INTRODUCTION
Cross-sectional imaging of the small bowel is replacing conventional barium studies in many centres, with magnetic resonance (MR) enterography becoming particularly popular for the assessment of small bowel Crohn’s disease, given its superior tissue contrast with improved visualisation of the entire bowel and lack of ionising radiation. In addition, MR enterography provides functional information on the peristalsis and distensibility of the involved small bowel segment with dynamic sequences, which is an advantage over computed tomography (CT).

Over 15 years of performing MR enterography examinations, we have encountered a variety of clinically significant findings that mimic or are associated with Crohn’s disease, where the initial clinical suspicion was for Crohn’s disease. As a experience with MR enterography increases, there is also increasing clinician confidence in MR enterography, which has led to referral for evaluation of small bowel diseases other than Crohn’s disease.(1)

The manifestations of Crohn’s disease on MR enterography have been well described, but there is comparatively little in the literature about MR enterography appearances of diseases that can mimic Crohn’s disease or diseases other than Crohn’s disease.(2)

In this pictorial essay, we present a range of enteric and extra-enteric diseases that mimic or are associated with Crohn’s disease, and provide examples of imaging features. In addition, we review the use of MR enterography for the evaluation of small bowel diseases other than Crohn’s disease. Our aim is to raise awareness of the range of diseases that may be encountered on MR enterography, and to add to the limited literature on findings unrelated to Crohn’s disease.

MR enterography technique
Our MR enterography technique employs a biphasic oral bowel distending agent, prepared by forming a solution containing 0.2% locust bean gum and 2.5% mannitol to produce consistently satisfactory small bowel distension. Patients drink up to 1.5 L of agent over 45 minutes prior to scanning. After planning using scout acquisitions with the patient in supine position, we administer an intravenous spasmolytic agent to minimise motion artefacts related to peristalsis, usually 20 mg hyoscine-N-butylbromide, with 0.5-μg glucagon as an alternative. Only breath-hold acquisition sequences are employed. In all cases, we acquire T2-weighted half-Fourier acquisition single-shot turbo spin-echo (HASTE) and true fast imaging with steady state precession (FISP) sequences in the coronal and axial planes. Fat saturation may be applied to increase the conspicuity of inflammatory changes in the bowel wall and perienteric tissues. Diffusion-weighted imaging is acquired when active inflammatory disease is suspected. In cases where contrast enhancement characteristics may aid lesion detection and/or characterisation, we also acquire T1-weighted volumetric interpolated breath-hold examination (VIBE) sequences in the axial and coronal planes, before and after administration of intravenous gadolinium chelate agents at 0.1 mg/kg.

Imaging findings
This pictorial essay is presented in three sections. The first section describes enteric diseases that can mimic the presentation of Crohn’s disease. These cases were encountered when Crohn’s disease was initially suspected by clinicians. The second section describes extra-enteric findings that mimic the presentation of Crohn’s disease or are associated with Crohn’s disease. The third section describes a range of rare enteric diseases unrelated to Crohn’s disease but which have been referred for MR enterography over the years.

SECTION 1: ENTERIC DISEASES THAT MAY MIMIC CROHN’S DISEASE
Superior mesenteric artery syndrome
Superior mesenteric artery syndrome is a potentially lifethreatening disease characterised by compression of the third part of the duodenum between the abdominal aorta and the superior mesenteric artery (SMA) (Fig. 1). Presentation may be acute or chronic, with postprandial abdominal pain, nausea and vomiting leading to severe malnutrition. Patients who are very thin as a result of their diet or other wasting disease are anatomically predisposed to the condition. Imaging reveals proximal duodenal dilatation with an abrupt transition in D3 where the bowel passes through the angle between the aorta and the SMA. Reduction of the aortomesenteric angle to less than 22° is characteristic.(3)
Intussusception

Intussusception is a telescopic invagination of the bowel into the lumen of an adjacent bowel segment. It is a common cause of small bowel obstruction in children but is less common in adults. In adults, almost 90% of intussusceptions have a pathological lead point (usually neoplastic). Some patients may present acutely and some with symptoms of intermittent bowel obstruction over several weeks, which may lead to clinical suspicion for inflammatory bowel disease.

