

Photographs of the A. Mirena, B. Skyla, and C. Paragard intrauterine devices.

28-year-old female with history of IUD that perforated the uterus, status post new IUD placement. A. Plain radiograph shows two IUDs, one which appears to be in normal orientation (yellow arrow) and one that is in abnormal horizontal orientation (red arrow). B. Sagittal CT shows the appropriately positioned IUD within the endometrial cavity (yellow arrow). C. Axial CT shows the other IUD in the rectouterine pouch (red arrow), with one arm embedded in the uterine wall (blue arrow).
Key Facts / Considerations

- Laparoscopic procedure for contraception
- Clips are usually placed along the isthmic portion of the fallopian tubes

Complications

- Dislodgment and migration:
  - Some movement of the clips is expected on consecutive plain radiographs. However, drastic movements should raise suspicion for dislodgment.
  - CT can better evaluate the tubal ligation clips in relation to the fallopian tubes
  - Does not cause symptoms, but can lead to unintended pregnancy

33-year-old female with history of laparoscopic tubal ligation. A. Photograph of Filshie clips, which are commonly used for laparoscopic tubal ligation. B. Plain radiograph shows two surgical clips projecting over the left hemipelvis (yellow and red arrows), one of which appears too high (red arrow). C. Subsequent axial CT image shows one tubal ligation clip appropriately positioned at the isthmic portion of the left fallopian tube (yellow arrow). No clip is seen along the course of the right fallopian tube (blue arrow). D. Axial CT image at a higher level shows migration of the clip since prior radiograph into the right paracolic gutter (red arrow).
Essure Contraceptive Devices

Key Facts / Considerations

- Minimally invasive procedure for contraception
- Coils placed in the fallopian tubes, leading to fibrosis and occlusion
- Appropriately positioned coils should lie across the uterotubal junction
- Hysterosalpingography performed 3 months after placement is necessary to ensure proper positioning and confirm tubal occlusion

Complications

- Failure of tubal occlusion:
  - Reported to be 3% on hysterosalpingogram at 3 months
- Migration or fragmentation:
  - The whole device or fragments of the device may migrate into the peritoneal cavity. CT can be used for localization prior to laparoscopic retrieval.

33-year-old female status post placement of Essure coils for contraception. A. Photograph of Essure coils. B. Spot radiograph shows bilateral Essure coils projecting over left hemipelvis (arrows). C. Follow-up hysterosalpingogram three months after placement shows flow of contrast past the right Essure coil (yellow arrow) and opacifying the right fallopian tube (red arrow).
Vaginal Pessaries

Key Facts / Considerations

- Vaginal pessaries are used to treat pelvic organ prolapse
- There are a multitude of devices, usually made of either rubber or silicone
  - Variable radiodensity depending on material, although usually more radiodense than soft tissues

Complications

- Erosion and fistula formation
  - Extremely rare reported cases
  - Result from neglected devices that have been left in place for prolonged periods

46-year-old female with history of uterine prolapse, treated using a Gellhorn pessary. A. Photograph of a silicone Gellhorn pessary. B. Plain radiograph shows the slightly radiopaque pessary (arrow). C. Coronal and D. axial CT images demonstrate the appearance of the pessary in appropriate position within the vagina (arrows).

Vascular Stents

Key Facts / Considerations

- **Types of stents**
  - Balloon-expandable versus self-expandable
  - Bare-metal versus drug-eluting
  - Covered versus uncovered

Complications

- **Occlusion or restenosis**
  - Most common complication
  - Drug-eluting stents delay time to thrombosis

- **Malposition**
  - Self-expandable stents more prone to initial malposition due to their deployment method

- **Extrinsic compression or deformation**
  - Balloon-expandable stents more prone to deformation due to their malleability

- **Migration**

- **Fracture**

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62-year-old female with history of total abdominal hysterectomy, complicated by left external iliac artery injury, treated with covered arterial stent. Patient now presents several months later with left hip and buttock claudication. A. Peripheral vascular stent. Used with permission from Cook Medical. B. Scout radiograph shows a vascular stent projecting over the left hemipelvis (yellow arrow), in abnormal orientation that does not follow the expected course of the left iliac artery. C. Axial CT image shows that the stent (yellow arrow) has partially migrated to an extra-arterial location, with the tip perforating through the sigmoid colon (red arrow). D. Axial CT image at a lower level shows non-opacification of the distal left external iliac artery (red arrow), secondary to proximal occlusion. Patient underwent exploratory laparotomy, which confirmed the findings.
IVC Filters

Key Facts / Considerations

- Numerous types of IVC filters
  - Greenfield filter is the most extensively studied
  - Bird's Nest filter is the only filter suitable for use when the IVC diameter is greater than 28 mm
- Newer filters have been designed to be retrievable

Complications

- Rates of complication is variable between designs
  - IVC thrombosis: approaches 50% in some studies
  - IVC penetration: common, reportedly up to 95%, typically clinically insignificant
  - Migration: change in position to a more cephalad part of the SVC, the heart, or pulmonary arteries, which often necessitates retrieval
  - Fracture: fracture can lead to decreased efficacy of the filter, and the filter or its fragmented portions can migrate as well
  - Recurrent pulmonary embolism: reportedly up to 5% in one study

A. Photograph of a Bird's Nest IVC filter. Used with permission from Cook Medical. B. Plain radiograph shows the Bird's Nest filter with 4 radiopaque arms (yellow arrows). C. Coronal CT image shows the arms penetrating through the wall of the IVC (red arrows), which is a common finding.

