THE ROLE OF ABDOMINAL ULTRASOUND IMAGING IN EVALUATING THE VOMITING CHILD

KENYATTA NATIONAL HOSPITAL AND UNIVERSITY OF NAIROBI RADIOLOGY DEPARTMENT

STUDY

A DISSERTATION SUBMITTED IN PART FULFILLMENT FOR THE DEGREE OF MASTER OF MEDICINE IN DIAGNOSTIC IMAGING AND RADIATION MEDICINE, UNIVERSITY OF NAIROBI.

BY

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DECLARATION

Candidate

This dissertation is my original work and has not been presented for a degree in any other University.

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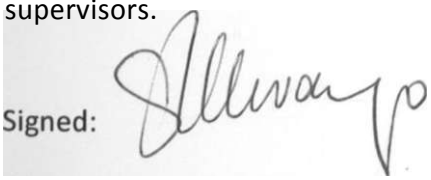
Signed: 

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CONTENTS

ABBREVIATIONS

CT……Computed Tomography

CTZ……chemoreceptor trigger zone

CD……Colour Doppler

GER……Gastroesophageal reflux

GERD……Gastroesophageal reflux disease

GI……Gastrointestinal

HPS……Hypertrophic pyloric stenosis

IBD……Inflammatory Bowel Disease

KNH……Kenyatta National Hospital

LES……Lower esophageal sphincter

NEC……Necrotizing Enterocolitis

PD……Power Doppler

RLQ……Right Lower Quadrant

SPSS……Statistical Package for Social Sciences

SMV……Superior mesenteric vein

SMA……Superior mesenteric artery

SBI……Small bowel intussusception

US……Ultrasound

UGI……Upper Gastrointestinal

UON……University of Nairobi

VC……Vomiting centre

SUMMARY

Introduction: Children are generally very suitable subjects for ultrasound (US) examinations. US is often the first investigation performed for suspected abdominal or pelvic pathology. It may precede radiographic examination and has many advantages. It is non-invasive, does not use ionizing radiation and can be performed quickly and portably, if necessary. It is generally well tolerated by babies and children. Increasingly in pediatric practice, ultrasound is used for investigating suspected disease of the hollow gastrointestinal (GI) tract.

Aim: The aims of this study was to evaluate the sonographic abdominal findings in a vomiting child, to establish indications for sonography and to show the disease patterns that cause vomiting in children, that can be evaluated by ultrasound.

Method: A descriptive prospective study was carried out at the Radiology Department of Kenyatta National Hospital and University Of Nairobi for duration of six months. During this study period, all children referred to Kenyatta National Hospital and University Of Nairobi Radiology Department for upper gastrointestinal tract contrast study and/or ultrasound with history of vomiting was recruited in the study. Informed consent was obtained from parents for each child participating in the study and the study scanning protocol was followed. All ultrasound examinations was done by the researcher under supervision of consultant radiologist. Data collection sheets were used to record the personal, clinical data, sonographic findings and diagnosis. The data was eventually analyzed using computer software and the results presented in form of tables, charts and graphs.

Results: A total of 56 children under 12 years of age were investigated. 64.3% of the children were male. The most common sonographic finding was intussusception which was found in 32.1% and gastro-esophageal reflux (GER) in 28.6% of the patients. The male **to** female ratio in intussusception was 1.5:1 while gastro-esophageal reflux male **to** female ratio was 1.6:1.

The most common clinical presentation in children found to have intussusception was palpable abdominal mass, and few of them presented with blood stained stool. More than 2/3 of these children with gastro-esophageal reflux presented with complications of recurrent pneumonia and failure to thrive. Gastro-esophageal reflux was more severe in patients with recurrent pneumonia compare to those that presented without complications.

Discussion: The result of this study indicates that transabdominal ultrasonography was useful and highly specific in evaluating the vomiting child and can be considered a valuable first choice examination. In some diseases of the gastrointestinal system, such as hypertrophic pyloric stenosis, intussusception sonography has almost entirely substituted contrast studies. Further more ultrasound is the only diagnostic examination which can be repeated several times with high diagnostic accuracy. The technique offers several advantages in that it has low costs, it is simple and non-invasive.

Conclusion: Findings in this study confirm that ultrasound is an accurate, reliable, and rapid screening method to evaluate the causes of vomiting in children.

Recommendation: It is recommended that such children referred to the x-ray department should have an initial sonographic examination and thereby avoid or limit the use of ionizing radiation.

INTRODUCTION

A child is a human being aged 12years and younger. This includes neonates (0-29 days), infants (lmonth-2year) and children (2years- 12years).[1]

Ultrasound is the name given to high frequency sound wave, over 20 000 cycle per second (20 kHz). These waves, inaudible to humans, can be transmitted in beams and are used to scan the tissues of the body.[2]

Utrasound examination in the field of medicine was introduced in the early 1950's, but it became of profound use in the late 1960's where its main application was in cardiology and obstetrics.[3] Currently, real time ultrasound has various uses in the diagnosis, guidance of percutaneous procedures, follow up of patients and in the evaluation of disease management.

Vomiting is the forceful expulsion of gastric contents through the mouth that involves an integrated and largely somatic motor response. It represents a protective reflex in the body's defense system. Parental complaints of vomiting or regurgitation in children are common especially in the first year of life.[4]

Vomiting is not an illness but a symptom that goes along with many diseases and conditions. Almost all children will vomit several times during their childhood. Dehydration is the main concern in a child who is vomiting persistently.[7] In the evaluation of such a child; most clinicians request for upper gastrointestinal contrast study that uses ionizing radiation.

Due to the harmful effects of ionizing radiation especially to the cells undergoing rapid mitosis, the risk of neoplasia is of great concern in children due to their life expectancy. Therefore various authors suggest that sonography should be the initial modality of choice in the investigation of many pediatric problems.[3]

Although bowel gas reduces the usefulness of sonography, US can be used to investigate suspected disease in the Gl tract. Modern sonography techniques that can be used to evaluate the gastrointestinal tract in pediatric age include high-resolution real-time scanners, graded compression technique, color-flow and power Doppler.[8]

Further development in ultrasound equipment particularly the development of high-frequency linear-array transducers, has led to better visualization of the gastrointestinal tract by ultrasound. It is now possible to examine the bowel with transabdominal or transperineal ultrasound from the gastro-esophageal junction to the rectum.[3]

The current practice of evaluating the vomiting child at the Kenyatta National Hospital is the use of ionizing radiation. The aim in this study was to determine the role of abdominal ultrasound in evaluating the vomiting child at the Kenyatta National Hospital and University of Nairobi, Radiology departments, and give appropriate recommendations.

LITERATURE REVIEW

The common causes of vomiting in infancy are gastro-esophageal reflux, intussusception hypertrophic pyloric stenosis, pylorospasm, necrotizing enterocolitis (NEC) and bowel malrotation with midgut volvulus. As shown in 2005 by the Expert Panel on pediatric imaging, all these conditions can be evaluated by ultrasound.[3]

A prospective study of abdominal ultrasound was undertaken in 100 consecutive infants aged 5 days to 90 days who presented with a history of persistent vomiting. In this study, 44 infants were documented as having pyloric stenosis, 44 confirmed having gastro-esophageal reflux, three with anatomical abnormalities of the gastrointestinal tract, and nine were reported as normal.[9] This study showed that abdominal ultrasound was an accurate, reliable and rapid screening method to differentiate the causes of severe vomiting in infants.

A case - control study involving 56 patients and 50 controls was done to evaluate the sensitivity and specificity of ultrasound in diagnosing gastro-esophageal reflux disease(GERD) in children. The findings in this study showed ultrasound has a sensitivity of 76%, specificity of 100%, positive predictive value of 100% and negative predictive value of 79% in diagnosing gastro-esphageal reflux disease. GERD manifestation were significantly more frequent among sick cases compared to the controls, thereby confirming that ultrasound can be successfully used as the first diagostic approach to evaluate children with gastro-esophageal reflux disease.[10]

In a study done by Cohen and others in 2005, found US to be 100% sensitive and 87.5% specific in diagnosing gastro-esophageal reflux. Another study by the same author found ultrasound successful in diagnosing 48 true positive and 6 true negative cases of gastro-esophageal reflux with only 1 false negative, giving a sensitivity of 87% and specificity Of 75%.[3]

24hour esophageal pH monitoring is the gold standard in the evaluation of GERD. A study comparing color Doppler (CD) ultrasound and 24hour esophageal pH monitoring in 34 patients showed, gastro-esophageal refluxes in 32 out of 34 patients (94%) on color Doppler ultrasonography. In the remaining 2 patients, pH measurements were positive for reflux,

and color Doppler ultrasonography did not show reflux. This study showed that 24hour esophageal pH monitoring is more sensitive than color Doppler ultrasound in detecting gastro-esophageal reflux.[11]

Ultrasound is reliable in diagnosis of hypertrophic pyloric stenosis. In a study done by Smoljanic and others in 2001 on 107 children manifested with clinical signs of hypertrophic pyloric stenosis. The ultrasound studies revealed hypertrophic pyloric stenosis in 55 patients (51.4%). There were 48 boys (87.3%) and 7 girls (12.7%). Patients were aged 17 to 75 days (average about 40 days). The sonogram finding was typical for hypertrophic pylorus, which made the diagnosis easier. There were no false positive or false negative ultrasound findings.[12]

