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ROLE OF ABDOMINAL ULTRASOUND IMAGING IN EVALUATION OF CHILDREN WITH SUSPECTED UPPER GASTROINTESTINAL DISEASE
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ROLE OF ABDOMINAL ULTRASOUND IN EVALUATION OF CHILDREN WITH SUSPECTED UPPER GASTROINTESTINAL DISEASE

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ABSTRACT

Objectives: **To evaluate the sonographic abdominal findings in children with suspected upper gastrointestinal disease, establish indications for sonography and describe the gastrointestinal disease patterns that can be evaluated by ultrasound.**
***Design*: Descriptive prospective study.**
***Setting*: Kenyatta National Hospital and Department of Diagnostic Imaging and Radiation Medicine, University of Nairobi.**
***Subjects*: Fifty-six children who presented with vomiting and suspected upper gastrointestinal disease. Age range was from six days to 12 years with mean age of one year five months. Seventy seven percent were two years and below.**
***Results*: Of the 56 children, six were normal on sonography; 18 (32.1%) had intussusception, 16 (28.6%) gastroesophageal reflux, seven (12.5%) pyloric stenosis, four appendicitis, three jejunal/ileal atresia and two enteric duplication cysts. All the children with pyloric stenosis were male. The male: female ratio for intussusception and GER was 1.5:1 and 1.6:1 respectively. The most common clinical presentation in children found to have intussusception was palpable abdominal mass, and few of them presented with bloodstained stool. More than two thirds of the children with gastro-oesophageal reflux presented with complications of recurrent pneumonia and failure to thrive. The sonographic findings correlated with fluoroscopy for GER except in two children where sonography was found to be more sensitive. The sonographic findings correlated with surgical outcome for pyloric stenosis, intussusception, jejunal/ileal atresia and enteric duplication cysts.**
***Conclusion*: Trans-abdominal sonography has a definite role in investigating the child suspected to have upper gastrointestinal disease and should be considered as the initial imaging modality, instead of fluoroscopy, thereby avoiding or limiting the use of ionising radiation. Findings in this study confirm that ultrasound is an accurate, reliable and rapid screening method to evaluate the causes of upper gastrointestinal disease in children.**

INTRODUCTION

Ultrasound (US) examination in the field of Medicine was introduced in the early 1950's and since then has rapidly developed to have a premier role in the diagnosis, intervention, follow-up and evaluation of disease management. In a child with suspected upper gastrointestinal disease, most clinicians request for an upper gastrointestinal contrast study, which exposes the growing child to ionising radiation increasing the risk for neoplasia. It is for this reason that ultrasound is the preferred imaging modality of choice in paediatrics.

In the evaluation of the gastrointestinal tract, bowel gas reduces the usefulness of sonography. However, modern scanning techniques with high-resolution real time scanners, graded compression and colour Doppler have been found to enable effective evaluation (1). It is now possible to examine the bowel with trans-abdominal and trans-perineal US from the

gastroesophageal junction to the rectum (2). Most children with suspected upper gastrointestinal disease present with vomiting. The Expert Panel on Paediatric Imaging in its latest review 2011, listed the common causes of vomiting in infancy as gastroesophageal reflux (GER), hypertrophic pyloric stenosis (HPS), pylorospasm, necrotising enterocolitis (NEC) and bowel malrotation with midgut volvulus (3). All these conditions can be evaluated by ultrasound which has been shown to be 100% sensitive and 87.5% specific in the diagnosis of GER (4,5). Several studies have proven the reliability of US in the diagnosis of HPS. The typically thickened pyloric muscle measures > 4mm (5, 6). In intussusception, multicentric bowel loops or doughnut signs are demonstrated in 85% of patients (7). In malrotation with volvulus, there is reversal of the superior mesenteric vessel relationship with a whirlpool appearance of the proximal bowel around the superior mesentery end vessels. These sonographic features are however not always diagnostic and additional features of bowel dilatation, hyperdynamic and/or truncated appearance of the superior mesenteric artery have been found to be contributory to the sonographic diagnosis of malrotation with volvulus (8).

