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Abdominal X-Ray in the Evaluation of Pediatric Abdominal Pain in an Economically Advanced Environment

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Abstract

Objectives: Current guidelines recommend against abdominal radiograph (AXR) in the evaluation of pediatric recurrent or chronic abdominal pain (RAP). Based on our positive experience with AXR, we revisited this recommendation.

Methods: A worldwide pediatric gastroenterology (PGI) physician survey was performed. Twenty pediatric RAP cases of the same physician were reviewed, where AXR was systematically employed. The PGI physician and two radiologists blindly scored stool burden in patients and 20 matched controls.

Results: 17% of PGI specialists indicated using AXR in RAP patients without clinical constipation. Paradoxically, 81% reported recommending constipation therapy if AXR showed fecal retention. None of the 20 RAP patients met clinical criteria for constipation, however there was increased stool burden on 90% of AXRs. Constipation-predominant RAP remained the diagnosis in 90% after 6-month follow-up. Intra- and inter-observer agreement between blinded AXR interpretations were fair to perfect by Fleiss's kappa analysis. The PGI physician called for fecal retention more commonly in cases than controls, significantly better than the radiologists.

Conclusions: PGI-interpreted AXR during RAP evaluation may be valuable in certain settings and should be re-examined through prospective randomized trials.

Keywords: Fecal Retention, Abdominal Pain, KUB, Children, Radiograph

Introduction

For the purposes of this study, recurrent/chronic abdominal pain (RAP) refers to the broad spectrum of pediatric abdominal pain that encompasses constant or recurrent, chronic or subacute symptoms of either organic or non-organic etiology. The most common chief complaint of patients referred for pediatric gastroenterology (PGI) evaluation in an economically advanced setting such as the United States is RAP. Many of these patients meet criteria for functional abdominal pain disorders (FAPD) (1). Only 5-10% of RAP, defined in the literature as at least three episodes of abdominal pain over at least three months, is attributed to organic causes in children (2).

Constipation is a leading organic cause of pediatric abdominal pain, though a considerable functional component is often present (3). The diagnosis of functional constipation relies on the Rome IV criteria based on a constellation of patient-reported signs and symptoms meant to guide clinical decision-making (4). Though created to aid in the clinical diagnosis of functional GI disorders (FGIDs), the Rome criteria have inherent limitations, including dependence on patient report, which further complicate the often-challenging identification of FGIDs (5). These limitations allow for substantial variation in clinical practice during the subspecialist evaluation of RAP.

Current clinical guidelines recommend against laboratory and imaging workup during the initial evaluation of RAP in the absence of alarm signs or physical exam abnormalities (4,6). Our observation is, however, that this recommendation is frequently disregarded in the real-world practice of pediatric gastroenterology in the US. Additionally, our clinical impression is that a single-view frontal abdominal radiograph (AXR) may be useful in the management of RAP in an urban outpatient setting. Such radiographs may be helpful for detecting stool retention in abdominal pain with subclinical constipation (i.e., fecal retention (7)), in paradoxical diarrhea (8), and in stool retention-associated dyspepsia or vomiting (9). We report our findings on worldwide PGI physician approach to AXR for RAP and our single practice case series.

Methods

World-wide survey

We developed a survey of five questions regarding individual provider practices involving AXR for the evaluation of RAP (Supplemental Methods). Survey questions sought to gauge frequency of AXR use in this setting if patients were not clinically constipated. The method of interpreting AXR findings, simultaneous testing, and recognition of current clinical guidelines for the workup of pediatric abdominal pain were assessed. The survey questions and answer options were entered into Survey Monkey (www.surveymonkey.com; Momentive, Inc.) for data collection purposes.

A hyperlink to the survey was dispersed by electronic mail via the worldwide pediatric gastroenterology listserv (pedgi@list.uvm.edu) consisting of providers in our field who have voluntarily subscribed. While the listserv includes trainees, advanced practice providers, and other ancillary professionals, the study team requested that only attending-level physicians complete the survey. Informed consent was waived due to the anonymous and completely voluntary nature of the study, without any direct or indirect risks or benefits to the participants. Responses were recorded in SurveyMonkey and downloaded to a password-protected server on the institutional network upon closure of the survey after one week.

