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Ultrasound diagnostics of rectal intussusception

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ABSTRACT *AIM: analysis of dynamic transrectal ultrasound (TRUS) and dynamic transperineal ultrasound (TPUS) accuracy in rectal intussusception (RI) diagnosis.*

PATIENTS AND METHODS: a prospective cohort single-center diagnostic accuracy study of ultrasound for RI detection (January 2023 — October 2024) included 151 patients with obstructive defecation syndrome, without signs of complete rectal prolapse and without history of surgical treatment for pelvic floor descent syndrome. All patients underwent dynamic TRUS, dynamic TPUS and X-ray defecography. Ultrasound results were compared with X-ray defecography data.

RESULTS: according to the X-ray defecography, RI was detected in 126/151 (83.4%) patients, according to dynamic TRUS — in 108/151 (71.5%), according to dynamic TPUS — in 110/151 (72.8%), according to complex dynamic ultrasound — in 124/151 (82.1%). The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of dynamic TRUS in RI detection were 82.5% (95% confidence interval (CI): 74.8–88.7), 84.0% (95% CI: 63.9–95.5), 96.3% (95% CI: 90.8–99.0), 48.8% (95% CI: 33.3–64.5) and 82.8% (95% CI: 75.8–88.4), respectively, dynamic TPUS — 81.7% (95% CI: 73.9–88.1), 72.0% (95% CI: 50.6–87.9), 93.6% (95% CI: 87.3–97.4), 43.9% (95% CI: 28.5–60.3) and 80.1% (95% CI: 72.9–86.2), complex dynamic US — 92.1% (95% CI: 85.9–96.1), 68.0% (95% CI: 46.5–85.1), 93.6% (95% CI: 89.1–96.3), 63.0% (95% CI: 46.95–76.6) and 88.1% (95% CI: 81.8–92.8), no statistically significant differences were found.

CONCLUSION: ultrasound is a safe, highly sensitive method for RI detection in patients with obstructive defecation syndrome. Equivalent diagnostic accuracy of dynamic TRUS, dynamic TPUS and complex dynamic US allows using any available technique to detect RI. Complex dynamic US seems to be universal method for assessment the anatomical and functional state of rectum.

KEYWORDS: *rectal intussusception, ultrasound, defecography*

CONFLICT OF INTEREST: *the authors declare no conflict of interest*

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INTRODUCTION

Rectal intussusception(internal prolapse of the rectum) is understood as prolapse of the rectal wall into its lumen without exiting through the anus, which develops due to weakness of the pelvic ligaments and muscles [1,2]. A prolapsing intestinal wall can interfere with the feces evacuation, which is manifested by obstructive defecation syndrome: patients experience impaired defecation, experience a feeling of incomplete emptying, and resort to manual assistance [2–5]. In some patients (up to 78% of cases), due to chronic ischemia and traumatization of the intestinal wall, RI is complicated by the solitary rectal ulcer [6,7]. The main method of instrumental diagnosis of RI is X-ray defecography [1]. The study is closest to the natural process of defecation and allows us to assess the mobility of the rectal wall during its emptying, identify the invaginate and identify the level of its location [8,9]. The disadvantages of X-ray defecography include ionizing radiation, limitations in visualizing the anatomical structures involved in the act of defecation, and the inability to assess the structure of the intestinal wall.

Ultrasound has several advantages: the absence of ionizing radiation, good tolerability, and the possibility of series of strained samples [10–13]. All ultrasound techniques developed for patients

