Transabdominal Ultrasound of Rectum as a Diagnostic Tool in Childhood Constipation

Iben Moeller Joensson,* Charlotte Siggaard, Soren Rittig, Soren Hagstroem and Jens Christian Djurhuus

From the Clinical Institute, University of Aarhus (IMJ, SH, JCD) and Department of Pediatrics, Skejby University Hospital (CS, SR), Aarhus, Denmark

Purpose: We tested whether transverse rectal diameter measured by ultrasound could identify rectal impaction, investigated whether transverse diameter is enlarged in constipated children compared to healthy children and evaluated transverse diameter during treatment of constipation.

Materials and Methods: A total of 51 children 4 to 12 years old were included in the study. Of the children 27 (mean age 7.0 ± 1.8 years) had been diagnosed with chronic constipation by Rome III criteria and 24 (9.1 ± 2.7 years) were healthy controls. All patients underwent a thorough medical history and physical examination, including digital rectal examination and measurement of rectal diameter by transabdominal ultrasound. Constipated children underwent repeat investigations after 4 weeks of laxative treatment.

Results: Average rectal diameter of children with negative digital rectal examination was 21 ± 4.2 mm (mean ± SD), leading to the approximation that a value greater than 29.4 mm (mean ± 2 SD) indicates rectal impaction. All children with rectal impaction identified by digital examination had a rectal diameter larger than 29.4 mm. Moreover, constipated children had a significantly larger rectal diameter (42.1 ± 15.4 mm) than healthy children (21.4 ± 6.0 mm, $p < 0.001$). After 4 weeks of laxative treatment constipated children had a significant reduction in rectal diameter (mean 26.9 ± 5.6 mm, $p < 0.001$).

Conclusions: Transverse rectal diameter seems to be a valuable tool to identify rectal impaction and may replace digital rectal examination. Constipated children have a significantly larger rectal diameter compared to healthy children, and when constipation is treated the diameter is reduced significantly.

Key Words: constipation, ultrasonography, child, case-control studies, fecal impaction

Urinary and fecal elimination problems are common, are extremely unpleasant physically and often have significant ramifications for social functioning and development in the child. The prevalence of constipation in children reportedly varies from 0.3% to 28%.[1–3] Constipation is a well-known etiological factor in fecal incontinence, and up to 90% of children have constipation as the main cause of fecal incontinence.[4] Furthermore, several studies have identified an association between defecation disorders, urinary incontinence and UTI (the "dysfunctional elimination syndrome").[5,6]

Previous studies have revealed that treating constipation often cures or relieves urinary elimination problems, which makes it crucial for physicians treating urinary incontinence to be able to define, diagnose and treat childhood constipation.[5] Recently, a new definition of constipation (Rome III criteria) was published to create a common language for research, and to provide clinicians with a better approach to diagnosis and treatment.[7] According to these criteria, rectal impaction is present in 40% to 100% of all cases,[8–11] and is among the 6 elements of childhood constipation.

Until recently, digital rectal examination was the only way of assessing rectal impaction. It is well-known that many children and physicians find this procedure unpleasant, and recently it was reported that 85% of primary care physicians did not perform this examination before referral for constipation.[12] In 2 separate studies Klijn[13] and Singh[14] et al investigated the use of ultrasound measurement of rectal diameter as an alternative tool. Defining constipation after the Iowa criteria, both studies demonstrated that the diameter of the rectum was significantly larger among constipated children compared to healthy children. Neither study showed that transverse diameter could be used as a sole predictor of constipation, but both considered it a "valuable parameter" when diagnosing constipation. Moreover, they did not address whether the diameter was enlarged because of rectal impaction. To date, no known studies have investigated the ability of ultrasound to diagnose rectal impaction, and no studies have documented the effect of constipation treatment on rectal diameter.

The primary aim of this study was to look into a possible correlation between a dilated rectum measured by ultrasound and a fecal mass detected by digital rectal examination. We also evaluated whether this method could diagnose constipation according to the new Rome III criteria, whether

Submitted for publication August 29, 2007.

Presented at the biennial meeting of the International Children's Continence Society, Antalya, Turkey, September 14-17, 2006.

Study received approval of local ethics committee and Danish Data Protection Agency.

Study was supported by the Karen Elise Jensen Foundation.