RAP cohort

We subsequently identified an observational cohort of new patients who were referred to outpatient pediatric gastroenterology at a tertiary/quaternary pediatric hospital system in the Southern US for the primary complaint of abdominal pain. Informed consent was waived due to the retrospective nature of the study with routine care provided, and no more than minimal perceived risk to participants (institutionally approved protocol; IRB H-50062). Consecutive new patient cases of a single physician (over 12-year clinical experience) with the chief complaint of abdominal pain were studied. The practice of the single pediatric GI physician was to systematically utilize AXR in the evaluation of children with the primary complaint of abdominal pain, regardless of the defecation pattern they or their caretaker described. We retrospectively identified, and examined 20 such patients who had a minimum of 6 months follow-up period. AXR was employed in real-time during each of these visits. All patient visits occurred within a three-month period and were identified sequentially to eliminate selection bias.

Our clinic is within a large outpatient facility that is equipped to provide AXR within 15 minutes of the order being placed. Single-view antero-posterior AXR (or kidney-ureter-bladder [KUB] radiograph) was performed during each visit with real-time review of the images within 30 minutes. The physician performed the interpretation independently, recorded the impression, and discussed that with the patient and caregiver before the official read from the radiologist was documented in the electronic medical record (EMR). Pain characteristics, presence or absence of alarm signs, AXR findings, and management plan were recorded. Any additional workup ordered at the consultation, along with the historical workup prior to the clinic visit (i.e., emergency room visits, previous primary and/or subspecialty investigations) was also recorded. A minimum of 6 months of follow-up period was evaluated through each patient's EMR.

Controls and blinded reads

A cohort of control patients were identified from the electronic database on the criteria of having AXR at our institution with the primary indication of trauma (i.e., motor vehicle crash, monkey bar accident). Controls were age- and sex-matched to the studied case cohort. The AXRs for both cases and controls were then arranged in randomized order and presented to the PGI physician and two independent pediatric radiologists from the same institution. All were blinded to AXR indication and patient information. The fecal burden on each AXR was qualified as average, moderate, or large. Moderate and large stool burden were interpreted as clinically significant (i.e., fecal retention). The radiographs were independently randomized and reviewed by the PGI and two radiologists, six weeks apart, to assess for inter- and intra-observer agreement. Fleiss's kappa method (10) was used to examine inter- and intra-observer agreement between "normal" and "fecal retention" calls. The arbitrary interpretation of kappa agreements is the following: 0.2-0.4: fair; 0.4-0.6: moderate; 0.6-0.8: substantial; >0.8 perfect. The number of fecal retention calls were compared between the readers by t-test.

Results

Worldwide Physician Practices

A total of 219 pediatric gastroenterologists participated in the web-based survey. Not all participants completed all questions, and participants were directed to discontinue the survey if they do not routinely utilize AXR in the outpatient work-up of chronic or recurrent abdominal pain. The majority (87%, 140 out of 161) reported being familiar with the current clinical guideline recommending against AXR in the initial workup of RAP in children. In the outpatient evaluation of RAP, 38 out of 219 participants (17%) reported routinely ordering AXR in patients who do not meet Rome IV criteria for constipation. Amongst those who reported utilizing AXR in such patients, 40% (15/38) reported using AXR more than half of the time. Of those that were not familiar with the clinical guideline, only 24% (5/21) reported using AXR to evaluate abdominal pain in clinically non-constipated patients. Amongst all responders, 9% (14/157) reported relying on the radiologist's impression for fecal retention on AXR. Interestingly and paradoxically, however, 81% (126/156) would recommend constipation therapy before further testing or treatments, if fecal retention was found on AXR during the evaluation of abdominal pain.

