Transabdominal ultrasound for standardized measurement of bowel wall thickness in normal children and those with Crohn’s disease

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Abstract
Background: The intestinal wall can be visualized using high resolution transabdominal ultrasound (TUS). TTUS measurement of the bowel wall thickness has been described in adults but data are lacking in children. The purpose of this prospective study was to sonographically investigate bowel wall thickness in healthy children and children with Crohn’s disease.

Material and methods: TUS (5-15 MHz) of the intestine was performed in 58 healthy children (age range 3 to 16 years) and in 30 children with Crohn’s disease (age range 8 to 17 years). The following regions were assessed and bowel wall thickness measured: terminal ileum, cecum, right flexure, and sigmoid colon. In patients with Crohn’s disease, the involved region was additionally assessed regarding length of involved segment and sonographic signs of transmural inflammation and fistula.

Results: TUS allowed adequate measurement of bowel wall thickness in all 58 healthy children (100%) and in all 30 Crohn’s disease patients (100%). The bowel wall thickness significantly differed between groups. Bowel wall thickness (mean ± SD) in all segments was less than 2 mm in all healthy children (1.0±0.1 mm terminal ileum, 1.1±0.1 mm cecum, 1.1±0.1 mm right flexure, and 1.3±0.1 mm sigmoid colon). In Crohn’s disease patients, bowel wall thickness was ≥ 3 mm in the ileocecal region and was significantly increased (5.1±1.9 mm) compared to the healthy children. The mean length of involved segment was 15±6.5 cm [5 - 30 cm]. Additional findings in Crohn’s disease patients were: transmural inflammation (3/30), interenteric fistula (1/30) and vesicoenteric fistula (1/30). Conclusions: Similar to adults, normal bowel wall thickness in children is always less than 2 mm. In all patients with Crohn’s disease, increased bowel wall thickness could be detected. TUS is a helpful tool in the diagnosis and assessment of activity and complications in Crohn’s disease.

Keywords: Crohn’s disease, bowel wall thickness, transabdominal ultrasonography

Introduction

The intestinal wall can be visualized using high resolution transabdominal ultrasound (TUS) [1-8]. TUS measurement of bowel wall thickness (BWT) has been described in adults but data are lacking in children.

Standards for normal BWT in adults have been established by computed tomography (CT) [9,10] and ultrasonography [11,12]. Sonographically measured mean BWT in adults ranges from 1 to 3 mm in the small bowel to 1 to 5 mm in the colon [11-13] (table I).

The aim of this prospective study was to sonographically evaluate the normal range of BWT in healthy children (HC) and to assess BWT and sonographic signs of disease activity and complications in children with established diagnosis of Crohn’s disease (CD).

Material and methods

Patients and controls
In the present study, 58 HC (27 male, 31 female, mean age±SD 11±4 years) and 30 patients with CD and involvement of the ileocecal region with or without rectal or colonic involvement (9 male, 21 female, 13±2.7 years)
Table I. Bowel wall thickness [mm] assessed by transabdominal ultrasound at different intestinal sites in healthy adult subjects.

<table>
<thead>
<tr>
<th>Jejunum</th>
<th>Ileum</th>
<th>Colon</th>
<th>Frequency [MHz]</th>
<th>Author year [reference]</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1.1</td>
<td>&lt;1.4</td>
<td>&lt;1.8</td>
<td>7.0</td>
<td>Haber 2000 [15]</td>
</tr>
<tr>
<td>2.0</td>
<td>2.0</td>
<td>2.0-3.0</td>
<td>3.5; 5.0</td>
<td>Worlicek 1986 [27]</td>
</tr>
<tr>
<td>&lt;2.0</td>
<td>&lt;2.0</td>
<td>2.0-5.0</td>
<td>5.0</td>
<td>Abu-Yousef 1987 [28]</td>
</tr>
<tr>
<td>&lt;3.0</td>
<td>&lt;3.0</td>
<td>&lt;5.0</td>
<td>3.5; 5.0</td>
<td>Kedar 1994 [29]</td>
</tr>
<tr>
<td>&lt;4.0</td>
<td>&lt;4.0</td>
<td>&lt;4.0</td>
<td>5.0</td>
<td>Bozkurt 1994 [30]</td>
</tr>
<tr>
<td>&lt;4.0</td>
<td>&lt;4.0</td>
<td>&lt;4.0</td>
<td>7.5</td>
<td>Maconi 1996 [31]</td>
</tr>
<tr>
<td>&lt;5.0</td>
<td>&lt;5.0</td>
<td>5.0</td>
<td>2.4-5.0</td>
<td>DiCandio 1986 [32]</td>
</tr>
<tr>
<td>&lt;5.0</td>
<td>&lt;5.0</td>
<td>&lt;5.0</td>
<td>na</td>
<td>Dubbins 1984 [33]</td>
</tr>
<tr>
<td>&lt;5.0</td>
<td>&lt;5.0</td>
<td>&lt;5.0</td>
<td>3.5; 5.0</td>
<td>Sheridan 1993 [34]</td>
</tr>
<tr>
<td>&lt;3.0</td>
<td>&lt;3.0</td>
<td>2.0-3.5</td>
<td>na</td>
<td>Odegaard 2012 [25]</td>
</tr>
<tr>
<td>0.9</td>
<td>1.1-1.2</td>
<td>1.0-1.2</td>
<td>8.0; 12.0</td>
<td>Nylund 2012 [26]</td>
</tr>
<tr>
<td>Na</td>
<td>1.1-1.3</td>
<td>1.1-1.3</td>
<td>7.0</td>
<td>Dialer 2003 [23]</td>
</tr>
</tbody>
</table>

