Sonographic demonstration of stomach pathology: reviewing the cases

Abstract

Introduction: The stomach can be the source of complaints for many patients attending for upper abdominal ultrasound. It is not routinely imaged as part of most upper abdominal ultrasound protocols, with sonographers and sonologists alike commonly muttering the line; "I can't see the stomach on ultrasound". However, this is incorrect, as the gastric antrum can almost always be visualised sonographically.

Discussion: It is possible to detect a range of pathologies affecting the stomach sonographically, from common, largely tolerable conditions such as hiatus hernias through to life-threatening neoplasms.

Conclusion: The stomach can easily be assessed during routine abdominal ultrasound providing the sonographer has knowledge of stomach anatomy, normal ultrasound appearances and limitations to its visualisation. While endoscopy is the gold standard for investigation of the stomach and upper gastrointestinal tract, many patients will initially present for abdominal ultrasound due to its easy, non-invasive nature, ready availability and low cost. For patients with mild abdominal symptoms, a normal abdominal ultrasound may be the extent of their imaging investigations meaning stomach pathologies may go undiagnosed.

Keywords: abdominal ultrasound, gastric adenocarcinoma, gastric cyst, hiatus hernia, Ménétrier's disease, stomach imaging.

Alison Deslandes

BMRad[NM], GradDip
MedSono, AMS

North Coast
Radiology Group
New South Wales
Australia

Correspondence to email
ali.alec@iinet.net.au

Introduction

Normal Anatomy

The stomach is the first part of the gastrointestinal tract located within the abdominal cavity. It is located in the left upper quadrant and is shaped like a bagpipe. The anterior wall neighbours the left lobe of liver, abdominal wall and transverse colon. The posterior wall lies adjacent to the pancreas, spleen and left hemi diaphragm.¹

Ultrasound assessment of the stomach

The stomach can be easily visualised with transabdominal ultrasound. Hambridge, *et al.*² were able to visualise the gastric antrum in 100% of patients in their recent study although the body and fundus were not viewed so readily. A six-hour fast is required for an ultrasound examination of the stomach. The patient should be given 400 mL of still water to drink immediately prior to imaging. This must be consumed as quickly as possible to minimise ingestion of air.

Begin by locating the gastroesophageal junction (GEJ) by placing the probe just to the left of the xiphisternum and rotating so the probe is pointing towards the right shoulder. The GEJ will be seen deep to the left lobe of liver below the diaphragm and deep to the heart above.

To assess the rest of the stomach, locate the pylorus or first part of the duodenum in the right upper quadrant (RUQ). From there, move

the probe left to assess the short axis of the stomach. The probe will need to be angled up on an oblique angle at the left costal margin in order to assess the body and fundus. To assess the long axis, hold the probe transversely on the epigastric region of the abdomen and fan the probe (cranial to caudal). Repeat this (left to right) until you have adequately seen the entire stomach. Table 1 shows a quick reference guide to assessing the stomach.

The greater curvature of the stomach can sometimes be assessed by utilising the spleen as a window. Colour Doppler assessment should be performed on any area of abnormality. Flow setting need to be optimised for low-flow.

Normal ultrasound appearance

The stomach walls appear as three discreet layers on ultrasound and have a train track like appearance. The inner mucosa and outer serosa appear echogenic. Between these two echogenic lines, the hypoechoic muscularia propria can be seen (Figure 1). The stomach wall should measure no more than 5 mm³ in the body and fundus and 7 mm at the gastric antrum.⁴

The gastric mucosa (rugae) can be seen as echogenic folds of mucosa that are best appreciated in real-time. Peristalsis should be visualised throughout the entire organ every few seconds however, if the patient has been

Table 1: Assessment protocol.