* Correspondence: Department of Pediatrics A, Skejby University Hospital, DK-8200 Aarhus N, Denmark (telephone: 45-8949-6773; FAX: 45-8949-6011; e-mail: iben.jonsson@ki.au.dk).

age influences rectal diameter within the 4 to 12-year age range and what effect treatment may have on rectal diameter.

MATERIALS AND METHODS

Subjects

Written informed consent was obtained from both parents before any procedures were initiated. The study was designed as a 2-group prospective controlled study. A total of 51 children 4 to 12 years old were included.

The patient group consisted of 27 children. Subject eligibility included age 4 to 12 years and referral to our outpatient clinic with either constipation or fecal incontinence, with or without urinary incontinence and a history of UTI. At entry all patients fulfilled the Rome III criteria of constipation, which meant that they had at least 2 of the following characteristics—fewer than 3 bowel movements weekly, more than 1 episode of fecal incontinence weekly, large stools in the rectum by digital rectal examination or palpable on abdominal examination, occasional passing of large stools, display of retentive posturing and withholding behavior, and painful defecation. Urinalysis, uroflowmetry and ultrasound determination of post-void residual volume were performed in all children. Children with known organic causes of constipation, including Hirschsprung disease, spinal and anal congenital abnormalities, previous surgery on the colon, inflammatory bowel disease, allergy, and metabolic or endocrine diseases, were excluded from the study, as were children receiving drugs known to affect bowel function during a 2-month period before initiation. Investigation for vesicoureteral reflux was not part of the study arrangement.

The healthy control group comprised 24 healthy children recruited from employees of the Department of Pediatrics at Skejby University Hospital. These children had no history of urinary incontinence, UTI, chronic constipation (Rome III criteria), fecal incontinence, laxative use or any other disease affecting the digestive system. Children receiving medications known to affect bowel function were excluded from the study.

Design

The study consisted of 3 visits and a 3-week stool diary for the constipated children, while the healthy children only participated in the first visit and filled out the stool diary. During the first visit the children underwent a thorough medical history, followed by transabdominal ultrasound measurement of the rectal diameter and a complete physical examination, including digital rectal examination. Before measurement of rectal diameter the volume of the bladder was measured by ultrasound (bladder scan). This assessment was followed by a 3-week home based stool diary patterned after the Bristol scale. Children with constipation underwent repeat transabdominal ultrasound and initiation of laxative treatment during a second visit shortly after completion of the diary. During a third visit after 4 weeks of treatment another rectal diameter measurement was performed and treatment response was evaluated.

TABLE 1. *Demographic data of healthy and constipated children*

	Constipated Children	Healthy Children
No. pts	27	24
Age ± SD (yrs)	7.2 ± 1.8	9.1 ± 2.7
Wt ± SD (kg)	27.1 ± 8.7	32.1 ± 9.4
Height ± SD (cm)	122.2 ± 24.0	136.2 ± 16.1

TABLE 2. *Clinical characteristics of 27 constipated children*

	No. Pts (%)
Rome III criteria:	
Fewer than 3 bowel movements/wk	4 (15)
Fecal incontinence more than once/wk	22 (81)
Painful defecation	19 (70)
Passing of large stools	9 (33)
Withholding behavior	19 (70)
Rectal impaction	20 (74)
Absence of urinary symptoms	4 (15)
Urinary incontinence:	
Daytime incontinence	11 (41)
Nocturnal enuresis	3 (11)
Nighttime and daytime incontinence	9 (33)
Other urinary symptoms:	
History of UTI	12 (44)
Urgency	11 (41)
Abnormal uroflowmetry*	13 (72)
Post-void residual vol greater than 20 ml	15 (56)
Prior treatment:	
Laxatives	15 (56)
Toilet training	2 (7)

* Uroflowmetry was performed in 18 patients.

Methods

For transabdominal measurement of rectal diameter a 7.5 MHz sector probe was applied to the abdomen approximately 2 cm above the symphysis at a 10 to 15-degree downward angle, as described by Klijn et al.[13] The diameter of the rectum was measured in the transverse plane. At each session diameters were measured 3 times, and mean value was calculated. All children had a partly full bladder range (28 to 450 ml) corresponding to 20% to 155% of expected bladder capacity for age at the time of the measurement. In case of an empty bladder fluid was offered orally and scanning was repeated. If the child had a bowel movement within 3 hours before the investigation or had an urge to defecate, the result was excluded. All investigations were performed by the same observer (a pediatric intern).