Only studies using transabdominal ultrasound are included. Those trials using endoscopic ultrasound [44-48], hydrocolon ultrasound [49], in vitro measurements [50] or postmortem examination [51,52] are not included; <: indicates values below this level are considered normal; na: not available.

Results

All HC and CD patients even in the young ages tolerated the transabdominal ultrasound investigation of the bowel without objection. TUS allowed adequate measurement BWT in all 58 HC (100%) and all 30 CD (100%).

Bowel wall thickness in healthy subjects

BWT was less then 2 mm in all HC in all bowel segments. In detail: 1.0 ± 0.1 [0.9 -1.2 mm] mm in the terminal ileum, 1.1 ± 0.1 [1.0 -1.3 mm] mm in the cecum, 1.1 ± 0.1 [0.9 -1.3 mm] mm at the right flexure, and 1.3 ± 0.1 mm [1.2 -1.7 mm] in the sigmoid, respectively (table II) (fig 1).

Bowel wall thickness and additional findings in patients with Crohn’s disease

In all 30 CD patients, BWT was significantly increased as compared to HC (5.1±1.9 [3.0-10] mm versus 1.0 ± 0.1 [0.9 -1.2 mm] mm in the terminal ileum, 1.1 ± 0.1 [1.0 -1.3 mm] mm in the cecum, 1.1 ± 0.1 [0.9 -1.3 mm] mm at the right flexure, and 1.3 ± 0.1 mm [1.2 -1.7 mm] in the sigmoid, respectively (table II) (fig 1).
1.0±0.1 [0.9-1.2 mm] mm in the terminal ileum; p<0.001) (fig 2). Seven of the 30 CD, were clinically in remission according to a CDAI of ≤ 150. There was a trend for higher values in patients with symptoms (5.2±2.1 mm) compared to patients without symptoms (4.7±0.75 mm) (not significant). The mean LoIS was 15±6.5 cm [5-30 cm].

The ultrasound appearance of the bowel wall layers in the ileocecal region was accentuated in 15/30 cases and lost in 6/30 patients. In 9/30 patients with BWT <4 mm the bowel wall layer structure was preserved.

The presence of a TMR, representing a preliminary stage for fistula development in Crohn’s disease, was detected in 3/30 CD patients (fig 3). In 5/30 CD patients fistula were detected; 3 interenteric fistula, one gastrocolic fistula, and one vesicoenteral fistula. Free fluid was found in 4/30 CD patients. TUS findings are presented in table III.

Spearman Rank correlation of bowel wall thickness and CDAI in children with Crohn’s disease revealed a weak but significant association between BWT and activity index (r=0.4; p<0.04) (fig 4). By normal standards, the association between the two variables would be considered statistically significant.

Discussions

The intestinal wall can be visualized using high resolution TUS in healthy adults and children. The development of high resolution ultrasound transducers has facilitated the identification of the different layers of the bowel wall [6,7,14,15]. Linear transducers are preferable over convex probes due to the higher resolution. In some children convex probes have to be used due to anatomical reasons.

