Radiometric analysis of contrast enema for encopresis in children. (Review).

The term "encopresis," by analogy with the term "enuresis," was introduced by Weisenberg in 1926 to designate those forms of fecal continence disorder in which there is no organic damage to the elements involved in fecal retention. Most often, encopresis occurs in children with chronic constipation. However, the pathophysiology and pathogenesis of this phenomenon are not well understood. Less commonly observed is non-retentive fecal incontinence, the etiology and pathogenesis of which are unknown. It is not accompanied by fecal retention in the rectum, and therefore there is no constipation. This article is based on a review of our published studies using radiometric analysis, from which we came to the following conclusions. In children with chronic constipation large amounts of feces accumulate in the rectum due to delayed bowel movements. In the dilated rectum (megacolon - megarectum), large fecal stones form, which stretched the pelvic floor muscles. A stretch of the puborectalis muscle (PRM) weakens fecal continence, leading to stool leaking into panties. Various degrees of damage to the PRM function are shown up to the development of descending perineal syndrome. In children with encopresis without constipation, a decrease in the width of the rectum and left half of the colon was found. In most of them, proctoscopy revealed macroscopic signs of inflammation. We hypothesize that the inflammatory process in them leads to increased intestinal tone and rapid movement of the bolus into the rectum, and high rectal tone stimulates the defecation reflex with small volumes of feces. The data obtained allow the use of pathogenetic treatment.

Keywords: Encopresis; functional constipation; barium enema, nonretentive fecal incontinence; pathophysiology.

Introduction The term "encopresis," by analogy with the term "enuresis," was first introduced by Weisenberg in 1926 to designate those forms of continence disorder in which there is no organic damage to the elements involved in fecal retention [quote from 1]. In childhood, the term fecal incontinence is most often used, which includes both organic damage and functional disorder [2,3]. Among modern pediatric doctors, the idea is firmly established that: - "The pathophysiology of functional fecal incontinence related to constipation in children is not clear" [4,5]. In 10% of patients present with encopresis as a single symptom without any organic cause or sign of constipation and is currently classified as functional nonretentive fecal incontinence (FNRFI) and neither etiology nor pathogenesis of it is known [6, 7]. This means that there is no pathogenetic treatment, and a trial-and-error search is used.

This review is devoted to the radiometric analysis of children with encopresis who were treated at the children's surgical center in Minsk (Belarus). Research materials were published in 1983-2020. From this study were excluded patients after surgery on the anorectal area, because of which the muscles involved in fecal continent are damaged. Their fecal incontinence was of an organic nature. All 166 patients with encopresis were divided into two groups according to the clinical picture and the results of barium enema. In 127 (77%) patients of group 1, encopresis was combined with constipation, and a barium enema revealed megacolon of varying degrees. The 39 (23%) patients of group 2 had no history of constipation and no dilatation of the rectum according to barium enema [1,8,9, 10, 11].

The purpose of this article is to show the effectiveness and reliability of radiometric analysis of a contrast enema in the diagnosis of various forms of encopresis and its role in determining the cause of encopresis in both groups.

Method. Radiometric analysis is based on a standardized barium enema technique and standards for the width of different parts of the colon and rectum, as well as the length of the anal canal in children of different ages (control), which were determined using this technique [12].

The study was conducted by the hydrostatic barium enema. A barium was introduced from the graduated bag. The bottom of this bag at the beginning of the study was located 40 cm above the deck of the table. A barium was introduced into the colon up to the reflux into the terminal ileum. The difference of barium volume in the bag before and after the colon filling corresponds to the colon volume. The radiopaque marker is strung on the tip of the enema. It is in contact with the anus during the study. At least two radiographs (frontal and lateral) have been made after the filling of the colon. On a frontal radiograph the widths of the different parts of the colon are measured **(Figure 1 a).** Since the rectum forms two bends in two projections, it cannot be differentiated on the frontal radiograph, which makes it impossible to measure its width. On a lateral radiograph were measured the maximum width of the vertical portion of the rectum, as well as interval not containing contrast medium between the rectum and a contrast marker on the posterior contour of the tip of the enema **(Figure 1b).**

This distance is due to the contraction of the anal canal and is equal to the length of the anal canal measured during a manometric study.

