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EMERGENCY RADIOLOGY SPECIAL FEATURE: REVIEW ARTICLE

Emergency abdominal MRI: current uses and trends

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ABSTRACT

When evaluating the abdomen in the emergency setting, CT and ultrasound are the imaging modalities of choice, mainly because of accessibility, speed and lower relative cost. CT has the added benefit of assessing the whole abdomen for a wide spectrum of gastrointestinal disease, whereas ultrasound has the benefit of avoiding ionizing radiation. MRI is another tool that has demonstrated increasing utility in the emergency setting and also avoids the use of ionizing radiation. MRI also has the additional advantage of excellent soft-tissue contrast. However, widespread use of MRI in the emergency setting is limited by availability and relative cost. Despite such limitations, advances in MRI technology, including improved pulse sequences and coil technology and increasing clinician awareness of MRI, have led to an increased demand in abdominal MRI in the emergency setting. This is particularly true in the evaluation of acute pancreatitis; choledocholithiasis with or without cholecystitis; acute appendicitis, particularly in pregnant patients; and, in some cases, Crohn's disease. In cases of pancreatitis and Crohn's disease, MRI also plays a role in subsequent follow-up examinations.

INTRODUCTION

Acute abdominal pain is among the most common chief complaints in the emergency department (ED) setting, accounting for approximately 8% of ED visits.^{1,2} Among these patients, many are diagnosed with minor problems such as dyspepsia, gastroenteritis and gastro-oesophageal reflux.^{3,4} However, some patients with abdominal pain have more serious diagnoses that require hospitalization and, in some cases, surgical intervention. Among these patients, acute pancreatitis is the most common diagnosis for hospitalization. Other common diagnoses include cholelithiasis with acute cholecystitis, acute appendicitis and inflammatory bowel disease, including Crohn's disease and ulcerative colitis.³ In addition to the history and physical examination, complete work-up for acute abdomen frequently includes the use of diagnostic imaging.⁵

CT is typically performed with intravenous (i.v.) contrast.⁵ In cases where i.v. contrast cannot be administered, whether due to contrast allergy, poor renal function or lack of i.v. access, oral contrast can be considered. CT is often favoured in the acute setting, as it is fast, accurate and readily available. More recently, a growing awareness of the risks of radiation exposure has prompted the need for alternative imaging modalities that avoid ionizing radiation. This is particularly true in select patient populations such as children and pregnant patients.⁶⁻⁸

Ultrasound is a fast, inexpensive and readily available⁸ alternative to CT and does not use ionizing radiation. The

major disadvantage of ultrasound is its inability to penetrate bowel gas, which often precludes full assessment for pathology. It is also limited by patient body habitus and is highly operator dependent.⁷

Another alternative is MRI, which has the inherent advantage of excellent soft-tissue contrast resolution and avoidance of ionizing radiation.⁸ In patients with impaired renal function, non-contrast MRI protocols may be utilized and are often diagnostic. However, MRI is not readily accessible in all institutions and is relatively expensive and time consuming. MRI also requires patient co-operation, as the patient must not be claustrophobic and must be able to remain still for extended periods of time, both of which may be difficult in an acutely ill patient. For these reasons, the American College of Radiology (ACR) has not supported routine use of MRI as a primary imaging modality in most acutely ill patients. It is typically reserved for selected populations, such as pregnant and paediatric patients, where MRI has been proven to be the examination of choice.⁸⁻¹⁰

MRI PROTOCOLS

MRI protocols in the acute setting should be tailored to answer the clinical question. At Boston University Medical Center (Boston, MA), in patients with pancreaticobiliary pathology, an abdominal MR with MR cholangiopancreatography is performed (Table 1). i.v. contrast is optional as

Table 1. Abdominal MRI with MR cholangiopancreatography (MRCP)

