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Upper GI series in infants and children with vomiting: insights into ACR appropriateness criteria

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Abstract

Background: Although upper gastrointestinal series (UGI) series are frequently requested in pediatric radiology department, there are few articles investigating its value in children with vomiting. The purpose of this study was to review imaging findings perceived during UGI series in infants and children presented with vomiting in correlation to their symptoms based on the ACR appropriateness criteria. This was to identify clinical scenarios with higher diagnostic yield.

Results: A cross-sectional study including UGI series of 76 patients presented with vomiting (1 month–17 years) was performed. Patients were grouped according to their age into 5 groups and stratified according to the type of vomiting into 3 groups (bilious vomiting, new-onset nonbilious vomiting, intermittent nonbilious vomiting since birth). Associated symptoms were described with calculation of a novel clinical score. Radiological abnormalities in different age groups were described in relation to the type of vomiting. All patients with bilious vomiting or nonbilious vomiting associated with melena or dysphagia had abnormal findings. Gastroesophageal reflux was detected in 25% of cases. Patients with normal and abnormal study were compared according to their clinical score. The clinical score was significantly higher in the group of patients with abnormal findings ($p < .001$). Patients with recurrent chest symptoms and loss of weight had significantly higher rate of abnormal findings.

Conclusion: UGI series had a higher diagnostic yield in patients with bilious vomiting, children with nonbilious vomiting with higher clinical scores when associated with recurrent chest symptoms, loss of weight, dysphagia, or GIT bleeding especially melena.

Keywords: Hiatus hernia, Malrotation and volvulus, Dysphagia, Loss of weight, Gastroesophageal reflux, ACR appropriateness criteria

Background

Vomiting is relatively a common presenting symptom in infants and children. It is defined as forceful expulsion of gastric contents into the mouth or sometimes the nose. Vomiting can be bilious or nonbilious; non bilious vomiting is most commonly representing gastroesophageal reflux (GER). GER can be a benign condition in the

first 3 months of life that resolve with time; however, gastroesophageal reflux disease (GERD) includes troublesome symptoms or complications associated with reflux. Bilious vomiting is usually related to obstruction which mandates early surgical intervention [1].

Although diagnosis of GER and the cause of vomiting is based primarily on clinical suspicion, depending on symptom-based diagnostic approach to reach the cause of vomiting especially in young patients is not usually helpful. Scintigraphy and ultrasound were found to be non-invasive radiologic investigations for the diagnosis

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and grading of GER [2, 3]. Moreover, diagnostic interventions especially upper gastrointestinal (UGI) series are frequently requested in the pediatric radiology department not to document GER but to exclude underlying anatomical abnormalities [4].

Aiming for proper management, clinical practice guidelines (by the North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition and the European Society for Pediatric Gastroenterology, Hepatology, and Nutrition) have been developed for diagnosis and management of infants and children presenting with vomiting [4]. Moreover, American College of Radiology (ACR) developed appropriateness criteria for imaging specifically infants below 3 months of age. In these guidelines, different clinical scenarios have been described [5, 6]. However, to the extent of our knowledge, there are few papers in the literature that describe the imaging findings depicted by UGI series in pediatric patients with vomiting in correlation with those different clinical scenarios and other patients' symptoms [7, 8]. In addition, imaging features and clinical scenarios of children with vomiting, beyond infancy, were not previously investigated.

The aim of this study was to review different imaging findings perceived during upper GI series in infants and children presenting with vomiting in correlation to their symptoms and clinical events described by ACR Appropriateness Criteria (ACR AC) for vomiting to help reach informed decisions for requesting UGI series in children.

Methods

Study population

After internal review board and ethical committee approval, a cross-sectional study was conducted at the pediatric hospital radiology unit, starting from April 2018 till December 2018. All patients in the pediatric age group (below 18 years of age) presented to our unit complaining of vomiting, for whom UGI series was requested, were initially included in the study. Patients with history of corrosive ingestion or prior upper GI surgeries were excluded. Patients with uncompleted UGI studies were also excluded. In addition, patients with medical history that could explain their symptoms were excluded as well (e.g., patients with history of metabolic diseases, known syndromes). Informed oral consent including all procedure details was obtained from all parents or guardians before the procedure. Patients with abnormal study underwent follow-up by phone calls, operative details, abdominal ultrasound, or post-contrast CT to reach the final diagnosis if it was not obvious by the UGI series.

