Pediatric Gastrointestinal MRI

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Pediatric Gastrointestinal MR 2008/Overview

- Liver and Spleen
- Bile Ducts, Gallbladder, and Pancreas
- Esophagus and Stomach
- Small Intestine
- Large Intestine and Rectum

Pediatric GI MRI

- Presentation will concentrate on 3 primary areas of evaluation by MRI
- Liver masses
- Pancreatic and biliary tract anomalies
- Small bowel/Colonic inflammatory disease

Pediatric Gastrointestinal MR 2008/Overview

- For each anatomic section, the following outline will be used:
  - Common pediatric indications
  - Pulse sequences and technical parameters
  - Anatomy
  - Imaging Pathology
  - Future considerations

Liver MRI

- Common pediatric indications
  - Pre-liver transplant evaluation
  - Evaluation of liver mass
  - Metastatic disease surveillance
  - Evaluation of size in patients with storage diseases

Liver MRI/Sequence selection

- Pulse sequence selection
- Depends on whether patient is of age to be
  - Sedated
  - Breath-holding
  - Not sedated but quiet free-breathing
  - Uncooperative

Liver MRI/Pulse sequence selection

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- Fast techniques including single-shot T2W SE (SS-FSE, HASTE) or fast SE (FSE, TSE) imaging and pre- and post-contrast T1W GRE imaging in axial and coronal planes are helpful
- Post-contrast images can be obtained immediately after contrast bolus injected as well as after 1 min and 3 min delay to help characterize vascularity of masses. Fat sat is usually employed
- In and out of phase T1 imaging may be helpful to characterize presence of fat in lesions.
- For evaluation of liver vascular anatomy for transplant evaluation or mass lesion, CE-MRA and balanced fluid-sensitive sequence (FIESTA/TFISP) are helpful

Liver MRI/Coil selection

- Dependent on patient age
- For infants, a head or extremity coil may be sufficient
- For older children, multichannel phased-array surface or torso coil is preferred

Liver MRI/Metastatic Disease

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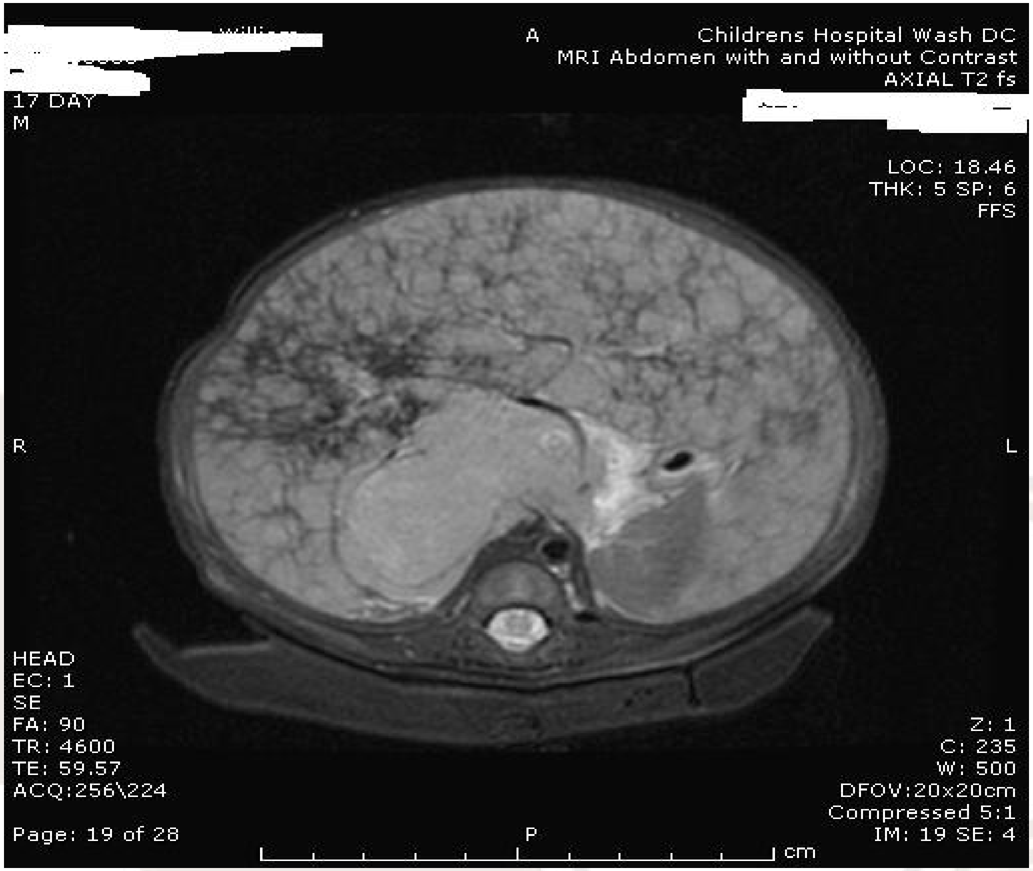
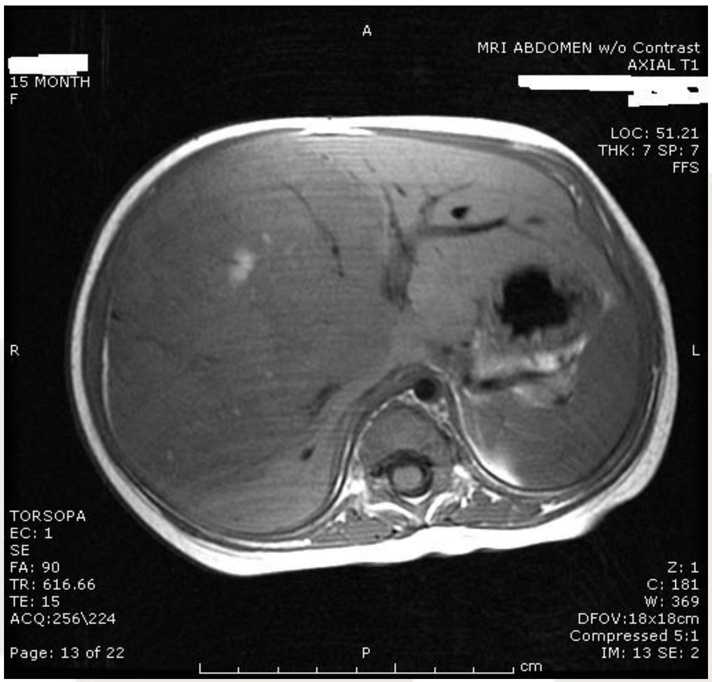


17 day old male with massive hepatomegaly secondary to Stage 4S neuroblastoma

Liver MRI/Primary Tumors
Hepatoblastoma



15 month old female with hepatoblastoma

Primary Liver Tumors/Hepatoblastoma

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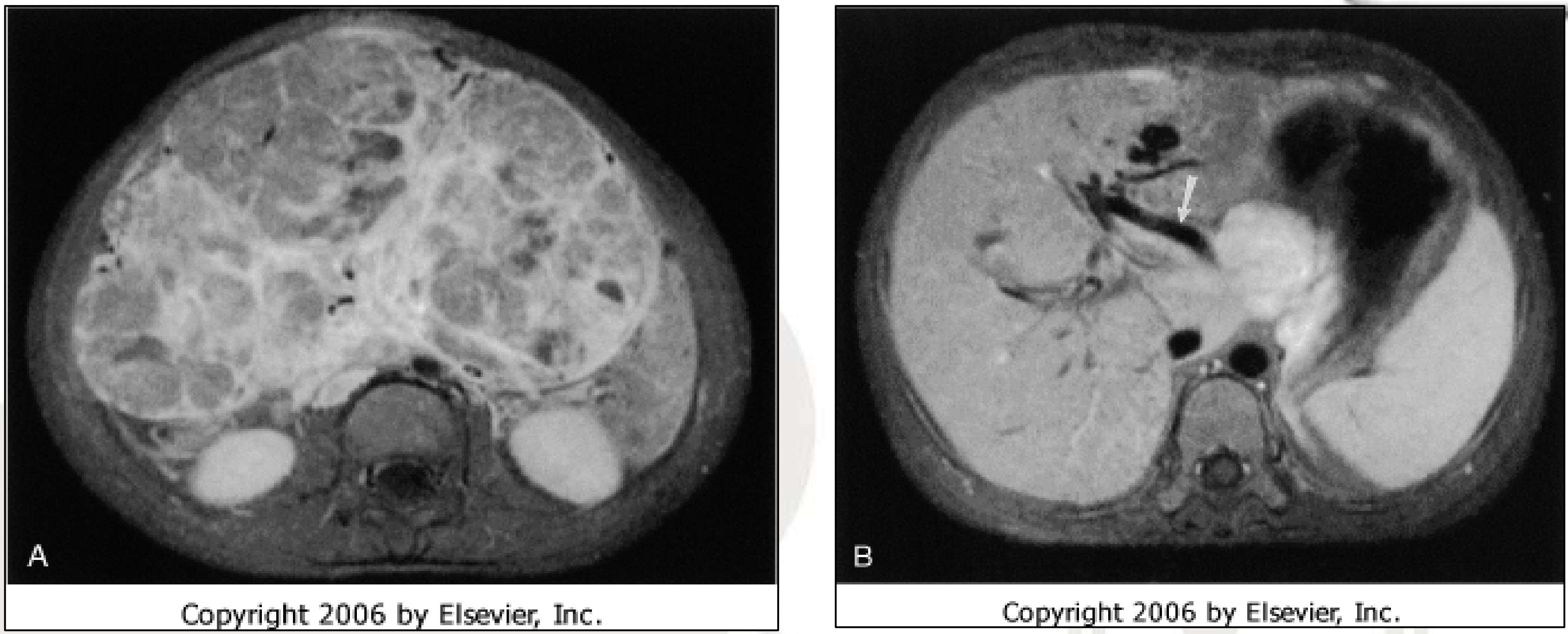


Figure 95-19 Hepatoblastoma, 7-year-old boy. A, T1-weighted axial gadolinium-enhanced and fat-suppressed MR image shows a large, heterogeneously enhancing tumor replacing most of the upper abdomen. B, A more superior T1-weighted contrast-enhanced MR section shows the enhancing regional lymphadenopathy next to the large hepatic artery (arrow).

Liver MRI/Hepatoblastoma

- Infants and toddlers
- Usually solitary, occasionally multicentric
- 3 histologic types: epithelial, mixed, and anaplastic
- Primary management is surgical, so evaluation of tissue/vascular planes is very important
- T1W: low
- T2W: mildly high
- Post-contrast: hepatic arterial phase enhancement

Primary Liver Tumors/Hepatocellular Carcinoma

Figure 95-18 Hepatocellular carcinoma, 17-year-old man. Axial T2-weighted, fat-suppressed, breath-hold MR image shows multiple high signal intensity hepatic masses. Note the extensive retroperitoneal lymphadenopathy (arrows) splaying the inferior vena cava away from the aorta

Primary Liver Tumors/HCC

- Biphasic pediatric peak: pre-school and teenagers
- Older patients can have fibrolamellar variant
- Associated with chronic liver disease/metabolic abnormalities
- Can be multicentric and heterogenous
- T1W: low
- T2W: can have two zones, inner low and outer high
- Post-contrast: diffuse heterogenous enhancement
- Fibrolamellar variant has large central scar with heterogenous characteristics on imaging

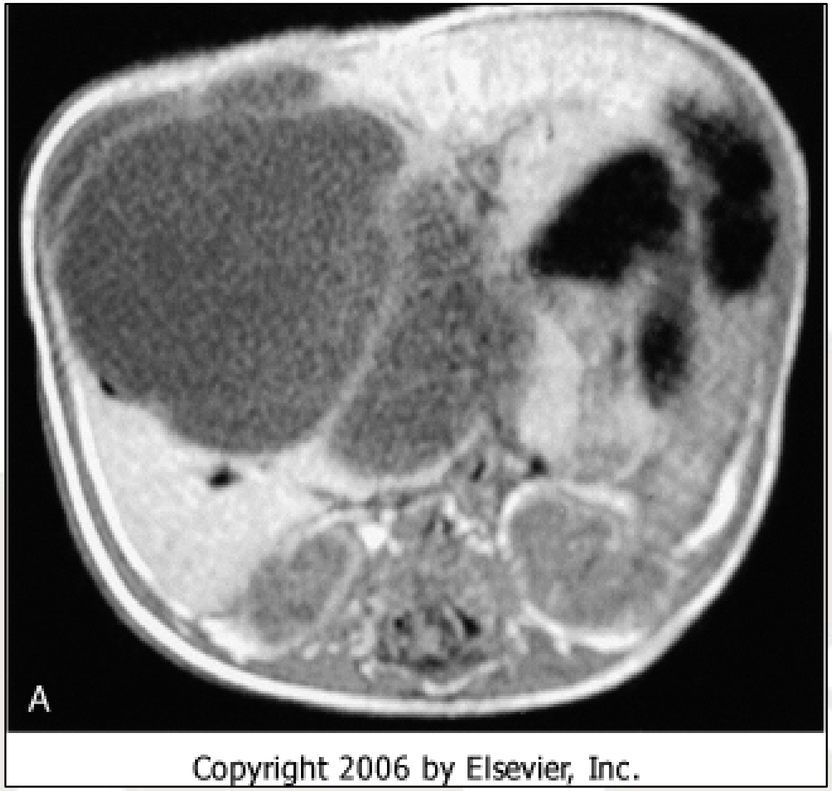
Liver MRI/Primary Tumors/Embryonal Sarcoma

Figure 95-21 Embryonal sarcoma, 12-year-old boy with a large abdominal mass. A, Breath-hold coronal short tau inversion recovery (STIR) image (TR/TE 4000/76, flip angle 130 degrees) demonstrates a large, predominantly low signal intensity hepatic mass with areas of high signal intensity representing hemorrhage. B, Coronal source images from contrast-enhanced MR angiogram (TR/TE 5/2, flip angle 25 degrees) shows a predominantly intermediate signal intensity mass with some low signal intensity septations. At surgery, only the periphery of this tumor was viable.

Liver MRI/Embryonal Sarcoma

- School age
- Large cystic mass with septations
- T1W: heterogenously low, with increased signal in lesions with hemorrhage
- T2W: high
- Post-contrast: moderate enhancement of stromal elements
- Resembles mesenchymal hamartoma in imaging, but usually older patient and is malignant

Liver MRI/Primary Tumors/Mesenchymal Hamartoma



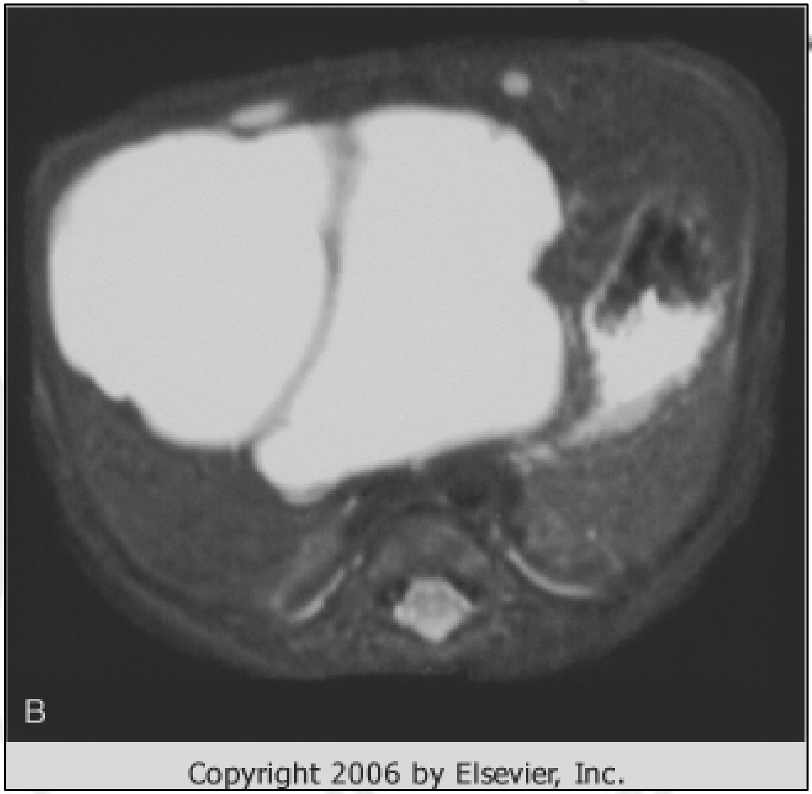


Figure 95-24 Mesenchymal hamartoma, 3-week-old infant. A, T1-weighted image shows a low signal intensity mass in the right hepatic lobe. B, T2-weighted (TR/TE 3500/85) image. The lesion has become hyperintense to adjacent parenchyma. Several septations can be noted. (Courtesy of Lane Donnelly.)

