Are We Using Abdominal Radiographs Appropriately in the Management of Pediatric Constipation?

Beate Beinvogl, MD[1,2], Sabina Sabharwal, MD, MPH[2], Maireade McSweeney, MD, MPH[2], and Samuel Nurko, MD, MPH[1,2]

Objective To identify the reasons why pediatric gastroenterologists obtain abdominal radiographs in the management of pediatric constipation.

Study design This was a prospective study surveying providers regarding their rationale, interpretation, resultant change, and confidence in their management before and after obtaining KUBs in patients seen for suspected constipation. Demographics and clinical findings were obtained from medical records.

Results A total of 24 providers were surveyed after 72 patient encounters. Reasons for obtaining an abdominal radiograph included evaluation of stool burden (70%), need for a clean out (35%), fecal impaction (27%), cause of abdominal pain (24%), demonstration of stool burden to families (14%), assessment of response to therapy (13%), or encopresis (10%). The plan was changed in 47.6% of cases based on radiographic findings. In cases in which a plan was outlined before obtaining the radiograph (69%), the initial plan was implemented on average in 52.5%. In cases with no plans before obtaining the radiograph, previously unconsidered plans were implemented in 8.7%. Provider confidence in the management plan increased from 2.4 ± 2.7 to 4.1 ± 1.8 ($P < .05$) after the abdominal radiograph.

Conclusion Abdominal radiographs commonly are obtained by pediatric gastroenterologists in the evaluation and management of constipation. The majority used it to make a diagnosis, and nearly one-half changed their management based on the imaging findings. Overall, they reported an improved confidence in their management plan, despite evidence that radiographic findings poorly correlate with clinical severity. This study highlights the need for further provider education regarding the recommendations delineated in existing constipation guidelines. *(J Pediatr 2017;191:179-83).*

Functional constipation, a common problem in children and adolescents, is a clinical diagnosis based on patient history, physical examination, and use of the Rome IV criteria and necessitating no further routine diagnostic testing.[1] However, providers frequently obtain plain abdominal radiographs to assist with the evaluation and/or management of constipation.[2,3] Current evidence, including multiple prospective studies and systematic reviews, does not support a diagnostic association between clinical symptoms and fecal loading on abdominal radiographs.[4-7] More specifically, studies have shown a lack of intra- and interobserver reliability in the interpretation of plain radiographs.[5,8] Studies also show that relying on an abdominal radiograph for the evaluation of constipation in patients with abdominal pain may lead to the wrong diagnosis or may lead to an overlooking of other diagnoses.[9,10] Obtaining radiographs further increases cost and poses a significant radiation exposure, especially because children often undergo repeated studies.[11,12]

Guidelines published by the North American Society for Pediatric Gastroenterology, Hepatology and Nutrition and the European Society for Pediatric Gastroenterology, Hepatology and Nutrition, as well as the Rome IV criteria, clearly recommend that abdominal radiographs should not be used in the routine evaluation of functional constipation, with the only exceptions being an unreliable patient history, psychological factors that make a digital rectal examination (DRE) inappropriate (such as a history of trauma), obesity, or patients with a suspicion of sexual abuse history.[1,12-14] No studies evaluating provider adherence to these guidelines, specifically with regard to the use of radiographs, or their rationale for obtaining abdominal films, exist. In addition, no data exist on how routine abdominal radiographs may influence provider's clinical management. The aim of this study was to assess how pediatric gastroenterology providers use abdominal radiographs to evaluate and manage constipation. Understanding why subspecialty providers obtain abdominal films against current recommendations may reveal gaps in the provider's knowledge of the current guidelines and provide opportunities for educational intervention.

Methods

This prospective study was conducted at Boston Children's Hospital and was approved by the local institutional review board. Members of the Pediatric Gastroenterology Division (attending physicians, fellows, or nurse practitioners) were

DRE Digital rectal examination

From the [1]Center for Motility and Functional Gastrointestinal Disorders; and [2]Division of Pediatric Gastroenterology, Boston Children's Hospital, Boston, MA

The authors declare no conflicts of interest.