Other conditions that can be evaluated include appendicitis with sensitivity 98.7% and specificity 95.4% especially as children have minimal adipose tissue (9). The differential diagnoses of the ileocecal region, which includes abdominal adenitis and terminal ileitis, can be demonstrated with a sensitivity of 94.7% and a specificity of 92-100% respectively (10). The study further reported that lymph nodes measuring ≥4mm in AP diameter and / or thickening of the terminal ileum of > 8mm in symptomatic children were significant findings (10).

Colour Doppler has revolutionised detection of NEC in premature infants where the detection of necrotic or dead bowel directly impacts on the infant's chance of survival. Studies have shown that Colour Doppler was more sensitive and specific in determining NEC in neonates than plain radiography (11). Other conditions include acute and chronic pancreatitis and enteric duplication cysts (12, 13).

Locally, the clinical and diagnostic workup of children with vomiting with suspected upper gastrointestinal disease does not include ultrasound as an initial imaging modality. The aim of this study was to evaluate if the findings in literature on the use of ultrasound in evaluating children who present with vomiting and suspected upper gastrointestinal disease could be replicated in our population and thereby give appropriate recommendations.

MATERIALS AND METHODS

All children who were referred for an upper GIT study and with a history of persistent vomiting were recruited into the study, following permission from the KNH ethics committee. Informed consent was obtained from the parents/ guardians. The study period was six months from October 2008 to March 2009. Sonography was performed using high-resolution real-time scanners at the ultrasound units of KNH and department of Diagnostic Imaging and Radiation Medicine, University of Nairobi, which serve the same patient population. Equipment used included GE ultrasound Logiq Q7, GE ultrasound Logiq 5 Expert, HP image point HX and Philips SD800. Both curved and linear transducers were used with frequency ranges of 3.5 to 12 MHz. No preparation was required except in children suspected to have GER. In these children, the study was done following breastfeeding.

All the abdominal quadrants were evaluated initially with the 3.5-5 MHz curvilinear scanner followed by the linear probe (6-12 MHz) using pre-warmed acoustic coupling gel. Graded compression was used to displace bowel gas. Observation for reflux at the gastroesophageal junction for at least 10 to 15 minutes as well as peristalsis and fluid movement at the pylorus was performed. The superior mesenteric vein and artery (SMV/SMA) relationship was established to evaluate for malrotation.

Areas of tenderness elicited during the examination were further evaluated with Doppler to detect for vascularity and inflammation. The total average examination for each child were 15 to 20 minutes. Upper GIT studies, surgical and histological outcome was obtained for correlation as required. Data collection sheets were used to record personal, clinical, sonographic and diagnostic findings. The obtained data were analysed using SSPS and p-value of ≤0.05 was considered significant.

RESULTS

Fifty six children were evaluated. Age range was six days to twelve years. Mean age was one year five months. 64.3 % of the children were male. The age group presentation was 8.9% neonates (≤1 month), 71.4 % infants (>1month-24 months) and 19.7 % children (>24 months) (Table 1).

All the children had vomiting as a clinical presentation. Other modes of presentation included abdominal pain (21), failure to thrive (19), abdominal mass (18), recurrent pneumonia (13), abdominal distension (7), bloody stool (3), failure to pass stool (3) and diarrhoea (1) (Table 2).

The sonographic findings were as follows: 18 (32.1%) had intussusception, 16 (28.6%) gastroesophageal reflux, seven (12.5%) pyloric stenosis, four appendicitis, three jejunal/ileal atresia and two enteric duplication cysts (Table 3). There were normal findings in six children (10.7%). Due to the unavailability of portable US units, neonates in the newborn unit suspected to have NEC could not be interrogated. The male to female ration was 1.5:1

in intussusception and 1.6:1 in GER. All the children with pyloric stenosis were male (Table 3).

Children with intussusception presented with palpable abdominal mass, vomiting and abdominal pain (Table 4). The mean age of presentation was six point three months with peak incidence at three to eight months.

