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Real-time ultrasound in Crohn's disease: characteristic features and clinical implications

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Abstract. Thirty-two children with Crohn's disease were evaluated by real-time ultrasonography. The typical pattern of Crohn's disease caused by bowel wall thickening is the "bull's eye phenomenon", the elongated tubular stiff bowel loop with narrowing of the lumen and the small bowel conglomerate tumor. In indefinable abdominal complaints sonography may lead to the correct diagnosis. The differential diagnosis of similar sonographic features and the limitations of ultrasound in gastrointestinal disease must be considered. In proven Crohn's disease the findings in follow-up match the clinical course and may delineate complications, such as ileus, abscess, hydronephrosis, gallstones or involvement of parenchymal organs, as seen in 15 patients. Thus ultrasound will restrict repeated x-ray studies and support patient management.

Abdominal ultrasound has been established as a valuable diagnostic modality in abdominal diseases, especially if parenchymal organs are involved. Sonographic diagnosis of the gastrointestinal tract is often limited by intestinal air, which causes complete reflection of the ultrasonic pulse. Nevertheless, the careful evaluation of the intestine by ultrasound elicits the finding of bowel wall thickening for example in hypertrophic pyloric stenosis [1], in intussusception [2, 3] and malignant intestinal neoplasms [4]. More or less typical ultrasound features are reported in Crohn's disease in adults [5, 6, 7, 8, 9, 10] but no data on a larger sample of children has been published up to now. We report the results of an ultrasound study in 32 children with proven Crohn's disease and the implications for clinical management of the patients.

Patients and methods

From March 1977 to April 1984 a total of 32 children with Crohn's disease were examined. Diagnosis was confirmed by clinical, endoscopic, radiological and biopsy studies. The age of the patients (15 boys, 17 girls) ranged from 6 to 16 years.

Table 1. Sonographic criteria in Crohn's disease

Bull's eye phenomenon:
- thickened sonolucent mantle
- dense central echoes
Elongated tubular structure:
- thickened echo-poor bowel wall
- narrowing of the lumen with bright central echoes
Rigid bowel segment:
- no peristaltic motion
- diminished compressibility
- decreased mobility
Inconstant findings:
- intestinal conglomerate tumor
- prestenotic bowel dilatation
- thickening of the mesentery

Table 2. Sonographic findings in 32 children with Crohn's disease

Ultrasound pattern[a]	No of patients
Definite pathological sonographic findings	28/32
Bull's eye phenomenon and elongated tubular structure	22/28
Conglomerate tumor of small bowel	16/28
Complications of Crohn's disease	
- Ileus	6/28
- Abscess, peritoneal or retroperitoneal	5/28
- Infiltration of the liver	1/28
- Renal calculus	1/28
- Hydronephrosis due to inflammatory ureteral obstruction	4/28
- Infiltration of urinary bladder	2/28