Intussusception is the most common cause of small bowel obstruction in children. Ultrasound imaging has a major role both in the diagnosis and management of this condition. A 12-year retrospective study was done to determine the sonographic features and surgical findings of 13 pediatric patients with suspected small bowel intussusception. This study demonstrated doughnut or crescent-in-doughnut sign, or a multiple-concentric-rings sign for 11 of the 13 patients(85%). Subsequent barium enemas were performed for these 11 patients, none of which revealed colon lesions. Surgery revealed ileoileal intussusceptions for eight cases, jejunoileal for three, and jejunojejunal for the remaining two.[13]

Raymond at al in 2002 reported a case of term neonate who had emesis on the first day of life. A diagnosis of malrotation with midgut volvulus was made on the basis of the sonographic findings, that are the reversal of the superior mesenteric artery - superior mesenteric vein relationship with a whirlpool appearance of the proximal bowel and mesenteric vessels. Previously done upper abdomen plain radiographs and upper gastrointestinal series was nondiagnostic.[14]

US of the abdomen in a vomiting child gives great diagnostical value for differential diagnosis of acute appendicitis and other more frequent inflammatory diseases of the ileocaecal region. In a prospective study of over nearly 9 years, 1285 children aged 1-15 years (m=514, f=771) using a S-MHz curved array transducer the right lower quadrant was examined in a graded

compression technique. Ultrasound in detecting acute appendicitis, achieved a sensitivity of 92% specificity of 98%, a positive predictive value of 90% and a negative predictive value of 98%- The overall accuracy was 98%. Mesenteric lymphadenitis was seen in 181 cases (prevalence 12%) and terminal ileitis occasionally accompanied by mesenteric lymphadenitis was seen in 116 cases (prevalence 9%).[15]

It has been shown that ultrasound is sensitive in detecting mesenteric lymphadenopathy. A study was carried out to compare abdominal sonographic features of patients with mesenteric lymphadenitis versus sonographic features of the asymptomatic children. Ultrasound data from 113 children with acute abdominal pain whose suspected sonographic diagnosis was mesenteric adenitis or ileitis was inspected in a child hospital in March 2004 to March 2005. The control group, was a hundred asymptomatic children referred from health centers or kindergartens. The number of enlarged mesenteric lymph nodes (more than 8mm) was observed in symptomatic children compared to the controls (less than 4mm). The highest rate of sensitivity was seen with the presence of right lower quadrant lymphadenopathy (94.7%).[16]

Because of the simplicity of the sonographic examination and the sensitivity and specificity of the findings, abdominal sonography has also been shown to be effective in the early evaluation of infants suspected of having necrotizing enterocolitis. Sonographic detection of portal venous gas in infants with necrotizing enterocolitis study was done and compared with the radiographic findings.[17] This study showed characteristic pattern of hepatic parenchymal and portal venous abnormalities in 12 infants with necrotizing enterocolitis. In five cases these changes were seen before any radiographic abnormalities were observed; thereby underlining the sensitivity of ultrasound compared to radiography in infants with necrotizing enterocolitis. Sonography of 232 infants without necrotizing enterocolitis did not show these changes.[17]

Color Doppler sonography speeds detection of necrotizing enterocolitis in premature infants. From 2000 to 2002, Dr. Faingold and colleagues at the University of Toronto used color Doppler sonography to examine 30 premature and full-term infants with suspected or proven

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necrotizing enterocolitis. This study showed that earlier detection of necrotic or dead bowel in necrotizing enterocolitis will improve an infant's chance for survival. This results indicated that color Doppler sonography was more sensitive and specific than x-ray for determining necrotizing enterocolitis in new boms.[18]

Ultrasonography of the pancreatic duct has been found to be valuable in diagnosis and monitoring of pancreatitis in children. In case-cotrol study to investigate the diameter of pancreatic duct using ultrasonography in 51 children with pancreatitis and age-matched healthy control children over a 5 year period showed that, a significant difference in diameter of the pancreatic duct between children with acute and chronic pancreatitis versus that of age-matched control. The mean diameters of the pancreatic duct in acute pancreatitis and chronic pancreatitis were 2.34 +/- 0.47 mm and 2.84 +/- 0.67 mm, respectively, which was greater than that of normal children (1.65 +/- 0.45 mm).In addition, a significant difference in diameter of the pancreatic body was found between children with acute pancreatitis and age-matched controls, but there was no marked difference in diameter of the pancreatic body between normal persons and those with chronic pancreatitis.[19]

Enteric duplication cysts are uncommon congenital abnormalities that may be located anywhere along the course of the gastrointestinal tract. Ultrasound can clearly demonstrates the presence of the cysts. A case report of 5-year-old boy who had a several-month history of increasing episodes of vomiting and poor appetite was undertaken. This study showed at least 3 contiguous anechoic, avascular, cyst like lesions located in the region of the distal stomach. These findings favored gastric duplication cysts because of their sonographic "gut signature" appearance and location. Erect and supine abdominal radiographs showed mild gastric distention of the stomach with an otherwise nonobstructed pattern, where was not diagnostic, thereby underlining the usefulness of sonography in evaluating the vomiting child.[20]

The clinical and diagnostic work-up of the vomiting child in our local set-up does not include sonography as an initial imaging modality. The aim of this study was to evaluate if the findings

jn this literature review could be plicated in our population and thereby evaluate the role of sonography locally. No such study has been done in Kenya or Africa.

Vomiting Pathophysiology

Vomiting is a physical act that has clearly associated gastrointestinal motor activity. Nausea, on the other hand, although frequently accompanyingvomiting is an uncomfortable feelingthat is relieved by vomiting.[21]

Vomiting occurs after stimulation of either the vomiting center (VC), a central "control center" in the medulla near the respiratory center, or the chemoreceptor trigger zone (CTZ) in the area postrema on the floor of the fourth ventricle. Vomiting resulting from psychological stress occurs via pathways traveling through the cerebral cortex and limbic system to the VC.[21]

Once the vomiting centers are stimulated, the cascade of motor events leading to the act of vomiting is initiated. Nonperistaltic contractions in the small intestine increase, the gallbladder contracts, and some of the duodenal contents regurgitate into the stomach. This is followed by a large retrograde peristaltic wave that pushes small bowel contents and pancreatobiliary secretions into the stomach and suppresses gastric activity. Meanwhile, the inspiratory muscles contract against a closed glottis, resulting in esophageal dilatation.[21]

Asthe abdominal muscles contract, the stomach contents are forced into the distal esophagus. The cycles of retching quicken until the esophagus no longer empties between cycles, and the contents finally are extruded.[21]

The gastrointestinal motor events of vomiting are mediated through vagal and sympathetic efferents from the VC, as are the autonomic events associated with the act of vomiting, namely, increased salivation, increased respiratory and heart rates, and pupillary dilatation.[21]

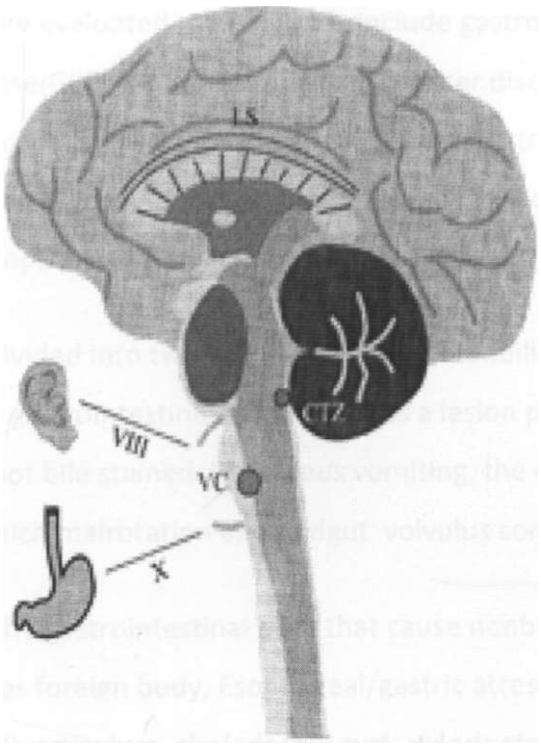


Figure 1: Central nervous system coordination of vomiting: LS = limbic system, CTZ = chemoreceptor trigger zone, VC = vomiting center, VIII = vestibular nerve, X = vagus nerve.

Conditions that lead to vomiting in children

Vomiting is often a frightening and exhausting illness for young children. Most of the time, vomiting in children is caused by gastroenteritis, usually due to a virus infecting the gastrointestinal tract. Sometimes vomiting can be the symptom of more serious underlying diseases such as heart conditions, kidney or liver disorders, central nervous system disorders, brain tumors, and some forms of cancer.[6]

Although the causes of vomiting in children are many, a thorough history of the nature of the vomiting and any associated signs or symptoms as well as a complete physical examination generally helps narrow the differential diagnosis.[21] Not all cases of vomiting are investigated radiologically. However when the vomiting is prolonged or can not be explained imaging studies [ar]e usually performed.

