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Pitfalls in ultrasound imaging of the stomach and the intestines

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Abstract

The gastrointestinal tract is an extraordinary human organ in terms of its morphology and function. Its complex structure and enormous length as well as frequent presence of gas discourage many doctors performing ultrasound examination from its exploration. Moreover, there are anatomical structures in multiple locations which can mimic certain abnormalities. It is difficult to present an exhaustive account of the problem of gastrointestinal tract ultrasound imaging errors in a single work; therefore, this study focuses mainly on false positive errors which usually result from a lack of knowledge of anatomical variants of the gastrointestinal tract structure. In the case of the stomach, rugae and muscle layer thickening towards the pylorus have been mentioned, which constitute variants of the structure of this organ examined when empty. Diagnostic pitfalls in the small intestine may include the dudenojejunal flexure (ligament of Treitz), the horizontal part of the duodenum and the ileocaecal valve. The status of the apparent lesions in all of the cases mentioned will be resolved following fluid intake by the patient. In the colon, the varied structure of semilunar folds should be taken note of. Their large thickness can warrant suspicion of wall invasion or a polyp. In addition, the study emphasises the importance of appropriate preparation of a patient for gastrointestinal tract examination since it determines the accuracy of the diagnosis. The authors also take note of common 'sins' of physicians such as hasty examination and failure to comply with the stomach and appendix examination protocol.

After thousands of years have passed, there are still various errors being made by physicians at various stages of diagnosis and treatment of patients, including in diagnostic imaging such as sonography. Berlin analysed 11,203 court cases associated with medical malpractice, 12% (1391) of which concerned radiology. Diagnostic errors accounted for the highest number of errors (40%)[1]. It was determined that among 182 radiological mistakes described by Renfrew *et al*.[2] 126 resulted from errors of perception (64 false negatives, 15 false positives and 47 cases of incorrect classification). To begin with, a general distinction needs to be drawn between error and negligence of a medical standard in force, particularly regarding sonography. Even though the effect on the patient may be similar in both cases, the legal consequences will be very different for the physician. A professionally conducted examination, i.e. the one which is conducted according to a standard in force, not only reduces the number of errors, but also receives lenient treatment in court. Renfrew *et al*.[2] list the following causes of errors in radiology based on Smith's work:

- a high level of complacency, which leads to false positives;
- faulty reasoning, which results in an erroneous classification of a lesion through a tendency to overdiagnose, with the diagnosis in itself being rightly positive;
- lack of knowledge, which contributes to a lesion being detected, but results in its erroneous interpretation;
- underreading, which runs the risk of a false negative error;

Fig. 1. *A sonogram showing distal appendicitis (arrow)*

- poor communication: a lesion has been detected and correctly classified, but information has not been properly relayed to a clinician;
- miscellaneous: a lesion was not identifiable even in retrospection, which may be due to the procedure's limitations or its incorrect performance; this error leads to a false negative error;
- complications: adverse effects which are associated with the type of procedure, usually an invasive one.