Stata® 8.0 software was used for statistical analysis. Results are reported as mean ± standard deviation unless otherwise stated. Student's t test was used for comparisons between groups. Correlation was analyzed by Pearson's correlation test. A p value of less than 0.05 was considered statistically significant.

RESULTS

All of the constipated children fulfilled the Rome III criteria and completed the study. Among the initial population of recruited healthy children 1 child fulfilled the Rome III criteria of constipation and, therefore, was excluded from the study. Table 1 outlines the demographic data of the healthy and constipated subjects. There was no significant difference in height and weight distribution between the 2 groups. However, the healthy children were significantly older than the constipated children. Table 2 outlines the clinical characteristics of the constipated children.

The digital rectal examination revealed a palpable fecal mass in 2 healthy children (8%) and 20 constipated children

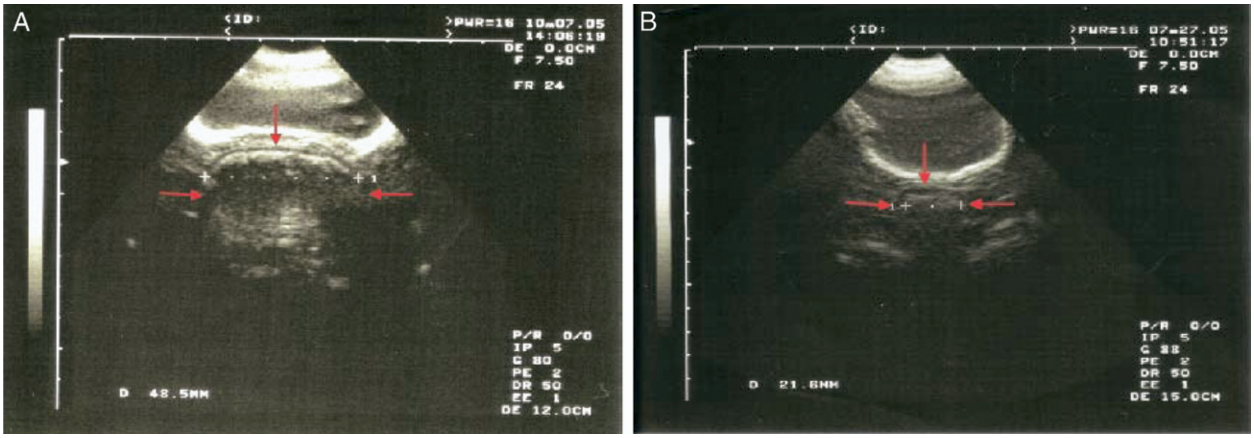

FIG. 1. *A*, transabdominal ultrasonography of rectum (red arrows) in constipated child. *B*, transabdominal ultrasonography of rectum (red arrows) in healthy child.

(74%). In all children it was possible to visualize the transverse diameter of the rectum at least 3 hours after the last bowel movement, and to obtain sufficient quality images to measure the distance in triplicate (fig. 1). The study demonstrated a small intraobserver variability, as shown by a low coefficient of variation of the 3 consecutive measurements of 5.8% ± 4.3%. Furthermore, there was no significant correlation between bladder volume at the time of measurement and the rectal diameter (r = 0.04, not significant).

The distribution of measurements in subjects with and without rectal impaction on digital rectal examination is illustrated in figure 2. The rectal diameters obtained in children without rectal impaction were normally distributed, with an average of 21.0 ± 4.2 mm. Children with rectal impaction had markedly larger rectal diameters (40.5 ± 7.9 mm, $p < 0.001$). Interestingly, the 2 healthy children with rectal impaction had a markedly larger rectal diameter (38 and 31 mm) than the other healthy controls, and the 7 constipated children without impaction had smaller rectal diameters (range 19.9 to 27 mm) compared to the remaining patients. The cutoff value for the presence of rectal impaction was determined as the average rectal diameter of children without impaction plus 2 SD (ie 29.4 mm). With this cutoff value a complete separation between the 2 impaction groups was obtained.