Assessment	Assess For		Normal Findings	Imaging pitfalls
<ul style="list-style-type: none"> • Give 400 mL of water to drink • Locate the GEJ by scanning just left of the xiphisternum, probe pointing towards right shoulder • Locate the pylorus in the RUQ and sweep probe left to assess short axis of stomach • Repeat at 90° to assess long axis • Obliquely angle probe upwards under the left costal margin to assess fundus • Utilise multiple patient positions (Supine, RLD, erect) 	Gastroesophageal Junction	<ul style="list-style-type: none"> • Presence • Widening of the alimentary tract 	<ul style="list-style-type: none"> • Should be visible • Distal esophagus < 16 mm 	<ul style="list-style-type: none"> • Body Habitus
	Fundus/ Body/ Antrum walls	<ul style="list-style-type: none"> • Layering • Thickening 	<ul style="list-style-type: none"> • Wall thickness < 5 mm (body/ fundus) • < 7 mm antrum 	<ul style="list-style-type: none"> • Gas within the stomach may obscure walls • Peristalsis may periodically thicken walls • Fundus and body may not be fully visible due to their high subcostal location
	Stomach contents	<ul style="list-style-type: none"> • Peristalsis • Contents within the stomach 	<ul style="list-style-type: none"> • Peristalsis in real-time • Empty cavity 	<ul style="list-style-type: none"> • Antispasmodic drugs (buscopan) may reduce peristalsis • Non-fasting

Figure 1: The stomach walls are seen on ultrasound as three distinct layers. The inner mucosa (red arrow) appears as a thin, echogenic line; the central muscularis propria appears as a thicker, hypoechoic line (blue arrow); and the outer serosal layer (green arrow) appears as a thin echogenic line. The contour of the entire organ should be smooth with the exception of the small folds of gastric mucosa (rugae) often visible in real-time.

taking antispasmodic medication (buscopan) this will reduce peristalsis. The stomach will appear as a large cystic organ when distended with fluid (Figure 2). When distended with clear fluid, the stomach should appear anechoic with the possible exception of small echogenic foci due to gas.

Colour Doppler may show a very small amount of flow within the walls. This can be difficult to detect as the peristalsis

of the stomach will often cause colour noise. If colour is readily seen within the walls, this is abnormal.

Visualisation of the stomach, particularly the body and fundus can be limited by its position relative to the ribs (a high sitting stomach many not be seen well). Overlying gas in the transverse colon can also obscure its view. The presence of food within the stomach has the potential to create a false-positive

Figure 2: A stomach distended with 200mL of water. The stomach walls appear obviously smooth when distended and takes on a cystic appearance. The anechoic content is the water. The small, echogenic specks within the water are due to bubbles of air and are normal to see and will be mobile in real-time.

Figure 3: A simple cyst of the stomach. It can be seen abutting the posterior wall of the left-lobe of liver however, the exact origin of this cyst is not clear as gas within the stomach is obscuring the posterior anatomy.

Figure 4: The stomach has been distended with 200 mL of water in this picture. The cyst can now be clearly seen as a separate structure from the left-lobe of liver and is arising from the anterior wall of the stomach in the gastric antrum region.

Figure 5: This is a mid-sagittal image through the left upper quadrant demonstrating the left lobe of liver and heart anteriorly. The GEJ is seen directly posterior to the liver and heart as indicated by the white arrow. Note the hiatus hernia shown by the funnel-like widening of the distal esophagus.

result and as such, careful attention to the patients fasting state needs to be considered when assessing the stomach.

Case one: Simple cyst

Case details

A 25-year-old female presented with 6 weeks of abdominal pain radiating to the back. While assessing the epigastric region, a 10mm cystic structure was seen posterior to the left lobe of liver but

appearing separate from the pancreas (Figure 3). Approximately 200 mL of water was given to the patient to drink in order to highlight the stomach and assist with anatomic localisation of the cyst. With the stomach distended, the cyst was clearly seen arising from within the stomach wall anteriorly (Figure 4).