Utility of AXR in a Single Physician Practice

We reviewed the charts of 20 consecutive new patients evaluated by a single physician for the chief complaint of abdominal pain. Pain and stooling history are summarized in Table 1.

Table 1: Patient demographics, clinical characteristics, and management plans

Patient	Age (years)	Pain Location	Duration of pain (weeks)	Stooling pattern	Red flag signs/symptoms	Prior workup?*	Additional workup at initial visit?*	Management Plan
1	15	Periumbilical	4	1-2 stools per day; mBSFS-C 3	Unintentional weight loss	Yes	Yes	PEG 3350 cleanout
2	15	Epigastric	52	2 stools per day, hard	None	Yes	No	PEG 3350 cleanout
3	5	Epigastric	3	3-4 small loose stools per day	None	No	Yes	1 cap PEG 3350 QD and PPI
4	15	Periumbilical	80	mBSFS-C 2	None	Yes	No	PEG 3350 cleanout
5	17	Epigastric	104	1 stool per day; mBSFS-C 2-3	Family history of IBD	Yes	No	PEG 3350 cleanout
6	15	Diffuse	25	3-4 stools per day; mBSFS-C 4-5	None	No	No	PEG 3350 cleanout
7	8	Epigastric	16	1 stool per day, mBSFS-C 3	None	Yes	Yes	PEG 3350 cleanout
8	8	Diffuse	102	1 daily, mBSFS-C 3	None	Yes	Yes	PEG 3350 cleanout
9	14	Periumbilical	NR	1 stool per day	None	No	No	PEG 3350 cleanout
10	11	LUQ, LLQ	15	1 stool per day, mBSFS-C 3	Blood in stool	No	No	PEG 3350 cleanout
11	13	Periumbilical	208	Alternates 1 stool every other day (mBSFS-C 3) and multiple times per day (mBSFS-C 4-5)	Family history of IBD	Yes	No	PEG 3350 cleanout
12	8	RLQ, periumbilical	80	Daily, mBSFS-C 1 or 4	Unintentional weight loss	Yes	Yes	2-4 caps PEG 3350 per day and senna
13	9	Diffuse	28	Daily, intermittently hard stools	None	Yes	Yes	High fiber diet, additional workup
14	15	Epigastric	52	2 stools per day, mBSFS-C 3	Unintentional weight loss	Yes	Yes	2 caps PEG 3350 QD
15	15	Periumbilical	26	Diarrhea	Unintentional weight loss	No	Yes	PEG 3350 cleanout
16	6	Diffuse	12	1 stool every other day, mBSFS-C 2-3	None	Yes	No	PEG 3350 cleanout

17	10	Right side	3	Stools most days, mBSFS 2-3	None	Yes	Yes	PEG 3350 cleanout
18	14	Right side	7	2-4 stools per day; mBSFS 3-4	None	Yes	Yes	PEG 3350 cleanout
19	8	Periumbilical	104	Stools every other day or less frequently; mBSFS 3	None	Yes	No	PEG 3350 cleanout
20	16	Epigastric	156	mBSFS 4	None	No	Yes	PEG 3350 cleanout

IBD = inflammatory bowel disease; LLQ = left lower quadrant; LUQ = left upper quadrant; mBSFS-C = modified Bristol Stool Form Scale for Children[33]; NR = not recorded; PEG = polyethylene glycol; PPI = proton pump inhibitor; QD = daily; RLQ = right lower quadrant

*See Supplementary Table 1 for details

The average duration of pain was 57 weeks, and the most common location of the pain (75%) was periumbilical and/or epigastric. Four patients had duration of pain less than three months, and documentation of pain duration was not available for one patient. Most (70%) patients reported at least one stool per day, and five (25%) described some degree of loose stools. None of the patients met Rome IV criteria for functional constipation.

