CLINICAL AND LABORATORY OBSERVATIONS

Ultrasonographic assessment of inflammatory bowel disease in children: Comparison with ileocolonoscopy

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Objectives: **To determine the feasibility and value of transabdominal ultrasonography of the terminal ileum and colon of children with inflammatory bowel disease (IBD) and to compare the findings with those of ileocolonoscopy.**
Study design: **Thirty-eight patients ranging in age from 4 to 18 years who underwent ileocolonoscopy for management of IBD or for diagnosis were studied prospectively. Twenty-one patients had Crohn disease, nine had ulcerative colitis, and eight served as control subjects. Transabdominal ultrasonography was performed on the day before ileocolonoscopy. Ultrasonographic findings were compared with the results of ileocolonoscopy, used as the reference method.**
Results: **Peristalsis was recorded in all segments of the control subjects; the thickness of the terminal ileum was always less than 2.5 mm, and that of the large bowel, 2 mm or less. In the two patient subgroups, the thickness range of affected ileal and colonic segments was similar, but values were significantly different from those of the control subjects (chi-square test, $p < 0.0001$). The overall sensitivity of the method was 88%, and the specificity, 93%.**
Conclusion: **Transabdominal ultrasonography should prove to be a useful clinical and investigational technique, although further studies are needed to assess its value in the treatment of children with IBD. (J Pediatr 1997;130:147-51)**

Optimal management of inflammatory bowel disease in children requires determination of disease localization. Transabdominal ultrasonography of the terminal ileum and large bowel is safe and noninvasive and has been used to detect polyps[1] and to assess inflammatory bowel disease.[2-7] The ultrasonographic aspect of the normal intestinal wall has been described in vitro[8] and shown to be thinner than that of patients with inflammatory bowel disease.[9] Ultrasound studies of adults with Crohn disease or ulcerative colitis have provided information on transmural changes and the sites of involvement in inflammatory bowel disease.[2-7]

The aims of this study were to determine the feasibility and value of tUS examination of children with inflammatory bowel disease and to compare these findings with those of ileocolonoscopy.

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METHODS

Patients. We prospectively studied 38 patients aged 4 to 18 years (median, 11.1 years) who underwent ileocolonoscopy for management of their disease or for diagnosis. Twenty-one patients had CD (11 cases newly diagnosed), and nine had UC (four cases newly diagnosed); eight patients whose endoscopic examination showed normal results served as control subjects. The latter were examined because of suspected inflammatory bowel disease (2 patients) or rectal

See commentary, p. 10.

CD	Crohn disease
tUS	Transabdominal ultrasonography
UC	Ulcerative colitis

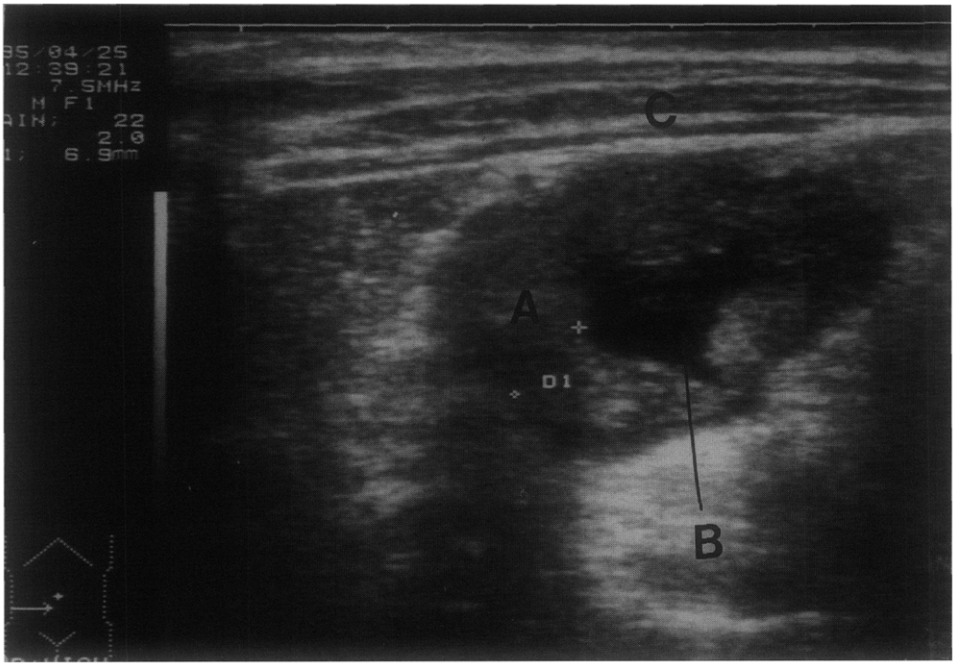

Fig. 1. Thickened right colon wall (6.9 mm) showing Crohn disease in transverse section. *A*, Thickened colonic wall with total loss of stratification; *B*, lumen; *C*, abdominal wall.

bleeding (4) or for the investigation of familial adenomatous polyposis (2). Informed consent was obtained from the children, their parents, or both.