Parameter	T_2 weighted single-shot turbo spin echo	T_2 weighted turbo spin echo	T_1 weighted in and out of phase	Diffusion ($b = 0, 600 \text{ s mm}^{-2}$)	MRCP	T_1 fat-suppressed 3D gradient echo
Imaging plane	Axial and coronal	Axial	Axial	Axial	–	Axial
Contrast	None	None	None	None	None	Pre-Gd, Post-Gd in arterial, venous and equilibrium phases
Field of view (mm^2)	400	400	400	400	300	400
Technique	Fast spin echo	Fast spin echo	GRE	Diffusion	Fast spin echo for 2D, 3D turbo spin echo for 3D	GRE
Scanning mode	Multisection 2D	Multisection	Multisection, dual echo	Multisection 2D	Multisection 2D or 3D	3D
Repetition time (ms)	∞	2000	180	3.6	8000	3.6
Echo time (ms)	80	80	2.3/4.6 (out-of-phase/in-phase)	1.8	800	1.7
Slice thickness (mm)	5	5	5	7	40 for 2D, 1.6 for 3D	4
Flip angle (degrees)	90	90	90	60	90	15
parallel imaging acceleration factor	2	2	1.8	2	2	1.7
Respiration control technique	Respiratory triggered	Respiratory triggered	Breath-hold	Respiratory triggered	Respiratory triggered	Breath-hold
Fat suppression technique	SPIR (optional)	SPIR	None	None	None	SPIR

2D, two-dimensional; 3D, three-dimensional; Gd, gadolinium; GRE, gradient echo; SPIR, spectral presaturation with inversion recovery.

gastrointestinal pathology often involves inflammation and oedema, which is readily detected on fluid-sensitive sequences. Gadobenate dimeglumine is used as an i.v. contrast (Multi-Hance®; Bracco Imaging, Milan, Italy). Gadoxetate disodium (Eovist®; Bayer Healthcare Pharmaceuticals, Berlin, Germany) is used with additional delayed phase (10–20 min) imaging when biliary leak is suspected. i.v. contrast is administered at a dose of 0.1 ml per kilogram of body weight at a rate of 2 ml s^{-1} .

Situations precluding the use of i.v. contrast are renal failure and pregnancy. In the setting of renal failure, contrast is not administered when glomerular filtration rate is $<30 \text{ ml min}^{-1} 1.73 \text{ m}^{-2}$. Although the effect gadolinium on the foetus is not well understood, gadolinium is also avoided during pregnancy as it has been shown to cross the placenta into the foetus, which is subsequently excreted into the amniotic fluid. Regarding the post-partum patient, there is often concern about excretion of gadolinium through breast milk. Currently, it is felt that breastfeeding remains safe as $<0.0004\%$ of the intravascular dose is actually absorbed by the infant. However, the decision to temporarily stop breastfeeding is left to the discretion of the ordering provider and patient. In patients who choose to temporarily stop breastfeeds, the recommendation is to express and discard breast milk from both breasts for 24 h.

For the work-up of acute appendicitis, the MR protocol is modified and contains axial T_1 in and out of phase, as well as axial, sagittal and coronal T_2 weighted single-shot sequences with and without spectral presaturation with inversion recovery, preferably using a large field-of-view, torso coil. The MR enterography protocol is also modified and contains axial, sagittal and coronal T_2 weighted single-shot images; axial, sagittal and coronal balanced turbo field echo (bTFE) images; coronal bTFE and T_2 weighted single-shot dynamic images, as well as coronal T_1 fat-suppressed 3D gradient echo pre- and post-contrast sequences, in the arterial, venous and equilibrium phases, preferably using a torso coil.