AXR indicated moderate to large stool burden in 18 patients (90%) (Supplemental Figure 1). The remaining two patients were noted to have average stool burden. The pediatric gastroenterologist's impression of the AXR findings agreed with the clinical radiologists' interpretation in all but one patient [patient 12]. Therefore, real-world interdisciplinary agreement between the independent reads of the gastroenterologist and radiologists was 95%. Home based bowel cleanout with polyethylene glycol (PEG) was recommended in 16 out the 18 patients with above average fecal retention, followed by strict daily bowel regimen. In those two patients not recommended to complete a rigorous cleanout, intense daily bowel regimen with PEG was still advised. Consequently, all patients with clinically significant stool retention received therapeutic guidance for constipation management.

Additional workup was initiated in 55% of all patients, 36% of whom had alarm signs for possible organic disease. The most common alarm sign was unintentional weight loss. The supplementary workup yielded an actionable result in only two patients (10% of all in the cohort), both of whom were found to have *Helicobacter pylori* infection. These latter examinations were also done against current NASPGHAN/ESPGHAN guidelines (11) since the patients did not report dyspepsia. Patients were encouraged to return to clinic if the constipation management recommendations did not improve or resolve their complaints. After the initial consultation, two out of 20 (10%) patients had at least one additional follow-up visit with the gastroenterologist during the 6-month follow-up, but no change in the diagnosis was made. Two different patients (10%) presented to the institution's emergency care center for persistent pain within the 6-month follow-up period, however, no new diagnoses or treatments were proposed. RAP related to fecal retention (arguably indicating slow transit constipation) remained the diagnosis for 90% of the cases, 78% of whom did not complain, or require medical care within 6 months based on their EMR.

Blinded AXR Interpretation in Matched Cases and Controls

Inter-observer and intra-observer agreement of stool burden scores were evaluated between the PGI physician and two radiologists for 20 cases and 20 controls in two independent blinded reads. Scores were assigned to each AXR based on either average, or clinically significant (moderate or large) stool burden.

Inter-observer agreements in the two reads were moderate and fair, 71.67% (Fleiss kappa: 0.43) and 66.67% (Fleiss kappa: 0.33), respectively. Intra-observer agreements were substantial, perfect, and fair: 85% (Fleiss kappa: 0.69) for the PGI physician, 92.55 (Fleiss kappa: 0.85) for the first radiologist, and 60% (Fleiss kappa: 0.2) for the second radiologist, respectively.

The blinded PGI physician called fecal retention more commonly in cases than controls, with significantly greater sensitivity ($p<0.001$) than the radiologists (Table 2).

Table 2: Fecal retention calls for 2 sets (recurrent abdominal pain cases [Cases] and trauma controls [Controls]) of 20 blinded AXR reads, listed by physician (pediatric gastroenterologist [PGI], or radiologist 1 or 2) scoring the radiographs.

Fecal retention calls	PGI Read 1	PGI Read 2	Rad 1 Read 1	Rad 1 Read 2	Rad 2 Read 1	Rad 2 Read 2	T test p-value for PGI vs Rad calls
Cases (n=20)	16	15	9	9	7	9	*<0.001*
Controls (n=20)	8	9	9	7	13	9	0.630
Fischer's exact p-value	*0.023*	0.105	1.000	0.748	0.113	1.000	

Fischer's exact p-value is shown for differences in each read by cases versus controls. T-test p-value is for comparison between the number of PGI and radiologist calls for fecal retention in either Cases or Controls

Discussion

Expert opinion-based guidelines are important in quality improvement of clinical care, but have inherent limitations (12). This can lead to impractical and/or subsequently unsubstantiated advice to be perpetuated (examples in 13,14). Therefore, clinical guidelines should be continuously reviewed and revisited by practitioners in order to maintain their goal of quality improvement.

Our personal experience after discussions with PGI providers around the US has been that many routinely use AXR when evaluating RAP in spite of being familiar with the clinical guidelines. Therefore, in this study, we assessed world-wide practice in this respect, and studied the utility of AXR in the initial workup of pediatric RAP within an economically advanced urban setting.