Conditions which may be evaluated radiologically include gastro- esophageal reflux, gastro-esophageal reflux disease(GERD), hiatal hernia, peptic ulcer disease, hypertrophic pyloric stenosis(HPS), intussusception, acute appendicitis, duodenal atresia, midgut malrotation, jejunal/ilea' atresia, enteric duplication cyst, necrotizing enterocolitis(NEC), acute pancreatitis, mesenteric lymphadenopathy and inflammatory bowel disease(IBD).[22]

True vomiting can be divided into two broad categories: Nonbilious and Bilious. Neonatal non-bilious vomiting due to gastrointestinal causes implies a lesion proximal to the ampulla of Vater, hence the vomiting is not bile stained. For bilious vomiting, the obstruction is distal to the ampulla of Vater, of which malrotation and midgut volvulus constitute the greatest causes.[21]

Physical conditions of the gastrointestinal tract that cause nonbilious vomiting include structural causes such as foreign body, Esophageal/gastric atresia, Esophageal/gastric stenosis, Stricture, duplication, diverticulum, choledochal cyst, pyloric stenosis, annular pancreas and web. Disorders of motility can also cause nonbilious vomiting and include achalasia, ileus, scleroderma, gastroparesis, and pseudo-obstruction. Appendicitis and peptic ulcer disease cause nonbilious vomiting through stimulation of the autonomic nervous system.[21]

Conditions that can cause bilious vomiting in children are intestinal atresia and stenosis, malrotation with or without volvulus, ileus from any cause, intussusception, intestinal duplication, compressing or obstructing mass lesion, incarcerated inguinal hernia, superior mesenteric artery syndrome, peritoneal adhesions, and pseudo-obstruction.

Gastroesophageal reflux and gastroesophageal reflux disease

In gastro-esophageal reflux there is the retrograde movement of gastric contents into the oesophagus. The acid and pepsin contents of the stomach irritate the oesophageal mucosa, which has no defense against their corrosive activity. It results from an incompetent lower esophageal sphincter (LES) which leads to the reflux of gastric contents into the esophagus. The pathogenesis of GER is not well understood.[3]

Gastroesophageal reflux can be classified in to functional, pathogenic and secondary gastroesophageal reflux. In functional gastroesophageal reflux patients have no underlying predisposing factors or conditions. Growth and development are normal, and treatment is typically not necessary. Pathogenic gastro-esophageal reflux or gastro -esophageal reflux disease, patients frequently experience complications, including strictures, malnutrition, respiratory disorders, esophagitis, bleeding, and changes in the normal epithelial lining of the lower esophagus. Patients require careful evaluation and treatment. Pathogenic gastroesophageal reflux is common in infants, with a reported high prevalence in many communities.[2] Secondary gastroesophageal reflux refers to a case in which an underlying condition predisposes to gastroesophageal reflux. Examples include hiatal hernia and gastric outlet obstruction.

The investigations that can be used to evaluate for gastroesophageal reflux include upper gastrointestinal contrast studies, endoscopy, manometry,twenty four hour pH testing, nuclear medicine and ultrasound. Whereas twenty-four-hour pH testing is the gold standard in diagnosing gastroesophageal reflux with a sensitivity of 96% and specificity of 95%, it does not document the reflux of all kinds of fluid from the stomach into the esophagus, but only documents acid material. Other disadvantages of 24hour PH testing include patient should be admitted, and is not always available.[3,23] Ultrasound on the other hand has a relatively cost-effective noninvasive, safe and physiologic method for detecting gastroesophageal reflux. Gastroesophageal reflux may be sonographically diagnosed with 95% sensitivity, but as reflux is an intermittent phenomenon, and prolonged scanning times may be required, it may not always be practical.[3,24]

intussusception

Intussusception consists of a telescoping of a segment of bowel (intussusceptum) into a more distal segment (intussuscipiens). The cause of most intussusceptions is unknown. The incidence varies from 1-4 in 1,000 live births.[25] The male:female ratio is 4:1. The majority of children are under 1 year of age. Peak incidence between 5 and 9 months of age. In about 90% of cases, the invagination is localized in the ileocecal region, and others are ileocolic, colocolic and ileoanal. [25,26]

In over 90% of intussusceptions there is no leading mass, and it is believed that in these cases the thickening of the lymphatic follicles in the terminal ileum is the main etiologic factor, resulting in the disturbance of peristalsis and subsequent invagination.[25]

The clinical history and physical findings are usually sufficiently typical for diagnosis. Plain abdominal radiographs may show a density in the area of the intussusceptions, and may be normal in over 50% of cases of intussusception. A barium enema shows a filling defect or cupping in the head of barium where its advance is obstructed by the intussusceptum.[25]

Ultrasonography has been shown to be a sensitive diagnostic tool in the diagnosis of intussusception.[27] The diagnostic findings of intussusception include a tubular mass in longitudinal views and a doughnut or target appearance in transverse images. Ultrasonography is also useful in demonstrating reduction of the intussusception by hydrostatic or air techniques.[25] Colour Doppler and power Doppler (PD) are helpful in assessing viability of intussuscepted bowel.[27,28] Detection of blood flow in intussusception has been reported as a promising predictor of bowel viability and hydrostatic reducibility. If no Doppler signal is obtained this indicates the presence of bowel ischemia or gangrene thereby non surgical reduction is contraindicated.[13]

Hypertrophic Pyloric Stenosis

Another mojor differential diagnosis for infants who present with vomiting is hypertrophic pyloric stenosis (HPS). The etiology of hypertrophic pyloric stenosis (HPS) is unknown. Hypertrophic pyloric stenosis occurs in approximately 3 in 1,000 infants.[25]

Studies have shown that hypertrophic pyloric stenosis is more common in whites of northern European ancestry, less common in blacks, and rare in Asians.[25] It presents with non bilious projectile vomiting and associated clinical findings include weight loss, dehydration and hypochloraemic alkalosis. The age of presentation is typically between 4 and 6 weeks. There is often a family history. It tends to occur in first-born boys and is three times more common in boys than girls.[25,27]

Plain abdominal radiographs may show a fluid-filled or air-distended stomach, suggesting the presence of gastric outlet obstruction. If the patient has recently vomited the radiographic findings are normal. UGI study was once considered the procedure of choice for HPS.[29] Findings on UGI studies include the following: Delayed gastric emptying, cephalic orientation of the pylorus, shouldering, mushroom or umbrella sign, double-track sign, string sign, pyloric tit, retained secretions and retrograde peristalsis.[29]

Ultrasound is an accurate method for diagnosis of HPS and has replaced the barium meal in the vomiting child. Indeed, the accuracy approaches 100% and ultrasound is now the procedure of choice for detecting of pyloric stenosis. Pylorospasm may mimic hypertrophic pyloric stenosis on ultrasound. The measurement vary in pylorospasm with time, which can help distinguishing it from hypertrophic pyloric stenosis.[25]

In the classic case of hypertrophic pyloric stenosis, the thickened muscle mass is seen as an hypoechoic layer just superficial to the more echogenic mucosal layer of the pyloric canal. In cross section, this olive on clinical palpation, resembles a sonolucent doughnut medial to the gallbladder and anterior to the right kidney. In hypertrophic pyloric stenosis, muscle width

greater or equal to 3mm, pyloric canal length greater or equal to 1.2cm, no peristalsis through pylorus.[29]

Acute Appendicitis

The incidence of appendicitis increases with age, peaking in adolescence and rarely occurring in children younger than 1 yr old. The incidence in the pediatric age group is about 4 per 1,000.[25] Most children with acute appendicitis present with typical clinical findings and do not require investigation. Approximately 30-40% have atypical findings. Accurate clinical diagnosis can be particularly difficult in very young children and infants. The classic triad consists of pain, nausea with vomiting, and fever.

Plain abdominal radiograph is nonspecific. However it may demonstrate calcified appendicolith, small bowel distention or obstruction, and soft tissue mass effect. Ultrasonography is helpful. The swollen appendix is usually a tubular, fluid-filled structure, which is non-compressible and measures 6 mm or more in diameter. The echogenic mucosal lining may be intact or poorly defined.[27] A periappendicular fluid collection occurs with early perforation. Enlarged reactive lymph nodes are commonly seen, in subacute chronic cases.

CT is usually used in the diagnosis of acute appendicitis. Therefore Ultrasound and CT are both sensitive for the diagnosis of acute appendicitis.[27] CT is more sensitive and specific than ultrasonography and more likely to change patient management. Ultrasound advantages include low cost, lack of ionization radiation, and ability to evaluate compressibility and vascularity.[25,30]

Enteric Duplication Cyst

Enteric duplication cysts are due to abnormal canalization of the GI tract. They can occur anywhere along the length of the gut and are most frequently found in the ileum where they lie along the mesenteric border and share a common muscle wall blood supply. They have a mucosal lining and 43% contain ectopic gastric mucosa.[7]

Clinically they usually present in the first year of life with vomiting or abdominal pain, an asymptomatic palpable abdominal mass or melana. An abdominal radiograph may show displacement of bowel loops by a mass. Ultrasound will demonstrate the cyst, which is usually spherical in shape and less often tubular. It will have an inner echogenic mucosal layer and an outer hypoechoic muscular layer. Contrast studies may show displaced or obstructed loops of bowel. 99m Tc is taken up by ectopic gastric mucosa and is helpful in diagnosing duplication cysts which present with gastrointestinal bleeding.[7]

Duodenal Atresia

Duodenal atresia represents complete obliteration of the duodenal lumen. Duodenal atresia is much more common than duodenal stenosis. The etiology of duodenal atresia and stenosis is unknown.. The incidence of duodenal atresia is 1 in 10,000 births and accounts for 25-40% of all intestinal atresias.[6] The membranous form of atresia is most common, with obstruction occurring distal to the ampulla of Vater in the majority of patients.[21]

Down syndrome occurs in 20-30% of patients with duodenal atresia.[21] Other congenital anomalies that are associated with duodenal atresia include malrotation (20%), esophageal atresia (10-20%), congenital heart disease (10-15%), and anorectal and renal anomalies (5%). The diagnosis is suggested by the presence of a "double-bubble sign" on plain abdominal radiographs. Contrast studies are usually not necessary and may be associated with aspiration if attempted. Contrast studies may occasionally be needed to exclude malrotation and volvulus.

