

Submitted: 10.07.2016

Accepted: 01.08.2016

Published: 31.03.2017

Mistakes in the ultrasound diagnostics of the abdominal cavity in pediatrics

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DOI: 10.15557/JoU.2017.0009

Key words

ultrasonography,
ultrasonography
in pediatrics,
ultrasound
diagnostics of the
abdominal cavity
in children

Abstract

The diagnostics of the abdominal cavity in children, especially in the neonatal-infantile period, requires knowledge in the field of anatomical and physiopathological differences as well as clinical symptomatology and pathology at every stage of the child's development. Errors and mistakes in ultrasound diagnostics of the abdominal cavity in children result from many factors, including lack of experience in examining children and the knowledge concerning most frequent ailments and pathologies as well as the incidence or no changes in the ultrasound image of the abdominal cavity organs. The assessment of the ultrasound image should be always based on clinical data of the patient, information on the past diseases, surgeries and the results of additional examinations and laboratory tests. Particular attention should be paid to the occurrence of congenital diseases and inflammations, which may have varied clinical manifestation – especially in the case of pediatric diagnostics. The variety and non-specific nature of clinical symptoms may also mask the developing neoplastic process. Mistakes in ultrasound diagnostics, especially among the youngest children, may also be caused by technical difficulties related to carrying out the examination. The above situation results from lack of cooperation with the child, who is uneasy, wailing, fails to perform orders, which may lead to overlooking the existing lesion or overinterpreting, e.g. a full stomach or residual stool in the intestines to be a pathology. It is also of high importance to have a good class of the ultrasound equipment and technical knowledge concerning its operation. When performing an ultrasound examination in children, it is necessary to apply a wide range of phased-array, convex and linear heads and appropriate applications, the so-called pediatric software (stomach, kidneys, true pelvis, organs at the surface).

Introduction

Errors and mistakes in ultrasound diagnostics of the abdominal cavity in children result from many factors. The major one is lack of experience in examining children and lack of the knowledge on physiological processes in the developing body which translate into the ultrasound image of some organs. The diversity and non-specific nature of clinical symptoms in children, which may imitate congenital diseases, inflammations as well as mask the neoplastic process, constitute the next reason for difficulties in pediatric diagnostics. It is imperative in the diagnostic process to obtain the correlation of the ultrasound image with clinical data of the patient, the results of other imaging and the scope of the performed surgery⁽¹⁾.

Knowledge on the most common pathologies in particular periods of a child's life and their relation with clinical examina-

tions and the results of laboratory tests constitute the basis for a reliable ultrasound examination. The following are of crucial importance: knowledge concerning the clinical state of the patient, results of laboratory tests, the past and current diseases and the information on what the examination is supposed to explain. Errors and mistakes in interpreting the ultrasound image may result in lack of cooperation with the child during the examination. Bad preparation for the examination, severe child's condition as well as a patient following a trauma or a surgery are the next factors affecting the quality of the assessment of the abdominal cavity organs. It is also of high importance to have a good class ultrasound equipment and the knowledge concerning its operation. The article presents errors and mistakes in pediatric diagnostics in accordance with the following division: 1) errors resulting from the lack of knowledge/failure to adjust the ultrasound apparatus for examining children (pediatric applications, proper heads);