[a] Up to three features were observed in one patient

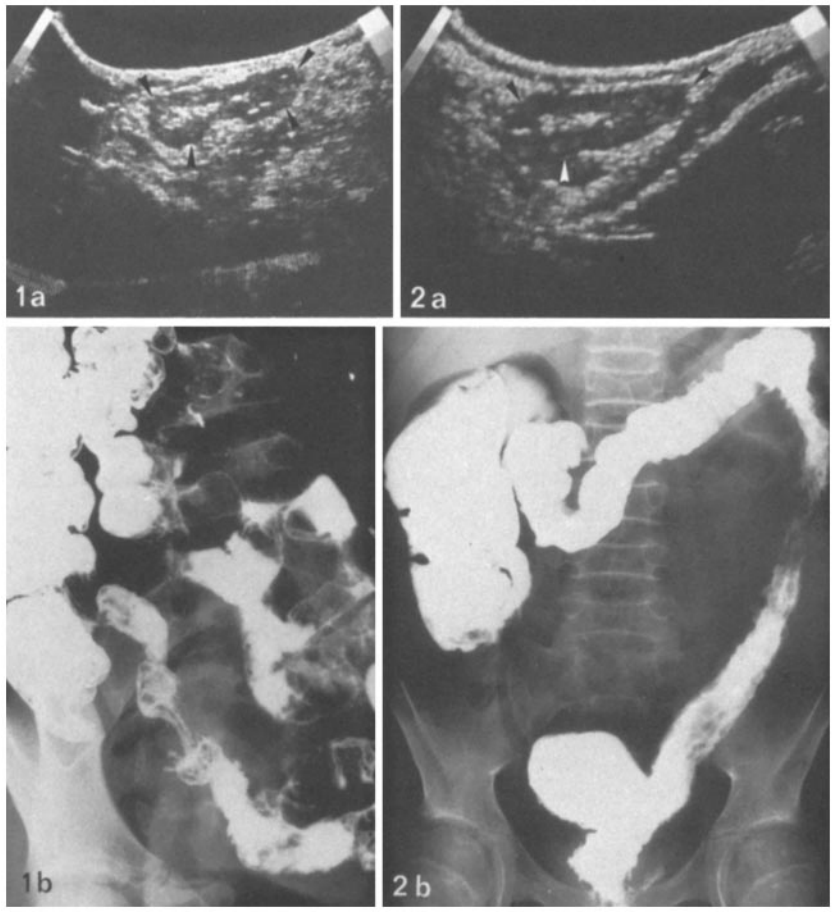

Fig. 1 a, b. Transmural inflammation (**a**) of the terminal ileum (▲). The dumb-bell-shaped ileum with its thickened wall does not imply narrowing of the lumen. Oblique section of the right inferior abdomen. **b** Barium study of the small bowel with the radiological feature of Crohn's disease of the terminal ileum with cobblestone pattern and separation of bowel loops indicating mucosal-mural involvement

Fig. 2 a, b. Crohn's disease of the descending colon with wall thickening up to 1.6 cm. The oblique section of the affected colonic segment in the left inferior quadrant presents a pattern resembling the aspect of a kidney, the so-called "pseudo-kidney sign" (▲). Crossed renal lumbar ectopia must be excluded

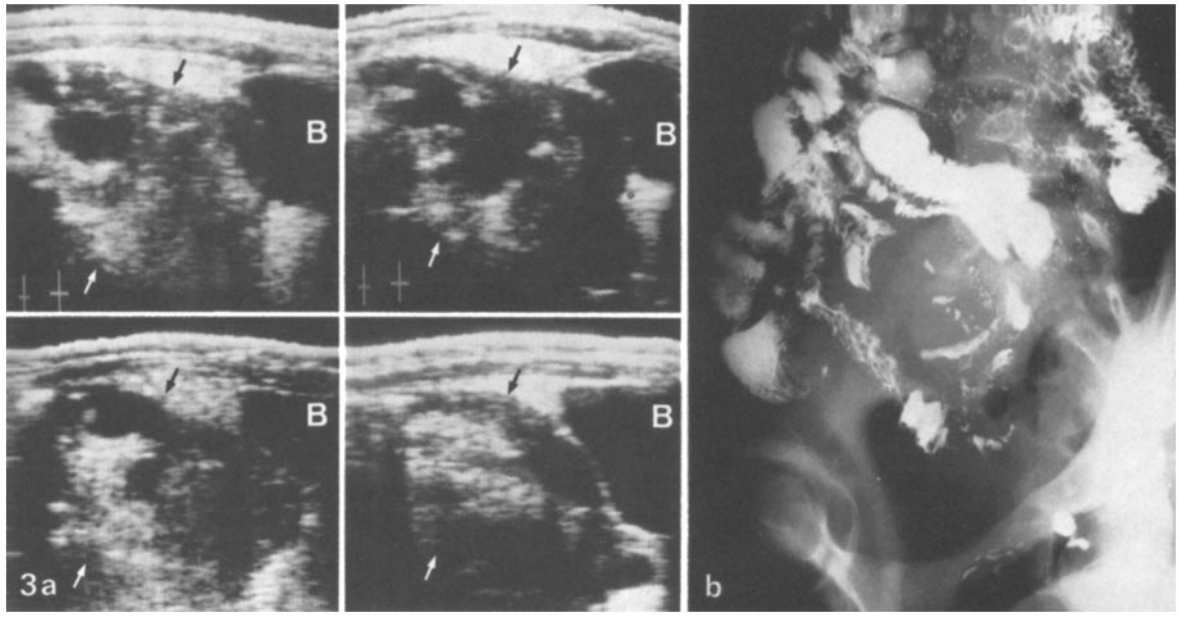

Fig. 3 a, b. Conglomerate tumor of the matted small bowel consisting of solid structures, which match the thickened bowel wall and mesentery and echo-free fluid filled dilated bowel loops and bright reflections caused by intestinal air (**a**). The longitudinal and oblique sections in the lower abdomen display a wide variety of findings; individual bowel loops can not be demarcated. 12-year-old girl. *B* = urinary bladder. **b** Barium radiography of the small bowel with the features of a conglomerate tumor: cobblestone mucosal pattern, separation of bowel loops, segmental narrowing, prestenotic distension of single bowel loops