Sonography can readily identify an obstructed, fluid filled, distended duodenum, and frequently the level of obstruction can be determined. Proximal duodenal obstruction resulting in the classic double sign occurs with duodenal atresia. This condition may be diagnosed with antenatal ultrasound showing fluid filled double bubble and polyhydramnios.[21]

Midgut malrotation

Infants often present within the 1st week of life with bilious emesis and acute bowel obstruction. The abdominal plain film is usually nonspecific but may demonstrate evidence of

duodenal obstruction with a double-bubble sign. Barium enema usually demonstrates malposition of the cecum but may be normal in 10% of patients.[25]

The standard of reference for imaging diagnosis of malrotation is the upper gastrointestinal series. The location of the duodenojejunal junction is the critical anatomic landmark. The duodenojejunal junction is normally located over or to the left of the left vertebral pedicles and rises to the level of the duodenal bulb.[25]

A sonographic finding suggesting malrotation is reversal of the superior mesenteric artery (SMA)—superior mesenteric vein (SMV) relationship on transverse images. However, the utility of this finding is limited, because reversal of the superior mesenteric vessel relationship can occur in the absence of malrotation, and a normal relationship does not exclude the diagnosis of malrotation. Vascular sonographic signs described include a hyperdynamic pulsating SMA, dilatation of the distal SMV and the "whirlpool" sign of clockwise wrapping of the SMV around the SMA.[14,31]

Jejunal/Ileal atresia

Intestinal atresias account for about one third of all cases of neonatal intestinal obstruction. Most infants become symptomatic during the 1st day of life with abdominal distention and bile-stained emesis or gastric aspirate. 60% to 75% of the infants fail to pass meconium. Jaundice has been found in 20-30% of the patients.[25]

The diagnosis of jejunoileal atresia may be made by prenatal ultrasonograms. Polyhydramnios occurs in 25% of affected patients. Plain radiographs demonstrate many air-fluid levels or peritoneal calcification associated with meconium peritonitis. Plain radiography is usually diagnostic and further radiological evaluation (upper gastrointestinal series) is not necessary. Sonography may be useful in differentiating meconium ileus and ileal atresia. In meconium ileus, the dilated bowel loops are filled with echogenic material, whereas in ileal atresia the bowel contents are echo-poor.[32]

Mesenteric Lymphadenopathy

Mesenteric lymphadenitis refers to inflammation of the mesenteric lymph nodes. It causes a clinical presentation that is often difficult to differentiate from acute appendicitis. Up to 20% of patients undergoing appendectomy have been found to have nonspecific mesenteric adenitis.[16]

Mesenteric adenitis can occur in adults, but it is most common in children and adolescents younger than 15 years.[16] Plain radiographic findings can never indicate a specific diagnosis in mesenteric adenitis, but they can occasionally confirm an alternative diagnosis. Contrast computed tomography (CT) demonstrates enlarged mesenteric lymph nodes, with or without associated ileal or ileocecal wall thickening, and a normal appearing appendix. Abdominal ultrasound scanning with Doppler scanning is a useful adjunct for excluding other differential diagnoses. Nodes are more rounded and hypoechoic than normal. They are typically larger and more numerous with mesenteric adenitis than with appendicitis.[16,27]

Acute Pancreatitis

The patient with acute pancreatitis has abdominal pain, persistent vomiting, and fever. Acute pancreatitis is usually diagnosed by measurement of serum amylase and lipase activities. The serum amylase level is typically elevated for up to 4 days.[25] Plain abdominal radiograph may demonstrate nonspecific findings. Ultrasound and computed tomography (CT) scanning have major roles in the diagnosis and follow-up of children with pancreatitis. Findings may include pancreatic enlargement, a hypoechoic, sonolucent edematous pancreas, pancreatic masses, fluid collections, and abscess. Endoscopic retrograde cholangiopancreatography (ERCP) or magnetic resonance cholangiopancreatography (MRCP) are essential in the investigation of recurrent pancreatitis.[25]

Necrotizing Enterocolitis

Necrotizing enterocolitis (NEC) is a serious gastrointestinal disease of unknown etiology in neonates. Most commonly affected sites being the terminal ileum and colon. Infants with suspected necrotizing enterocolitis should undergo periodic radiography of the abdomen.

)n some centers, infants in whom necrotizing enterocolitis is highly suspected undergo routine frontal abdomen radiography every 4-6 hours.[33]

Abdominal radiographs may demonstrate multiple dilated bowel loops that change little in their location and appearance with sequential studies. Pneumatosis intestinalis, or gas in the bowel wall with a linear or bubbly pattern, is present in 50-75% of patients. Portal venous gas and gallbladder gas are indicative of serious disease. Pneumoperitoneum indicates a bowel perforation. Radiography is sufficient for an accurate diagnosis of necrotizing enterocolitis, and the presence of air on a horizontal-beam radiograph is sufficient to diagnose a bowel perforation.[31]

The use of CT is not advocated in the diagnosis of NEC or possible perforation. CT scanning or an examination with a water-soluble enema may be used to demonstrate pneumatosis or a site of perforation. Ultrasonography of the abdomen characteristically shows thick-walled loops of bowel with hypomotility. Intraperitoneal fluid is often present. In the presence of pneumatosis intestinalis, gas is identified in the portal venous circulation within the liver. Ultrasound is more sensitive than a plain radiograph in the detection of ascites and portal venous gas.[34]

AIMS AND OBJECTIVES

/\jm:- To demonstrate the sonographic findings in pediatric patients presenting with vomiting.

Objectives:-

1. To determine the age and sex distribution.
2. To show the disease pattern in the vomiting child.
3. To establish the different indications for abdominal ultrasound in children.

Study design:-

Descriptive prospective study done over a 6 months period.

JUSTIFICATION

Sonography has become an important diagnostic imaging modality in the examination of the gastrointestinal(GI) tract of children. Ultrasound provides a non invasive, safe, readily available, portable, repeatable, fast, highly sensitive cost-effective technique. It is particularly attractive for the use in the pediatric age group.

Specific concern over the potentially harmful effects of exposure to radiation in children began to develop in the 1940s when it was suggested that fluoroscopy use in infants should be restricted according to clinical indications. An increased susceptibility of children to radiation-induced cancer is biologically plausible because of the fact that their tissues are still growing and therefore the dividing cells are more prone to somatic genetic damage. In addition, children have a longer life expectancy during which oncogenic effects may develop. Ultrasound does not have ionizing effects. Ultrasonography can be used into a very low-resource setting such as refugee camp and rural area and requires little servicing or installation.

A study evaluating the role of US in the vomiting child has not been undertaken in Kenya. The current practice of evaluating the vomiting child at the Kenyatta National Hospital is the use of ionizing radiation. The aim of this study was to define the role of ultrasound in these children and there by reduce the use of fluoroscopic studies.

JVIATERIALS AND METHODS

In this study the technique used varied according to the suspected clinical problem.

Equipment

All patients were scanned using high-resolution real-time scanners.

- Phillips ultrasound machine (model SD 800) at Kenyatta National Hospital.
- G.E Ultrasound machine (model Logic Q. 7) at Kenyatta National Hospital.
- Hewlett Packard Image Point HX machine at Department of Diagnostic Imaging and Radiation medicine (DDIRM) University of Nairobi.
- G.E Logic 5 Expert machine at DDIRM University of Nairobi.

Technique & Scanning Protocol

Informed consent was obtained from parents for each child participating in the study and the study scanning protocol was followed. A linear or curved transducer, ranging in frequency from 3.5to 11 MHz, was used, depending on the body size of the patient. No preparation was required, except in children with suspected gastro-esophageal reflux disease, the study was done after the ingestion of a low volume liquid meal. The ultrasound gel was warmed by immersing the container in hot water. The mother was requested to hold the child. For bigger children where cooperation could be ensured, the child was requested to lie supine on the examination table. The babies were allowed to breast feed during the examination. Using initially the curvilinear probe (3.5 MHz-5 MHz) the liver was evaluated in transverse and saggital planes through each segment. In a sagittal plane the stomach was identified and assessed. The esophagus and the gastro-esophageal junction were studied by transverse and longitudinal scans at the epigastrium at the level of the left lobe of the liver. The observation was carried out continuously for at least 10-15 minutes.[36]

On transverse plane the pancreas was examined and the superior mesenteric artery (SMA)-superior mesenteric vein (SMV) relationship was established. Using the linear probe the pylorus was carefully evaluated in transverse and longitudinal section using the gallbladder as a guide-mark. Observation for peristalsis and fluid movement through the pylorus were also assessed. The examination of each abdominal quadrant using gentle graded compression was carried out. The cooperative child was asked to localize the area of maximal pain or tenderness and attention was focused on that area.[34] Color Doppler examination technique was used to assist in the detection of inflammation. The total examination time was approximately 15-20 minutes.

Quality Control

Ultrasonography was done by the researcher under the supervision of a consultant radiologist using the scanning protocol. Only children in whom an ultrasound examination was done were included in the study.

Data Collection

The age, sex, clinical and sonographic findings of the child were recorded in the interview form (appendix 1).