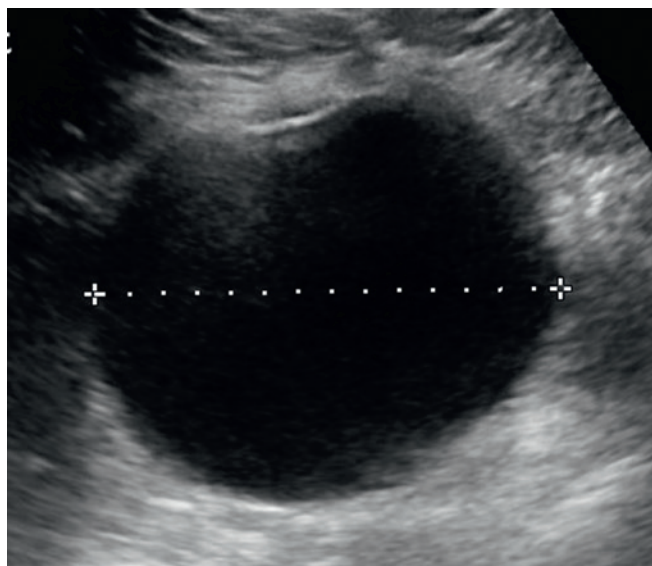


Fig. 1. Echoless ovarian cyst assessed to be a correct bladder

- 2) errors resulting from inappropriate examination method (lack of cooperation with the patient, patient's built, improper patient preparation to the examination);
- 3) errors resulting from the lack of knowledge on physiological varieties of organs construction in a child;
- 4) errors resulting from the lack of knowledge concerning the most common pathologies of the age of childhood and the lack of clinical data about the patient.

Errors resulting from insufficient quality of the ultrasound apparatus and the lack of knowledge concerning the ultrasound apparatus functions

Insufficient quality of the ultrasound apparatus as well as lack of appropriate heads and software pose the risk of erroneous assessment of organs, misinterpreting the existing pathology or interpreting artifacts as pathologies. Children (especially

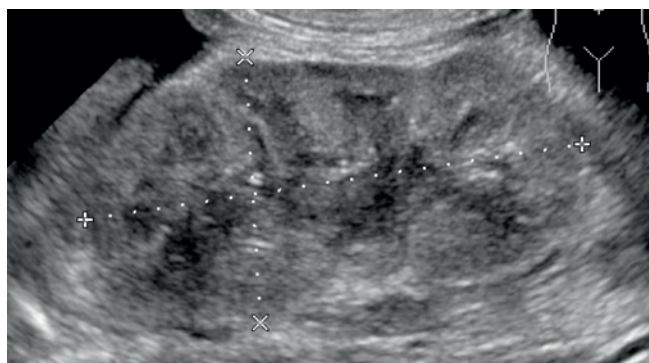


Fig. 2. Kidney of a newborn – correct high echo of the parenchyma, echoless pyramids

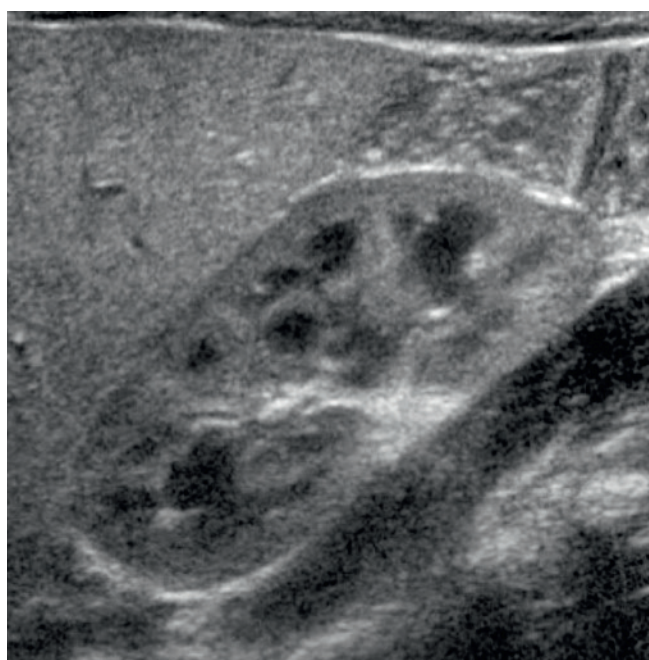


Fig. 3. Right kidney of a newborn – correct higher echo of the parenchyma, hypoechogenic pyramids