A target-like (bowel-into-bowel) appearance of the bowel is pathognomonic. On transverse section, the inner central structure is the invaginating loop (intussusceptum), which is enveloped by the receiving loop (intussuscipiens) (Fig. 2). Intussusception may complicate other small bowel diseases including Crohn’s and coeliac disease, Peutz-Jeghers syndrome and lymphoma.

Adhesion

Abdominal adhesions are fibrous bands connecting loops of bowel to each other or the peritoneum. They form in response to surgical handling or due to inflammatory intra-abdominal disease, and cause bowel obstruction either by direct extrinsic compression or by acting as a pivot for torsion or kinking of the bowel (Fig. 3). The actual fibrous band itself is usually undetectable on imaging, its presence being inferred from secondary signs including an abrupt transition point with no associated mass. Adhesion is the most common cause of small bowel obstruction in developed countries, followed by hernias, Crohn’s disease, malignancy and volvulus. In cases of closed loop obstruction, early identification and treatment is particularly important, as this condition can quickly progress to strangulation, ischaemia and necrosis.

Malrotation

A wide range of congenital gastrointestinal anomalies may be encountered, including luminal stenosis, anomalies of rotation or fixation, mesenteric cysts, anorectal anomalies and intestinal duplication. Patients may be asymptomatic and these anomalies may be discovered incidentally, or they may present with intermittent abdominal symptoms suggestive of Crohn’s disease or intermittent bowel obstruction.

Intestinal malrotation occurs when the midgut fails to complete its 180° counterclockwise rotation in embryo. The duodenojejunal junction lies low and to the right of the midline, with the small bowel lying in the right and the mid abdomen (Fig. 4). Another feature of intestinal malrotation, which may be recognised on cross-sectional imaging, is that the superior mesenteric vein lies anterior and to the left of the artery. Associated mesenteric folds (Ladd’s bands) may extend from the liver and posterior abdominal wall to the caecum; they cross the second part of the duodenum and may cause obstruction. Obstruction may also be precipitated by volvulus of the midgut around the shortened mesenteric root.
A 19-year-old woman presented with intermittent abdominal pain and clinical suspicion for Crohn’s disease. Coronal true FISP MR enterography image shows malrotation with the entire small bowel in the right side of the abdomen (arrowheads) and the entire large bowel in the left (arrows). There was no evidence of Crohn’s disease.

SECTION 2: EXTRAMENTERIC DISEASES THAT MAY MIMIC OR BE ASSOCIATED WITH CROHN’S DISEASE

Urinary tract
Common diseases of the urinary tract (obstruction, inflammation, neoplasm) often present with non-specific abdominal symptoms that can mimic bowel pathology, including pain, nausea, vomiting or palpable mass. Urological complications are common in patients with Crohn’s disease and may be related to the disease itself or to its treatment. Affected patients may have bowel symptoms that overshadow the urinary tract disease, resulting in delayed diagnosis. Two illustrative examples were encountered in patients with known or suspected Crohn’s disease.

Hydronephrosis
Hydronephrosis may be either obstructive or non-obstructive. Non-obstructive hydronephrosis is usually due to congenital structural abnormality, such as vesicoureteral reflux (Fig. 5). Obstructive causes include stones, tumour and extrinsic compression. Urinary stones are a well-recognised complication of Crohn’s disease. Occasionally, ureteric compression can occur in Crohn’s disease due to abscess or inflammatory phlegmon. Ureteral stenosis related to fibrous adhesion has also been observed. In addition, the complex abdominal surgery in the management of Crohn’s disease is associated with a risk of ureteral injury, which may result in obstructive hydronephrosis. Obstructive hydronephrosis, therefore, may be observed when a patient with Crohn’s disease is referred for MR enterography to investigate non-specific abdominal symptoms.