The data presented indicate that the most common errors include false negatives and false positives. At this point it is worth taking note of the inherent features of sonography associated with a significant restriction of ultrasound propagation in gas, bone tissue and adipose tissue and a high ability of ultrasound to produce artifacts. These may cause examiners to avoid such areas since examining them requires the use of variable imaging access and artifacts as an important diagnostic sign[3]. The main factor discouraging from ultrasound examination of the gastrointestinal tract is the fairly common presence of gas, whose significance is definitely exaggerated. Even in ileus, in which gas is usually a dominant sign, high diagnostic indicators can be achieved by applying the right examination protocol[4]. Despite these difficulties ultrasound has consolidated its position in the diagnosis of gastrointestinal diseases as the method of first choice, e.g. for hypertrophic pyloric stenosis, for suspected ileus, tumours and inflammation, as well as for treatment efficacy follow-up[4–13]. This examination, unlike other, more sophisticated imaging techniques such as CT or MRI, requires expert command of all imaging modes, starting from grey scale in various improved versions (including 3D and 4D) through Doppler options and ending with contrast-enhanced ultrasound (CEUS), sonoenteroclysis, double contrast-enhanced ultrasound (DEUS) of the gastrointestinal tract, sonoelastography and guided fine-needle aspiration biopsy. Except for emergency indications sonographic examination of the gastrointestinal tract should be preceded by appropriate preparation of the patient for the procedure. In order to enable a correct assessment of the gastrointestinal tract, the patient is required to abstain from consuming any food and drinks, smoking and chewing gum for 6–8 hours before the procedure and asked not use any anti-gas remedies[13–16]. An example of bad preparation is, for instance, drinking even a few mouthfuls of a neutral liquid since during this activity some amount of air is also consumed, which initiates digestion with the secretion of an appropriate amount of gastric juice. Bad preparation significantly reduces the chance for the diagnosis of a number of pathologies whose first sonographic sign is often an increased amount of liquid in the stomach and the small intestine. These include, but are not limited to:

- gastric hypersecretion;
- gastritis of various origin;
- diabetic gastropathy;
- duodenogastric reflux;
- Zollinger–Ellison syndrome;
- functional dyspepsia;
- pyloric stenosis;
- high ileus;
- complications following gastrectomy (vagotomy, small stomach syndrome);
- malabsorption syndrome;
- small intestinal bacterial overgrowth and others.

Sonography is a real-time imaging technique which allows for a continuous observation of gastrointestinal structure behaviour during various dynamic tests. Transducer compression is, for example, recommended in the examination of the intestines since it enables to determine the plasticity, movability and pain reaction of a given lesion and improves its image by reducing the distance from the transducer. Moreover, this manoeuvre can move gas away from the region of interest (ROI)[6,7,13–15]. Failure to use this test sometimes results in the lack of visualisation of appendicitis[6,17]. Similarly, an appropriate type of transducer should be consciously selected for a given case, thus matching its frequency to the range of ultrasound beam penetration. However, these issues are only part of the optimum examination of

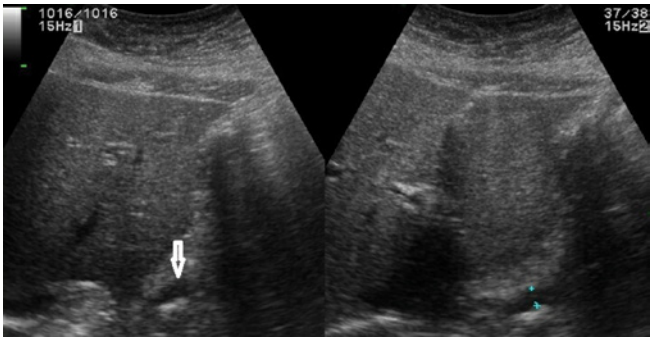

Fig. 2. *On two sections, only in a standing position was cancer invasion of the cardiac orifice revealed*

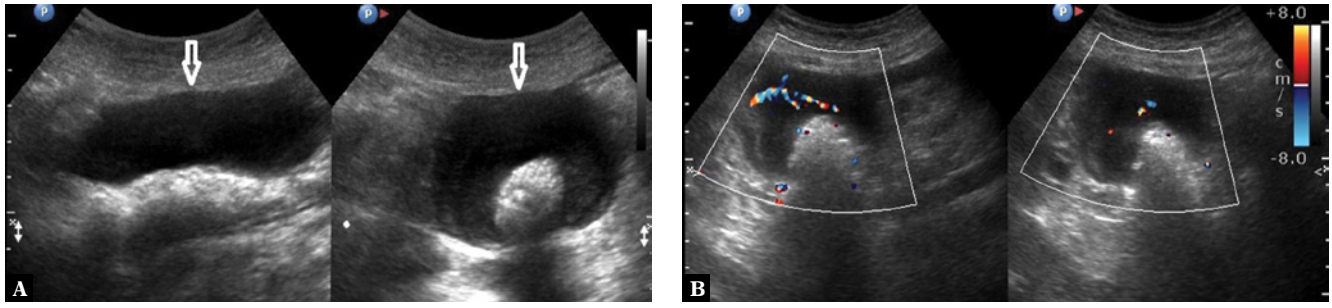

Fig. 3. A. *A fluid collection diagnosed in the mid abdomen below the pancreas (arrows).* **B.** *The same patient: the apparent fluid collection displays internal vasculature in colour Doppler imaging. A MALT lymphoma was diagnosed in samples collected from the transverse colon*