Inclusion criteria

This study included all the children who were 12 years of age and below with history of vomiting, recurrent pneumonia and failure to thrive who were booked for an upper gastrointestinal study during the study period October 2008 to March 2009 at Kenyatta National Hospital and Department of Diagnostic Imaging and Radiation Medicine, University of Nairobi. This included of patients referred from the private clinics, wards and the pediatric out-patient departments.

Exclusion criteria

Parents with vomiting children who decline participation in the study.

^ample size determination

The sample size was determined by the following formula by Fisher et al (1998)

$$_{p}\ a\ \frac{Z^2\ P\ (I'D)}{d^2}$$

Where n = desired sample size

z = standard normal distribution

p = known prevalence rate for the factor of interest under study

d = the level of significant desired

When this formula is applied at d = 0.05, z = 1.96, and p = 4 %

$$n = \frac{1.96^2 * 0.04(1-0.04)}{0.05^2}$$

n=60

The expected sample size was 60 children in the proposed six months of data collection.

Due to variable prevalence of suspected pathologies in this study the commonest (intussusception 4%) was taken as factor of interest under study.

RESUUS

The study involved 56 patients who were 12 years of age and below. It took a period of 6 months (October 2008 to march 2009). Age range was 6 days to 12years (144 months). Mean age was 1 year 5 months (figure 2). Most of the patients were males - 64.3% (figure 6). This was reflected across all the age groups in the study. The age group distribution was; 76.8% infants, 8.9% neonates and 14.3% children (figure 5). The most common indication necessitating the ultrasound study was vomiting seen in all children. The next common indications in order of frequency were abdominal pain (21), failure to thrive (19), abdominal mass (18), recurrent pneumonia (13), abdominal distension (7), regurgitation (4), bloody stool (3), failure to pass stool (3), diarrhea (1). (figure 3)

Of the 56 patients studied 6 had normal findings. This comprised 10.7%. The most common findings was intussusception seen in 18 patients 32.1%, and gastro-esophageal reflux disease(GERD) seen in 16 patients 28.6% (Table 4). The male to female ratio in intussusception was 1.5:1 while GER male to female ratio was 1.6:1. The other sonographic findings included pyloric stenosis 7, acute appendicitis 4, jejunal/ileal atresia 3, enteric duplication cyst 2. Intussusception accounted for 32.1% and GER 28.6% of the sonographic findings respectively. Hypertrophic pyloric stenosis (HPS) accounted for 12.5%, they were all male patients.
The clinical indications for the patients found with intussusception were palpable abdominal mass, vomiting, abdominal pain and bloody stool. Palpable abdominal mass was the most common finding seen in all patients. Ileocolic intussusception was the most common type seen in these children at operation.

Gastro-esophageal reflux disease presented with vomiting, regurgitation, failure to thrive and history of recurrent pneumonia. The most frequent symptoms found in these children with GERD was failure to thrive and recurrent pneumonia. Infants with recurrent pneumonia had more refluxes than those without respiratory symptoms.

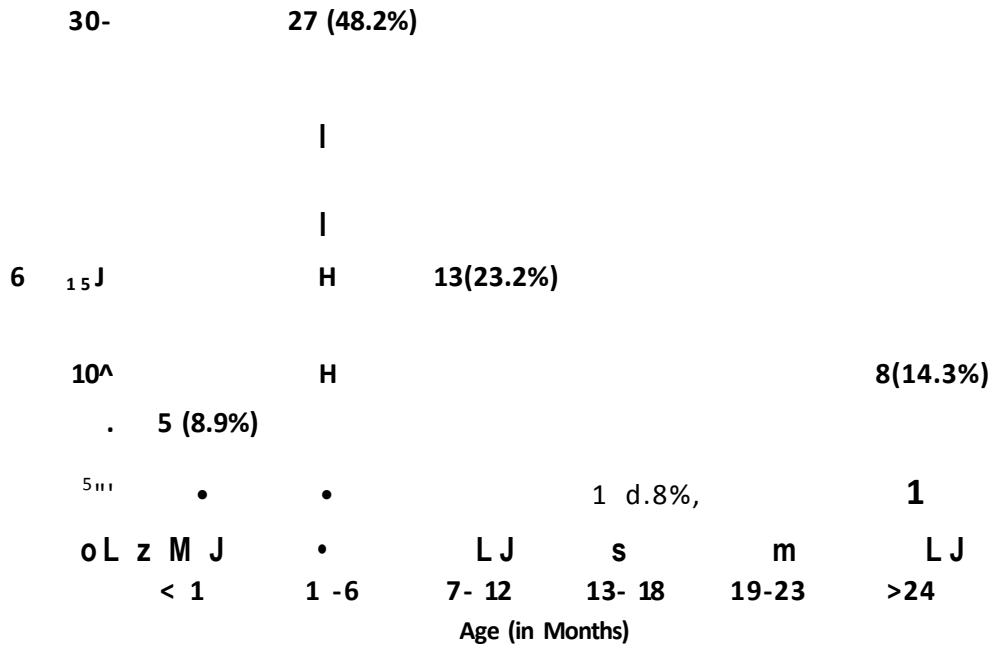
Hypertrophic pyloric stenosis presented with a history of persistent projectile nonbilious vomiting and associated clinical findings of weight loss with dehydration. All of them 7 were male patients with age range (3 - 8 weeks) and mean age of 5 weeks.

Acute appendicitis presented with nonspecific symptoms like nausea and vomiting. The specific symptom for sonography was localized right lower quadrant pain. Infants who presented with failure to pass stool and abdominal distension were found to have ileal atresia. One of the children was found to have enteric duplication cyst of which abdominal distension was also a clinical feature.

In this study 6 Children were confirmed to have normal sonography findings. These children presented with blood stool and vomiting. The clinician requested ultrasound study to rule out intussusception. No further radiological study was requested and the six children were managed based on clinical findings as acute gastroenteritis with dysentery.

i

Figure 2: Distribution by Age (in Months) n = 56

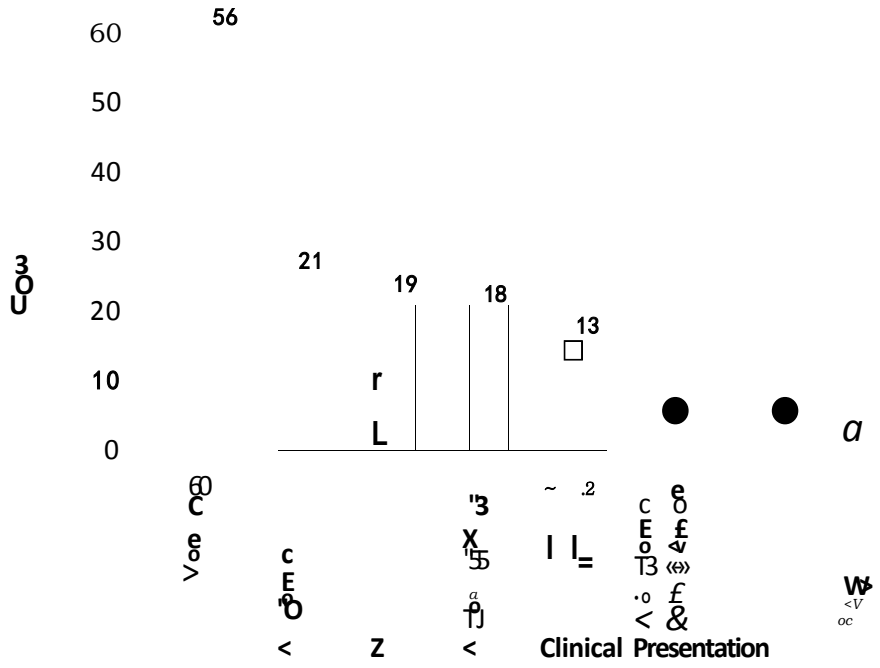


The mean age was 17.5 months, median of 6 month; STD was 36.0, with a range of 0.2 to 144 months.

Table 1

Age in month	Sex	
	Male, n (%) i	Female, n (%)
< 1	2 (5.6) |	3 (15.0)
1 - 6	17 (47.2) j	10 (50.0)
7 - 1 2	7 (19.4)	6 (30.0)
13- 18	1 (2.8) j	0
£24	7 (19.4)	1 (5.0)

Figure 3: Clinical Presentation



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

Table 2

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

Figure 4: Pathology

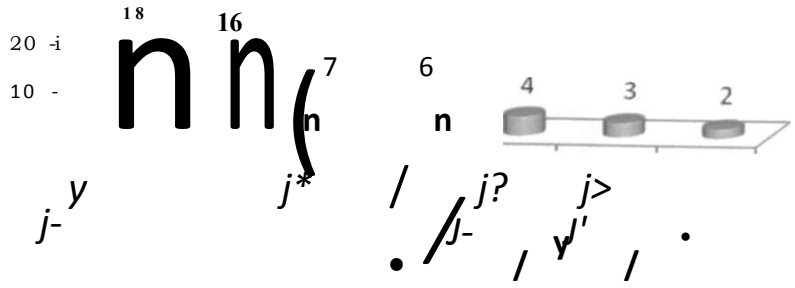


Figure 5: Distribution by Age Status (n = 56)