0022-3476/$ - see front matter.
https://doi.org10.1016/j.jpeds.2017.08.075

surveyed after any outpatient clinical encounter in which a plain abdominal radiograph was obtained when constipation was known or suspected. A survey was designed and tested with providers. In the final version, providers were asked about their rationale for obtaining a radiograph, what management they were considering before the film, how they interpreted the radiograph (mild, moderate, or large stool burden) and then asked if and how the abdominal imaging changed their management, as well as their level of confidence in their treatment plan before and after obtaining the radiograph. Providers also were asked if they thought the radiograph was useful.

Medical records of the patients who had an abdominal radiograph were reviewed for patient demographics, clinical history, pertinent physical examination findings, as well as radiology reports. No formal scoring system for stool burden was used, given their poor and inconsistent sensitivity and specificity.[4,6] The primary outcome measure was whether obtaining an abdominal radiograph changed an individual providers' constipation management plan. Secondary endpoints included relative frequencies of providers' reasons for obtaining a radiograph, diagnoses, and management changes made based on the radiograph. Provider's interpretation of abdominal radiographs in relation the expectation based on history and physical examination also was assessed. The confidence in the management plan before and after obtaining an abdominal radiograph (via a modified Likert Scale: 0 = unsure to 5 = very confident) was calculated with the Wilcoxon Rank Sum Test. Data were analyzed with SPSS Statistics 20 (IBM Corp, Armonk, New York).

Results

A total of 24 providers were interviewed after 72 patient encounters in which constipation was either considered as the chief complaint or patients were seen for follow-up of a known diagnosis of constipation. Providers included pediatric gastroenterologists (77.1%), nurse practitioners (18.6%), and fellows (4.3%). The mean patient age was 10.2 ± 6.1 years, and 43.9% were female and 56.1% male. Nearly equal numbers were seen for an initial consultation (47%) vs follow-up visit (53%). The chief complaint(s) of patients sent for and abdominal radiograph were constipation (33.3%), abdominal pain (30.6%), diarrhea or loose stools (16.7%), and fecal soiling (15.2%). Other complaints included feeding difficulties, nausea, heartburn, bloating, or nocturnal enuresis (21.2%). Of all patients, 56.9% had a history of constipation, and 61.1% were on laxatives at the time of presentation. Comorbidities were found in 18.3% of patients and included genetic syndromes with developmental delay (n = 2), cerebral palsy (n = 3), inflammatory bowel disease (n = 2), type 1 diabetes (n = 2), celiac disease (n = 2), Ehlers-Danlos syndrome (n = 1), attention-deficit/hyperactivity disorder (n = 2), autism (n = 1), and neurogenic bowel (n = 1). Surgical history included cecostomy tube placement (n = 3), subtotal colon resection for necrotizing enterocolitis (n = 2), repaired imperforate anus (n = 1), and detethering of a tethered chord (n = 1).

Of all patients, 34.7% had a previous abdominal radiograph for evaluation of constipation at the same or another institution. An abnormal abdominal examination was noted in 34.7% of patients, including mild tenderness to palpation (20.6%), palpable stool (17.6%), or distension (10.3%). Only 2.8% of patients had an abnormal finding on perianal examination, including rectal prolapse, skin tag, or fissure. A DRE was performed in only 12 of the 72 patients (16.7%). Of patients who had a DRE, 3 had no palpable stool in the rectum, and their radiograph showed a small amount of stool in 1 case and moderate amounts of stool in 2. A small amount of soft stool was palpated in 5 cases, with the radiograph showing moderate amounts of stool in 4 of these cases and small stool burden in 1 case. All 4 cases described to have large amounts and/or hard stool on the DRE had large colonic and rectal fecal burden on radiograph.

The assessment of stool burden (70%) was the most common reason for obtaining a radiograph, followed by determination for the need of a clean out (35%), presence of fecal impaction (27%), cause of abdominal pain (24%), demonstration of stool burden to families (14%), assessment of response to therapy (13%), to determine presence of encopresis (10%), or to confirm fecal impaction (6%) (**Figure**).

