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PEDIATRIC ABDOMINAL EMERGENCIES: WHAT CAN WE EXPLORE WITH ULTRASOUND!

Radiology

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ABSTRACT

Introduction: The etiologies of abdominal emergencies in children differ notably from that of adults. Fast and accurate diagnosis is imperative due to the need for instituting immediate and accurate treatment. Ultrasonography (US) is fast and accurate dynamic imaging modality, which involves no radiation exposure.

Methods: We retrospectively analyzed the US imaging features of 100 consecutive pediatric patients who were referred to our department with acute abdominal pain. The different etiologies, their presentations and their complications were analyzed.

Results: The average age of presentation was 8.2 + 1.7 years (4-12 years), with mesenteric volvulus and hypertrophic pyloric stenosis presenting in first year. The commonest etiology in our series was acute appendicitis (43%), with complications like perforation (34.8 %), peritonitis (4.6 %) and phelgmon formation (11.6%). Mesenteric adenitis was noted in 5% patients. Ileo-cecal wall thickening with mesenteric lymphadenopathy was noted in 19% patients, with 47.4% of these diagnosed with Salmonella ileo-cecitis and 52.6% diagnosed with abdominal tuberculosis. 17% presented with intussusception, with the commonest site being ileo-cecal [12(70.5%)] with one of these (8.3%) showing obstruction. 5% presented with mesenteric volvulus and HPS each. Other etiologies were urinary tract calculi and liver abscesses.

Conclusion: US can accurately diagnose the commonly encountered pediatric abdominal emergencies and their complications which can expedite the patient management and hence improve patient outcome.

KEYWORDS

Introduction:

Pediatric abdominal emergencies are routinely encountered in clinical practice, which require accurate diagnosis and prompt institution of appropriate treatment. The clinical presentation in most of the pathologies is overlapping, and hence imaging plays a pivotal role in identifying the exact etiology. US plays an important role in the initial evaluation of pediatric abdominal emergencies as it is easily available, fast, radiation free and dynamic modality. Hence, radiologists should know the common pathologies which present to the emergency department and the imaging features that clinch the diagnosis.

Methods and materials:

We retrospectively evaluated the records of 100 consecutive patients presenting to the pediatric emergency department of our hospital with acute abdomen and being referred to our department for an abdominal ultrasonography. The images of these patients were reviewed for the etiology, associated findings and complications.

All the ultrasound examinations were performed in our department using Toshiba Xario machines using convex (5MHz) and linear (7MHz) probes. The images were evaluated by two radiologists with more than 5 years of experience in interpreting ultrasound images.

Results:

We evaluated 100 consecutive pediatric patients, with 58 males (58%) and 42 females (42%). The average age of presentation of these patients was 8.2 + 1.7 years (4-12 years), except the patients who presented with mesenteric volvulus and HPS who presented in the first year. Mesenteric volvulus (5 patients) presented in first month after birth (mean age-14 days) and HPS (5 patients) presented with a mean age of 6 weeks.

The commonest etiology presenting with acute abdomen in our series was acute appendicitis, in 43 patients (43%). The complications of appendicitis noted in our series were perforation with abscess formation [15 patients (34.8%)], peritonitis [2 (4.6 %)] and phlegmon formation [5 (11.6%)]. Of the patients complicated with appendicular perforation, 9/13 (69.2%) showed appendicoliths, with a total of 17 (39.5%) patients showing appendicoliths. 5 (5%) patients presented with mesenteric adenitis. Ileo-cecal wall thickening with peri-cecal inflammatory changes and mesenteric lymphadenopathy was noted in 19 patients (19%) with 9/19 (52.6%) patients diagnosed with Salmonella ileo-cecitis. Two of these patients [2/9 (22.2%)] were complicated with perforation and consequent peritonitis. 10/19 (52.6%) of the patients with ileo-cecal thickening were diagnosed with abdominal tuberculosis, 4/10 presenting with intestinal obstruction (40%). None of these patients in our series presented with perforation. 17 patients (17%) presented with intussusception, with the commonest site being ileo-cecal intussusception [12 /17 (70.5%)]. Rest of the patients presented with jejuno-jejunal [3 (17.6 %)] or ileo-ileal intussusception [2 (11.8%)], with none of the patients showing colo-colic intussusception. 1/12 (8.3%) patients with ileo-cecal intussusception showed obstruction. Mesenteric volvulus was noted in 5 patients (5%) with average age of presentation being 2 weeks, three being males and two females. All patients presented with bilious vomiting and were diagnosed with intestinal malrotation, inverted SMA-SMV relationship and whirpool sign of mesenteric twist and obstruction at the level of duodenum. None of the patients in our study showed intestinal ischemia/ bowel perforation. 5 (5%) patients presented with HPS, all of them being males (100%) with the mean age being 6 weeks. None of the patients presented with any complications.