IMAGING FINDINGS

Acute pancreatitis

As previously mentioned, acute pancreatitis is the most common reason for hospitalization in the acute setting.³ Estimates suggest a worldwide incidence of 4.9–73.4 cases per 100,000.¹¹ Acute pancreatitis has numerous aetiologies, the most common being alcohol and gallstones. Other benign causes include medications, infection and metabolic abnormalities. Neoplastic aetiologies are also possible secondary to malignant obstruction of the pancreatic duct.¹¹

Abdominal imaging is highly sensitive and specific for detecting pancreatitis, although it is usually not necessary in the acute setting as the diagnosis is often made clinically.¹¹ CT performed in the early phase ($<72 \text{ h}$) of acute pancreatitis may underestimate the disease. According to the ACR appropriateness criteria, CT with i.v. contrast is recommended in the early phase during initial presentation when atypical signs and symptoms are noted, such as equivocal amylase and lipase levels. In these cases, the purpose of CT is to detect other possible causes of abdominal pain. Imaging within the first 48–72 h may also be

Figure 1. Interstitial pancreatitis. 40-year-old male with right upper quadrant pain, found to have leukocytosis and elevated liver function tests. (a) Axial T_2 weighted fat-suppressed image demonstrates subtle T_2 hyperintensity of the pancreas. (b) Axial T_1 weighted fat-suppressed post-contrast image demonstrates heterogeneous enhancement of the pancreas.

useful for the detection of pancreatic and peripancreatic collections. In situations where the patient is critically ill beyond the 48- to 72-h window or when symptoms are present for 7–21 days, MRI is an alternative to CT, as per the ACR appropriateness criteria.¹²

Normal pancreatic anatomy is best depicted on T_1 weighted fat-suppressed images. The pancreas is typically hyperintense because of pancreatic acinar proteins.^{8,13} On T_2 weighted images, pancreatic parenchyma is typically hypointense.¹³ In the setting of mild acute pancreatitis, the pancreas may appear enlarged with normal signal on T_1 weighted sequences, which are insensitive for demonstrating oedema. However, mesenteric oedema may be seen on out-of-phase T_1 weighted images because of signal drop out in pixels which contain both fat and water. Post-contrast imaging may demonstrate hypoenhancement or heterogeneous enhancement in the setting of pancreatic oedema or necrosis

Figure 2. 31-year-old male with necrotizing pancreatitis presenting with persistent fevers and leukocytosis. (a) Axial CT performed 8 weeks after the initial onset of pancreatitis demonstrates a rim-enhancing peripancreatic fluid collection (solid arrow). (b) Axial T_2 weighted images again demonstrate both peripancreatic and pancreatic necrosis with debris (dotted arrow) identified within an encapsulated T_2 hyperintense collection. (c) Axial T_1 weighted fat-suppressed post-contrast images show enhancement of the peripheral capsule (dashed arrow). Findings are consistent with walled-off necrosis.

(Figure 1). In more severe cases, T_2 weighted images offer the additional advantage of evaluating for fluid collections.^{8,13} Superior tissue contrast on T_2 weighted imaging allows for detection of solid debris. These images may also be evaluated

for the detection of pancreatic necrosis, which may appear as T_2 -hyperintense collections in or adjacent to the pancreas containing dependent T_2 -hypointense debris (Figure 2). Evaluation of the pancreatic and common bile ducts is also possible

Figure 3. 31-year-old male with haemorrhagic pancreatitis, presenting with persistent fevers and leukocytosis. (a) Axial contrast-enhanced CT and (b) axial T_2 weighted MR image performed 8 weeks after the initial onset of pancreatitis demonstrates a peripancreatic fluid collection with solid debris (solid arrows), consistent with necrotizing pancreatitis. (c) Axial T_1 weighted fat-suppressed MR image demonstrates a focal area of T_1 hyperintensity (dotted arrow), consistent with haemorrhage.

Figure 4. Mirizzi syndrome. 59-year-old male with history of cholecystectomy 2 months earlier presents with right upper quadrant pain and abnormal liver function tests. Axial T_2 weighted single-shot MR images demonstrate (a) dilatation of the cystic duct stump (solid arrow) and (b) intrahepatic ductal dilatation. (c) Thin-section source image from three-dimensional MR cholangiopancreatography (3D MRCP) sequence demonstrates a filling defect in the cystic duct stump (dotted arrow). (d) Maximum-intensity projection images from 3D MRCP shows impacted stone in the distal cystic duct (dashed arrow) with associated common hepatic and intrahepatic ductal dilatation. Note low cystic duct insertion.