the intestines. Due to the variable anatomical position of the appendix and clinical conditions of the procedure the protocol proposed by Lee *et al*.[18] is useful for the examination. These authors determined that in hyposthenics the appendix should be visualised directly from above the pubic bone or through a full urinary bladder, while in obese individuals, the procedure should be performed by pressing the transducer to the front, and the hand to the back in order to reduce the distance from ROI. In pregnant women and for a retrocaecal appendix the procedure should be performed with the patient lying on the left side and the transducer applied to the right flank. In addition, the appendix needs to be visualised along its whole length since sometimes it is only partly affected by inflammation, usually in the tip (tip appendicitis) (Fig. 1). The issues regarding appendix examination protocol mentioned above do not include many other problems associated with ultrasound assessment of this residual organ.

The protocol for stomach examination performed upon fasting using oral contrast or double contrast-enhanced ultrasound (DCEUS) is equally complex[7,9,10,15,16,19–22]. The visualisation of this organ requires the use of different approaches (subcostal, intercostal), different positioning of the patient's torso and performing the examination partly in a standing position. Non-compliance with these protocol requirements is associated with the risk of failing to detect existing lesions (Fig. 2). It is sometimes observed that the evaluation of the vasculature of a detected focal lesion is skipped during the procedure despite the clear imperative to use Doppler imaging to that end. Fig. 3 A presents an anechoic lesion in the mid abdomen, which was found to be a cyst by the examiner. The use of colour Doppler imaging would have allowed to avoid a wrong diagnosis. Fig. 3 B presents the same lesion, which was mucosa associated lymphoid tissue (MALT) lymphoma in the transverse colon. At this point it is worth emphasising the significance of the ability to adjust the parameters of Doppler imaging to certain examination conditions[13].

Another aspect of ultrasound is the time devoted to examine abdominal organs, including the stomach and the intestines. The latter are extraordinarily difficult to evaluate in whole due to their length, high topographical variability and frequent presence of gas. The majority of complaints directed at physicians who performed abdominal ultrasound examination involve extremely short time of the procedure. We believe that 20 minutes is the average time needed for such a procedure. However, if there is a need for a general evaluation of the gastrointestinal tract at least 8 minutes should be added (2 minutes for the stomach and 3 minutes each for the

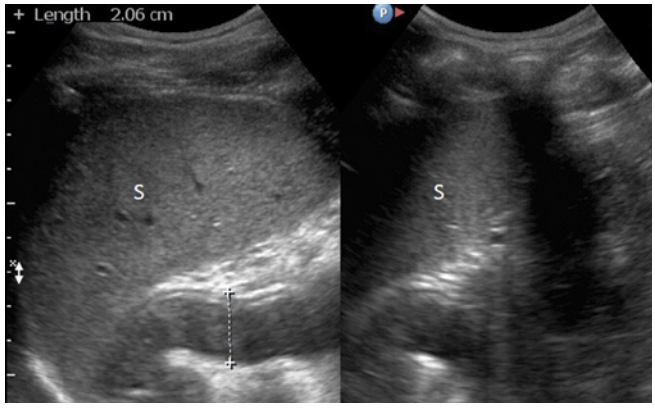

Fig. 4. *Dense rugae of the greater curvature of the stomach body visualised through the spleen (S; distance markers)*