In GER, the main presentation was vomiting, regurgitation, failure to thrive and history of recurrent pneumonia. The mean age was ten months. Most of these children were premature at birth. Pyloric stenosis was seen in persistent projectile non-bilious vomiting, weight loss and dehydration (Table 4). Acute appendicitis was presented by non-specific symptoms of nausea, vomiting, abdominal pain and right iliac fossa (RIF) pain. It was seen in the older children with mean age of 10.8 years. The infants with failure to pass stool and abdominal distension were found to have ileal atresia.

There was no statistical significance between patient age and pathology or between sex of patient and pathology except for hypertrophic pyloric stenosis.

The six children with normal findings had presented with bloody stool and vomiting. They were re-evaluated by the clinician, started on the appropriate management for acute gastroenteritis with dysentery, and improved clinically.

Surgery in the 18 children with intussusception confirmed the diagnosis, which was ileocecal in 12 and ileoileal in six (Table 5). For the children with GER on sonography, the upper GIT study demonstrated 14 with reflux and two were negative showing that US was the more sensitive study (Table 6). All the seven children with HPS demonstrated on US, were also confirmed on surgery and pyloroplasty done (Table 7). For the four children with acute appendicitis, three were confirmed on both surgery and histology while one was negative on histology (Table 8). Surgery confirmed the duplication cysts and the cysts were excised (Table 9).

Table1

Distribution by Age and Sex (in Months) n = 56

Age in months	Sex		
	Male	Female	Total
	n (%)	n (%)	n (%)
< 1	2 (3.6)	3 (5.3)	5 (8.9)
1 – 6	17 (30.3)	10 (17.9)	40 (71.4)
7 – 12	7 (12.5)	6 (10.7)	
13 – 18	1 (1.8)	0	
19 - 23	2 (3.6)	0	
≥ 24	7 (12.5)	1 (1.8)	11(19.6)

The mean age was 17.5 months, median of six month; STD was 36.0, with a range of 0.2 to 144 months. .

Table 2

Clinical presentation

Clinical Presentation	Count	Per Cent
Vomiting	56	100.0
Abdominal Pain	21	37.5
Failure to thrive	19	33.9
Abdominal Mass	18	32.1
Recurrent pneumonia	13	23.2
Abdominal distension	7	12.5
Other	7	12.5
Regurgitation	4	7.1

Other included diarrhoea 1, failure to pass stool 3, bloody stool 3.

Table 3
Sonographic findings and sex frequency

Finding	Sex			
	Male n (%)	Female n (%)	Total n (%)	P-value
Normal	3 (8.3)	3 (15.0)	6 (10.7)	0.440
Intussusception	11 (30.6)	7 (5.0)	18 (32.1)	0.733
GER	10 (27.8)	6 (3.0)	16 (28.6)	0.860
HPS	7 (19.4)	0	7 (12.7)	0.035
Acute Appendicitis	3 (8.3)	1 (5.0)	4 (7.1)	0.643
Jejunal/Ileal atresia	1 (2.8)	2 (10.0)	3 (5.4)	0.250
Enteric duplication cyst	1 (2.8)	1 (5.0)	2 (3.6)	0.668

There was no significant association between the sex of the patient and the pathology expect for hypertrophic pyloric stenosis ($p < 0.05$).

Table 4
Clinical presentation and sonographic findings

	Sonographic Findings						
Clinical Indication	Normal	Gastrooesophageal Reflux Disease (GERD)	Intussusception	Hypertrophic Pyloric Stenosis (HPS)	Acute Appendicitis	Jejunal/Ileal atresia	Enteric duplication cyst
Vomiting	6	16	18	7	4	3	2
Abdominal Pain	1	0	16	0	4	0	0
Failure to thrive	1	13	0	6	0	0	0
Abdominal Mass	0	0	15	1	0	0	2
Recurrent Pneumonia	0	12	0	0	0	0	0
Abdominal distension	2	0	1	1	0	3	0
Regurgitation	1	3	0	0	0	0	0