with heavily T_2 weighted images. These images can be used to identify the presence of obstructing stones, masses or strictures.^{12–14}

As previously mentioned, MRI is useful for the detection and characterization of fluid collections, which can develop as a complication of pancreatitis because of inflammation and subsequent release of proteolytic enzymes.^{8,11} In the revised Atlanta criteria, pancreatic and peripancreatic fluid collections are classified based on the duration from the onset of pancreatitis and the presence or absence of necrosis.^{14,15} In the setting of interstitial oedematous pancreatitis, fluid collections can be classified as acute peripancreatic fluid collections if they are present less than 4 weeks after the onset of pancreatitis or as pseudocyst if present after 4 weeks of the onset. Although these collections can be identified on CT, MRI is useful as it may detect necrotic debris within a collection that otherwise appears homogeneous and isodense to normal pancreas on CT. In some instances, MRI may also detect a persistent communication between the collection and the pancreatic duct. If necrotic debris is present, the collection can be classified as acute necrotic collection when less than 4 weeks after the onset or as walled-off necrosis thereafter. Acute necrotic collections can be further classified based on whether there is parenchymal necrosis, peripancreatic necrosis or both (Figure 2). All of these collections can be sterile or infected.¹⁴ Pancreatic abscesses can also appear as a fluid collection approximately 4 weeks following the onset. They are differentiated by the presence of gas within the collection.¹³

Vascular complications can also result from acute pancreatitis, including pseudoaneurysm with possible rupture and venous

thrombosis.^{8,13} Pseudoaneurysms result from release of pancreatic enzymes, which causes weakening of vessel walls. A potential complication of pseudoaneurysm is identification of haemorrhage, which must be treated emergently (Figure 3). On MRI, acute haemorrhage or thrombus will appear hyperintense on T_1 weighted images secondary to the presence of methaemoglobin.^{7,13} Post-contrast images may also identify the pseudoaneurysm by demonstrating opacification similar to that of the adjacent arteries.¹³ Venous thrombosis can be seen in the splenic, portal and superior mesenteric veins. Thrombi are seen as filling defects within the veins on post-contrast images.¹³

Cholelithiasis/choledocholithiasis/ acute cholecystitis

Following acute pancreatitis, the next most common gastrointestinal cause for hospital admission is cholelithiasis with cholecystitis.⁵ The prevalence of cholelithiasis in the adult Western population is approximately 10–15%, with 1–4% of these patients developing symptoms. Among the symptomatic patients, 56% of patients have biliary colic and 36% have acute cholecystitis; others develop jaundice, ascending cholangitis, pancreatitis, Bouveret's syndrome and gallstone ileus.¹⁶

Abdominal imaging in the ED typically begins with abdominal ultrasound, which is the examination of choice as recommended by the ACR appropriateness criteria.¹⁷ It is highly sensitive and specific for the detection of cholelithiasis; however, ultrasound has a limited sensitivity for the detection of choledocholithiasis because of the presence of bowel gas. Choledocholithiasis can be suggested on CT or ultrasound when dilatation of the common

Figure 5. Acute cholecystitis. 45-year-old male presents with abdominal pain and nausea. Abdominal ultrasound demonstrated dilated intrahepatic and extrahepatic ducts. (a) Coronal and (b) axial T_2 weighted single-shot MR images demonstrate a distended gallbladder filled with stones (solid arrows). Note gallbladder wall thickening and pericholecystic fluid. (c) T_1 weighted fat-suppressed post-contrast MR images demonstrate hyperaemia in the gallbladder fossa (dotted arrow). (d) Three-dimensional MR cholangiopancreatography image demonstrates a distended gallbladder along with intrahepatic and extrahepatic ductal dilation.

