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Fecal Loading Evaluation by Two Radiological Scores: Comparisons between Functional Constipation and Irritable Bowel Syndrome-Constipation in Children and Adolescents

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Abstract

Aim: Compare fecal loading (FL) using Leech and Starreveld methods in children and adolescents with functional constipation (FC) or irritable bowel syndrome (IBS-C).

Methods: Single-center, observational, retrospective, cross-sectional study of consecutive cases referred with unresponsive constipation. Inclusion criteria: FC and IBS-C, according to the Rome IV Criteria, age between 4 and 15 years old. Exclusion criteria: underlying chronic disorders, no medication during the two weeks preceding the radiography. Data collection is executed from electronic medical records. Before the analysis, two pediatric gastroenterologists discussed the methods to ensure an accurate evaluation. The scores were applied to the entire colon.

Results: 114 children/adolescents were divided into the FC group (59 patients) and the IBS-C group (55 patients). Baseline characteristics highlight the more prevalent duration of symptoms and painful defecation in FC and female sex, defecation frequency, and abdominal pain in IBS-C. There is a high level of agreement between the two pediatric gastroenterologists in their assessment of FL for both FC and IBS-C, indicating the reliability of the methods. The FL scores in FC were higher than IBS-C, Leech ($p<0.001$), and Starreveld ($p<0.002$). The Leech proportion of positive score was FC (93%) and IBS-C (78%), and Starreveld, FC (95%) and IBS-C (89%). Results underscore the effectiveness of the methods in identifying FL. However, in the comparison of the proportion of positive results, FC was higher than IBS-C using only Leech ($p<0.02$) with Sensitivity (0.93) and Specificity (0.21), and the Starreveld method does not differentiate FC and IBS-C ($p=0.30$).

Conclusions: FC and IBS-C effectively identify groups with differences in FL. Notably, IBS-C had a significantly lower FL score than FC. Thus, the simplicity, low cost, and applicability of the Leech and the Starreveld for observing the FL and gas distribution in the colonic segments may permit better therapeutic planning.

Keywords: Functional constipation, Irritable bowel syndrome, Abdominal radiography, Children, Leech method, Starreveld method, Fecal loading

Abbreviations: FC: Functional Constipation; FL: Fecal Loading; FGIDs: Functional Gastrointestinal Disorders; FAPDs: Functional Abdominal Pain Disorders; IBS: Irritable Bowel Syndrome

Introduction

Disorders of gut-brain interactions or functional gastrointestinal disorders (FGIDs) are common causes of pediatric gastroenterology visits [1]. Indeed, in a cross-sectional study, 24% of infants/toddlers and 25% of children/adolescents fulfilled the Rome IV criteria for FGIDs, a set of diagnostic criteria widely used in the field due to its comprehensive approach to classifying these disorders [2,3]. Indeed, functional constipation (FC) and functional abdominal pain disorders (FAPDs) are very prevalent in a Tertiary Pediatric Gastroenterology Clinic [2].

FC is not just a common chronic disorder in children but a global health concern, representing a significant reason for health expenditure [1,4]. In a systematic review and meta-analysis, and according to the Rome III and Rome IV Pediatric Criteria, the prevalence was defined as 9.5% (95% CI 7.5–12.1)[5]. This global impact of FC is a driving force behind our research. Regarding FAPDs, the worldwide-pooled prevalence in a meta-analysis of 58 studies was 13.5% [6] and comprised four conditions: functional dyspepsia, abdominal migraine, functional abdominal not otherwise specified, and IBS according to the Rome IV criteria [3].

The main symptoms of IBS are recurrent abdominal pain and change in bowel habits, allowing classified into IBS with predominant constipation (IBS-C), IBS with predominant diarrhea, IBS mixed bowel habits, or unspecified IBS [3]. The Bristol Stool Chart, a tool used in clinical practice to describe fecal consistency, is crucial in classifying patients into the correct subtype of IBS by assessing the stool form, which is a vital indicator of the condition [7].

Complaints of constipation and abdominal pain are frequently associated, and a focused history and no warning signs are vital to diagnosing FC and IBS-C, and limited testing is required. However, the current diagnostic process is not without its challenges, particularly in cases where the symptoms of FC and IBS-C overlap, leading to potential misdiagnosis. So, when faced with a child/adolescent with these two symptoms, doubts arise about the diagnosis. Since FC and IBS-C are associated, the Rome IV Criteria establishes that the child must first be treated for constipation. If, despite adequate treatment, the abdominal pain persists, the child should be considered as IBS-C [8].

An updated systematic review [9] recently screened eleven eligible studies and identified two [10,11] that assessed the diagnostic accuracy of abdominal radiographs to evaluate constipation, concluding that there is insufficient evidence to support the use of abdominal radiographs as part of the diagnostic workup of FC. Thus, supporting clinical guidelines that do not recommend imaging [12,13].