Stool burden on the abdominal radiograph was as expected (39.7%), worse (39.7%), or less (20.6%) than expected based on history and physical examination. Both the personal and the radiologist read of the abdominal radiograph was used in 63.9%, whereas 33.3% relied on the radiologist's report and 2.8% on their personal interpretation alone. Per radiology report, 18.2% had a normal colonic stool burden, 53% moderate, and 28.8% large stool burden on the radiograph. Minimal or no stool burden in the rectum was found in 80.6% of patients, and 19.4% had moderate-to-large stool burden in the rectum.

Providers found the abdominal radiograph useful in 97.2% of patient encounters to diagnose constipation as reason for abdominal pain (27.6%), diagnose constipation (22.4%), demonstrate stool burden to the family (15.5%), diagnose fecal impaction (10.3%), assess for worsening fecal retention (8.6%), determine whether fecal retention was the reason for incontinence (5.2%), or determine the need for an inpatient clean out (1.7%). Overall, the plan was implemented or changed based on the imaging findings in 47.6% of cases. In cases in which a plan had been outlined before obtaining the radiograph (69%), the initial plan was implemented on average in 52.5% of cases. In patients in whom no or alternate plans had been considered before the radiograph was obtained, previously unconsidered plans were implemented on average in 8.7% of cases. Details of the changes in management plan based on abdominal radiograph findings are shown in the **Table**. The mean level of confidence in the management plan before obtaining abdominal radiograph was 2.4 ± 2.7 and increased to 4.1 ± 1.8 ($P < .05$) after viewing the radiograph.

Discussion

Evidence-based guidelines clearly suggest that an abdominal radiograph is not necessary for the evaluation of constipa-

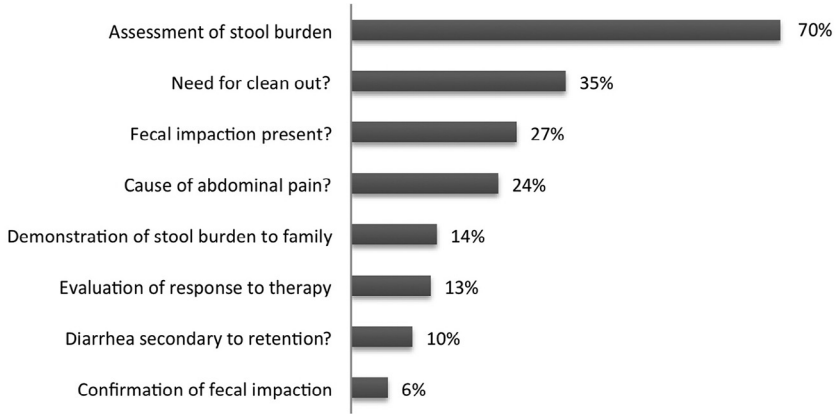

Figure. Reasons for obtaining an abdominal radiograph.

tion, except in very limited circumstances.[12-14] The poor adherence to aforementioned guidelines has been described previously by Yang and Punati, who showed that 84.3% of general pediatricians reported being unfamiliar with or uncertain about current guidelines, including 54.8% of providers obtaining an abdominal radiograph as part of the routine evaluation for functional constipation.[3]

This study, designed to understand the rationale used by pediatric gastroenterology providers at an academic institution for ordering abdominal films during the routine evaluation of patients with suspected or known constipation, provides an understanding of their practice. We found that most abdominal radiographs were used to assess stool burden and the presence of constipation, particularly in patients with concomitant abdominal pain. Multiple studies as well as systematic reviews have shown, however, that abdominal radiographs poorly correlate with clinical symptoms or severity of fecal retention, and the interrater reliability of their interpretation is poor.[4-6,8,15] A systematic review consisting of 6 studies reported sensitivity ranging from 60% (95% CI 46-72) to 80% (95% CI 65-90) and specificity ranging from 43% (95% CI 18-71) to 90% (95% CI 95-100).[4] de Lorijn et al reported an area under the curve of 0.68 (95% CI, 0.58-0.80), indicating poor diagnostic accuracy.[8] We and others have not only described a lack of interobserver agreement between gastroenterologists when fecal loading is measured but also between gastroenterologists and radiologists as well as a lack of correlation with the clinical diagnosis.[4,5]

