Large bowel imaging: more than meets the eye

Introduction

The large bowel is the fourth most common site of cancer worldwide. It is the second most common cancer in the UK with approximately 30 000 new cases and 20 000 deaths a year. Other non-malignant diseases, such as diverticular disease or inflammatory or infective conditions, comprise a significant part of large bowel pathology. Patients with these conditions very often present as surgical or medical emergencies and require immediate treatment.

Imaging plays a pivotal role in diagnosing and differentiating large bowel pathologies and helps patients to get the correct treatment at the right time.

Background

The large bowel extends from the terminal ileum and ileo-caecal valve to the anus. The main components of the large bowel include the caecum, appendix, ascending, transverse, descending and sigmoid colon, rectum and anal canal.

Clinical symptoms include: abdominal pain, distension, change in bowel habits and rectal bleeding. Laboratory investigations may show iron deficiency anaemia, faecal occult blood or raised inflammatory markers in an acute setting.

Radiological investigations

Plain abdominal radiography

As other imaging techniques have evolved, the role of plain radiographs has diminished considerably. Its main role remains in patients presenting with symptoms of acute abdominal pain, where it still remains a valuable initial investigation.

Plain radiographs are useful in the diagnosis of large bowel obstruction (*Figure 1*), presence of free peritoneal air, possible presence of foreign bodies and also to look for other non-colonic pathologies such as renal stones or gall stones. Abdominal X-ray should not be performed in patients with chronic or recurrent abdominal symptoms, because of its low sensitivity and specificity.

The large bowel is characterized on plain film by its position and gas pattern. Colon is seen in the periphery of the abdominal cavity, with sigmoid and rectum usually present in the mid part of the pelvis. Mucosal folds are much thicker than in the small bowel and extend throughout the whole lumen. Haustrations and sacculations are usually most prominent in the ascending and transverse colon.

Dr Guru Karnati *is Consultant Radiologist and* **Dr Joanna Kasznia-Brown** *is Consultant Radiologist in the Department of Radiology, Musgrove Park Hospital, Taunton TA1 5DA*

Correspondence to: Dr G Karnati

Contrast studies

The double contrast barium enema has long been the mainstay of assessment of the large bowel. The bowel is prepared using a combination of dietary restriction, overhydration and osmotic purgation.

The examination itself involves filling the bowel with barium, gas insufflation and obtaining multiple abdominal X-rays of the patient in different positions. This allows good visualization of mucosal details and examination of the colonic wall from many different angles (*Figure 2*). The quality of the examination depends on a number of factors such as effective bowel preparation, patient fitness and operator experience.

Figure 1. Plain radiograph shows gas-filled dilated large bowel suggestive of large bowel obstruction.

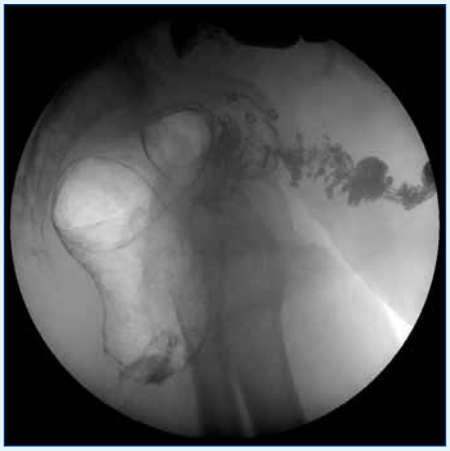


Figure 2. Double contrast barium enema shows a tight stricture in the mid sigmoid related to diverticular disease.

It requires technical excellence and thoroughness, with meticulous attention to detail balanced by sound radiological judgment.

Disadvantages include the radiation dose, the inability to assess extraluminal information and reduced accuracy of polyp or cancer detection in the presence of sigmoid diverticular disease.

The single contrast barium enema may be used in the very old, disabled or ill patient where mobility is limited to exclude obstruction or large colonic lesions.

Ultrasound

Careful graded views can provide good views of the colon, particularly the left colon. The bowel wall thickness, Doppler flow and pericolic tissues can be assessed. Newer techniques include intravenous injection of ultrasound contrast agents; this may be the surface of a small air bubble or a more complex structure. Microbubbles have a higher degree of echogenicity and thereby provide greater contrast against the background soft tissues. This technique is particularly promising in the assessment of the large bowel in inflammatory bowel diseases.