with suspected RI, as well as X-raydefecography, are aimed at detecting invaginate and determining its level. Dynamic TPUS is considered the most studied, easy-to-perform and widely available technique, with high diagnostic information content (sensitivity reaches 95%, specificity — 100%) [14,15]. Echodefecography (dynamic TRUS with 3d image reconstruction and ultrasound gel contrast of the rectum) is a less studied, more complex and expensive technique with high diagnostic information content (sensitivity up to 100%, specificity up to 91%) [16,17]. Dynamic transvaginal US using a linear intracavitary sensor has high specificity (89%), but low sensitivity (56%) [18]. A common disadvantage of the methods described above is the inability to assess the structure of the rectal wall, and hence to diagnose RI complicated by solitary ulcer, as well as other rectal comorbidities. TRUS, on the contrary, can be used both for a detailed assessment of the structure of the intestinal wall and for determining its mobility in patients of both sexes [19,20]. However, to date, the results (sensitivity up to 64%, specificity up to 98%) of single studies of the diagnostic information content of dynamicTRUS, with a small number of patients included, do not allow us to confidently recommend this study as a universal method for determining the anatomical and functional state of the rectum [12,21,22]. Therefore, the aim of the study was to determine the possibilities of ultrasound techniques (dynamic TRUS and dynamic TPUS) in the diagnosis of RI.

PATIENTS AND METHODS

From January 2023 to October 2024, patients over the age of 18 with obstructive defectaion syndrome (with complaints of difficulty emptying the rectum, and/or a feeling of incomplete emptying, and/or the need for manual assistance for emptying) were included in a prospective cohort study to assess the diagnostic information of ultrasound techniques in detecting RI.

Non-inclusion criteria: — the presence of complete prolapse of the rectum; — the condition after surgical treatment of perineal prolapse syndrome.

Exclusion criteria: — the patient's refusal to participate in the study at any stage.

All patients underwent dynamic TRUS, dynamic TPUS, and X-raydefecography. Ultrasound examinations were performed with a HiVisionPreirus device (Hitachi, Japan). During the ultrasound, the patients were lying on their left side with their knees brought to their stomachs.

For TRUS, an intracavitary rectal biplane sensor (linear scanning format) with a frequency of 5–10 MHz, pre-coated with a latex balloon filled with water, was inserted into the rectum at a distance of 10 cm from the anal edge. The first stage was to evaluate the thickness and structure of the wall of the rectum, anal canal, neighboring organs and tissues along the entire circumference. The second stage of dynamic TRUS, at 3, 6, 9, and 12 o'clock as per a conventional clock face, was performed with straining tests aimed at detecting displacement of individual layers of the intestinal wall in the distal direction or a symptom of intussusceptions — full-layer prolapse of the intestinal wall into the rectal lumen (intrarectal intussusception), anal canal intraanal intussusception) or beyond the anal canal (rectal prolapse) (Fig. 1).

With dynamic TPUS, a convex sensor with a frequency of 1–5 MHz was installed on the perineum in the sagittal plane, then a straining test was performed to detect the symptom of intussusceptionalong the posterior and anterior semicircle (Fig. 2).

The result of a complex US scan was considered positive if the result of at least one technique (dynamic TRUS and/or dynamic TPUS) was positive; the result was considered negative if the results of both techniques were negative. Intraanal intussusception was concluded by a complex ultrasound scan if it was detected by the results of at least one technique; intrarectal intussusception was concluded if it was detected by the results of at least one technique and no intraanal intussusceptionwas detected.

The result of a complex ultrasound was considered negative if the results of both techniques were negative.

Before X-ray defecography, a thick barium suspension was injected into the rectum, imitating fecal matter. During the test, the patients sat on a special chair. Radiography and fluoroscopy of the rectum were performed in a lateral projection at rest, with muscle contraction, straining and emptying. An X-ray sign of intussusception was considered a "funnel" symptom, depending on its size and height, mucosal prolapse, intrarectal and intraanal intussusception, and rectal prolapse were distinguished [8,9].

Statistical Data Analysis

The data analyzed in the study was entered into the Access database (Microsoft Office 2021). Statistical analysis was performed using RStudio (Rv.4.4.1 (RCoreTeam, Vienna, Austria)) using the libraries base, dplyr, RODBC, gtsummary and GenBinomApps. Quantitative indicators were evaluated for compliance with the normal distribution using Kolmogorov-Smirnov's test; in the case of Gaussian's distribution, they were described using arithmetic averages (M) and standard deviations (SD). Categorical data was described with absolute values and percentages.