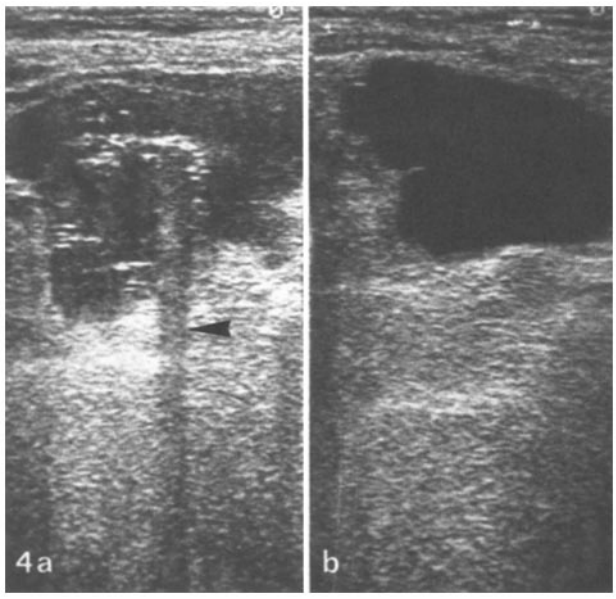

Fig. 4a, b. Conglomerate tumor of the small bowel (**a**). Distended fluid-filled prestenotic bowel loops; solid areas due to the thickened bowel wall and mesenteric fat; bright echoes with typical reverberation echoes caused by intraluminal air (▲). The complicating abscess could not be delineated. Transverse section of the lower abdomen. **b** Fluid filled prestenotic dilated descending colon shown on a transverse section of the lower abdomen

The ultrasound examinations were performed with a mechanical real-time scanner (Combison 100, Kretz, Zipf, Austria) with a 3.5 or 5 MHz transducer. The scanner was equipped with a water display.

The intestine was examined by longitudinal, transverse and oblique sections with special reference to the typically preferred localizations of Crohn's disease, i.e. ileum and colon. Liver, spleen, kidney, gallbladder and urinary bladder were screened for possible involvement.

Results

Ultrasound pattern in Crohn's disease

Definite pathological sonographic findings were detected in 28 of 32 patients (Table 1, Table 2). The characteristic bull's eye phenomenon on transverse and the elongated tubular structure on longitudinal bowel sections represent the thickened bowel wall due to the transmural inflammation; the dense central echoes are caused by the mucosal surface, intraluminal air and food particles (Figs. 1, 2). The involved bowel segment usually showed a symmetric pattern, but asymmetry was found as well.

Thickness of the bowel wall was judged on longitudinal sections to prevent false positive findings of pathological wall thickness because of an inclined transverse section. The degree of wall thickening (large bowel - 0.8 to 1.7 cm) and spread of lesion correlated to the extent of disease as documented by x-ray studies. Conglomerate tumors presented as complex mass lesions with an irregular echo-pattern in 16 patients (Fig. 3). Follow-up studies under conservative treatment usually revealed a tremendous decrease of size of the conglomerate tumor within a week or fortnight, paralleled by clinical improvement.

Involvement of the colon could be differentiated from small bowel disease because of the fixed colonic position. The sonographic staging of the small bowel was difficult because of greater variability in localization and intensive peristalsis with rapid changing echo patterns. The terminal ileum, however, with its well defined topographical localization showed somewhat better diagnostic properties and was delineated as a stiff bowel segment in 7 patients (Fig. 1).

Ultrasound diagnosis of complications in Crohn's disease

The most frequent complication in our series was ileus of various degrees. Predominant findings were distended fluid-filled bowel loops with absent or severely diminished peristalsis, but in two patients hyperperistalsis due to mechanical obstruction was seen.

Abscess formation was found in 5 patients. The typical feature was an echo-free area with a more or less well defined wall which was attached to inflamed bowel loops. In about half of the patients with a conglomerate tumor one could not differentiate between matted, inflamed bowel loops and complicating abscess formation (Fig. 4); both presented tenderness and pain due to slightly increased pressure with the transducer. A 15 year old girl presented with painful immobilization of the left leg and a tender mass in the mid abdomen. Ultrasound revealed a conglomerate tumor and a swollen left psoas muscle with homogenous but decreased echogenicity, indicating suppuration, and this settled under antibiotic treatment. In one patient the inflammatory process spread from the hepatic flexure to the liver. There was loss of the inferior liver border and increase in parenchymal echogenicity.