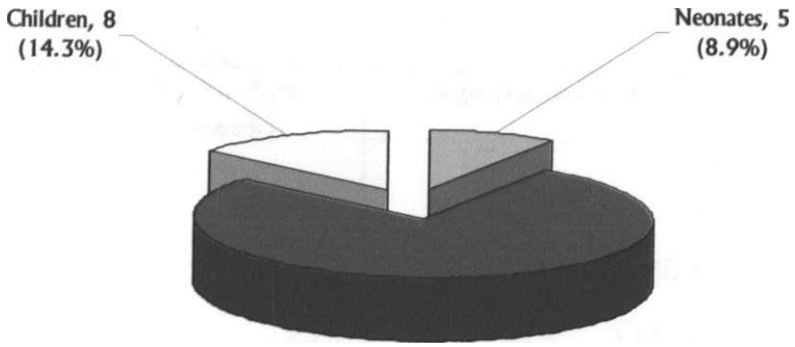


Figure 6: Distribution by Sex (n = 56)

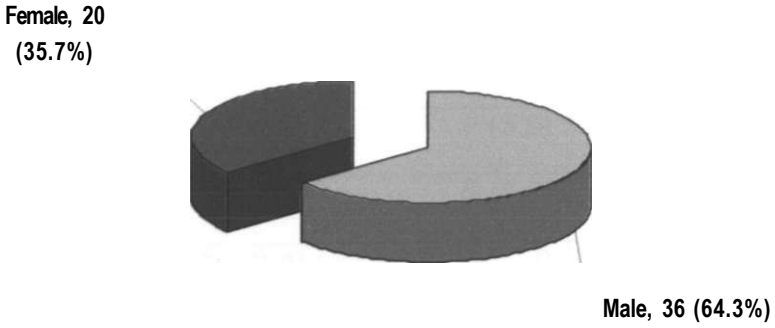


Table 3: Association between Age vs. Pathology

Pathology	**Mean Age (Week)**	**Age (in months)**		**p-value**
		< 12, n (%)	**^ 12, n | (%)**	
GER	43.6	12 (27.9)	4(30.8)	0.841
Intussusception	25.1	15(34.9)	3(23.1)	0.424
Jejunal/Ileal atresia	1.5	3 (7.0)	0	
HPS	5.9	7 (16.3)	0	
Acute Appendicitis	564.0	0	4 (30.8)	
Enteric duplication cyst	124.0	0	2 (3.8)	

There was no significant association between the age of the patient and the pathology($p > 0.05$)

Table 4: Sonography findings and sex frequency

Finding and sex frequency	Sex		Total, n (%)	P-value
	Male, n (%)	Female, n (%)		
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($p > 0.05$) except for hypertrophic pyloric stenosis.

Table 5: Clinical presentation and sonographic findings

Clinical Indication	Sonographic Findings						
	Normal	Gastroesophageal 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 6: Ultrasound finding and surgical outcome in intussusception.

Ultrasound finding	Surgical outcome for intussusception	
	Ileo-caecal	Ileo-ileal
Intussusception	12	6

Table 7: Ultrasound and barium swallow correlation in gastroesophageal reflux.

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

Table 8: Ultrasound finding and surgical outcome in hypertrophic pyloric stenosis

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

Table 9: Ultrasound finding and surgical outcome in acute appendicitis

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

Table 10: Ultrasound finding and surgical outcome in duplication enteric cyst

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

MLUSTRATIONS

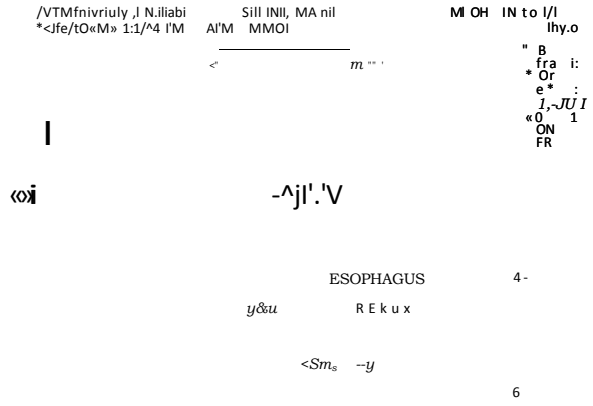


Figure 7: 5-month-old female presented with vomiting, failure to thrive and recurrent pneumonia. Longitudinal U/S scan shows severe gastro-esophageal reflux (GER).

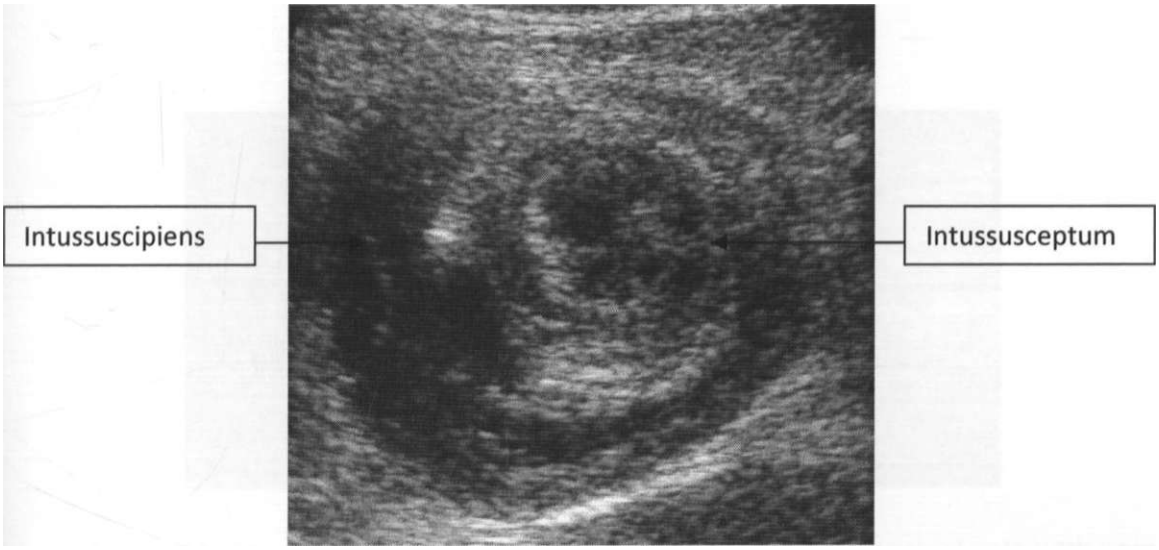


Figure 8: Six months female infant presented with vomiting and palpable mass

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 9: Six months female infant presented with vomiting and palpable abdominal mass. Longitudinal ultrasound of an intussusception—the pseudokidney sign. Trapped mesenteric fat in the central echogenic area resembles fat in the renal sinus.

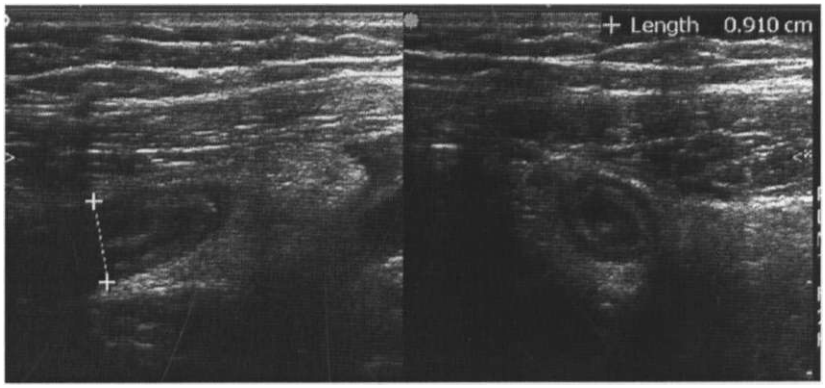


Figure 10: 12 years old male child presented with acute abdominal pain with vomiting. Longitudinal and transverse images shows swollen appendix which is non-compressible and measures 9.1 mm in diameter.

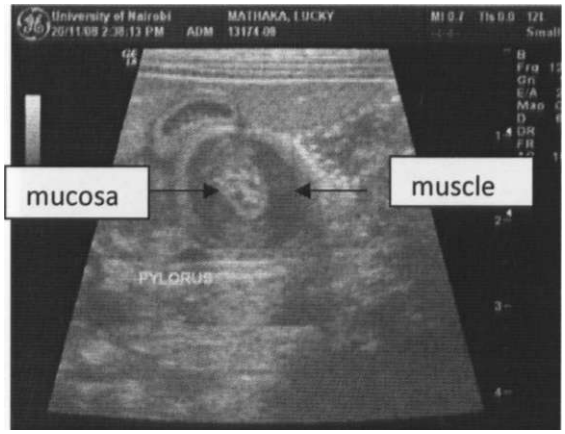


Figure 11: Hypertrophic pyloric stenosis. Seven weeks old male infant presented with nonbilious projectile vomiting. Longitudinal sonogram shows elongated pyloric canal with thickened hypoechoic muscle. Transverse sonogram of the pylorus of the same patient with central echogenic mucosa and surrounding hypoechoic muscle.

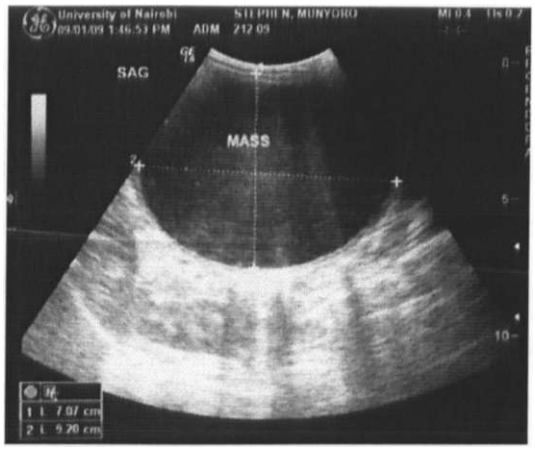


Figure 12: 5 year old male child presented with vomiting and palpable abdominal mass, transverse scan through the lower abdomen shows an anechoic mass with an echogenic inner lining of the mucosa. Enteric duplication cyst.