Endoluminal sonography using high frequency probes provides detailed views of the mucosa. The main role is in local staging of early rectal tumours and to demonstrate sphincter damage in patients with faecal incontinence.

Computed tomography

Computed tomography scanning is the investigation of choice for diagnosis of abdominal diseases, acute and chronic. It is extensively used to investigate acute abdominal pain. Common causes of large bowel obstruction include cancer, diverticular disease, volvulus or abscess. Computed tomography provides accurate assessment and differentiation of the various causes. Other major applications include the staging and follow up of neoplasms, assessment of inflammatory bowel disease and diverticular disease.

Standard computed tomography scanning in large bowel disease includes oral and intravenous contrast administration and scanning in the supine position. Rectal contrast administration and multiphase scanning can be used depending on clinical indications.

Computed tomography colonography

Computed tomography colonography is a relatively new imaging technique which is a less invasive alternative to colonoscopy. The computed tomography colonography scan provides information of the mucosa of the bowel in addition to its well-established role in extramural assessment.

The basic technique includes bowel preparation, distension of the colon using carbon dioxide or room air, intravenous muscle relaxants and abdominal computed tomography scanning in prone and supine positions.

Computed tomography colonography is a sensitive method for the detection of colorectal cancer. The basis of polyp detection in computed tomography colonography depends on the high contrast resolution between the colonic mucosa and the intraluminal gas (*Figures 3a* and *b*).

Intravenous contrast is usually reserved for symptomatic high risk patients and offers additional information, by increasing bowel wall conspicuity, and helping assessment of pericolic tumour infiltration, local lymph nodal involvement and spread to distant sites.

Volumetric data sets acquired are reconstructed into multiplanar two- or three-dimensional image sets (*Figure 4*), and studies are read at remote workstations.

Computed tomography colonography is well tolerated by patients and is particularly useful in frail, immobile and elderly patients. Additionally it provides information outside the colon and rectum. It can be used for staging malignant disease such as local invasion, liver metastases or lymph node spread.

The radiation dose with modern equipment and best practice can be comparable to conventional barium enema radiation dose levels.

Magnetic resonance imaging

The role of magnetic resonance imaging is well established in local staging of rectal cancer and local tumour recurrence following resection (*Figures 5* and *6*). Other uses include detecting fistulae and abscesses in inflammatory bowel disease (*Figure 7*).

The use of fast scanning techniques in magnetic resonance imaging and the development of intraluminal contrast agents are likely to lead to wider application of this modality in large bowel disease, especially polyp detection.

Figure 3. a. Supine scans of a computed tomography colonography shows a pedunculated polyp in the mid sigmoid. b. Prone scans of the same patient shows the pedunculated polyp has moved anteriorly.

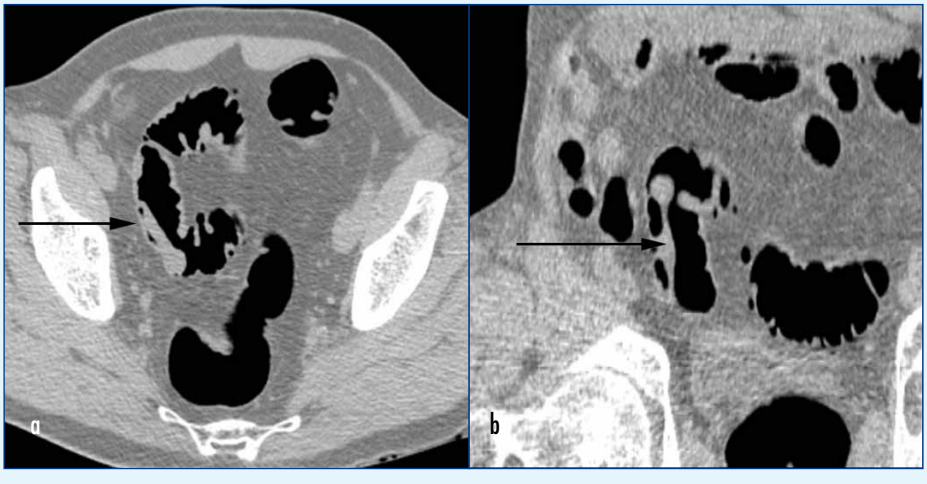


Figure 4. Three-dimensional endoluminal view of computed tomography colonography demonstrating a large tumour with surface nodularity.