Ultrasonography. Ultrasonography was performed by using a HITACHI EU B415 CFM ultrasound apparatus (Tokyo, Japan) with a lateral resolution of 0.9 mm and axial resolution of 0.6 mm and a 7.5 MHz linear transducer. The ultrasonographer received no information on the diagnosis, the aim of the examination, the site of lesions, or disease activity. To avoid artifacts, gas production, and difficulties in interpretation, tUS examination was performed on the day before ileocolonoscopy. The bowel was not prepared, and the patients were not required to fast. The children remained supine during the 30-minute examination.

The entire abdomen was scanned in both the longitudinal and transverse directions in every case. The terminal ileum and large bowel were separated into five segments (terminal ileum, right colon, transverse colon, left colon including the sigmoid, and rectum).

We noted the presence or absence of normal stratification of the intestinal wall,[8] the intestinal wall thickness on a single side, including the mucosa through the serosa, and peristalsis with respect to the five segments.

Ultrasonographic findings were compared with the results of colonoscopy, used as the reference method.

Ileocolonoscopy. Conventional endoscopy was performed under general anesthesia as part of the diagnostic evaluation or follow-up of inflammatory bowel disease.

Endoscopic lesions were described according to the previously mentioned segments. A segment was considered endoscopically abnormal when it contained at least one elementary lesion (CD: aphthoid ulceration, linear ulceration, or nodularities; UC: erythema, mucosal friability, or clear-cut hemorrhagic ulceration).

Statistical analysis. Bowel wall thickness of the affected segments in the patients was expressed as mean ± SD. The control subjects and patients were compared by using the chi-square test or the chi-square test with continuity correction. A p value of less than 0.05 indicated a statistically significant difference.

RESULTS

Control subjects. All the control subjects had normal ileocolonoscopic findings, which were used to define normal values and to describe the normal ultrasonographic aspect of the terminal ileum and large bowel in children.

Peristalsis was recorded in all segments. The bowel wall was visualized as a thin echogenic structure, limited on the outside by the serosa and subserosal fat and on the inside by the lumen.

The thickness of the terminal ileum was less than 2.5 mm in every case, and that of the large bowel 2 mm or less. In cases in which the ileal or colonic wall was clearly visible but its thickness was below the resolution of the instrument, wall thickness was taken as less than 2 mm.