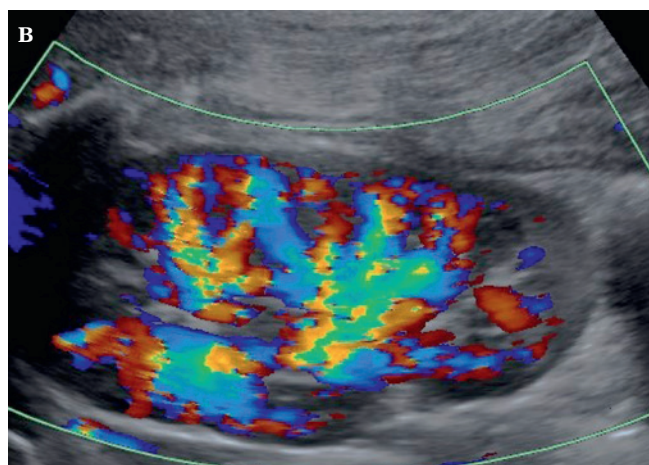
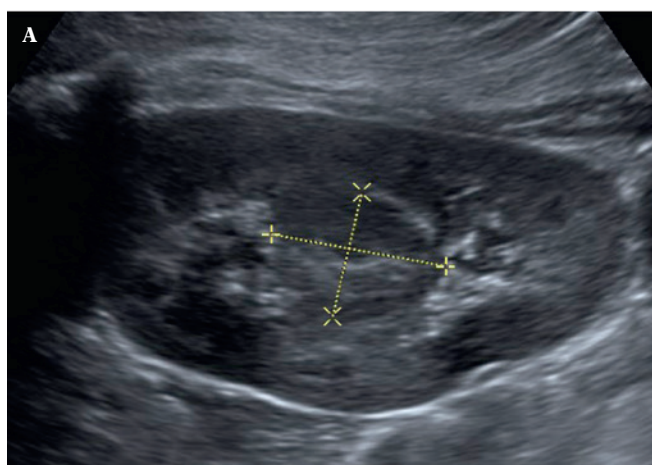


Fig. 4. Kidney, hypertrophy of the column of Bertin: **A.** variant of standard; **B.** Color Doppler imaging option, correct vascularization of the kidney

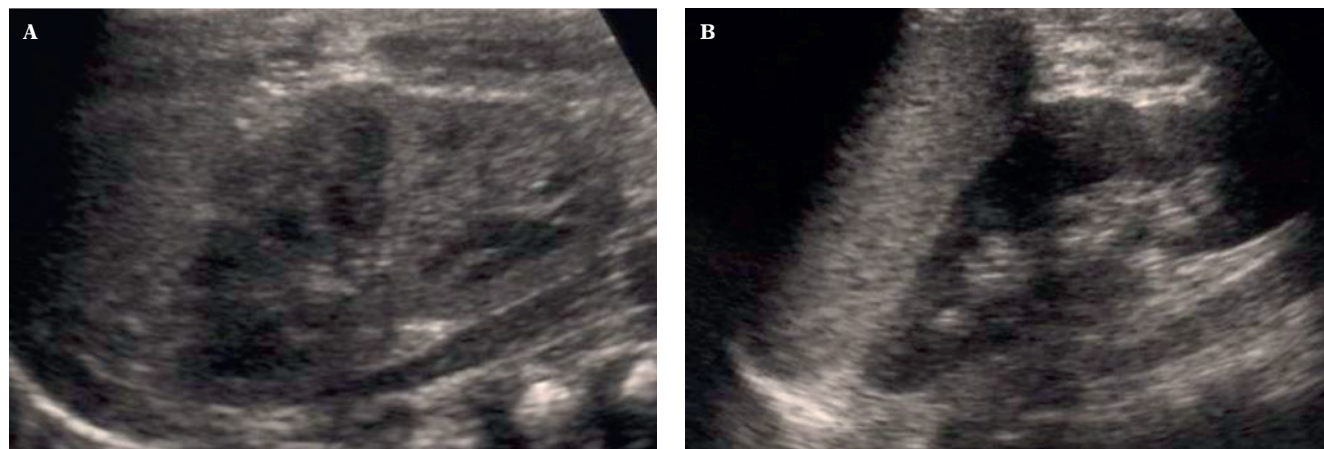


Fig. 5. Physiological prominence of the left kidney: **A.** in a newborn with the presence of correct echoless pyramids; **B.** in an older child

younger ones) have smaller organs, which are located closer to the abdominal integuments and a thinner subcutaneous adipose tissue, therefore – depending on the child's age – electronic heads of wide spectrum of frequency should be utilized (preferably with changing frequency) from 3.5 to 10 MHz and with various sizes (shape and length of the head)²⁾:

- convex head 2D with the frequency of 3.5–5 MHz and 4–7 MHz;
- phased array head 2D with the frequency of 4–7 MHz and 5–8 MHz;
- linear head 2D with the frequency of 5–10 MHz;
- linear head 2D with the frequency of 7–12 MHz.