ACR AC with its new updates in 2020 described clinical scenarios for infants with vomiting. Infants were stratified according to three clinical scenarios: bilious

vomiting, intermittent nonbilious vomiting since birth, and new-onset nonbilious vomiting with special emphasis on neonates in the first 2 days of life [3, 4]. We categorized the clinical presentation of all patients (not only infants) according to those clinical scenarios. Moreover, a novel clinical score for each patient was calculated. One-point score was given for vomiting and each associated symptom: dysphagia, changes in bowel habits, hematemesis, melena (with documentation of the number of bleeding attacks), aspiration during feeding, recurrent attacks of lower respiratory tract infection, and loss of weight or failure to thrive.

Upper gastrointestinal series (UGI) technique

Pulse fluoroscopy with last screen capture at a rate 3–4 frames/sec is routinely done at our institution using digital X-ray television system (ZEXIRA DREX-BLF-15B; TOSHIBA Medical Co., Ltd. Tokyo, Japan). The procedure usually lasts for 15–20 min. A scout film is obtained (antero-posterior (AP) view starting from the nasopharynx down to the upper abdomen) to exclude any abnormality such as situs abnormalities, any calcifications, skeletal abnormalities, any devices, tubes, or abnormal bowel gas.

Imaging starts from the oropharynx till the duodenojejunal flexure using single-contrast technique, through administration of oral barium (diluted light barium) using a bottle or through a nasogastric tube if the patient is unable to drink. In case there is a risk of aspiration, water-soluble low-osmolar contrast was used. Once the patient begins drinking, an AP view of the esophagus is obtained, and then the patient was turned to the right lateral position to obtain a lateral view of the esophagus and oropharynx. When the contrast passes through the pylorus and begins to fill the first and second part of the duodenum, a lateral view showing the pylorus and posterior course of the duodenum is obtained. Then, the patient is quickly turned into the supine position to obtain an image of the contrast flowing into the duodenum and proximal jejunum to visualize the duodenojejunal flexure position. Finally, an AP image is obtained once the contrast has passed into the jejunum to document the jejunum and to show if there is GER. No specific maneuvers are performed to initiate reflux [9, 10].

Data analysis

The patients were grouped into five groups according to their age range: (A) neonates in the first month of life, (B) infants in the second and third months of life, (C) more than 3 months to 1 year, (D) more than 1 to 2 years, and (E) more than 2 years. The prevalence of the radiological findings in each group was calculated in correlation to their type of vomiting either bilious vomiting,

new-onset non bilious vomiting, or nonbilious vomiting since birth. Different age groups were compared regarding the prevalence of abnormal and normal findings

Images were analyzed searching for any radiological abnormality with emphasis on luminal distension, gastric emptying, and the site of the duodeno-jejunal flexure which is an important sign in the diagnosis of midgut malrotation.

The level of GER was documented if it was detected during the procedure, either up to the middle or upper third or not exceeding the lower third of the esophagus. Patients with idiopathic GER or GER associated with other anomalies were compared regarding the detected level of reflux.

The UGI series findings were categorized into normal and abnormal group according to the presence or absence of any radiological abnormalities, respectively. The two groups were compared according to their clinical scores by Mann-Whitney *U* test; also, they were compared according to the presence of different associated symptoms using the Fischer test with multiple variants regression analysis.

Results

Out of 81 patients presented to the radiology department for UGI series in the study period, five patients were excluded (two patients with Alport and Petz-Juger syndromes, another three with incomplete images). Finally, 76 patients were included. Their age ranged from 5 days to 17 years (median 12.6 months), 31 girls and 45 boys.

Table 1 demonstrates various radiological abnormalities in different age groups in relation to their presenting symptoms. A nearly statistically significant difference

was found between different age groups regarding the prevalence of normal and abnormal study results (χ^2 (4, $N = 76$) = 9.2, $p = < .056$). All neonates presented in our series (4 patients) had abnormal findings; one patient with malrotation (5 days of age); another one with duodenal atresia (complaint started at day 2 of life); and two patients with infantile hypertrophic pyloric stenosis (IHPS) at their 4 week of life. However, 71.4% of infants in the second and third months of life (group B) and only 45% of children in the first year of life (group C) had abnormal findings of which idiopathic GER was the most prevalent. Most of those patients were presenting with intermittent nonbilious vomiting dated since birth. On the contrary, children more than 2 years of age (group E) mostly presented with new-onset nonbilious vomiting with higher prevalence of normal findings (63%) (Fig. 1).

Gastroesophageal reflux was detected in 19 patients (25%). It was a sole finding in 11 patients (idiopathic GER); and associated with hiatus hernia in 7 patients; and gastric volvulus in one (Fig. 2). Idiopathic GER detection was more prevalent in group B and to lesser extent in group C patients and only detected in one patient that belonged to group D. Isolated idiopathic GER was not detected in patients more than 2 years of life (group E). The detected gastroesophageal reflux was reaching up to the level of upper esophagus in 12 patients, middle third of the esophagus in 5 patients, and not exceeding the lower third in only two patients. There was no significant relation of the level of detected reflux to whether it was idiopathic or associated with other radiological signs. Among patients with detected GER, eleven had dilated esophagus.

