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ORIGINAL ARTICLE

The usefulness of ultrasound examination of the bowel as a method of assessment of functional chronic constipation in children

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Abstract
Background Ultrasonographic assessment of stool retention in children with chronic constipation requires the diagnosis of megarectum.
Objective The aim of the study was to evaluate an atypical method of US assessment of megarectum, fecal impaction and enlarged colon in order to decide whether it can be used as an assessment method for children with functional chronic constipation.
Materials and methods A total of 120 children with a positive diagnosis of chronic constipation were included in the study. All patients fulfilled the ROME II diagnostic criteria for defecation disorders. The control group comprised 105 patients with a normal defecation pattern. Children with a US diagnosis of megarectum, fecal impaction and enlarged colon were referred for proctoscopy and measurement of colonic transit time.
Results The transverse diameter of the rectal ampulla increases with age and thus influenced the US measurements in both the patient and control groups. The numerical values of this parameter differed significantly between patients and controls in all age groups. The rectopelvic ratio is the ratio of the width of the rectal ampulla (as seen by US) to the distance between the anterior superior iliac spines (measured externally using a measuring tape). This allows the definition of megarectum. In the diagnosis of fecal impaction, US showed a sensitivity of 88.3% relative to proctoscopy. In children with fecal impaction the colonic transit time, average segmental transit time for the rectum and sigmoid colon, and average segmental transit time for the left colon were significantly longer. There was no statistically significant difference for the right side of the colon.
Conclusion US assessment of stool retention and overfilling of the colon in children with functional chronic constipation has a high correlation with proctoscopy findings and colonic transit time. The rectopelvic ratio can be used to diagnose megarectum in children with functional chronic constipation with a cut-off value of 0.189.

Keywords Ultrasonography · Constipation · Children · Selection

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Introduction

Until now, US assessment of stool retention has been described by only a few authors. The rectal ampulla is the upper part of the rectum above the laevator ani muscle and is enlarged in chronic constipation. Klijn et al. [1] determined the width of the rectal ampulla in children with functional chronic constipation and dysfunctional voiding. They obtained very promising results: the group of children with constipation showed a significantly larger transverse diameter of the rectal ampulla than healthy controls. Diagnosis of megarectum by US will allow the separation of children with constipation from those with dysfunctional voiding. Singh et al. [2] have described the use of rectal

ampulla width as determined by US in the diagnosis of megarectum in children with constipation.

The aim of this study was to determine whether a new method of US assessment of stool retention could be used as a method of identifying children with functional chronic constipation, and to determine whether children with an enlarged rectum and colon (as seen on US) should be referred for further diagnostic procedures such as proctoscopy and assessment of colonic transit time.

Materials and methods

A total of 120 children (72 boys, 48 girls; age 1.6–17.9 years, mean 6.25 years) were included in the study. They had been referred to the paediatric gastroenterology outpatient clinic because of chronic constipation. Diagnosis of constipation was based on patient history and physical examination. In all patients the defecation disorders had persisted longer than 6 months and all patients fulfilled the ROME II diagnostic criteria for defecation disorders: the frequency of bowel movements was less than twice a week, the consistency and size of the stool caused pain during defecation, and where children were assuming the position to defecate but attempted to withhold stool (contracting their anal sphincter and gluteal muscles). Some children showed irritability, abdominal distension, fecal soiling and decreased oral intake [3].

Children were excluded from the study when chronic constipation was caused by the following:

- Anatomic abnormality (Hirschsprung disease, congenital abnormalities of the anorectal region).
- Neurological and psychiatric conditions (cerebral palsy, spina bifida, mental retardation, anorexia nervosa).
- Metabolic conditions (diabetes mellitus, diabetes insipidus).
- Endocrine disorders (hypothyroidism).
- Previous thoracic or abdominal surgery.

The control group comprised 105 patients with a normal defecation pattern who were diagnosed and treated for various symptoms (chronic abdominal pain, food allergies). The control group did not differ from the patients with regard to gender, and their average age was 8.25 years. The two population groups were subdivided by age: ≤3 years, 3.1–6 years, 6.1–12 years and >12 years.

Children with diagnosed constipation were first examined by US, then digital rectal examination, enema, proctoscopy and US again, and finally referred for colonic transit time assessment.