Table 5
Ultrasound finding and surgical outcome in intussusception

Ultrasound finding	Surgical outcome for intussusceptions	
	Ileo-cecal	Ileo-ileal
Intussusception(18)	12	6

Table 6
Ultrasound and barium swallow correlation in gastroesophageal reflux

	Outcome for GER	
Examination	Positive	Negative
Ultrasound	16	0
Barium swallow	14	2

Table 7
Ultrasound finding and surgical outcome in hypertrophic pyloric stenosis

	Outcome for HPS	
	Positive	Negative
Ultrasound Examination	7	0
Operation	7	0

Table 8
Ultrasound finding and surgical outcome in acute appendicitis

	Outcome for appendicitis	
	Positive	Negative
Ultrasound Examination	4	0
Operation	3	1

Table 9
Ultrasound finding and surgical outcome in duplication enteric cyst

	Outcome for enteric cyst	
	Positive	Negative
Ultrasound Examination	2	0
Operation	2	0

Figure 1
Six-month female infant presented with vomiting and palpable mass. Target sign on transverse ultrasound of an intussusception. The concentric layers of the mass represent the different tissues in the bowel wall of the intussusceptum and the intussuscipiens

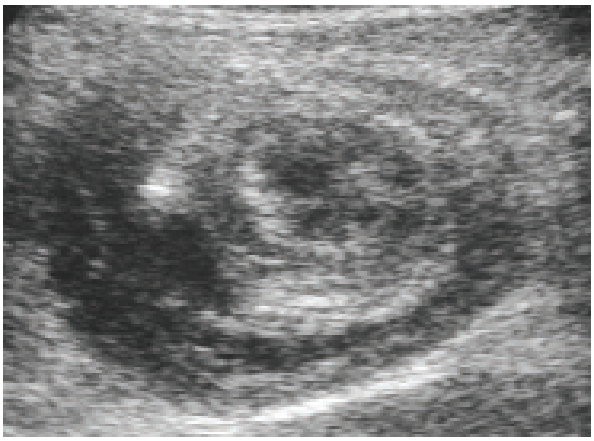


Figure 2
Twelve-year old male child presented with acute abdominal pain with vomiting. Longitudinal and transverse images shows swollen appendix, which is non- compressible and measures 9.1 mm in diameter

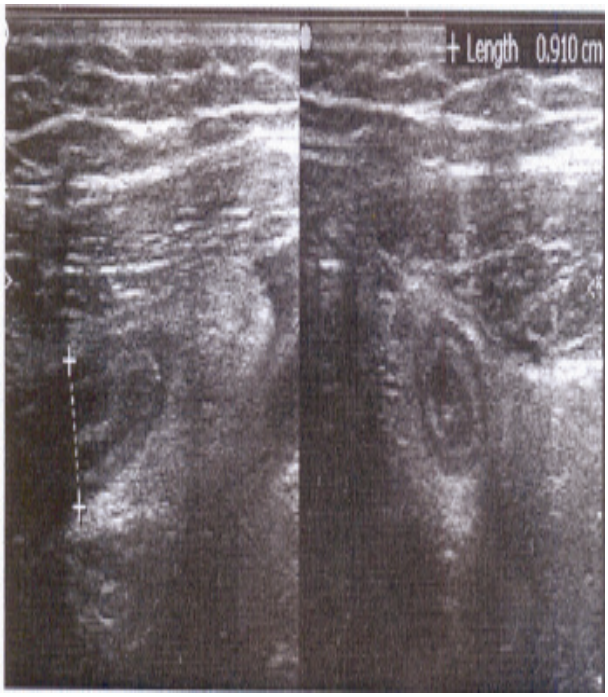


Figure 3
Hypertrophic pyloric stenosis. Seven weeks old male infant presented with nonbilious projectile vomiting. Longitudinal sonogram shows elongated pyloric canal with thickened hypoechoic muscle. Transverse sonogram of the pylorus of the same patient show central echogenic mucosa and surrounding thickened hypoechoic muscle