Ultrasonography of the abdominal cavity in newborns is performed with the use of heads having the frequency of 7.5 MHz, in infants and younger children 5 MHz, in older children and teenagers – 3.5 MHz. In the case of newborns and infants, head with the length of the head not exceeding 3–4 cm should be used.

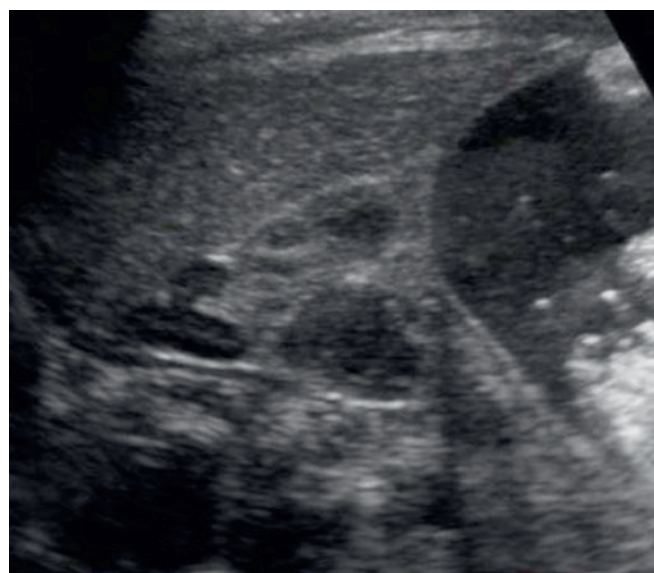


Fig. 6. Right adrenal gland of a newborn, correct image



The ultrasound apparatus should be factory-equipped with the so-called pediatric software (abdomen, kidney, pelvic, bowel) and technical parameters (e.g.: GAIN, TGC, FOCUS) proper for examining a child at every age, which will make it possible to precisely assess the parenchymatous organs of the abdominal cavity and intestinal loops and the retroperitoneal space.

Large physical activity and breathing a lot in the case of small patients connected with the need to perform measurements of the abdominal cavity organs require one to possess the registration option and going back to the examined cross-sections, the so-called sine loop.

Errors in the assessment of the examination may also result from improperly prepared ultrasonography room, interferences caused by the proximity of other electronic devices or fatigue of the examiner.

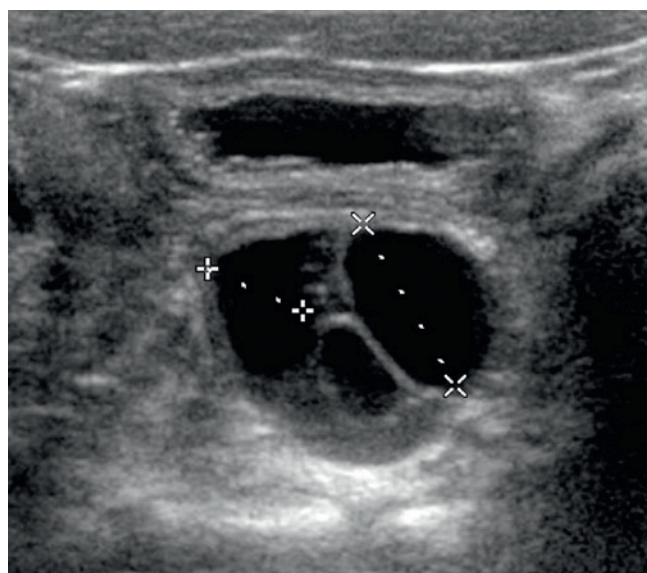


Fig. 7. Correct ovary of a newborn with follicles. Urinary bladder with residual amount of urine



Fig. 8. Pancreas of a small child – correct, with low echogenicity

Errors resulting from difficult examination (lack of cooperation with the patient, improper patient preparation to the examination, patient's built)

Lack of cooperation with the child as regards performing orders (breathing in, keeping bladder full), crying and anxiety make the examination harder and prolong it. Unfortunately, this creates the hazard of not observing the existing pathology or overinterpreting the artifacts, or e.g. stomach full of food or the residual stool in the intestine as being abnormalities. Precise assessment of the urinary system requires examination with full bladder, which in the case of youngest children is very hard⁽³⁾. The bladder not being filled sufficiently, or being filled poorly, the presence of echoless, smooth-walled ovarian cyst may be interpreted as correct bladder (Fig. 1).



