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Is it possible to differentiate between pseudopneumoperitoneum and similar pathologies ultrasonographically?

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Key words
gas below the diaphragm, pneumoperitoneum, intestinal interposition, differentiation, ultrasonography

Abstract

Aim: The goal of the work was comparing gas ultrasound images below the right diaphragm in two groups: in people with intestinal interposition below the diaphragm and ones with pneumoperitoneum and extracting the traits differentiating these two conditions. **Material and methods:** Retrospectively, the documentation of 22 patients with intestinal interposition below the diaphragm (group 1) was utilized. Clinical material was used for comparison, previously published, composed of 15 cases of pneumoperitoneum following laparotomy and of 14 cases following that symptom as a result of ulcer perforation – group 2 (in total $n = 29$). Moreover, the distance in millimeters of the gas surface reflecting ultrasounds from the parietal peritoneum was measured, the smoothness of the surface, parietal peritoneum enhancement at the place of gas adherence, gas continuity below the diaphragm with gas in the intestine located below the liver. **Results:** Direct adherence of the gas surface to the diaphragm was observed in 100% of the cases of emphysema, but in no cases of intestinal interposition. Yet, in the group of patients with colonic interposition ($n = 21$) there was always a small gap (2–3 mm) and the gas surface among those patients in 100% of the cases was uneven. **Conclusions:** In differentiation between pneumoperitoneum and liver-diaphragm interposition of the intestine one should take into account – apart from gas movement below the diaphragm at body position changing – the presence of protrusion and section enhancement of the diaphragmatic peritoneum as well as the distance of the gas from the diaphragm, the smoothness of its surface and the continuity with the intestine below the liver. Interpositions of small diaphragm-liver penetration may subside in erect position.

Introduction

Gas under the diaphragm on X-ray of the thorax or the abdominal cavity is usually a disturbing symptom and – first of all – requires the exclusion of pneumoperitoneum. Sometimes, in order to account for this phenomenon, it is imperative to perform computed tomography which resolves the issue best[1,2]. Taking into consideration all the benefits of ultrasonography, including examination in emergency and in extremely difficult conditions, it is worth determining whether the method enables one to differentiate between pneumoperitoneum and simulating conditions, namely between pneumoperitoneum and pseudopneumoperitoneum[3–5]. The last term covers mainly unusual location of the intestine between the diaphragm and the liver, which in literature is termed the Chilaiditi sign (named after the surname of the author of the first publication on the subject matter). The clinical and radiological symptomatology distinguishes also the Chilaiditi syndrome which indicates the existence of a causal link between the existing diaphragm-liver intestinal interposition and various ailments as regards the gastrointestinal tract, respiratory and/or circulatory system[1,2,6–10]. Ultrasonography is rarely applied in differentiating pneumoperitoneum with the Chilaiditi sign[4,11–15]. In order to extend the diagnostics, 22 cases were analyzed retrospectively – with intestinal interposition under the diaphragm and compared with the previously obtained data in cases with spontaneous pneumoperitoneum and after laparotomy (in total $n = 29$)[16–18].

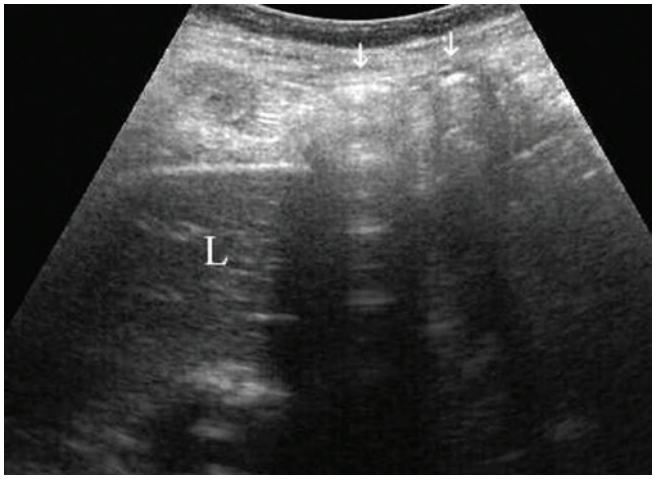

Fig. 1. *Colon over the right lobe of the liver (L) visible on the right cross-section. Arrows indicate the wavy outline of the gas in the intestine*