2 patients (2%) presented with urinary tract calculi, both of them being males. One of the patients had lower ureteric calculus with upstream obstruction and presented with complication of pyelonephritis. The other had renal calculus with no associated complications. 4 (4%) patients had liver abscesses and presented with right hypochondriac pain and fever. 3 of the patients were males and 1 being a female. One of these patients presented with rupture of the liver abscess with peri-hepatic collection, while other had no complications.

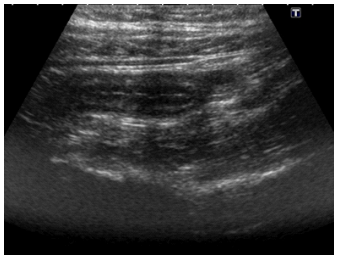


Figure 1: USG reveals dilated appendix with distinctly visible wall layers.

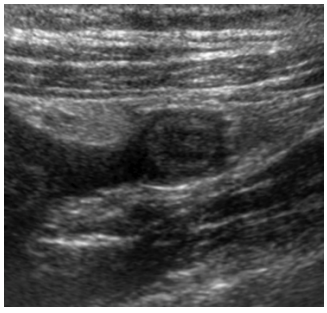


Figure 2: Transverse sonogram reveals 'target appearance' of appendicitis

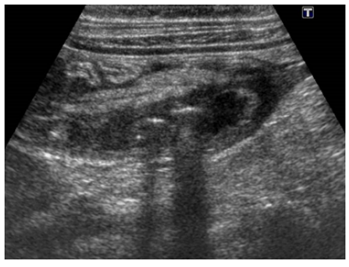


Figure 3: USG reveals dilated appendix with distended lumen showing appendicoliths (black arrow).

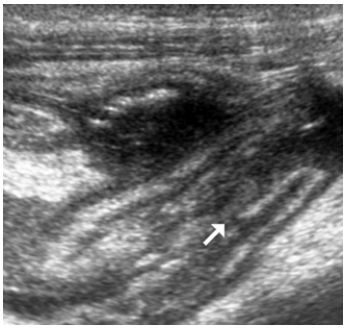


Figure 4: USG reveals features of appendicitis with a rent in the appendicular wall (white arrow) suggestive of perforation.

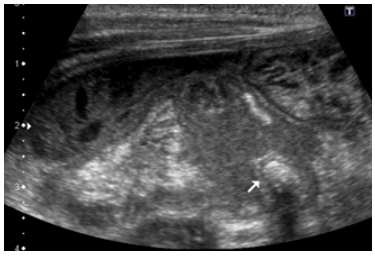


Figure 5: Transverse sonogram in a patient with appendicular perforation reveals an echogenic appendicolith (white arrow). Surrounding fluid with internal echoes is noted.

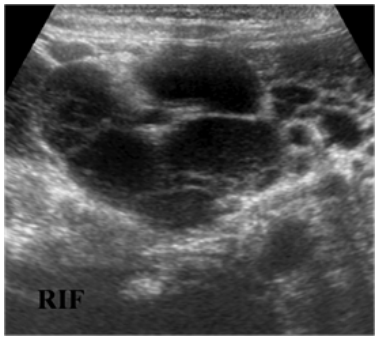


Figure 6: Right iliac fossa pain in a 3 year old child. USG reveals more than three mesenteric lymph nodes in the right lower quadrant satisfying the size criteria (> 10 mm in short axis), suggestive of mesenteric adenitis.