US assessment of stool retention and colonic enlargement involved measurement of the transverse diameter of the rectal ampulla (by US) and pelvic width (externally using a measuring tape). Pelvic width is understood as the distance between the external margins of the anterior superior iliac spines. The ratio between the transverse diameter of the rectal ampulla and transverse diameter of the pelvis was calculated to give the rectopelvic ratio. Children diagnosed with megarectum, fecal impaction and enlarged colon were referred for proctoscopy and measurement of colonic transit time. Total and segmental colonic transit time were measured by the modified sixth day Hinton method. Total and segmental time expressed in hours was obtained by multiplying the number of radioopaque markers seen on the radiograph by 1.2 (the time in hours divided by the number of markers swallowed by the patient, i.e. 144/120). Based on literature the upper limit was established as 66 h [4].

For colonic transit time, patients were divided into three groups:

1. Normal-transit constipation (≤66 h)
2. Slow-transit constipation (66–100 h)
3. Very delayed slow-transit constipation (>100 h)

The Philips HDI 4000 US unit (Philips, Best, The Netherlands) used in the study was equipped with three electronic transducers with various frequencies from 2 to 14 MHz. Children were examined before food and had a slightly filled bladder. Patients who passed stool on the day of the examination were temporarily excluded from the study until they became constipated again. The following parameters were assessed by US:

1. *Rectal ampulla width.* The probe was applied to the anterior abdomen above the symphysis. Measurement was performed on the oblique transaxial scanning plane to obtain an image of the transverse diameter of the rectal ampulla (Fig. 1). The location of the plane was then slightly readjusted. The measurement was taken several times because too large a deflection of the probe from the

Fig. 1 An 8-year-old boy with functional chronic constipation. US measurement of the transverse diameter of the rectal ampulla

transverse plane may give a false result by measuring the upper part of the anal canal. The highest recorded measurement was taken as the final measurement.

2. *Rectal ampulla filling (present or absent).* The assessment of fecal impaction was performed in the sagittal plane. With a slightly filled bladder, the scan showed the following visible pelvic structures: rectal ampulla, anal canal, front surface of the sacrum; in girls also the uterus and vagina. This US image corresponded to the normal rectal examination when the rectal ampulla is not filled or the fecal masses are soft. When pelvic structures were covered by stool masses and were not even partially visible by US, fecal impaction was diagnosed. On digital rectal examination this image corresponded to a rectum overfilled by hard masses. Images of fecal impaction were diverse, from well-defined visible images of bowel haustra (Fig. 2) to a smooth line with no visible bowel haustra (rectum greatly enlarged; Fig. 3). When the rectal ampulla was filled with gas, the pelvic structures were not visible; fecal impaction was not diagnosed when this occurred.
3. *Bowel filling at the splenic flexure (present or absent*). This was based on the visualization of the left kidney through the US window of the spleen. The probe was applied to the long axis of the spleen. In this way the entire length of the left kidney was visible. If it was impossible to obtain such a scan due to lack of visibility of the lower pole of the kidney because of bowel contents, then overfilled bowel at the splenic flexure was diagnosed (Fig. 4). Patients with serious anatomical abnormalities of the left kidney such as absence or ectopic kidney were not included.

Fig. 2 A 4-year-old girl. Sagittal US image of the rectum and sigmoid colon shows colonic haustra

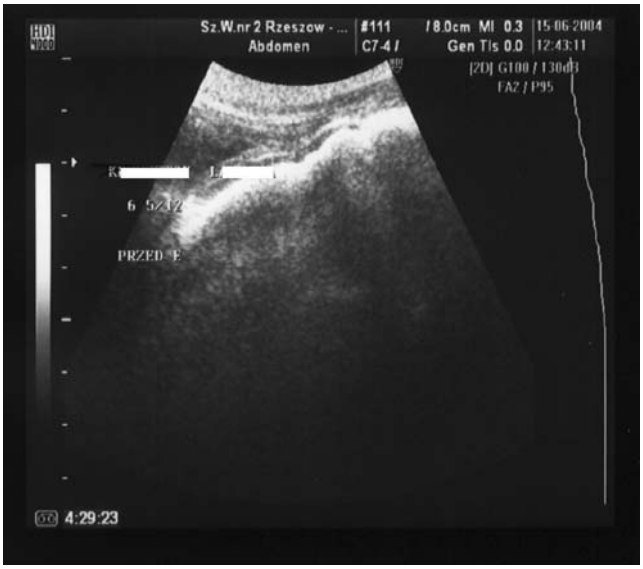

Fig. 3 A 6-year-old boy. Sagittal US image of a greatly enlarged rectum. No haustra are visible