Material and method

Within the last 8 years (from 2008 to 2015) 22 people were observed, in whom intestine located between the diaphragm and the liver was diagnosed in ultrasound imaging (group 1). The condition was confirmed in the case of 16 patients on the X-ray of the thorax and in 2 other with the use of computed tomography owing to the co-existence of a focal lesion in the liver. In the remaining 4 people with small intestinal interposition, change of the examination position from recumbent into erect resulted in the regression of improper intestine location, therefore no other imaging examinations were performed. The analyzed group was composed of 18 men and 4 women aged 45 to 86 (on average 64). In a 45-year-old woman, clinical symptoms could be referred to transient intestinal interposition as an early consequence of the endoscopy of the upper section of the gastrointestinal tract performed. In another, 49-year-old patient with periodical flatulence and the position of the intestine in the right iliac fossa, colonic interposition was observed in the hepatorenal recess. Among the

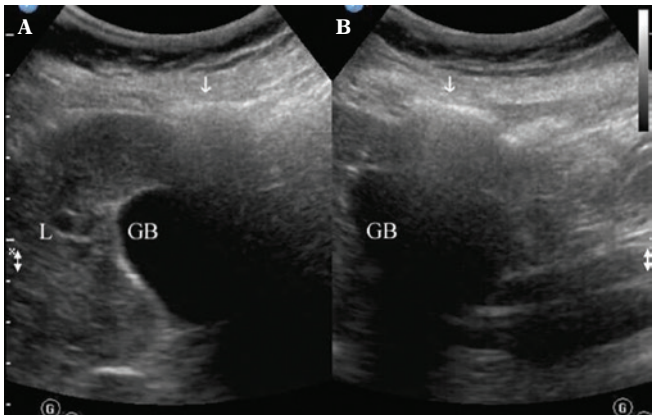

Fig. 3. *On two cross-sections, the transverse colon (arrows) over the liver partly shades the gallbladder (GB)*

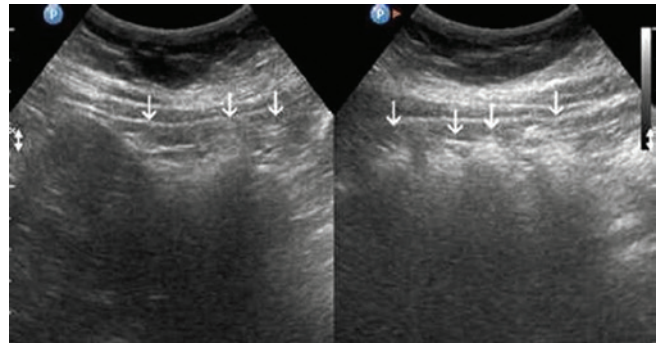

Fig. 2. *Colon visible on two cross-sections over the liver. Arrows indicate visible haustra*

remaining people, colonic translocation below the diaphragm caused no ailments.

Ultrasound examinations were performed with digital ultrasound units of various companies, by utilizing convex heads with frequencies in the range 3.5–5 MHz, sometimes also linear heads with frequencies 7–12 MHz. The area of the diaphragm on the right side was examined through the intercostal spaces when the patient is positioned on the left side and on the back, by observing the structures at free and deep breath. Moreover, the area of the diaphragm on the left side from below the right costal arch and the epigastric fossa was examined. In the case of gas detection below the diaphragm, an attempt was made to determine its conduct after change in the patient's position from left to the back (the probe was continuously located in the same position). Upon intestine diagnosis (especially in the case of protrusions presence – haustration) the depth from the border of the liver under the diaphragm was evaluated. In 12 people, the goal was to determine changes in the location of the intestine by additional examination in erect position. Moreover, the distance in millimeters of the gas surface reflecting the ultrasounds from the parietal peritoneum was measured, the smoothness of the reflecting sur-