Figure 7: Right iliac fossa pain in a 5 year old child. Transverse sonogram of right iliac fossa reveals wall thickening of the distal ileum and caecum, suggestive of ileocecitis

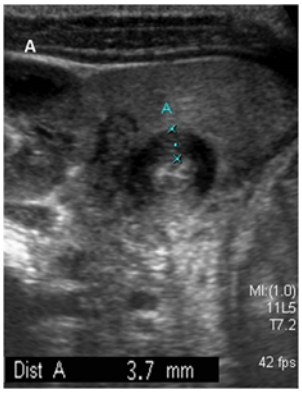
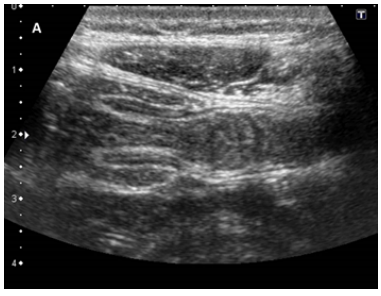


Figure 8 (A): A 6 week old child presenting with non-bilious vomiting. Transverse sonogram reveals 'target' appearance of the pylorus with thickened hypoechoic muscular layer, suggestive of HPS. (B): Longitudinal image in the same patient reveals elongated and thickened pylorus- 'the cervix sign'.



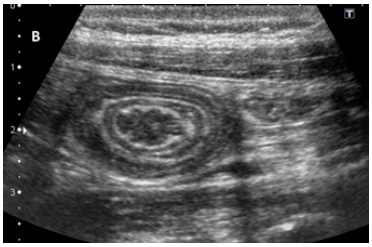


Figure 9: (A): Longitudinal US image of a 1 year old child with right iliac fossa pain, reveals telescoping of the intussusceptum into the intussuscipiens. (B) Transverse sonogram reveals 'target' or 'doughnut' appearance of intussusception.

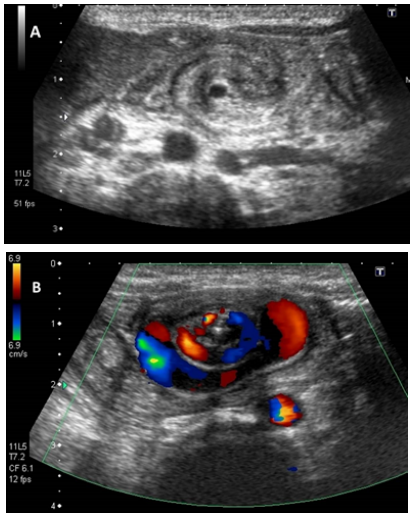


Figure 10: Bilious vomiting in a neonate. (A)Transverse grey-scale sonogram with (B) color Doppler reveals 'whirlpool' appearance (arrow) of midgut volvulus, where is the superior mesenteric vein swirling around the superior mesenteric artery.

Discussion:

1. Appendicitis:

Appendicitis is one of the commonest causes of acute pediatric abdominal surgical emergencies (1-4). The patient classically presents with Murphy's triad - pain, vomiting and fever. The pain generally originates in the periumbili¬cal region and then migrates to the right lower quadrant (RLQ) at McBurney's point over a period of 12–24 hours. Younger children may present with an atypical clinical picture; anorexia being a useful and constant feature (5,6). Delay in diagnosis can lead to serious complications like perforation, peritonitis, bowel obstruction, sepsis and even death. This mandates timely and accurate diagnosis of acute appendicitis.

US forms the initial investigation of choice for evaluation of appendicitis. Orr et al (1995) reported an overall sensitivity of 85% and specificity of 92% for US detection of appendicitis based on meta-analysis of pediatric and adult studies published between 1986 and 1994 (7). Doria et al. (8) also concluded that the pooled sensitivity and specificity for US alone in the diagnosis of appendicitis in children were 88% and 94% respectively.US evaluation of appendix is performed using a high-resolution linear-array transducer. The 'graded compression' technique (9) is utilized where gradual pressure is applied with the probe to dis¬place the bowel loops. Adequate compression is achieved when the iliac vessels and the psoas muscles are visualized. Many other operator dependent techniques may be combined with this for better visualization and evaluation of appendix (10), like upward graded compression technique, posterior manual compression, left oblique lateral decubitus position of the body and use of low frequency convex transducer.

The normal appendix appears as a blind ending, compressible, concentrically layered, mobile, tubular structure with a maximum diameter of less than 6 mm and no appreciable colour Doppler flow in its wall (11).

US features of appendicitis (4,6,11)-

- **Dilated appendix** (> 6 mm outer diameter) (Figure 1)
- **Noncompressible**
- **Distinct appendiceal wall layers with target appearance** (axial section) (Figure 2)-
- **Appendicolith (Figure 3)** - it is seen as a hyperechoic structure within appendix with intense posterior acoustic shadowing. It is significant, as the chances of perforation increase due to obstruction caused by an appendicolith (12).
- **Reactive mesenteric nodes may be seen**
- **Peri-appendiceal fat inflammation-** progressive inflammation spreads to the adjacent fat of meso-appendix
- **Peri-appendiceal fluid collection**
- **Hyperemia within the appen¬diceal wall on color Doppler images.**

If appendicitis is not detected and treated optimally, it can lead to various complications like:Perforation- it becomes difficult to detect perforated appendix, since it gets decompressed. The contour of appendix becomes irregular; sometimes a rent being identified (Figure 4). The layered structure of the appendix may be lost. Peri-appendiceal fat inflammation is evident in the right iliac fossa along with peri-appendiceal fluid with echoes within (Figure 5).