The comparison of features of this type was carried out using Pearson's c^2 test with expected values of more than 10 for four-field tables and more than 5 for multi-field tables, as well as Fisher's two-way precise test in the other cases. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were calculated with 95% coincidence intervals (95% CI) calculated using Klopper-Pearson's test. Differences in these indicators between the methods were considered statistically significant in the absence of a 95% CI overlap, as well as at $p < 0.05$. In the case of pairwise comparisons, the correction of the significance level was carried out using Benjamini-Hochberg's test. The consistency between the two categorical variables was assessed using Cohen's kappa.

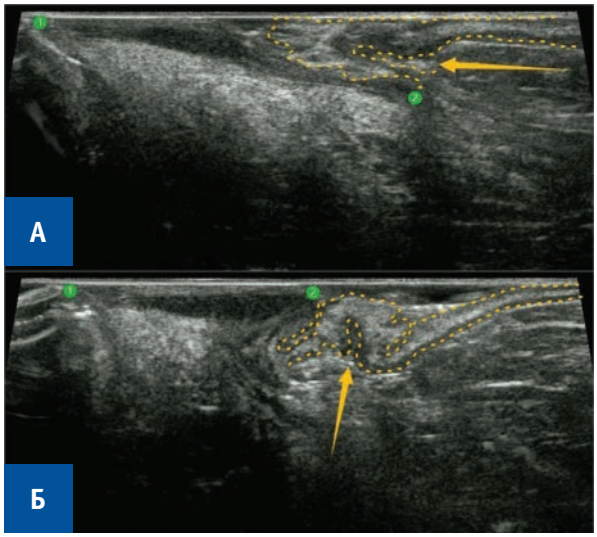

Figure 1. *Echogram of the rectal wall during straining, dynamic TRUS in B-mode. Rectal intussusception is indicated by yellow arrow. А — intraanal intussusception, Б — intrarectal intussusception, 1 — distal edge of the anal canal, 2 — proximal edge of the anal canal.*

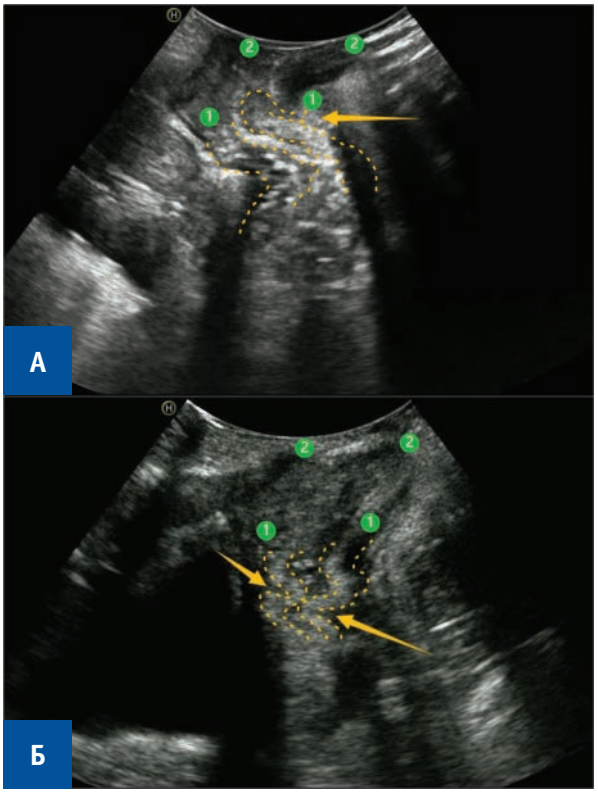

Figure 2. *Echogram of the rectal wall during straining, dynamic TPUS in B-mode. Rectal intussusception is indicated by yellow arrow. А — intraanal intussusception, Б — intrarectal intussusception, 1 — proximal edge of the anal canal, 2 — distal edge of the anal canal.*

RESULTS

One hundred and fifty-one patients were included in the study: 14 (9.3%) male and 137 (90.7%) female with obstructive defectaion syndrome. The clinical and demographic characteristics of the patients are presented in Table 1.