Liver MRI/Mesenchymal Hamartoma

- Infants to school-age children
- Benign tumor with origin from portal tissue
- Two types: Cystic and Stromal
- T1W: low for both types
- T2W: high for cystic, low for stromal
- Stromal elements can enhance

Liver MRI/Vascular Lesions

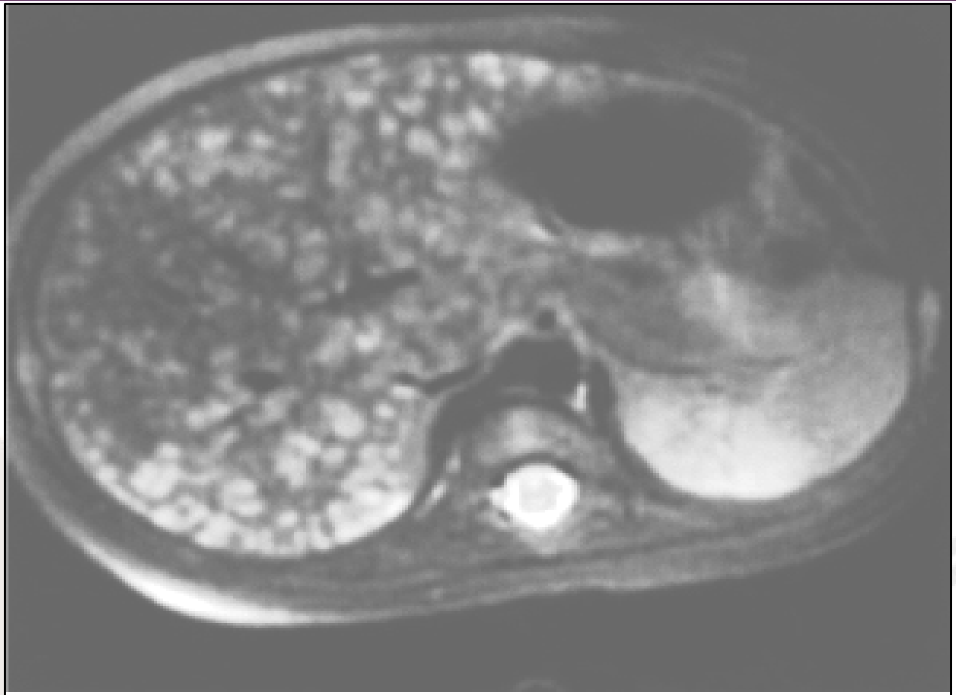
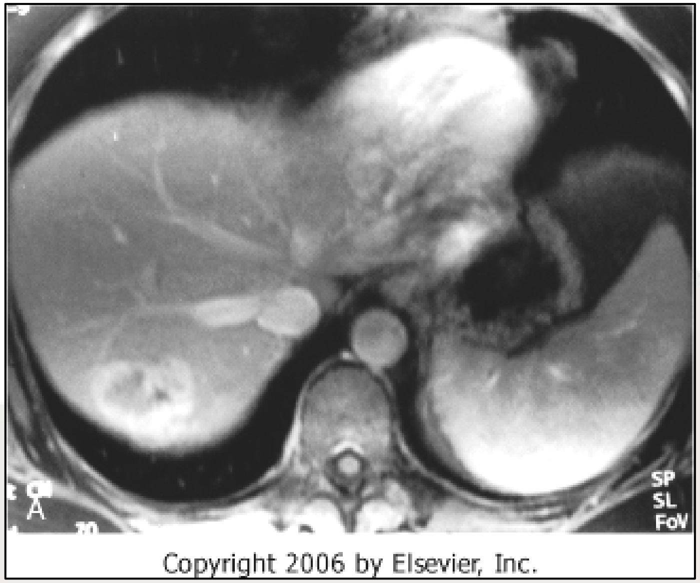


Figure 95-22 Multiple hemangioendotheliomas in a newborn girl. Axial T2-weighed spin-echo fat-suppressed image shows multiple lesions that are hyperintense to the normal liver parenchyma. (Courtesy of Sudha Anupindi, MD.)

Liver MRI/Hemangioendothelioma

- Most common primary benign tumor
- Infants
- Can be associated with congestive heart failure or consumptive coagulapathy (Kasabach-Merritt syndrome)
- Single mass or multifocal
- TIW: low
- T2W: high
- Bright vascular enhancement with prolonged retention of contrast

Liver MRI/Vascular Lesions



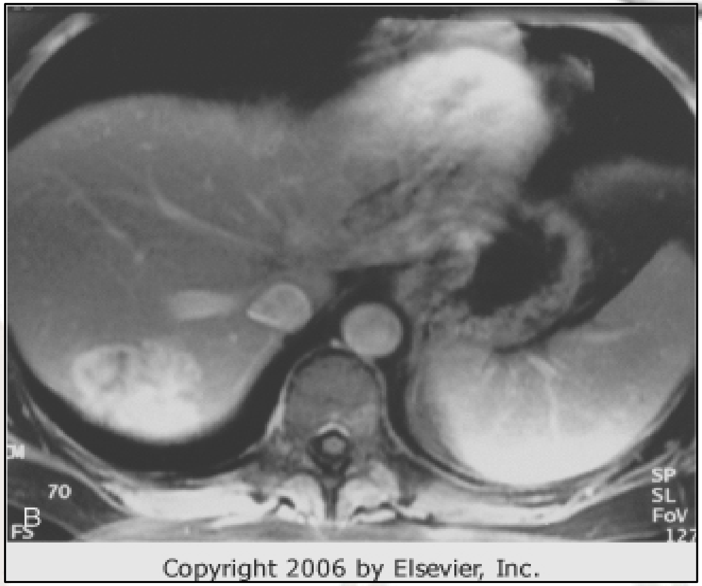
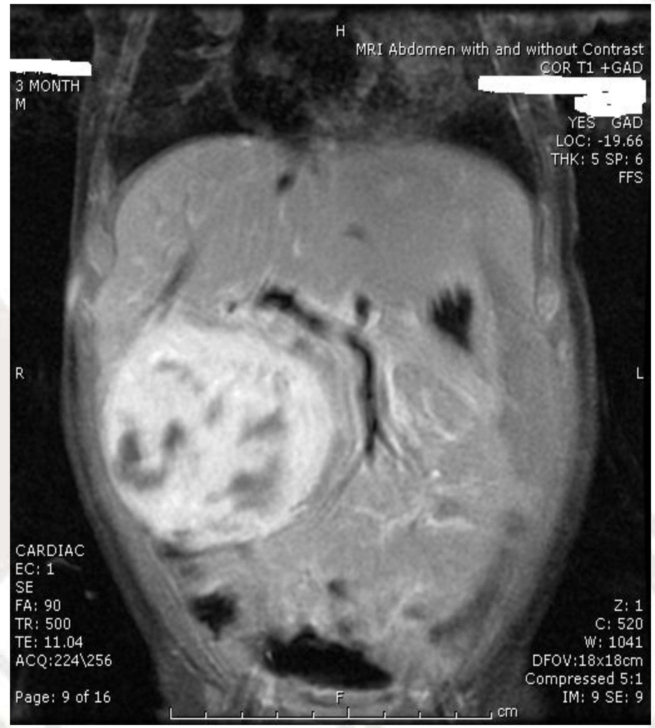


Figure 95-23 Cavernous hemangioma. A, Early-contrast gradient-echo fat-suppressed image (TR/TE 200/6, flip angle 70 degrees) shows peripheral enhancement in a lesion in the right lobe posteriorly. B, An image 2 minutes later shows nearly complete enhancement of the mass

Liver MRI/Primary Tumors



3 month old male with large liver tumor

Liver MRI/Future Considerations

- **Use of diffusion imaging to characterize liver masses and biologic behavior of tumors**
  - Radiology. 2008 Mar;246(3):812-22. Epub 2008 Jan 25. Links
    - **Focal liver lesion detection and characterization with diffusion-weighted MR imaging: comparison with standard breath-hold T2-weighted imaging.**
    - Parikh T, Drew SJ, Lee VS, Wong S, Hecht EM, Babb JS, Taouli B.
    - Department of Radiology, New York University Medical Center, 530 First Ave, MRI, New York, NY 10016, USA.
  - J Magn Reson Imaging. 2008 May;27(5):1069-76. Links
    - **Diffusion-weighted PROPELLER MRI for quantitative assessment of liver tumor necrotic fraction and viable tumor volume in VX2 rabbits.**
    - Deng J, Virmani S, Young J, Harris K, Yang GY, Rademaker A, Woloschak G, Omary RA, Larson AC.
    - Department of Radiology, Northwestern University, Chicago, Illinois

- **Evaluation of novel tumor fighting strategies such as cryotherapy, RF and focused ultrasound**
  - J Magn Reson Imaging. 2008 Feb;27(2):421-33. Links
  - **Magnetic resonance guidance for radiofrequency ablation of liver tumors.**
  - Clasen S, Pereira PL.
  - **Eberhard-Karls-University, Department of Diagnostic Radiology, Tübingen, Germany**

Biliary Tract and Pancreas MRI

- Primary indications
  - Congenital anomalies of the bile ducts and pancreas
  - Investigation of etiology for pancreatic or biliary ductal dilatation
  - Tumors/masses

MRCP Indications/Delaney et al

Indication	Normal MRCP (n=43)	Abnormal MRCP (n=42)	All MRCPs (%) (n=85)
Pancreatitis	24	23	47 (55%)
Elevated liver function tests	14	15	29 (34%)
Occult abdominal pain (normal laboratory tests)	9	2	11 (13%)
Evaluate choledochal cyst	0	6	6 (7%)
Rule out common bile duct calculus	6	6	12 (14%)
Rule out primary sclerosing cholangitis	1	3	4 (5%)
Evaluate liver or pancreas mass	0	4	4 (5%)
Trauma	1	2	3 (4%)
Abscess	0	1	1 (1%)
Pre-liver transplant evaluation	0	1	1 (1%)
Evaluate liver transplant	0	1	1 (1%)

Biliary Duct and Pancreas MRI

- Use combination of fast T1W and fast T2W sequences usually in axial and coronal planes
- Supplement with thin or thick slab MRCP sequence (very long T2, essentially nulls non-fluid tissues) obtained in 2D or 3D acquisition either in coronal or coronal oblique plane
- Use phased-array multichannel torso or cardiac coil

Biliary Tract and Pancreas MRI/Delaney et al protocol

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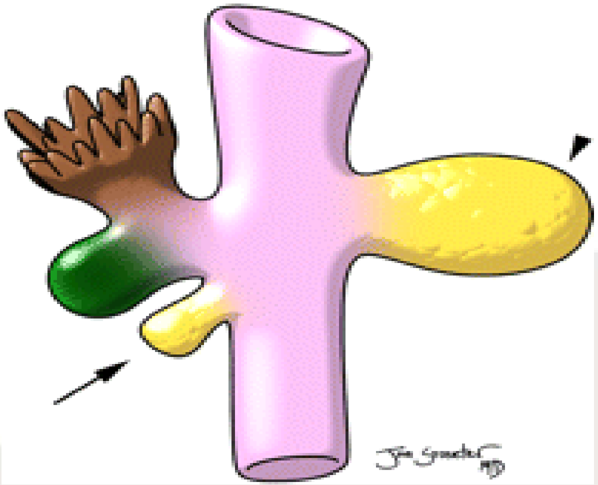
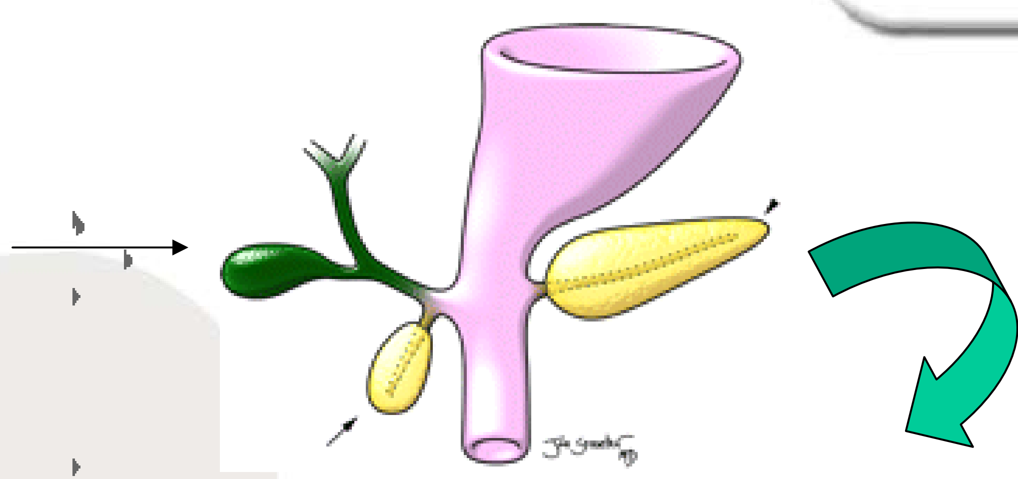
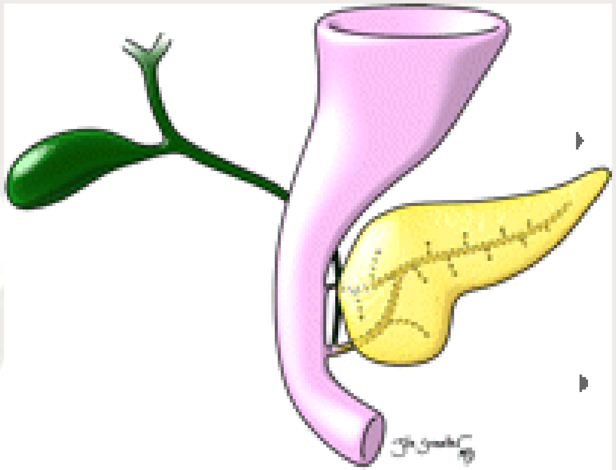
Table 1	MRCP technique (using a 1.5-T scanner)							
Parameter	Scan 1	Scan 2	Scan 3	Scan 4	Scan 5a	Scan 6b	Scan 7c	Scan 8
Coil	Cardiac or torso phased array							
Plane	Three-plane Axial Coronal		Axial oblique	Coronal oblique	Coronal oblique	Coronal	Axial	
Pulse sequence	localizer multiplanar fast spin spoiled echo gradient echo	Three-plane Fast Single-shot echo	echo	Single-shot fast spin echo	Single-shot fast spin fast spin echo T2-W	Single-shot fast spin fast spin echo XL	3-D fast recovery	Fast recovery
Echo time (ms)		4.76 In phase 90		90	750	750	654	102
Echo train length		230	230	256	256	127 (4 ET/slice)		13
Repetition time (ms)		2.81 100–200	1,450–1,800	1,115–1,800	4,000	4,000	1,500	1,500
Flip angle	90 180	180	180	180	180	180		
Receiver bandwidth (kHz)		781 62.5 62.5	62.5	62.5	62.5	32.25	31.25	
Field of view	Determined by size of child							
Slice thickness (mm)		10 6–7 4	4	20–30	20–30	1.8	5–7	
Slice spacing (mm)		5 1 0	0	3.5–8	3.5–8	3.5–8	1	
Matrix frequency (pixels)		256 256 256	256	256	256	256	256	
Matrix phase (pixels)		160 160 160	160	256	256	128	224	
Frequency direction		R/L L/R S/I	L/R	S/I	S/I	A/P	R/L	
No. of excitations		1 1 1.25	1	1.5	1.5	1.5	4	
Secretin	No No No	No	No	Yes	No	No		
Fat saturation	No No No	No	Yes	Yes	Yes	Yes		
Gating	None None None		None	None	None	Respiratory	Respiratory	

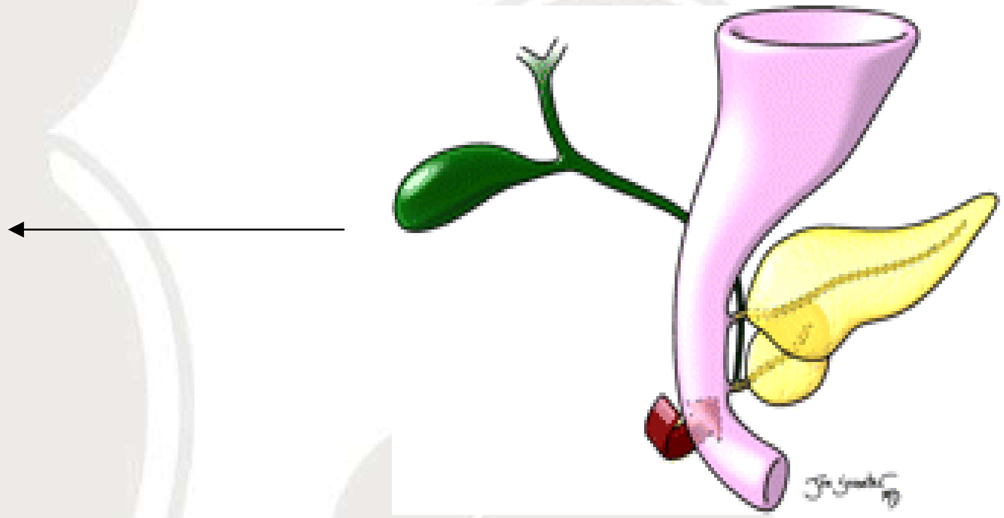
Pancreas MRI/Normal development





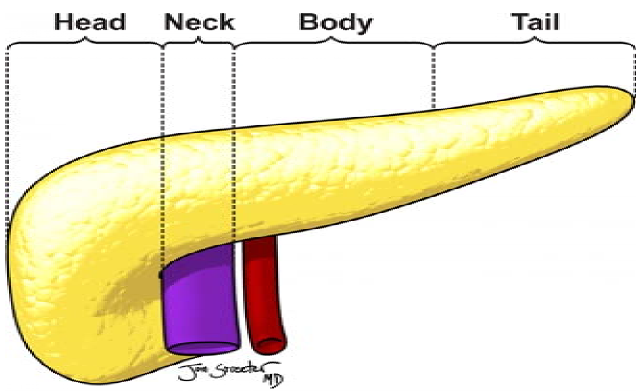
RadioGraphics 2006;26:715-731





Pancreas MRI/ Normal Anatomy

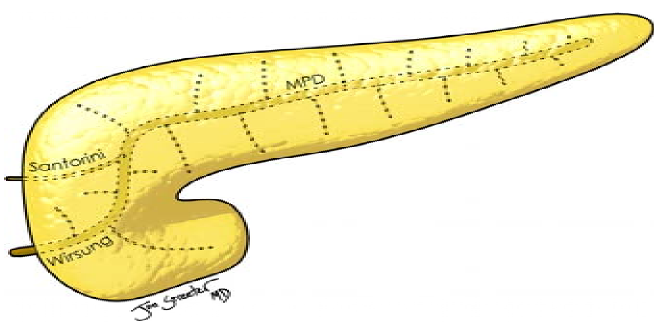
Figure 2c. Normal pancreatic anatomy



Mortele, K. J. et al. Radiographics 2006;26:715-731

RadioGraph

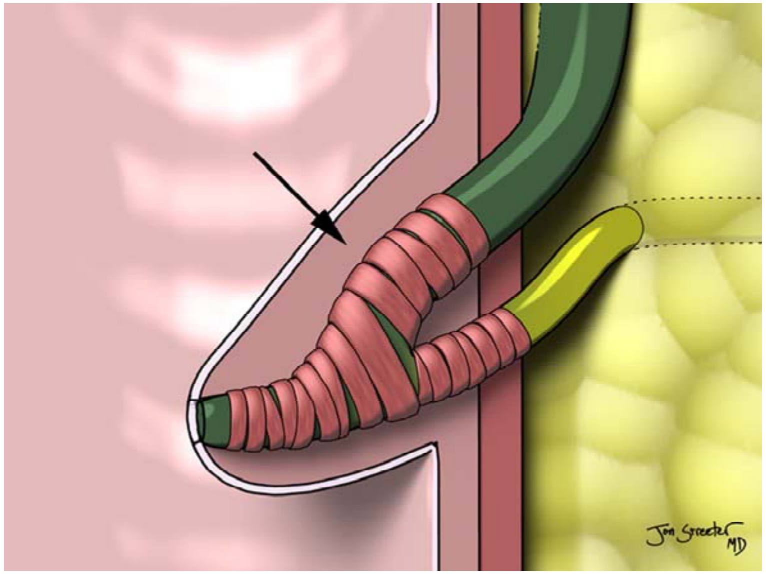
Figure 3a. Normal pancreatic ductal anatomy