Controversially, abdominal radiographs are commonly used in clinical practice to assess fecal loading (FL), complement the clinical history/physical examination, and evaluate enlargement of the colon-rectum, particularly among children presenting to the Pediatric Emergency Department with abdominal pain [14]. So, the path remains open to new proposals using FL scores in constipated patients. To our knowledge, no study has compared FL between FC and IBS-C in children/adolescents. Our research, with its unique focus on this comparison, aims to address the critical need for improved diagnostic methods, making it highly relevant and novel in the field.

Therefore, this study aims to assess and compare FL using two radiographic scoring methods in children and adolescents with FC or IBS-C who underwent plain abdominal radiography at the first visit. Our secondary objectives are to compare the inter-observer agreement and define the method with the best clinical applicability, further underlining the significance of our research.

Methods

Study design, setting, and selection of participants

This single-center, observational, retrospective, cross-sectional study included consecutive cases of children/adolescents referred from the Brazilian Public Health System to Pediatric Gastroenterology Outpatient visits from August 2016 and December 2019 with diagnoses of unresponsive constipation. Inclusion criteria: FC and IBS with Constipation pattern (IBS-C), according to the Rome IV Criteria [3]. The patient is between 4 and 15 years old, has undergone simple abdominal radiography at the first visit, and has no constipation treatment. Two experienced pediatric gastroenterologists (MAC, NCM) determined the final diagnosis after four months of follow-up. Exclusion criteria were underlying chronic disorders: genetic, metabolic, immune, cardiac, hepatic, renal diseases, delayed neurodevelopmental, previous surgery, and having no medication for the treatment of IBS or FC during the two weeks preceding the radiography. Approval was obtained by the institution's Ethics Committee (CAAE 12665613.0.0000.5411); parents permitted radiology to be applied.

Data collection

The data collection process was designed and executed by two authors' abstractors (JTD, CDFJ) from electronic medical records using a standardized form developed according to the Rome IV diagnostic questionnaire. Blood cell count, C-reactive protein, urinalysis, stool for ova and parasites, and *Helicobacter pylori* serology were performed for all patients. Another test was performed at the discretion of the gastroenterology team.

Anthropometric data

At the first visit, experienced pediatric nurses obtained

anthropometric measurements of body weight (kilograms) and height (centimeters) according to World Health Organization guidelines [15]. Body Mass Index/Age [kg/m^2] was evaluated according to WHO AnthroPlus [16,17]. Data were adjusted for age and sex [18].

Radiological evaluation

Before the radiological analysis, the two methods [19,20] were discussed intensively by two pediatric gastroenterologists (GNH, MAC), ensuring a comprehensive and accurate evaluation. Radiographs were evaluated independently after coding without identifying the group. The Leech score was applied to the entire colon and can range from 0 to 15, with scores ≥ 9 suggesting fecal retention. The Starreveld minimum score is 4, and the maximum is 16. In his original publication, Starreveld does not establish a cut-off point at which the result is considered positive for fecal retention. Later, the cut-off point was defined as ≥ 10 for children [21].

Statistical analysis

Data was continuously entered into Excel (Microsoft 365, version 2409) by one author and checked by another. Analysis was performed using GraphPad Prism version 8.00 for Windows. Variables are presented as median and interquartile range, number, and percentage. The data normality distribution was verified with the Shapiro–Wilk test. The Mann-Whitney and Fisher's exact tests were used to compare the two groups of children. The Kappa test was used to verify inter-rater agreement. A p-value <0.05 was considered significant.

Results

One hundred and fourteen children and adolescents were included and divided into two subgroups for comparison: FC Group (59 patients) and IBS-C Group (55 patients). **Table 1** compares the baseline characteristics of the patients, highlighting the more prevalent and statistically significant differences in the duration of symptoms and painful defecation in FC. On the other hand, female sex, defecation frequency, and abdominal pain in IBS-C. There is no fecal incontinence in the IBS-C group, and the BMI/age z score was not different between the two groups. **Table 2** presents good or excellent inter-observer agreements for FC and IBS-C according to Leech and Starreveld FL scoring.

Table 3 presents Leech and Starreveld FL scores according to observers for FC and IBS-C. There are no statistically significant differences between observers. **Table 4** demonstrates that the FL scores in FC were consistently higher than IBS-C, both for the Leech (p<0.001) and Starreveld (p<0.002) methods. The Leech proportion of positive score was FC (93%) and IBS-C (78%), and Starreveld, FC (95%) and IBS-C (89%). These results underscore the effectiveness of the methods in identifying a high proportion of FL. However, in the comparison of the proportion of positive results, FC was higher than IBS-C using only Leech (p<0.02) with Sensitivity (0.93) and Specificity (0.21), and the Starreveld method does not differentiate FC and IBS-C (p=0.30).