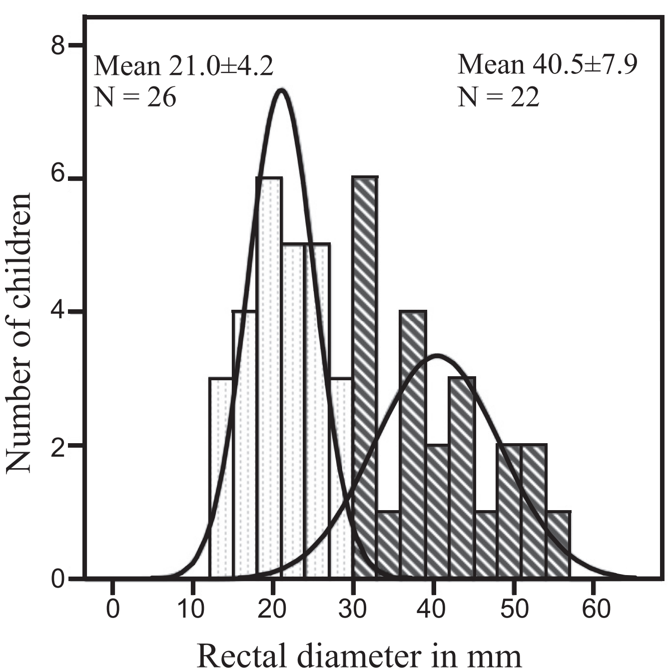

FIG. 2. Histogram of rectal diameters of healthy and constipated children with no rectal impaction (dotted bars), and constipated and healthy children with rectal impaction (striped bars) at digital examination. Cutoff value of 29.4 mm is determined as mean ± 2 SD. Children with rectal diameter below cutoff value are considered to have empty rectum, whereas diameter above this value is sign of rectal impaction. Rectal diameters of children are all above cutoff point, indicating rectal impaction.

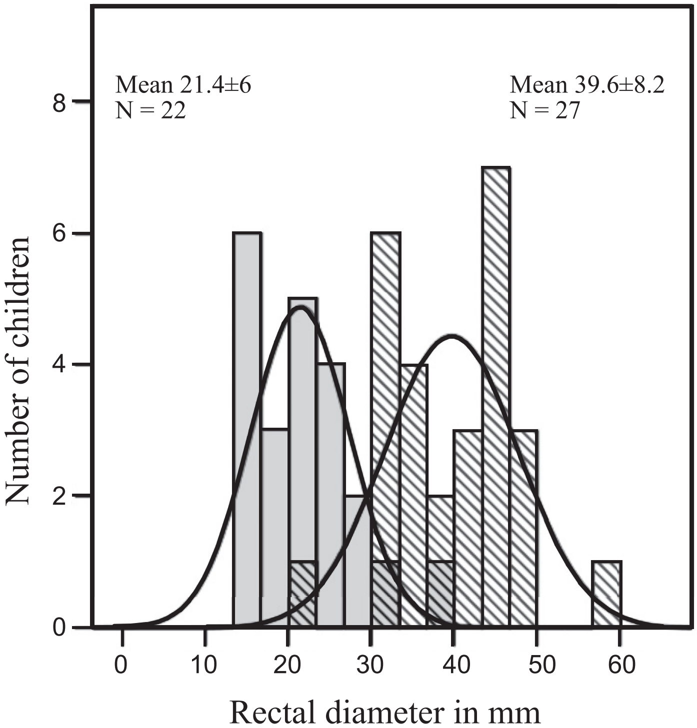

FIG. 3. Histogram of recorded data on rectal diameters of healthy (solid bars) and constipated children (striped bars). Mean diameter is significantly different between healthy and constipated children ($p < 0.001$). Overlap above cutoff point represents 2 healthy children with rectal impaction at physical examination. Overlap below cutoff point represents constipated child (according to Rome III criteria) who had no impaction at digital examination.