Patients. All the patients completed tUS; however, the

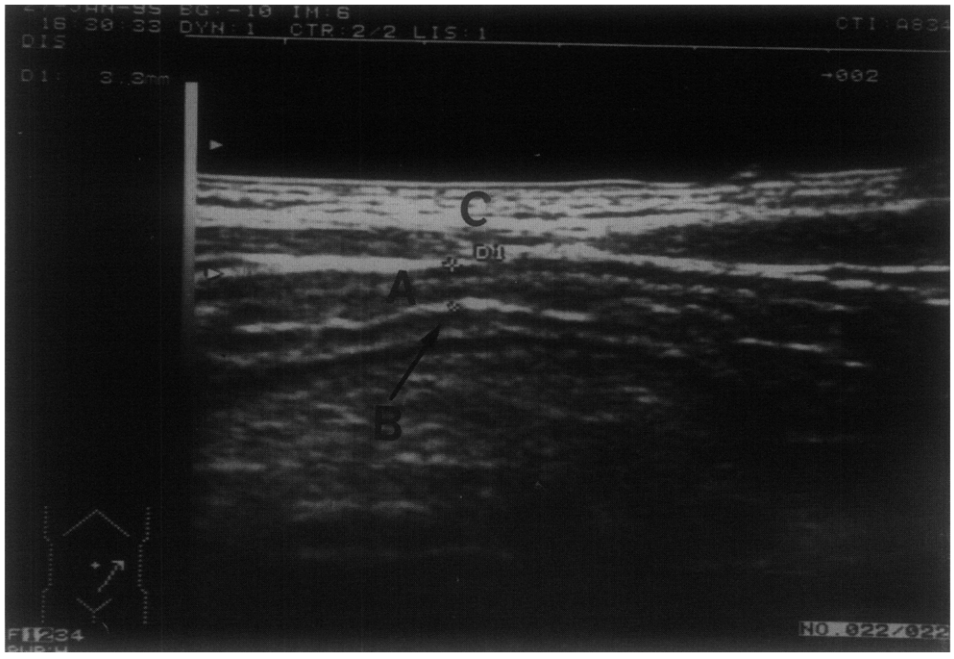

Fig. 2. Thickened left colon wall (3.3 mm) showing ulcerative colitis in longitudinal section. *A*, Thickened colonic wall with normal five layers of stratification; *B*, lumen; *C*, abdominal wall.

Table I. Colonic wall thickness in control subjects, affected segments in UC and CD, and intact segments in UC and CD

Thickness (mm)	CS (n = 32)	UC nonaffected (n = 9)	CD nonaffected (n = 44)	UC affected (n = 27)	CD affected (n = 40)
<2	27 (100%)	7 (100%)	31 (97%)	5* (19%)	8† (22%)
>2	0 (0%)	0 (0%)	1 (3%)	21 (81%)	28 (78%‡)
Nonstudied segments (No.)	5	2	12	1	4

CS, Control subjects.
*All these segments were affected, with superficial lesions on endoscopy.
†Six of these segments were affected, with aphthoid ulcers on endoscopy.
‡p <0.0001 versus control subjects and nonaffected segments; chi-square test.

Table II. Ileal wall thickness in control subjects, patients with UC, and affected and intact ileal segments in CD

Thickness (mm)	CS (n = 8)	UC (n = 9)	CD nonaffected (n = 5)	CD affected (n = 16)
<2.5	8 (100%)	9 (100%)	4 (80%)	0 (0%)
>2.5	0 (0%)	0 (0%)	1* (20%)	16 (100%†)

CS, Control subjects.
*This segment was normal on endoscopy and was incorrectly measured (3.2 mm) during tUS because of the proximity of the affected right colon.
†p <0.0001 versus control subjects and those with UC. Chi-square test with continuity correction.

rectal wall could not be examined in 17 cases. Peristalsis was absent from all affected segments, regardless of the nature of the disease. The wall thickness of the affected colonic segments was 4 ± 1.9 mm (maximum, 8 mm) in the patients with CD and 3.5 ± 1.6 mm in those with UC (maximum, 7 mm; Figs. 1 and 2).

Table I shows wall thickness in all the colonic segments studied. The thickness range of affected segments was similar in the two patient subgroups, but values were significantly different from those in control subjects and in unaffected segments of the corresponding patient subgroups. Most of the affected segments showing reduced wall thickness bore very superficial lesions on endoscopy (five of five in UC; six of eight in CD).

Table III. Sensitivity and specificity of transabdominal ultrasonography compared with ileocolonoscopy

	Sensitivity (%)	Specificity (%)
Terminal ileum	100	92
Right colon	77	91
Transverse colon	80	90
Left colon; sigmoid	93	100
Rectum	89	Not calculated
Total	88	93

Sensitivity and specificity were calculated for each digestive-tract segment studied.

Ileal wall thickness was similar in the control subjects and the patients with UC; it was significantly greater in the patients with CD when ileitis was present (mean, 4.7 ± 1.9 mm; range, 3 to 10) but not when it was absent (Table II).

Bowel wall stratification was clearly visible in 33% of the affected segments. In the remaining 66%, normal stratification was unrecognizable. Among affected UC and CD segments, 40% and 74%, respectively, had no visible stratification.

Sensitivity and specificity. The overall sensitivity of the method was 88% but varied according the segment (Table III). Sensitivity was highest for ileitis in patients with CD, and lowest in the transverse and right colon. The specificity was 93%, regardless of the segment (Table III).