Fig. 10. Neuroblastoma of the right adrenal gland – tumor displacing the kidney downwards

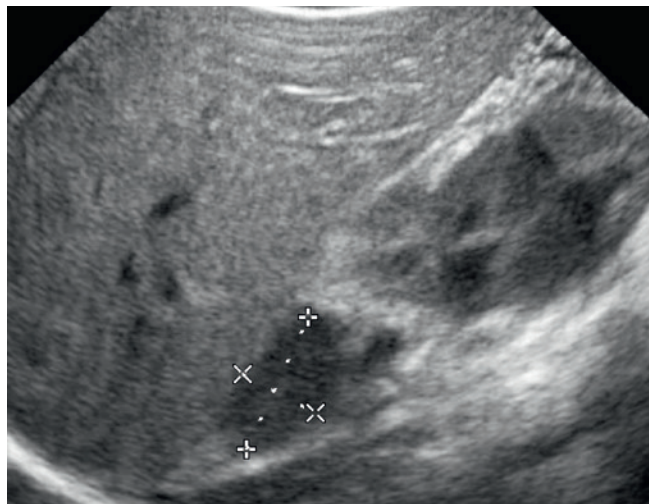


Fig. 9. Hematoma of the right adrenal gland

Errors and mistakes in the assessment of the abdominal cavity organs also result from a large amount of gases filling the intestines, which hide internal organs. As in the case of intestines distended with a liquid mass residue or filled with stool, which displace the neighboring organs hindering their assessment.

Errors resulting from the lack of knowledge on physiological varieties of organs construction in a child

The ultrasound image of the abdominal cavity organs in children basically does not vary from the one of adults, apart from increasing the size of organs when the child grows (the size of organs is assessed in correlation with the length/growth of the patient). However, there are organs which change their morphological image in ultrasound examination as a person matures: kidneys, adrenal glands, pancreas and ovaries.

The kidneys of a newborn and infant have a different built than in children aged above 12 months of age. Lack of the knowledge on this fact is unfortunately sometimes the reason for erroneous diagnosis of the presence of pathological lesions⁽⁴⁾. Correct kidney of a newborn or infant is characterized by the following features⁽⁵⁾:

- echogenicity of the renal cortex is equal to or higher than the one of the liver and spleen; in premature babies it is even strongly visible (Fig. 2);
- visible dominance of echoless renal pyramids, smaller volume of the cortex may be misinterpreted for the presence of cysts (Fig. 3);
- owing to a small amount of the adipose tissue, poor echogenicity of the renal sinus; in some patients, there is a clearly visible hypertrophy of the column of Bertin, which may be taken for a tumor (Fig. 4);
- renal pelvis (with no widening of the calyces) in the AP cross-section should not exceed 10 mm.

It should be borne in mind that – especially in the case of children – the physiological prominence of the left kidney