bile duct (>8 mm) is detected, but neither modality is sensitive or specific for detection of biliary stones.^{6,7} MR cholangiopancreatography has demonstrated high sensitivity (93–99%) and specificity (95–99%) for the detection of abnormalities of the biliary tree. Filling defects in the biliary tree, as seen on heavily T_2 weighted imaging, can represent calculi, sludge, air, malignancy or blood clot.^{6,18} One finding of particular importance, which may be seen on heavily T_2 weighted images, is extrinsic compression of the common hepatic duct secondary to impacted calculi within the gallbladder neck or cystic duct, an entity known as Mirizzi syndrome (Figure 4).^{6,7,19} Detection of this finding as a cause of intrahepatic ductal dilatation is important, as it can mimic cholangiocarcinoma.¹⁹

As with cholelithiasis, evaluation for acute cholecystitis in the ED also begins with an abdominal ultrasound. Typical ultrasound findings of acute cholecystitis include gallbladder distension (>5 cm transverse diameter), gallbladder wall thickening (>3 mm) and pericholecystic fluid.^{6,8} These findings are also well demonstrated on T_2 weighted images on MRI.⁷ Contrast-enhanced images can also demonstrate hyperenhancement in the adjacent hepatic parenchyma because of hyperaemia (Figure 5). Evaluation of post-contrast images may reveal non-enhancing regions along the gallbladder wall, representing gangrenous cholecystitis (Figure 6). Susceptibility artefact within the gallbladder wall on gradient echo imaging can indicate foci of air.^{6–8} Complications of gangrenous cholecystitis include perforation and abscess formation (Figure 7).

Acute appendicitis

Acute appendicitis is the fourth most common gastrointestinal diagnosis leading to hospital admission.³ It is defined by

inflammation of the appendix. The aetiology is unclear but is thought to be related to mechanical obstruction, inadequate dietary fibre intake and/or familial susceptibility.²⁰

In the emergency setting, the study of choice as per ACR appropriateness criteria is a CT abdomen and pelvis with i.v. contrast. Oral contrast may not be needed, although this depends on institutional preference. CT is fast, accurate and easily accessible to the ED with sensitivities of 77–98% and specificities of 83–100%.²¹ CT findings of a dilated, blind-ending tubular structure in the right lower quadrant with adjacent inflammatory stranding clinches the diagnosis. However, in the setting of pregnancy, alternative modalities which avoid ionizing radiation must be considered.

Appendicitis in the pregnant patient is the most common non-obstetric cause of an acute abdomen, with an incidence of 1 : 500 to 1 : 3000.²² In a pregnant patient with fever, leukocytosis and right lower quadrant pain, initial work-up should begin with an ultrasound using a graded compression technique, as per the ACR appropriateness criteria.^{22,23} Although this examination may be limited by the gravid uterus causing displacement of the caecum and appendix, it remains the initial diagnostic study.²² Ultrasound findings of acute appendicitis include a non-compressible, fluid-filled, blind-ending structure with a diameter >6 mm.²²

In cases where ultrasound is equivocal, MRI of the abdomen and pelvis without i.v. contrast can be performed. A meta-analysis of eight studies evaluating MRI diagnosis of acute appendicitis

Figure 6. Gangrenous cholecystitis. 56-year-old female with severe right upper quadrant pain with ultrasound findings suspicious for acute cholecystitis. (a) Coronal and (b) axial T_2 weighted single-shot MR images demonstrate a distended, fluid-filled gallbladder with wall thickening and surrounding inflammatory changes. There are also sloughed membranes in the gallbladder fundus as seen on the coronal image (solid arrow). (c) Axial T_1 weighted fat-suppressed post-contrast MR image demonstrates hyperaemia in the gallbladder fossa with discontinuous gallbladder wall enhancement (dotted arrow) consistent with gangrenous cholecystitis.