Values for TUS measured BWT are comparable for children as for adults. Differences to other published results might be explained by the method used. We require air bubbles to delineate and define the ventral luminal border of the mucosal wall layer and apply dosed compression for improved reproducibility which was not a

<table>
<thead>
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<th>Sonographic findings</th>
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<tbody>
<tr>
<td>Bowel wall thickening [mm]</td>
<td>5.1±1.9 [3.0 - 10]</td>
</tr>
<tr>
<td>Transmural inflammatory reaction (TMR)</td>
<td>3/30 (10 %)</td>
</tr>
<tr>
<td>Interenteric fistula</td>
<td>3/30 (10%)</td>
</tr>
<tr>
<td>Gastrocolic fistula</td>
<td>1/30 (3.33%)</td>
</tr>
<tr>
<td>Vesicoenteral fistula</td>
<td>1/30 (3.33%)</td>
</tr>
<tr>
<td>Ascites</td>
<td>4/30 (13.33%)</td>
</tr>
</tbody>
</table>

The results are expressed in mean±standard deviation [minimum – maximum] or percent.

Fig 4. Spearman Rank correlation of bowel wall thickness and CDAI in 30 children with Crohn’s disease (r=0.4; p<0.04).
described criterion in other studies [14,15]. Comparing our data in children to those in adults from our previous studies (table II), age dependent differences in BWT were not obvious, but a trend was reported by Haber et al [15].

MacSweeney et al [22] examined 38 healthy subjects (age range, 1 month to 39 years) and found that the maximum colon wall thickness was 0.8 mm. Haber et al [15] performed TUS of the small bowel and the colon in 128 subjects (age range, 3 days to 40 years). They found that BWT increased significantly (p<0.0001) with age, reaching a maximum colon wall thickness of 2.0 mm at the age of 20 to 29 years. In the ileum, maximum bowel wall thickness reached 1.5 mm at the age range of 10 to 14 years. Haber et al [14] also sonographically evaluated 46 healthy patients (22 females) with a mean age of 17 (SD 11.3) (median 13; range 0.4–40) years. Maximum thickness of the wall of the small intestine was 1.5 mm and maximum thickness of the colon wall was 1.9 mm. There was a slight, but significant (r =-0.594; p<0.001) increase with age. Dialer et al [23] sonographically evaluated bowel wall thickness at the level of terminal ileum, cecum, ascending and descending colon in 31 healthy probands (mean 13.3 years, range 0.7–32), representing a control group for their study evaluating bowel wall thickening is not a pathognomonic finding in inflammatory bowel disease. A large spectrum of other intestinal diseases can also lead to thickening of the bowel wall, infectious, vascular, or neoplastic conditions should also be considered [11,14,40,41].

TUS is a useful examination technique to determine morphological alterations of the bowel wall associated with active CD compared to HC [12,42]. In contrast to endoscopic procedures, which are generally restricted to the evaluation of the mucosal surface, ultrasonography is able to confirm transmural inflammatory activity [4]. In addition, it could be shown that routinely performed ultrasonography of the abdomen reveals pathological findings with therapeutic implications not only in symptomatic but also in asymptomatic patients with Crohn’s disease [4]. As endoscopic techniques in children usually require deep sedation, the non-invasiveness of the TUS not even requiring bowel preparation is intriguing.

In adults, attempts have been made to correlate wall thickness with disease activity particularly Crohn’s disease activity index (CDAI); the results have been summarized [43]. In a large series of 255 patients, it was evidenced that wall thickness is significantly higher in CD compared to normal (4.9+/−2.7 mm versus <2.0 mm) and greater in active (CDAI >150) than in inactive disease (CDAI <150): 5.8+/−2.9 mm versus 4.3+/−2.2 (p<0.0001) [4]. In a smaller unpublished trial including 92 consecutive adult patients a weak but significant association (correlation) of BWT with the CDAI was found (Rχ2=0.44, p<0.00001) [43]. In our study, a weak but significant association between BWT and activity index could also be seen in children.

Ultrasound has been used as screening procedure in adults to evaluate the bowel wall and extraintestinal manifestations in inflammatory bowel diseases [20] but data are still lacking in children. Ultrasound has also proven to be of value in similar diseases compared to inflammatory bowel diseases [1,2,21,43].

In conclusion, ultrasound is a valuable tool for the quantitative assessment of normal and pathological BWT in children. In HC, the normal bowel wall is less than 2 mm in the terminal ileum and throughout the colon. In children with CD, the BWT is increased, often even in quiescent disease.

Conflict of interest: none

References