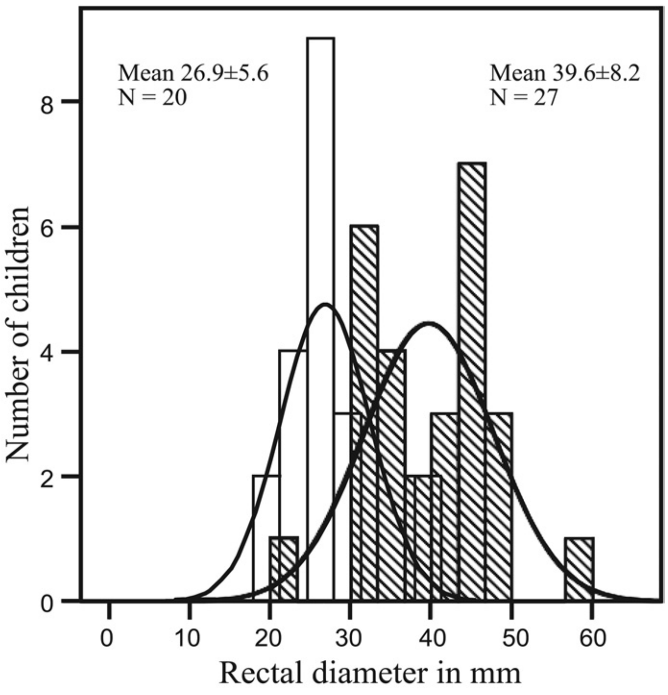

FIG. 4. Histogram of rectal diameter before (white bars) and after treatment (striped bars). Diameter is significantly reduced after treatment ($p < 0.001$).

The distribution of rectal diameter measurements in constipated and healthy children is illustrated in figure 3. Constipated children had a significantly larger rectal diameter than healthy children (39.6 ± 8.2 mm vs 21.4 ± 6.0 mm, respectively, $p < 0.001$). Using mean + 2 SD of healthy controls as a cutoff value for constipation (ie 33.4 mm), 13 subjects (12 constipated and 1 healthy) would be misclassified if rectal diameter were used as the sole variable. There was no correlation between age and average rectal diameter in healthy or constipated children, and no gender difference was observed. The second measurement of transverse rectal diameter at visit 2 in the constipated children did not differ significantly from the first measurement.

We observed that 3 days of disimpaction followed by 4 weeks of laxative treatment with polyethylene glycol and behavioral therapy significantly reduced rectal diameter in constipated children. Mean rectal diameter was reduced to 26.9 ± 5.6 mm ($p < 0.001$, fig. 4). Although treatment reduced the diameter significantly, the average diameter was still significantly greater than in healthy children ($p < 0.05$). However, as illustrated in figure 5, the rectal diameter of the children responding to treatment (no constipation or fecal incontinence) was significantly reduced ($p < 0.01$), whereas no significant difference was observed among the nonresponders ($p = 0.70$).

DISCUSSION

The major finding of this study was that ultrasound determination of rectal diameter exhibited excellent agreement with the findings obtained by digital rectal examination, ie children with a palpable fecal mass exhibited markedly larger rectal diameters than those without rectal impaction. To our knowledge no other studies have documented such a correlation between ultrasound and digital rectal examination. This observation might prove valuable, especially in cases where the child cannot or will not cooperate with the digital examination. It also makes it possible to avoid repeat digital examinations during treatment followup.

In the present study all investigations were performed by the same observer, who had no prior radiological experience. The study indicated small intraobserver variability, as illustrated by a small coefficient of variation of 5.8% ± 4.3%. Furthermore, we could not determine any effect of bladder volume on the measurement of rectal diameter. However, further validation of this technique requires evaluation of the interobserver variability and testing of the cutoff point in another patient population. Furthermore, the transabdominal ultrasound technique might bear technical limitations.[15] Since ultrasound technology is based on a series of theoretical assumptions, there is a possibility that in reality a series of artifacts may appear. The 3 most common sources of artifacts in this situation are acoustic enhancement, speed errors and refraction artifacts, of which the latter are the

