The future of barium imaging

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Introduction

Barium sulphate has been used as a gastrointestinal (GI) contrast agent for over 100 years. Since the first report of single contrast barium radiography in 1910, barium techniques have evolved in parallel with technical developments such as fluoroscopic image intensification.¹ Double contrast techniques were first described in the 1920s but did not become mainstream until the 1960s and 1970s when double contrast techniques were refined. This development facilitated high quality examination of bowel segments inaccessible to compression.²⁴ Rectal tube insufflation for barium enema was followed by nasogastric tube insufflation for upper GI barium studies, eventually superseded by gastric insufflation using carbon dioxide producing oral preparations.¹

Barium techniques to examine the GI tract extend all the way from the mouth to the anal canal. They are well-established and widely practised. However, barium imaging faces stiff competition from other technical innovations that have occurred over its long history. It has become evident that the indications for which barium imaging remains the investigation of choice have diminished considerably.

Evidence of better diagnostic performance has seen several barium applications supplanted by emerging radiographic techniques. This to the dismay of "traditionalist" radiologists who appreciate and enjoy the skill required to produce high quality barium examinations, and because barium images often have an aesthetic quality independent of their subject matter or clinical utility. When endoscopy was limited to diagnosis only, the battle lines were fairly drawn but the pendulum started to swing irrevocably with the development of endoscopic techniques to biopsy and treat lesions.

This article describes the current and predicted future role of barium imaging from top to bottom (pun intended) and discusses the alternative, competing investigations in each anatomical area.

Mouth and oropharynx

The modified barium swallow (MBS) using videofluoroscopy is a dynamic evaluation of the oral, pharyngeal and upper oesophageal phases of swallowing. It is performed both to evaluate suspected disorders of swallowing and to assess the impact of therapeutic interventions. The commonest indication is dysphagia following stroke and current guidelines for this indication robustly support the MBS as the optimal investigation.⁵ However, MBS does require that the patient is fit for transfer to the fluoroscopy suite and that they are able to sit upright. Fibreoptic endoscopic evaluation of swallowing (FEES) is an alternative to the MBS which has advantages in some settings, principally that it is portable and therefore suitable for unfit patients. A further recent innovation is evaluation of swallowing using ‘real time’ MR fluoroscopy.⁶

Oesophagus, stomach and duodenum

Before the advent of flexible endoscopy the investigation of suspected upper GI disease relied heavily on barium studies. The introduction of flexible endoscopy in the late 1960s, with further development of therapeutic applications from the late 1970s onwards, has led to a progressive decline in the role of barium imaging. More recently, the development of powerful acid-suppressing drugs and reliable eradication therapy for gastric Helicobacter pylori infection has significantly reduced the need for investigation.⁷

Robust evidence-based guidelines for the management of dyspepsia recommend onward referral to secondary care for patients with recurrent symptoms or ‘alarm features’ (anaemia, weight loss). The investigation of choice is endoscopy, with barium studies being reserved only for those intolerant of endoscopy.⁸ High quality double contrast barium studies can indicate risk for Barrett’s oesophagus in patients with gastro-oesophageal reflux but follow-up surveillance for malignant transformation is with structured endoscopic biopsy protocols.⁹,¹⁰

Barium studies were traditionally employed for the assessment of anastomotic integrity after upper GI surgery. Modern practice prefers water-soluble contrast agents for fluoroscopic studies, and often CT instead. However, barium imaging remains the investigation of choice for selected complications following laparoscopic fundoplication or gastric banding surgery.¹¹,¹²

Another resilient indication for barium studies is in the investigation of suspected pharyngeal pouch (figure 1), not least because there is good evidence that barium findings correlate well with clinical outcome after surgical treatment.¹³ Oesophageal motility disorders often require a multi-modality approach, with some disorders being associated with characteristic barium findings.¹⁴ Oesophageal manometry is the definitive investigation for oesophageal dysmotility but barium studies and/or endoscopy are also recommended as the initial ‘screening’ investigations.¹⁵

Small bowel

The most common indication for small bowel investigation is known or suspected Crohn’s disease (CD). The initial diagnosis of Crohn’s disease relies on a combination of clinical, laboratory, endoscopic, histological and imaging information.¹⁶ The European Crohn’s and Colitis Organisation (ECCO) consensus on CD states that “...ileocolonoscopy and biopsies from the terminal ileum as well as each colonic segment to look for microscopic evidence of Crohn’s disease are first line procedures to establish the diagnosis. Irrespective of the findings at ileocolonoscopy, further investigation is recommended to examine the location and extent of any Crohn’s disease in the upper gastrointestinal tract or small bowel.”¹⁷

Although there is no irrefutable evidence, it is generally accepted that barium studies (follow through or enteroclysis) are more sensitive for detecting subtle, early mucosal disease than the current competitor investigations such as MR or CT enterography/enteroclysis. Thus, for suspected CD where ileocolonoscopy is unrewarding, barium studies retain...
a role for the detection of early disease. However, in patients with an established diagnosis there is no need to detect subtle mucosal disease. These patients may be effectively followed up with MR or CT enterography/enterolysis that have the advantages of detecting and depicting the peri-enteric complications that characterise CD (fistula, abscess). There are also indications that MR and CT findings may provide additional information about the stage of inflammation (acute vs chronic) which may help to guide appropriate therapy (figure 2).