Table 1 Imaging findings in different age groups in different clinical scenarios

Type of vomiting	(A) Neonates in the first month of life ($n = 4$)	(B) Infants in the second and third months of life ($n = 14$)	(C) More than 3 months to 1 year ($n = 20$)	(D) More than 1 year to 2 years ($n = 11$)	(E) More than 2 years (number of patients) ($n = 27$)**
Bilious vomiting (9 patients)	Malrotation with gastric volvulus (1) Duodenal atresia (1)	Malrotation (2)	Malrotation (1)	0	Malrotation (2) Malrotation and gastric volvulus (1) Superior mesenteric artery syndrome (1)
New-onset nonbilious vomiting (36 patients)	IHPS (2)	Normal study (2) Idiopathic GER (1)	Normal study (4) Idiopathic GER (1)	Normal study (4) Pyloric obstruction (1)	Normal Study (17) Lymphoma (1) Hiatus hernia (2) Bochdalek with volvulus (1)
Intermittent nonbilious vomiting since birth (31 patients)	0	Idiopathic GER (4) Gastric volvulus (2) Vascular ring (1) Normal (2)	Normal (7) Idiopathic GER (3) Hiatus hernia (2) Gastric volvulus (1) Dilated esophagus (1)	Hiatus hernia one has volvulus (3) Gastric volvulus (1) Idiopathic GER (2)	Hiatus hernia (1) Peptic stricture (1)

**Only four patients were in the adolescence age (more than 12 years), three had normal study, and one with superior mesenteric artery syndrome syndrome
IHPS infantile hypertrophic pyloric stenosis, n number of patients

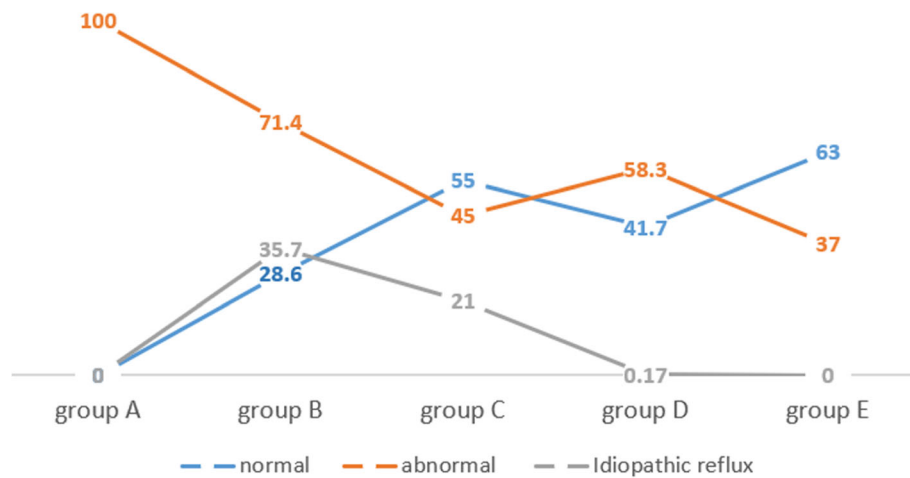


Fig. 1 Diagram illustrating the percentage of normal and abnormal study results in addition to the prevalence of detected idiopathic gastroesophageal reflux in different age groups

All patients presenting with bilious vomiting (nine patients) had serious findings necessitating surgical intervention as malrotation was present in seven patients, one patient with duodenal atresia (with double bubble sign on initial X-Ray), and another one with superior mesenteric artery syndrome confirmed later by post-contrast CT of the abdomen (Fig. 3).

Patients presented with new-onset nonbilious vomiting (36 patients) were found to have pyloric obstruction (two patients with IHPS and one patient with idiopathic acquired gastric outlet obstruction) (Fig. 4), idiopathic GER (two patients), hiatus hernia (two patients), and Bochdalek hernia (one patient) (Fig. 5). Relative narrowing of the esophageal lumen with small intestinal mucosal thickening was seen in another patient which proved to be related to lymphomatous infiltration, while normal study was found in 27 patients most of them more than 2 years of age (17 patients).

Patients with intermittent nonbilious vomiting dated since birth (31 patients) were found to have idiopathic

GER (9 patients), hiatus hernia (6 patients), isolated primary gastric volvulus (4 patients); vascular ring (one patient), esophageal dilatation only (one patient), peptic stricture (one patient) (Fig. 6), and normal study in 9 patients.