According to the X-ray defecography data, RI was detected in 126/151 (83.4%) patients, of whom 112/126 (88.9%) patients had intrarectal intussusception, and 14/126 (11.1%) ones had intraanal intussusception. In addition, X–ray signs of perineal prolapse were found in 112/151 (74.2%) cases, and sigmocele in 10/151 (6.6%) cases. Among women, 108/137 (78.8%) ones had a rectocele with an average size of 43.6 ± 16.0 mm.

Dynamic TRUS revealed ultrasound signs of RI in 108/151 (71.5%) patients, of whom 83/108 (76.9%) ones had intrarectal intussusception, and 25/108 (23.1%) patients had intraanal. In addition, 29/151 (19.2%) patients had solitary ulcer of the rectum, and 10/151 (6.6%) ones had fistula of the rectum.

According to the dynamic TPUS data, 110/151 (72.8%) patients had RI: 86/110 (78.2%) — intrarectal, 24/110 (21.8%) — intraanal. The level of concurrence between dynamic TPUS and dynamic TRUS in the detection of RI was average (Cohen's kappa = 0.51, 95% CI: 0.35–0.66). According to the complex dynamic US, RI was detected in 124/151 (82.1%) patients: in 88/124 (71.0%) — intrarectal, in 36/124 (29.0%) — intraanal.

The results of comparing dynamic TRUS, dynamic TPUS, and complex dynamic US with X-ray defecography are presented in Table 2. When comparing the sensitivity of ultrasound techniques, the p value turned out to be less than 0.05 (p = 0.035), but there was an overlap of 95% CI, so the differences were considered statistically insignificant.

When comparing the methods for the remaining parameters of diagnostic information, no statistically significant differences were found.

An analysis of the possibilities of dynamic TRUS, dynamic TPUS and complex dynamic US in determining the level of intussusception was also carried out. The results of comparing ultrasound techniques with X-ray defecography data are presented in Tables 3–5. When comparing the diagnostic information content of ultrasound techniques in the detection of intrarectal and intraanal RI, no significant differences could be found.

Table 1. *Clinical and demographic characteristics of patients*

Parameters	Patients N = 151
Age (years), M ± SD	53.8 ± 12.9
Gender, *n* (%) Male Female	 14 (9.3%) 137 (90.7%)
Complaints	
Constipation, *n* (%)	64 (42.4%)
Liquid stool *n* (%)	8 (5.3%)
Discharge from the anus *n* (%) No Mucus Blood Mucus + Blood	 106 (70.2%) 9 (6.0%) 29 (19.2%) 7 (4.6%)
Difficulty emptying, *n* (%)	70 (46.4%)
Excessive strain, *n* (%)	42 (27.8%)
Incomplete emptying, *n* (%)	119 (78.8%)
The need for manual assistance, *n* (%)	76 (50.3%)
Incontinence of intestinal contents, *n* (%) No Gases Liquidf eces Formed feces	 126 (83.4%) 6 (4.0%) 17 (11.3%) 2 (1.3%)
Lack of urge to defecate, *n* (%)	18 (11.9%)
The need for laxatives and/or enemas, *n* (%)	51 (33.8%)
Abdominal pain, *n* (%)	15 (9.9%)
Pain in the anal canal, *n* (%)	35 (23.2%)
Digital rectal examination	
Excessive folding of the intestinal wall, *n* (%)	43 (28.5%)
Rectocele, *n* (%)	96 (70.1%)*
Ulcerative defect of the rectal wall, *n* (%)	3 (2.0%)

*Note: * Among women (N = 137)*

DISCUSSION

False negative results occurred in dynamic TPUS and dynamic TRUS in approximately the same number of cases (22 and 23), which may be due to the non-physiological position of the patient

Table 2. *Diagnostic accuracy of ultrasound for RI detection in comparison with X-ray defecography*