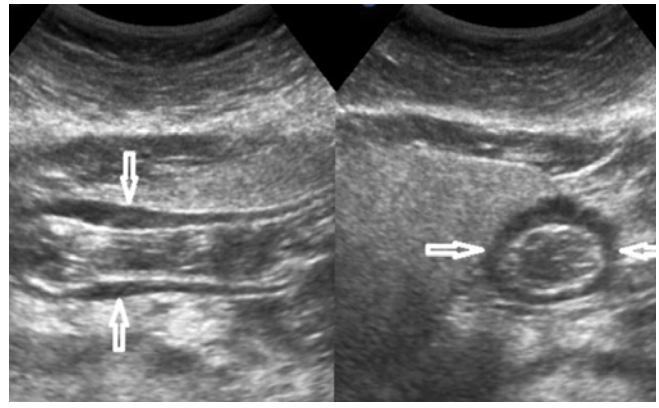

Fig. 5. *On two sections, muscle layer proper of the antral part of the stomach thickening towards the pylorus can be seen (arrows)*

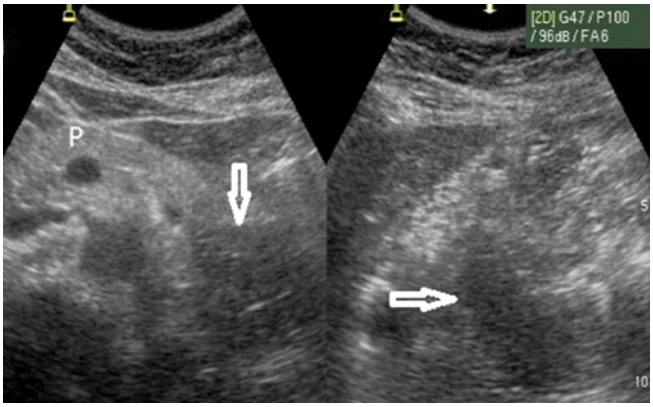

Fig. 6. *Two sections show duodenojejunal flexure mimicking a retroperitoneal tumour (arrows)*

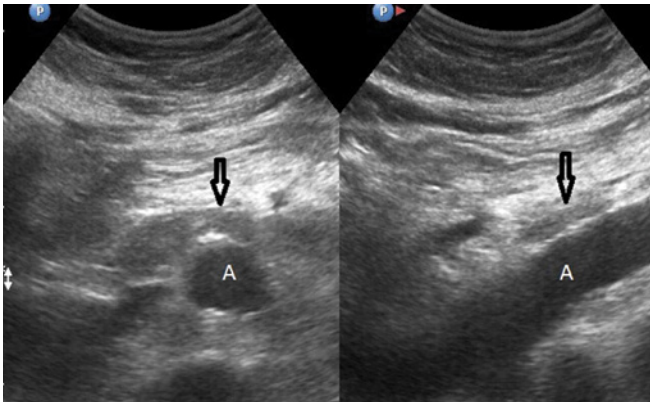

Fig. 7. *Two sections demonstrated a hypoechoic lesion (arrows) in the retroperitoneal space which was the horizontal part of the duodenum*

small intestine and the large intestine). This time will be longer if any abnormality is detected. Naturally, detailed examination of these segments of the gastrointestinal tract will require 30–40 minutes.

The problem of errors in ultrasound imaging is particularly rich. Apart from the already discussed issues special attention should be paid to the need for continuous physician training conducted by experts, self-education using the latest literature and the Internet, constant verification of the efficacy of self-conducted procedures based on the results of other imaging methods, endoscopy, surgery and pathology examinations. To conclude this article on this very rich topic, we discuss a few anatomical pitfalls regarding ultrasound imaging of the gastrointestinal tract.

