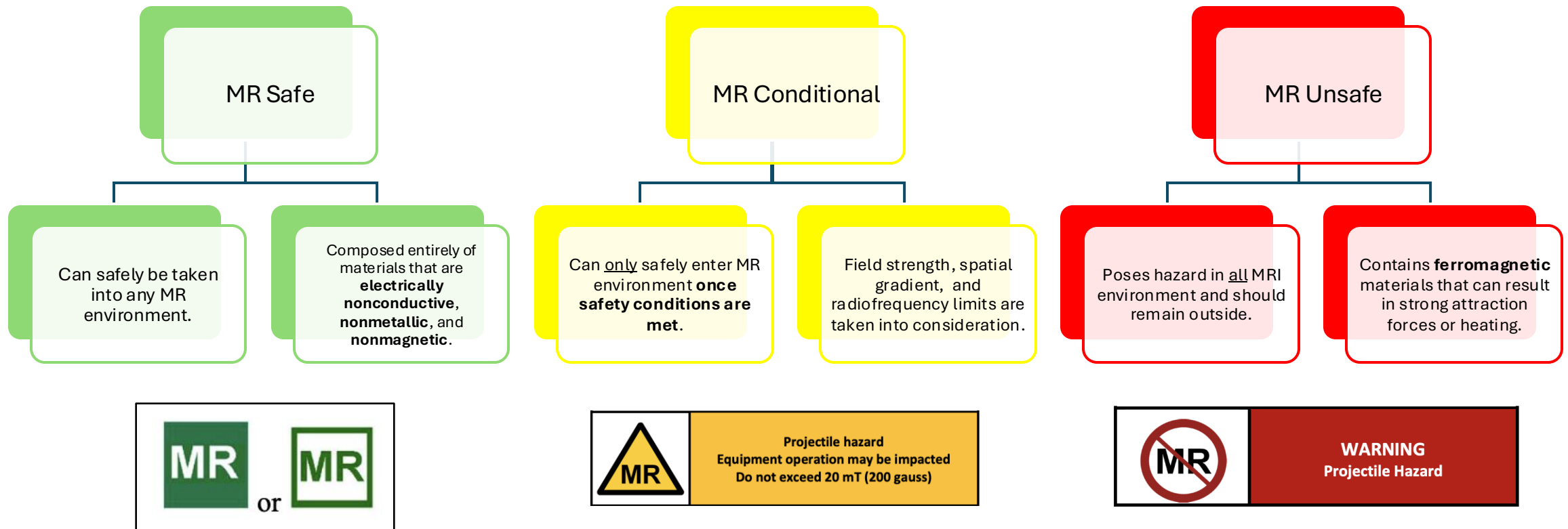


# MRI Compatibility of Common Medical Devices in the Abdomen and Pelvis

Caleb Iness MD , Senglee Loa MD , Alena Nixon MD, Alex Lee MD, Yosef Buchen MD, Morris Hayim, MD, David Sarkany MD, Nassier Harfouch MD

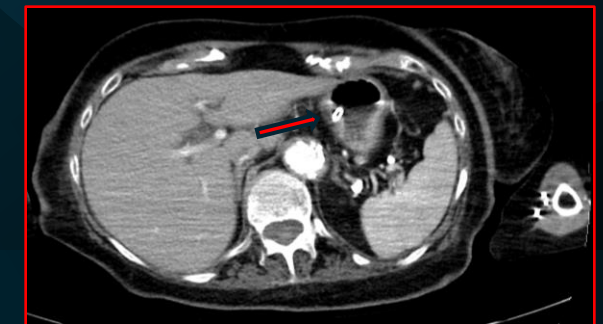
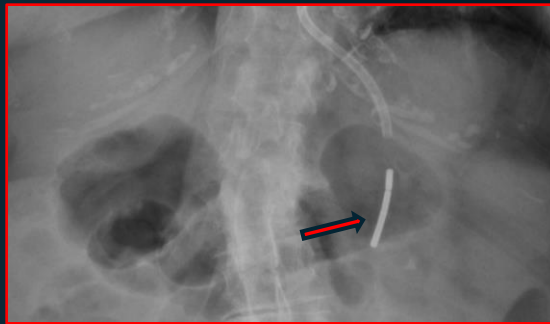
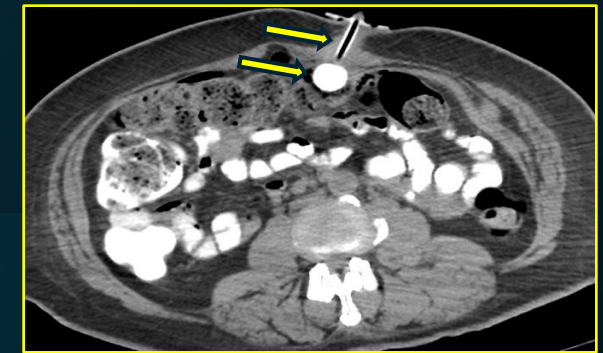
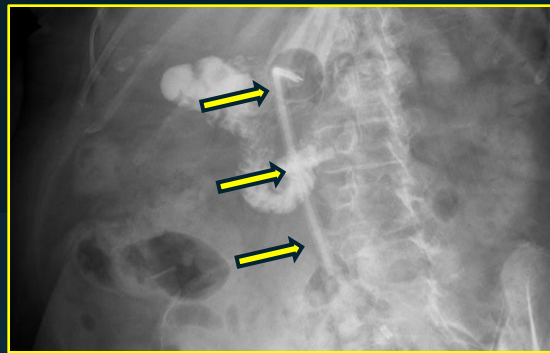
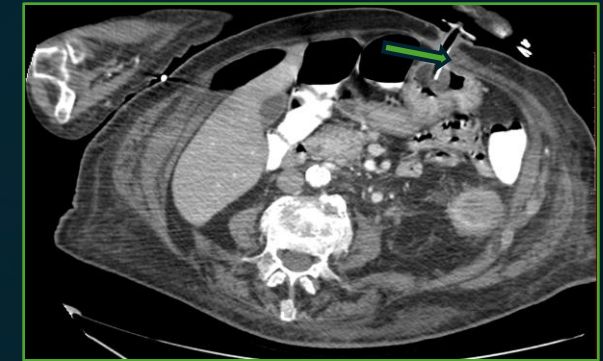
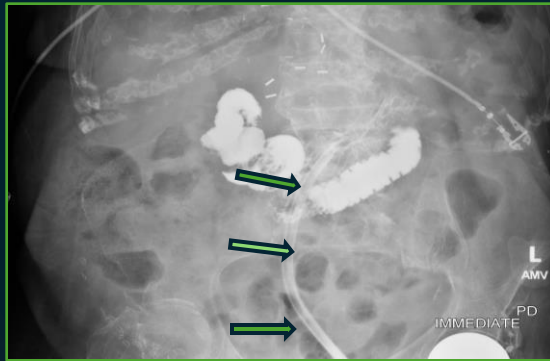
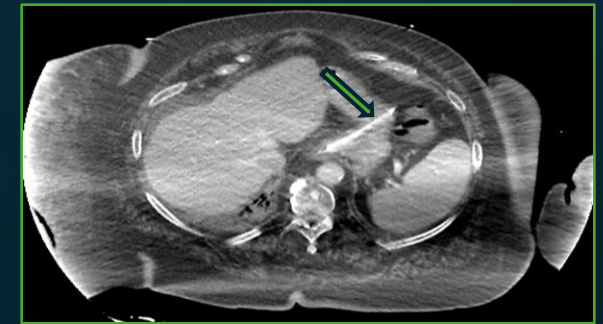
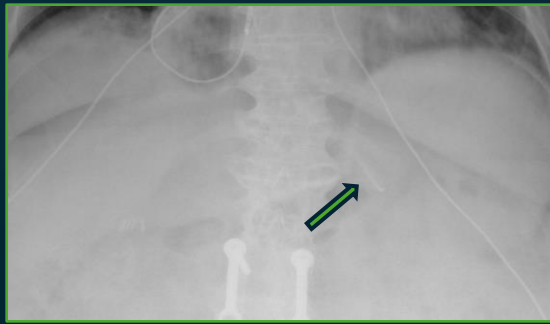
# MR Safety Classification