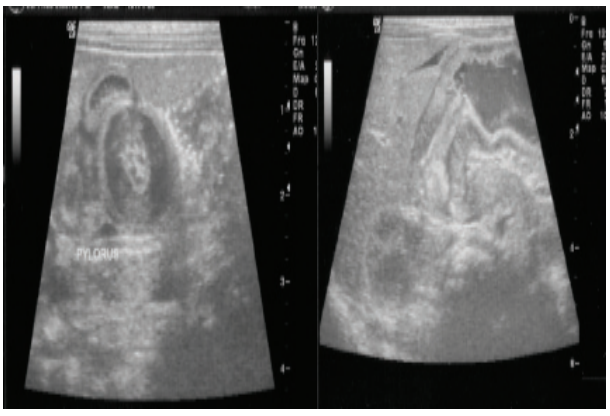


Figure 4

Five-year old male child presented with vomiting and palpable abdominal mass. Transverse scan through the lower abdomen shows an anechoic mass with an echogenic inner lining of the mucosa. Enteric duplication cyst

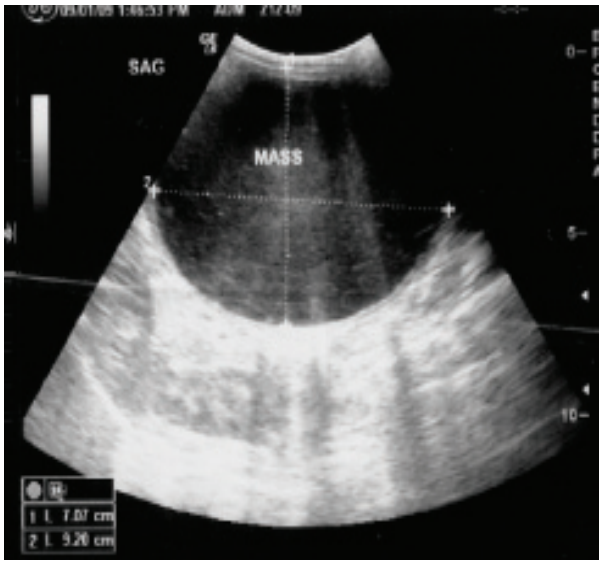
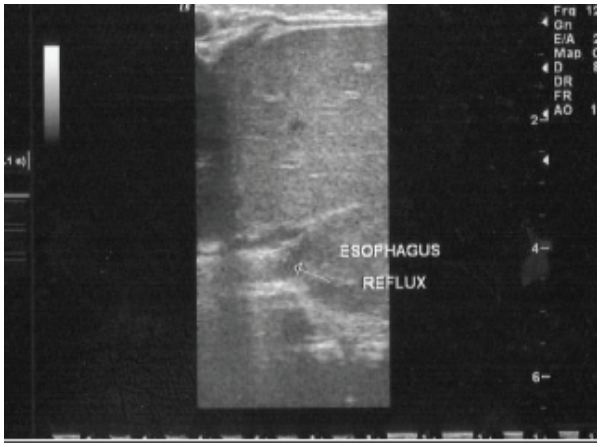


Figure 5

Five-month old female presented with vomiting, failure to thrive and recurrent pneumonia. Longitudinal U/S scan shows gastro- esophageal reflux (GER)



DISCUSSION

This study has shown that abdominal sonography has diagnostic value in differentiating the causes of suspected upper gastrointestinal disease in the 56 children evaluated. Male predominance was found in GER, intussusception and HPS. In both GER and intussusception, the male predominance of 1.6:1 was consistent with reported studies that showed male to female ratios ranging from 1.5:1 (4) for GER and 1.4:1 to 4:1 for intussusception (5,14,15). In HPS, all the seven children were male which was found to be statistically significant (p-value ≤ 0.05). This male predominance was consistent with reported studies, which place the male to female ratios at 4:1 (9). However, the low prevalence of HPS in this study compared to others (9) can be attributed to small sample size and different study populations, as HPS is more prevalent in the Caucasian population (16). The other causes of upper gastrointestinal disease in this study did not show any sex predilection.