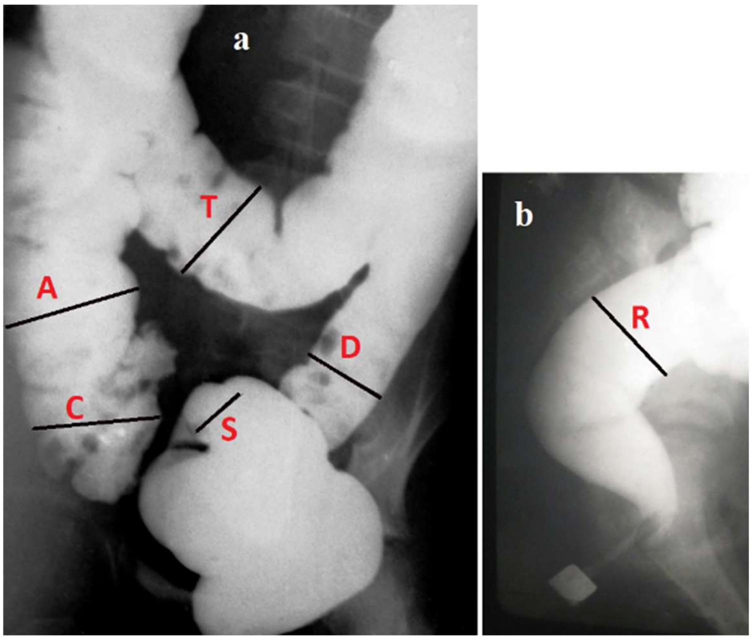

Figure 1. (a). The frontal radiograph shows the measurement sites: c - caecum, a - ascending colon, t - transverse colon, d - descending colon, s - sigmoid colon. **(b).** On a lateral radiograph, the measurement location for the descending branch of the rectum is shown as (R). The length of the anal canal is measured between the rectum and a radiopaque marker located near the anus.

Filling of the colon occurs under low hydrostatic pressure, resulting in slow colonic filling that is easily tolerated by children of all ages. Therefore, in children with encopresis there was no case of contrast agent leakage, and thus there was no need for an inflated of the rectal balloon. This made it possible to measure the length of the anal canal.

Method of the analysis of the radiographs

The distance between the marker (anus) and the rectum, which does not contain a contrast agent is equal to the anal canal length measured by the manometric method. This is a zone of the anal canal contraction. The true values were obtained by multiplying of the size measured on radiographs, on a factor of projection magnification (k), which is equal to the ratio of the true diameter of the marker to its value on the radiograph. To compare the different studies as well as studies of the same patient at different ages, we calculate the constant (C), which is the integral characteristic of the colon value. It is calculated using the following formula:

$$C = \frac{V \times R \times \kappa}{h}$$

Where: **C** – constant, **V** – colon volume (ml).

R – rectal width (cm).

к – projection distortion factor, which is the ratio of the true width of the marker to its image on the radiograph;

h – patient height (cm).

In healthy children, "Constant" was in the range of 17-31, regardless of age. Megacolon determined if «Constant», exceeds 31. It has been possible to differentiate megacolon varying degrees depending on the constant (C):1st degree - (C = 32 - 45); 2nd degree - (C = 45-60) and 3rd degree - C> 60.

Since the sigmoid colon over the age of 5 years is normally located in the small pelvis, its location in the abdominal cavity always indicates its elongation. The lengthening of the sigmoid colon is due to the presence of the mesentery. Since it is not fixed to the wall of the abdominal cavity, it lengthens simultaneously with expansion. Thus, elongation of the sigmoid colon is evidence of overfilling of the colon with feces during megacolon, or in the past, after which the volume of the intestine has decreased because of the inflammatory process. The transverse colon also has a mesentery and can elongate and sag into the pelvis in very severe forms of megacolon in adults. Filling the colon prior to barium reflux into the ileum has proven to be very useful in determining the etiology and pathogenesis of functional megacolon (FM). Since the width of the rectum does not change after filling the splenic angle, to determine the megarectum it is enough to fill the colon to the splenic angle. **Table 1** shows the normal true dimensions of the rectum and anal canal, which in practice are sufficient to judge the megarectum and the condition of the pelvic floor muscles, including PRM.