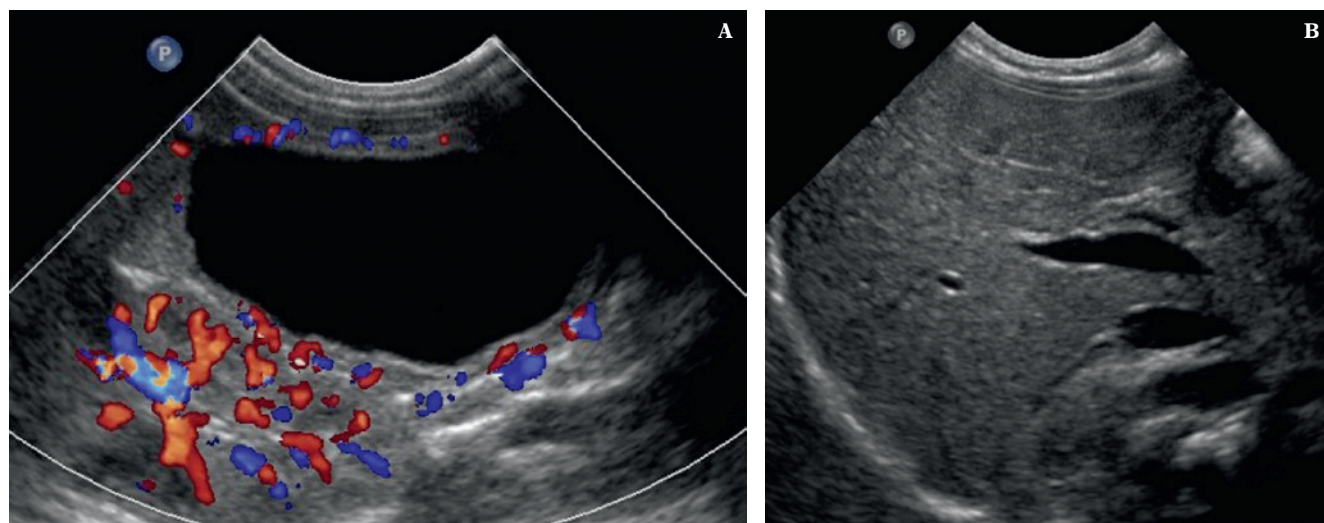


Fig. 11. A. Common bile duct cyst, echoless cyst in the region of the hilum of the liver; **B.** extended common bile duct cyst

is well visible, it is also sometimes taken to be a lesion with the nature of a tumor (Fig. 5).

Adrenals, until the age of approximately 5–6 months, are large and usually are Y-, V or L-shaped and have the typical built for that age – with preserved cortex-medulla differentiation (Fig. 6). In the case of agenesis of the kidney, the adrenal gland is prolonged and larger, which may be mistakenly diagnosed as an improperly developed kidney. In girls in the period of being a newborn and infants, it is frequent to make visible large ovaries with the presence of multiple follicles, the diameter of which may even amount to a dozen or so mm⁽⁶⁾. This is a typical image related to hormone stimulation of the mother and should not be diagnosed as the formation of cysts in the ovaries (Fig. 7). Approximately at the age of 2, the size of ovaries starts to decrease to develop again in puberty. Uterus undergoes similar changes – in newborns, it is large, with dominating cervix and well visible hyperechogenic cavity.

The next organ, whose ultrasound image changes at the time the child grows, is the pancreas. In younger children, a correct pancreas has the echogenicity equal to or lower than the echogenicity of the liver, and in the period of being a newborn it may be higher (Fig. 8). In the period of being an infant, high echo of the pancreas proves a pathology.

Errors resulting from the lack of knowledge concerning the most common pathologies of the age of childhood and lack of clinical data about the patient

Ultrasound diagnostics of the abdominal cavity in a child is difficult, especially when it concerns the youngest children, including newborns and infants. It requires knowledge in the field of the incidence of congenital defects (of bile ducts, urinary and reproductive systems, intestinal loops), inflammations and the proliferative process. These abnormalities

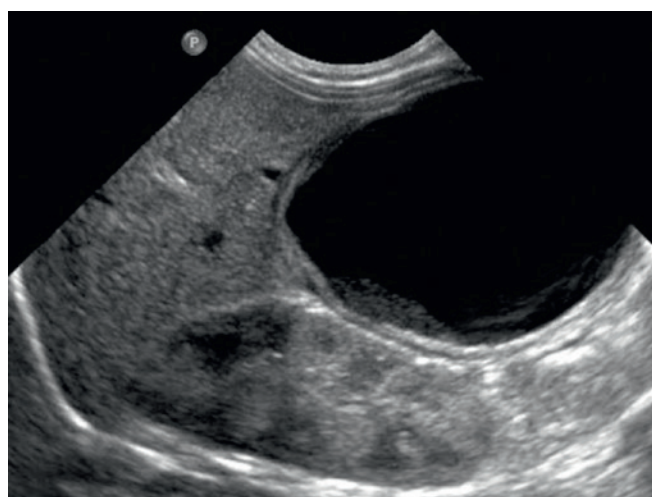


Fig. 12. Duplication of the alimentary canal; echoless cyst with a wall typical of the intestinal structure