- 'Phlegmon' formation- Mesentery and omentum get adherent to the appendix in an attempt to wall-off the inflammation in the right iliac fossa, leading to the formation of an inflammatory mass in the right iliac fossa called the 'phlegmon'.
- Abscess formation- A localized right iliac fossa or pelvic abscess may develop
- Generalized peritonitis- It is suspected when generalized ileus with free intraperitoneal fluid and air is noted. Multiple intra-peritoneal abscesses may be also be seen.
- Portal pyemia- Portal vein thrombosis and consequent hematogenous spread leading to multiple hepatic abscesses is a rare but documented complication.

2. Mesenteric adenitis

'Mesenteric adenitis' implies inflammation of the mesenteric nodes. It is reported to be the second most common cause of right lower quadrant pain in pediatric patients after appendicitis . The clinical presentation closely mimics that of appendicitis (13,14). However, it is a self-limiting condition that does not require surgery. Mesenteric adenitis can be divided into - primary and secondary types. Traditionally, primary mesenteric adenitis is defined as three or more mesenteric lymph nodes in the right lower quadrant with short axis diameter of at least 5 mm; without an identifiable acute inflammatory process or with only mild (<5 mm) wall thickening of the terminal ileum (Figure 6) (13). Secondary mesenteric adenitis is defined as lymphadenopathy associated with a detectable intra-abdominal inflammatory process (13). Simanovsky et al.(15) however found that using more than 5 mm short axis diameter to define enlarged nodes classifies many asymptomatic individuals into the group of 'mesenteric adenitis'. So they recommended that enlarged abdominal nodes of 10 mm or more in their short axis, in the clinical scenario of abdominal pain may be termed as 'mesenteric lymphadenitis'

3. Ileo-cecal infection:

Ileitis-ileocecitis (Figure 7) can mimic appendicitis and present as acute abdomen. It can be of infectious (Salmonella, Yersinia or Campylobacter species) or inflam¬matory (eg, Crohn disease) origin (16). A thickened terminal ileum may be the only finding at US. Peristalsis is not entirely absent in the inflamed loop, which helps differentiate it from an inflamed appendix, when a blind end is not visualized.

Abdominal tuberculosis commonly affects the ileo-cecal region which is postulated to be due to factors like stasis, presence of abundant lymphoid tissue, increased rate of absorption at this site and closer contact of the bacilli with the mucosa (17-21) . The most common pattern of bowel involvement is focal or segmental regular, symmetric wall thickening.

4. Hypertrophic Pyloric Stenosis (HPS):

HPS is a common developmental GI anomaly with male predominance and a higher incidence in first-born males. Majority of the cases present between 2nd and 6th week of life with non-bilious vomiting. An 'olive' mass is usually palpated in the epigastrium with few cases showing visible antral peristaltic waves. The underlying pathology is hypertrophy of the pyloric circular muscle with redundant pyloric mucosa. This leads to gastric outlet obstruction, dehy¬dration, electrolyte imbalances, weight loss and failure to thrive in severe cases.

US is the initial modality of choice for evaluating an infant with suspected HPS. HPS classically reveals elongated and thickened pyloric canal. Qualitative and quantitative assessment of the pyloric canal is essential to confirm the diagnosis. Qualitatively, transverse section reveals central echogenic mucosa and submucosa surrounded by the hypoechoic muscle layer, which is termed as 'target' or 'doughnut' appearance (Figure 8 A). On longitudinal images, the thickened hypoechoic muscle bundles have been likened to the uterine cervix and hence their appear¬ance has been termed the "cervix" sign (Figure 8 B). The redundant central mucosa is seen evaginating into the antrum which is termed as 'nipple sign' (22,23).

Quantitatively, a muscle width measurement of > 3.5 mm (Figure 8 A) and a pyloric length of > 16 mm in a term infant are usually taken as diagnostic of HPS (11).

HPS has to be differentiated from pyloric spasm, which is transient and generally resolves in about 30 minutes (24).