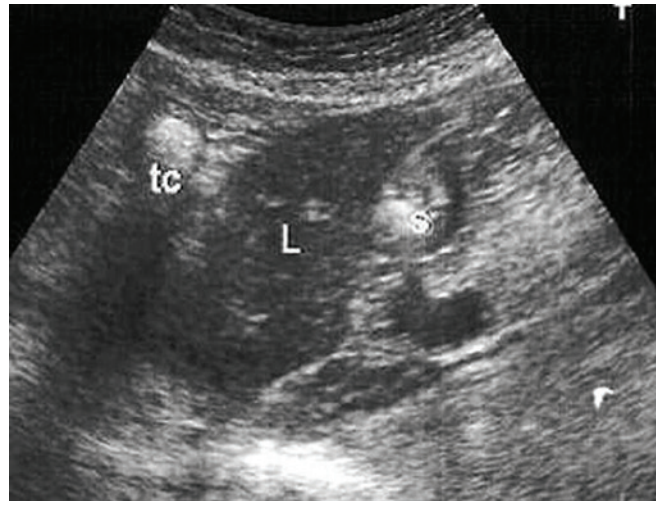

Fig. 4. *Transverse colon (tc) visible over the left lobe of the liver (L) in the cross-section with arrows. S – stomach*

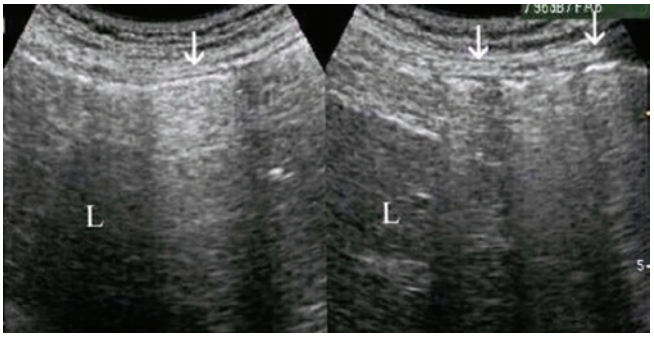

Fig. 5. *On two cross-sections, below the diaphragm, there is the loop of the small intestine with gas (arrows), which simulating pneumoperitoneum. L – liver*

face, the presence of parietal peritoneum enhancement at the place of gas adherence, the presence of gas continuity under the diaphragm with gas in the intestine located below the liver. It was also determined over which segments of the liver the intestine was located and the area was observed for several minutes in order to detect the presence of peristalsis. The majority of these parameters were analyzed in the previously analyzed 15 cases with pneumoperitoneum after laparotomy[16] and in 14 cases with spontaneous occurrence of that symptom as a result of ulcer perforation[18] – group 2 (in total $n = 29$).

Results

In group 1, hepatic flexure over the right hepatic lobe was diagnosed in 15 cases (Fig. 1), colon over the whole liver in 2 cases (Fig. 2), colon over segments IV, III and II of the liver in 2 cases (Fig. 3), colon over the left hepatic lobe in 2 people (Fig. 4) and small intestine over the right hepatic lobe in the patient following endoscopy of the upper section of the gastrointestinal tract (Fig. 5). The colon reached into the subdiaphragmatic area from 3 cm to 8 cm (from the liver border), never crossing the apex of the phrenic dome. Gap of the gas surface from the parietal peritoneum ranged within 2–3 mm (on average 2.7 mm). Only in the case of small intestine relocation below the diaphragm, the gap reached approx. 1 mm. Among 12 people examined in erect position, in 4 with a slight intestinal transposition, remission was observed in that position (Fig. 6); among the remaining patients, the intestine still remained under the diaphragm (Fig. 7). Other data concerning intestinal interposition under the diaphragm are included in Tab. 1. In group 2, in all the patients, a changing location of the gas in the peritoneal cavity was observed as well as sectional parietal peritoneum enhancement at the place of direct contact with gas. In this group, no gap between the diaphragm and the permanently smooth surface of the gas was observed (Fig. 8). Depending on the amount of gas collected, there were various artifacts: bubbles caused an artifact close to the comet tail, while its greater amount caused the release of artifact of multiple reflections or closed curtain. The greatest diagnostic difficulty was present in the case of a patient with small intestine relocation below the diaphragm right after gastroscopy. The gas surface was smooth in this case and almost directly adjoining the diaphragm (Fig. 5). On the other hand, the basic symptom against pneumoperitoneum was the constant location of the gas below the diaphragm despite the attempts to change the position of the patient. Finally, the diagnosis was determined after X-rays made of the abdominal cavity, where – in the place colon below the diaphragm, there was a small intestine loop, and on the basis of control ultrasound examination after 2 hours from pain in the abdomen remission. This examination showed no presence of the previously observed symptom. An extraordinary discovery was finding an impressed right colonic flexure into the hepatorenal recess (Fig. 9).