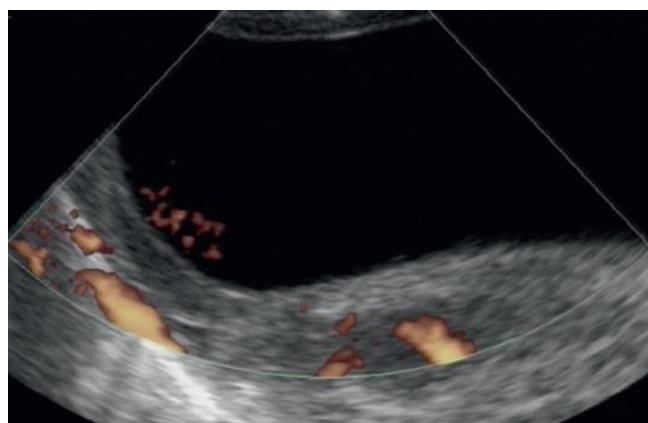


Fig. 13. Cyst of the mesentery. Echoless space undergoing compression under the pressure of the head, invisible pouch

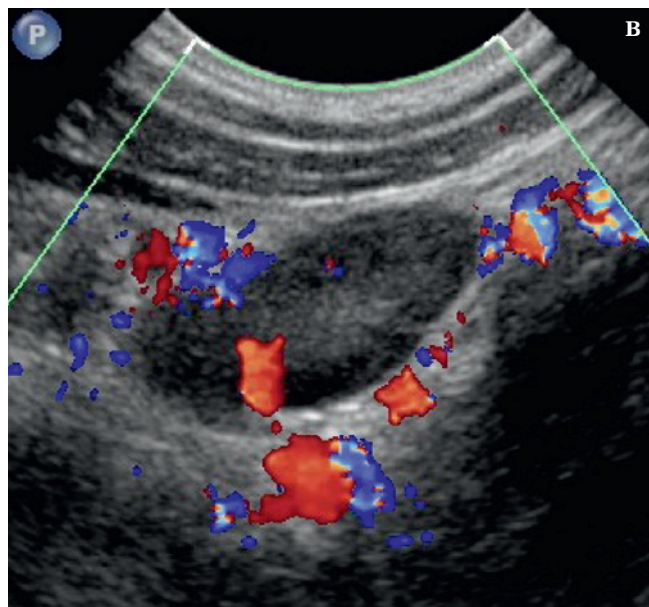
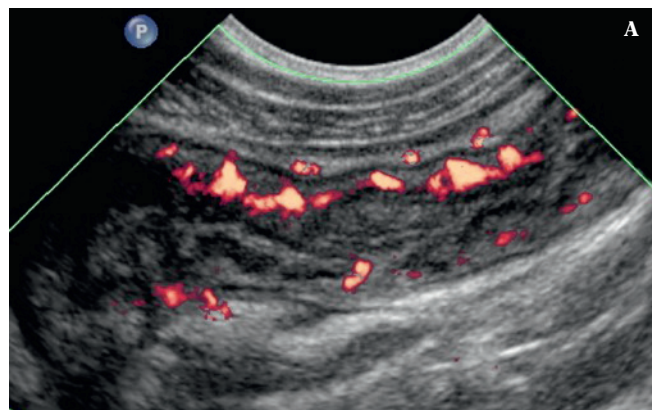


Fig. 14. A. Thickened wall of the final part of the ileum with increased vascular flow; **B.** enlarged lymph node in the right iliac fossa. Enteritis caused by the *Yersinia* bacteria

may take a varied clinical nature as well as ultrasound image. Interpreting the ultrasound image always needs to be based on clinical data of the child, the results of laboratory tests and other imaging as well as the knowledge of the most common abnormalities in specific age periods of a child.

In newborns, bleeding may occur as a result of antepartum hypoxia or perinatal trauma, most frequently to one adrenal gland (Fig. 9). Ultrasound image may be mistaken for the presence of a neoplastic lesion of a neuroblastoma type (Fig. 10). Clinical data and the assessment of the level of catecholamines and their products in urine may prove helpful in the assessment as well as the evolution and changes in the ultrasound image of the hematoma in time.