5. Intussusception

'Intussusception' implies telescoping of one bowel segment into the other. The portion of the bowel prolapsing into the other is called the 'intussusceptum' and the one that receives it is called the 'intussuscipiens'. The classic clinical triad consists of acute colicky abdominal pain, "red currant jelly" stools, and either a palpable abdomi¬nal mass or vomiting. However, very few patients actually have this classical presentation. Hence, imaging modalities play an important role in timely diagnosis, and prevent significant sequelae including bowel necrosis.

US is a highly accurate test for intussusception and is the currently the imaging modality of choice (25-27). US reveals alternating concentric hypoechoic and hyperechoic layers of an intussus¬ception which is usually re¬ferred to as the "target" or "donut" sign (Figure 9). Majority of the hypoechoic external ring is formed by the everted returning limb of intussusceptum with some contribution from the intussuscipiens. The doughnut's center varies according to the scan level. Scans obtained at the middle or at the base of the intussusception shows a hyperechoic crescent which is formed by the mesentery enclosing the entering limb of the intussusceptum. This is called the "crescent- n-doughnut sign." The scans obtained at the apex of the intussusceptions show a hypoechoic centre owing to the entering limb of the intussusceptum and the absence of the mesentery. Longitudinal images when obtained, confirm a bowel-within-bowel appearance. If the intus¬susception is imaged obliquely, "pseudokidney" sign is seen (25-27).

US may contribute to depict the lead point of intussusceptions, if any. Most of the intussusceptions are idiopathic in childhood, with the primary abnormality being hypertrophied lymphoid tissue. Few patients have an underlying mass (eg, Meckel diverticulum, duplication cyst, polyp, or tumor) that serves as a lead point for the intussuscep¬tion. A lead point may lead to recurrent intussusception.

6. Midgut volvulus:

Midgut volvulus is a complication of malrotated bowel which involves torsion of entire gut around its mesentery due to a short mesenteric attachment or 'malfixation'. This leads to extrinsic compression of the bowel and consequent bowel obstruction. Progression causes venous obstruction due to wrapping of the superior mesenteric vein around the superior mesenteric artery. Gradual onset of ischemia consequently leads to bowel necrosis. Abdominal distention and tenderness ensues with eventual peritonitis and shock. In these patients with 'malfixation', further obstruction is caused by 'Ladds bands'; which are aberrant peritoneal bands attaching from the malpositioned caecum to the liver hilum, posterior peritoneum or abdominal wall. Clinically, the neonate is normal until it suddenly presents with bilious vomiting. It can also present in older children with intermittent pain, nausea, vomiting and failure to thrive.

Ultrasound can be utilized to detect malrotation and bowel obstruction due to volvulus. Ultrasound shows distended proximal duodenum with tapering in front of the spine. Ischemia in volvulus may lead to edematous bowel which is generally seen to the right of the midline along with free peritoneal fluid. On colour Doppler, USG classically shows the 'whirlpool sign' which refers to the clockwise spiraling of mesentery and SMV around the SMA (Figure 10, Video 1). It reveals side-by-side arrangement of vessels with opposing flow, which indicates that the whirlpool contains not only the SMV and its tributaries but also branches of the SMA.USG may also demonstrate inverted SMA/SMV relationship (28,29).

Conclusion:

Ultrasound forms the initial investigation of choice to image pediatric abdominal emergencies. Hence, every radiologist should be well aware of the imaging features of the commonly encountered pathologies that can be accurately diagnosed with US. This would not only help in instituting appropriate timely management, but also aid in avoiding unnecessary investigations.