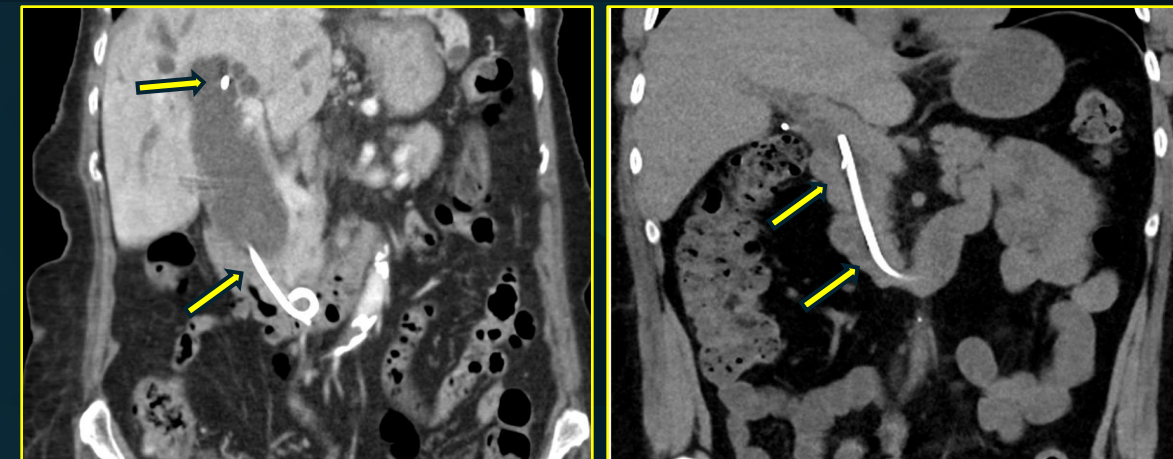
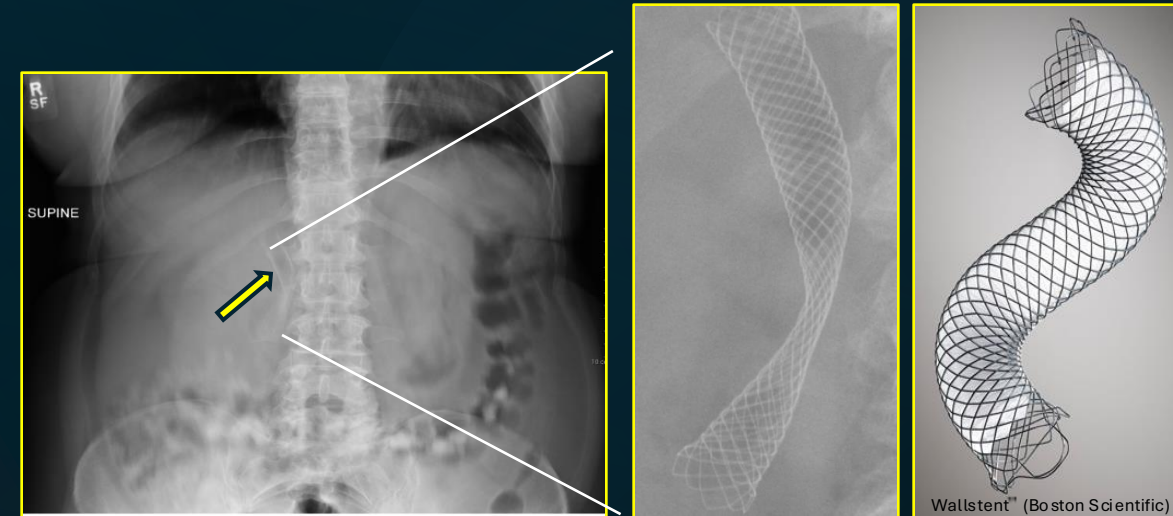
# Feeding Tubes

MR Safety Classification	Radiographic Appearance
MR Safe	Faint radiopaque tube with minimal visibility. Made of non-metallic, non-conductive materials, common brands include Corflo® (Corpak MedSystems), Kangaroo™ (Covidien).
MR Conditional	Radiopaque tip with more dense tube, may contain metallic components.
MR Unsafe	Bright metallic weighted tips. Contains ferromagnetic materials.

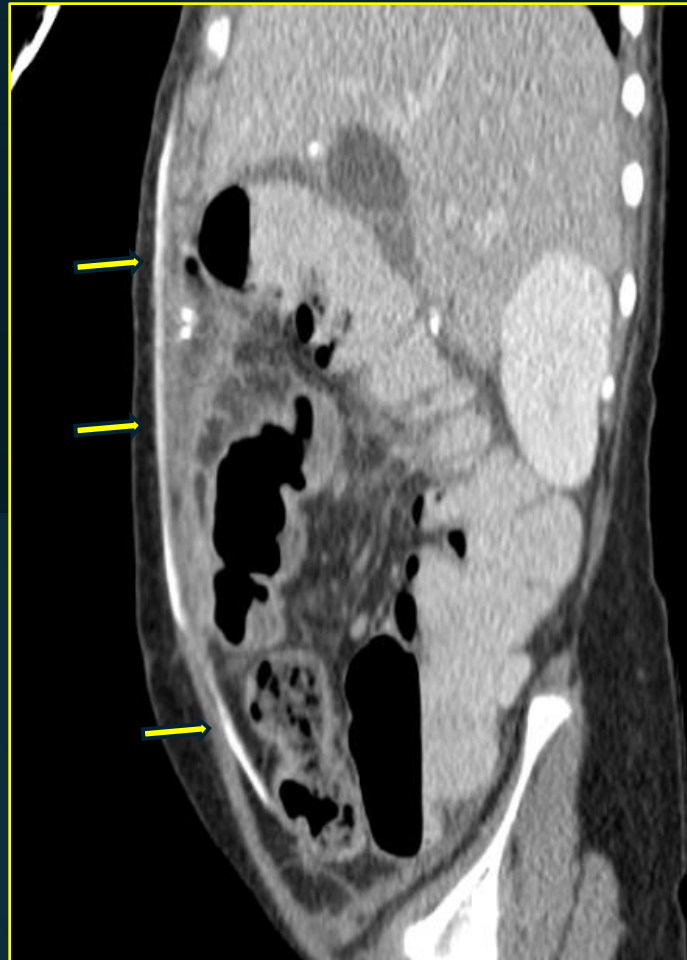
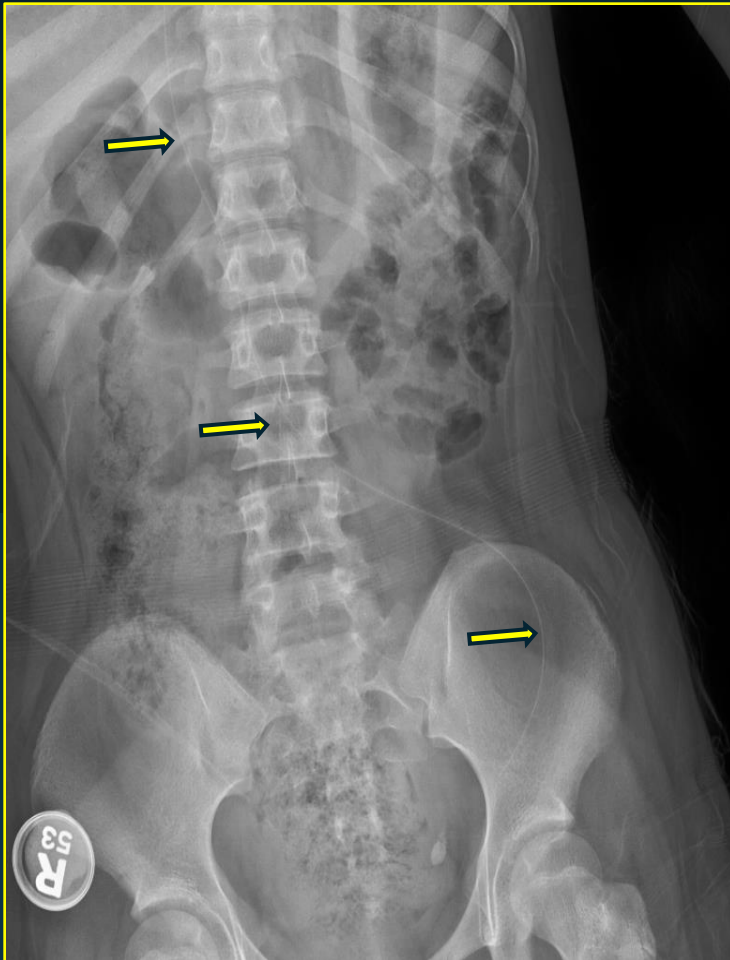