Mortele, K. J. et al. Radiographics 2006;26:715-731

RadioGraphics

Figure 3d. Normal pancreatic ductal anatomy

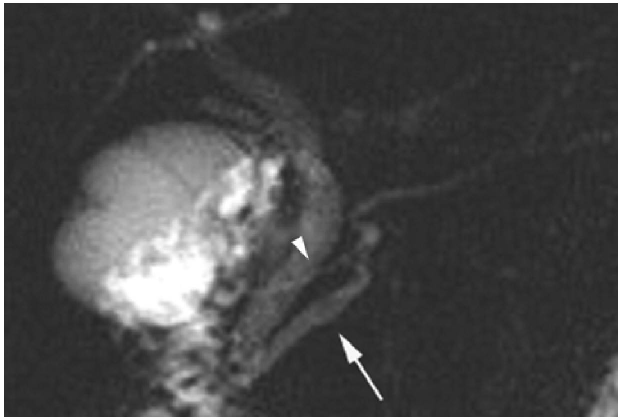


Mortele, K. J. et al. Radiographics 2006;26:715-731

RadioGraphics

Pancreas MRI/Normal Appearance

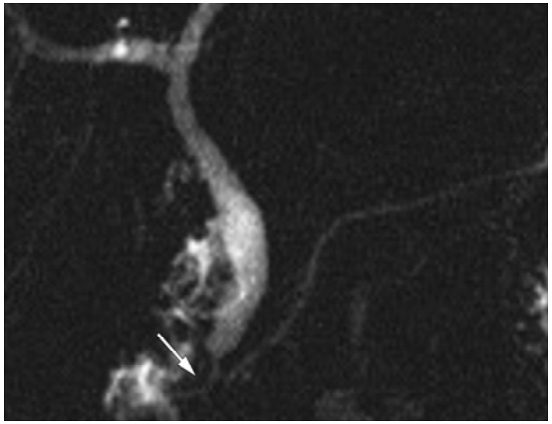
Figure 3b. Normal pancreatic ductal anatomy



Mortele, K. J. et al. Radiographics 2006;26:715-731

RadioGraphics

Figure 3c. Normal pancreatic ductal anatomy



Mortele, K. J. et al. Radiographics 2006;26:715-731

RadioGraphics

Normal pancreatic ductal anatomy. (a) Drawing illustrates the MPD, the duct of Wirsung, and the duct of Santorini. The latter empties at the minor papilla. (b) Coronal magnetic resonance (MR) cholangiopancreatogram shows the normal bifid configuration of the pancreas with main drainage of the gland through the duct of Wirsung (arrow). The duct of Santorini (arrowhead) drains into the minor papilla. (c) Coronal MR cholangiopancreatogram shows a narrowed intersphincteric segment of the CBD (arrow) and pancreatic duct due to contraction of the sphincter of Oddi. (d) Drawing illustrates the sphincter of Oddi complex (arrow) encompassing the distal CBD and pancreatic duct.

Pancreas MRI/Normal Study with Secretin

- To increase visualization of the normally very small pancreatic ducts in children, exogenous secretin can be given, which will increase pancreatic juice flow
- Delaney et al use technique of injecting 0.2 micrograms of secretin/kg slowly over 1 minute, and then obtaining normal slab MRCP images
- I have only tried this once, on a patient a few days out from acute pancreatitis, and caused such pain with the bolus that patient was unable to hold still for 10 minutes, negating any distention the secretin may have given
- Delaney et al report use of secretin in 41 patients, 18 of whom had pancreatitis by lab values, without a single adverse effect! They also routinely use negative enteral contrast (either GastroMARK or pineapple juice) to get better contrast resolution

Pancreas MRI/Normal Study with Secretin

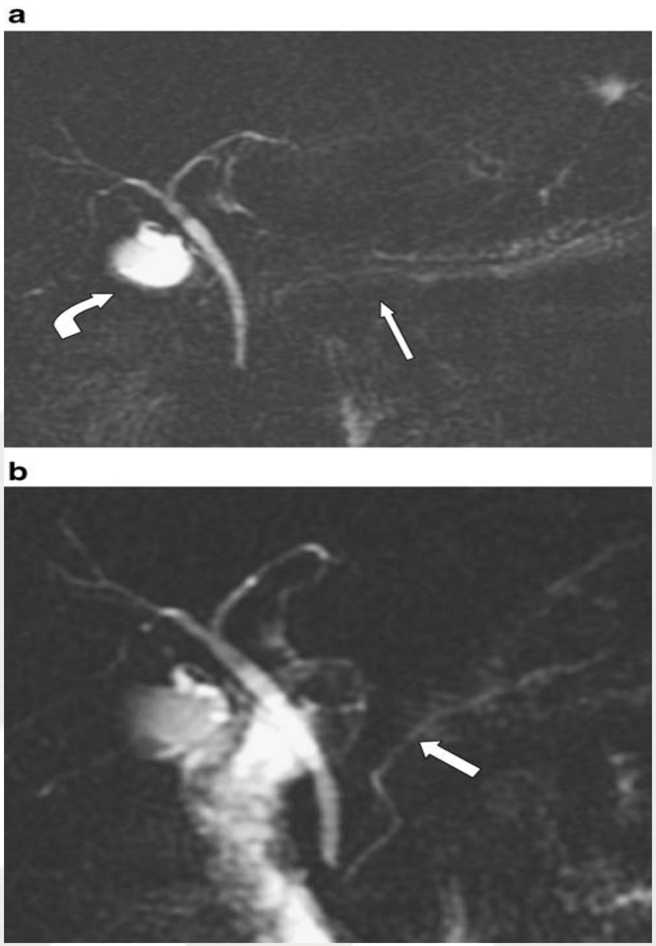
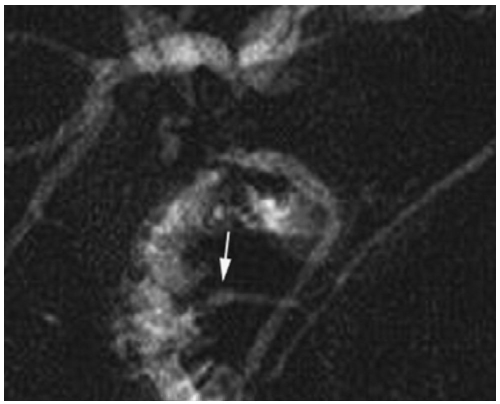


Fig. 1 Normal MRCP image obtained from a 15-year-old girl with right upper quadrant pain and no history of pancreatitis. a The image before secretin administration is of a normal intra- and extrahepatic biliary tree, gallbladder (curved arrow) and pancreatic duct (straight arrow), which is not well visualized. b The pancreatic duct (arrow) is better visualized after intravenous secretin administration

From Delaney et al : Pediatr Radiol. 2008 Jan;38(1):64-75. Epub 2007 Nov 13.

Pancreas MRI/Normal Variants

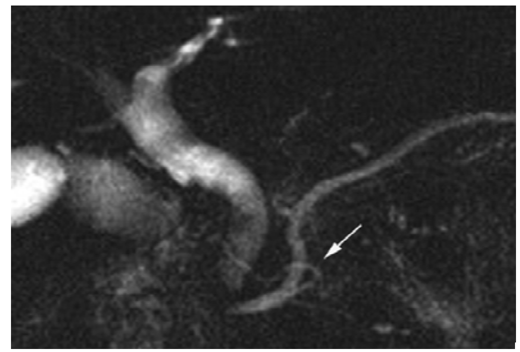
Figure 6a. Variant pancreatic ductal anatomy



Mortele, K. J. et al. Radiographics 2006;26:715-731

RadioGraphics

Figure 6b. Variant pancreatic ductal anatomy

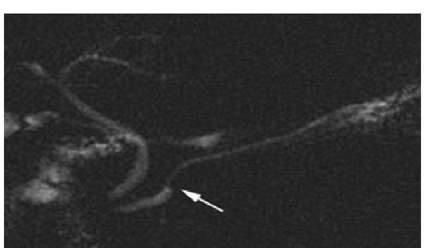


Mortele, K. J. et al. Radiographics 2006;26:715-731

RadioGraphics

Variant pancreatic ductal anatomy. Coronal MR cholangiopancreatograms show a dominant dorsal duct with a "santorinicele" (arrow in a) and ansa pancreatica (arrow in b).

Figure 7. Variant pancreatic ductal anatomy



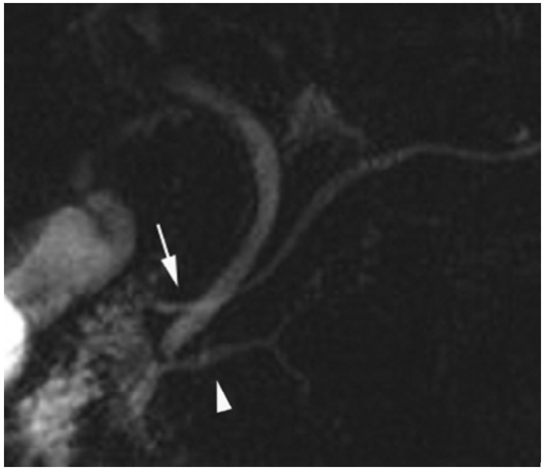
Mortele, K. J. et al. Radiographics 2006;26:715-731

RadioGraphics

MR cholangiopancreatogram shows a change in the caliber of the pancreatic duct (arrow) at the level of fusion between the MPD and the duct of Wirsung. Note the lack of upstream dilatation, which indicates that this change in caliber represents an anatomic variant.

Pancreas MRI/Congenital Anomalies/Pancreas Divisum

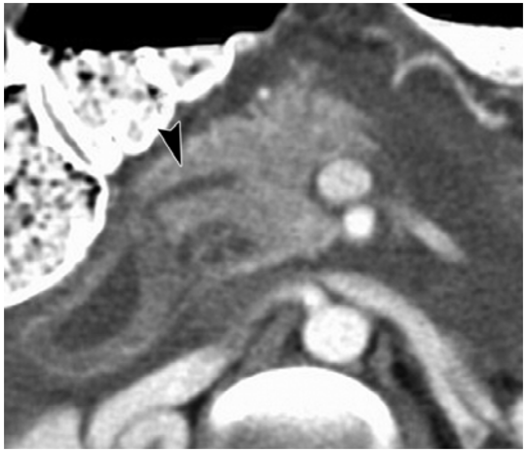
Figure 11a. Pancreas divisum



Mortele, K. J. et al. Radiographics 2006;26:715-731

RadioGraphics

Figure 11b. Pancreas divisum

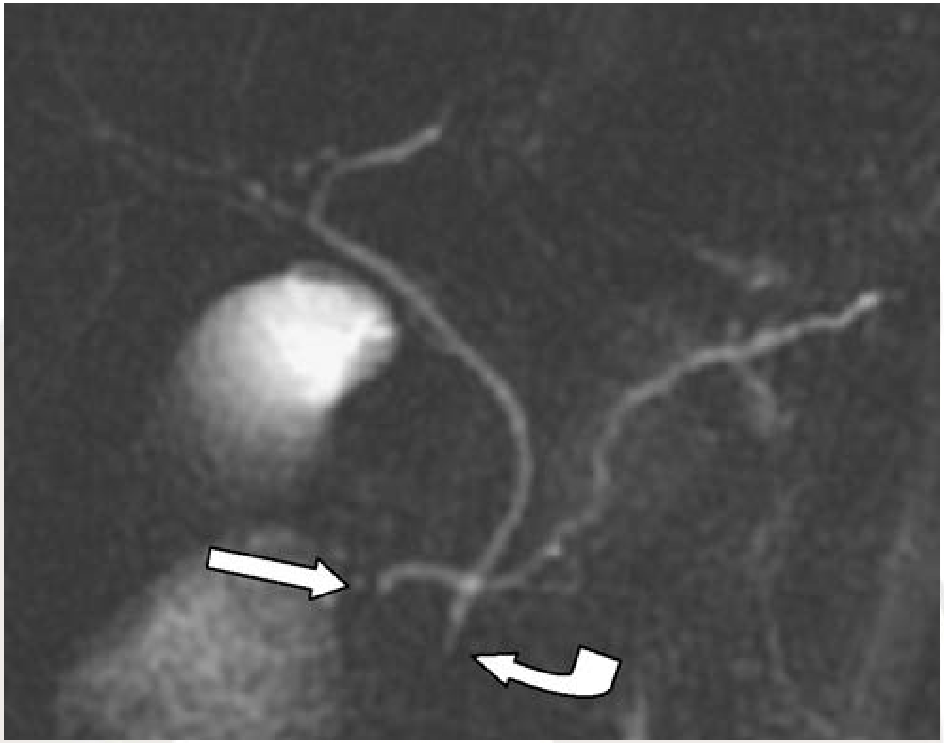


Mortele, K. J. et al. Radiographics 2006;26:715-731

RadioGraphics

Pancreas divisum. (a) Coronal MR cholangiopancreatogram shows drainage of the pancreas through the duct of Santorini (arrow). Note that the MPD is not fused with the duct of Wirsung (arrowhead). (b) CT scan obtained in a patient with acute recurrent pancreatitis and pancreas divisum shows a dilated duct of Santorini (arrowhead).

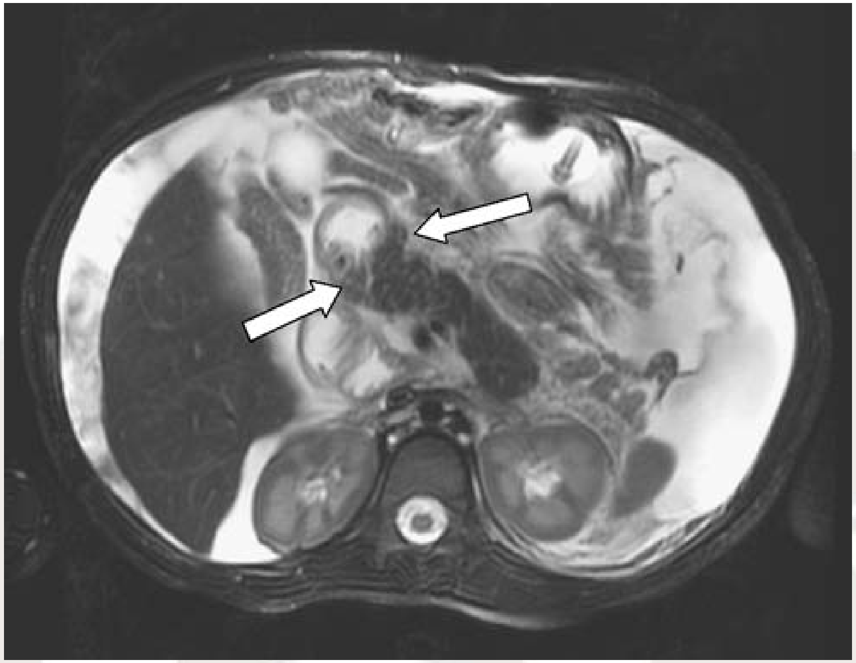
Pancreas MRI/Congenital Anomalies/Pancreas Divisum



Pancreas divisum in a 10-year-old boy with a history of Crohn disease and acute pancreatitis. The main pancreatic duct empties into the minor papilla (arrow). The common bile duct empties into the major papilla (curved arrow). There is no ductal dilation and the gallbladder has normal fluid signal

From Delaney et al : Pediatr Radiol. 2008 Jan;38(1):64-75. Epub 2007 Nov 13.

Pancreas MRI/Congenital Anomalies/Annular Pancreas



A 5-year-old girl with annular pancreas and a history of protein-losing enteropathy, double outlet right ventricle and AV canal, now being evaluated for an abscess. MR image demonstrates the pancreas partially wrapping around the second portion of the duodenum (annular pancreas, arrows) and complex ascites From Delaney et al : Pediatr Radiol. 2008 Jan;38(1):64-75. Epub 2007 Nov 13

Pancreas MRI/Mass

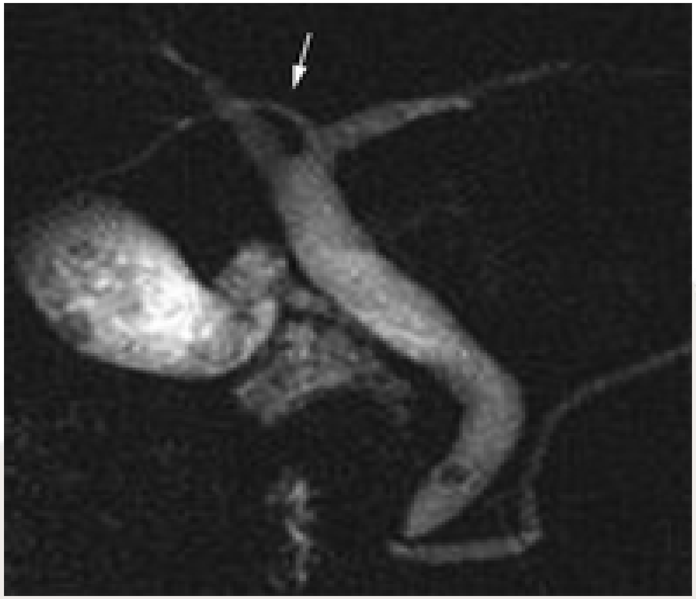
Hemangioma in head of pancreas causing Obstructive jaundice in 7 yr old girl. Post-Contrast T1 with fat sat shows low signal Mass in the head of the pancreas.