Discussion

It was proven that in general population, X-ray of the thorax and the abdominal cavity show intestinal translocation between the diaphragm and the liver with the frequency of 0.025–0.28%. However, at the evaluation of geriatric patients, the rate reaches 1%. In this age group, the Chilaiditi sign is observed four times more frequently in men[1,2,4,6,7,9]. It is present least frequently in children[1,19]. Utilizing computed tomography as a diagnostic tool, the liver to diaphragm interposition of the intestine is observed in 2.4% of the patients[20,21].

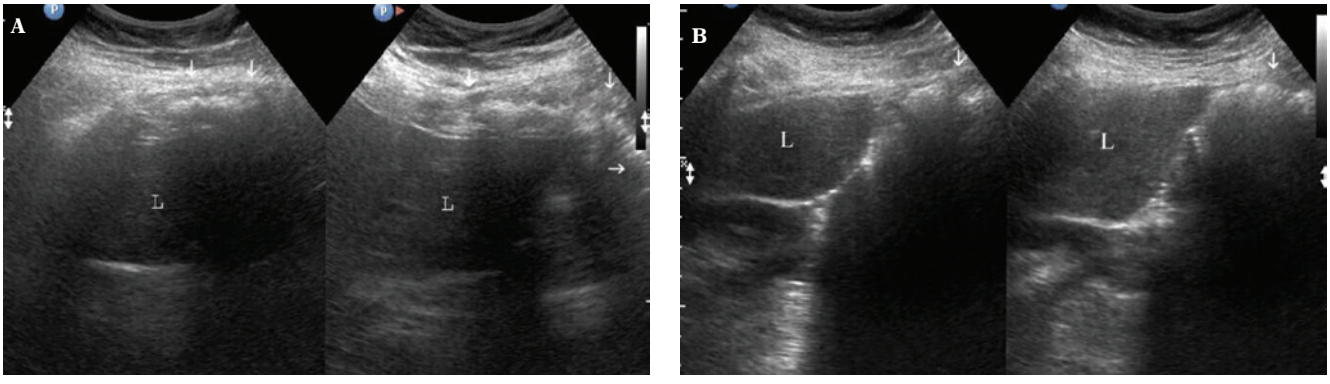

Fig. 6. A. *Recumbent position on the left side. Transverse colon (arrows) visible on two cross-sections over the liver (L).* **B.** *The same patient examined in an erect position. Complete withdrawal of the intestine (arrows) from above the liver (L)*

There are three predisposing main factors presented:
- lesions in the intestines and their mesenteries (e.g. elongation of the intestine, increased length and movement of the mesentery, colon volvulus);
- lesions concerning the liver (undeveloped segments, lobes, diseases of that organ combined with the decrease in its size);
- lesions as regards the diaphragm (defects of the diaphragm and the ligaments anchoring the liver, its flaccidity or paralysis).