# Gastrointestinal/Biliary Stents

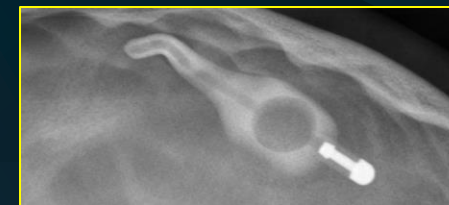
- Most biliary stents are **MR safe** or **conditional**, with most **MR unsafe** stents discontinued in the early 2000s (Wang et al., 2023)
- Stents are MR safe (up to 1.5 T):
  - **Nonferromagnetic**: can be scanned immediately after implantation
  - **Weakly ferromagnetic**: can be scanned 6-8 weeks after implantation (Shellock 2022).
- Common **MR conditional** brands: Boston Scientific WallFlex™ Biliary RX Stent, Cook Medical Evolution® Biliary Controlled-Release Uncovered Stent, Medtronic Complete SE® Biliary Stent System



# Ventriculoperitoneal Shunts

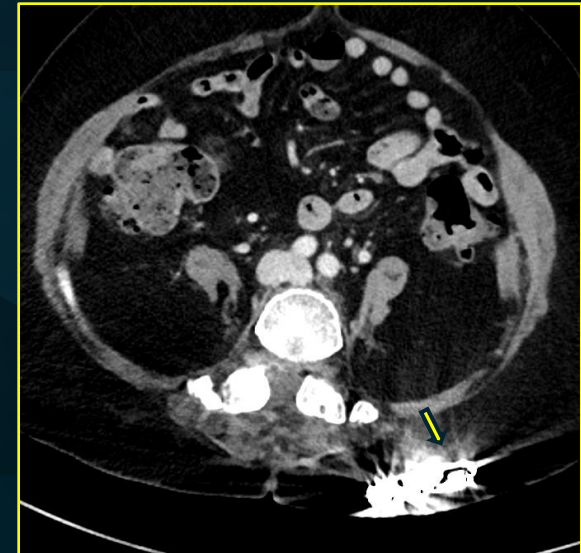
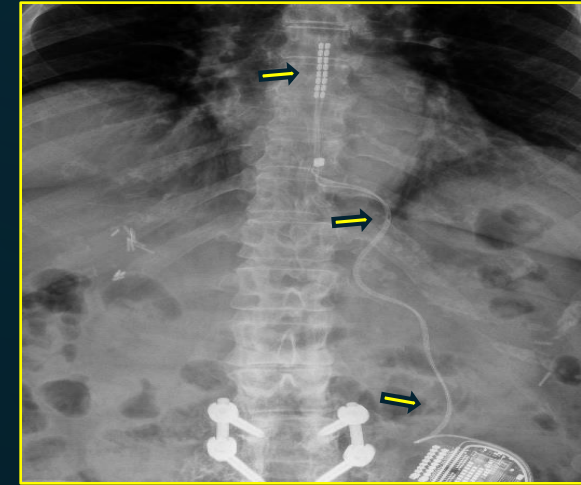


- Most ventriculoperitoneal (VP) shunts are **MR conditional** (up to 3.0 T) (Lavinio et al., 2008)
- Common **MR conditional** brands: Codman Hakim<sup>®</sup>, Miethke proGAV<sup>®</sup> /proGAV<sup>®</sup> 2.0.
- Programmable VP shunt valves, such as Codman Certas<sup>®</sup> Plus, found to be **MR unsafe** at 7T (Chen et al., 2003).

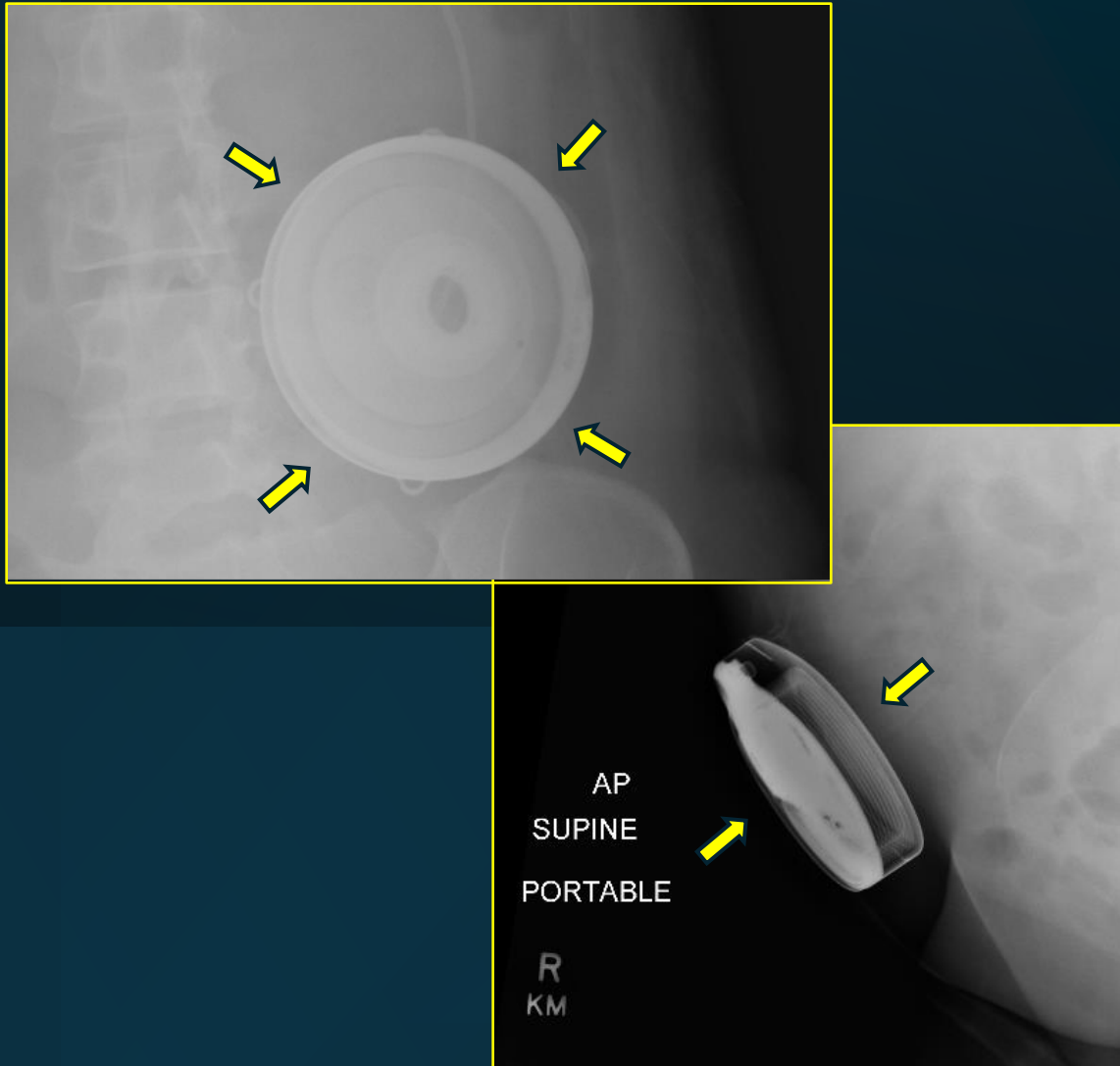


# Spinal Cord Stimulators

- Most spinal cord stimulators are **MR conditional** up to 1.5 T or 3.0 T (depending on brand).
- According to the American Society of Pain and Neuroscience, certain spinal cord stimulators are **MR conditional** when using 50 cm leads for head/extremity MRI **and** when device is placed below T10 (Chapman et al., 2023).
- Stimulators with **implanted electrodes** or **pulse generators** are considered **MR unsafe** (Mutter et al., 2013).
- Common **MR conditional** brands: Boston Scientific: The Precision™ and Spectra™ systems and Abbott: Proclaim™ XR