Most pediatric gastroenterologists were familiar with the current clinical guideline (4,6) recommending against AXR in the initial outpatient evaluation of RAP. Only a small percentage reported to routinely employ AXR in this setting for patients that do not meet the Rome IV criteria for functional constipation. This did not vary based on reported awareness of clinical guidelines. However, the majority would treat for constipation before pursuing other testing for abdominal pain if AXR showed fecal retention. This suggests that pediatric gastroenterologists appreciate that pain can stem from fecal retention, and that clinical history may be overruled by AXR. Furthermore, the controversy revealed by our questionnaire insinuates that AXR findings are viewed as more objective than patient-reported clinical history in practice.

In our RAP cohort, none met clinical criteria for functional constipation. Nevertheless, all had screening AXR as part of the clinical practice of the study gastroenterologist. Despite lack of clinical clues to point towards functional constipation, 90% of patients were interpreted to have significant stool burden on AXR. All of those patients were advised to complete home bowel cleanout (followed by maintenance bowel regimen) or to initiate stool softeners as the primary therapy for the abdominal pain. Even in the remaining two patients, AXR was helpful in guiding clinical care. This supports our opinion that AXR is a valuable tool in the initial GI evaluation of RAP in the absence of definitive clinical constipation.

AXR is non-invasive, inexpensive and generally safe in children. The reported range of effective dose of a single-view fontal abdominal radiograph in children is between 0.03 and 0.46 mSv depending on imaging center calibration (15,16). To put this in perspective, annual background radiation exposure is between 1.5 to 3.5 mSv (15). While clearly not insignificant, this radiation dose is much less than that for many other diagnostic and therapeutic modalities. The literature has not shown significant associations between exposure to early life diagnostic radiation and childhood cancers (17).

The sensitivity and specificity of AXR in detecting fecal retention in children have been reported as between 60-84% and 33-90%, respectively (18,19). One must recognize, however, that without an objective gold standard for diagnosing fecal retention, such figures are questionable. Clinical scoring systems for detecting fecal retention on AXR have been shown to have higher reliability than a subjective classification solely based on amount of stool seen in the radiograph, though diagnostic accuracy was not dissimilar (20). Intra-observer reliability has been reported to be higher than inter-observer reliability for detecting fecal retention (18,20,21). Our study did not confirm these findings, but indicated that a GI physician could outperform radiologists in diagnosing clinically relevant stool retention on AXR in the background of abdominal pain (i.e., significantly more calls for fecal retention in the RAP group by blinded GI than radiologists in the RAP group, while similar in controls).

We found AXR helpful in all cases in our "real-world" study. Most of the patients were interpreted to have significant fecal retention while none met current clinical criteria for constipation. Fecal retention has previously been shown to positively correlate with colon transit time (7), and constipated children have been shown to have significantly prolonged colon transit time compared to non-constipated controls (22). It can thus be extrapolated that fecal retention serves as a marker of slow transit constipation in the appropriate clinical context.

No gold standard objective test exists for the diagnosis of constipation, and the clinical criteria rely on subjective signs and symptoms. This creates room for discrepancy in diagnosing functional constipation in children (23). In the clinic we find that children and caregivers often do not (or cannot) visualize bowel movements, nor can they accurately recall stooling patterns. Additionally, fecal retention has been associated with a wide range of symptomatology in children (24). A systematic review reported limited amount of data available, which showed conflicting evidence for an association between clinical symptoms of constipation and fecal loading on abdominal radiographs in children (25). Based on this limited literature and our clinical experience above, we conclude that reliance on clinical criteria may fail to identify patients with subclinical, but functionally important and actionable slow transit constipation.

Beyond facilitating the detection of fecal retention, we believe that AXR also has several other benefits. Use of AXR can narrow the diagnostic approach and limit further workup, which is often expensive, time-consuming, and anxiety-producing for both families and the medical system. For example, one of our patients (patient 4, see Supplementary Table 1) had already undergone an abdominal CT scan, and esophagoduodenoscopy and colonoscopy under general anesthesia prior to presenting to our clinic, without ever having a simple and inexpensive AXR done. AXR can also help visually promote self-awareness about stool retention, bowel habits and abdominal pain in children and caregivers, who may not otherwise be mindful of such a connection. Finally, AXR review and demonstration during the visit is a valuable resource for patient and family education, both concerning acceptance of the diagnosis and adherence to the management plan.