Constipation is a clinical diagnosis based on patient history, physical examination, and fulfillment of the Rome criteria, necessitating no further routine diagnostic testing in the absence of warning signs of organic disease.[1] In particular, a DRE can be helpful in the evaluation of fecal impaction. However, the examination is not performed routinely because of patient anxiety or physician discomfort.[16] Even though our study was not designed to evaluate the sensitivity/specificity of DRE, we observed that all patients with hard stool in the rectal vault showed large amounts of stool by radiograph, although there was no correlation between stool burden by DRE and radiography otherwise. Therefore, when a DRE is performed and fecal impaction is found, the diagnosis of fecal impaction can be made and the patient treated accordingly. No further testing

Table. Changes in management plan before and after obtaining the AXR

I	II	III	IV	V
	Group A		Group B	
Management plans	Management plan considered before AXR, n, (%)	Number of cases in which initial plan was actually implemented after AXR, n, (%)	Number of cases in which plan was not chosen before AXR, n, (%)	Number of cases in which plan was implemented after AXR, n, (%)
Clean out at home	29/72 (40.3)	12/29 (41)	43/72 (59.7)	9/43 (21)
Inpatient clean out	2/72 (2.8)	1/2 (50)	70/72 (97.2)	0/70 (0)
Add stimulant laxative	8/72 (11.1)	4/8 (50)	64/72 (88.9)	4/64 (6.3)
Add osmotic laxative	9/72 (12.5)	6/9 (66.7)	56/72 (77.8)	7/56 (12.5)
Decrease laxative	1/72 (1.4)	1/1 (100)	70/72 (97.2)	2/70 (2.9)
No changes	6/72 (8.3)	0/6 (0)	66/72 (91.7)	3/66 (4.5)
To show the family	5/72 (6.9)	3/5 (60)	67/72 (93.1)	9/67 (13.4)

AXR, abdominal radiograph.
Column I shows the intervention categories that were proposed before the AXR. Group A reflects the cases in which the defined intervention was being considered before the AXR. Group B reflects the cases in which the defined intervention was not considered before the AXR. Group A: Column II reflects those patients in whom the provider decided to implement the outlined intervention before the AXR, whereas column III shows the actual number of patients in which the intervention was implemented. Group B: Column IV reflects those patients in whom the providers did not decide to implement the outlined interventions, whereas column V shows the actual number of patients in which the intervention was indeed implemented after the AXR.

is necessary, including an abdominal radiograph.[14] In cases in which a DRE cannot be performed, and the history or other clinical tools do not allow the determination of fecal impaction, the performance of an abdominal radiograph may be considered, acknowledging the limitations of radiographs in diagnosing constipation.[4,14]

It also has been shown that the routine use of abdominal films for the evaluation of constipation has some risks. An incorrect diagnosis of constipation by radiograph, in particular in the emergency department, may lead to erroneous diagnosis in which other medical/surgical conditions are not considered or overlooked.[4,6,9,10] Children with functional abdominal pain frequently are diagnosed as having constipation and treated with laxatives, and radiographs carry cost and radiation exposure.[1] A single abdominal radiograph exposes a child to 0.46 mSv per film, and to put this in context again, the average annual ionizing exposure is 1.5-3.5 mSv.[11,12] In the present study, 34.7% had previous abdominal radiographs performed, often more than once, demonstrating again the increased radiation risk of using repeated films to assess need or success of therapy.