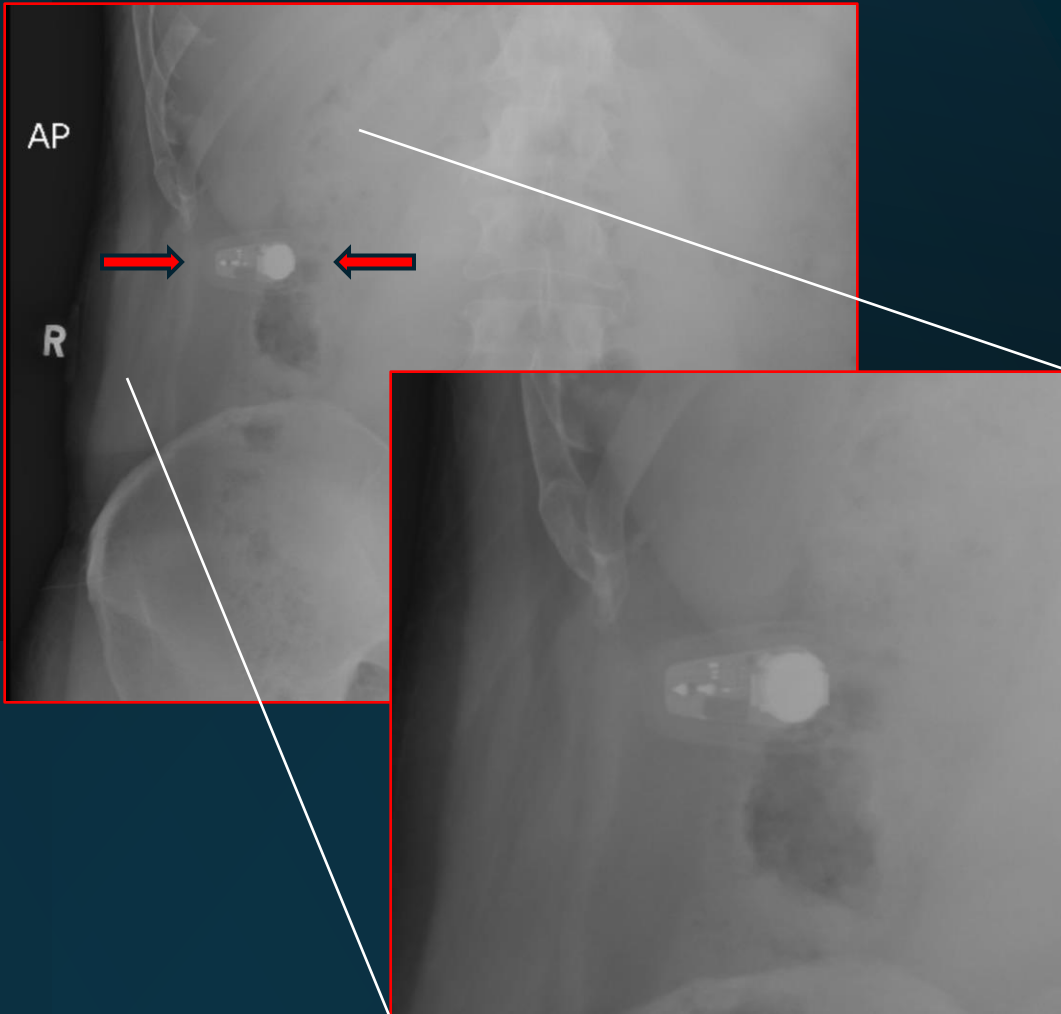


# Implantable Infusion Pumps



- All currently manufactured drug infusion pumps are **MR conditional** to 1.5 T or 3.0 T depending on brand.
  - Common brands include Intera<sup>®</sup> 3000 Hepatic Artery Infusion Pump (Intera), SynchroMed<sup>™</sup> (R) II intrathecal pump (MedTronic), Prometra<sup>®</sup> Programmable Pump (Flowonix).
- U.S. Food & Drug Administration (FDA) issued safety communications regarding serious adverse events if pumps are not properly handled in MRI, including motor stalling, failure to restart leading to therapy interruption, or valve failure leading to overdose.

# Continuous Glucose Monitors



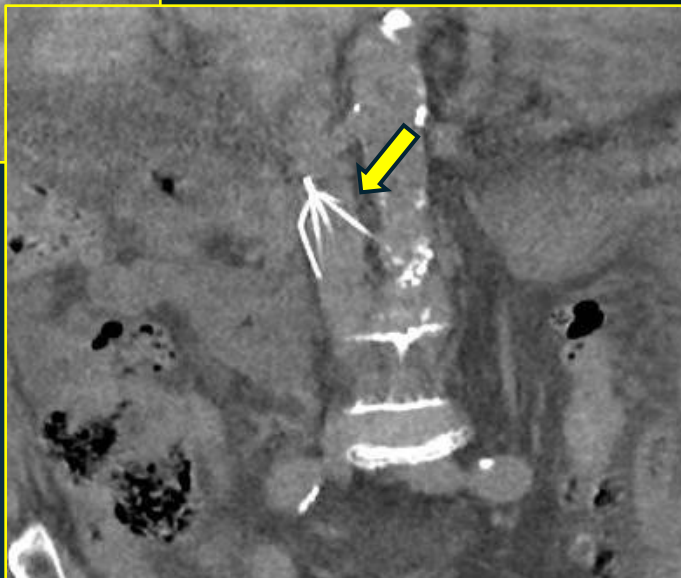
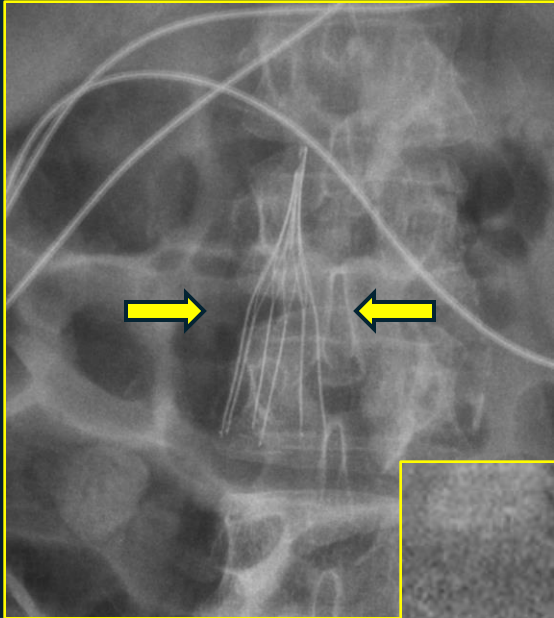
- Multiple models, most commonly used are FreeStyle Libre (Abbott), Dexcom G6 (Dexcom), Guardian Connect (Medtronic).
- Most are deemed **MR unsafe**, battery and electronics within the recorder/transmitter portion may be damaged by the magnetic fields.
- Exception - Eversence 365 system (Ascensia), subcutaneous glucose sensor, **MR conditional** if external transmitter is removed.
- Recent study demonstrated that MRI simulations have no effects on Dexcom G6 transmitter data storage and communications, minimal magnitude of heating and displacement force (Thomas et al, 2021).