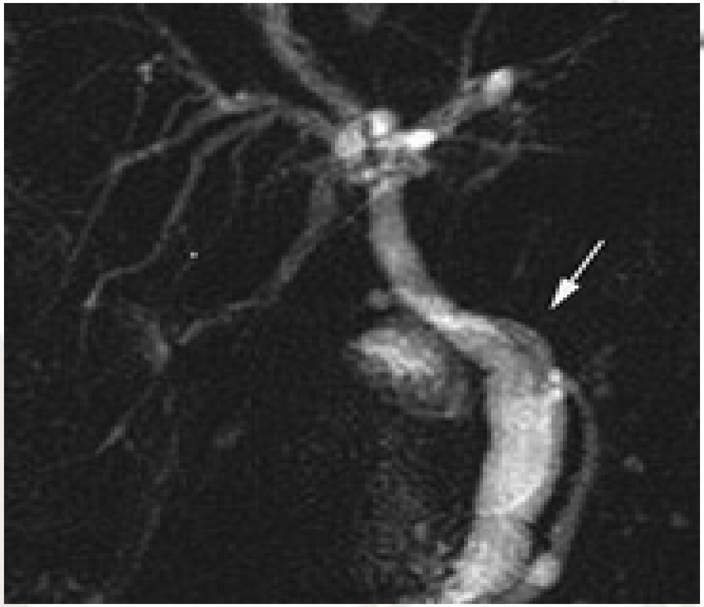
From Delaney et al : Pediatr Radiol. 2008 Jan;38(1):64-75. Epub 2007 Nov 13.

Biliary Tract MRI/Normal Anatomy

Normal biliary anatomy. Coronal MR cholangiopancreatogram shows the left hepatic duct (LHD) and RHD (long arrow) forming the common hepatic duct (CHD). Note that the RHD is formed by two branches: the RPD (short arrow), which drains posterior segments VI and VII; and the RAD (arrowhead), which drains anterior segments V and VIII

Biliary Tract MRI/Normal Variants

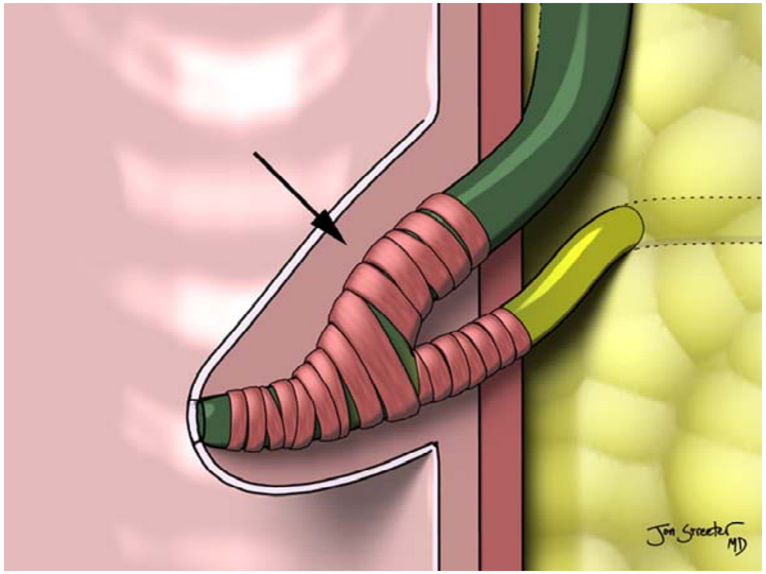




Variant biliary ductal anatomy. Coronal MR cholangiopancreatograms show the RPD (arrow in a) draining into the LHD and a medial and low insertion of the cystic duct (arrow in b).

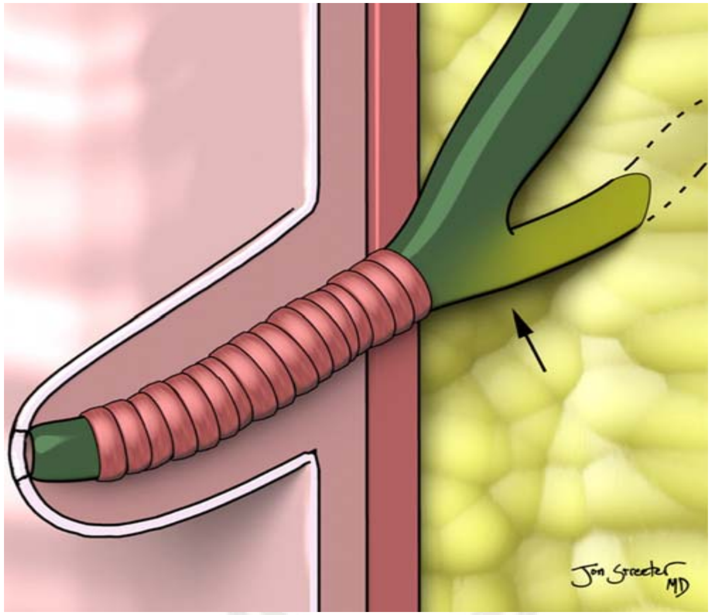
Biliary Tract MRI/Common Channel Hypothesis

Figure 3d. Normal pancreatic ductal anatomy



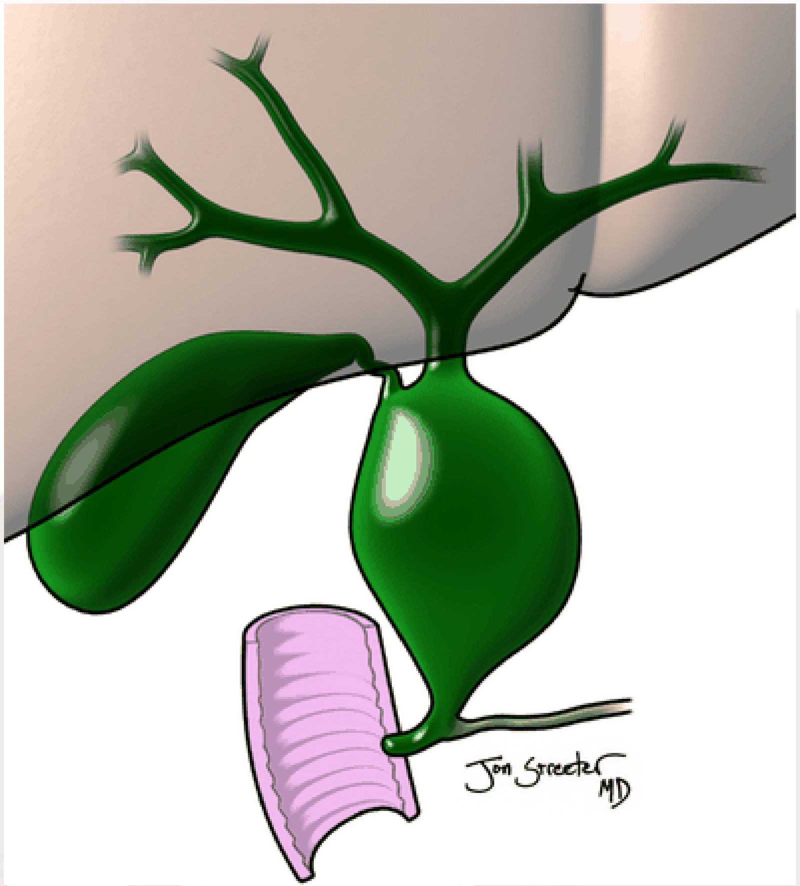
Mortele, K. J. et al. Radiographics 2006;26:715-731

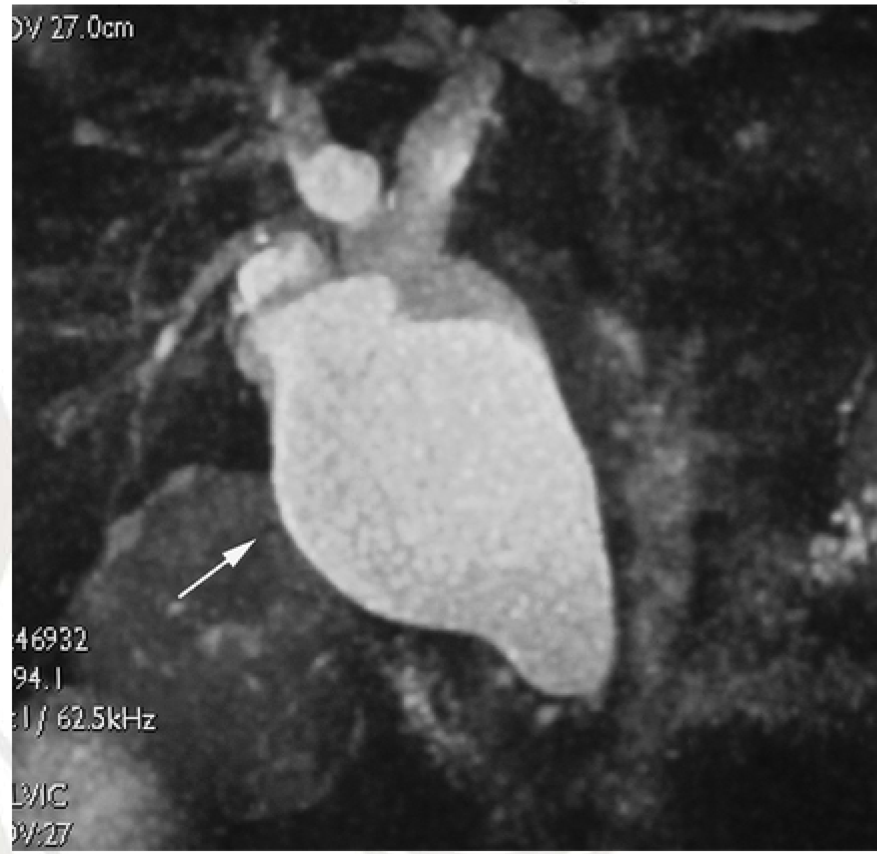
Long common channel



RadioGraphics

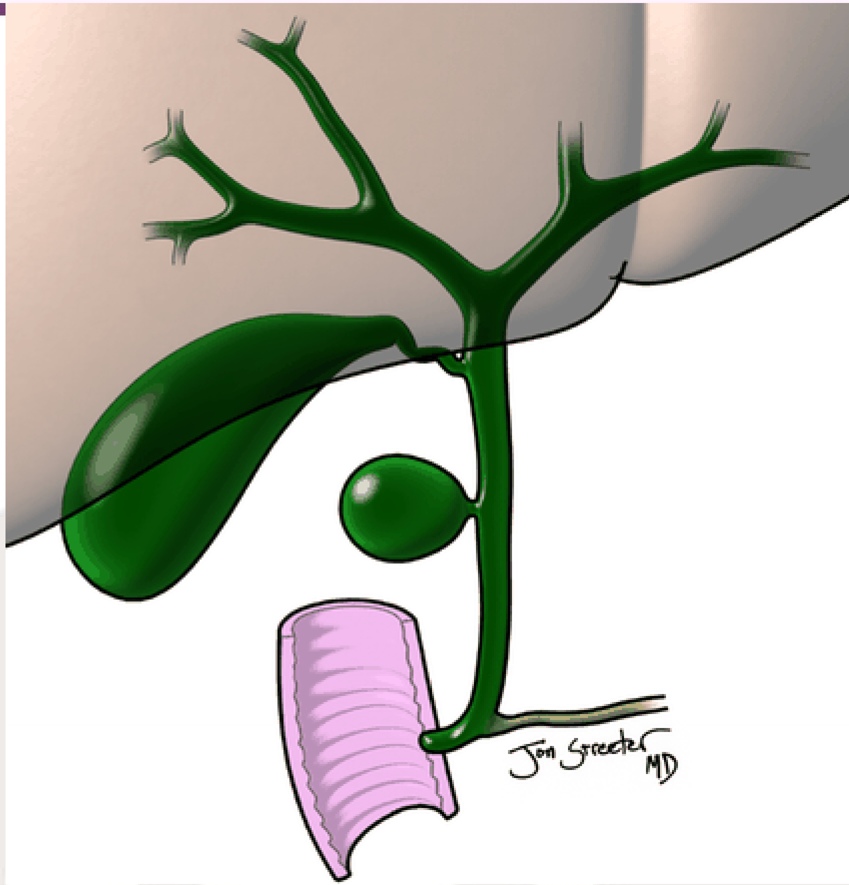
Biliary Tract MRI/Congenital Anomalies/Choledochal Cysts

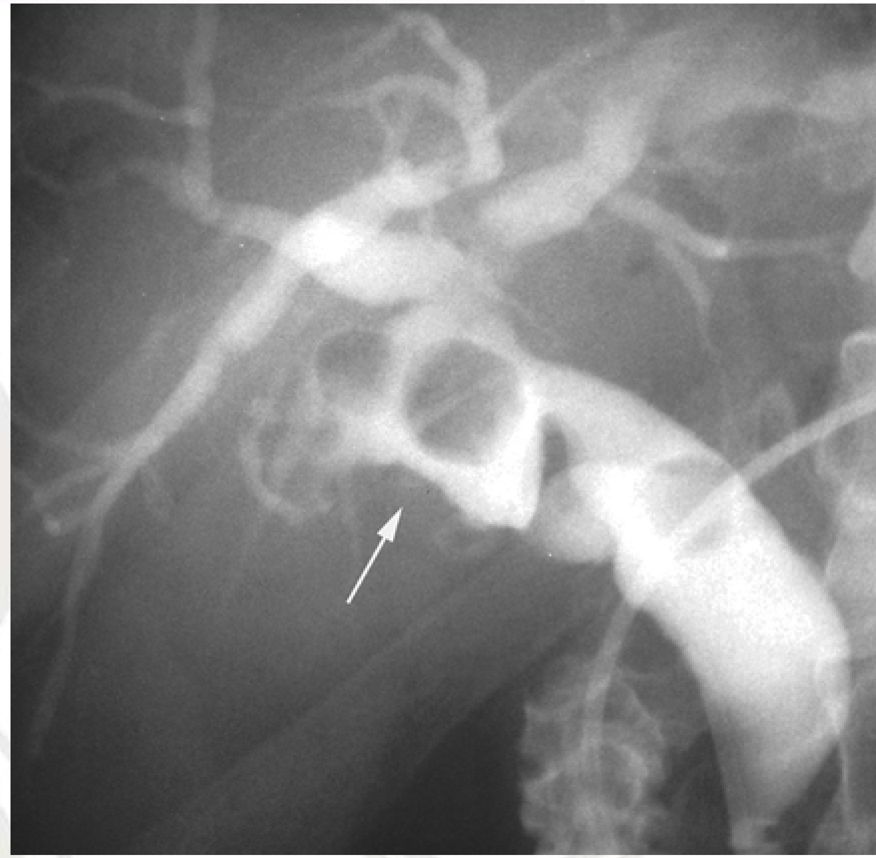




Type I Choledochal Cyst

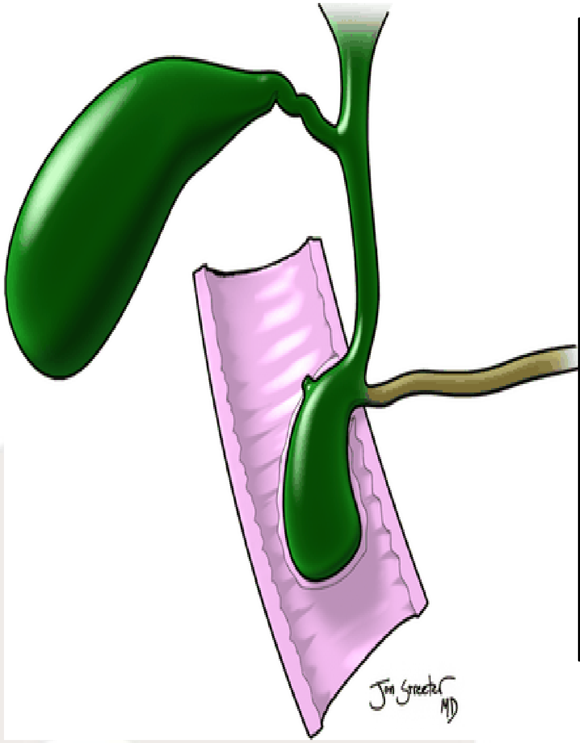
Biliary Tract MRI/Congenital Anomalies/Choledochal Cysts