Discussion

Gastric cysts are a rare finding regardless of the modality utilised

Figure 6: This is a transverse section through the stomach with the patient in an erect position after ingesting 200 mL of water. Multiple echogenic, polyp-like lesions can be seen arising from the stomach walls and protruding into the fluid-filled cavity. These remained fixed their position when the patient was in both the erect and supine position, confirming their attachment to the stomach wall.

to diagnose them and their etiology. A simple appearing cyst is unlikely to be of any clinical significance however, follow-up of such lesions with endoscopic ultrasound has been shown to be useful in further evaluating the nature of the cyst and reveal or rule out any malignant potential not visible by transabdominal ultrasound.⁵ If proven benign, monitoring is advisable as large gastric cysts can become symptomatic causing abdominal pain, weight-loss and nausea. In cases of large gastric cysts, both surgical resection and endoscopy-guided aspiration have been shown to be effective treatment options.⁶

Case two: hiatus hernia

Case details

A female patient in her fourth decade presented for abdominal ultrasound with chest and upper abdominal pain. She had a history of gastroesophageal reflux disease (GORD).

The upper portion of the stomach and the gastroesophageal junction (GEJ) were well visualised within the left upper quadrant. A funnel-like widening of the esophagus was seen at this point (Figure 5) consistent with hiatus hernia.

Discussion

Hiatus hernia is an anatomic abnormality in which the stomach is displaced into the thorax through a defect or weakness within the diaphragm. It is a common occurrence affecting approximately 15% of the population with a markedly increased incidence in the population over 50 years-of-age.⁷ The most common symptom of hiatus hernia is GORD.

There are two types of hiatus hernias, sliding and paraesophageal. Sliding hernias are those in which the gastroesophageal junction (GEJ), and a portion of stomach, transiently moves into the thorax with swallowing. Paraesophageal hernias occur when the GEJ is normally located but part of the stomach is permanently located within

the thorax. This variety is more prone to complication than sliding hernias, however, is much less common⁷. Hiatus hernia is usually diagnosed by barium studies or endoscopy. In severe cases, surgery will be required to correct the hernia.

The use of ultrasound in the diagnosis of hiatus hernia is uncommon and there is little mention of it within the literature. However, its potential to be a useful imaging modality has been reported. Aliotta, *et al.* reported ultrasound findings of non-visualization of the GEJ and a widening of the alimentary tract at the diaphragmatic hiatus (greater than 16 mm) to have a 100% positive predictive value for sliding hiatus hernia. In normal subjects, the GEJ should always be visible and the alimentary tract at the diaphragmatic hiatus should range from 7–10 mm.⁸ There were no reports of paraesophageal hiatus hernias being seen on ultrasound within the literature reviewed.

Case three: Ménétrier's disease

Case details

An 81-year-old male presented for upper abdominal ultrasound with bloating and general malaise. He had undergone a cholecystectomy and gastroscopy revealing ulcers 40 years earlier but had been in generally good health since then. His ultrasound was unremarkable, however his pancreas could not be seen due to overlying gas. Approximately 200 mL of water was given to the patient to drink with the intention of displacing the gas and allowing for visualisation of the pancreas. Once distended with fluid, multiple polyp-like lesions could be seen arising from the gastric mucosa and projecting into the stomach cavity (Figure 6). The patient was quizzed about fasting and denied consuming anything since the previous evening. The lesions were present and unchanged in multiple patient positions and could be seen swishing back and forth in real-time confirming that they were attached to the stomach wall.

The ultrasound features were suggestive of Ménétrier's

Figure 7: This is a transverse image through the stomach in the lower gastric antrum/ pyloric region. The stomach can be seen as a “target” like structure. The organ to the left of the image is the liver, and to the right lays the pancreas. Note the intense hypoechogenicity of the stomach walls in comparison to these organs.

Figure 8: This is a longitudinal image of the stomach in the lower gastric antrum pyloric region with colour Doppler. Colour Doppler shows hyperemia of the walls. This is an abnormal finding.

Disease, which is also known as hypoproteinemic hypertrophic gastropathy.