# GI Endoscopy Clips

- Most are made of titanium or non-ferromagnetic stainless steel, **MR conditional** up to 3.0 T (Shin *et al*, 2020).
  - Common brands include Instinct Plus™ (Cook Medical), EZ Clip (Olympus), DuraClip™ (CONMED)
- QuickClip2 Long Model HX201 LR-135 (Olympus) - only endoclip in production that is **MR unsafe**.
- Most clips detach spontaneously within 1-3 weeks. For clips with unknown compatibility, radiographic confirmation of detachment is recommended before MRI scanning.



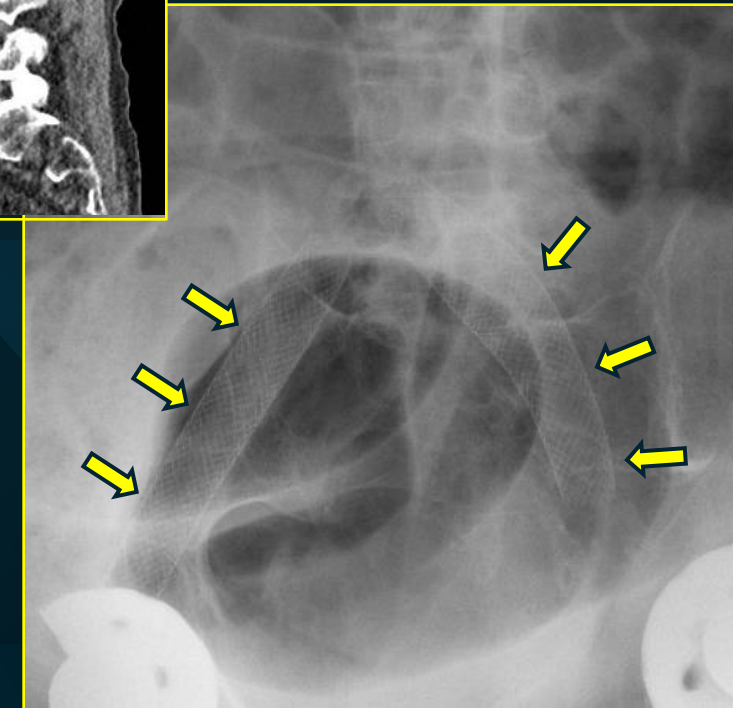
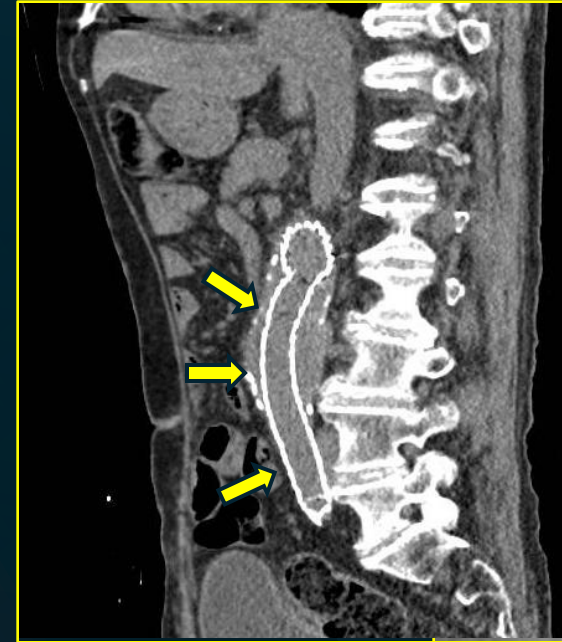
# IVC Filters



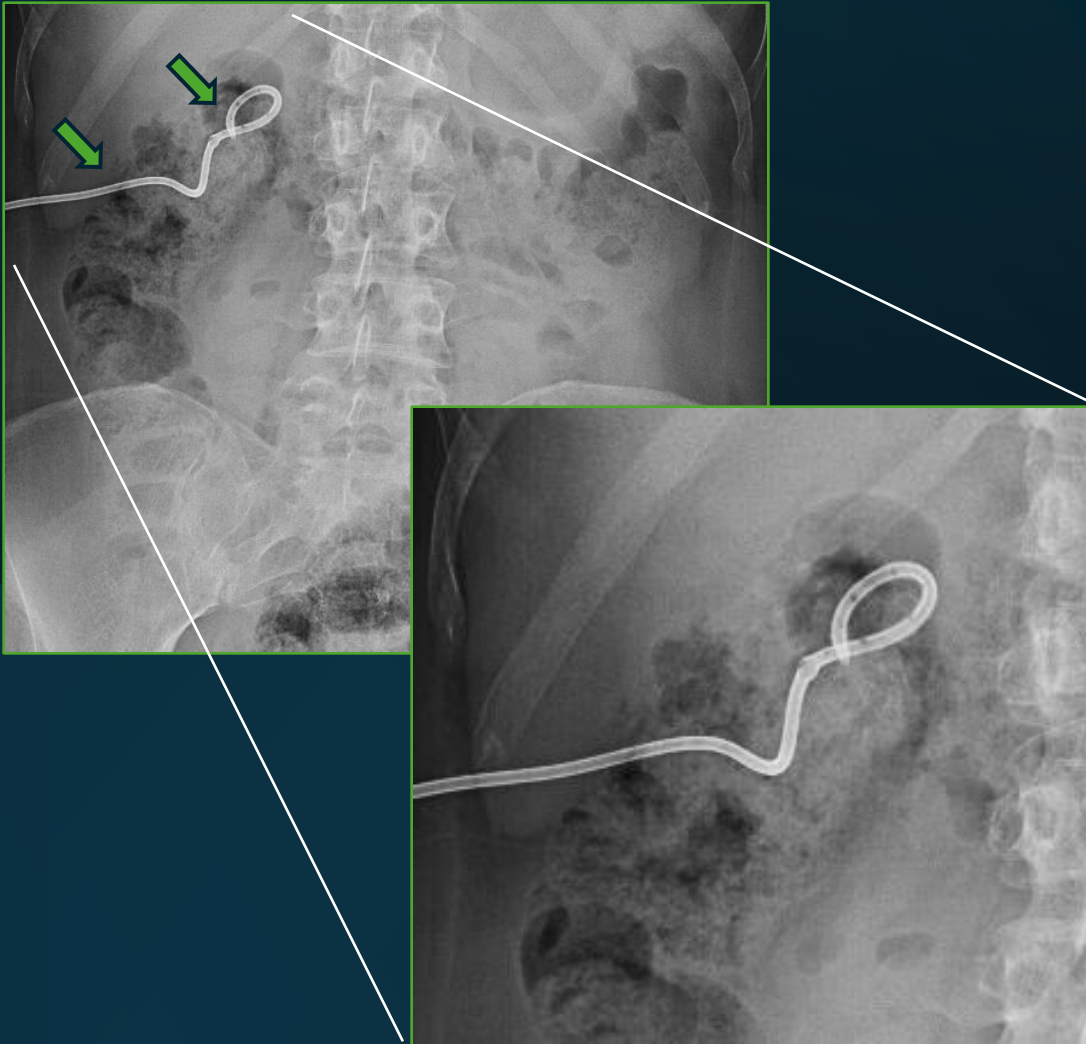
- Many filter types, made of titanium or nonferromagnetic alloys, **MR conditional** to 3.0 T (Winokur et al., 2019)
  - Common brands include Option™ ELITE (Argon Medical Devices), OPTEASE™ (Cordis), VenaTech® Convertible (B. Braun Intervention Systems), Denali™ (BD)
- MRI imaging can occur immediately after placement
  - Spontaneous migration rate of properly implanted modern IVC filters ~1%.