Vomiting and abdominal pain were non-specific presentations. The most common and specific presentation for intussusception was palpable abdominal mass, seen in 15 out of the 18 children. A finding of an abdominal mass in association with intussusception has been found in previous studies (14). At surgery, all the 18 cases were proven intussusceptions confirming the diagnostic reliability of US. During surgery, the predominant site was found to be ileocecal in 12 out of the 18 children. The other six had ileo-ileal intussusceptions. However, the US examinations could not demonstrate the level of intussusception. Similar findings have been reported in studies done elsewhere (14, 15).

Colour Doppler assessment of the intussusception cases detected blood flow in 10 out of the 18 patients (56%). Various studies have shown that detection of blood flow is a promising indicator of bowel viability and hydrostatic reducibility (7). Air enema is the preferred method of reducing the intussusception having lower risk of complications, than barium enema. Studies have shown that air enema reduction is successful at 100% compared to 75% in barium enema reduction (14). In this study, the ten children who demonstrated blood flow in the intussusceptions would have been suitable candidates for non-surgical treatment, however, the current practice at KNH is surgical reduction.

GER was more prevalent in preterm infants, who comprised 67.7% of the 16 children. The increased association of prematurity with GER has been reported in literature (17). Other clinical presentations included failure to thrive and recurrent pneumonia, seen in 81 and 75% respectively. The association of respiratory diseases and GER has been studied in several physiopathological and epidemiological studies, and the complex interplay between these two frequent clinical conditions is still under debate (18). It is postulated that the involvement of the respiratory tract is partly due to micro-aspiration of reflux materials (18). Visualisation of reflux by US is limited to the distal oesophagus. Studies have shown that the use of colour Doppler increases the sensitivity of detecting GER (19). However; this study found grey scale easier as it omitted the motion artifacts seen with colour Doppler. In this study, there was a higher rate of detection of GER by ultrasound compared to barium swallow. Two out of the sixteen patients diagnosed on US did not show any reflux on upper GIT study. There are two possible reasons

for this. First, the patient's normal feed was used during US. This feed is less viscous than the barium mixture and thus portrays the normal course of events. Secondly, longer periods of continuous scanning were safely employed by ultrasound. This increased the likelihood of detecting the intermittent nature of reflux, which may be missed by the shorter period, and periodic nature of fluoroscopy to limit radiation exposure. A study by Naik and others reported that barium swallow missed 15% of GER, which had been detected on US but abnormalities not shown by ultrasound, namely peptic oesophagitis, strictures and uncoordinated swallowing (20). However, in an otherwise healthy baby with normal weight gain and suspected to have GER; upper GIT studies have a remarkably low yield of 0.06% for abnormalities and thus not justified (21). In such children where GER is suspected, ultrasound should then be the preferred and safer imaging modality.

Although this study found HPS only in male patients, studies have documented the male to female ratio as 4:1 (6). The reason why this study did not pick any female patients could be attributed to sample size. However, there was correlation in age range (three to eight weeks) with mean age of six weeks as in reported studies (6). The classic 'olive' of hypertrophied pyloric muscle was palpable in only four children (57%). Studies have reported the presence of the clinical sign in 33.3% (22). Palpation of the 'olive' is related to the stage of presentation. It is more easily found in late stage where the muscle has fully developed, and the presence of dehydration and reduced abdominal fat from weight loss, make it more easily palpable. The patients in our study reported late with indications and failure to thrive and therefore it was easier to clinically palpate the hypertrophied muscle (Table 4). The length of the pylorus was measured at between 16-28mm and the muscle thickness was 3 to 6mm. All the seven cases detected in the study were confirmed on surgery. No case of pylorospasm was seen in this study due to the small sample size. However, it has been documented in literature that in three infants suspected to have pylorospasm; the pyloric muscle thickness was 2 to 3 mm, which further decreased to < 2 mm during a two-week follow-up period (22). It has also been found that the lower limit of muscle thickness is variable, ranging from 3 to 4.5 mm (6,22,23) which has resulted in one author stating that the actual numeric value may be less important than the overall morphology of the pyloric canal and realtime sonographic observations (23). The author in this paper states that hypertrophic pyloric stenosis was unequivocal where there was visibly thickened pyloric muscle, redundant pyloric mucosa and failure of the preduodenal portion of the stomach to distend by active gastric peristalsis (23).