Discussion

Ménétrier's disease is a rare condition characterised by a benign enlargement of the rugae. It most commonly presents in men between the ages of 30 and 60.⁹ The exact cause is unknown, however it is believed the disease is triggered by a virus (cytomegalovirus) or bacterial infection (*Helicobacter pylori*). Patients will typically present with post-prandial pain, vomiting and weight loss. Although benign, it carries an increased risk of low plasma protein levels, ulceration and gastric carcinoma.¹⁰ As such, screening gastroscopy is advisable for sufferers. There is no known treatment available so sufferers are usually assigned a high protein diet to compensate for the protein loss.

Case four: gastric adenocarcinoma

Case details

A 43-year-old male first presented to his GP with pain in the abdomen and back. He underwent several investigations (plain radiographs, pathology, physical and CT) but no cause could be identified and he was offered pain-relieving medication only. The patient had a history of drug and alcohol abuse and was unwilling to take medication for fear of addiction, so he stopped seeing his GP, and decided to “just deal with it”.

He re-presented to his GP after 8 months as the pain had become unbearable. He had also developed fatigue, nausea and shortness of breath. On physical examination his liver was enlarged and blood tests revealed extremely elevated Alkaline Phosphatase (ALP) of 664 IU/L (normal 40–120 IU/L). An upper abdominal ultrasound was ordered to assess the liver.

The patient limited the technical quality of the scan. Although

Figure 9: Elevated ALP in a patient with a primary malignancy is a strong indicator of bony metastases. Along with this patient's severe pain, his elevated ALP warranted investigation. The whole body bone scan above shows markedly increased Tc99m-MDP uptake throughout the ribs, spine, skull, pelvis, both humeri and both femora consistent with widespread bony metastases.

very thin, his severe pain made lying flat and still very challenging and his shortness of breath made breathing techniques difficult.

Real-time scanning of the pancreas, aorta, liver, gallbladder, bile ducts, kidneys and spleen revealed no abnormality. Assessment of the epigastric region revealed thickened (12 mm) and hypoechoic (Figure 7) gastric antrum walls. Colour Doppler revealed a small amount of vascularity within the walls (Figure 8). These findings were highly suspicious for neoplasm.

The patient was admitted to hospital the following day because of the ultrasound findings. He underwent endoscopy with biopsy that confirmed the diagnosis of gastric adenocarcinoma.

Due to his extremely elevated ALP, he underwent a nuclear medicine bone scan to determine the presence and extent of bony metastases. The bone scan revealed increased uptake throughout the entire axial skeleton as well as areas of increased uptake in the long bones consistent with wide spread bony metastases (Figure 9). Due to the advanced stage of the disease, only palliative care was offered and the patient subsequently passed away.

Discussion

Gastric adenocarcinoma is the second most common malignancy worldwide although in Australia, it affects approximately 1 in 153 people making it significantly less prevalent than several other cancers (breast, lung and melanoma).¹¹ It typically presents after the age of 40 and affects twice as many men as women. Risk factors include smoking, poor diet, excessive alcohol consumption, obesity, chronic atrophic gastritis, hypertrophic

gastropathy (Ménétrier's disease) and gastric polyps.^{11,12} There is a well-recognised association between gastric carcinomas and the helicobacter pylori bacterium.¹¹⁻¹³

The clinical diagnosis of gastric adenocarcinoma is difficult in the early stages when the disease is surgically curable as approximately 50% of sufferers will be asymptomatic.¹² Early signs present in the symptomatic population include abdominal pain, belching, loss of appetite, nausea, vomiting, abdominal fullness, fatigue and weight loss.¹³ As these symptoms are vague and associated with many common, minor gastric disorders, sufferers will often delay seeking medical advice. Symptoms worsen as the disease progresses and diagnosis is often made once the cancer has reached an advanced stage or metastasized¹³, as was true for the patient in this case.