Table 2. The true rectal width and anal canal length depending on age.

Age	n	Rectal width (cm)	n	Anal canal length (cm)
5 days-11 months	12	1,3-3.0 (2.24±0.09)	7	1.7-2.5 (2.21±0.15)
1-3 years	9	3.0-3.7 (3.21±0.11)	7	2.3-2.8 (2.55±0.10)
4 – 7 years	9	3.0-3.9 (3.43±0.14)	8	2.3-3.6 (3.11±0.10)
8 – 10 years	9	3.2-4.1(3.70±0.06)	8	2.6-3.7 (3.07±0.11)
11 – 15 years	19	3.6-4.6 (39.5±0.07)	18	3.1-3.9 (3.43±0.10)

Encopresis in children with functional megacolon (1st group).

It appears that the cause of chronic constipation (CC) in early childhood has different origins. Very rarely CC begins in the first year of life, most often after cessation of breastfeeding, when the stool becomes formed. As shown in the studies of Duhamel [13] and Clayden with Lawson [14], in some children with severe megacolon, the cause of constipation is minor forms of anorectal malformations, such as anterior anus, anal or rectal stenosis with a relatively wide, but the not normal of the hole width. Clayden and Lawson found secondary megacolon in 5% of children who were initially diagnosed with functional megacolon [15]. As shown in Figure 2 B, FM begins after one year of age during potty training, with a peak between 3 and 8 years of age during social adaptation to the group. Encopresis appears 1–5 years after the onset of constipation. Figure 2 C shows that the more severe the degree of megacolon, the more likely it is to be accompanied by encopresis [8].

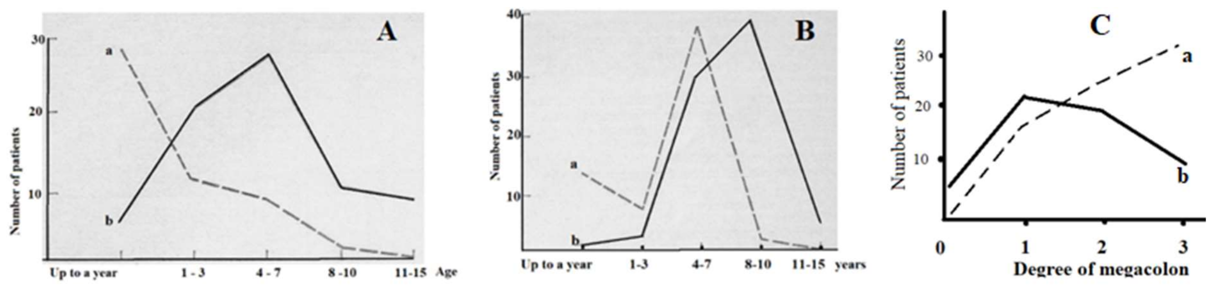

Figure 2. A). Graphic representation of the frequency of megacolon depending on the time of occurrence of constipation - (a), and the time of going to the surgical hospital (b). **B).** Graphical representation of megacolon frequency depending on the time of onset of constipation- (a), and the time of onset of encopresis - (b). **(C).** The relationship between numbers of patients with encopresis - (a), and without encopresis - (b) depending on the degree of megacolon.

Analysis of the above graphs shows that encopresis mainly occurs over the age of 3 years, sometime after the onset of constipation, because of the progression of megacolon. The greater the degree of megacolon, the more likely it is that the disease will be complicated by encopresis.

Because of the dilation of the rectum, its anterior wall is pushed forward, because of which the lower horizontal branch of the rectum is absent (Figure 3 b-e). This figure also shows the different degrees of damage to the pelvic floor muscles in sequential order.