Endovascular Cooling Catheters

Key Facts / Considerations

• Therapeutic hypothermia has been gaining acceptance for its cardioprotective and neuroprotective effects after cardiac arrest

• Several studies suggest a target temperature of 32 to 34 ºC (mild hypothermia)

• Placement is usually via the femoral vein with the cooling portion mostly in the inferior vena cava

Complications

• Complications are not well established given that this is a relatively new tool

• Various complications have been suggested
  - IVC thrombosis
  - Deep vein thrombosis
  - Bleeding
  - Bradycardia
  - Electrolyte imbalance

24-year-old male with hypoxic respiratory failures and cardiac arrest with pulseless ventricular tachycardia. Patient was started on a therapeutic hypothermia protocol for 24 hours using an endovascular cooling catheter. Afterwards, patient was successfully resuscitated and rewarmed with no neurologic compromise. A. Plain radiograph shows the cooling portion of the endovascular cooling catheter mostly within the IVC (red arrow). The remainder of the catheter is slightly less radiopaque (yellow arrow).
Bioabsorbable Sponges

Key Facts / Considerations

- Bioabsorbable sponges are used in surgical beds to control intraoperative and postoperative bleeding
- Absorbs over 1 to 2 weeks
- Appears as an ill-defined fluid collection with internal foci of gas
- Imaging evaluation requires differentiation from an abscess
- Helpful clues that suggest bioabsorbable sponge rather than abscess
  - Lack of an air-fluid level
  - Lack of a rim-enhancing wall
  - Early postoperative period with decreasing size on subsequent imaging
  - Gas bubbles that maintain position on consecutive imaging

Complications

- Evaluate for postoperative bleeding

73-year-old male who is status post open thoracoabdominal incision and repair of a suprarenal abdominal aortic aneurysm. A. Coronal and B. axial CT images show ill-defined fluid-attenuation collections surrounding the aorta (yellow arrows) with scattered foci of gas (red arrows). These mimic the appearance of a postoperative abscess. However, further review of the operative report revealed the use of Gelfoam bioabsorbable sponges.

Insulin Pumps

Key Facts / Considerations

- As technology improves, insulin pumps have become more popular for continuous monitoring of glucose with proportional delivery of insulin
- Delivery of insulin is into the subcutaneous tissues via an infusion set

Complications

- Metabolic disturbances
  - Hypoglycemia
  - Diabetic ketoacidosis
- No significant complications that can be evaluated by imaging

A. Plain radiograph shows the continuous glucose monitor projecting over the left lower quadrant. B. Axial CT image demonstrates the continuous glucose monitor (yellow arrow) as well as the infusion set (red arrow) on the skin surface of the anterior abdominal wall.

Spinal Cord Stimulators

Key Facts / Considerations

- Spinal cord stimulators are used to treat chronic neuropathic spinal pain
- Effective treatment is based on proper location of the electrodes
  - The electrode should be in the epidural space, in the posterior one-third of the spinal canal
  - If pain is bilateral, the electrodes should be midline
- The implantable pulse generator is usually placed in the subcutaneous tissues of the flank or buttock

Complications

- Electrode migration
- Electrode lead fracture
- CSF leak
- Infection

62-year-old female with chronic neuropathic pain, treated with spinal cord stimulators, now with recurrent pain. A. Photograph of a spinal cord stimulator, composed of an implantable pulse generator (blue arrow) and electrodes (red arrows). Image provided courtesy of Boston Scientific. © 2016 Boston Scientific Corporation or its affiliates. All rights reserved. B. Plain radiograph shows two spinal cord stimulators projecting over the abdomen (blue arrows), with one set of electrodes projecting over the lower thoracic spine (red arrow) and the other set of electrodes not in the field-of-view. C. Magnified view of the leads shows a fracture of one of the leads (red arrow). Patient underwent redo thoracic laminotomy to replace the fractured lead, which confirmed the findings.
Conclusion

• New medical devices are constantly being released for clinical use and are more frequently being encountered in the practice of radiology.

• Lack of familiarity with new or uncommon devices can undermine the utility of imaging.

• Understanding the appearance and clinical significance of these devices greatly simplifies evaluation, allowing radiologists to provide clinically relevant information.
Thank You

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