A further pertinent point is that patients with CD are typically young and require repeated investigation. Accumulated ionising radiation burden is an important factor, with one in seven CD patients accumulating over 75mSv from diagnostic tests. MR enterography for follow-up of established CD avoids this risk.

Large bowel

The double contrast barium enema (DCBE) (figure 3) is a time-honoured investigation and is widely available. However, for most indications colonoscopy is the investigation of choice for suspected colorectal pathology. More recently CT colonography (CTC) (figure 4) has emerged as a further alternative to DCBE.

Colorectal cancer (symptomatic)

Current guidelines recommend colonoscopy as the most sensitive technique to diagnose colorectal cancer (also enabling biopsy and therapy). CTC is recommended as a sensitive alternative to colonoscopy. These guidelines examined a meta-analysis which concluded that CTC was “...the most accurate and best tolerated radiological imaging method of diagnosing colorectal cancer...”. This view is supported by the results of the recently published SIGGAR multicentre randomised trial comparing DCBE and CTC in symptomatic patients. The study demonstrated that CTC detects 31% more cancers or large polyps (≥10mm) than DCBE. For suspected colorectal cancer CTC has effectively supplanted DCBE as the radiological investigation of choice.

Colorectal cancer (screening)

There is no compelling evidence to support colonoscopy, CTC or DCBE as a primary modality for general population screening for colorectal cancer. The current UK Bowel Screening Programme utilises guaiac faecal occult blood (FOB) testing as the primary modality. Individuals who test positive for FOB are invited to attend for colonoscopy. Only a very small proportion of patients undergo radiological imaging, typically as an adjuvant investigation following an incomplete colonoscopy.

Individuals at increased risk of developing colorectal cancer because of familial genetic mutations, long-standing ulcerative colitis or prior history of high risk adenomatous polyps are offered colonoscopic surveillance in accordance with guidelines developed by the BSG/ACPGBI and SIGN. Ulcerative colitis

The diagnosis of ulcerative colitis (UC) is typically based on clinical suspicion augmented by appropriate macroscopic findings at endoscopy, typical histology on biopsy and exclusion of infectious agents on stool samples. Barium imaging is no longer indicated in either the acute or the non-acute setting.

Rectum and anal canal

Evacuation provography for the assessment of defaecation has been performed in specialised centres for over 50 years. The technique is associated with a high ionising radiation dose as it involves lateral fluoroscopy through the pelvis. In recent years, dynamic MR defaecography has emerged as an alternative to conventional barium technique. The MR approach has the advantage that it not only demonstrates the morphology of the bowel lumen but also the position and movement of the important soft tissue structures around the bowel during defaecation. A further advantage is that all of this additional information comes with no radiation burden. It seems likely that as the relevant equipment and expertise become more widespread, MR defaecography will supplant barium techniques.

Gastrointestinal haemorrhage

Although historically barium studies were recommended investigations in the management of acute GI bleeding, their role was being challenged almost immediately. CT angiography, endoscopy/colonoscopy and cathereter angiography have completely superseded barium imaging in the diagnosis of acute GI bleeding, with the latter having an additional therapeutic role. Current guidance for both variceal and non-variceal acute upper GI bleeding is early endoscopy and endotherapy. Similarly, for patients with massive lower GI bleeding, the initial investigation of choice is colonoscopy.

Conclusion

After a long run in the spotlight it is clear that recent years have seen a substantial contraction of indications for which barium imaging is the investigation of choice. The likely abandonment of the DCBE in favour of CTC will be the hallmark for colonic barium imaging. However, barium imaging remains the preferred modality for a limited range of indications including the MBS for functional assessment of swallowing, assessment of pharyngeal pouch, and small bowel barium studies for the detection of early, subtle Crohn’s disease. In addition, there will always be a proportion of patients intolerant of endoscopy or colonoscopy, or for whom MRI is contraindicated. The heyday of barium imaging has undoubtedly passed, a consequence of relentless innovation in diagnostic imaging, but some applications remain and they remind us all of the pivotal role barium once played in diagnostic radiology practice for so many years.

References

Figures 1
Barium swallow examination demonstrating a large pharyngeal pouch.

Figures 2A, 2B and 2C
(A) Barium follow-through examination showing persistent short segment terminal ileal narrowing and spatial separation of small bowel loops in a patient with confirmed Crohn's disease. (B and C) MR small bowel examination of the same patient as in (A) performed eight months later showing terminal ileal active disease manifest as layered bowel wall thickening.
Figure 3
Barium enema examination showing an annular carcinoma of proximal sigmoid colon.

Figure 4
CT colonography examination showing a polypoidal lesion of the sigmoid colon.