In addition to vomiting, loss of weight and recurring chest symptoms were the most common associated symptoms in 49 and 24 patients, respectively. History of abdominal pain and aspiration were present in 17 and 8 patients, respectively. Dysphagia was present in three patients found to have benign looking esophageal stricture (peptic stricture), mucosal thickening proved to be lymphomatous infiltration, and esophageal dilatation with no evidence of obstruction in the third one. Hematemesis was present in another two (one patient had solitary attack, and the other had two attacks). One patient experienced an attack of melena, and two patients had combined hematemesis and melena (one of them experienced the attacks once, and the other had frequently experienced melena with only two attacks of

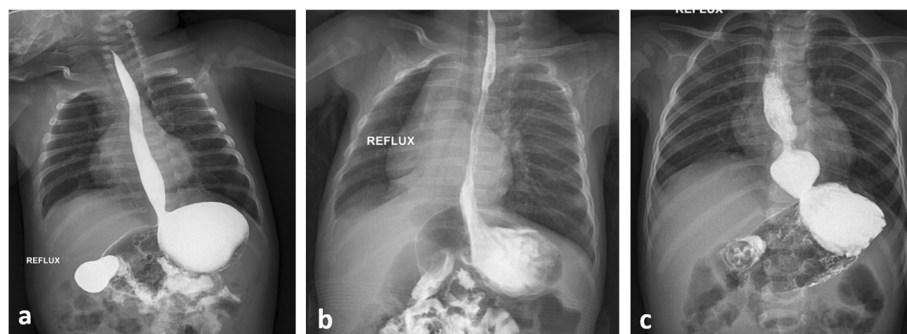


Fig. 2 Different patterns of gastroesophageal reflux **a**) idiopathic reflux reaching up to the level of upper esophagus; **b**) reflux associated with organoaxial gastric volvulus; **c**) reflux associated with sliding hiatus hernia

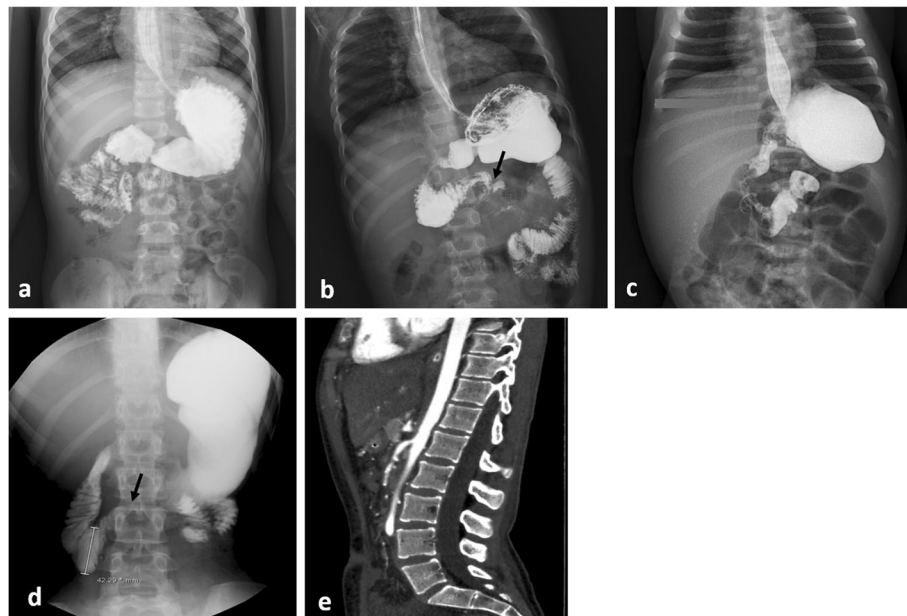


Fig. 3 Upper gastrointestinal series of four different patients presenting with bilious vomiting; the upper row shows three different patterns of malrotation **a**) the jejunum is seen in the right side of the abdomen; **b**) the duodenojejunal junction is seen at a lower level than the duodenal bulb with cork-screw appearance of the proximal jejunal loops (arrow); **c**) malrotation accompanied by organoaxial gastric volvulus. **d, e**) A case of superior mesenteric artery syndrome showing persistent filling defect at the third part of duodenum; sagittal CT angiography showing decreased aortomesenteric angle