1. An apparent pathology seen in an examined stomach upon fasting can have two causes:
- dense rugae formed by a contracted gastric reservoir with the subsequent creasing of an extensive area of the mucosa: in our research in such cases the thickness of the proximal part of the stomach walls was even 30 mm (Fig. 4); a preserved layer pattern of the gastric wall is an important feature: the mucosa is the thickest one. Doubts are resolved following the intake of 1000 ml of water, which causes the wall to return to its normal thickness of 5–6 mm;
- muscle layer proper thickening towards the pylorus (Fig. 5): symmetry of the observed changes on the anterior wall and posterior antral part of the stomach and its normal peristalsis after the stomach has been filled with liquid prove that it is a structural variant of the gastric wall found in approximately 40% of the examined individuals[15].

2. The following pitfalls can be found in the small intestine:
- duodenojejunal flexure sometimes mimics a nodular lesion located below the border between the body and tail of pancreas (Fig. 6); observation of this area for some time, particularly after the patient has drunk some liquid, reveals the false nature of the observed change as a result of the presence of liquid, gas and peristalsis;
- the horizontal part of the duodenum located between the aorta and the inferior vena cava and superior mesenteric vessels can give a similar effect (Fig. 7): doubts in this case can also be resolved by fluid intake and reobservation of this area;
- sometimes, particularly in individuals who have had colon cleansing or loose stools, an echogenic structure can be visualised in the bottom of the caecum which resembles intestinal lipoma on a sonogram (Fig. 8). A fatty Bauhin'sileocaecal valve often looks like this. Based on the location of the lesion at the end of the ileum, the possibility of visualising its motility following the intake of fluid and the demonstration of the presence of the valve's lips a normal anatomy of this area can be determined (Fig. 9)[15].

3. In the colon, the variability of the structure of semilunar folds should be taken note of. Their large thickness can warrant suspicion of wall invasion or the presence of a polyp (Fig. 10)[23]. Such changes are usually present in a longer fragment of the intestine with each fold having a similar morphology.

Fig. 8. *The appearance of the ileocaecal valve in an empty caecum. An echogenic structure (arrows) mimics intestinal lipoma*

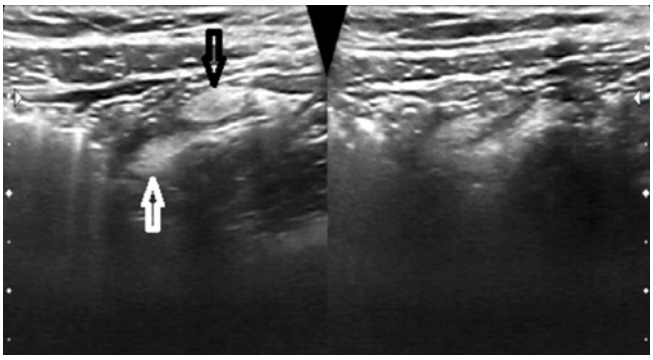

Fig. 9. *In another case in a similar location two lips of the ileocaecal valve can be seen (arrows)*

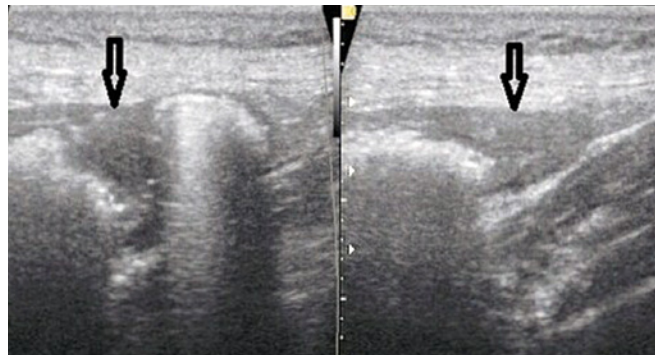

Fig. 10. *A semilunar fold in the descending colon mimicking wall invasion (arrows)*

As mentioned previously, it is difficult to provide an exhaustive account of the problem of diagnostic errors in gastrointestinal tract ultrasound examination in a single study. Therefore, only selected issues have been discussed, primarily those responsible for false positive errors.

Conflict of interest

The authors do not report any financial or personal affiliations to persons or organisations that could negatively affect the content of or claim to have rights to this publication.

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