The gold standard for diagnosis of gastric adenocarcinoma is endoscopy^{4,11-14} as it allows for direct visualization of tumour location, the extent of mucosal involvement and simultaneous biopsy for definitive diagnosis. Upper gastrointestinal barium studies are considered to have equivalent diagnostic capabilities to endoscopy, although endoscopy is favoured.¹² The use of endoscopic ultrasound for staging is widely accepted. Willis, *et al.* found a 78% accuracy rate in determining the T stage from endoscopic ultrasound and found it to be a valuable pre surgical tool.¹⁵

One of the strongest indicators of gastric adenocarcinoma on ultrasound is thickening of the stomach wall.^{3,4,16} Rapaccini, *et al.* reported a mean antrum thickness of 5.1 mm ($\pm$ 1.1mm) in normal subjects and mean antrum thickness of 15.9mm ($\pm$ 4.4

mm) in neoplastic subjects⁴. The gastric antrum of the patient in this case measured 12 mm, which is consistent with neoplasm by these findings. Marginal wall thickening (5–8 mm) without a loss of normal wall stratification is more suggestive of a benign process rather than neoplasm¹⁶.

Few studies have been conducted into the usefulness of abdominal ultrasound as a diagnostic tool for assessing the stomach. However, the small amount of literature there is has shown transabdominal ultrasound to be a reliable modality for the diagnosis of gastric carcinoma.

Singh and Chowdhury³ correctly identified all cases of gastric carcinoma with transabdominal sonography in their study of symptomatic patients undergoing endoscopy for investigation. They also found ultrasound was able to determine which layers were affected and the local anatomical relationship which endoscopy alone cannot. Rappacinni, *et al.* 1988⁴ found stomach wall thickening was visible by transabdominal ultrasound in all cases of gastric carcinoma diagnosed by endoscopy and biopsy. Abdominal ultrasound can also be used to screen for secondary spread (local lymph nodes and liver metastases) at the time of initial assessment.

Conclusion

Pathologies of the stomach can be detected on ultrasound even though there exists a large belief in the ultrasound community that they cannot. As the capabilities of ultrasound instrumentation increases, it is likely the range of pathologies we can detect within the stomach will also increase along with the ease with which we see them.

The literature reporting stomach findings using transabdominal ultrasound is minimal, however those studies that have been conducted have shown great potential of this modality.

As transabdominal ultrasound is low in cost, readily available and very low risk when compared both endoscopy and barium studies, it has potential to play a greater role in the diagnosis and monitoring of gastric conditions, particularly benign conditions such as hiatus hernia. Further studies in this area are needed to determine its true diagnostic power.

Ultrasound findings suggestive of a stomach abnormality include increased stomach wall thickening, loss of normal wall stratification, widening of individual layers, loss of wall echogenicity, reduction in peristalsis and solid or cystic focal lesions^{3,16}. These features are easy to see sonographically, especially if the scanning sonographer has good skills in recognising the normal echo pattern of the stomach.

The early symptoms of gastric adenocarcinoma are vague and non-specific (nausea, pain, weight-loss). These are however, the exact symptoms many patients will present for an abdominal ultrasound suffering from, and for these patients, a normal abdominal ultrasound may be the extent of their imaging investigations. Taking a few seconds to assess the stomach during an upper abdominal ultrasound could be life saving for these patients.

Acknowledgements

Case One and Three: Dr Scott Hawkins

Case Two: The team at Ultrasoundpedia (www.ultrasoundpedia.com)

Case Four: Mr Bill Dunn and Dr John Mulholland (North Coast Radiology Group)