Figure 5. Axial views of magnetic resonance imaging of the rectum demonstrates extramural spread, T3 rectal tumour.

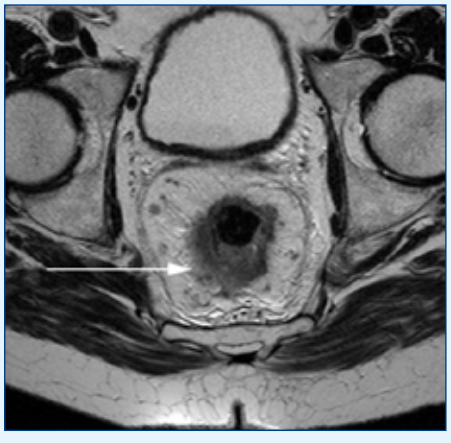
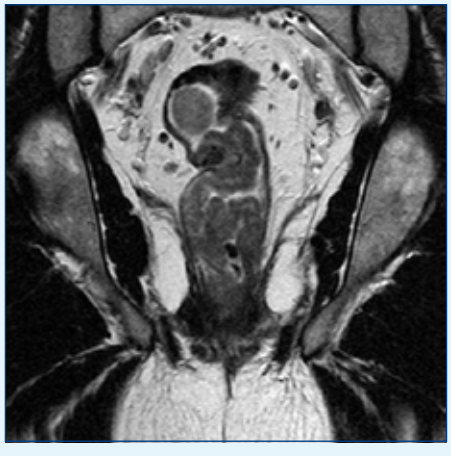


Figure 6. Coronal views of magnetic resonance imaging of the rectum and anal canal demonstrate a large anorectal tumour with no obvious extramural spread.



The single most important advantage of magnetic resonance imaging over the other imaging modalities described is the lack of ionizing radiation.

Most common colon pathologies

Polyps: benign or malignant

The single most important feature of a polyp is its size, as this is directly related to the cancer risk. A polyp less than 1 cm in size has a less than 1% chance of being malignant, whereas this rises to 20% in a polyp of more than 2 cm.

Visualization of the polyp on barium enema depends on the angle at which it is viewed and its relationship to the barium pool. Common signs of colon polyps include the meniscus sign, stalk and target sign and increased density sign.

Reported diagnostic accuracies of computed tomography colonography for polyps more than 5 mm exceeds that of conventional barium enema and approaches that of conventional colonoscopy (*Figures 3a* and *b*).

Polyposis syndromes

Familial adenomatous polyposis is associated with multiple colonic adenomas throughout the bowel. Two thirds of symptomatic patients will have an overt cancer, and all affected patients eventually develop colorectal cancer. Gardner's syndrome is characterized by extracolonic manifestations in addition to the polyposis.

Peutz–Jeghers syndrome is associated with hamartomas in the bowel, with low malignant potential.

Colorectal carcinoma

The rectum and sigmoid regions are the commonest sites for carcinoma.

The radiographic appearances on barium studies are:

- Annular constricting (apple core) lesions: the most common
- Polypoid lesions
- Infiltrating, plaque-like
- Ulcerating tumours.

Plaque-like lesions are more likely to be overlooked than polypoid or annular ones.

Computed tomography is useful for determination of local tumour spread, lymph node metastasis and distant metastasis. Accuracy of computed tomography staging of the primary tumour and lymph node metastasis varies from 48–74%. The chief limiting factor is the inability of computed tomography to detect minor degrees of perirectal or pericolic tumour infiltration and the incidence of metastatic disease in non-enlarged lymph nodes.