demonstrated a sensitivity of 97% and a specificity of 95%.²⁴ Other prospective studies investigating the use of MRI for diagnosis of acute appendicitis have demonstrated sensitivities of 85–100% and specificities of 97–99%.^{25,26} MR findings consistent with acute appendicitis are similar to those of CT and ultrasound, with an outer appendiceal wall diameter >7 mm and a wall thickness of >2 mm. These findings are best identified on T_2 weighted images (Figure 8). Periappendiceal inflammatory changes characterized by T_2 hyperintensity within the wall and/or the surrounding fat are best seen on fat-suppressed T_2 weighted images.^{7,27} It should be noted that in the setting of pregnancy, localization of the appendix may be difficult because of enlargement of the gravid uterus causing superior and outward displacement of the caecum. This is an important consideration when trying to localize the appendix.²⁸

Another finding to be cautious of is abscess formation, which can be seen as periappendiceal fluid collections if distinguished from adnexal structures. Air, identified as T_1 - and T_2 -hypointense foci within the collection, which may demonstrate susceptibility artefact on gradient echo imaging, is highly suspicious for abscess formation.²⁷ If the appendix is not identified or is normal in appearance, MRI may be useful for the detection of other pathologies as a cause for right lower quadrant pain.⁶

Crohn's disease

The prevalence of Crohn's disease is the highest in Europe with 322 per 100,000, followed by North America with 319 per 100,000.²⁹ Crohn's disease is a chronic granulomatous inflammatory process, which involves the entire gastrointestinal

tract extending from the mouth to the anus. In up to 80% of cases, the small bowel is affected. Crohn's disease is characterized by transmural bowel wall inflammation, erosions, ulcerations and formation of fistulas and fissures.³⁰ Skip lesions, defined by diseased regions separated by normal regions, are characteristic of this disease. To date, the aetiology has not been determined, although association is seen with living in an industrialized nation.²⁹

Imaging options for Crohn's disease include barium studies, CT and MR enterography. Barium studies have fallen out of favour, mainly because they do not provide information about disease activity. Areas of stricture or fistulae may be identified, although little information about whether disease is active *vs* quiescent can be offered. CT, in the acute setting, can be used to detect wall thickening and degree of enhancement, which may suggest disease activity. It may also detect additional findings such as strictures, fistulae, bowel obstruction, perforation and abscess formation.^{30,31}

MR enterography has become an invaluable tool in the assessment of patients with Crohn's disease, as it provides information about disease activity and bowel motility. Although the examination is not typically carried out through the ED, there are instances when clinicians request the study for triage purposes. This is particularly true in children, where the ACR recommends MR enterography as the first-line examination in a child with initial presentation of suspected Crohn's disease.³² Another consideration is that Crohn's patients are at risk of undergoing repeated imaging examinations with disease flares, thus, are

Figure 7. Perforated gangrenous cholecystitis in a 63-year-old male with fever and leukocytosis. (a) Axial ultrasound image demonstrating large collection in the gallbladder fossa (solid arrow). (b) Coronal T_2 weighted MR image demonstrating multilocular fluid collection in the gallbladder fossa (dotted arrow). Axial (c) T_2 weighted fat-suppressed and (d) T_1 weighted fat-suppressed post-contrast MR images demonstrate discontinuity of the gallbladder wall with communication between the peripherally enhancing collection and the gallbladder (dashed arrows). Findings are consistent with perforated gangrenous cholecystitis with adjacent abscess formation.

prone to receiving large cumulative radiation doses over their lifetimes. MR enterography is an excellent modality for the detection of Crohn's disease. Findings include bowel wall

thickening of >3 mm in distended small bowel with or without intramural oedema, mesenteric oedema, mucosal hyperaemia, wall enhancement, ulceration and fistula formation, vascular

Figure 8. Acute appendicitis. 24-year-old female who is 7 weeks pregnant presents with right lower quadrant pain and leukocytosis. (a) Axial, (b) coronal and (c) sagittal T_2 weighted single-shot MR images demonstrating distended appendix with multiple appendicoliths (solid arrows) and surrounding inflammatory changes, consistent with acute appendicitis.