Technique	TP	FP	TN	FN	Sensitivity (95%CI)	Specificity (95%CI)	PPV (95%CI)	NPV (95%CI)	Accuracy (95%CI)
TRUS	104	4	21	22	82.5% (74.8–88.7)	84.0% (63.9–95.5)	96.3% (90.8–99.0)	48.8% (33.3–64.5)	82.8% (75.8–88.4)
TPUS	103	7	18	23	81.7% (73.9–88.1)	72.0% (50.6–87.9)	93.6% (87.3–97.4)	43.9% (28.5–60.3)	80.1% (72.9–86.2)
TRUS + TPUS	116	8	17	10	92.1% (85.9–96.1)	68.0% (46.5–85.1)	93.6% (89.1–96.3)	63.0% (47.0–76.6)	88.1% (81.8–92.8)
p					0.035*	0.5	0.6	0.3	0.4

*Note: TP — truly positive results, TN — truly negative, FP — falsely positive, FN — falsely negative, PPV — positive predictive value, NPV — negative predictive value, 95% CI -95% coincidence interval, * $p_{TRUS–TRUS+TPUS} = 0.035$, $p_{TPUS–TRUS+TPUS} = 0.035$*

Table 3. *Results of comparison of ultrasound with X-ray defecography*

		TRUS, n				TPUS, n				TRUS + TPUS, n			
		No	IR	IA	Total	No	IR	IA	Total	No	IR	IA	Total
X-ray defecography, n	No	21	3	1	25	18	6	1	25	17	6	2	25
	IR	21	74	17	112	22	77	13	112	9	80	23	112
	IA	1	6	7	14	1	3	10	14	1	2	11	14
	Total	43	83	25	151	41	86	24	151	27	88	36	151

Note: IR is intrarectal intussusceptions, IA is intraanal intussusceptions

Table 4. *Diagnostic accuracy of ultrasound for intrarectal RI detection in comparison with X-ray defecography*

Technique	TP	FP	TN	FN	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Accuracy (95% CI)
TRUS	74	9	30	38	66.1% (56.5–74.7)	76.9% (60.7–88.9)	89.2% (80.4–94.9)	44.1% (32.1–56.7)	68.9% (60.8–76.2)
TPUS	77	9	30	35	68.8% (59.3–77.2)	76.9% (60.7–88.9)	89.5% (81.1–95.1)	46.2% (33.7–59.0)	70.9% (62.9–78.0)
TRUS + TPUS	80	7	32	32	71.4% (62.1–79.6)	82.1% (66.5–92.5)	92.0% (85.3–95.8)	50% (41.9–58.1)	74.2% (66.4–80.9)
p					0.7	0.8	0.8	0.8	0.6

Note: TP — true positive results, TN — true negative, FP — false positive, FN — false negative, PPV — positive predictive value, NPV — negative predictive value, 95% CI — 95% coincidence interval

Table 5. *Diagnostic accuracy of ultrasound for intraanal RI detection in comparison with X-ray defecography*

Technique	TP	FP	TN	FN	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Accuracy (95% CI)
TRUS	7	18	119	7	50.0% (23.1–77.0)	86.9% (80.0–92.0)	28.0% (12.1–49.4)	94.4% (88.9–97.7)	83.4% (76.5–89.0)
TPUS	10	14	123	4	71.4% (41.9–91.6)	89.8% (83.4–94.3)	41.7% (22.1–63.4)	96.9% (92.1–99.1)	88.1% (81.8–92.8)
TRUS + TPUS	11	25	112	3	78.6% (49.2–95.3)	81.8% (74.3–87.8)	30.6% (16.3–48.1)	97.4% (92.6–99.5)	81.5% (74.3–87.3)
p					0.4	0.15	0.6	0.5	0.3

Note: TP — true positive results, TN — true negative, FP — false positive, FN — false negative, PPV — positive predictive value, NPV — negative predictive value, 95% CI — 95% coincidence interval

common to ultrasound techniques (lying on his/her left side) during the test, as opposed to the sitting position during X-ray defecography.