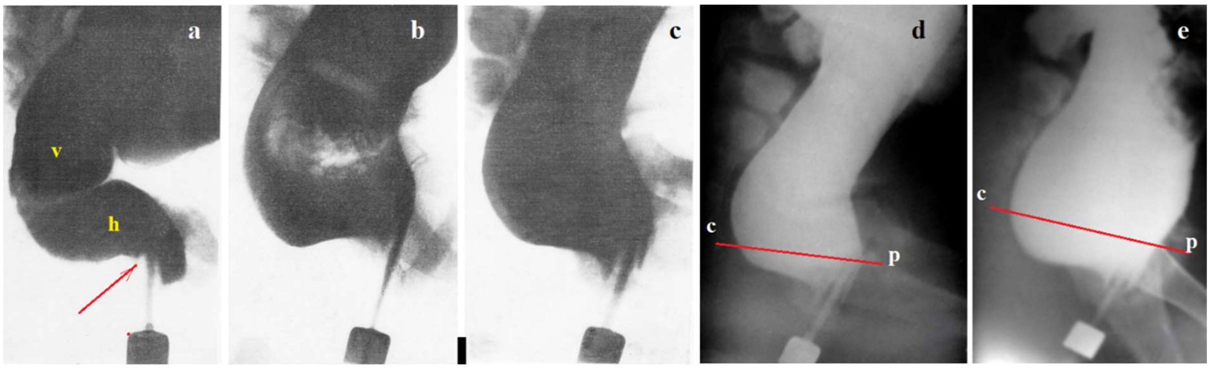

Figure 3. Lateral radiographs of the anorectal area in normal conditions **(a)** and with FM **(b-e). (a)** Two branches of the rectum are identified: vertical (v) and horizontal (h). The length of the anal canal is measured from the anorectal angle (arrow) to the radiopaque marker located near the anus. In the upper part of the anal canal in front of the enema tip, penetration of barium is determined, which is due to relaxation of the internal anal sphincter (IAS). The posterior wall of the anal canal at this level is pressed against the tip of the enema by the contracted PRM. The lower part of the anal canal is closed by contraction of the external anal sphincter (EAS). This is a retention reaction, which is the radiological manifestation of the rectoanal inhibitory reflex [15]. (**b-c**). Dilatation of the rectum is accompanied by the disappearance of the horizontal branch and the appearance of contrast material in the upper part of the anal canal behind the enema tip due to weakness of the PRM. **(d-e).** The expansion of the rectum is accompanied by a sharp shortening of the anal canal because of incompetent PRM.

83 (65%) patients had grade 1–2 megacolon, and the length of the anal canal was within the age norm. In the initial stage of the disease, due to large fecal stones pressing through the pelvic floor muscles, swelling of the pelvic floor occurs. This is manifested by concavity of the rectum behind the anal canal, which leads to the impression of its elongation. In the patients listed above, encopresis was not detected. Different degrees of PRM weakness were determined by the appearance of barium in the anorectal angle (Fig. 3c). In 18 patients, barium leakage was evident into the upper part of the anal canal behind the enema tip, and the length of the anal canal was near the lower limit of normal (Fig. 3d). In 26 cases, a decrease in the length of the anal canal by almost 2 times compared with the norm was detected (Fig. 3e). Encopresis in patients with FM was always accompanied by varying degrees of PRM weakness. A sharp shortening of the anal canal is caused by insufficiency of the PRM and levator plates, which in the literature is called descending perineal syndrome (DPS) [16, 17].

Figure 4 shows the mechanism of development of DPS and our proposed method for diagnosing it.