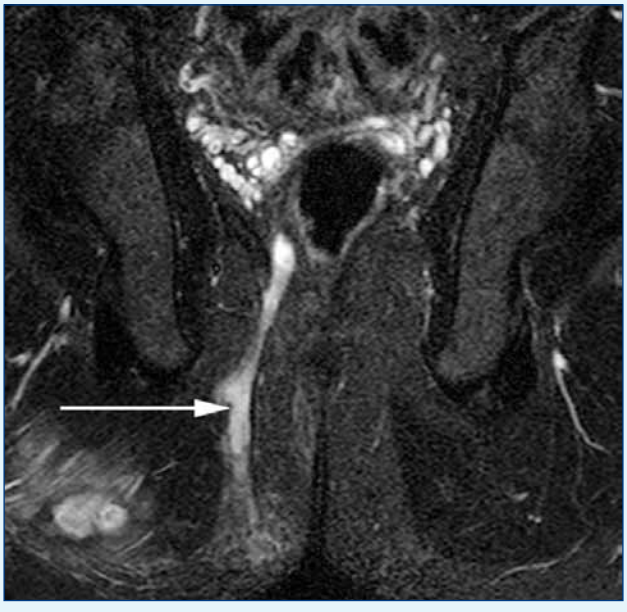
Endorectal ultrasound for rectal carcinoma staging has reported accuracies of 80–90%. This is especially useful for staging early tumours. However, there is a slight tendency to overstage tumours.

Magnetic resonance imaging is extensively used in the preoperative staging of rectal cancers. Invasion into pelvic muscles and bone by rectal tumours may be better seen on magnetic resonance imaging (*Figures 5* and *6*). The use of endorectal coils has improved T staging, but problems remain particularly related to detection of nodal metastases.

Obstruction, perforation, pericolic abscess formation, intussception or ischaemic colitis may complicate colo-rectal cancer.

Barium enema and computed tomography can often have difficulty in distinguishing extensive diverticular disease and cancer, especially in the presence of pericolic inflammation.

Figure 7. Coronal fat suppressed scans show perianal sepsis with right-sided fistula extending above the right levator muscles.



Diverticular disease

Diverticular disease is common in the elderly, being present in one third of patients over 60 years. Diverticular disease is seen predominantly in the sigmoid and distal descending colon, is characterized by the muscle abnormality and is usually associated with diverticula (*Figure 2*). The simple presence of diverticula is termed as diverticulosis. Inflammatory changes within one or more of these diverticulae is termed as diverticulitis.

The appearance of diverticula on barium enema depends on the angle from which they are viewed, degree of bowel distension, and presence of faecoliths within them. En face they are seen as rounded collections of barium. When viewed in profile or obliquely, diverticula appear as barium-coated or barium-filled outpouchings.

Barium enema is contraindicated in the presence of acute diverticulitis. Computed tomography is the modality of choice in this setting and can confirm the presence and site of inflammed diverticula, and demonstrate peri-colic inflammation and abscess.

Computed tomography signs include wall thickening and inflammation of the peridiverticular fat. In addition to detecting even small collections computed tomography can help plan management, especially in the case of abscess, surgical or percutaneous drainage.

Complications of diverticular disease include perforation, abscess, fistula formation, obstruction, venous thrombus and hepatic abscesses, haemorrhage and giant cyst formation. All these are optimally assessed using computed tomography.

Ultrasound has a limited role and is useful for guided drainages and follow up of localized collections.

Colitis

The two main groups of colitides are infective (identifiable micro-organisms) and non-specific – ulcerative colitis and Crohn's disease.

The early changes of colitis are often vascular and readily apparent endoscopically making colonoscopy a very sensitive test.

The main role of radiological imaging is to determine the extent and severity of the disease and assess complications.

Ulcerative colitis is characterized by remissions and exacerbations. Typical fea-

tures of ulcerative colitis include a finely granular mucosal pattern in the earlier stages and superficial erosions with stippled appearance in the later stages. As the lesions heal a coarsely granular appearance is seen.

More severe disease manifests as deeper ulceration, pseudopolyposis and fissuring ulceration. A narrowed, shortened and featureless colon, often referred to as a 'pipe-stem' colon, is characteristic of chronic disease.

Crohn's disease is a chronic disorder with acute exacerbations. The main feature of Crohn's disease is transmural inflammation with propensity for sinus, fistula and stricture formation. Approximately 15% of patients with this disease have colonic involvement only. The small bowel only is affected in 30%, and ileocolic involvement is present in 55%. Discrete aphthoid ulcers and discontinuous changes are usually seen.

Ultrasound shows thickening of the wall, more than 4 mm, usually the terminal ileum and proximal right colon. The surrounding fat is more reflective. The findings in computed tomography are similar with non-specific wall thickening, serosal and pericolic changes.