We are left with the question as to why are abdominal films still being used so frequently? Studies have modeled physician's problem-solving efforts into 3 main components: (1) the early formulation of hypotheses based on clinical data initially available in conjunction with physician's prior experience and knowledge, (2) the pursuit of more clinical data to confirm or reject these hypotheses, and (3) the selection of a final hypothesis after critical level of confirmation.[17,18] According to this model, the use of abdominal radiographs to diagnose constipation potentially could be a useful confirmatory tool, except that it clearly has been shown that it lacks sensitivity and specificity. This could be addressed with more education to increase physicians' knowledge of the limitations of this modality. More judicious and informed use of diagnostic testing may in turn decrease the use of unnecessary studies and thereby help mitigate rising medical costs.

Previous studies have shown that an expert clinician typically forms a notion of what is wrong with a patient within 20 seconds.[19] In 69% of cases, providers had a management plan in mind after taking a history and examining the patient but were reluctant to start therapy. After obtaining the radiograph, the initial plan was implemented in only 52.5% of cases. In contrast, in the cases with no plan in place before the radiograph was obtained, previously unconsidered plans were implemented on average in 8.7% of cases (**Table**). These findings show that obtaining a radiograph does change management plans in approximately one-half of the cases when a plan existed previously and conversely, not having a plan in place before obtaining the radiograph only resulted in initiation of an intervention in a small percentage. In our study, obtaining an abdominal film appears to serve as confirmatory evidence to support or reject provider's initial management plan, but its poor sensitivity and specificity as described in the literature are being disregarded.[4] It has been shown that a provider's internal state, his or her amount of tension, and possibly insecurities may enter into and influence his or her clinical judgments and decision-making process.[19] An additional or alternate reason for using the abdominal films, therefore, may be the providers' need to increase their level of confidence in the diagnosis and therapy, as shown by the difference in confidence levels before and after viewing the radiograph, from 2.4 ± 2.7 before to 4.1 ± 1.8 ($P < .05$) respectively (scale 0 = unsure to 5 = very confident). Our study offers insight into the thought process of the provider who orders the radiograph, as nearly all reported it to be useful, perhaps not surprising, as each provider had a reason for ordering it. It is likely the interpretation of the abdominal film also conformed to the provider's pretesting expectations.

Our findings suggest that there is an opportunity to intervene, as some of these issues may be addressed with improved provider education. For example, is it possible that the use of abdominal radiographs will decrease if providers better understand its limitations? Kurowski et al showed that educating providers in emergency departments significantly reduced their use of abdominal radiographs (69.5% vs 26.4%) and significantly increased the use of a DRE (22.9% vs 47.3%) before and after appropriate education, without affecting patient outcome.[16] It is therefore likely that providing further education around functional constipation and limitations with the routine use of abdominal radiography will increase gastroenterology provider confidence in the diagnosis without obtaining unnecessary testing.

The strength of this study is that it addresses and reflects a common practice and experience in a busy clinical department. This study not only looks at reasons for obtaining an abdominal radiograph but also the underlying rationale used by ordering providers and their level of confidence, suggesting there are other factors, in addition to the clinical question, for which an imaging study was obtained. Therefore, our findings it may provide new venues for research on how to better educate clinicians and their patients/families. It also alerts us to be aware as to why we are using radiographs and how to hopefully avoid unnecessary radiation risk.

There are limitations to the study. This study was conducted at a single center with institution-specific practices. Given the design of the study, we could not have the providers commit to a therapy before they saw the abdominal film. Our questionnaire was completed after the decisions had been made, allowing some bias toward showing it was always useful, as it is possible the ordering provider would have had a tendency to find it useful. The absence of a control group of constipated children in whom no abdominal film was obtained does not allow us to evaluate why abdominal films were obtained in the first place. Also, the small sample size and possible clustering effect of providers seeing multiple patients (some more than others) may have influenced the results. However, despite the limitations of our study, we were able to identify key reasons for the performance of the abdominal films that may be amenable to educational efforts.