4. *Transverse colon filling (present or absent).* In a similar manner to the method described above, this method was based on visualization of the structures of the mesogastrium through the US window of the left lobe of the liver. The probe was applied in the sagittal plane over the aorta to identify the celiac and superior mesenteric arteries. Overfilling of the transverse colon was diagnosed when the superior mesenteric artery was not visible. Overfilling of the transverse bowel was absent when the superior mesenteric artery was clearly visible or could be observed when (a) controlled

Fig. 4 A 6-year-old girl. Longitudinal US image along the axis of the spleen and left kidney. Overfilled bowel at the splenic flexure is seen as an acoustic shadow. The lower pole of the kidney is not visible (the patient's head is to the right of the image)

Table 1 Diameters of the rectal ampulla (in millimetres) measured by US (values are means±SD)

Study group	Age group (years)				Mean all ages
	<3	3.1–6	6.1–12	>12	
Patients	38.35±8.65	41.16±8.72	46.15±9.56	49.09±10.19	43.060±9.68
Controls	27.07±8.00	29.25±6.86	32.85±8.73	35.15±7.18	31.83±8.24
P value[a]	<0.001	<0.001	<0.001	<0.001	

[a] Nonparametric Mann-Whitney test.

pressure was applied or (b) the patient expanded the abdominal wall with a deep inspiration. The mesogastrium is very commonly obscured by the stomach and duodenum; it is crucial that the patient is fasted.

Statistical analysis

All data were analysed using STATISTICA 6.0 and Microsoft Excel using the chi-squared test, the nonparametric Mann-Whitney test and the Wilcoxon test for conjoined pairs.

Results

Fecal impaction and overfilling of the splenic flexure and transverse colon as demonstrated by US occurred significantly more often in children with constipation than in controls ($P<0.001$). The transverse diameter of the rectal ampulla measured by US increased with age in both patients and controls. The numerical values of this parameter differed significantly in all age groups ($P<0.001$; Table 1). The mean rectopelvic ratios (defining megarectum) in each patient age group were: ≤3 years 0.24, 3.1–6.0 years 0.23, 6.1–12.0 years 0.22, and >12.0 years 0.19. The ratios in each control age group were: ≤3 years 0.17, 3.1–6.0 years 0.16, 6.1–12.0 years 0.15, and >12.0 years 0.14. The differences between patients and controls were highly significant ($P<0.001$) for the youngest three age groups; the difference was less significant for the oldest age group ($P=0.002$). The mean value of the rectopelvic ratio in the oldest patients was higher than in the youngest controls. The cut-off value was 0.189 (Table 2; Fig. 5). The diagnosis of fecal impaction by US showed a sensitivity of 88.3% relative to proctoscopy.

The mean colonic transit times in children with confirmed symptoms of fecal impaction were compared with the values in children without such symptoms. In children with fecal impaction the colonic transit time, average segmental transit time for the rectum and sigmoid colon, and average segmental transit time for the left colon were significantly longer ($P<0.001$, $P=0.0015$, and $P=0.0104$, respectively; Fig. 6). There was no statistically significant difference for the right side of the colon.

Children with an overfilled transverse colon on US had a significantly longer mean segmental transit time in the right side of the colon than those without ($P=0.153$), just as children with an overfilled splenic flexure on US had a significantly longer transit time in the left side of the colon ($P=0.0029$).

Discussion

We describe a new method of diagnosis of stool retention and megarectum by US. Its development was based on several assumptions derived from previous reports. First, quantitative and qualitative evaluation of overfilling of the colon was abandoned; radiological studies in this respect have given negative results, and the scoring method of Barr et al. [5] has been reported to be unreliable [6]. The method presented in this study is extremely simple and allows only two yes/no possibilities: (bowel overfilled/not overfilled, fecal impaction present/not present). Second, the technique of measuring the transverse diameter of the rectum was slightly modified from the methods described by Klijn et al. [1] and Singh et al. [2]. The results of this study were

Table 2 Rectopelvic ratios for the different age groups (values are means±SD)

Study group	Age group (years)				Mean all ages
	<3	3.1–6	6.1–12	>12	
Patients	0.24±0.060	0.23±0.05	0.22±0.05	0.19±0.04	0.22±0.05
Controls	0.17±0.05	0.16±0.04	0.15±0.05	0.14±0.03	0.15±0.04
P value[a]	<0.001	<0.001	<0.001	0.002	

[a] Nonparametric Mann-Whitney test.