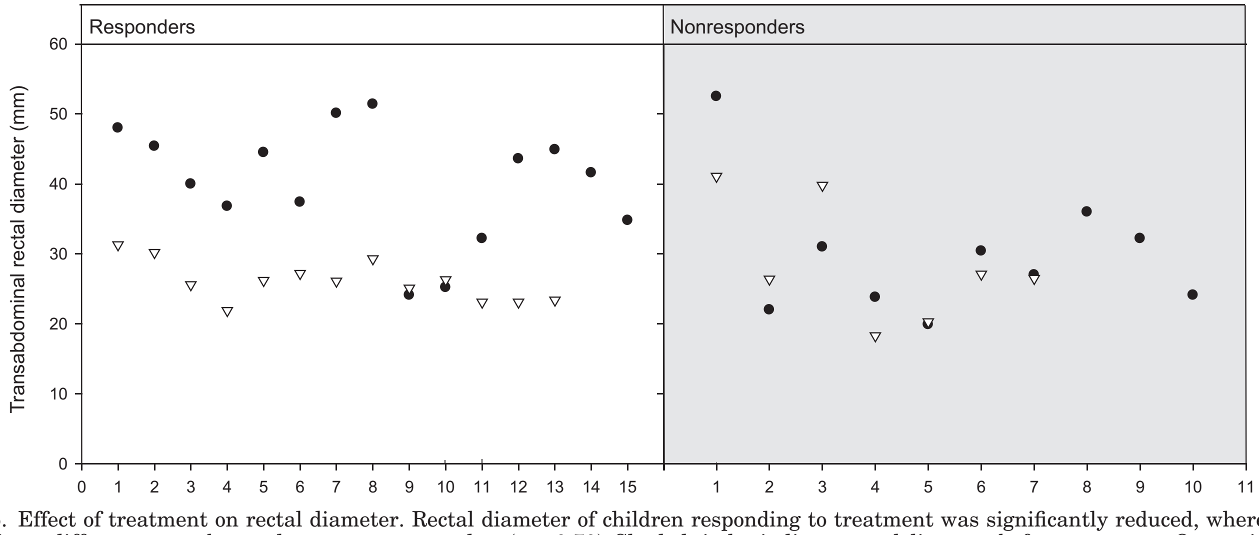

FIG. 5. Effect of treatment on rectal diameter. Rectal diameter of children responding to treatment was significantly reduced, whereas no significant difference was observed among nonresponders ($p = 0.70$). Shaded circles indicate rectal diameter before treatment. Open triangles indicate rectal diameter after treatment.

most important.[16] Whether these artifacts may be important enough to influence our results is unclear.

Prior studies regarding rectal ultrasound have focused on the difference in rectal diameter between constipated children and healthy children. Two known studies have tested the use of rectal diameter measured by ultrasound to diagnose constipation.[13,14] We also found that constipated children had a significantly enlarged rectal diameter compared to that of healthy children ($p < 0.001$). However, 7 children (26%) had a rectal diameter smaller than the established cutoff point for rectal impaction, despite the fact that they fulfilled the Rome III criteria for constipation. Likewise, an enlarged rectal diameter was observed in 8% of children not suffering from bowel problems. Hence, the finding of an enlarged rectal diameter by ultrasound cannot be the sole predictor of whether a child is constipated.

Children with normal defecation patterns in the studies by Klijn[13] and Singh[14] et al had an average rectal diameter of 21 mm and 24 mm, respectively, which is in accordance with our findings (fig. 3). However, the rectal diameter in constipated children in these studies differed from our findings. Klijn et al[13] observed a larger rectal diameter (49 ± 10 mm), and Singh et al[14] observed a smaller diameter (34 ± 10 mm) compared to our study. The discrepancies may be the result of differences regarding definition of constipation (Rome III vs Iowa criteria) and type of symptoms (eg lower urinary tract symptoms), and also the fact that Singh et al[14] did not ascertain the interval between bowel movement and measurement of rectal diameter. The fact that all studies have revealed an enlarged diameter in constipated children compared to nonconstipated children is likely due to a higher frequency of rectal impaction in the constipated group. In our study 74% of constipated children had rectal impaction compared to 8% of healthy children.

We were unable to demonstrate any correlation between rectal diameter and age or sex of the children in either of the groups. This finding is in contrast to a study showing that rectal diameter correlates positively with age and height.[14] However, that study included a much broader age range (0.30 to 16.40 years, compared to 4.1 to 12.8 years in our study). Defecation parameters such as stool weight, frequency and colonic transit time are known to change when the child is around 3 years old, and again around puberty.[17,18]

We also aimed to elucidate whether measurements of rectal diameter could be used as an effective tool to evaluate response to treatment of constipation. We observed that a relatively short laxative treatment course significantly reduced the rectal diameter in constipated children (fig. 5). The posttreatment measurements were made after 4 weeks of treatment, and it is likely that a further reduction in rectal diameter could be expected if the measurements were taken after a longer treatment period. Furthermore, 10 children included in the posttreatment measurements in the constipated group did not respond to treatment, and the treatment effect on rectal diameter was much smaller in these patients compared to children who responded (fig. 4).