Moreover, there are many other factors mentioned, such as: obesity, ascites, chronic constipation, internal hernia, multiple labor, intestinal obstruction, aerophagia, especially in mentally ill, and others[1,2,5,6,8,22]. Intestinal translocation between the diaphragm and the liver may be of a transitional or permanent nature. Most often hepatic flexure is observed, ascending colon, transverse colon, but also cecum and sigmoid colon were observed and even the small intestine along with the colon. It is worth noting that such intestinal interposition may be secondary, e.g. when it results from intestine obstruction on various grounds or it accompanies other pathologies, e.g. gastric volvulus[2,6,21]. The Chilaiditi syndrome is observed with the frequency of 1 per 50,000 people[8] and seldom following unsuccessful conservative therapy it requires surgical intervention aimed at preventing necrosis or intestine perforation[1,4,6,13–15,21]. An important issue is that at the moment of finding gas below the diaphragm on the right, the differentiation should account for several pathologies: free gas in the peritoneum, interposition of the intestine, subdiaphragmatic abscess, abscess of the liver with gas, Morgagni hernia and interposition of the intestine above the diaphragm after traumatic rupture. In the case it is possible to diagnose interposition of the intestine certainly, based on clinical data and then imaging, it should be determined whether it is only a sign, or Chilaiditi syndrome, which sometimes may lead to serious consequences[1,6,11,22,23]. Even asymptomatic intestinal interposition in such a place may hinder conducting colonoscopy and constitutes a contraindication to perform biopsy of the liver in a typical manner[1–3,6,7,22,24]. The presence of disturbing abdominal symptoms may also take place as an expression of intestinal interposition following endoscopic examination, e.g. after colonoscopy[2,25]; in our case the iatrogenic Chilaiditi syndrome occurred after gastroscopy. In addition, the co-existence of the Chilaiditi sign with right-side pneumothorax requires specifically cautious drainage insertion to the pleural cavity not to damage the intestine[9]. A real challenge is the coincidence of intestine below the diaphragm with pneumoperitoneum[26,27]. In the so far most extensive clinical material covering 18 cases with interposition of the colon below the diaphragm, diagnosed with ultrasounds, in two patients the authors obtained the image of echogenic mass (Fig. 3)[13]. In our opinion, the documenting sonogram presents the caught greater omentum in that place (Fig. 3 A), while the corresponding computed tomography (Fig. 3 B) simultaneously shows, apart from the omentum, also part of the colon. According to Changchien[12] such a tissue makeup below the diaphragm is supposed to condition lack of mobility of the colon at an attempt to change the position of the body.