This work has several limitations. It is an observational cohort involving a small number of patients seen by one pediatric gastroenterologist. We did not confirm the fecal retention diagnosis with colonic transit time studies. Perhaps the most important limitation of this study was the lack of formal patient follow-up. We did track follow-up visits through a minimum of 6 months, but only through our EMR system. Therefore, it is possible that patients sought further treatment outside of our facility. In the meantime, our EMR allows easy online communication towards the medical staff, making it unlikely that a significant number of the studied patients would have decided to seek alternative PGI care or refrained from requesting follow-up care in the presence of persistent symptomatology.

Additionally, our findings may only be relevant for similar socioeconomic and medical environments: 1) We recognize that the etiology of abdominal pain in children may greatly vary between populations around the world based on socioeconomic status, dietary habits and other environmental factors. For instance, the gut microbiome that is considered critical in modulating the gut-brain axis associated enteric pain circuits (26,27) significantly differs in children based on dietary habits influenced by living circumstances (28). Intriguingly, the same circumstances (rural versus urban) influence the prevalence of pediatric constipation as well (29). 2) Our medical system uniquely allows for real-time performance and interpretation of AXR during an outpatient clinic visit. In healthcare settings where this is not possible, it may be challenging to obtain and interpret the AXR in a clinically feasible fashion. 3) The use of point-of-care ultrasound to diagnose rectosigmoid dilation/fecal retention (without radiation exposure, but requiring specific training and extra visit-time on behalf of the consulting GI physician) has not been commonly incorporated into the GI practice of the USA due to its medical system characteristics.

Lastly, we cannot rule out the placebo or indirect effect of colon cleansing and prolonged bowel regimen with recommendations towards high fiber diet (the routine recommendations given to all our patients with diagnosis of constipation) on RAP in children. Bowel preparation/colon cleansing can indeed profoundly affect the gut microbiome for example, even if only for 14 days (30). If such AXR based interventions and lifestyle changes resolve RAP with high efficiency, however, then this consideration further supports the use of AXR in this clinical setting.

In spite of the limitations, we find our study to demonstrate the importance of ruling out clinically actionable fecal retention in pediatric patients with RAP at GI visits. We conclude that AXR is a practical modality for this purpose, and is more objective than clinical history. Importantly, AXR for this indication is well accepted by families and can provide tangible evidence to support

adherence to the prescribed bowel regimen. AXR can perform well if utilized systematically in clinical practice, as we showed that an experienced clinician more commonly diagnosed fecal retention in patients with RAP than in matched controls, with a higher efficacy than radiologists. Our work calls for carefully designed, prospective, randomized trials to further examine the utility of AXR in children with RAP in economically advanced, urban settings. Early recognition of organic causes of chronic pain, such as fecal retention, may support timely interventions (31) to counteract the evolution of such syndromes, which lead to significant morbidity and healthcare costs (32).

Conflict of Interest

None declared

Author contributions

AB - design of the study, acquisition of data, analysis and interpretation of data, drafting the article and revising it critically for important intellectual content, final approval of the version to be submitted

EB - acquisition of data, analysis and interpretation of data, revising the article for critically important intellectual content, final approval of the version to be submitted

MD - acquisition of data, analysis and interpretation of data, revising the article for critically important intellectual content, final approval of the version to be submitted

DK - analysis and interpretation of data, final approval of the version to be submitted

RK - conception and design of the study, acquisition of data, analysis and interpretation of data, drafting the article and revising it critically for important intellectual content, final approval of the version to be submitted

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Supplemental Methods

Text of survey regarding provider practices involving AXR:

1. Do you routinely use abdominal X-ray during outpatient evaluation of chronic or recurrent abdominal pain in children (in patients who do not have constipation by Rome IV criteria)?

a. Yes (please go to next question
b. No (you are done)

2. How often do you use abdominal X-ray in patients with abdominal pain who do not have constipation by Rome IV criteria during their initial outpatient evaluation (i.e. to address subclinical constipation associated pain, paradoxical diarrhea, stool retention induced dyspepsia, etc.)?
a. <10%
b. >10%
c. >50%

3. Do you rely on the radiologist for interpreting fecal retention, or you make the decision on your own?
a. I rely on the radiologist interpretation
b. I interpret the X-ray myself

4. In cases of abdominal pain where you find fecal retention, but no alarm signs for potential organic disease (Hyams JS, Di Lorenzo C, Saps M, Shulman RJ, Staiano A, van Tilburg M. Functional disorders: children and adolescents. Gastroenterology. 2016; 150(6):1456-1468.e2.), do you first recommend constipation therapy before other testing or treatments?

a. Yes
b. No (I still do some additional workup or other treatment trials as well)

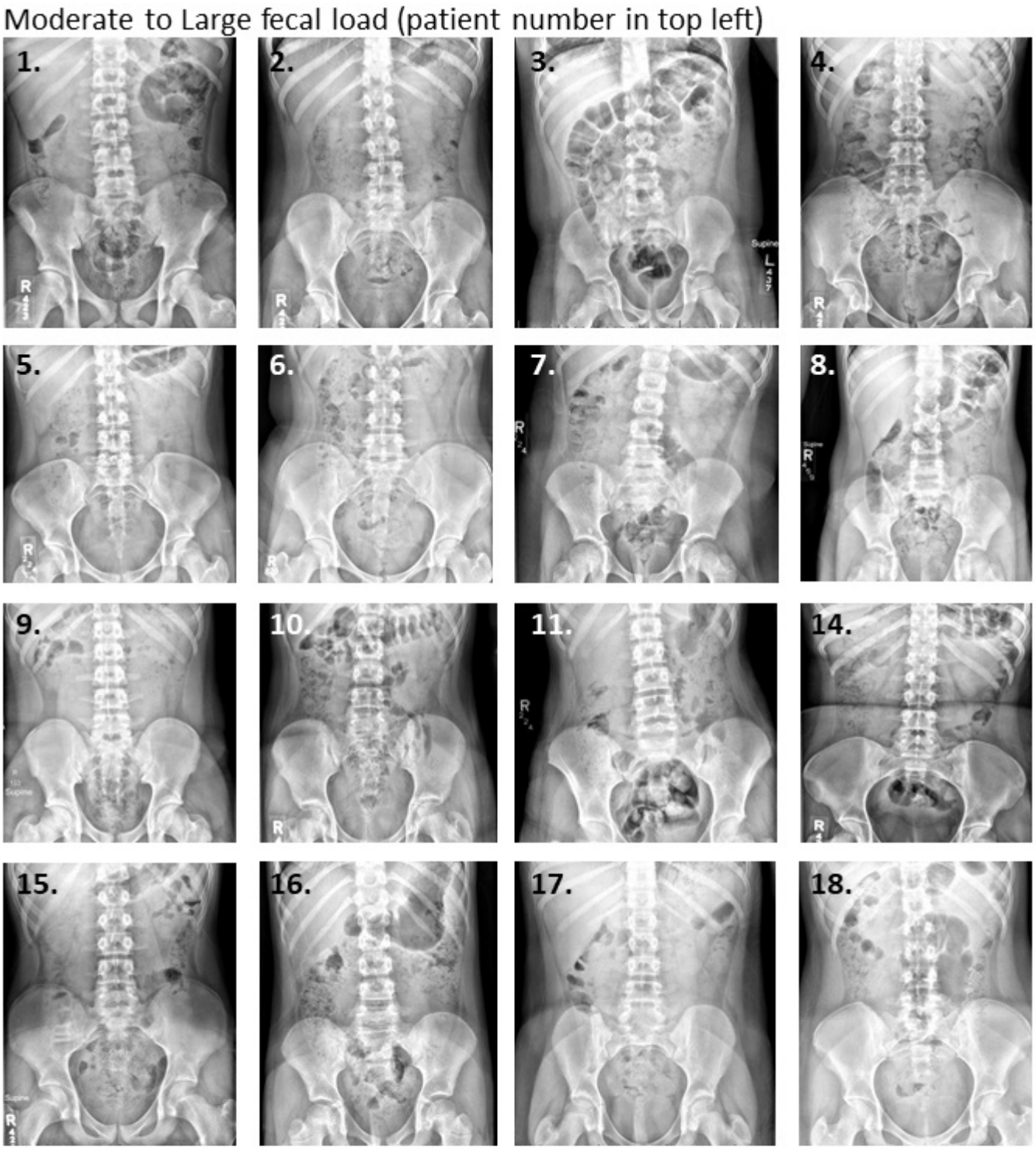
5. Are you aware that current guidelines do not recommend the use of abdominal x-ray in the workup for chronic or recurrent abdominal pain in children? (please do not modify your answer to the prior questions based on you response to this question)