There was no expected predominance of false negative results in dynamic TRUS due to the presence of an ultrasound sensor in the rectal lumen,

which prevents the formation of intussusception. This factor could probably be compensated by the inability to visualize the symptom of intussusception along the lateral semicircles of the rectum during dynamic TPUS due to the location of the ultrasound sensor in the sagittal plane, as well as lower image detail due to the greater distance between the sensor and the examined rectal wall. The combination of the above factors seems to lead to discrepancies in the conclusions of the methods in some cases (Cohen's kappa = 0.51, 95% CI: 0.35–0.66, average concurrency level). False positive results (4 with dynamic TRUS, 7 with dynamic TPUS) may be due to the difficulty in differentiating between the symptom of intussusception and normal folds of the rectum. With dynamic TPUS and dynamic TRUS, 13 and 17 cases were identified, respectively, of "overestimation" of the RI level (detection of intraanal intussusception instead of intrarectal). This may reflect different US and X-ray defecography approaches to determining the boundary between the anal canal and the lower ampullary rectum: in X-ray defecography, the distal boundary of the anorectal zone is considered its landmark, while in US, the proximal boundary of the internal sphincter is considered its landmark. In addition, 3 and 6 cases of "underestimation" of the RI level (detection of intrarectal intussusceptions instead of intraanal) were observed with dynamic TPUS and dynamic TRUS, respectively. These discrepancies may be due to the previously described non-physiological position of the patient with both ultrasound techniques, as well as the presence of a sensor in the intestinal lumen during TRUS.

The high sensitivity of ultrasound techniques (81.7–92.1%) in detecting RI allows using this study as a first-line diagnostic method. The high PPV of US (93.6–96.3%) makes it possible to abandon further X-ray defecography in case of a positive ultrasound result. At the same time, a negative US result does not exclude the presence of RI (NPV 43.9–63.0%) — X-ray defecography is necessary. Detection of intrarectal RI using ultrasound techniques does not require rechecking in X-ray defecography (PPV 89.2–92.0%). However, detection of intraanal intussusceptions does not guarantee its presence in X-ray defecography (PPV 28.0–41.7%). The analysis did not reveal statistically significant differences in diagnostic information content between dynamic TRUS, dynamic TPUS and complex dynamic US in detecting RI in general and in determining the level of intussusception. Therefore, for the diagnosis of RI, it is sufficient to carry out one of the methods — dynamic TPUS or dynamic TRUS. The advantages of dynamic TPUS include: ease of implementation and good tolerability of the examination, as well as its accessibility and low cost, thanks to the use of a widely used convective ultrasound sensor. The low-frequency sensor makes it possible to visualize deeply located pelvic organs and detect other manifestations of perineal prolapse syndrome (rectocele, cystocele, enterocele, etc.) with the greatest accuracy, while detailed visualization of the structure of the rectum and anal canal is impossible in case of TPUS. This technique can be used in outpatient appointments of doctors (coloproctologists, urologists, gynecologists) dealing with the problem of perineal prolapse syndrome. Dynamic TRUS seems to be a more universal technique that allows, in addition to diagnosing RI, to additionally identify concomitant diseases of the rectum and anal canal (solitary ulcer of the rectum as a complication of RI, inflammatory bowel diseases, tumors, hemorrhoids, fistulas, etc.), the presence of which may affect treatment approach. Performing TRUS requires a less accessible endorectal sensor and additional specialist training, which can be implemented in specialized coloproctological units. Under the same conditions, it is possible to make a complex dynamic US (a combination of TRUS and dynamic TPUS), which most fully covers the spectrum of pathologies of the rectum and anal canal.

CONCLUSION

Ultrasound is a safe, highly sensitive method for diagnosing RI in patients with obstructive

defecation syndrome. The equivalent indicators of diagnostic information content of dynamic TRUS, dynamic TPUS, and complex dynamic US make it possible to use any available technique to detect RI. Complex dynamic US is the most universal method of determining the anatomical and functional state of the rectum.

AUTHORS CONTRIBUTION

Concept and design of the study: *Yuliya L. Trubacheva*
Collection and processing of the material: *Anastasiya E. Pershina*
Writing of the text: *Anastasiya E. Pershina*
Editing: *Yuliya L. Trubacheva, Oleg M. Biryukov*

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