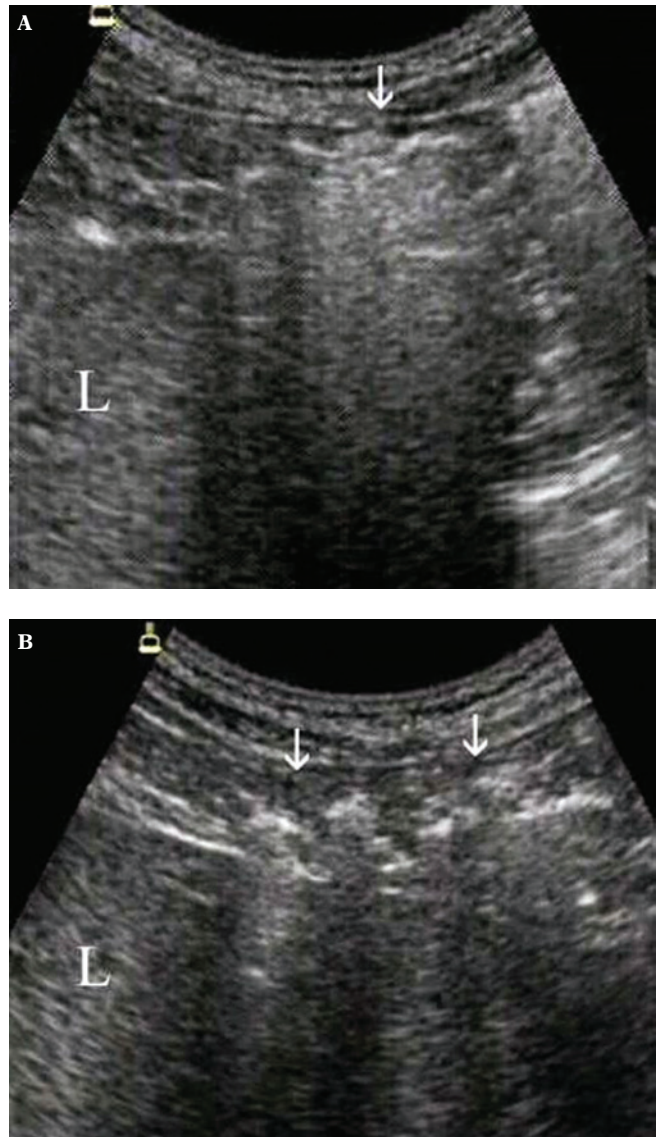

Fig. 7. A. *Recumbent position on the left side. Colon (arrow) over the liver (L).* **B.** *Supine position (head placed in the same place as in Fig. 7 A). The intestine remained in the same position*

The goal of the work was to compare ultrasound images of gas under the right diaphragm in two groups: in people with interposition of the intestine (n = 22) and in patients with pneumoperitoneum (n = 29). It allowed us to distinguish a few features so far not taken into consideration in differentiation. As regards direct adherence of the gas surface to the diaphragm, it was observed in 100% of the cases of emphysema. On the other hand, in the group of patients with colonic interposition (n = 21) there was always a small gap (2–3 mm) and the gas surface among those patients in 100% of the cases was uneven. In addition, in this group, among 18 people (81%) it was possible to show the continuity of the colon located on the liver and below its border. These results additionally facilitate differential diagnostics of both the conditions, so far taking into account the movement of the gas below the diaphragm at various positions of the body, showing or not showing

Feature	Pneumoperitoneum (n = 29)	Chilaiditi sign (n = 22)	Figure no.
Impact of body position change on the movement of the gas	29 (100%)	4/12 (33.3%)	6 and 7
Presence of colonic haustra	0 (0%)	21 (95.5%)	1–4, 6, 7
Gas surface directly adjoins the diaphragmatic peritoneum	29 (100%)	0 (0%)	8
Gas surface distant from the diaphragmatic peritoneum	0 (0%)	21 (95.5%)	1–4, 6, 7
Smooth gas surface	29 (100%)	1 (4.5%)	5, 8
Uneven gas surface	0 (0%)	21 (95.5%)	1–4, 6, 7
Presence of segmental augmentation of the peritoneum at the place of gas adjoining	29 (100%)	0 (0%)	8
Gas continuity below the diaphragm with the colon below the lower border of the liver preserved	0 (0%)	18 (81.8%)	6A
Intestinal peristalsis observed	not examined	2 (9%)	

Table 1. *Specification of the analyzed ultrasound features in the group with pneumoperitoneum (n = 29) and in the group with intestinal transposition below the diaphragm (n = 22)*

segmental enhancement of the diaphragmatic peritoneum, observing the presence of protrusions of the intestine and possible peristalsis[5,12–14].

Three cases require additional discussion. It was hardest to diagnose interposition of the small intestine below the diaphragm, since this examination proved no haustration, the surface of the gas was smooth, while a deviation from the criterion of emphysema were: permanent gas presence under the diaphragm despite attempts made to change the position of the patient as well as segmental enhancement of the diaphragmatic peritoneum at the place of gas adherence. It is the second case in literature documenting ultrasound image of interposition of the small intestine under the diaphragm[15]. Among intestinal interposition below the diaphragm, such cases are estimated to constitute 3–5%[28]. Another issue determined in our material is reporting complete remission of slight colonic interposition in an erect position, which has so far not been described. The last unique case was translocation of the hepatic flexure into hepatorenal recess. It is true that there are interpositions of the intestine below the diaphragm – anterior and posterior, however so far literature remains silent as regards the description of such a case diagnosed with ultrasounds[25].