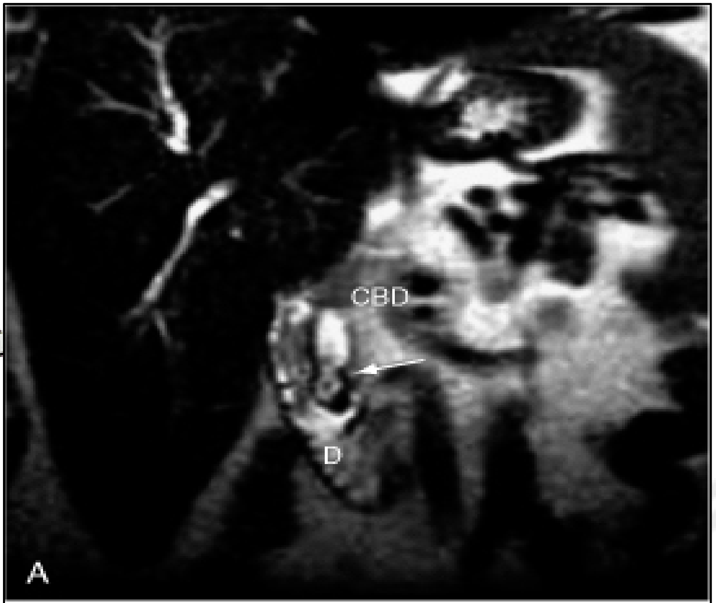




Type II choledochal cyst

Biliary Tract MRI/Congenital Anomalies/Choledochal Cysts





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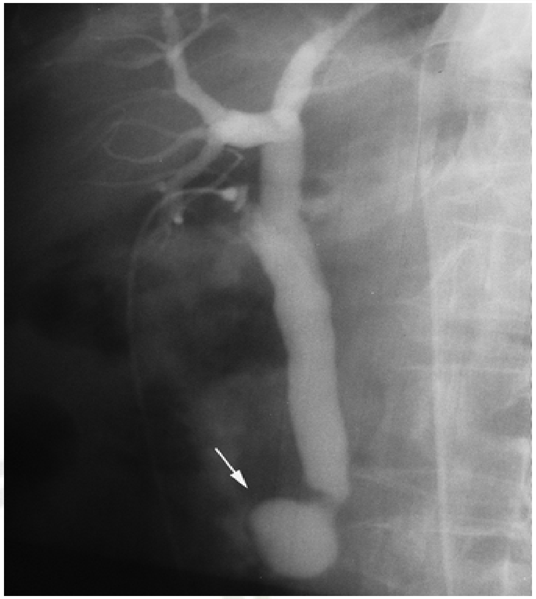
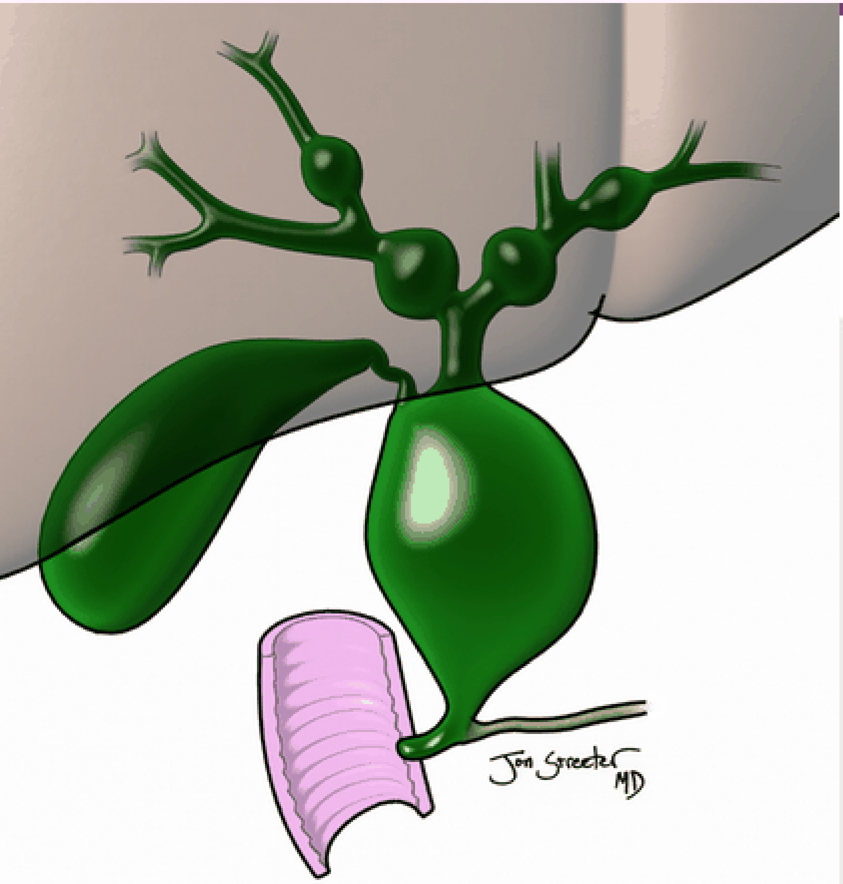
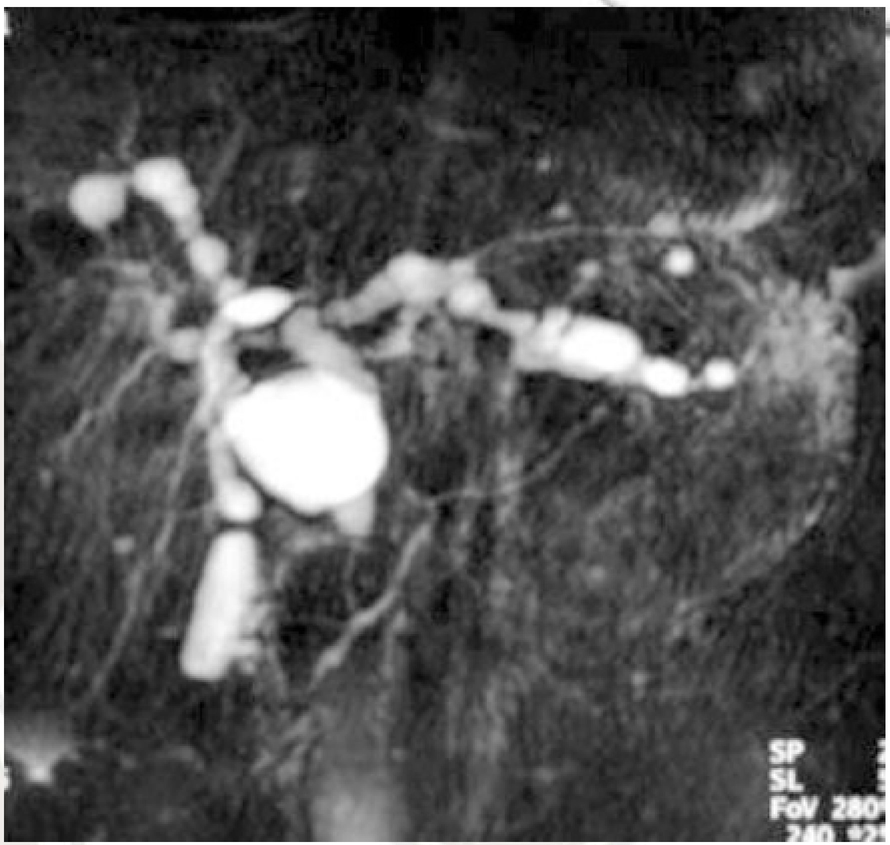


Type III Choledochal Cyst (choledochocele)

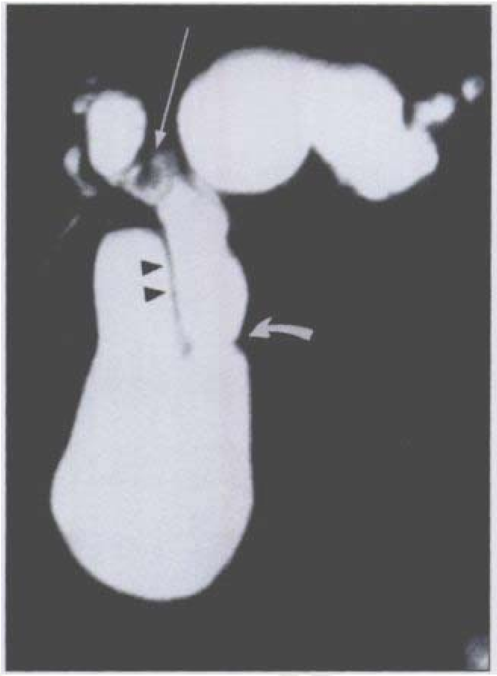
Biliary Tract MRI/Congenital Anomalies/Choledochal Cysts



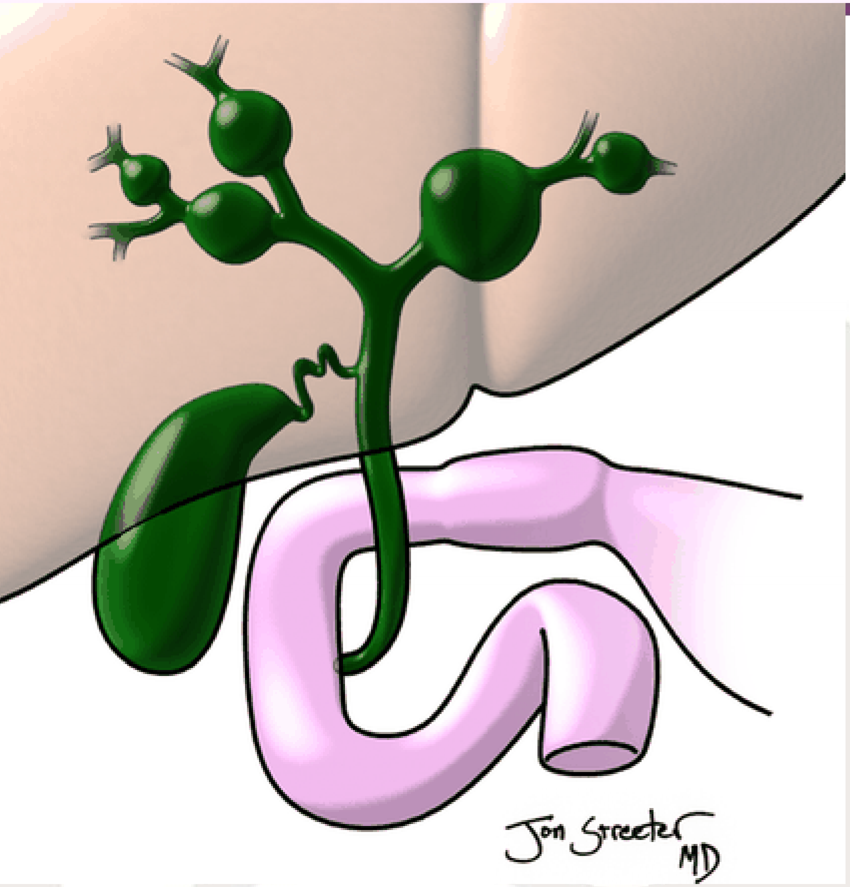


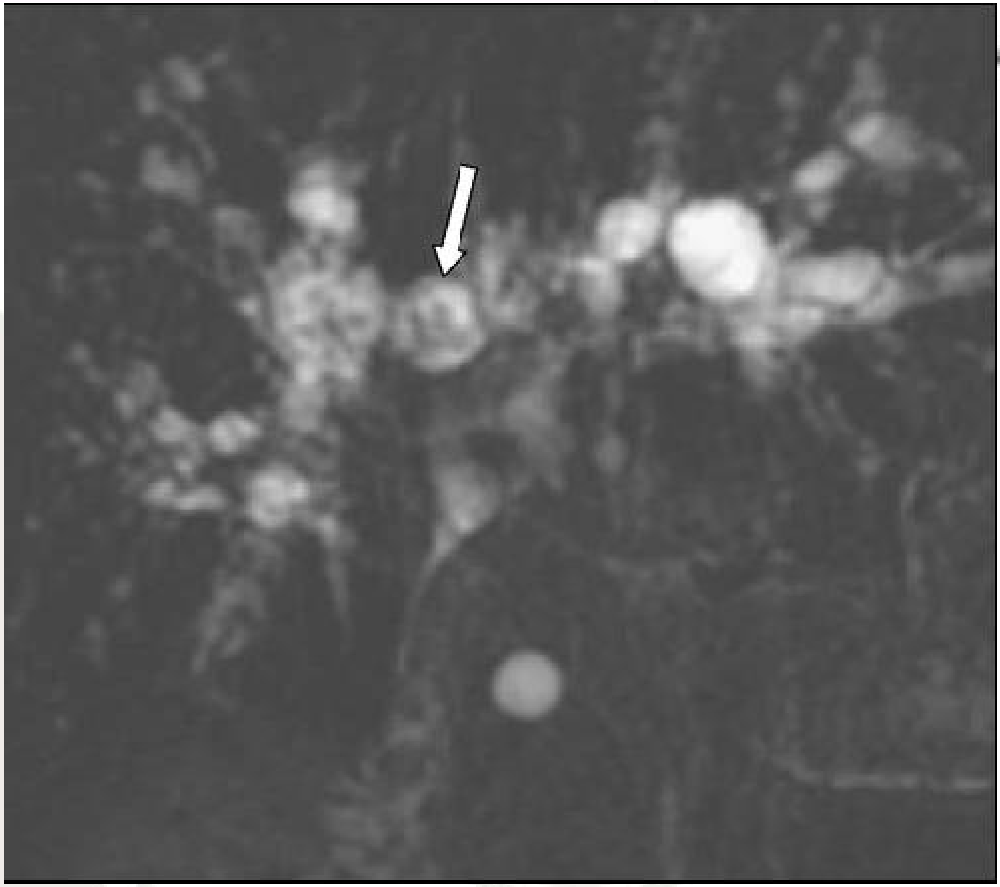
Type IV Choledochal Cyst

Type IVA Choledochal Cyst



Biliary Tract MRI/Congenital Anomalies/Choledochal Cysts





Type V Choledochal Cyst (Caroli Disease)

Pancreatic and Biliary Tract MRI/Future Considerations

- **Better evaluation of dynamic processes involving the biliary tree and pancreas using pharmacologic agents that mimic natural processes**
  - Hepatobiliary Pancreat Dis Int. 2008 Apr;7(2):192-5. Links

    - **Exocrine pancreatic function assessed by secretin cholangio-Wirsung magnetic resonance imaging.**
    - Calculli L, Pezzilli R, Fiscaletti M, Casadei R, Brindisi C, Gavelli G.
    - Departments of Radiology, Digestive Diseases and Internal Medicine, and General Surgery, Sant' Orsola-Malpighi Hospital, Bologna, Italy.raffaele.pezzilli@aosp.bo.it.
    - Magn Reson Med Sci. 2002 Jul 1;1(2):65-71. **Dynamic MR cholangiography after fatty meal loading: cystic contractility and dynamic evaluation of biliary stasis.**
    - Omata T, Saito K, Kotake F, Mizokami Y, Matsuoka T, Abe K.Department of Internal Medicine 5, Tokyo Medical University, Kasumigaura Hospital, 3-20-1 Ami-Machi-Chuoh, Inashikigun, Ibaraki 300-0395, Japan. oma@jd6.so-net.ne.jp

Small Bowel MRI/Primary Pediatric Indication

- Most authors have used MR enterography for evaluation of inflammatory bowel disease, specifically Crohn's Disease
- MR has several inherent strengths for imaging of this condition
  - No radiation. Very helpful since Crohn's is a chronic condition often necessitating multiple scans to monitor disease activity or response to treatment in radiosensitive children and young adults
  - Wide field of view with direct multiplanar acquisition
  - High soft tissue contrast resolution

Small Bowel MRI

- Primary imaging challenges include
  - Freezing peristaltic and gross patient motion
  - Obtaining adequate distention of the entire small bowel
  - Having sufficient contrast resolution between the lumen and bowel wall/serosa/mucousa

Small Bowel MRI/Freezing Motion

- Need to decrease both peristaltic and gross patient motion
- This can be done through pharmacologic adjuncts, pulse sequence selection, and sedation/anesthesia

Small Bowel MRI/Freezing Peristaltic Motion

- **Pharmacologic approaches include**
  - Glucagon
  - Scopalamine
  - Both of these agents have been used routinely in some centers to increase diagnostic quality of fluoroscopic GI studies
  - I have not used either in pediatric patients except for rare glucagon use for enteroclysis
  - Diabetes mellitus is contraindication for glucagon

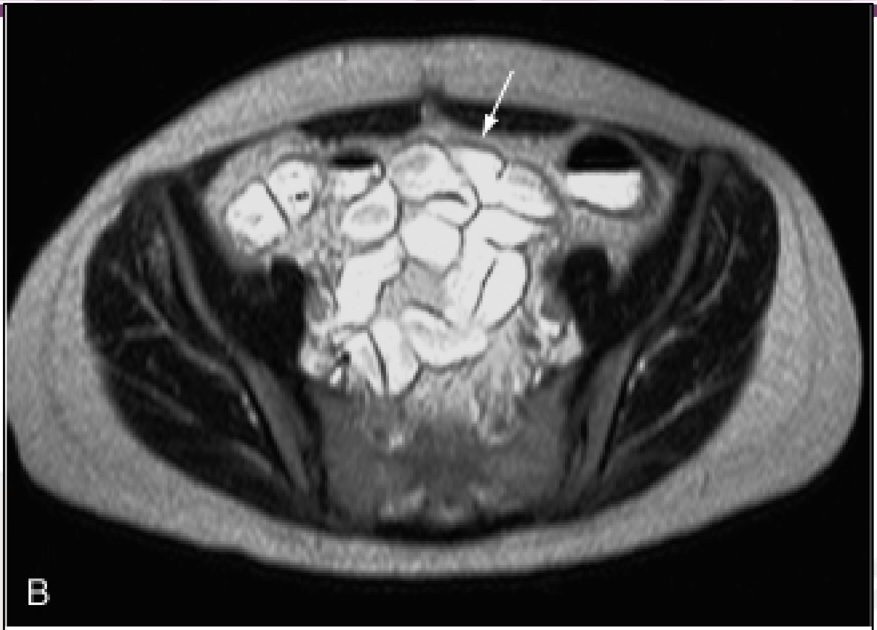
Small Bowel MRI/Freezing Peristaltic Motion

- Pulse sequence selection
- Major advance in pediatric GI imaging has been routine use of single-shot breath-hold techniques that require only a few seconds per image
- SSFSE/HASTE/SSRARE SE techniques for T2 weighting
- LAVA/THRIVE is a GRE T1 volumetric technique that rapidly images the abdomen in quiet breathing, can do before and after gadolinium enhancement
- True FISP/FIESTA is a balanced SE sequence that is fluid-sensitive (fluid containing structures are bright)

Small Bowel MRI/Freezing Peristaltic Motion

Figure 85-3 Examples of MR pulse sequences. Single-shot rapid relaxation enhancement (SSRARE) images in the coronal (A) and axial (B) planes show excellent definition of the bowel wall (arrow) seen as a thin dark line surrounding the bowel lumen distended with water-soluble contrast material. Fat-suppressed T2-weighed images (C) can be obtained to assess for edema in the bowel wall or to look for metastatic tumor in a patient with malignant gastrointestinal disease. Fat-suppressed gadolinium-enhanced images (D) are obtained in the axial plane twice as well as in the coronal and sagittal plane.