References

- 1 Kapoor VK. Stomach Anatomy [Internet]. *Medscape Reference Drugs, Diagnosis and Procedures* 2011; 2–6. Available at <http://emedicine.medscape.com/article/1899301-overview#aw2aab6b3>. Verified October 2013.
- 2 Perlas A, Chan VWS, Lupu CM, Mitsakakis NHA. Ultrasound Assessment of Gastric Content and Volume. *Anesthesiology* 2009; 111 (1): 82–89.
- 3 Singh S, Chowdhury V. Efficacy of high resolution transabdominal sonography of the fluid filled stomach in the evaluation of gastric carcinomas. *Indian J Rad Imag* 2005; 15 (4): 421. Available at <http://www.ijri.org/text.asp?2005/15/4/421/28763>. Verified October 2013.
- 4 Rapaccini GL, Aliotta A, Pompili M, Grattagliano AAM. Gastric wall thickness in normal and neoplastic subjects: a prospective study performed by abdominal ultrasound. *Abdom Imaging* 1988; 13 (3): 197–9.
- 5 Tanaka M, Akahoshi K, Chijiwa Y, Sasaki I, Nawata H. Diagnostic value of endoscopic ultrasonography in an unusual case of gastric cyst. *Am J Gastroenterol* 1995; 90 (4): 662–3. Available at <http://www.ncbi.nlm.nih.gov/pubmed/7717335>. Verified January 2013.
- 6 Hlouschek V, Domagk D, Naehrig J, Siewert JR, Domschke W. Gastric duplication cyst: a rare endosonographic finding in an adult. *Scand J gastroenterol*; 40 (9): 1129–31. Available at <http://www.ncbi.nlm.nih.gov/pubmed/16211721>. Verified January 2013.
- 7 Marks JW. Hiatal Hernia Causes, Symptoms, Diagnosis, and Treatment Produced by Medical Doctors on MedicineNet.com. *Medicinenet.com*. Available at http://www.medicinenet.com/hiatal_hernia/article.htm. Verified January 2013.
- 8 Aliotta A, Rapaccini GL, Pompili M, Grattagliano A, Cedrone A, Trombino C, *et al.* Ultrasonographic signs of sliding, gastric, and hiatal hernia: their prospective evaluation. *J Ultrasound Med* [Internet]; 13 (9): 665–9. Available at http://cat.inist.fr/?aModele=a_ficheN&cpsidt=4211020. Verified January 2013.
- 9 National Institute for Health (NIH). Ménétrier Disease. *National Digestive Diseases Information Clearinghouse (NDDIC)*. 2009. Available at <http://digestive.niddk.nih.gov/ddiseases/pubs/menetrier/>. Verified January 2013.
- 10 Burdick JS, Chung E, Tanner G, Sun M, Paciga JE, Cheng JQ, *et al.* Treatment of Ménétrier's Disease with a Monoclonal Antibody against the Epidermal Growth Factor Receptor. *N Engl J Med* 2000; 343 (23): 1697–701. Available at http://www.medicinenet.com/hiatal_hernia/article.htm. Verified January 2013.
- 11 Barbour A. Stomach (Gastric) Cancer. *Surgical Oncology and Laparoscopy*. Available at [http://www.cancer.net.au/page/Stomach-\(Gastric\)-Cancer.aspx](http://www.cancer.net.au/page/Stomach-(Gastric)-Cancer.aspx). Verified January 2013.
- 12 Dicken BJ, Bigam DL, Fris C, Cass C, Mackey JR, Fris C, *et al.* Review and Considerations for Future Directions. *Ann Sur* 2005; 241 (1): 27–39.
- 13 Dugdale D, Chen Y, Zieve D. Gastric Cancer [Internet]. *MedlinePlus*. Available at <http://www.nlm.nih.gov/medlineplus/ency/article/000223.htm>. Verified May 2011.
- 14 Schoelmerich J, Diaz A, Volk BA, Spamer C, Brambs HJ GW. Clinical significance of abnormalities of the gastrointestinal tract detected by abdominal ultrasound. *Dig Dis Sci* 1988; 33 (3): 257–62.
- 15 Willis S, Truong S, Gribnitz S, Fass J SV. Endoscopic Ultrasonography in the preoperative staging of gastric cancer: accuracy and impact on surgical therapy. *Surg Endo* 2000; 14 (10): 951–4.
- 16 Wong M, Shum S, Chau W, Cheng C. Carcinoma of stomach detected by routine transabdominal ultrasound. *Biomed Imag Interv J* 2010; 6 (4): e39. Available at <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3097801&tool=pmcentrez&rendertype=abstract>. Verified January 2013.