Acute appendicitis was seen in only four out of the 56 children. The mean age was 10.8 years and all presented with non-specific abdominal pain and vomiting. The appendiceal diameter ranged from 6.0 mm to 9.1 mm. No appendicolith, lymph node or peri-appendiceal abscess was seen. The clinical and US findings were related with laparotomy findings and pathological outcome. Three patients were positive for appendicitis while one was negative for appendicitis on histology. In a prospective study for nearly nine years, involving 1285 children aged one to 15 years, the proven prevalence of acute appendicitis was remarkably low at 9% (24). However, US achieved a sensitivity of 92%, specificity of 98% (24). Recent studies using an appendiceal diameter of ≥7mm, have placed the sensitivity and specificity of US at 98.7 and 95.4% respectively (9). In a study of 200 patients, laparotomy based on clinical criteria alone for acute appendicitis, showed 22.5% negative appendicectomy, while laparotomy based on both clinical and US findings showed 4.7% negative appendicectomy (25). This study proved that routine US examination by graded compression does improve diagnostic accuracy and reduce adverse outcome. Studies to determine the local situation are required.

Enteric duplication cysts were found in two patients. One was male aged five years and the other was female aged two years. Both presented with abdominal distension and intermittent vomiting. Diagnosis based on sonography showed cysts with echogenic inner mucosal layer and hypoechoeic muscular layer (gut signature sign). Subsequent computer tomography findings were suggestive of enteric duplication cyst with differential diagnoses of mesenteric and omental cysts. Surgery and histology confirmed the cysts as enteric duplication cysts indicating the reliability of US in detecting the 'gut signature' sign. Cheng and others reported the successful diagnosis of two cases of enteric cysts based on these US features (13). However, Godfrey and others reported a case of a four-year-old girl with an abdominal mass, where sonography detected enteric duplication cyst but on laparotomy found to be a torsed left ovarian cyst showing that the 'gut signature' sign could not always be considered as pathognomonic (26).

In this study, three neonates were diagnosed with ileal atresia. One was male aged 11 days; the other two were female aged eight and 12 days respectively. Clinically they presented with bilious vomiting, abdominal distension and failure to pass stool. Initial radiographs were not diagnostic. Sonography showed markedly dilated fluid-filled echogenic bowel loops with changeable shapes and position as a result of more active peristalsis. Ileal atresia was suspected and confirmed at surgery, thereby underlining the crucial diagnostic role of abdominal US in intestinal disorders. It has been reported that small bowel atresias have specific sonographic patterns in obstetric

US (echogenic walls, fluid filled dilated stomach and proximal bowel, polyhydraminous), allowing specific prenatal diagnoses of most of the affected fetuses (27). In these three neonates, their prenatal US could not be traced.

In conclusion, ultrasound is a readily available, safe, and reliable tool for evaluating the child with suspected upper gastrointestinal disease and can provide the differential diagnoses for many of the common childhood pathologies. The use of ultrasound as an initial imaging tool markedly reduces the need for upper GIT fluoroscopy studies thereby reducing radiation dose to growing children. Upper GIT studies should be reserved for children with suspected upper gastrointestinal disease in whom the ultrasound examination is negative or inconclusive.

There is need for Radiologists and Hospital management to embrace non-surgical reduction of intussusception wherever viable bowel has been demonstrated on colour Doppler thereby drastically decreasing risks, costs and duration of Hospital stay.

Acquisition and application of high definition portable ultrasound would be beneficial in the evaluation of critically ill neonates and children.

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