Small Bowel MRI/Freezing Peristaltic Motion



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Small Bowel MRI/Freezing Peristaltic Motion

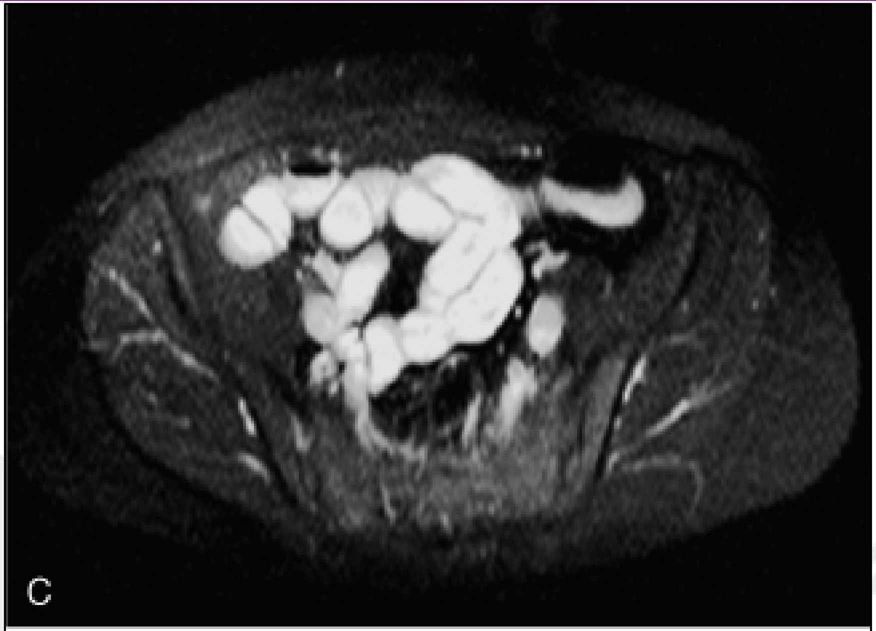

Figure 85-3 Examples of MR pulse sequences. Single-shot rapid relaxation enhancement (SSRARE) images in the coronal (A) and axial (B) planes show excellent definition of the bowel wall (arrow) seen as a thin dark line surrounding the bowel lumen distended with water-soluble contrast material. Fat-suppressed T2-weighed images (C) can be obtained to assess for edema in the bowel wall or to look for metastatic tumor in a patient with malignant gastrointestinal disease. Fat-suppressed gadolinium-enhanced images (D) are obtained in the axial plane twice as well as in the coronal and sagittal plane.

Small Bowel MRI/Freezing Peristaltic Motion

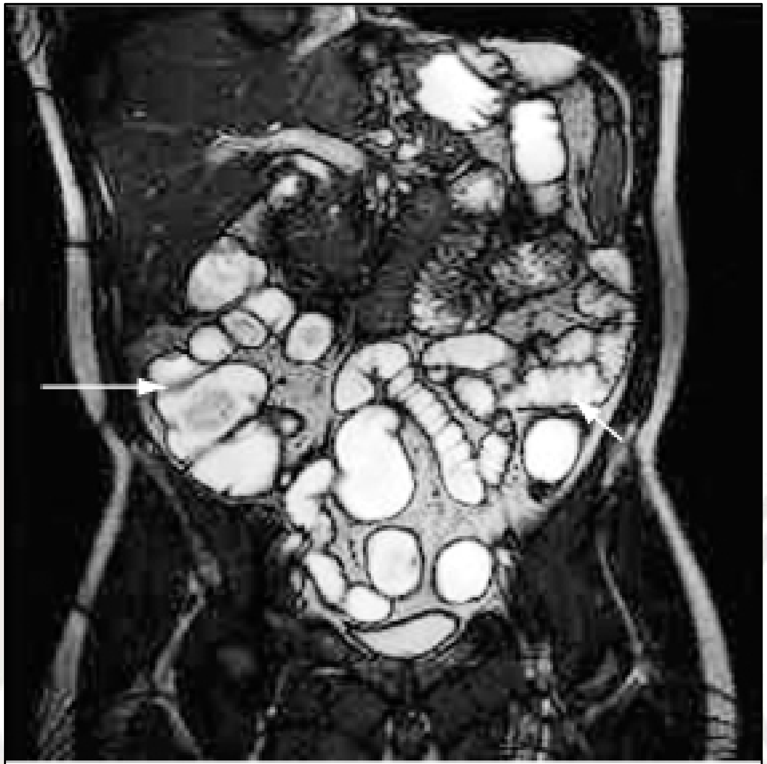

Figure 85-5 True fast imaging with steady precession (FISP) images of GI tract. Coronal true FISP image with high signal intensity water soluble intraluminal contrast material depicts normal small bowel (short arrow) and colon (long arrow). (Courtesy of Diego Martin, MD.)

Small Bowel MRI/Freezing Peristaltic Motion

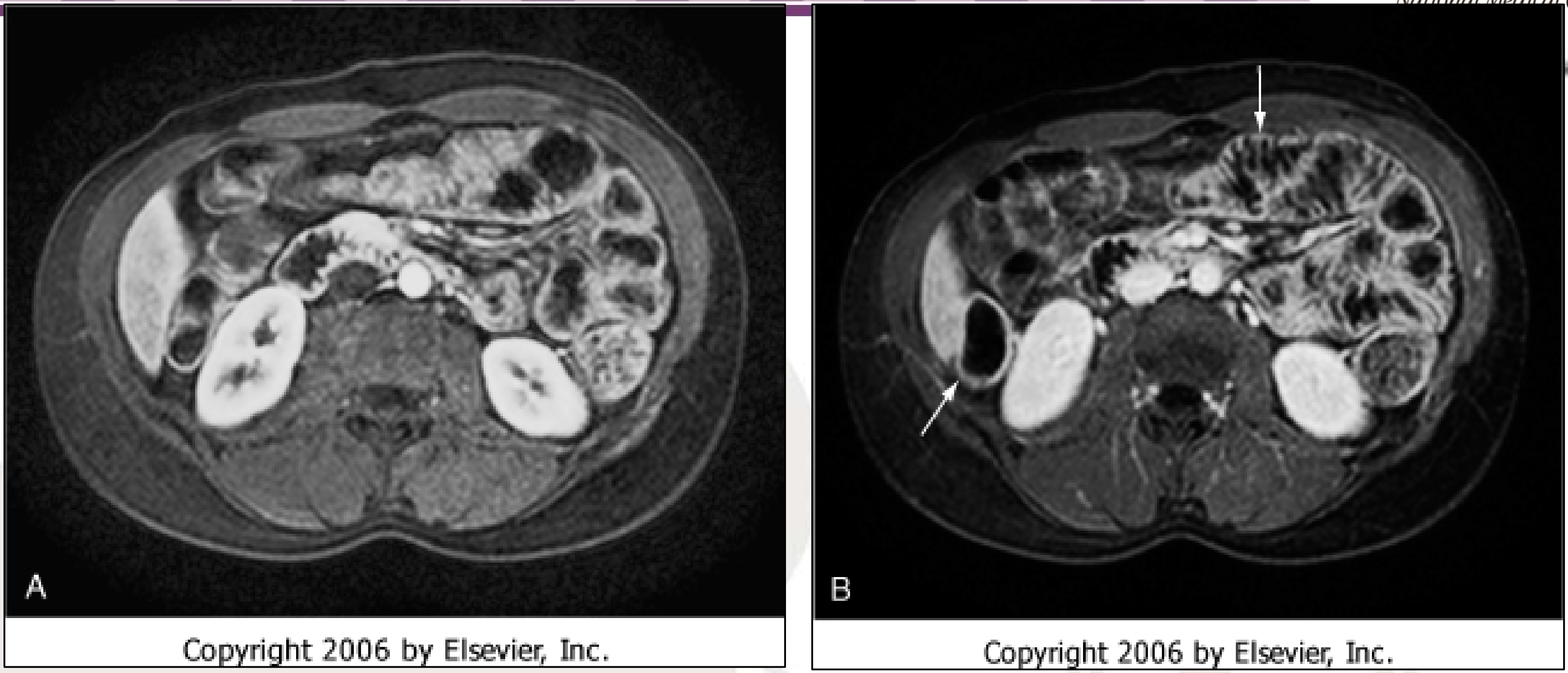

Figure 85-4 Thin-section 3D THRIVE images of GI tract obtained with a phased-array surface coil. Axial arterial (A) and delayed (B) gadolinium-enhanced 3D THRIVE images show normal bowel wall (arrows). Coronal (C) and sagittal (D) 3D THRIVE images depict the normal wall of the colon (short arrow) and small bowel (long arrow). THRIVE images have the advantage of thin slice profiles with 50% overlap, combined with homogeneous SPIR fat suppression

Small Bowel MRI/Freezing Peristaltic Motion

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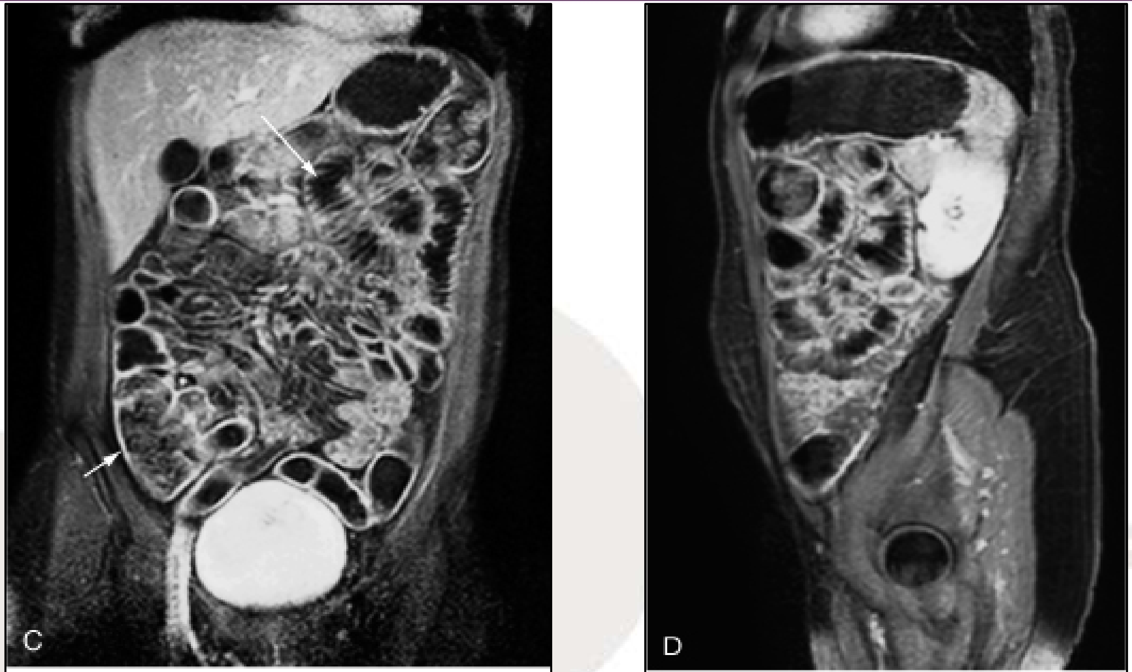

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Small Bowel MRI/Intraluminal Contrast

- Monophasic (either high or low signal on both T1 and T2)
- Biphasic (opposite signal on T1 and T2)

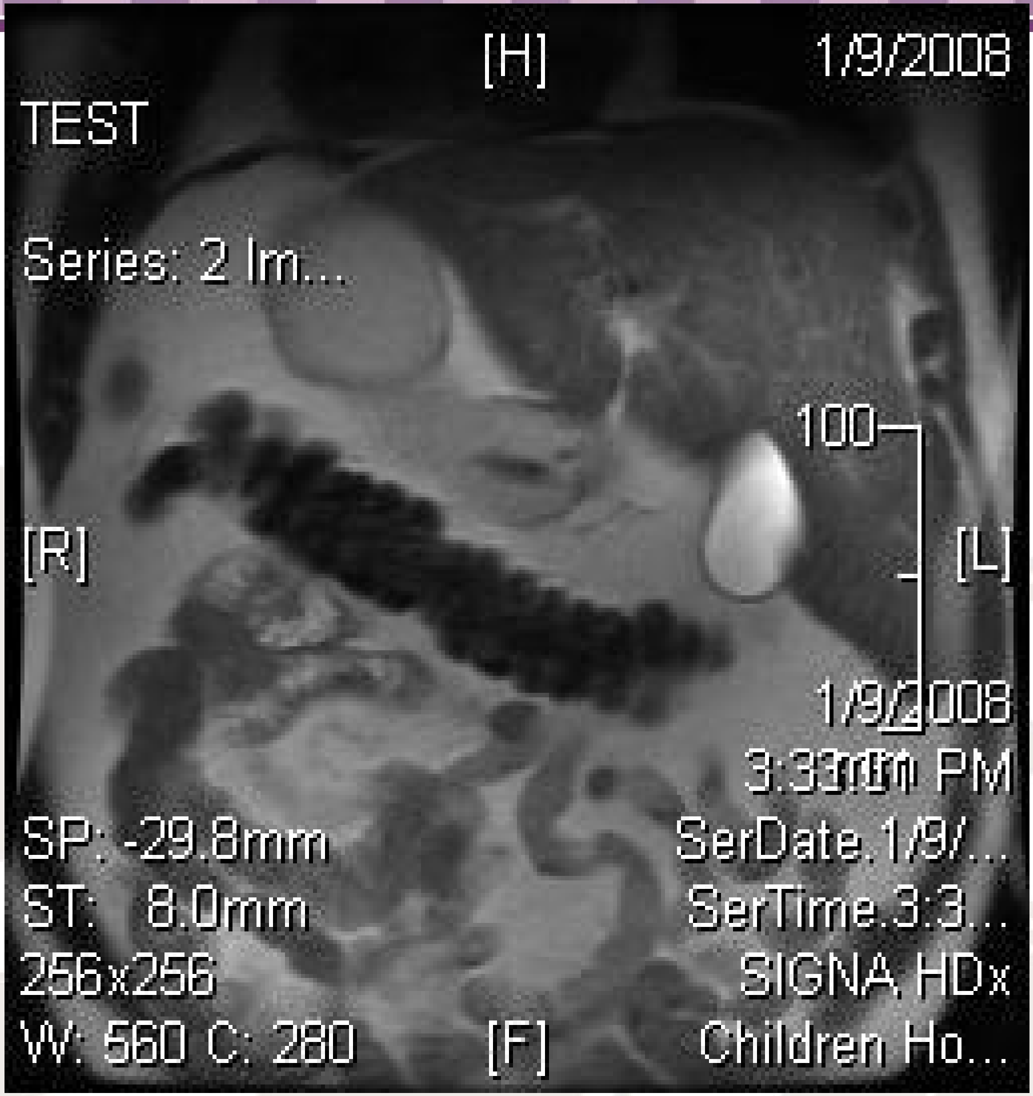
Small Bowel MRI/Intraluminal Contrast

- Monophasic
  - Iron oxide suspension, low on both T1 and T2 due to dephasing effects
  - Trade name is GastroMARK, common name is ferumoxsil
  - Rust colored viscous oral solution
  - Not very palatable, adverse effects include N/V/D
  - Could be useful for determining bowel-wall enhancement when performing pre- and post-contrast T1 imaging

Bowel MRI/Intraluminal Contrast/Monophasic

- Alternative to commercial iron oxide solution is blueberry or pineapple juice
- Both of these agents are low signal on both T1 and T2 due to high iron/and or manganese content
- In my experience works well for stomach/proximal small bowel, but not enough distention/tonicity to adequately study distal small bowel
- Helpful for MRCP to suppress bright signal from adjacent stomach and duodenum

Bowel MRI/Blueberry Vanilla Yogurt Smoothie



Small Bowel MRI/Intraluminal Contrast

- Biphasic
  - Usually low on T1, high on T2 due to high water content
  - Simplest is water itself
  - Wide variety of choices available, including commercial products such as Volumen, and mix-it-yourself solutions of water and osmotic agents such as mannitol, methycellulose, polyethylene glycol, locust bean gum, etc.
  - Gives excellent T2 contrast between bright intraluminal contents and normally dark bowel wall
  - Drawback is that inflamed bowel wall on T2 is also bright, making distinction between lumen and wall more difficult

Small Bowel MRI/Intraluminal Contrast/Biphasic

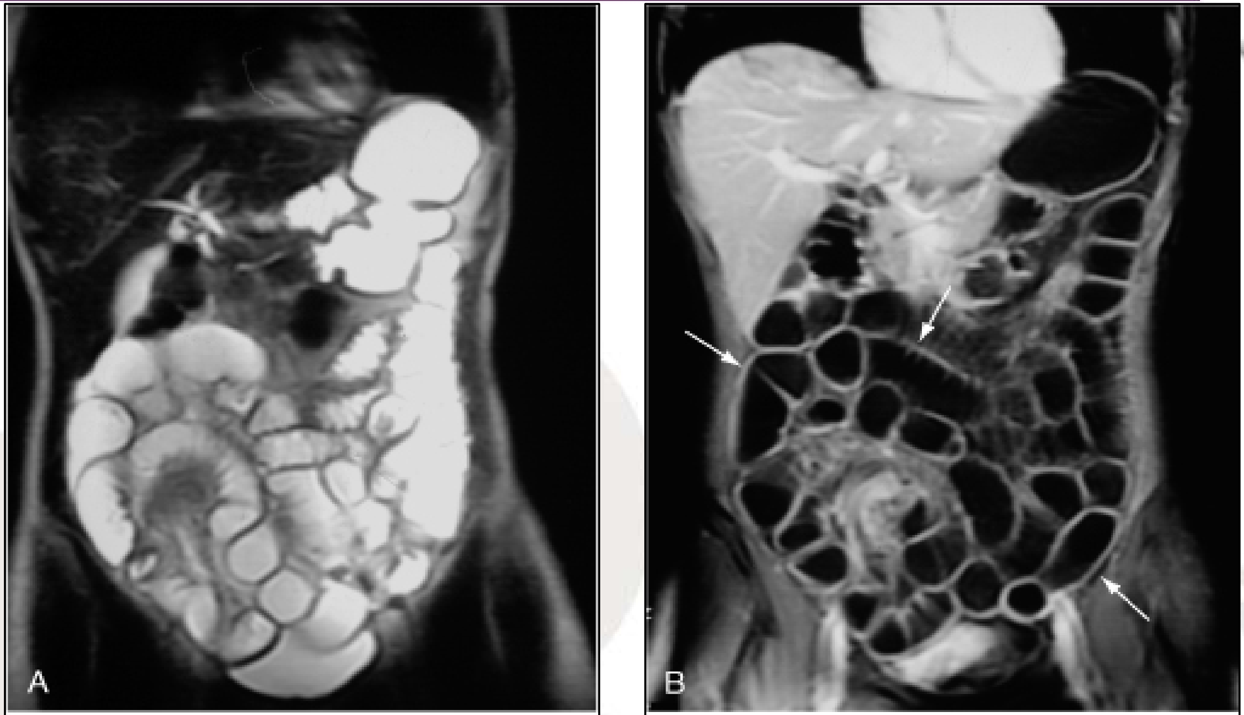


Figure 85-2 Biphasic intraluminal contrast material. Coronal single-shot fast spin-echo (SSFSE) image (A) shows the bowel distended with high signal intensity water-soluble contrast material. On the coronal fat-suppressed gadolinium-enhanced SGE image (B) the water-soluble intraluminal contrast material is low signal intensity. The combination of a dark intraluminal contrast agent, fat suppression, and IV gadolinium facilitates depiction of the bowel wall (arrows) shown as white lines and rings.