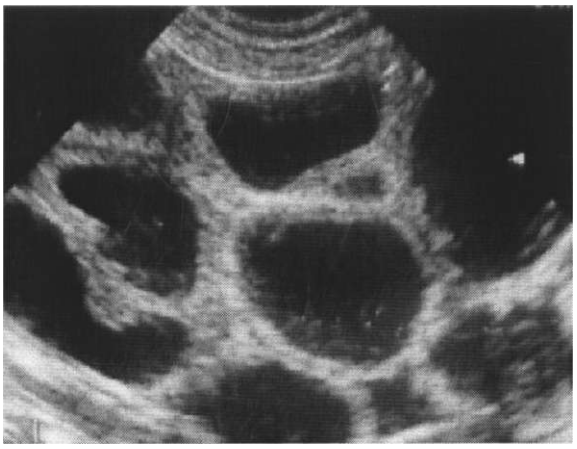


Figure 13: Small bowel (ileal) atresia: transverse scan of the lower abdomen shows dilated, echogenic fluid-filled small bowel loops. Ileal atresia was found at operation.

DISCUSSION

The findings in this study shows that abdominal sonography has diagnostic value in the evaluation of the vomiting child and differentiating the causes of vomiting in children. In this study 18(31.1%) children were diagnosed as having intussusception, 16(28.5%) were diagnosed with gastro-esophageal reflux disease, 7 (12.5%) had hypertrophic pyloric stenosis, 4(7%) had acute appendicitis, 3(5.3%) had jejunal/ileal atresia, and 2(3.5%) were seen with enteric duplication cyst. 6 children had normal findings. In a study done by Rollins and others on the value of ultrasound in differentiating causes of vomiting, showed 44 children had pyloric stenosis, 44 children had gastro-esophageal reflux disease, 3 had anatomical abnormalities of the digestive tract, and 9 were reported normal.[9] The discrepancy between our study and that of Rollins could be attributed by age limit of the patients and different study population. The age limit in Rollins study was up to 3 months, while in this study age limit was up to 12 years. Hypertrophic pyloric stenosis is more common in whites than in black population.[25]

In this study the most common finding was intussusceptions seen in 18 children out of 56 (32.1%) (table 4). Of these children 11 were males, 7 were girls (1.6:1). A male predominance of patients presenting with intussusception was consistently reported in studies from the USA and Canada by Murphy et al 2001[35]. Other studies from the Eastern Mediterranean also report a male predominance of patients presenting with acute intussusceptions. The male to female ratio ranging from 1.4:1 to 4:1.[35] The average age of children found to have intussuception in this study was 6.3 months and the majority of them (83.3%) were under 12 months (table 3). Isdale et al 1986 and Adebamowo et al 2000 studies revealed that the majority of cases with intussusception occurred in infants less than 1 year of age; peak incidence occurred between 3 and 8 months of age.[35] Yet in another study done in North America by Murphy et al 2001, showed that the mean age of presentation was 6.4 months.[35]

The common and specific clinical presentation was palpable abdominal mass, which was present in 15 out of 18 patients (table 5), however nonspecific symptoms, including vomiting, abdominal pain, blood stain stool and/or irritable crying were also presented. Eastern Mediterranean study on intussusception found that the presence of an abdominal mass was

commonly reported in patients presenting with intussusception throughout this region. In Qatar an abdominal mass was identified in two-thirds of patients.[35]

In this study the predominant site of acute intussusception was ileo-caecal, found in 12 out of 18 children (68.7%) at operation. The other six were found to have ileo-ileal intussusceptions. These findings are supported by studies done in Africa, Europe and America. In Africa twenty-five studies have reported a description of the anatomical location of intussusception. In the majority of these studies the predominant site in infants under 1 year of age was ileo-colic or ileo-caecal.[35] In Central and South America studies Ileo-caecal intussusception was detected in over three-quarters of infants.[35]

In the present study color Doppler sonography was also done to assess blood flow in the intussusceptum to determine the viability of the bowel and to assist in the prediction of reducibility of intussusception by pneumatic reduction. In this study the flow was detected in 10 out of 18 (55.5%) patients on Doppler study. In the previous studies, Doppler sonography for the detection of blood flow in intussusception has been reported as a promising predictor of bowel viability and hydrostatic reducibility.[13] A study done in Chile by Montes et al in 2000, revealed that barium enema reduction was successful in 73% of patients and air reduction was successful in 100%.[35] In these children non-surgical treatment for intussusception could have been attempted, but the current practice at Kenyatta National Hospital is by surgical reduction.

Another common finding in this study was gastro- esophageal reflux disease(GERD), which was seen in 16 patients (28.6%) of the sonography performed. 10 of them were male and 6 were female table 4. In a study done in University of Tehran by Fallahi et al showed that 67% of the patients who presented with gastro-esophageal disease (GERD) were male.[10] The mean age was 10 months. 12 patients out of 16(75%) were under 1 year and 4 patients were aboveone year (table 3). Study done by the same author revealed the mean age was 4.7 years.[10] The discrepancy between my study and that of Fallahi could be attributed by age limit and geographic location of the study population. The age limit for his study was 14 years.
The present study found that 11 out of 16 presented with gastro-esophageal disease were Preterm baby born with low birth weight. A study done in Italy by Pazzati and others in 2007,

on 31 premature infants using ultrasound showed twenty-one patients (67.7%) had significant gastro-esophageal reflux, ten newborns (32.3%) did not have significant gastro-esophageal reflux.[36]

The most frequent symptoms found in these children with GERD was failure to thrive seen in 13 out of 16 (81%) patients and recurrent pneumonia seen in 12 out of 16(75%) patients. Agostino et al and others in 2005 showed that recurrent pneumonia and subsequent failure to thrive is frequently linked with gastro-esophageal reflux disease.[37] Respiratory diseases and gastro-esophageal reflux disease have long been linked in childhood by both physiopathological and epidemiological studies, and the complex interplay between these two frequent clinical conditions is still under debate.[37] Same author documented that, visualization of reflux by ultrasound is limited to the distal esophagus, this results suggest the possibility that the involvement of the respiratory tract might be partly due to a greater chance for micro-aspiration of refluxed materials reaching the proximal esophagus.[37]

In the previous studies it was documented that, the use of color Doppler ultrasound increase the sensitivity of detecting gastro- esophageal reflux.[38] In my study only gray scale was used for all patients. It was found that the interpretation of reflux with gray scale was easier than using color Doppler. Also no local experties for interpretation of gastro-esophageal reflux by using color Doppler sonography.

In this study 7 out of 56 patients were diagnosed to have hypertrophic pyloric stenosis. All of them were male patients (table 4). In a study done in Belgrade by Smoljanic and others, showed that 48 (87.3%) were boys and 7 were girls (12.7%).[12] The reasons that in my study could not pick female patient could be attributed by sample size which was 107 in Smoljanic study, and male gender has been shown to be strongly associated with hypertrophic pyloric stenosis. The age range was (3 - 8 weeks) and mean age of 6 weeks (table 3). Same author this study showed that, patients were aged $2^1/_2$ to $10^1/_2$ weeks (average about 6 weeks).[12] The discrepancy in age distribution could be due to different study population and awareness of medical care. All patients presented with history of nonbilious projectile vomiting. This study revealed that toe classic "olive" of hypertrophied pyloric muscle was palpated in only 4 of them (57%). In a study done in Tehran by Mehdi and others showed that the clinical olive sign was seen in 33.3%

of cases.[39] The discrepancy between our study and that of Mehdi could be due to fact that in our setting patients present at late stage when the "olive" is bigger; with late stage presentation, the incidences of dehydration, metabolic alkalosis, weight loss, and failure to thrive as manifestations of hypertrophic pyloric stenosis increases dramatically. Consequently, infants who present at late stage are malnourished such that abdominal wall fat is absent which increase the possibility for palpation of the mass.

In the present study pyloric length was between 16-28 mm, and muscle thickness was 3-6mm. These findings are similar to that of Mehdi in Tehran which showed Pyloric length 16-28 mm muscle thickness 3-6.50 mm.[39] Stunden et al showed that pyloric length was the only precise indicator of hypertrophic pyloric stenosis.[2] Pylorospasm is documented to be a common finding in this age group.[25] However in this study no case of pylorospasm was picked, all cases were typical for pyloric stenosis. This could be due to the small sample size. Mehdi in their study also documented that three cases had pyloric thickness between 2-3 mm without morphologic signs of pyloric stenosis (pylorospasm).[41] Therefore follow up ultrasound and observation was done. During two weeks pyloric thickness decreased below 2mm.