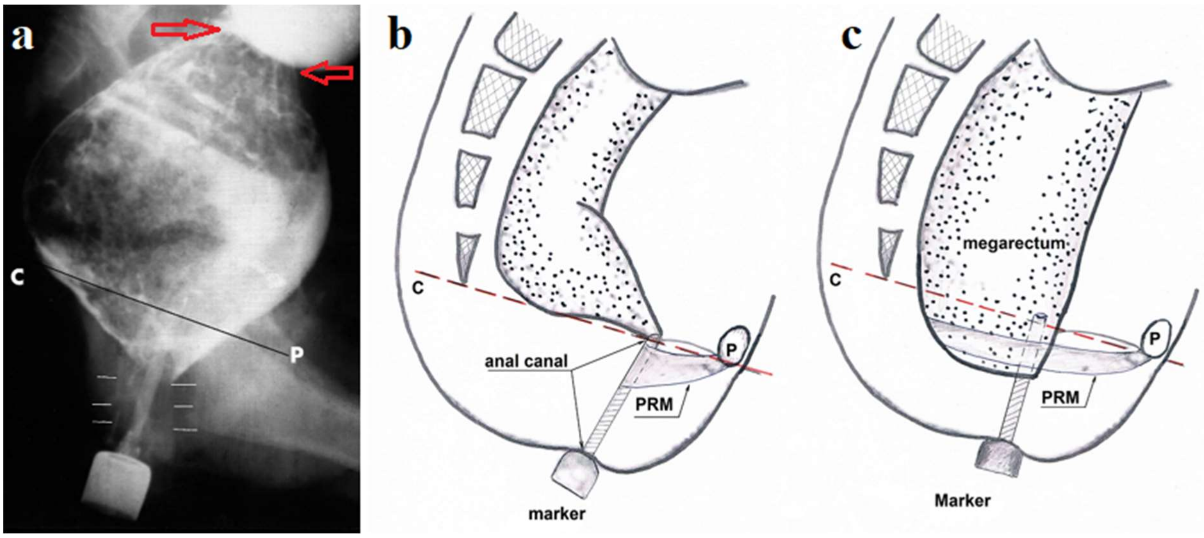

Figure 4. A 15-year-old patient with FM and encopresis. The true diameter of the X-ray contrast marker located near the anus is 1.6 cm. The width of the fecal stone is 9 cm is 2 times greater than the maximum normal limit for the width of the rectum (4.6 cm). A peristaltic wave starting from the rectosigmoid sphincter (red arrows) pushes the stone under great pressure. However, the width of the anal canal does not allow a stone of this width to pass through. The distance between the pubococcygeal line and marker is 4 cm and it is equal to the length of the normal anal canal. However, the bougie effect of the stone led to stretching of the pelvic floor muscles (PRM and levator plates). As a result of the weakness of the PRM, only the lower part of the anal canal functions to retain feces. Therefore, liquid barium under pressure passes along the enema tip outward (shown by white lines), which manifests itself as functional fecal incontinence (encopresis).

In adults, DPS is defined as the descent of the contrast-enhanced rectum several centimeters below the pubococcygeal line during defecation. For this purpose, defecography [17] or MRI defecography [18] is used during defecation on a radiolucent potty. This study, firstly, is associated with long-term ionizing radiation, and secondly, its assessment is sometimes difficult due to the difficulty of determining bone landmarks for drawing the pubococcygeal line. Because of these features, defecography is not used to determine DPS in children. The method described above defines DPS as the shortening of anal canal from the marker near the anus to the barium in the intestine during a conventional barium enema.

An analysis of the literature and our own research shows that in patients with FM, encopresis occurs because of overflow of the rectum with feces, which is always accompanied by megacolon. Large fecal stones stretch the pelvic floor muscles, which leads to the weakening of their functions. Without pathogenetic treatment, this process progresses from minimal damage, to DPS, which is the cause of encopresis. The presence of DPS is irreversible damage, the treatment of which is either PRM plication or the use of the transposition of the gracilis muscle. Symptomatic treatment, referred to as bowel management, including antegrade enemas for DPS, only complicates the lives of patients. It should be considered that stretching of the levator plates disrupts the function of opening the anal canal during an attempt to defecate [15, 18, 20,21], due to which the resistance to the movement of feces through the anal canal sharply increases. This is one of the reasons for the chronicity of FM.

Encopresis in children without constipation (2nd group).