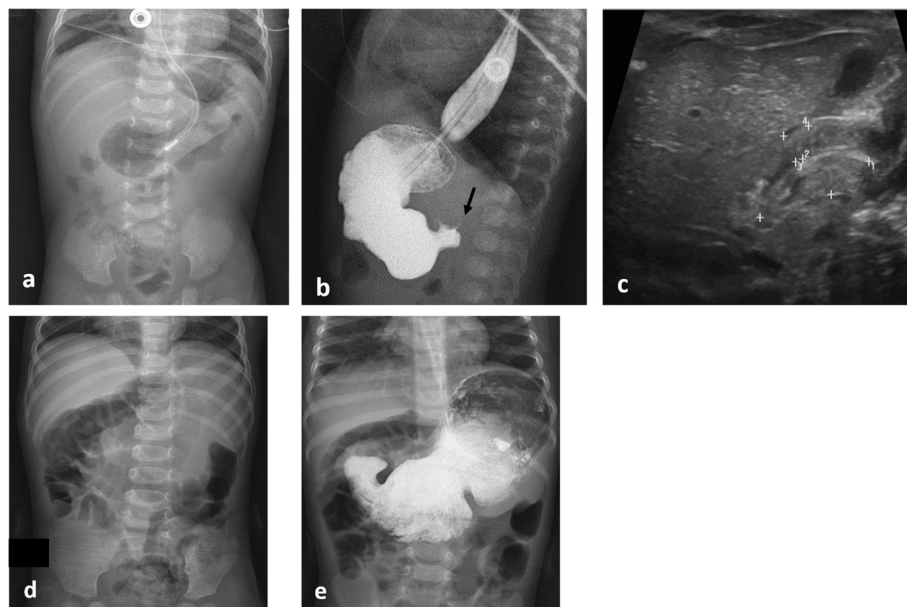


Fig. 4 Two different patients with gastric outlet obstruction. Upper row neonate with infantile hypertrophic stenosis; **a**) plain AP view shows air-filled stomach with wave-like contour (caterpillar sign) with paucity of abdominal gas distally; **b**) lateral view shows very narrowed pyloric canal (string sign, arrow) with delayed gastric emptying; **c**) ultrasound scan of the pylorus reveals elongated thickened pyloric canal, with length of 20 mm, transverse diameter of 11 mm and single wall thickness 4 mm. **d, e**) patient with idiopathic acquired gastric outlet obstruction; **d**) plain AP view shows dilated fluid filled stomach displacing the surrounding gas filled bowel loops; **e**) UGI series shows the dilated stomach with delayed gastric emptying

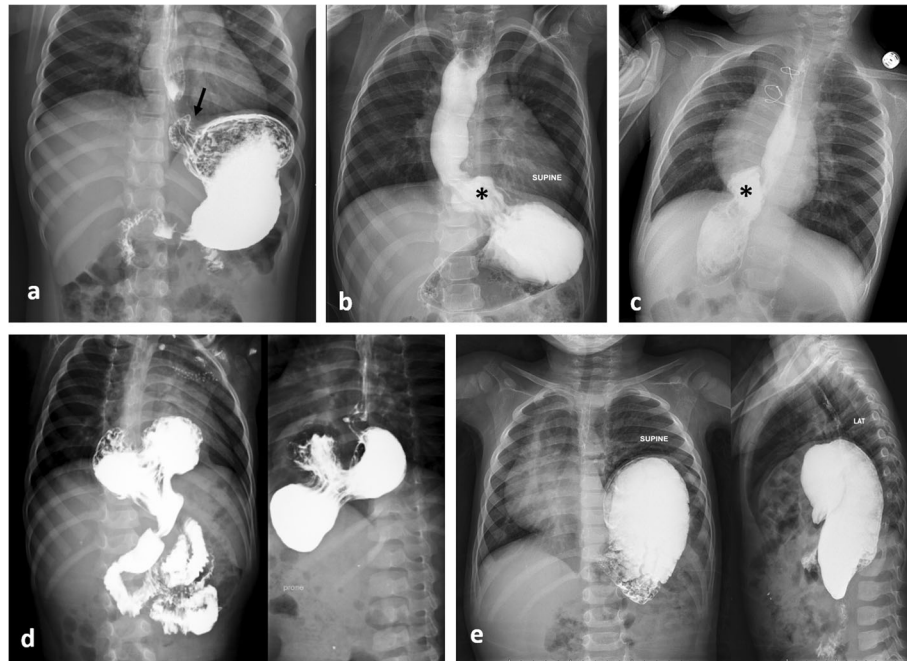


Fig. 5 Different patterns of diaphragmatic hernia **a**) small sliding hiatus hernia; **b**) relatively larger sliding hiatus hernia with dilated esophagus; **c**) mixed hiatus hernia in a patient with right isomerism underwent vascular surgery for complete common atrioventricular canal; **d**) AP and oblique views showing large hiatus hernia containing most of the stomach associated with volvulus; **e**) AP and lateral views showing left sided Bochdalek hernia containing the stomach and other bowel loops, mesentericoaxial volvulus is also noted

hematemesis). All our three patients with melena had positive study; hiatus hernia was diagnosed in two patients, one of them complained of combined hematemesis and melena and the other complained of melena only, while primary acquired gastric outlet obstruction was found in another patient complaining of hematemesis and melena. On the contrary, the two patients with hematemesis without associated melena was found to have normal study