The presence of liquid lesions with the nature of a cyst within the abdominal cavity and the pelvis of the child may also result in diagnostic difficulties. It mainly applies to small children owing to small sizes of the area being subject to examination, which in the majority of patients is filled by a large cyst. The assessment of the starting point of the cyst may be doubtful, it may be varied and most often covers: the ovary, alimentary canal, mesentery or the common bile duct cyst. Ovarian cyst in the case of girls may be very large and reach as high as the liver. Precise assessment of the parenchyma of the liver and the bile ducts and presenting the connection of the cyst and the bile duct make it possible to assess its nature (Fig. 11). A cyst being a duplication of the alimentary canal is characterized by the presence of a wall typical of the intestinal wall structure (Fig. 12), while the cyst of the

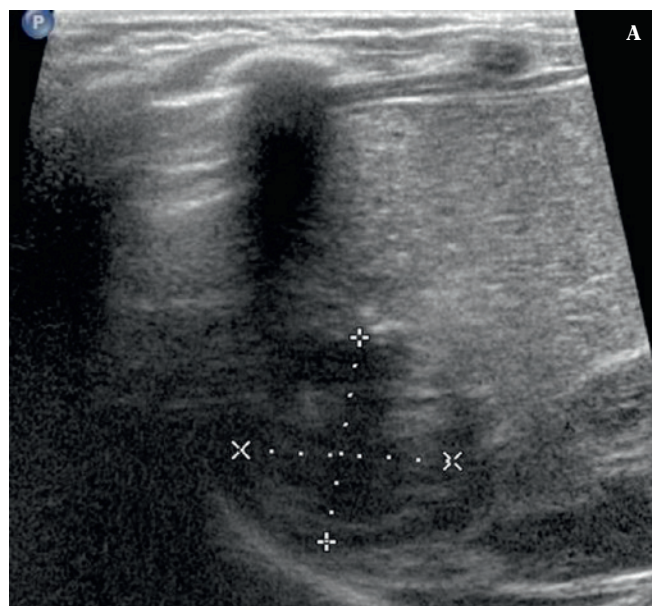


Fig. 15. Condition following hepatic tumor removal: A. area with mixed echo – site following the surgery; **B.** follow-up: liquid lesion – evolution of the hematoma

mesentery with no pouch undergoes compression and small displacement as a result of the head's pressure (Fig. 13).

In the course of ultrasonography of the abdominal cavity in children, it is an error not to perform the assessment of the stomach, pylorus, alimentary canal, including vermiform appendix, and the retroperitoneal space, also with the use of linear heads. It is especially recommended for patients with abdominal pain and concomitant vomiting, diarrhea or constipation, subfebrile body temperature, or the presence of blood in the stool^(7,8). Diagnosing pylorostenosis, intussusception and intestinal inflammation, or enlarged lymph nodes in ultrasonography provide essential information and make it possible to narrow down the diagnostic process (Fig. 14).

Errors in the assessment of the abdominal cavity may also result from the lack of accurate information concerning the treatment and the scope of the surgery performed, especially in the case of cancer patients. The application of chemotherapy and radiotherapy not only leads to changes in the echostructure and echogenicity of pathological lesions, but also affects the image of appropriate organs. In the case of the surgery performed, an essential piece of information is to what extent the lesion was removed and whether the visible abnormal image is a residual mass or post-operative hematoma (Fig. 15).

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Summary

Ultrasound examination of the abdominal cavity in children is a difficult one, requiring a lot of knowledge in the field of physiology of the developing body and the ability to connect the present symptoms and searching in ultrasonography for lesions typical of a given pathology. It entails a precise assessment of the whole abdominal cavity, true pelvis and the retroperitoneal cavity and the alimentary canal in order to minimize the possibility of an error.

The article presents the principles to follow when performing and assessing the ultrasound examination of the abdominal cavity in children, paying particular attention to the youngest patients. When performing an ultrasound examination in older children, it is necessary to follow the same standards as in the case of examining adults, ones described in articles on the subject matter in the journal.

Conflict of interest

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