At this point it is worth mentioning the result of various translocations of the intestines presented on the basis of computed tomography by Bredol et al.[29] Among 4338 such examinations, there were 130 cases diagnosed with various translocation of the intestines in the abdominal cavity (3%), mainly colon, while in 10 women the presence of several transpositions was observed. The largest group were patients with hepatodiaphragmatic interposition (n = 90). In the so-called non-Chilaiditi form, there was colon location: between the spleen and the kidney (n = 30), retrogastric (n = *12)*, hepatocaval (n = 5), retrosplenic (n = 4), retrorenal (n = 2). Only the following transpositions were

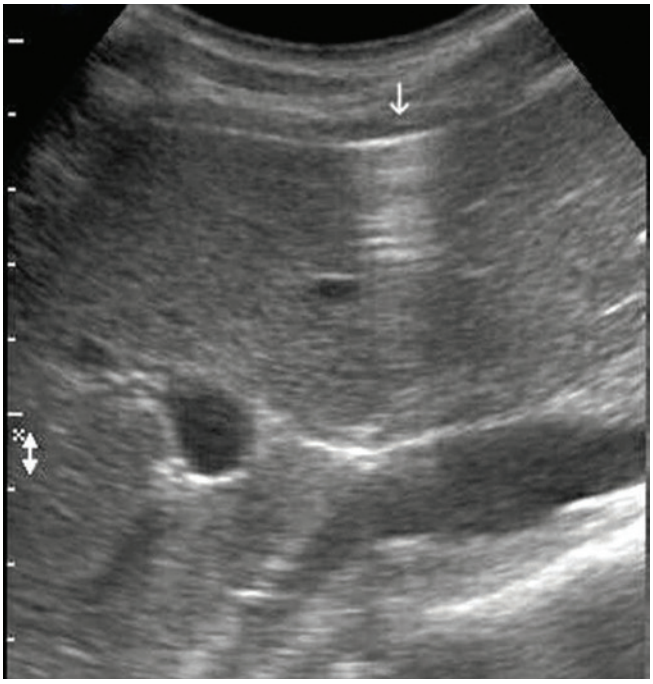

Fig. 8. *Pneumoperitoneum. Gas below the diaphragm (arrow) directly adjoins the parietal peritoneum. Visible augmentation of the peritoneum band in the section*

symptomatic: hepatocaval (5 out of 5), retrosplenic (2 out of 4) and rarely splenorenal (3 out of 30).

Conclusions

1. In differentiation between pneumoperitoneum and liver-diaphragm interposition of the intestine one should take into account – apart from gas movement below the diaphragm at body position changing – the presence of protrusion and section enhancement of the diaphragmatic peritoneum as well as the distance of the gas from the diaphragm, the smoothness of its surface and the existence of continuity with the intestine below the liver.

2. Interpositions of small diaphragm-liver penetration may subside in an erect position.

3. The hardest one to be diagnosed during ultrasound imaging is interposition of the small intestine below the diaphragm.

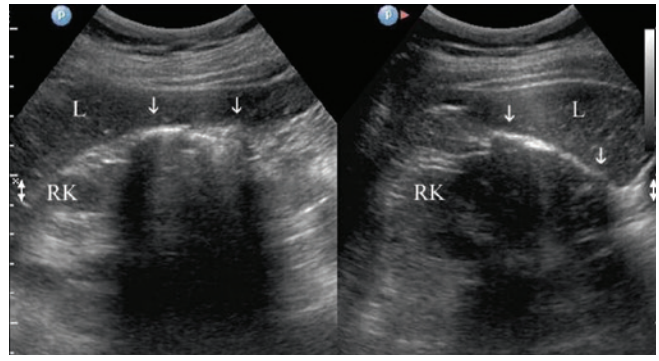

Fig. 9. *Right flexure of the colon (arrows) visible on two cross-section located between the liver (L) and the right kidney (RK)*

Conflict of interest

Authors do not report any financial or personal connections with other persons or organizations, which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

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