The clinical score was significantly higher in the group of patients with abnormal findings on upper GI series ($p < .001$) with cut of value of 3 between both groups (95% CI 0.65–0.86) (Fig. 7). Patients with recurrent chest symptoms and loss of weight had significantly higher rate of abnormal findings on upper GI series ($p < .01$; $p < .001$, respectively) (Fig. 7). However, multiple regression analysis revealed significant results with loss of weight only ($p < .04$).

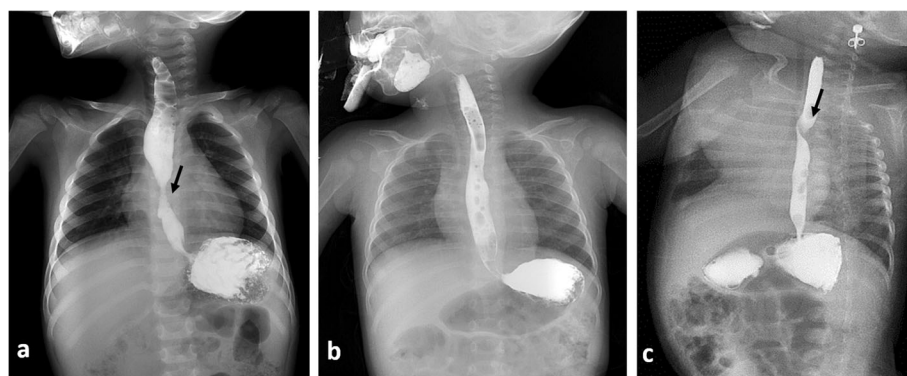
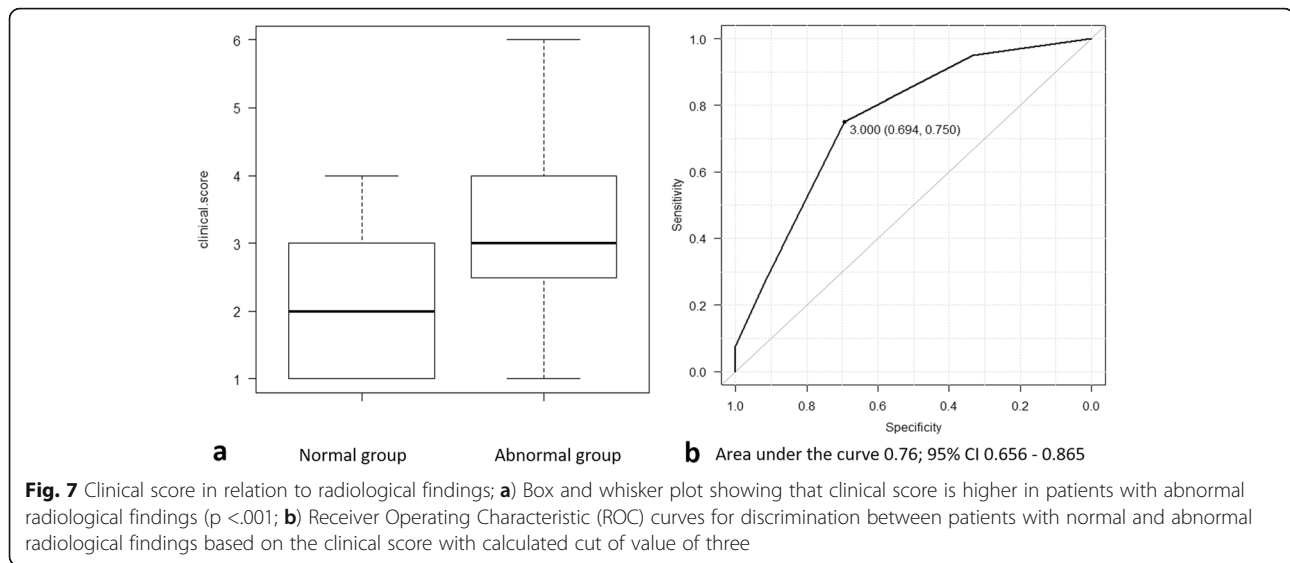