37 (95%) of 39 patients in group 2 (mean age 9.2+/-2.2 years), in addition to fecal incontinence, had complaints of periodic non-localized abdominal pain. There were 8 times more boys than girls. In 20 (51%) patients, encopresis was combined with enuresis. During an X-ray examination using the method described above, only in 5 (13%) cases the width of the rectum was within the age norm. In other observations, the width of the rectum and sigmoid colon was less than the minimum limit of the age norm. The descending colon was narrower than normal in 26 (67%) patients with asymmetric haustration. These data indicated high tone of the left half of the colon and served as the basis for prescribing proctoscopy. In 29 (74%) patients, macroscopic signs of the inflammatory process were detected during proctoscopy.

Analysis of the literature shows that differentiation between encopresis in FM and nonretentive encopresis is based only on the absence of a history of constipation. There is not a single research method that has diagnostic accuracy. Since the cause of this pathology is not known, the search for treatment methods cannot be considered pathogenetic, especially since none of the currently used methods have shown a significant breakthrough. So, for example, the guidelines that were approved with a “high consensus” included only one statement: - “Laxatives can worsen outcomes and should be avoided” [22]. When using biofeedback and/or laxative treatment only 29% of the patients were successfully treated after 2 years of intensive treatment. Despite recovery in most patients beyond puberty, at age 18 years, 15% continued to have fecal incontinence [23]. As it turned out, temporarily application of additional rectal enemas did not significantly improve treatment success compared with conventional therapy alone [24], which consist of education, a non-accusatory approach, and a toileting program encompassing a daily bowel diary and a reward system. Special attention is recommended to be paid to psychosocial or behavioral problems, since these frequently occur in affected children [25]. However, Jørgensen et al found the effectiveness of transanal irrigation in children with encopresis in a small number of patients [26]. A positive effect was recorded during the use of transcutaneous functional electrical stimulation [27] and transcutaneous posterior tibial nerve stimulation [7].

Our data show that encopresis without constipation is clinically characterized by periodic non-localized abdominal pain, an acute need to defecate and the inability to prevent defecation, as well as a frequent combination with enuresis, and a significant predominance of boys. Trial-and-error treatment results in "significant ($p < 0.05$)" symptom relief in some patients according to the results of their questionnaire. However, most often the symptoms do not disappear completely, and in some cases, they reappear after some time. It is known that laxatives can worsen symptoms.

X-ray analysis showed that in 13% of patients the width of the rectum was within normal limits, and in 87% of patients the rectal width and left half of the colon was less than the minimum limit of the age norm, which indicates a high tone of these sections. In 74% of cases, macroscopic signs of inflammation were found in the rectum and/or sigmoid colon. The combination of clinical and radiological symptoms allows us to understand the pathophysiological process. Inflammation leads to an increase in the tone of the left half of the colon and rectum, which causes the lump to quickly move into the rectum. Since the threshold defecation pressure in the narrow rectum occurs at a smaller bolus volume [15], a rapidly administered bolus leads to a defecation reflex as quickly as it occurs, for example, in acute diarrhea [28]. This understanding of the pathophysiology of encopresis without constipation allows us to understand why laxatives, which increase already high intestinal tone, increase the symptoms of encopresis. In this case, loperamide has a positive effect, slowing down intestinal motility and increasing the tone of the anal canal [29]. Based on the data presented, there is reason to assume that anti-inflammatory treatment through oral and/or transanal irrigation will be effective in children with encopresis without constipation.

Conclusion

Encopresis in children, defined as fecal incontinence of a functional nature, is divided into two diseases of different origins. In most cases, it occurs in children with chronic constipation, when, because of delayed defecation, large fecal masses accumulate in the rectum. In the dilated rectum (megacolon - megarectum), fecal stones form, which bougie (stretch) the pelvic floor muscles. Stretching of the puborectalis muscle (PRM) weakens the function of fecal continence, which leads to the penetration of feces into the panties. Varying degrees of damage to the PRM function before the development of descending perineal syndrome have been shown. In children without constipation, a decrease in the width of the rectum and left half of the colon was found. In most of them, proctoscopy revealed macroscopic signs of inflammation. High intestinal tone causes rapid advancement of the bolus into the rectum, and high rectal tone stimulates the defecation reflex with small volumes of feces. This leads to a situation like acute diarrhea, where bowel movements occur quickly and inexorably. These findings allow the use of pathogenetic treatment.

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