# Vascular Stents

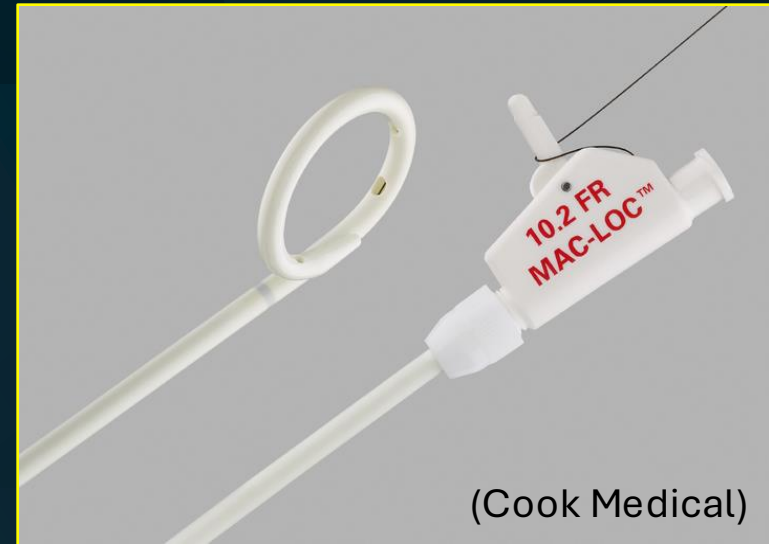
- Nearly all metal stents are made of non-ferric materials, considered **MR conditional** up to 3.0 T.
- Common brands include Absolute Pro™ Stent System (Abbott), TREO® Abdominal Stent-Graft (Terumo/Bolton), VIABAHN® Endoprosthesis (Gore), Endurant II Stent Graft System (Medtronic)
- Of note, can scan safely immediately after implantation
  - Significant susceptibility artifact can occur (Van der Laan *et al.*, 2004)



# Nephrostomy Catheters

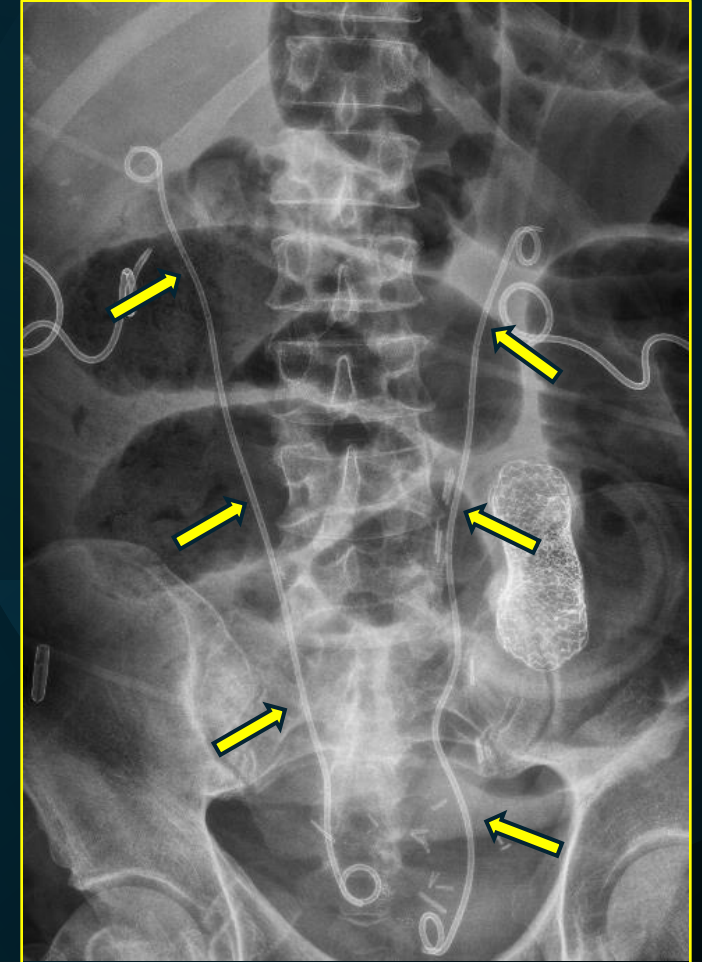


- Nearly all catheters are made of polyurethane, **MR safe**
- Some nephrostomy catheters made by Cook Medical have a locking mechanism (MacLoc<sup>®</sup>) on hub that contains metal, thus **MR conditional** to 1.5 T.

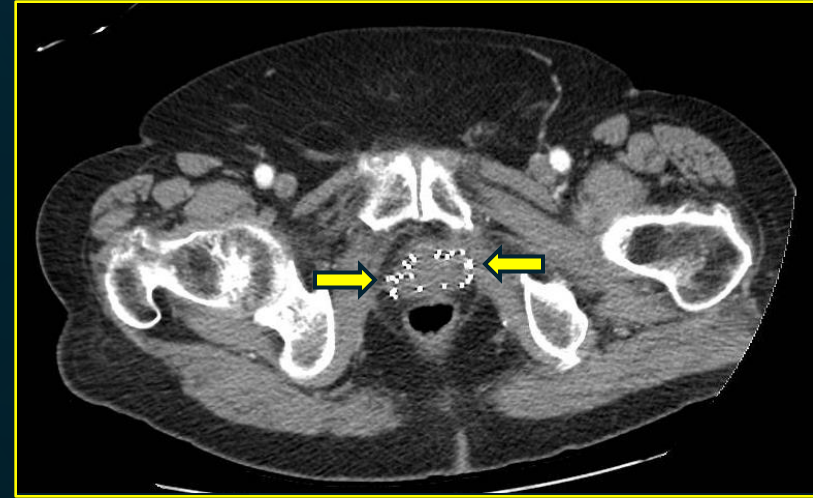
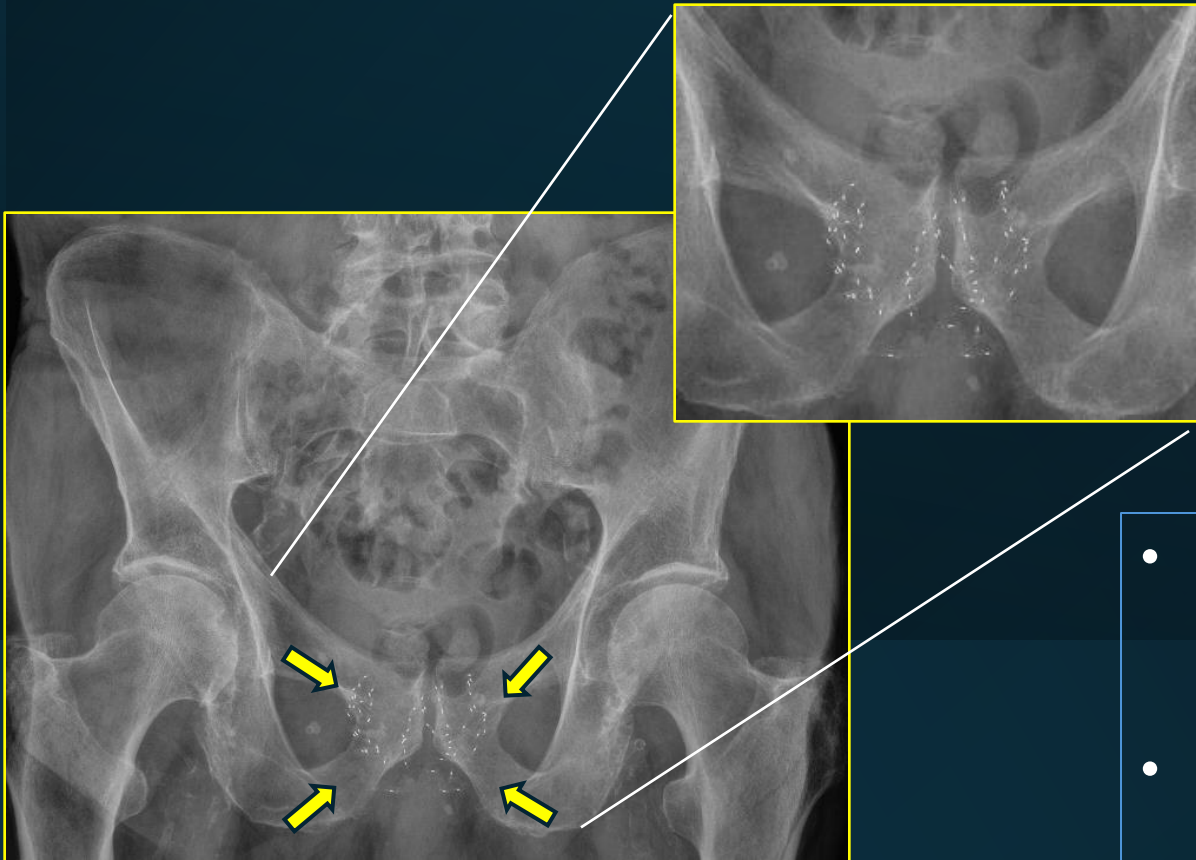


# Ureteral Stents

- Majority are **MR conditional** at 1.5 T or 3.0T – all-metal and metal-coil reinforced stents developed to improve patency and maintain shape (Tellambura *et al.*, 2021).
  - Common brands include Universa® (Cook), Percuflex™ Plus (Boston Scientific), Inlay Optima™ (BD), Resonance Metallic® (Cook)
- Magnetic Black Star® (Urotech) is **MR unsafe** – magnetic tip within the bladder, allows retriever device to be inserted and capture stent without need for cystoscopy.