In chronic ulcerative colitis, there is thickening of the muscularis mucosa and submucosal fatty infiltration. There may be widening of the presacral space secondary to fatty proliferation.

Extramural changes are prominent in Crohn's disease, with fibrofatty proliferation, increased attenuation of the fat, lymphadenopathy and increased mesenteric vascularity.

Abscesses may be imaged by ultrasound, computed tomography or magnetic resonance scanning. Magnetic resonance appears useful in delineation of perianal fistulae and abscesses (*Figure 7*). Rectal involvement occurs in 50% of patients with colonic disease.

Toxic megacolon and perforation are the major complications, accounting for most colitis-related deaths.

Other causes of colitis include ischaemia, radiation and Behçet's syndrome.

Volvulus

Volvulus of the large bowel results from torsion of the colon on its mesentry. Sigmoid colon is the most common site of volvulus followed by caecum. Other sites of the large bowel are rarely involved. Plain radiographs are useful in the acute setting (*Figure 8*). Caecal volvulus usually occurs in a younger age group (30–60 years). The twisted caecal pole can be seen in the left upper or right lower quadrant depending on the plane of twist and degree of inversion. Usually a few haustral folds can be seen within the dilated segment.

Sigmoid volvulus is seen in the elderly population and results in a massively distended U-shaped inverted loop with haustral margins overlapping the lower border of the liver, dilated descending colon and the left side of the pelvis (*Figures 8* and *9*).

Conclusions

The large bowel is an important and complex organ with varied clinical presentations. The key is a multimodality approach as the different imaging techniques provide useful information and complement each other. BJHM

Conflict of interest: none.

Further reading

Begg JD (1999) *Abdominal X-rays Made Easy.* 1st edn. Churchill Livingstone, London

Chapman S, Nakielny R eds (2009) *Aids to Radiological Differential Diagnosis.* 5th edn. Saunders, Edinburgh

Dahnert W (2007) *Radiology Review Manual.* 6th edn. Lippincott, Williams & Wilkins, Baltimore

Davis M, Houston JD (2002) *Fundamentals of Gastrointestinal Radiology.* 1st edn. Saunders, Philadelphia

Gore RM, Levine MS, Laufer I (2007) *Textbook of Gastrointestinal Radiology.* 3rd edn. Saunders, Philadelphia

Grainger R, Allison D eds (2007) *Diagnostic Radiology. A Textbook of Medical Imaging.* 5th edn. Churchill Livingstone, London

Semelka RC, Ascher SM, Reinhold C (1997) *MRI of the Abdomen and Pelvis.* Wiley-Liss, New York

Figure 8. Plain radiograph shows a large gas-filled inverted U-shaped loop overlapping the left upper quadrant and pelvis, suggestive of sigmoid volvulus.

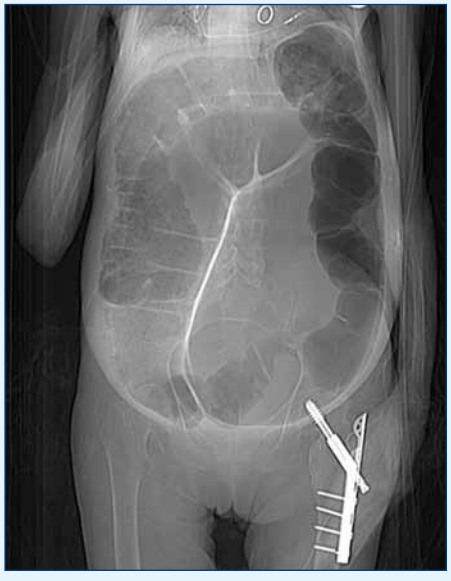


Figure 9. Coronal computed tomography of the same patient as Figure 8 confirms the diagnosis of sigmoid volvulus and also demonstrates the site of torsion and the degree of twist.

KEY POINTS

- Computed tomography remains the modality of choice for the evaluation of acute abdomen.
- Colorectal malignancy is one of the most common malignancies and imaging plays a very important role in diagnosis and management.
- Computed tomography colonography is a promising new semi-invasive technique for the detection of colorectal polyps and cancers.
- Magnetic resonance imaging is useful for local staging of rectal tumours.