References

1. Janik JS, Firor HV. Pediatric appendicitis: a 20-year study of 1,640 children at Cook County (Illinois) Hospital. Arch Surg 1979; 114:717–719.
2. Lund DP, Folkman J. Appendicitis. In: Walker WA, Durie PR, Hamilton JR, Walker-Smith JA,Watkins JB, eds. Pediatric gastrointestinal disease: pathophysiology, diagnosis and management. 2nded. St Louis, Mo: Mosby, 1996; 907–915.
3. Krishnamoorthi R, Ramarajan N, Wang NE, et al. Effectiveness of a staged US and CT protocol for the diagnosis of pediatric appendicitis: reducing radiation exposure in the age of ALARA. Radiology 2011;259(1):231–239.
4. Sivit CJ, Siegel MJ, Applegate KE, Newman KD. When appendicitis is suspected in children. RadioGraphics 2001;21(1):247–262.
5. Birnbaum BA, Wilson SR. Appendicitis at the millennium. Radiology 2000; 215 (2):337–348.
6. Cogley JR, O'Connor SC, Houshyar R, Al Dulaimy K. Emergent pediatric US: What every radiologist should know. Radiographics 2012;32: 651-665.
7. Orr RK, Porter D, Hartman D. Ultrasonography to evaluate adults for appendicitis: decision making based on meta-analysis and probablistic reasoning. Acad Emerg Med 1995; 2:644–650.
8. Doria AS, Moineddin R, Kellenberger CJ, et al. US or CT for diagnosis of appendicitis in children and adults? a meta-analysis. Radiology 2006; 241(1): 83–94.
9. Puylaert JB. Acute appendicitis: US evaluation using graded compression. Radiology 1986; 158:355-360.
10. Lee JH, Jeong YK, Hwang JC, Ham SY, Yang SO. Graded compression sonography with adjuvant use of a posterior manual compression technique in the sonographic diagnosis of acute appendicitis. AJR 2002; 178:863 –868
11. David Sutton. Textbook of Radiology and Imaging. Churchill Livingstone, 2003
12. Alaedeen DI, Cook M, Chwals WJ. Appendiceal fecolith is associated with early perforation in pediatric patients. J Pediatr Surg 2008; 43(5):889–892.
13. Macari M, Hines J, Balthazar E et-al. Mesenteric adenitis: CT diagnosis of primary versus secondary causes, incidence, and clinical significance in pediatric and adult patients. AJR Am J Roentgenol. 2002;178 (4): 853-8
14. van Breda Vriesman AC, Puylaert JB. Mimics of appendicitis: alternative nonsurgical diagnoses with sonography and CT. AJR Am J Roentgenol 2006;186 (4):1103–1112.
15. Simanovsky N, Hiller N. Importance of sonographic detection of enlarged abdominal lymph nodes in children. J Ultrasound Med. 2007; 26 (5): 581-4.
16. Puylaert JB, Van der Zant FM, Mutsaers JA. Infectious ileocecitis caused by Yersinia, Campylobacter, and Salmonella: clinical, radiological and US findings. Eur Radiol 1997;7(1):3–9
17. Lundstedt C, Myman R, Brismar J, Hugosson C, Kagevi I. (1996) Imaging of tuberculosis II. Abdominal manifestations in 112 patients. Acta Radiol.;37.
18. Balthazar EJ, Gordon R, Hulnick D. (1990) Ileocecal tuberculosis: CT and radiologic evaluation. AJR Am J Roentgenol.;154. doi:10.2214/ajr.154.3.2106212.
19. Underwood MJ, Thompson MM, Sayers RD, Hall AW. (1992) Presentation of abdominal tuberculosis to general surgeons. Br J Surg.;79. doi: 10.1002/ bjs. 1800791030.
20. Aston NO, de Costa AM. (1990) Abdominal tuberculosis. Br J Clin Pr.;44.
21. Horvath KD, Whelan RL. (1998) Intestinal tuberculosis: return of an old disease. Am J Gastroenterol.;93(5):692-696.
22. Reed AA, Michael K. Hypertrophic pyloric stenosis. J Diagn Med Sonography 2010; 26(3):157–160.
23. Blumhagen JD, Maclin L, Krauter D et-al. Sonographic diagnosis of hypertrophic pyloric stenosis. AJR Am J Roentgenol. 1988;150 (6): 1367-70
24. Cohen HL, Zinn HL, Haller JO, Homel PJ, Stoane JM. Ultrasonography of Pylorospasm: Findings May Simulate Hypertrophic Pyloric Stenosis. J Ultrasound Med 1998; 17(11):705-11.
25. Hryhorczuk AL, Strouse PJ. Validation of US as a first-line diagnostic test for assessment of pediatric ileocolic intussusception. Pediatr Radiol 2009;39 (10): 1075 –1079.
26. del-Pozo G, Albillos JC, Tejedor D, et al. Intussusception in children: current concepts in diagnosis and enema reduction. RadioGraphics 1999;19(2): 299–319.
27. John SD. The value of ultrasound in children with suspected intussusception. Emerg Radiol 1998;5(5): 297–305
28. Epelman M. The whirlpool sign. Radiology. 2006;240 (3): 910-1.
29. Berdon WE. Midgut volvulus with "whirlpool" signs. AJR Am J Roentgenol. 1999;172 (6): 1689-90.