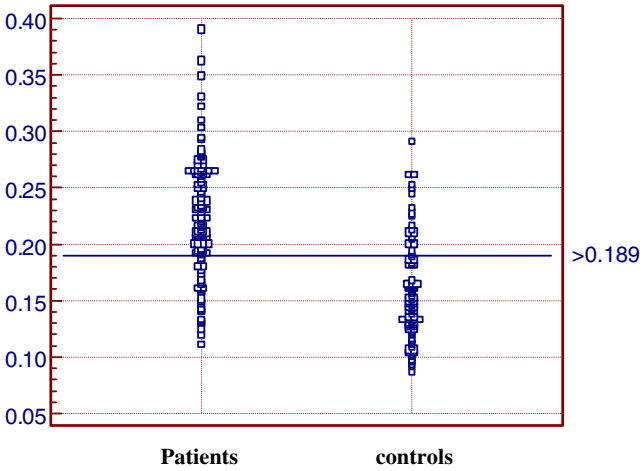

Fig. 5 Rectopelvic ratio allows the diagnosis of megarectum. The cut-off value is 0.189

comparable. In children with functional chronic constipation the transverse diameter of the rectum ranged from 4.4 to 5.3 cm (mean 4.9 cm) [1], 2.1–7.0 cm (mean 3.4 cm) [2] and 3.0–8.2 cm (mean 4.3 cm) (current study). The differences result primarily from difference in the patients' ages and slight differences in the method of measurement. Third, to define the megarectum the concept of rectopelvic ratio was used; this idea has been applied previously and proved to be repeatable [7, 8].

In the current study, the sensitivity of the US method in the diagnosis of fecal impaction, as compared to proctoscopy, was 88.3%. It should be noted that both US and digital rectal diagnosis depend on the subjective evaluation of the investigator. Further evaluation of the US method should include assessment of intra- and interobserver variability.

Conclusions

US assessment of stool retention and overfilling of the bowel in children with functional chronic constipation has a high correlation with proctoscopic examination and assessment of colonic transit time. The rectopelvic ratio allows diagnosis of megarectum in children with functional chronic constipation with a cut-off value of 0.189. The US assessment of stool retention and overfilling of the bowel is a simple and noninvasive method that can be easily applied

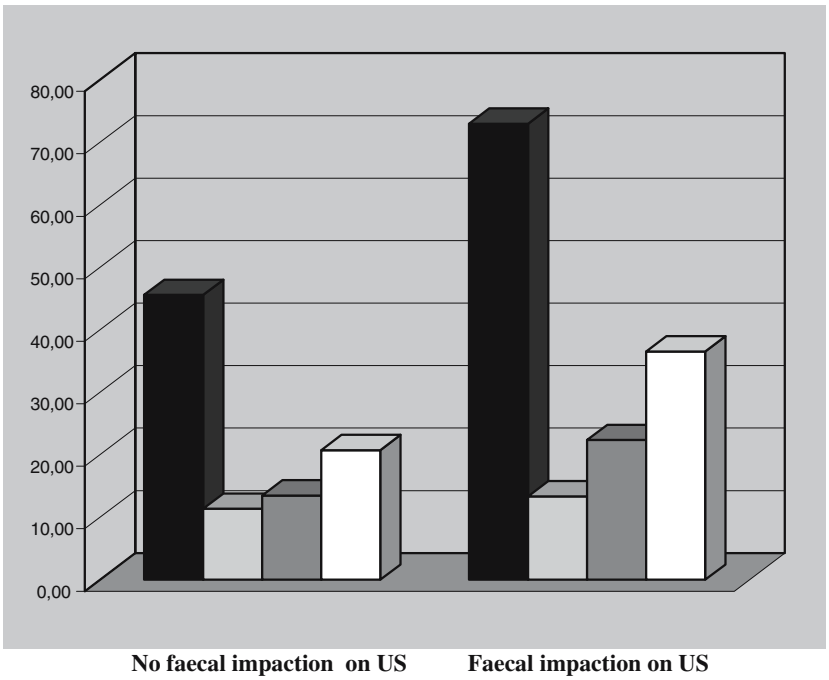

Fig. 6 Comparison of total and segmental colonic transit times in patients with and without fecal impaction on US. All times differ significantly, except for transit time in the right colon (P=0.382)

as a primary examination of children with functional chronic constipation and can be helpful in making decisions concerning referral of these children for further diagnostic procedures.

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