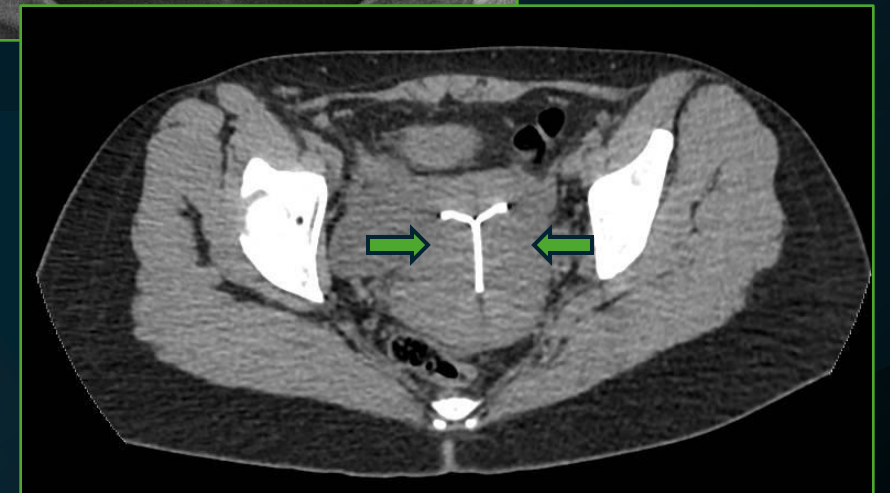
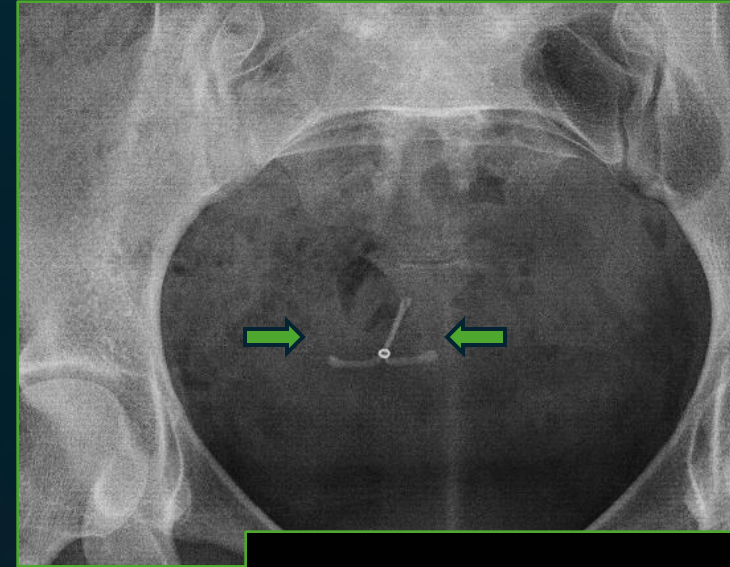
# Prostatic Seeds



- Brachytherapy seeds– radioactive implants, titanium capsules with Palladium-103 or Iodine-125
- Common brands include Advantage™ (IsoAid Corp.), Secure Strand® (IsoAid), and IsoSeed® (Eckert & Ziegler Medical)
- Considered **MR Conditional** up to 3.0 T (Thomas et al., 2009)

# Intrauterine Devices

- Copper IUDs are **MRI safe** up to 3.0 T (Zieman and Kanal, 2007)
  - Composition: Polyethylene frame, copper wire
  - Common brands: ParaGuard<sup>®</sup> (CooperSurgical), Nova T<sup>®</sup> (Bayer)
- Hormonal IUDs are **MRI safe** up to 3.0 T
  - Composition: Mainly plastic, may include small amount of barium or silver
  - Common brands: Kyleena<sup>®</sup> (Bayer), Liletta<sup>®</sup> (Abbvie), Mirena<sup>®</sup> (Bayer)



# Penile Prosthesis

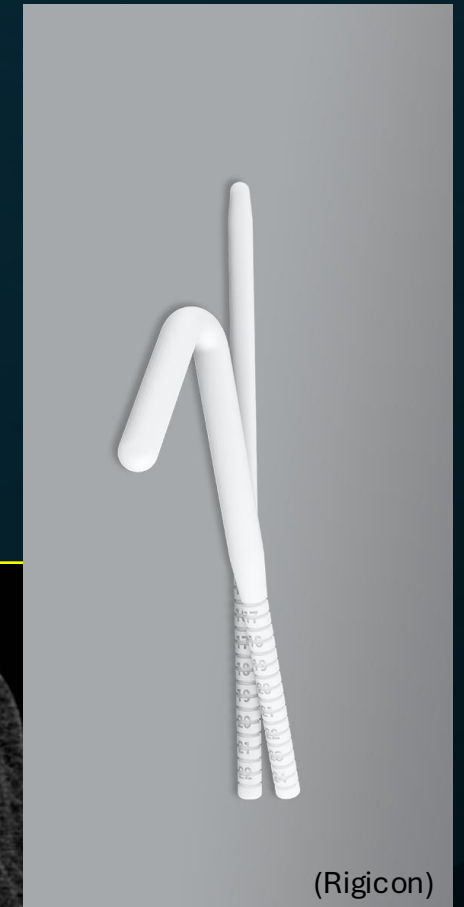
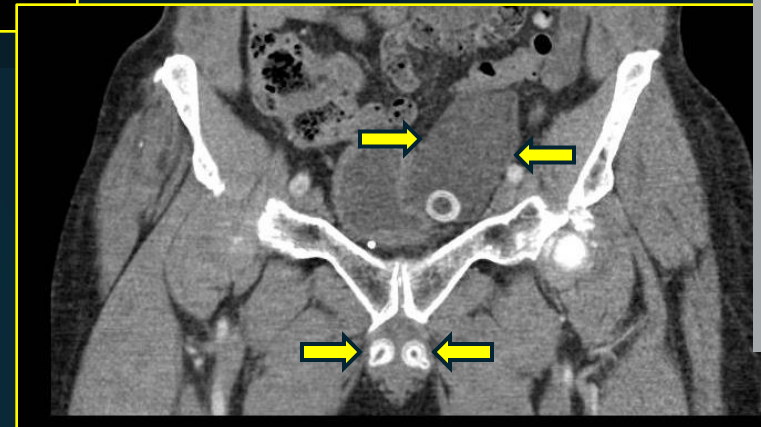
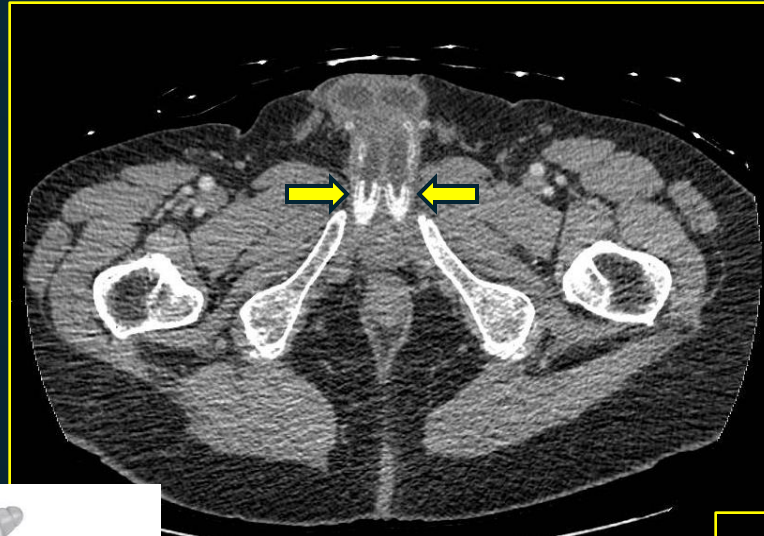
- **Inflatable**