Small Bowel MRI/Optimal Distention

- With conventional barium studies we make the distinction between a small bowel follow-through and enteroclysis
- Enteroclysis should give better results than a SBFT, since every loop is distended and able to be individually assessed. The problem is patient acceptance and cooperation is <u>LOW</u> due to need for nasojejunal tube.
- Need for techniques to achieve adequate distention of all small bowel loops with high patient tolerance

Small Bowel MRI/Optimal Distention

- Multiple additions to standard oral contrast media have been proposed for tubeless MR enteroclysis
  - PEG (polyethylene glycol) solution
  - Mannitol
  - LBG (Locust Bean Gum)
  - Mannitol plus LBG
  - Sorbitol (found in commercial product Volumen)

Small Bowel MRI/Optimal Distention

- All of the proposed additives increase the tonicity of the diluting fluid to the point that the solution is isotonic or hypertonic to normal bowel lumen contents
- This assures that the fluid ingested is not rapidly absorbed by the small bowel, especially the ileum
- Plain water can be used as a biphasic contrast medium, but since much of it is absorbed, evaluation of the small bowel, especially distally, is poor

Small Bowel MRI/Optimal Distention

- The drawbacks to many of the proposed additives are not surprisingly adverse effects such as nausea, bloating, and diarrhea
- Isotonic solutions of mannitol + LBG, as well as PEG, have been successfully used in the pediatric setting with good patient acceptance

Small Bowel MRI/Optimal Distention

FIGURE 7. Normal small bowel. Patient received oral contrast composed of water mixed with mannitol 2.5% and locust bean gum 45 minutes prior to the study. A, Coronal balanced field echo TFISP shows well distended small bowel. The ileum shows relatively few mucosal folds. B, Jejunum shows normal relatively higher density of mucosal folds.

Image and caption from : (Top Magn Reson Imaging 2005;16:77–98)

Small Bowel MRI/Crohn's Disease

- From a clinical perspective, reproducible imaging findings that could track flares and remissions of Crohn's as manifested in the Crohn's Disease Activity Index (CDAI) would make both treatment of individual patients as well as clinical trials for various therapies significantly more targeted and possibly effective
- MRI has inherent advantages over the luminography approach of SBFT in showing the mural and surrounding sequelae (abscess, fistulae)
- MRI may be superior to CT in helping to distinguish between active disease and fibrotic changes

Small Bowel MRI/Crohn's Disease/CDAI (from Wikipedia)

Clinical or laboratory variable	Weighting factor
Number of liquid or soft stools each day for seven days	x 2
Abdominal pain (graded from 0-3 on severity) each day for seven days	x 5
General well being, subjectively assessed from 0 (well) to 4 (terrible) each day for seven days	x 7
Presence of complications*	x 20
Taking Lomitil or opiates for diarrhea	x 30
Presence of an abdominal mass (0 as none, 2 as questionable, 5 as definite)	x 10
Absolute deviation of Hematocrit from 47% in men and 42% in women	x 6
Percentage deviation from standard weight	x 1

Small Bowel MRI/Crohn's Disease Technique

- Diagnostic images require both freezing of peristaltic motion as well as high contrast resolution and good bowel distention
- Pulse sequences include SSFSE T2 and pre- and post-GD T1 fast GRE (such as LAVA). The short duration of these sequences freeze peristalsis
- Biphasic (low T1, high T2) intraluminal contrast
- Intestinal distention provided by osmotic agent

Small Bowel MRI/Crohn's Disease/Clinical Images

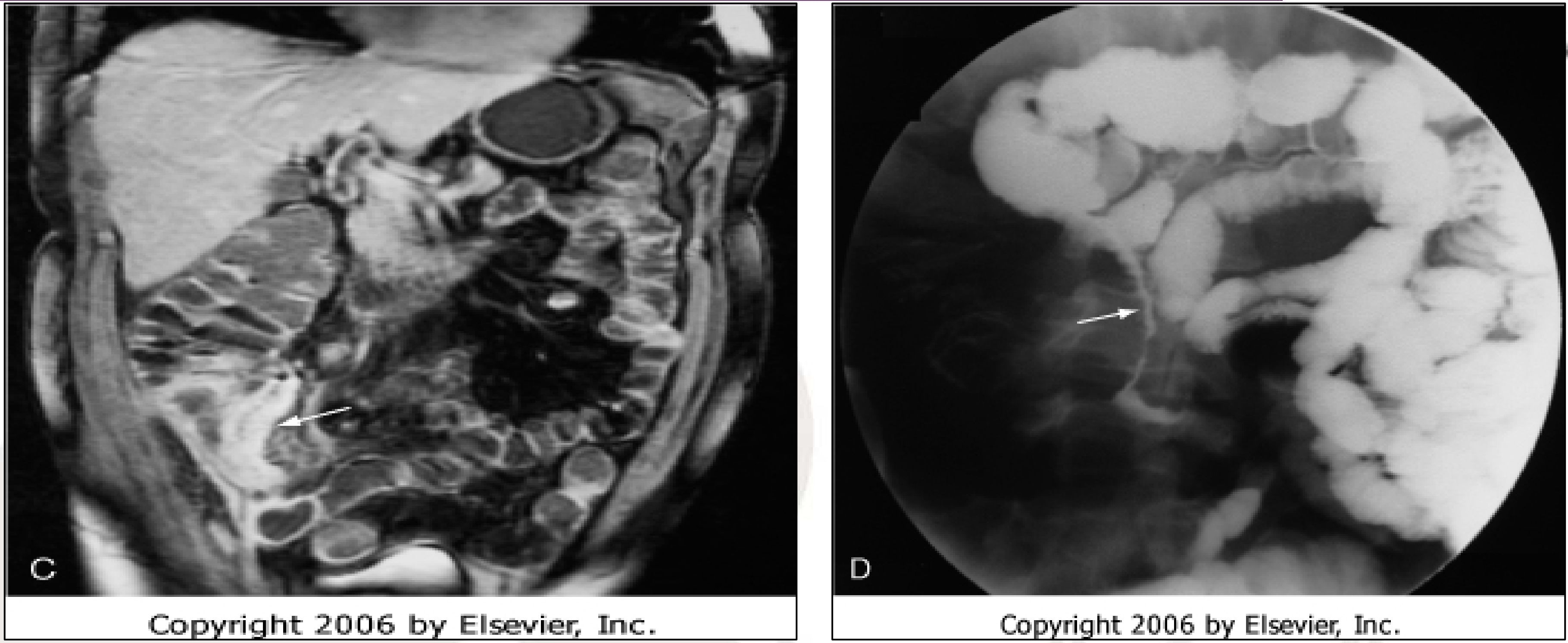


Figure 85-8 Crohn's disease SSFSE versus gadolinium-enhanced MRI. Single-shot fast spin-echo (SSFSE) image (A) shows mural thickening (arrow) involving the terminal ileum. Axial (B) and coronal (C) gadolinium-enhanced MRI shows marked enhancement of the thick wall terminal ileum (arrow). Small bowel barium examination (D) shows a "string sign"

Small Bowel MRI/Crohn's Disease/Clinical Images

Figure 85-7 Crohn's disease. Helical CT (A) depicts ileal mural thickening (arrow). Fat-suppressed gadolinium-enhanced SGE MR image (B) shows marked enhancement of the thickened ileum (arrows). Enhancement of the diseased small-bowel wall facilitates depiction of inflammatory changes of Crohn's disease.

Small Bowel MRI/Crohn's Disease/Clinical Images

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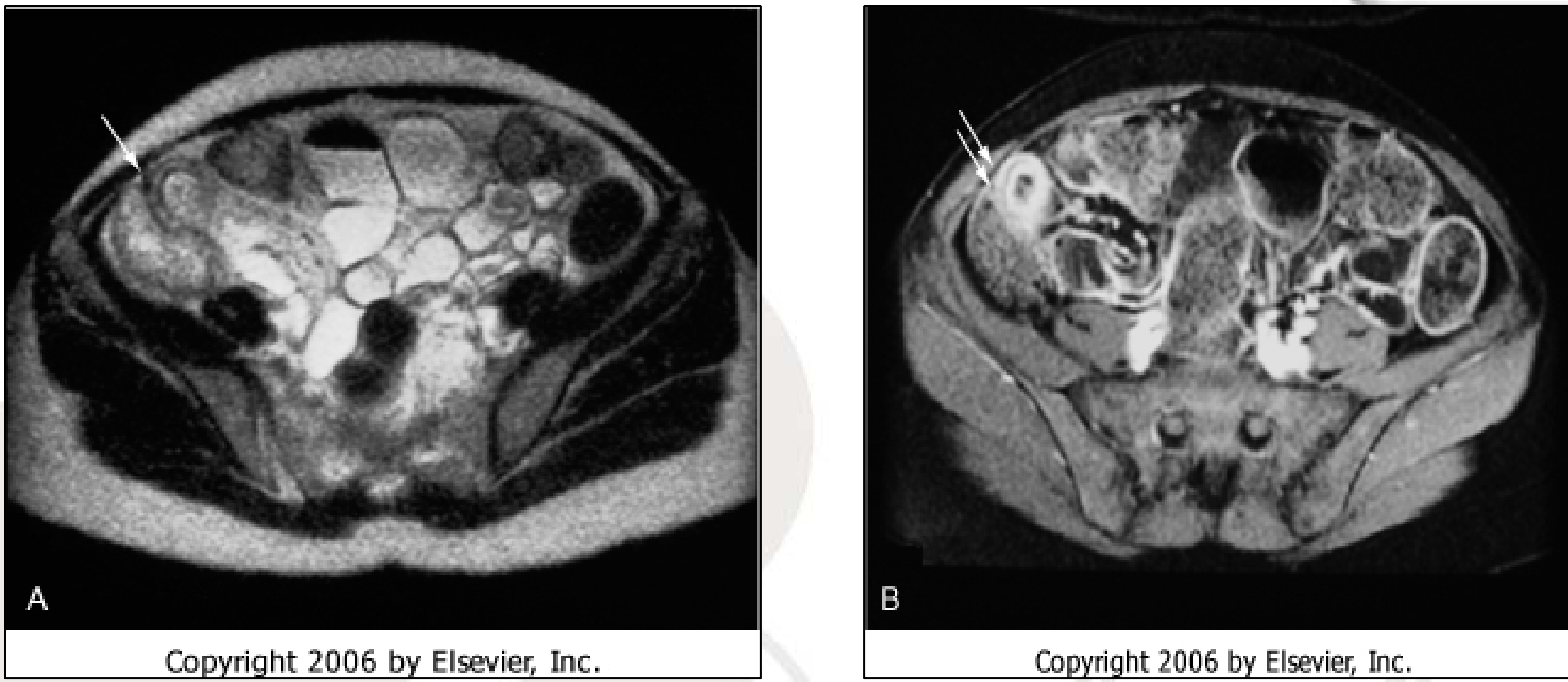
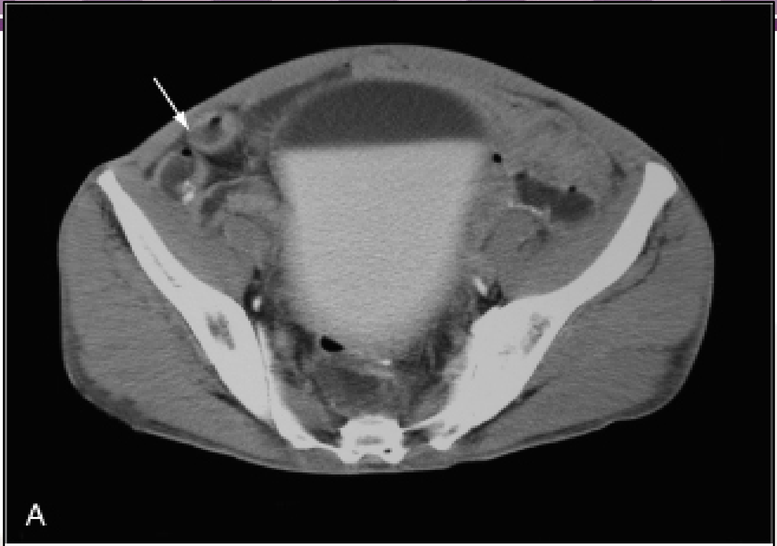
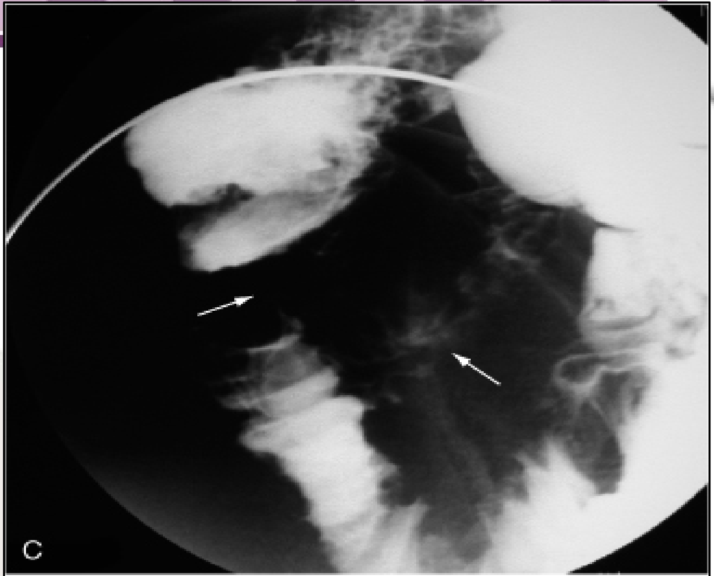


Figure 85-8 Crohn's disease SSFSE versus gadolinium-enhanced MRI. Single-shot fast spin-echo (SSFSE) image (A) shows mural thickening (arrow) involving the terminal ileum. Axial (B) and coronal (C) gadolinium-enhanced MRI shows marked enhancement of the thick wall terminal ileum (arrow). Small bowel barium examination (D) shows a "string sign" (arrow) with marked luminal narrowing of the distal ileum due to Crohn's disease.

Small Bowel MRI/Crohn's Disease/Clinical Images





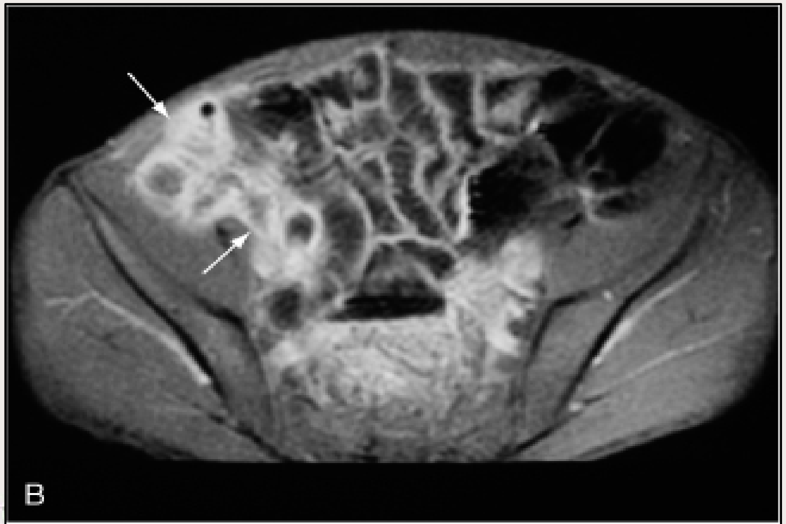


Figure 85-9 Mild Crohn's disease. Helical CT scan (A) shows possible distal ileal mural thickening (arrow) versus incomplete distension. Gadolinium-enhanced MRI (B) depicts marked enhancement (arrows) of the diseased distal ileum. Small-bowel barium examination (C) confirms changes of active Crohn's disease involving the distal ileum (arrows). The extent of the disease and confidence in diagnosis is better on the gadolinium-enhanced MR examination

Small Bowel MRI/Crohn's Disease/Complications

Figure 85-19 Crohn's recto-vaginal fistula. Axial (A) and sagittal (B) gadolinium-enhanced spoiled gradient-echo (SGE) images demonstrate air within a recto-vaginal fistula (arrows) in a patient with Crohn's disease.