Table 1. Baseline Characteristics of Children and Adolescents with Functional Constipation and Irritable Bowel Syndrome Subtype Constipation.

	Functional Constipation	**Irritable Bowel Syndrome- Constipation**	**p<**
	Median (Interquartile Ratio)		
Number of patients	59	55	-
Sex: Female *n (%)*	25 (43)	34 (62)	0,04
Age at the first visit, *yr*	7.7 (5.3–10.9)	8.5 (6.5–10.9)	ns
Duration of symptoms, *yr*	5.0 (2.0–7.0)	1.0 (0.5–3.0)	0.0003
Defecation frequency */week*	2 (2–3)	3 (2–5)	0.0004
Painful defecation, *n (%)*	34 (57)	6 (11)	0.0001
Fecal incontinence, *n (%)*	28 (47)	0 (0)	-
Abdominal pain, *n (%)*	30 (51)	55 (100)	0.0001
Mother's age, *yr*	34.0 (28.0–38.0)	30.0 (27.0–35.0)	ns
Father's age, *yr*	38.5 (33.0–43.5)	36.0 (30.5–40.0)	ns
Children at home, *n*	2.0 (1.0–2.0)	2.0 (2.0–3.0)	ns
Crowding index *(person/room)*	0.83 (0.7–1.0)	0.83 (0.6–1.2)	ns
Body Mass Index/age z score	0.55 (-0.14–1.67)	0.06 (0.68–0.85)	ns

Table 2. Interobserver Agreement for Functional Constipation and Irritable Bowel Syndrome Subtype Constipation According to Leech and Starreveld Radiological Fecal Loading Scoring.

	Functional Constipation		**Irritable Bowel Syndrome Subtype Constipation**	
	Interobserver agreement			
	Observer 1 versus 2	p<	Observer 1 versus 2	p<
Leech, kappa (interpretation)	0.92 (Excellent)	p<0.001	0.74 (Good)	p<0.001
Starreveld, kappa (interpretation)	0.90 (Excellent)	p<0.001	0.63 (Good)	p<0.001
Agreement interpretation: poor (<0.20), slight (0.20–0.39), moderate (0.40–0.59), good (0.60–0.79) or excellent (0.80–1.0).				

Table 3. Leech and Starreveld Fecal Loading Scores According to Observers for Functional Constipation and Irritable Bowel Syndrome Subtype Constipation.

	Functional Constipation		**Irritable Bowel Syndrome-Constipation**	
	Observer 1*	**Observer 2***	**Observer 1***	**Observer 2***
	Leech			
Median	12	11	10	10
Interquartile Ratio	11-14	10-12	9-12	9-12
95% Confidence Interval	11-13	10-11	9-11	10-11
Min - Max	7-15	7-14	6-15	6-15
	Starreveld			
Median	13	13	12	13
Interquartile Ratio	12-15	12-14	10-13	11-14
95% Confidence Interval	13-14	13-14	11-13	11-13
Min - Max	8-17	9-16	8-16	9-16
*p>0.05				

Table 4. Comparisons of Fecal Loading Scores between Functional Constipation and Irritable Bowel Syndrome Subtype Constipation and the Proportion of the Leech and Starreveld Positive Scores.

	Functional Constipation	**Irritable Bowel Syndrome-Constipation**	p<
	Median (Interquartile Ratio)		
Leech	11.0 (10.3–12.3)	10.3 (9.0–11.6)	0.001*
% with a score of positive (≥ 09)	55/59 (93%)	43/55 (78%)	0.02**
Sensitivity			0.93
Specificity			021
Starreveld	13.3 (12.0–14.3)	12.00 (10.6–13.3)	0.002*
% with a score of positive (≥ 10)	56/59 (95%)	49/55 (89%)	0.30**
Sensitivity			0.94
Specificity			0.10

Discussion

Assumed the lack of studies on the radiological characteristics between FC and IBS-C in pediatric gastroenterology outpatient clinics, our study stands out for assessing FL scores using Leech and Starreveld methods and inter-observer agreement. The main findings of our study include good/excellent inter-observer agreements, identification of a high proportion of FL by the methods, a higher proportion of favorable results in FC than IBS-C using the Leech method, and higher FL scores in FC than IBS-C. The literature highlights the controversial aspects of using plain abdominal radiography in constipation. Added to the proposal of its use in IBS-C.