Fig. 6 Esophageal findings in four different patients **a**) peptic stricture in its typical location (arrow) in a patient with vomiting and dysphagia; **b**) mild relative dilatation of the esophagus in a patient with vomiting and dysphagia; **c**) aberrant right subclavian artery appears as posterior oblique impression (arrow) on the contrast filled esophagus (Bayonet sign) in a patient with vomiting with repeated chest infection



Discussion

Diagnostic workup for infants and children presenting with vomiting usually starts with a thorough clinical evaluation which can lead to the definite diagnosis in many instances [11]. Radiologic imaging is reserved for selected cases, for whom clinical practice guidelines along with ACR AC have been developed aiming for proper management [4–6]. Due to lack of original studies investigating the value of UGI series in children presenting with vomiting, our aim was to study the findings of UGI series and correlate them to patients' symptoms in order to help reach standardized good quality of care for those children. In addition, we expanded the age range covered by ACR AC to involve children up to 18 years of age adopting the same clinical scenarios. Moreover, in our design, we considered associated clinical symptoms other than vomiting by calculating a novel clinical score to study the diagnostic yield of UGI series in patients with multiple symptoms associating vomiting.

Idiopathic GER was detected in only 14% of cases, and normal study was found in 47 % of cases. This relatively low diagnostic yield of UGI series especially for the diagnosis of GER is in agreement with the previously published work [12, 13] and supports the expert opinion which suggested not to use barium contrast for the diagnosis of GER in infants and children [4], and extended pH probe is considered the diagnostic test of choice for diagnosis of GER [14]. UGI series is reserved for diagnosing anatomical abnormalities that should be addressed at time of surgery especially in cases with severe GERD who are planned for surgery [4]. On the other hand, Society of Abdominal Radiology recommended to perform barium esophagography as the initial test for GERD or in conjunction with other tests such as

endoscopy. This is because it is a widely available, non-invasive and inexpensive diagnostic tool; although gastroesophageal reflux could not be detected during the examination, other abnormalities that could be related to GER can be found as peptic strictures [15].

Three clinical scenarios had been described by ACR AC 2015: bilious vomiting, new-onset nonbilious vomiting, and intermittent nonbilious vomiting since birth. New updates of ACR AC 2020 added clinical variants involving infants in the first two days of life. In our study, applying clinical scenarios of ACR AC and the use of UGI series were found to be of value not only in patients in the first 3 months of life, but also in older patients. Older children more than 2 years of age mostly presented with new-onset non bilious vomiting. Although bilious vomiting and intermittent non bilious vomiting since birth were not frequently encountered in this age group, all patients presented with these clinical events had positive findings increasing the diagnostic yield of upper GI series when examining patients with these symptoms.

Bilious vomiting is an ominous sign that should be attributed to intestinal obstruction until proved otherwise [16]. An initial X-ray abdomen help determine further work up strategy. If signs of upper GI obstruction are found, UGI series is considered searching for midgut malrotation and volvulus. However, normal radiograph does not exclude malrotation [17, 18]. Although malrotation was found to be the commonest cause of bilious vomiting in our series, other causes were diagnosed namely duodenal atresia in one neonate and superior mesenteric artery syndrome in another patient more than 2 years of age. Other less common causes of bilious vomiting were reported including diaphragmatic hernia involving the stomach and in unusual cases of gastric volvulus [19].

New-onset nonbilious vomiting can be caused by GER or gastric outlet obstruction. In our series, IHPS was found to be the offending cause in the first month of life. Beyond the neonatal period up to 2 years of age, no abnormality was detected by UGI series in most of the cases, idiopathic GER was detected in only two cases, and primary acquired gastric outlet obstruction was diagnosed in another one. Similarly, most cases above the age of 2 years had normal study with few cases with hiatus and diaphragmatic hernia and another case diagnosed finally as lymphoma. IHPS can be diagnosed clinically when the hypertrophied pyloric muscle is palpated (olive sign). If there is clinical suspicion, further imaging is requested. Ultrasound is the modality of choice for diagnosing IHPS. However, UGI series can be appropriate as first study for infants with atypical presentation [20]. Primary acquired gastric outlet obstruction is another cause of gastric outlet obstruction. UGI series reveals dilated stomach with delayed gastric emptying, while endoscopy reveals normal stomach without intraluminal lesions, and it is not associated with pyloric muscle hypertrophy or extraluminal obstruction [21].