a. Yes
b. No

Supplementary Table 1: Diagnostic testing done prior to initial consultation with study gastroenterologist and additional workup ordered at initial visit. Normal results unless noted

Patient	Prior workup	Additional workup at initial visit
1	Liver panel	CBC, liver panel, CRP
2	Urinalysis, STI testing, US pelvis, US appendix	No
3	No	Lipase, celiac panel, liver panel, H. pylori, stool O&P, stool calprotectin
4	Lipase, CRP, ESR, CMP, CBC, celiac panel, FOBT, stool O&P, stool calprotectin, CT, EGD & colonoscopy (2020)	No
5	H. pylori, RAST, US abdomen, US pelvis	No
6	No	No
7	Urinalysis, urine culture, CBC, BMP, liver panel, CRP, lipase	CBC, liver panel, lipase, celiac panel, H. pylori, stool calprotectin, stool O&P
8	US abdomen	CBC, TSH, celiac panel, H. pylori
9	No	No
10	No	No
11	CBC, CMP, CRP, ESR, celiac, H. pylori, stool culture, stool calprotectin, stool O&P, FOBT, US abdomen	No
12	CBC, CMP, celiac panel, urinalysis, stool culture, stool O&P, stool C. difficile, CT	CBC, BMP, TSH, celiac panel, stool calprotectin Went on to have EGD & colonoscopy
13	CBC, CMP, ESR, AXR (2020)	Lipase, celiac panel, H. pylori (*detected*), stool O&P, stool C. difficile, stool calprotectin
14	US abdomen (2020)	CBC, celiac panel, lipase, CRP, liver panel, H. pylori, stool O&P, stool calprotectin Went on to have EGD & colonoscopy
15	No	CBC, BMP, liver panel, CRP, TSH, celiac panel, stool calprotectin
16	Lipase, celiac panel, H. pylori, stool culture, stool O&P	No
17	CT	Monospot, liver panel
18	CBC, CMP, UA, US abdomen	UA, calprotectin, H. pylori (*detected*)
19	Calprotectin	No
20	No	H. pylori

BMP = basic metabolic panel; CBC = complete blood count; CMP = comprehensive metabolic panel; CRP = C reactive protein; CT = Computed tomography of abdomen; EGD = esophagogastroduodenoscopy; ESR = erythrocyte sedimentation rate; FOBT = fecal occult blood test; O&P = ova and parasites; RAST = radioallergosorbent test; STI = sexually transmitted infection; TSH = thyroid stimulating hormone; US = ultrasound



Supplementary Figure 1. Single-view, antero-posterior abdominal radiographs for the first 16 patients with moderate to large fecal load compared to those cases out of the 20 with recurrent abdominal pain who were interpreted with small to average stool burden