- Majority of currently implanted prostheses. Two devices placed in the corpus cavernosa, filled with a saline solution to produce rigidity.
- All commonly used ones (Zephyr ZSI 475, Boston Scientific AMS 800™, Coloplast Titan®, etc.) contain small amounts of metal within their components, **MR Conditional** to 1.5 or 3.0 T (Lowe *et al.*, 2012).

- **Malleable**

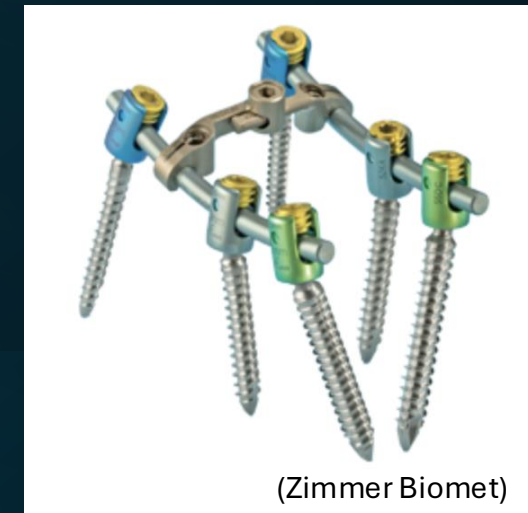
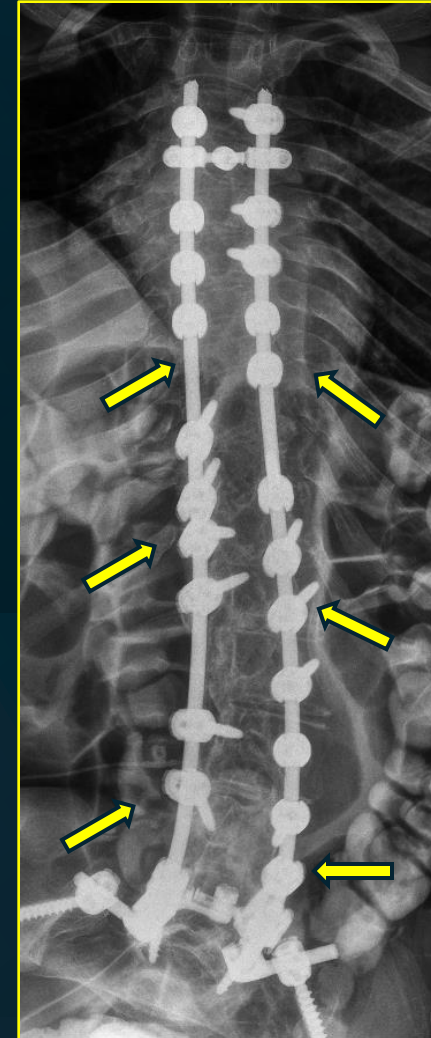
- Malleable shafts that are placed in each corpus cavernosum, primarily made of silicone, however distal portions contain silver/stainless steel central core. **MR conditional** to 1.5 T or 3.0 T depending on brand.
  - Common brands include Tactra™ (Boston Scientific), Rigi10™ (Rigicon), Genesis® (Coloplast).
- OmniPhase and DuraPhase (DacoMed) malleable shafts were predominantly used in 1980s and 1990s, **MR unsafe** due to ferromagnetic components, avoid imaging if necessary.

# Penile Prosthesis



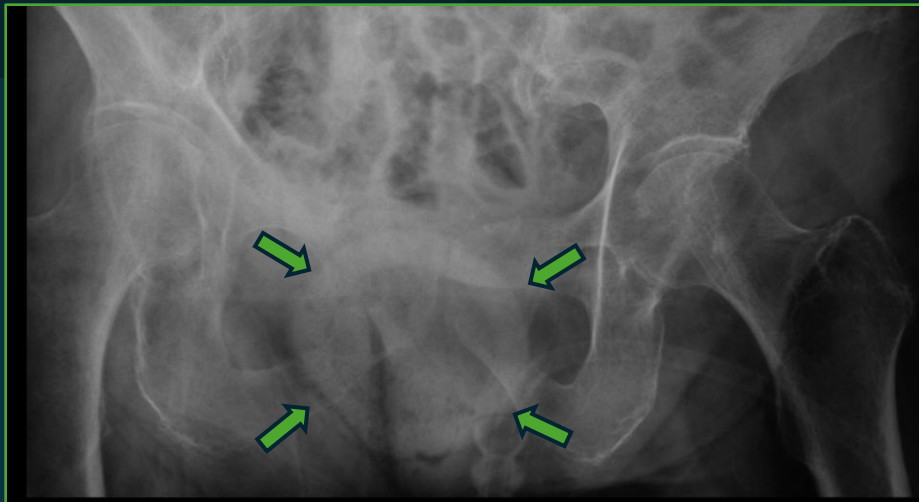
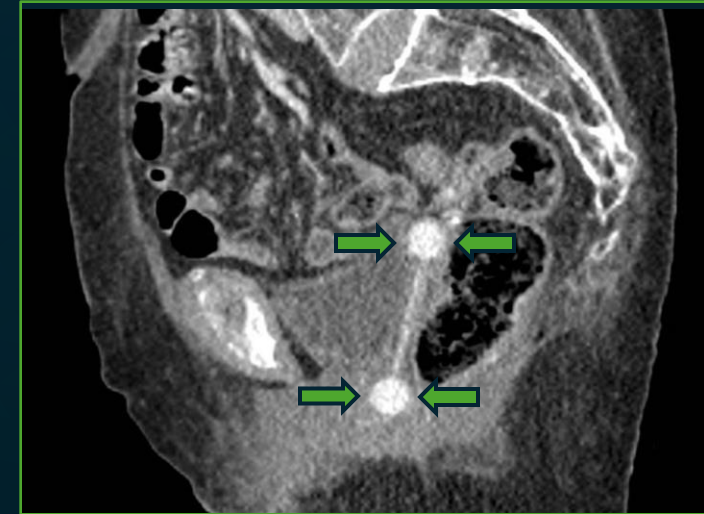
# Pedicle-Screw-Rod Systems

- For metal implants, weakly ferromagnetic or non-ferromagnetic metals are used (include cobalt-chromium, stainless steel, and titanium/titanium alloys), are thus **MR conditional** to 1.5 T or 3.0 T, depending on manufacturer (Henrich *et al.*, 2021).
  - Minimal concern for implant migration and heating (Mosher *et al.*, 2018).
- Common brands include the Universal Spine System™ (DePuy Synthes), Sequoia® Pedicle Screw System (Zimmer Biomet), Neo Pedicle Screw System™ (Neo Medical)
- Significant susceptibility artifact may occur, in which adjusting MR pulse sequences and scanning parameters can minimize distortion.



# Pessaries

- Most pessaries are pure silicone-based, **MR safe** (Hong *et al.*, 2022).
- Some are metal covered with silicone, considered **MR Unsafe**.
  - For example, the Milex® Incontinence Ring Pessary (Cooper Surgical) contains a wire coil, should be removed prior to imaging.





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Imaging the Individual

# Thank You!

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