There are many causes of intermittent nonbilious vomiting since birth. In our series, idiopathic GER was found to be the most common finding followed by hiatus hernia and primary gastric volvulus. Idiopathic GER was detected in the first 2 years of life with no evidence of idiopathic GER in older patients. Less common findings included benign esophageal stricture which constitute sequel of reflux esophagitis. Similarly, GER was found to be the most common cause of intermittent nonbilious vomiting in a study of 145 infants by O'Keeffe et al [22, 23]. The frequency of GER is higher in young infants due to immaturity of the lower esophageal sphincter [3]. Vascular ring is another cause of intermittent nonbilious vomiting; it was found in only one case in our series.

Gastric volvulus is relatively rare cause of nonbilious vomiting in children. It could occur due to absence, failure of attachment, or elongation of gastric fixation (primary volvulus) or occurs secondary to associated abnormalities to the nearby organs as in cases of diaphragmatic hernia or eventration (secondary volvulus) [3]. In our series, gastric volvulus was detected in seven patients. It was primary in three, while secondary volvulus was seen in other four accompanying malrotation, diaphragmatic, and hiatus hernia. Primary gastric volvulus was noticed in infants below 2 years of age, while secondary volvulus was mainly found in children above the age of 2 years.

Based on expert opinion, a list of red flag signs has been developed to suggest causes other than GER for vomiting. These alarming signs necessitate further investigations [4]. Failure to thrive, dysphagia, hematemesis,

and rectal bleeding are among those symptoms. We have found that the more clinical score the more the prevalence of abnormal findings (especially with the presence of three or more symptoms).

Loss of weight or failure to thrive and to a lesser extent recurrent chest symptoms were found to be the most important indicators of positive study. Moreover, we found that presence of gastrointestinal tract bleeding was an important indicator of abnormal study regardless of the number of attacks; hiatus hernia and primary idiopathic gastric outlet obstruction were found to be the offending cause in those patients. Dysphagia was found to be associated with abnormal study results as well. Two patients with dysphagia had luminal narrowing either secondary to peptic stricture or associated with lymphomatous infiltration. The third patient had abnormally dilated esophagus which could be related to esophageal sensitivity to the refluxed acid or esophageal dysmotility that could result from reflux esophagitis [24].

This study was limited by relatively small number of patients per each group for each clinical scenario with lack of appropriate imaging guidance for children more than 2 years of age in different clinical situations. However, we expanded the clinical scenarios of ACR AC to investigate those patients as well. In addition, the cause of vomiting and the presence of GER could not be established in relation to a reference standard (pH monitoring) to test the diagnostic performance of UGI series in the diagnosis of GER. However, our study was among the few original research articles that express various radiological findings in different clinical scenarios for patients with vomiting in different stages of the pediatric age, taking into consideration other symptoms that could be associated with vomiting aiming for more standardization of patients' management.

Conclusion

In the work up of vomiting, UGI series were found to be of value in patients with bilious vomiting and patients with nonbilious vomiting when associated with loss of weight and recurrent chest symptoms. UGI series also could help reach the cause of vomiting when associated with dysphagia or GIT bleeding especially melena. UGI series were of low yield for diagnosis of GER. However, if GER was detected, this could spare the children the cost, sedation, and invasiveness of other diagnostic tests adopted for reflux. Expanding the ACR AC to involve all pediatric patients with vomiting (not only infants but also older children) taking into consideration other associated symptoms and clinical score could represent a further step for appropriate care for those patients. Further research on the value of UGI series and the adopted clinical score especially in older children is recommended for more validation of this scoring system.

Abbreviations

ACR: American College of Radiology; ACR AC: American College of Radiology Appropriateness Criteria; AP: Antero-posterior; GER: Gastroesophageal reflux; GERD: Gastroesophageal reflux disease; UGI: Upper gastrointestinal; IHPS: Infantile hypertrophic pyloric stenosis

Acknowledgments

We gratefully acknowledge Mrs. Hadeer Ahmed Gab Allah and Mr. Mohamed Gaber Ata (Pediatric Radiology technicians) for their contributions

Authors' contributions

All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by SAM and EAH. The first draft of the manuscript was written by SAM. The authors read and approved the final manuscript.

Funding

None

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request

Ethics approval and consent to participate

The study was performed after the ethical committee approval in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. The study was approved by the ethical committee of Faculty of Medicine, Ain-Shams University. Oral informed consent for participation was given by the patients' parent or legal guardian. As the study imposes no additional risk to the participants, the committee's reference number was exempted.

Consent for publication

Identifying information about participants (patients' identity) did not appear in any part of the manuscript; therefore, consent for publication was not required.

Competing interests

The authors declare that they have no conflict of interest.

Received: 8 June 2020 Accepted: 12 August 2020

Published online: 25 August 2020

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