Renal cell carcinoma
Around 50% of renal cell carcinomas (RCCs) are identified incidentally on cross-sectional imaging investigation, as they are usually asymptomatic until very large or metastasised (Fig. 6). Clear cell (65%-70%), papillary (15%-20%) and chromophobe (6%-11%) tumours are the three most common subtypes of RCCs that differ in their prognosis and biologic behaviour. They usually manifest as solid masses with heterogeneous T1 and T2
signal that varies depending on histology, and often show post-gadolinium arterial enhancement. There is a nearly threefold increased risk of RCC in patients with Crohn’s disease. It has been suggested that the use of immunosuppressive therapy in patients with inflammatory bowel disease may increase the risk of RCC.\(^9\)

**Gynaecological**

Most female patients referred for MR enterography are of reproductive age, so presentations with iliac fossa or pelvic symptoms may be due to a gynaecological pathology. In these patients, ovarian cysts (and their complications) and endometriosis are not uncommon and may be identified on MR enterography in cases where Crohn’s disease has been suspected.

**Endometriosis/haemorrhagic ovarian cyst**

Patients with endometriosis (Fig. 7) or haemorrhagic ovarian cyst (Fig. 8) may present with non-specific abdominal or pelvic pain.

![Fig. 6](image1)

**Fig. 6** A 59-year-old woman with a history of Crohn’s disease presented with abdominal pain and altered bowel habit. Coronal gadolinium-enhanced VIBE MR enterography image shows the incidental finding of a 5-cm round, poorly enhancing mass arising from the lower pole of the left kidney (arrow). Histology of the surgical resection specimen confirmed the diagnosis of mixed papillary and clear cell carcinoma.

Endometrial tissue may be present outside of the uterus in the pouch of Douglas, on the ovaries, or covering the peritoneum of the bowel and bladder. A classic MR feature of ‘T2 shading’ with a relative decrease in T2 signal intensity when compared to hyperintensity on T1 is described in a majority of these lesions due to the high concentration of proteins and blood products from haemorrhages. This sign is considered highly sensitive but not specific for ovarian endometriomas and can also be present in other blood-containing lesions, such as haemorrhagic cysts.\(^10\)

A more specific feature is also described, called the ‘T2 dark spots sign’, with discrete, markedly hypointense intratissueal foci. The presence of dark spots is indicative of chronic haemorrhage in endometriomas and has a high specificity of 93%.\(^11\) Endometriomas > 1 cm are easily seen on MR imaging, but identification of smaller lesions remains a challenge for MR imaging and other imaging modalities.

**Retroperitoneal**

The retroperitoneum may harbour a wide range of inflammatory and neoplastic conditions, but it is difficult to evaluate clinically. Consequently, retroperitoneal pathology may be identified late after a protracted non-specific presentation.

**Pheochromocytoma/paraganglioma**

Pheochromocytomas are chromaffin cell tumours arising in the adrenal medulla. Paragangliomas arise from extra-adrenal chromaffin cells of the sympathetic nervous system (usually the retroperitoneum) or parasympathetic ganglia (usually adjacent to the aortic arch, in the neck or skull base). Hypertension and other catecholamine-related symptoms occur in approximately 90% of the population.\(^12\) Gastrointestinal presentations are common and include abdominal pain, vomiting and nausea, which can mimic Crohn’s disease. On MR imaging, the tumours are characteristically markedly hyperintense on T2-weighted imaging and slightly T1 hypointense in relation to the remainder of the adrenal (Fig. 9). Pheochromocytomas show no signal loss on

![Fig. 7](image2)

**Fig. 7** A woman of child-bearing age presented with a history of bowel dysfunction and anaemia. (a) Axial true FISP and (b) coronal HASTE MR enterography images show normal appearance of the small bowel, but examination revealed a few cystic lesions in the pelvis compatible with endometriotic cysts. The right adnexal cystic lesion contains a fluid-fluid level (arrowhead). The 7-cm left adnexal cystic lesion (arrows) shows relative decreases in T2-W signal intensity or ‘T2 shading’.
A 16-year-old girl had a short history of right iliac fossa pain. (a) Axial HASTE MR entero graphy image shows a normal small bowel but an abnormal right ovary with mixed high and low signal intensity on T2-W HASTE images (arrow). (b) Coronal unenhanced T1-W volumetric interpolated breath-hold examination (VIBE) MR entero graphy image shows intermediate signal intensity (arrowhead). The MR entero graphy findings suggest a diagnosis of recent right ovarian haemorrhage. Follow-up US imaging six months later was normal with complete resolution of the haemorrhagic cyst.