Figure 9. 24-year-old male with Crohn's disease. (a,b) Axial T_2 weighted MR images demonstrate bowel wall thickening and oedema involving the rectosigmoid colon (solid arrows). (c) Axial T_1 weighted fat-suppressed post-contrast MR image demonstrates multiple perianal and perirectal fistulas (dotted arrows).

engorgement and lymphadenopathy. MRI is also an excellent modality to assess for the presence of abscess formation.^{30,31} The additional advantage of MR enterography is the use of dynamic imaging to assess bowel motility/peristalsis and contrast enhancement, both of which can be used to assess disease activity.^{30,33,34}

Bowel wall thickening is best assessed on single-shot T_2 weighted images because of relative insensitivity to chemical shift and India ink artefacts.³⁰ Intramural oedema and mesenteric oedema are best assessed on single-shot T_2 weighted images with fat

suppression (Figure 9). Contrast-enhanced images provide information about hyperaemia and wall enhancement. A striated appearance represents mucosal hyperaemia with submucosal oedema indicating active disease; diffuse enhancement suggests transmural inflammation, and low levels of enhancement suggest fibrosis (Figure 10). Vascular engorgement can also be seen with post-contrast imaging and may demonstrate a “comb” sign (Figure 10).^{30,31} Fat-suppressed contrast-enhanced T_1 weighted images are also an excellent way to evaluate fistulae, sinus tracts and abscesses because of their avidly enhancing walls (Figure 9).³¹ Dynamic imaging allows for evaluation of motility

Figure 10. Crohn's disease in a 35-year-old female presenting with worsening abdominal pain and leukocytosis. (a) Coronal T_2 weighted single-shot MR image demonstrates pseudosacculation of a long segment of small bowel in the right hemiabdomen (solid arrow). (b) Coronal T_1 weighted fat-suppressed post-contrast MR image demonstrates hyperenhancing, thickened bowel wall with mural stratification suggesting active disease (dotted arrow). Linear enhancement along the mesenteric side of the bowel, perpendicular to the bowel wall, represents engorged vasa recta, also known as the “comb sign” (dashed arrow).

Figure 11. Crohn's disease in an 11-year-old male with failure to thrive and constipation. (a) Coronal T_2 weighted single-shot MR image demonstrating a long segment of bowel wall thickening with adjacent fatty proliferation involving the terminal ileum (solid arrow). (b) T_1 weighted fat-suppressed post-contrast MR image shows corresponding mural enhancement (dotted arrow). (c,d) Dynamic balanced gradient echo MRI shows that the inflamed segment is aperistaltic (dashed arrows). Note peristalsis is seen in the adjacent bowel loop (arrowheads).

(Figure 11) and can be used to differentiate between stricture and peristalsis (Figure 12).³³ Pitfalls of MR enterography include the appearance of submucosal oedema upstream to a region of obstruction, which may cause overestimation of the severity of

disease. Another potential pitfall is the presence of transiently collapsed normal bowel, which may appear thickened.³¹ This pitfall may be avoided by review of the dynamic images, which will typically demonstrate peristaltic motion of normal bowel,

Figure 12. Crohn's disease in a 33-year-old female status post ileal resection. (a) Coronal T_2 weighted single-shot image demonstrates a short segment of concentric narrowing involving the distal ileum (solid arrow) with mucosal enhancement on the (b) coronal T_1 weighted fat-suppressed post-contrast MR image (dotted arrow). (c,d) Dynamic balanced gradient echo MRI shows that the segment remains fixed consistent with stricture (dashed arrows).

whereas diseased segments usually show fixed areas with persistent wall thickening.

CONCLUSION

CT and ultrasound remain the first-line imaging modalities in the emergency setting, mainly because of accessibility, convenience and affordability. However, MRI has demonstrated utility and is becoming used more frequently in select patient populations. Major advantages of MRI include excellent

soft-tissue contrast resolution as well as lack of ionizing radiation. Public awareness of ionizing radiation exposure has increased in the recent years, particularly among select patient populations, specifically paediatric and pregnant patients as well as patients with Crohn's disease who are at risk of receiving repeated imaging examinations and large cumulative radiation doses over their lifetimes. For these reasons, the utilization of MRI in the emergency setting is expected to continue increasing.

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