Inflammatory involvement of the retroperitoneal space in 4 patients caused ureteral obstruction and hydronephrosis, which was asymptomatic in two children. Improvement occured under conservative treatment, but one child needed a transient nephrostomy. An urodynamically effective ureteral stenosis was ruled out if there were no sonographic signs of urinary tract obstruction under the standardized conditions of diuresis with a sufficient oral fluid load prior to the examination.

Discussion

Crohn's disease has been diagnosed in childhood with increasing frequency during the last decade [11]. Whether this is due to more sensitive diagnostic procedures, such as endoscopy or radiological double contrast examinations of the intestine, or reflects a real increase in incidence still remains an unanswered question.

Despite the high number of positive ultrasound findings in Crohn's disease the ultrasound pattern (Table 1) is not conclusive [5, 6, 7, 10]. Thickness of bowel wall of more than 3–5 mm should be considered pathological, but the nondistended large bowel segment in adults may present wall thickness of 6–9 mm physiologically [12]. The sonographic pattern of quite a number of intestinal diseases with bowel wall thickening is similar [13, 14, 15, 16, 17]. Findings in a child with intestinal tuberculosis were identical and even ulcerative colitis may show an indistinguishable echo-pattern [8].

Rare differential diagnoses include bowel carcinoma or bowel hematoma, if the pathological lesion is limited to a short segment of the intestine [4, 18]. Infiltration by lymphoma consists of extensive thickening of up to 2 cm of the almost echo-free bowel wall [19]. Intussusception shows a typical "target phenomenon", with a central echopoor area, which represents the edematous intussuscepted bowel segment [2, 3]. Age of the patient, history, laboratory findings and localization of the affected bowel will aid in differentiation of these disorders and often be conclusive.

Ultrasound examinations of the gastrointestinal tract are restricted by a few limitations, but generally the results in children are superior to those obtained in adults. Children present less fatty tissue both in the subcutaneous layer and intraperitoneally.

Mesenteric fat creates diffuse accumulations of heterogenous echoes and decreased transmission of ultrasound. This unsatisfactory imaging quality does not improve when ultrasound frequency is changed [20]. Moreover children usually show a smaller degree of meteorism, which causes artificial reverberation echoes and prohibit visualizing the region of interest. The approach from the body flank seldom helps to overcome this obstacle. Increased mechanical pressure by the transducer or a quick, light compression of the abdomen, i.e. "shaking" the bowel, may induce peristaltic movement and improve picture quality [10]. Antimeteoristic drugs, which are sometimes recommended [21], are of little help.

Enteritis provides a wide variety of ultrasound findings due to hyperperistalsis, intraluminal air, food particles and fluid filled loops; thus only very prominent pathological patterns can reliably be discriminated. Constipation may mislead in diagnosis and even mimick Crohn's disease and so requires reexamination after purgation. As inconclusive findings can be due to ingested food, one should examine a fasting patient. Ultrasound study should be prior to barium enema or upper gastrointestinal series, because barium contrast material interferes with the ultrasound propagation and causes artificial echoes [22].

Real-time equipment reduces the number of false positive findings of wall thickening due to localized contracted bowel segments for it delineates peristaltic motion. Whenever there are inexplicable or inconclusive findings or contradictory clinical findings reexamination will increase the diagnostic value.

Mucosal changes are invisible even with thorough ultrasound studies but can be detected by endoscopy or radiological double contrast studies [23], both of which are superior in early diagnosis, detection of fistula and in precise determination of the extent of the lesion.

Nevertheless, sonography is a useful diagnostic tool in Crohn's disease: in inconclusive abdominal complaints ultrasound is the initial method of diagnostic imaging and a pathological bowel pattern will initiate more invasive examinations.

Our experience in children matches reports of Crohn's disease in adult patients in that the ultrasound findings correspond to the course of the disease. Follow-up studies provide detail about the stage of the inflammatory process and show regression or recurrence. The determination of liver and spleen size by ultrasound helps to grade the inflammatory change in both organs [24]. Complications such as abscess formation or involvement of parenchymal organs can be looked for and excluded or verified by means of ultrasonography alone [25]. Intravenous urography, which is still recommended by several medical centers, is no longer necessary as a screening procedure, when obstructive uropathy is ruled out by ultrasound.

Thus ultrasound will not substitute for contrast radiography, but repeated radiological contrast examinations including computed tomography [26] can be restricted to a reasonable level.

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