A 27-year-old woman had a history of upper abdominal pain and intermittent sweating episodes. (a) Gadolinium-enhanced coronal VIBE MR entero graphy image shows a normal duodenum, but there is an ovoid soft tissue mass (arrow) to the right of the aorta with avid enhancement of a thick wall and a non-enhancing centre. (b) Axial coronal CT image done previously shows duodenal wall thickening (arrow), and Crohn’s disease was suspected. Biochemical findings reflected high levels of urinary catecholamine excretion. Histology of the resected surgical specimen confirmed a diagnosis of metabolically active paraganglioma.

Out-of-phase imaging due to lack of intralvesional fat, and avid and prolonged contrast enhancement after gadolinium administration. These features can be used to distinguish pheochromocytomas from adrenal adenomas, the most common adrenal lesion.

**Abdominal wall**

Abdominal wall abnormalities may mimic Crohn’s disease or be identified incidentally when reviewing MR entero graphy. The proximity of the small bowel to the abdominal wall predisposes the bowel to be involved in abdominal wall pathologies and vice versa.

**Abdominal wall hernia**

Abdominal wall hernia is a defect in the muscular wall of the abdomen through which the bowel, mesentery or omentum may protrude. Clinical manifestations may be non-specific and range from mild intermittent discomfort with reducible hernias to severe acute abdominal crisis if the bowel is incarcerated or strangulated. Incisional hernias are a result of an incompletely healed surgical incision. Parastomal hernias occur through the defect formed when creating a stoma (Fig. 10). Both are common after bowel surgery in patients with Crohn’s disease.

**SECTION 3: ENTERIC DISEASES OTHER THAN CROHN’S DISEASE REFERRED FOR MR ENTEROGRAPHY**

As experience and confidence accumulates, we have found that more clinicians are keen to refer patients with more unusual small bowel disease for MR entero graphy. Typically, these are cases where the conventional practice would be to perform barium studies or CT examinations. MR entero graphy may be preferred because, like the Crohn’s disease population, patients may be young and require repeated imaging.

**Coeliac disease**

Coeliac disease is an autoimmune disorder associated with a genetic predisposition. Patients typically present with weight
loss with features of malabsorption, including steatorrhoea. Hypersensitivity to the insoluble protein gluten results in flattening of the small bowel mucosa with truncation of the villi. Mural findings are similar to the classic barium appearances, including abnormalities of the fold pattern, such as reversal of the jejunoileal fold pattern, with decreased number of folds per inch in the jejunum and an increased number of folds per inch in the ileum. This finding is specific to coeliac disease (Fig. 11). However, it is important to appreciate that in most patients the fold pattern is normal. Patients with coeliac disease may be referred for MR enterography to assess for complications including lymphoma, small bowel intussusception, ulcerative jejunoileitis, pneumatosis intestinalis and cavitating lymphadenopathy.

Systemic sclerosis
Systemic sclerosis is characterised by widespread collagen deposition in the skin, blood vessels, muscles and internal organs. Up to 50% of cases include small bowel involvement. The classical small bowel follow-through finding is a ‘hide-bound’ appearance of the jejunum and proximal ileum caused by crowding of the valvulae. Hypomotility leads to stasis, bowel dilatation and pseudo-obstruction (Fig. 12).

Peutz-Jeghers syndrome
Autosomal dominant Peutz-Jeghers syndrome combines mucocutaneous pigmentation and hamartomatous gastrointestinal polyposis. Hamartomatous polyps result from proliferation of all the three layers of the mucosa and may occur anywhere, with the small bowel being the commonest site. The malignant potential of the polyps is estimated to be 2%-20%. Differentiation from other small bowel polyposis syndromes such as familial adenomatous polyposis, Cronkhite-Canada syndrome and juvenile polyposis requires correlation with clinical and histopathological findings. MR enterography is performed to monitor for polyps exceeding 1.5-2 cm in size, which are considered for resection in view of their malignant potential. Polyps appear as luminal filling defects, often with visible stalks, which enhance homogeneously. They may cause intussusception (Fig. 13), obstruction and gastrointestinal bleeding due to ulceration.