The degree of homogeneity of the socio-demographic data favored the analysis and interpretation of the results. The duration of the symptoms was longer in FC than in IBS-C, probably due to family members being more comfortable dealing with constipation than the worrying diagnosis of abdominal pain. Notice that in FC, there is no abdominal pain but more prevalent painful defecation and fecal leakage. Indeed, in patients with IBS-C, abdominal pain is the center of symptoms, as defined by the Rome IV criteria [3]. In a study of children with constipation and abdominal pain not defined as IBS-C [10], the mean Leech score and proportion of positive children with the same cut-off point were similar to the current study.

Until now, four different scores have been developed to quantify FL in plain abdominal radiography [19,20,22,23], describing good diagnostic accuracy, with over 80% of constipated patients correctly identified. In clinical practice, plain abdominal radiography is frequently used to evaluate children with constipation, complement clinical history and examination, quantify fecal impaction, support the diagnosis, suggest treatment, and assess therapeutic response [24]. In addition, it is simple and cheap and does not expose the patient to a high radiation dose [25]. However, only some studies compare these radiological scores, and no similar studies analyze FL in plain abdominal radiographs of children with IBS [10].

The literature is conflicting as to an association between the clinical- and radiological diagnosis of constipation and abdominal pain, reporting high inter- and intra-observer variability and poor diagnostic accuracy [26,27]. Previous studies [19,20] have reported that plain abdominal radiography is significantly correlated with symptoms of constipation. On the other hand, plain abdominal radiography does have some benefits. So, in a systematic review, inconsistent evidence was found regarding the diagnostic association between clinical symptoms and FL [28]. Although history and physical examination are sufficient to diagnose constipation reliably, many physicians turn to plain abdominal radiography to confirm the diagnosis [29,30]. One disadvantage could be that the study evaluated a single plain abdominal radiograph and a single observation in time. Fecal Loading may depend on daily variation, food intake, and child defecation before abdominal radiography and may report less diagnostic accuracy. An earlier study showed no correlation in the degree of FL when comparing two abdominal radiographs taken four days apart in the same child with FC while not receiving laxative treatment [31].

Scoring systems have been developed to reduce subjectivity in evaluating FL in abdominal radiographs. The Leech score that is frequently performed was reproducible, practical, and sensitive compared to the Barr scoring system [10]. In addition, it was highly correlated with the Bristol stool form scale, colonic transit time, defecation frequency, and abdominal pain frequency. van den Bosch *et al.*, Moon *et al.*, and Koh *et al.* [32-34], showed a statistically significant correlation between the Leech and the Starreveld scores. Besides, there needs to be more information on the use and utility of these different scoring methods during daily clinical work studies, which have compared the Leech and Starreveld scores to analyze children with IBS-C. Thus, the Leech and Starreveld scores were clinically helpful and were chosen for this study.

If each observer develops their interpretation of the original guidelines, substantial inter-observer variability may be possible. Therefore, in the current study, the observers were very concerned about appropriate training, resulting in a good/excellent agreement regarding the degree of stool retention when using the Leech and Starreveld scores. Similar results were obtained for the Leech score [32,35,36]. Consequently, if investigators are experienced and well-trained, we speculated that both scores might be a reliable and helpful tool for evaluating childhood fecal retention.

This study has limitations: First, It is retrospective and subject to data collection failure. However, a standardized form protocol specifically designed may have minimized this aspect.; Second, this was a single tertiary center study. Participants might have had a more prolonged and severe disease course than children evaluated in communities, and these results' generalizability is not recommended. Third, plain abdominal radiography characterizes a single observation in time, and a visual inspection may be subjective. Fourth, no segmental stool retention score was evaluated. The strengths were: First, to our knowledge, no study has compared the FL scores in children with FC and IBS-C using these two radiological scores. Second, all constipated patients were strictly classified according to the Rome IV criteria. Third, this study demonstrated good training and standardization among observers, resulting in good/excellent agreement.

Conclusion

The assessment of FL in FC and IBS-C showed good performance in identifying differences between groups. The simplicity, low cost, and applicability of the Leech and the

Starreveld are valuable diagnostic tools for complementing outpatient clinical histories and physical examinations. In addition, observing the FL and gas distribution in the colonic segments may permit better therapeutic planning, such as choosing the best laxative and sources of Dietary Fiber and FODMAPs. Prospective studies correlating clinical findings with these scores on plain abdominal radiography will further enhance their clinical utility and improve patient management.

Conflict of Interest

The authors have no conflicts of interest.

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Author Contributions

Bibliographical Survey (NCM, JTD, GNH, CDFJ, MAC), Clinical Data Collection (JTD, CDFJ), Radiographs Evaluation, Drafting of the Manuscript (GNH, NCM, MAC), Critical Revision of the Manuscript (JTD, GNH, MAC).

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