Besides being a rather precise diagnostic tool for identifying rectal impaction, transabdominal ultrasound might prove to be a strong educational tool when dealing with parents. It may help them visualize the nature of the problem and thereby make it easier to understand, especially in cases where the constipation has been "hidden."

CONCLUSIONS

Transverse rectal diameter measured by transabdominal ultrasound seems to be useful to identify rectal impaction, and may replace digital rectal examination if needed. Constipated children have a significantly larger rectal diameter compared to healthy children. However, since some constipated children do not have rectal impaction, the method is not the sole predictor of constipation. This promising technique should be further validated by determining the interobserver variability, and should be evaluated in larger patient groups.

Abbreviations and Acronyms

UTI = urinary tract infection

REFERENCES

1. Araujo Sant'Anna AM and Calcado AC: Constipation in school-aged children at public schools in Rio de Janeiro, Brazil. J Pediatr Gastroenterol Nutr 1999; **29:** 190.
2. Loening-Baucke V: Constipation in early childhood: patient characteristics, treatment, and longterm follow up. Gut 1993; **34:** 1400.
3. Molnar D, Taitz LS, Urwin OM and Wales JK: Anorectal manometry results in defecation disorders. Arch Dis Child 1983; **58:** 257.
4. Rasquin-Weber A, Hyman PE, Cucchiara S, Fleisher DR, Hyams JS, Milla PJ et al: Childhood functional gastrointestinal disorders. Gut, suppl., 1999; **45:** II60.
5. Loening-Baucke V: Urinary incontinence and urinary tract infection and their resolution with treatment of chronic constipation of childhood. Pediatrics 1997; **100:** 228.
6. Chase JW, Homsy Y, Siggaard C, Sit F and Bower WF: Functional constipation in children. J Urol 2004; **171:** 2641.
7. Rasquin A, Di LC, Forbes D, Guiraldes E, Hyams JS, Staiano A et al: Childhood functional gastrointestinal disorders: child/adolescent. Gastroenterology 2006; **130:** 1527.
8. Benninga MA, Buller HA, Tytgat GN, Akkermans LM, Bossuyt PM and Taminiau JA: Colonic transit time in constipated children: does pediatric slow-transit constipation exist? J Pediatr Gastroenterol Nutr 1996; **23:** 241.
9. Loening-Baucke V: Factors determining outcome in children with chronic constipation and faecal soiling. Gut 1989; **30:** 999.
10. Partin JC, Hamill SK, Fischel JE and Partin JS: Painful defecation and fecal soiling in children. Pediatrics 1992; **89:** 1007.
11. van Ginkel R, Buller HA, Boeckxstaens GE, Der Plas RN, Taminiau JA and Benninga MA: The effect of anorectal manometry on the outcome of treatment in severe childhood constipation: a randomized, controlled trial. Pediatrics 2001; **108:** E9.
12. Safder S, Rewalt M and Elitsur Y: Digital rectal examination and the primary care physicians: a lost art? Clin Pediatr (Phila) 2006; **45:** 411.
13. Klijn AJ, Asselman M, Vijverberg MA, Dik P and de Jong TP: The diameter of the rectum on ultrasonography as a diagnostic tool for constipation in children with dysfunctional voiding. J Urol 2004; **172:** 1986.
14. Singh SJ, Gibbons NJ, Vincent MV, Sithole J, Nwokoma NJ and Alagarswami KV: Use of pelvic ultrasound in the diagnosis of megarectum in children with constipation. J Pediatr Surg 2005; **40:** 1941.

15. Talley NJ, Nyren O, Drossman NJ, Heaton KW, Veldhuyzen van Zanten SJ and Koch MM: The irritable bowel syndrome: toward optimal design of controlled treatment trials. Gastroenterol Int 1993; **6:** 189.

16. Riis C: Systematic 3D Ultrasound Evaluation of Breast Lesions. University of Aarhus: Faculty of Health Sciences 2006; pp 11-26.

17. Weaver LT: Bowel habit from birth to old age. J Pediatr Gastroenterol Nutr 1988; **7:** 637.

18. Corazziari E, Cucchiara S, Staiano A, Romaniello G, Tamburrini O, Torsoli A et al: Gastrointestinal transit time, frequency of defecation, and anorectal manometry in healthy and constipated children. J Pediatr 1985; **106:** 379.