Ultrasound in the diagnosis of gastro-intestinal pathology

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The use of ultrasonography as a medical diagnostic tool dates back to the 1940s when Dr Karl Dussik, a neurologist and psychiatrist at the University of Vienna, pioneered its use in imagining the brain. The origins of sonography itself can be traced even further back to the discovery of the piezoelectric effect by Pierre Curie in 1877. Thirty-five years later, one of Curie’s students Paul Langevin adapted this concept to create a device capable of detecting submarines on behalf of the French government. This formed the basis for sonar technology which was widely used in Europe’s second Great War.

Medical men quickly cottoned onto the potential clinical uses for this new invention. Initially ultrasound was used as a therapeutic tool and throughout the 1920s and 30s was employed as an aid to physical therapy, as a cure for arthritis and gastric ulcers and even as an adjunct to radiation therapy in the treatment of cancer. Dussik, with other pioneers such as Professor Ian Donald of Glasgow, helped to promote the diagnostic applications of ultrasound.

Today, ultrasound is well established as a highly effective, radiation-free imaging modality for investigation of intra-abdominal pathology, particularly hepatobiliary disease (the first imaging of gallstones was reported by George Ludwig in 1908). However, it is not widely used for evaluation of bowel pathology due to a number of factors including operator skill and interest, prolonged scan times and availability of other imaging modalities. In this article we aim to demonstrate the value of transabdominal ultrasound in the assessment of a variety of clinical conditions, and provide a brief description of the main sonographic findings of some common gastro-intestinal pathologies. Endoscopic ultrasound is now a well-established and rapidly expanding field but its use is beyond the scope of this article.

The vast majority of abdominal ultrasound is performed using a curvilinear transducer with a banded frequency probe between 2.0-5.0MHz. In thin patients, particularly for bowel imaging, a linear 9MHz probe is used. The approach depends on the presenting complaint, a general abdominal ultrasound will cover all of the intra-abdominal organs but a more targeted examination may be performed where appropriate. In terms of bowel assessment, the area of maximal tenderness may be used as a starting point and gentle, graded pressure should be applied to displace endoluminal gas and faecal matter as well as decreasing the distance between the probe and the target. Free intraperitoneal air is best visualised in the left lateral position as air collects between the liver and diaphragm, although ultrasound is not performed for this diagnosis. Real-time imaging can provide valuable information on peristalsis, while Doppler flow imaging can be used to assess blood flow within the target organ, an abdominal mass or the major abdominal vessels.

The normal colonic wall is 4mm thick, the small bowel usually less than 2mm. There are five distinct identifiable layers representing serosa, muscularis propria, submucosa, muscularis mucosa and mucosa. The distinction between layers may be blurred, with compression causing stretching of the wall and mucosal unfolding, giving rise to a three layered appearance. Bowel wall visualisation may be improved with the use of endoluminal contrast agents, however these are not in widespread use as they are felt to be so time consuming as to negate any benefit that may arise. Ultrasound affords an opportunity to clearly visualise the bowel wall layers not as well seen on computed tomography (CT). This can be particularly helpful in assessing inflammatory bowel disease/colitis and in evaluating depth of tumour extension.

The following is an overview of some of the common gastro-intestinal pathologies and their sonographic appearances.

Biliary pathology
The most widely used application of ultrasound in gastro-intestinal pathology is in the diagnosis of biliary tract disorders, with a quoted sensitivity and specificity of 95-97%. The position and saccular structure of the gallbladder makes it highly amenable to examination by ultrasound. The normal gallbladder wall is <3mm thick. Stones and sludge may easily be visualised within the gallbladder itself, or indeed within the bile ducts. Gallbladder wall thickening and peri-cholecystic fluid may also indicate an acute inflammatory process. Bile duct diameter may be readily assessed, with dilatation >6mm usually indicative of distal obstruction. Elderly and post cholecystectomy patients may have a larger diameter and still be within normal range.