This study highlights the need for further provider education in the use of abdominal radiographs in children with

functional constipation and the importance to further educate on the recommendations delineated in existing constipation guidelines. ■

Submitted for publication Apr 14, 2017; last revision received Aug 22, 2017; accepted Aug 28, 2017

References

1. Hyams JS, Di Lorenzo C, Saps M, Shulman RJ, Staiano A, van Tilburg M. Childhood functional gastrointestinal disorders: child/adolescent. Gastroenterology. 2016;150:1456-68.
2. Freedman SB, Rodean J, Hall M, Alpern ER, Aronson PL, Simon HK, et al. Delayed diagnoses in children with constipation: multicenter retrospective cohort study. J Pediatr 2017;186:87-94, e16.
3. Yang CH, Punati J. Practice patterns of pediatricians and trainees for the management of functional constipation compared with 2006 NASPGHAN guidelines. J Pediatr Gastroenterol Nutr 2015;60:308-11.
4. Reuchlin-Vroklage LM, Bierma-Zeinstra S, Benninga MA, Berger MY. Diagnostic value of abdominal radiography in constipated children: a systematic review. Arch Pediatr Adolesc Med 2005;159:671-8.
5. Berger MY, Tabbers MM, Kurver MJ, Boluyt N, Benninga MA. Value of abdominal radiography, colonic transit time, and rectal ultrasound scanning in the diagnosis of idiopathic constipation in children: a systematic review. J Pediatr 2012;161:44-50, e41-42.
6. Pensabene L, Buonomo C, Fishman L, Chitkara D, Nurko S. Lack of utility of abdominal x-rays in the evaluation of children with constipation: comparison of different scoring methods. J Pediatr Gastroenterol Nutr 2010;51:155-9.
7. Beckmann KR, Hennes H, Sty JR, Walsh-Kelly CM. Accuracy of clinical variables in the identification of radiographically proven constipation in children. WMJ 2001;100:33-6.
8. de Lorijn F, van Rijn RR, Heijmans J, Reitsma JB, Voskuijl WP, Henneman OD, et al. The Leech method for diagnosing constipation: intra- and interobserver variability and accuracy. Pediatr Radiol 2006;36:43-9.
9. Freedman SB, Thull-Freedman J, Manson D, Rowe MF, Rumantir M, Eltorki M, et al. Pediatric abdominal radiograph use, constipation, and significant misdiagnoses. J Pediatr 2014;164:83-8, e82.
10. Petinaux B, Bhat R, Boniface K, Aristizabal J. Accuracy of radiographic readings in the emergency department. Am J Emerg Med 2011;29:18-25.
11. Linet MS, Kim KP, Rajaraman P. Children's exposure to diagnostic medical radiation and cancer risk: epidemiologic and dosimetric considerations. Pediatr Radiol 2009;39(suppl 1):S4-26.
12. Benninga MA, Tabbers MM, van Rijn RR. How to use a plain abdominal radiograph in children with functional defecation disorders. Arch Dis Child Educ Pract Ed 2016;101:187-93.
13. Bardisa-Ezcurra L, Ullman R, Gordon J, Guideline Development Group. Diagnosis and management of idiopathic childhood constipation: summary of NICE guidance. BMJ 2010;340:c2585.
14. Tabbers MM, DiLorenzo C, Berger MY, Faure C, Langendam MW, Nurko S, et al. Evaluation and treatment of functional constipation in infants and children: evidence-based recommendations from ESPGHAN and NASPGHAN. J Pediatr Gastroenterol Nutr 2014;58:258-74.
15. Hamm R. Clinical intuition and clinical analysis: expertise and the cognitive continuum. In: Dowie J, Elstein AS, eds. Professional judgment. Cambridge (MA): Cambridge University Press; 1987. p. 78-105.
16. Kurowski J, Kaur S, Katsogridakis Y, Wershil BK, Bass LM. Educational module improves emergency department evaluation for suspected constipation. J Pediatr 2015;167:706-10, e701.
17. Elstein AS, Rovner DR, Rothert ML. A preclinical course in decision making. Med Decis Making 1982;2:209-16.
18. Wolf FM, Gruppen LD, Billi JE. Differential diagnosis and the competing-hypotheses heuristic. A practical approach to judgment under uncertainty and Bayesian probability. JAMA 1985;253:2858-62.
19. Groopman J. How doctors think. New York: Houghton Mifflin Harcourt; 2008.