Primary adenocarcinoma of the small bowel
Adenocarcinoma is the commonest of the (rare) malignant primary small bowel neoplasms. They are usually seen in the duodenum and proximal jejunum, and rarely in the distal ileum. Typically, they are heterogeneous, enhancing, eccentric solitary masses, although they may ulcerate or manifest as irregular circumferential wall thickening (Fig. 14). Patients with coeliac disease, Crohn’s disease and Peutz-Jeghers syndrome are all at increased risk. The prognosis is poor with a five-year survival of less than 30%.
Fig. 13 A 22-year-old woman with Peutz-Jeghers syndrome had a recent history of intermittent abdominal pain. Coronal true FISP MR enterography images show (a) multiple small polyps (arrowheads) in the jejunum and (b) a transient intussusception (arrow) in this region, presumably caused by one of the polyps acting as a lead point. Transient intussusception is a recognised complication of small bowel polyposis associated with Peutz-Jeghers syndrome.

Lymphoma

The terminal ileum is the commonest site for lymphomas. Most are non-Hodgkin’s lymphomas and have a wide range of appearances. Typically, there is circumferential wall thickening and fold effacement, accompanied by mesenteric lymphadenopathy, all due to lymphomatous infiltration. Infiltration that reduces the integrity of the muscularis layer may result in aneurysmal dilatation of the bowel lumen. Polypoid protuberances may act as lead points, causing intussusception. Deeper transmural infiltration may lead to perforation and fistula formation, which may be difficult to distinguish from Crohn’s disease (Fig. 15).

CONCLUSION

This pictorial review familiarises radiologists with the MR enterography appearance of a range of diseases unrelated to Crohn’s disease, with and without bowel wall involvement, which may clinically mimic Crohn’s disease. In addition, we included a range of unusual enteric conditions unrelated to Crohn’s disease that clinicians have referred for MR enterography over the years as experience and confidence accumulates.

REFERENCES

1. Amzallag-Bellenger I, Oudjit A, Ruiz A, et al. Effectiveness of MR enterography for the assessment of small-bowel diseases beyond Crohn disease. Radiographics 2012; 32:1423-44.
2. Kavaliauskiene G, Ziech ML, Nio CY, Stoker J. Small bowel MRI in adult patients: not just Crohn’s disease—a tutorial. Insights Imaging 2011;2:501-13.
3. Agrawal GA, Johnson PT, Fishman EK. Multidetector row CT of superior mesenteric artery syndrome. J Clin Gastroenterol 2007; 41:62-5.
4. Gayer G, Zissin R, Aptser S, Papa M, Hertz M. Pictorial review: adult intussusception—a CT diagnosis. Br J Radiol 2002; 75:185-90.
5. Menzies D, Ellis H. Intestinal obstruction from adhesions—how big is the problem? Ann R Coll Surg Engl 1990; 72:60-3.
6. Gore RM. Diseases of paediatric stomach and duodenum. In: Gore RM, Levine MS, Textbook of Gastrointestinal Radiology. 3rd ed. Philadelphia, PA: Saunders Elsevier, 2008: 2251-69.
7. Ben-Ami H, Ginesin Y, Behar DM, et al. Diagnosis and treatment of urinary tract complications in Crohn’s disease: an experience over 15 years. Can J Gastroenterol 2002; 16:225-9.
8. Yellinek S, Krizzuk D, Nogueras JJ, Wexner SD. Ureteral injury during colorectal surgery: two case reports and a literature review. J Anus Rectum Colon 2018; 2:71-6.
9. Derikx LA, Nissen LH, Drenth JP, et al. Better survival of renal cell carcinoma in patients with inflammatory bowel disease. Oncotarget 2015; 6:38336-47.
10. Outwater E, Schiebler ML, Owen RS, Schnall MD. Characterization of hemorrhagic adnexal lesions with MR imaging: blinded reader study. Radiology 1993; 186:489-94.
11. Corwin MT, Gerscovich EO, Lamba R, Wilson M, McGahan JP. Differentiation of ovarian endometriomas from hemorrhagic cysts at MR imaging: utility of the T2 dark spot sign. Radiology 2014; 271:126-32.
12. Yeap PA, Tobias ES, Mavraki E, et al. Molecular analysis of pheochromocytoma after maternal transmission of SDHD mutation elucidates mechanism of parent-of-origin effect. J Clin Endocrinol Metab 2011; 96:E2009-13.
13. Scott RJ. Familial adenomatous polyposis (FAP) and other polyposis syndromes. Hered Cancer Clin Pract 2003; 1:19-30.
14. Terada T. Malignant tumors of the small intestine: a histopathologic study of 41 cases among 1,312 consecutive specimens of small intestine. Int J Clin Exp Pathol 2012; 5:203-9.
15. Chaiyasate K, Jain AK, Cheung LY, Jacobs MJ, Mittal VK. Prognostic factors in primary adenocarcinoma of the small intestine: 13-year single institution experience. World J Surg Oncol 2008; 6:12.
SINGAPORE MEDICAL COUNCIL CATEGORY 3B CME PROGRAMME
(Code SMJ 202104B)