DISCUSSION

Ultrasonographic studies of the terminal ileum and large bowel are capable of locating lesions in these children with inflammatory bowel disease. We found a good correlation of disease distribution between tUS and ileocolonoscopy. However, ultrasonographic differential diagnosis between CD and UC was not possible. Abnormal ultrasound images in patients with inflammatory bowel diseases usually correspond to wall thickening on pathologic examination.[9] Bowel wall stratification was rarely observed in the affected segments, regardless of the type of bowel disease. Our results confirm that affected segments can be detected by tUS through their wall thickening and lack of peristalsis.[2, 4, 7] The loss of stratification of the thickened bowel seems to be a structural alteration linked to the inflammatory process itself, independent of the nature of the disease.[6, 9]

The sensitivity and specificity of ultrasonography for inflammatory bowel lesions in adults are similar to those reported here. Limberg[5] reported a sensitivity and specificity of 91% and 100%, respectively, in 24 patients with CD and 89% and 97%, respectively, in 18 patients with UC.[5] Hata et al.[6] reported a sensitivity of 86% to 89% and a specificity of 97% to 98% in 36 patients with CD and 28 patients with UC, respectively. Other authors have found a good correlation between tUS findings and the findings of conventional investigations but provided few concrete data.[2, 4, 7] It should, however, be noted that these authors compared the results of ultrasonographic examination with those of barium enema or endoscopy, and that there was at least a 1-month interval between the two procedures.

Sensitivity varied according to the segment in our study and was best in the terminal ileum. As previously reported in adults,[5] very small superficial lesions such as aphthoid ulcers in CD, and such as erythema and a fragile, easily bleeding mucosa in UC, can be missed in children examined by means of ultrasonography. Other lesions such as clear-cut hemorrhagic ulceration and nodularities were always detected, on the basis of wall thickening and absent peristalsis.

Differentiation between CD and UC was not possible by ultrasonography, although ileitis was always detected when present in patients with CD. Similar findings have been reported in adults.[4, 7] Some authors described a loss of bowel wall stratification in CD but not in UC.[2, 5] In agreement with Worlicek et al.[4] and Lim et al.,[7] we found no clear difference between CD and UC, with a lack of stratification in both cases.

The main advantage of tUS is its noninvasive nature, so we did not prepare the bowel or use enemas during the examination, although some authors have reported high resolution of tUS after a saline enema, the entire colon being adequately visualized.[1, 5] Another reason for our decision not to prepare the colon was that patients with inflammatory bowel disease have fragile lesions and abdominal pain; this is also the approach adopted in most adult studies.[2, 4, 6, 7]

Our results suggest that tUS could be a useful clinical and investigational technique, although further studies are needed. Whereas ileocolonoscopy clearly remains the reference diagnostic method for inflammatory bowel disease in children, ileocolonic ultrasonography could be used initially and during follow-up. Furthermore, colonic ultrasonography could be a safe and reliable diagnostic method for acute severe inflammatory diseases of the colon. Doppler flow imaging of the superior mesenteric artery shows promise in the assessment of inflammatory bowel disease activity.[10] Further longitudinal studies are now required to determine the value of ileocolonic ultrasonography in the assessment of treatment and disease activity.

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Point-of-care glucose testing in the neonatal intensive care unit is facilitated by the use of the Ames Glucometer Elite electrochemical glucose meter

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Objective: **To evaluate the Ames Glucometer Elite glucose meter for use in point-of-care glucose testing in the neonatal intensive care unit.**
Methods: **An important part of our quality control program involves a weekly comparison of glucose values obtained with each of the seven Elite analyzers and the Beckman CX7 analyzer located in the central laboratory. Each "split" sample involves measurement of the glucose by using the Elite analyzer in a sample of blood obtained from a heel stick at the bedside, followed by bleeding ("milking") 150 to 200 μl (4 to 5 drops) of blood into a heparinized microcontainer. This process should take no longer than 1 to 2 minutes, whereupon the microcontainer is placed on ice and sent to the laboratory. The values obtained were compared by regression analysis. Imprecision of the Elite meter was estimated at four levels of blood glucose concentration and on a normal-level quality control sample used for a period of 4 months.**
Results: **Regression analysis between the glucose values obtained on the Elite meter and the CX7 meter revealed $r = 0.93$, p less than 0.0001, n = 188, Sy/x = 0.59 mmol/L, intercept = 0.47 ± 0.14 mmol/L (1 SEM), and slope = 0.91 ± 0.028 (1 SEM). When we switched to on-ice delivery of split samples to reduce metabolic activity during transport of the specimens to the laboratory, scatter about the regression line was decreased and the Sy/x was reduced to 0.45 mmol/L. Before the on-ice delivery of split samples, 24% of the Elite analyzer's results differed from those of the CX7 analyzer by more than 15%, whereas only 8% differed from those of the CX7 meter by more than 15% after on-ice delivery of split samples. Of 30 samples read as "Lo" by the Elite meter, 29 were less than 2.2 mmol/L on the CX7**

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