Small Bowel MRI/Crohn's Disease/Complications

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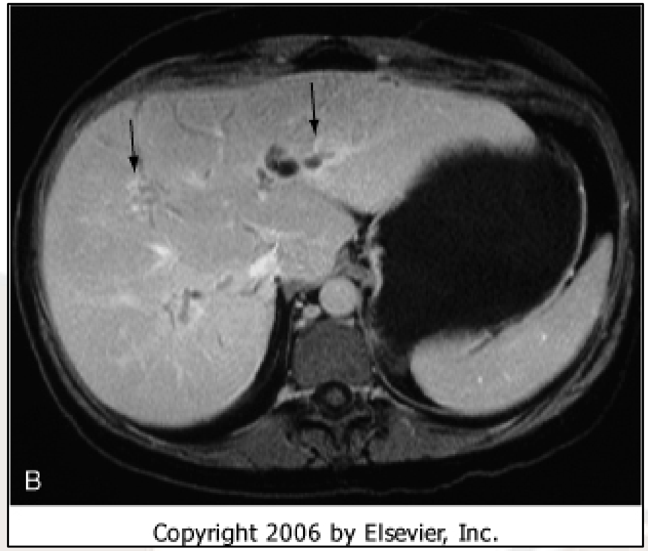

Figure 85-21 Crohn's disease with sclerosing cholangitis. Coronal gadolinium-enhanced MR image (A) shows an ahaustral colon (arrow) without enhancement indicating chronic Crohn's disease. Axial gadolinium-enhanced image through the liver (B) shows mild intrahepatic bile duct dilatation with peribiliary enhancement (arrows) correlating with sclerosing cholangitis.

Small Bowel MRI/Crohn's Disease/Complications

Figure 85-17 Crohn's entero-vesicle fistula. Axial (A) and coronal (B) gadolinium-enhanced spoiled gradient-echo (SGE) images depict an inflammatory mass (white arrows) involving the terminal ileum. Also note the eccentric thickening (black arrow in B) of the bladder dome at the site of an entero-vesicle fistula.

Small Bowel MRI/Crohn's Disease/Complications

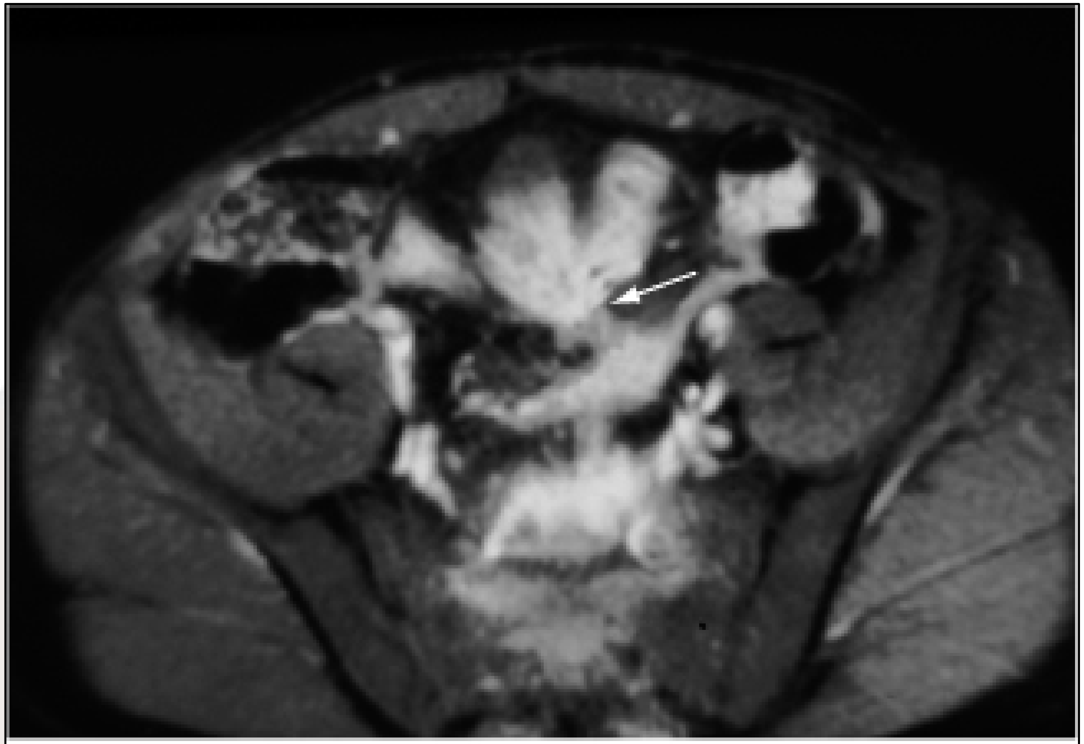

Figure 85-18 Crohn's entero-entero fistula. Axial gadolinium-enhanced spoiled gradient-echo (SGE) image shows marked enhancement of distorted pelvic bowel loops with fistulous communication (arrow).

Small Bowel MRI/Crohn's Disease/Complications

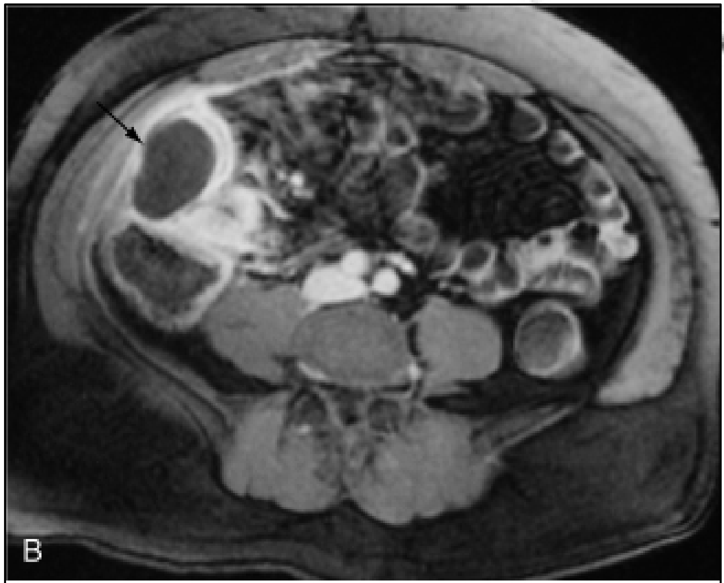

Figure 85-20 Crohn's disease abscess. Coronal (A) and axial (B) gadolinium-enhanced spoiled gradient-echo (SGE) images show a 4-cm right lower quadrant abscess (arrow) with an enhancing wall.

Colon MRI/Crohn's Disease/Clinical Images

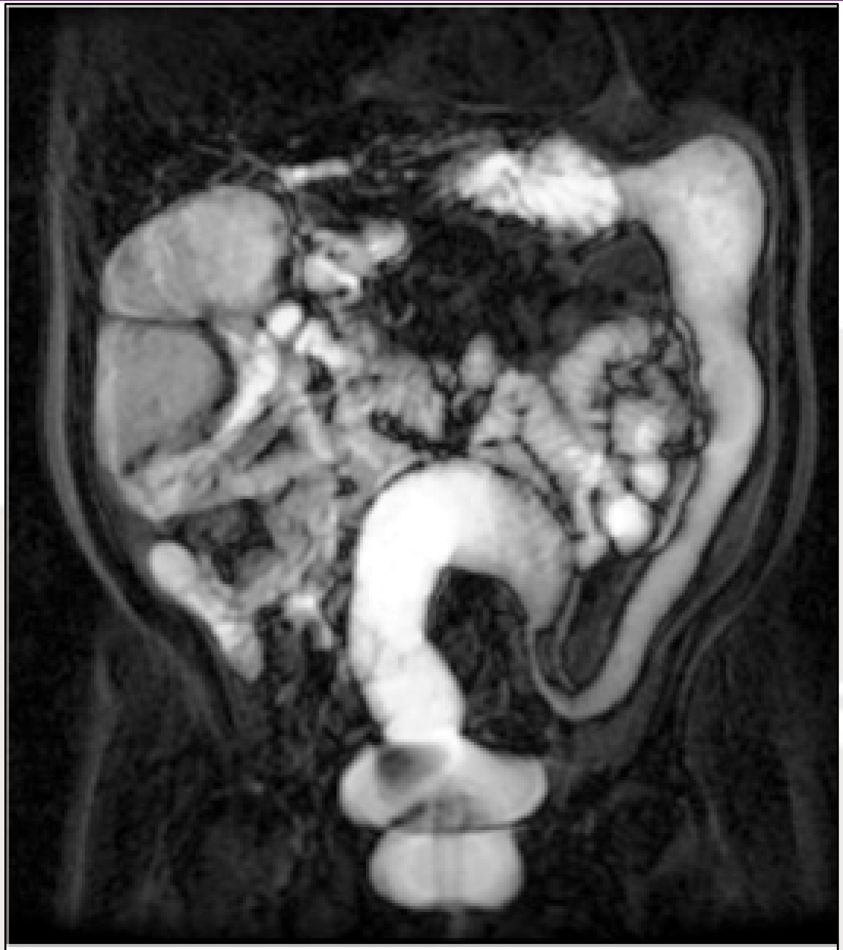

Figure 85-6 Magnetic resonance hydrogram. Coronal 10 cm thick-slab SSFSE acquisition (TE 900 msec) shows the high signal intensity intraluminal contrast material. In this patient with long-standing Crohn's disease, there is a high-grade smooth stricture of the distal descending and sigmoid colon.

Colon MRI/Ulcerative Colitis

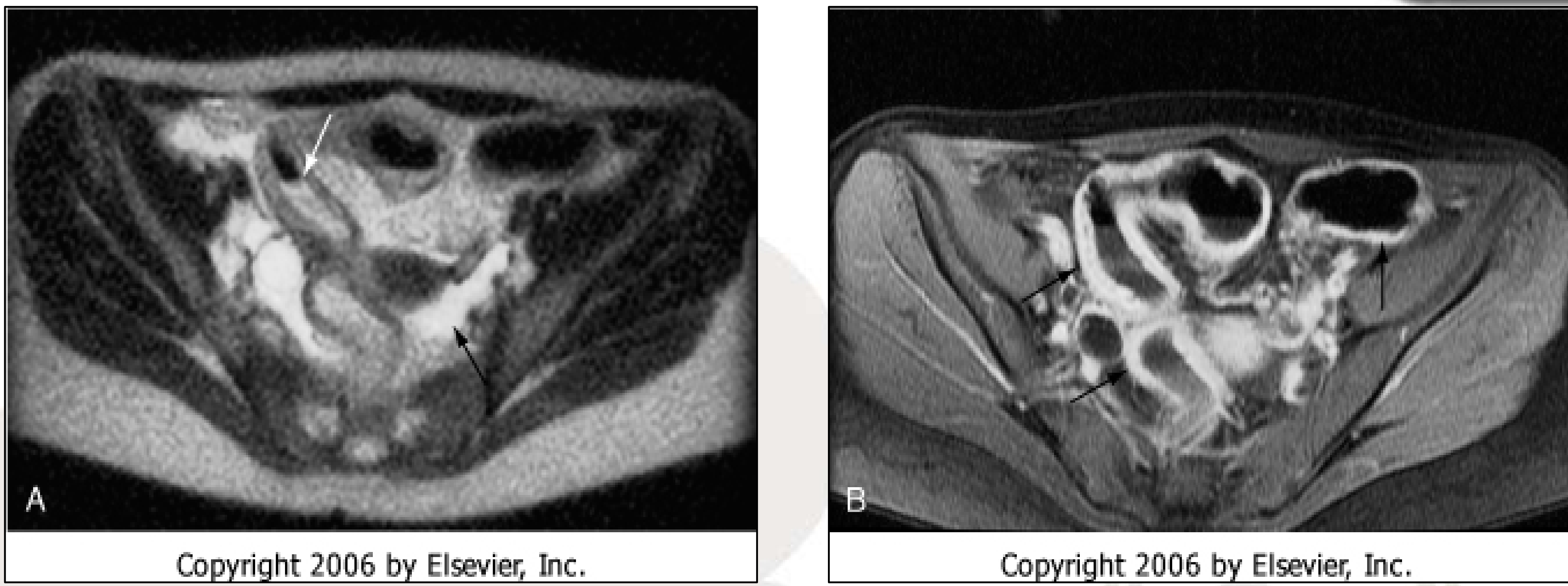

Figure 85-22 Ulcerative colitis. Single-shot fast spin-echo (SSFSE) image (A) shows rectosigmoid mural thickening (white arrow) and pelvic ascites (black arrow). Gadolinium-enhanced spoiled gradient-echo (SGE) image (B) shows marked enhancement of the thickened colon (arrows). Endoscopy confirmed pancolitis due to ulcerative colitis.

Colon MRI/Ulcerative Colitis

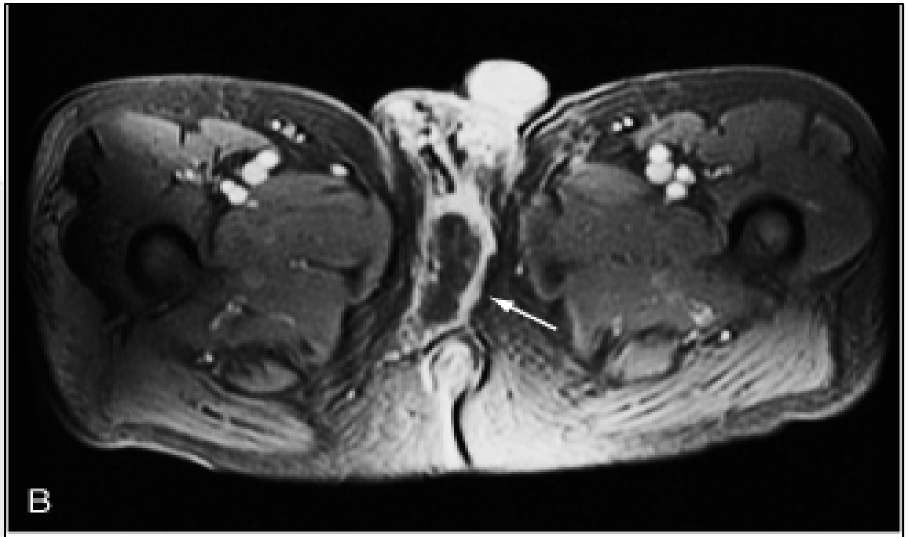

Figure 85-23 Ulcerative colitis with abscess. Sagittal gadolinium-enhanced image (A) shows a thickened rectosigmoid colon with mural enhancement (short arrows) correlating with history of ulcerative colitis. A large septated perineal abscess (long arrows) is also noted extending from the rectum to the base of the penis. Axial gadolinium-enhanced image (B) confirms the irregular perineal abscess (arrow) with surrounding enhancement.

Colon MRI/Typhlitis

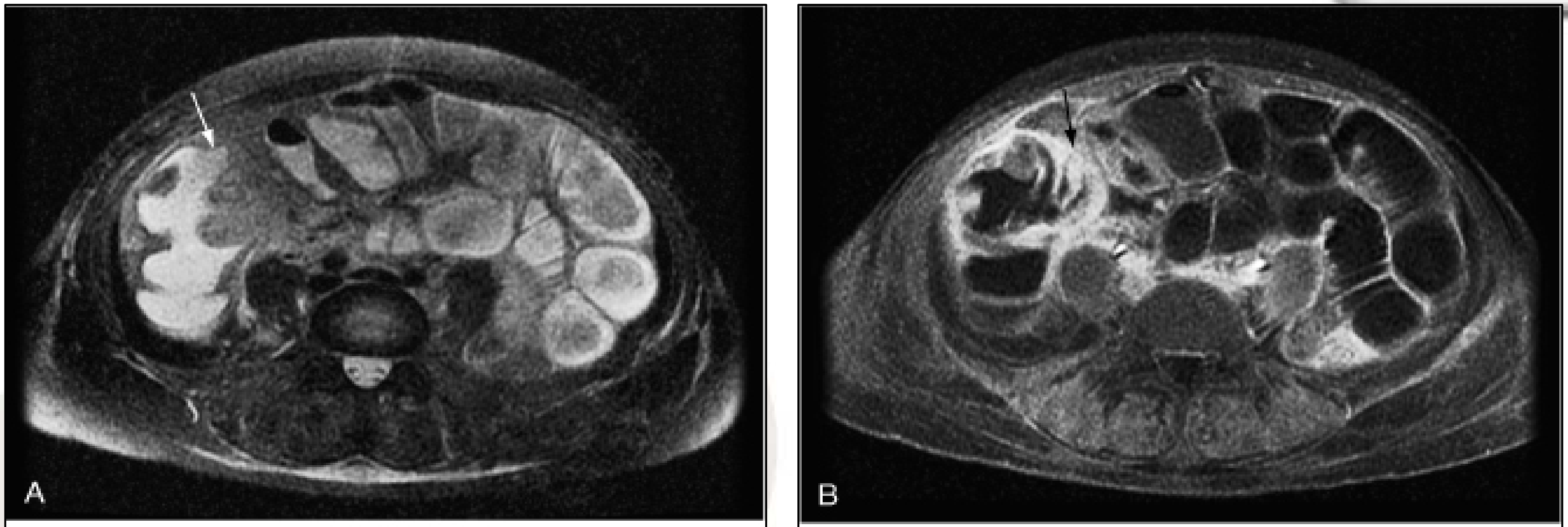

Figure 85-25 Typhlitis. Axial single-shot fast spin-echo (SSFSE) (A) image shows moderate mural thickening of the cecum (arrow). Axial (B), coronal (C), and sagittal (D) gadolinium-enhanced spoiled gradient-echo (SGE) images show marked enhancement of the irregularly thickened cecum (arrow) and terminal ileum correlating with typhlitis.

Intestinal MRI/Future Considerations

- **Evaluation of appendicitis**
  - Radiographics. 2007 May-Jun;27(3):721-43; discussion 743-53. Links
    - **MR imaging of acute right lower quadrant pain in pregnant and nonpregnant patients.**
    - Pedrosa I, Zeikus EA, Levine D, Rofsky NM.
    - Department of Radiology, Beth Israel Deaconess Medical Center, Harvard Medical School, 330 Brookline Ave, Boston, MA 02215, USA. ipedrosa@bidmc.harvard.edu
- **Development of new agents for intraluminal contrast**
  - Invest Radiol. 2005 Sep;40(9):621-9. Links
    - **Comprehensive magnetic resonance imaging of the small and large bowel using intraluminal dual contrast technique with iron oxide solution and water in magnetic resonance enterocylsis.**
    - Herrmann KA, Zech CJ, Michaely HJ, Seiderer J, Ochsenkuehn T, Reiser MF, Schoenberg SO.
    - Institute of Clinical Radiology, University Hospitals Munich-Grosshadern, Ludwig-Maximilians-University, Munich-Grosshadern, Germany. Karin.Herrmann@med.uni-muenchen.de