Question 1. Regarding magnetic resonance (MR) enterography:
(a) It is useful for assessment of small bowel Crohn’s disease.
(b) It has superior soft tissue contrast.
(c) It allows functional assessment of the small bowel.
(d) It exposes the patient to ionising radiation.

Question 2. The extra-enteric findings that can be picked up on MR enterography are:
(a) Endometrioma.
(b) Hydronephrosis.
(c) Renal cell carcinoma.
(d) Haemorrhagic ovarian cyst.

Question 3. Bowel diseases other than Crohn’s disease that can be referred for evaluation with MR enterography include:
(a) Coeliac disease.
(b) Peutz-Jeghers syndrome.
(c) Acute appendicitis.
(d) Systemic sclerosis.

Question 4. Regarding MR features:
(a) ‘T2 shading’ can be present in endometrioma and haemorrhagic cyst.
(b) The ‘T2 dark spots sign’ is indicative of chronic haemorrhage.
(c) Pheochromocytoma demonstrates avid and prolonged contrast enhancement after gadolinium administration.
(d) Pheochromocytoma shows signal loss on out-of-phase imaging.

Question 5. Regarding Crohn’s disease:
(a) There is a nearly threefold increased risk of renal cell carcinoma in patients with Crohn’s disease.
(b) Patients with Crohn’s disease are at increased relative risk of small bowel adenocarcinoma.
(c) Urinary stones are a well-recognised complication of Crohn’s disease.
(d) Intussusception may complicate Crohn’s disease.

Doctor’s particulars:
Name in full: ____________________________ MCR no.: ____________________________
Specialty: ____________________________ Email: ____________________________

SUBMISSION INSTRUCTIONS:
Visit the SMJ website: http://www.smj.org.sg/current-issue and select the appropriate quiz. You will be redirected to the SMA login page.
For SMA member: (1) Log in with your username and password (if you do not know your password, please click on ‘Forgot your password?’). (2) Select your answers for each quiz and click ‘Submit’.
For non-SMA member: (1) Create an SMJ CME account, or log in with your SMJ CME username and password (for returning users). (2) Make payment of SGD 21.40 (inclusive of 7% GST) via PayPal to access this month’s quizzes. (3) Select your answers for each quiz and click ‘Submit’.

RESULTS:
(1) Answers will be published online in the SMJ June 2021 issue. (2) The MCR numbers of successful candidates will be posted online at the SMJ website by 10 June 2021. (3) Passing mark is 60%. No mark will be deducted for incorrect answers. (4) The SMJ editorial office will submit the list of successful candidates to the Singapore Medical Council. (5) One CME point is awarded for successful candidates. (6) SMC credits CME points according to the month of publication of the CME article (i.e. points awarded for a quiz published in the April 2021 issue will be credited for the month of April 2021, even if the deadline is in June 2021).

Deadline for submission (April 2021 SMJ 3B CME programme): 12 noon, 3 June 2021.