Appendicitis
Acute appendicitis is classically a clinical diagnosis, however it is becoming more and more common to image patients prior to surgery, especially in cases of diagnostic uncertainty and in females where gynaecological causes of right iliac fossa pain may complicate the clinical picture. A normal appendix is visualised as a blind ending, mobile, compressible tubular structure with an overall diameter of <7mm. Ultrasound diagnosis of acute appendicitis can be made based on an increase in the overall diameter together with a wall thickness >3mm (figure 1). Classically, the inflamed appendix has a target-like appearance when viewed in transverse. An appendolith may be visualised within the inflamed appendix. There may also be surrounding free fluid or even abscess formation.

Diverticulitis
Several studies have shown sonography to be comparable to computed tomography in diagnosis of uncomplicated diverticulitis (sensitivity of 84-91%). This can be increased further by the use of endorectal or endovaginal scanning. Sonographic features of acute diverticulitis include the “dome” sign, representing an outward hemispheric protrusion from the colonic wall (figure 2). There may also be localised hypoechoic thickening of the adjacent colonic wall. The pericolonic fat may show signs of infiltration, appearing as a thickened echogenic mass. Abscess formation may also be seen.
Inflammatory bowel disease
Sensitivity may be as high as 89.7% and specificity 96% in diagnosing Crohn’s disease, figures comparable to those for CT. The affected segment is typically aperistaltic, rigid and incompressible with preservation of the layers of the bowel. It may be encased by a uniform hyperechoic layer of fatty tissue with a mass effect sometimes referred to as ‘creeping fat’. It has been suggested that sonography could be used to evaluate response to therapy in patients with Crohn’s disease, thereby avoiding irradiation or endoscopy, which may be associated with a higher morbidity in those with severely inflamed bowel. It may also be useful in detecting post-surgical recurrences of inflammation.

Intussusception
Ultrasound is the diagnostic modality of choice in children with suspected intussusception. The ‘multilayered target’ is typical of this condition, representing the muscle layers of the intussusceptum and intussuscipiens with the trapped mesenteric fat in between (figure 3). Sensitivity and specificity of diagnosis with ultrasound has been reported as high as 100%. It may represent underlying malignancy in adults or other pathology acting as a lead point. A transient intussusception may occur in coeliac disease (up to 20% patients).

Tumours
Gastric tumours – Endoscopic ultrasound has gained widespread acceptance in the diagnosis of upper GI tumours. Trans-abdominal ultrasound may also be useful, showing diffuse wall thickening and/or a mass with destruction of the normal bowel layers. This is particularly true in the pylorus and gastric antrum. Local and regional nodal involvement may also be seen.

Colonic tumours – Classically seen as a concentric, symmetric, short segment of bowel wall thickening contour or as a hypoechoic, irregularly shaped, lobulated, solid mass involving the colonic wall. Polypoid tumours appear as focal, irregular colonic wall thickening. The diseased lumen is typically severely narrowed. Abrupt loss of layer stratification is characteristic of malignancy. Regional nodal disease may also be apparent, as may more distant metastases.

Conclusion
Ultrasound has a role to play in the diagnosis of gastrointestinal disorders. It is a radiation-free modality which is especially useful in children and pregnant women, but is also valuable in reducing the radiation exposure to patients with chronic conditions such as inflammatory bowel disease. Its primary role in hepatobiliary disorders is well established. Bowel ultrasound, while a time consuming study requiring dedicated, trained sonographers, can yield accurate diagnostic information in a wide variety of conditions.

Further reading

FIGURE 1
Acute appendicitis. Longitudinal view showing increased diameter, a thickened wall and surrounding fluid.

FIGURE 2
Transvaginal ultrasound showing acute diverticulitis with the “dome sign” (arrow). Normal sigmoid colon and compressed lumen also visible.

FIGURE 3
Intussusception. Multiple concentric rings representing the muscle layers of the intussusceptum and intussuscipiens with the trapped mesenteric fat in between.