In the present study only 4 out of 56 patients were diagnosed with acute appendicitis. Three were male and one was female. The mean age was 11 years and all of them presented with non specific abdominal symptoms and vomiting. The visible pathology was seen in the right lower quadrant arising from the cecum. No appendicolith, lymph node or periappendiceal abscess was visible for all patients. In a prospective study over nearly 9 years involved 1285 children aged 1-15 years (m=514, f=771), the prevalence of proven acute appendicitis was remarkably low (9%), however in diagnosis of acute appendicitis in childhood US achieves a sensitivity of 92%, specificity of 98%.[40] In many cases of acute appendicitis, the diagnosis is made clinically based on classic signs and symptoms. As acute appendicitis is not common in this age group, this may explain the low detection rate in our study.[41]

In this study two cases were found with enteric duplication cysts. One was male aged 5years the other was female aged 2years. Both of them presented with abdominal distension and

intermittent vomiting. Cheng et al while working in Canada reported two cases of enteric duplication cyst. Both cases were female aged 5month and the other was 3years.
The clinical presentation of the patient reported by Cheng was abdominal distension and intermittent vomiting, and the diagnosis was made based on sonographic features.
The clinical presentation findings of Cheng correlate with our findings in this study, however the discrepancy in age distribution could not be explained in this study. State of medical care and set up aid in Canada could be a factor.

In this study 3 neonates were diagnosed with ilea atresia. One was male aged 11 days and two were female aged 12 and 8 days respectively. Clinically they presented with bilious vomiting, abdominal distension and failure to pass stool. Initial radiological investigation was plain radiographs of the abdomen, which were not diagnostic. Sonography in these children showed multiple markedly dilated fluid-filled echogenic intestinal loops with changeable shapes and positions secondary to more active peristalsis than usual. Ileal atresia was suspected and was confirmed at operation, thereby underlining the crucial diagnostic role of abdominal sonography in intestinal disorders.
It has been reported that Jejunal and ileal atresia have specific sonographic patterns in obstetric ultrasound (echogenic bowels, enlarged stomach, dilated bowel and polyhydramnios), allowing specific prenatal diagnoses in most affected fetuses. In these three neonates their prenatal ultrasound could not be traced.[42]

The children diagnosed with intussusception underwent explorative laparotomy, and our preoperative diagnoses were compared with the surgical outcome. 12 children found with ileo-caecal intussusception, and 6 children had ileo-ileal intussussception(table 6). Surgery confirmed the preoperative diagnosis in all cases. However the level of intussusception could not be determined by ultrasound. A study done by El Fortia et al and others showed that, thirty patients were diagnosed with intestinal intussusception using the ultrasound sign, after surgery all cases confirmed to have intussusception.[43] This finding showed that ultrasound is very reliable in diagnosing intestinal intussusception.

Both barium swallow and ultrasound examinations have a part to play in the detection of patients with gastro-oesophageal reflux disease. In this study there was a high rate of detection of gastro-oesophageal reflux by ultrasound in comparison with the barium swallow examination (table 7). 2 patient out of 16(12.5%) barium swallow did not show any reflux. There are two possible reasons for this. Firstly, the patient's normal feed was used, which may be more physiological. The feed is less viscous than the barium mixture and may portray the true course of events. Secondly, long periods of continuous scanning may be employed by ultrasound, thus increasing the likelihood of detecting the intermittent nature of the reflux, which may be missed by short periods and periodic of fluoroscopic screening. In one study done by Naik and others in England reported that,15% of cases of gastro-esophageal reflux were missed by barium swallow examination while ultrasound could detect all refluxes.[44] However barium examination detects abnormalities not shown by ultrasound namely peptic oesophagitis, stricture formation, and incoordination of swallowing.

Seven cases documented having hypertrophic pyloric stenosis in this study showed typical features on ultrasound examination, that is pyloric length between 16-28mm and muscle thickness between 3-6mm. All seven cases confirmed at surgery (100%) (table 8). Mehdi et al in his study, using muscle thickness 3mm or more as diagnostic for hypertrophic pyloric stenosis, showed that 74 patients with sonographic features of pyloric stenosis, confirmed all to be positive at surgery(100%). Similar findings was documented by Marta Hernanz- Schulman study in which sensitivity, specificity and accuracy of ultrasound were 100%.[39,45]

Our study showed only 4 out of 56 patients were sonographically diagnosed with acute appendicitis. Clinical and ultrasound findings were correlated with laparotomy findings and pathological outcome. 3 of 4(75%) patients had positive appendicectomy, and 1 of 4(25%) had negative appendicectomy(table 9). In a prospective study involved 200 patients, laparotomy done based on clinical criteria alone for acute appendicitis showed 22.5% negative appendicectomy. In the same study involved 200 patients laparotomy done based on clinical criteria and ultrasound finding for acute appendicitis showed 4.7% negative appendicectomy.[46] This study proved that routine ultrasound examination by graded compression technique can

improve the diagnostic accuracy and adverse outcome. The discrepancy raised between my study and this one could be attributed by small sample size and age limit.

Enteric duplication cyst has characteristic sonographic feature that is echogenic inner mucosal layer and hypoechoic muscular layer(gut signature sign). The two cases seen in this study had similar feature. Subsequent computer tomography was done in these two patients findings were suggestive of enteric duplication cyst with differential diagnosis of enteric cyst and omental cyst. Surgical findings confirmed the diagnosis of enteric duplication cyst in all two cases(table 10). Cheng et al reported diagnosis of two cases of enteric duplication cysts based on sonographic feature (gut signature sign).[20] The diagnosis was confirmed by surgery and histology, however in our case the histology was not done. Also Godfrey et al reported a case of 4 days old girl with abdominal mass where sonography revealed enteric duplication cyst. The patient underwent laparotomy and a left-sided ovarian cyst was found which had undergone torsion.[47] This case report showed that the wall characteristics described undoubtedly remain a reliable indicator of an enteric duplication cyst, they cannot be considered pathognomonic. Sonographic visualization of the cyst with gut signature sign increases the specificity in making the sonographic diagnosis of duplication cyst.

CONCLUSION

Ultrasound is a useful tool in investigating the child with vomiting and may provide a differential diagnosisfor many of the more common childhood pathologies.

Moreover its favorable cost, availability, flexibility, and user friendliness, as well as its high temporal and spatial resolution further enhance the utility of sonography in most of the pediatric clinical disorders.

Gastro-esophageal reflux is an intermittent phenomenon; during fluoroscopic screening the child gets a lot of radiation while radiologist waits for the reflux to occur. This study will help in the daily imaging practice of evaluating gastro -esophageal reflux disease with the use of ultrasound, particularly in those children with respiratory complications due to gastro-esophageal reflux. This will reduce radiation dose to young growing children.

STUDY LIMITATIONS

The major limitation of Gl tract sonography is the impaired visualization of lesions due to interposed bowel gas. However, its advantages (lack of radiation, availability, noninvasiveness, and accuracy in some diseases, such as HPS and duodenal atresia) outweigh its limitations in children.

Children with suspected necrotizing enterocolitis (NEC) were not investigated in this study due to inavailability of portable ultrasound. These children were very sick, unstable and could not be transported to the ultrasound room.

RECOMMENDATIONS

Ultrasound should be the first imaging modality to evaluate the vomiting child.

Increase the applicability of sonography at the bedside in critically ill patients through the acquisition of high resolution portable ultrasound equipment.

There is need for more training on non surgical reduction of intussusception.

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Appendix

Appendix 1: Questionnaire

Appendix 2: Consent form in English

Appendix 3: Consent form in Swahili

PATIENT'S BIO DATA

Study No:

U/S No:

IP/OP No:

Age of patient: Actual age—-

- Neonates(0-29days) |__[Infants(lmonth-2years)
- Children (>2years-12years)

Gender: Male Female-

CLINICAL PRESENTATION

I__I Vomiting I__I Regurgitation

- Abdominal pain |__| Abdominal distension

|__| Abdominal mass I__I Failure to thrive

|__| Recurrent pneumonia • Other

ULTRASOUND FINDINGS

PATHOLOGY

- GER I__I Hiatal hernia
- Peptic ulcer disease • HPS
- Intussusception • Acute appendicitis
- Duodenal atresia • Midgut malrotation

I__I Jejunal / Ileal atresia Enteric duplication cyst

- NEC |__| Acute pancreatitis

I__I Mesenteric lymphadenopathy • Other

NORMAL FINDING

CONTRAST STUDY FINDING (if available)

LIMITATIONS

|___| Inadequate patient information from the clinicians.

Excessive bowel gas.

- Inco-operative child.

Other

Appendix 2: Consent form.

Dr. Salim I.S; a Master of Medicine student at the Department of Diagnostic Imaging and Radiation Medicine, University of Nairobi. Is doing a study on the role of ultrasound imaging in evaluating the vomiting child. Your child has been selected to participate. Please note that the information you give and the examination findings will be handled with utmost confidentiality.

The child's name will not be included in data collection form, but the ultrasound number will be used.

Child's parent/guardian, I have been given the opportunity to ask questions concerning the study, and the questions have been answered to my satisfaction.

I understand that I am not obliged to participate, and that I may at any time during the course of the study revoke the consent for the study without any prejudice as the child's parent/guardian.

Date

Child's file/x-ray no

I certify that the child's parent/guardian has understood the nature of the study and

has consented to fully participate.

Dr. Salim Ismail

Signature

Date

Appendix 3: Kibali cha kushiriki katika utafiti.

Daktari Salim Ismail; ni mwanafunzi katika chuo cha udaktari, Chuo Kikuu cha Nairobi. Anafanya utafiti kuhusu thamani ya kutumia ultrasound kuwachunguza watoto wanaotapika, na naomba uniruhusu kumshirikisha mtoto wako katika utafiti huu.

Habari utakayotoa au ile itakayopatikana katika uchunguzi, itakuwa siri na kutumika tu katika utafiti huu. Jina lake halitohusishwa, bali nambari yake ya uchunguzi ndiyo tu itakayo tumika.

Mzazi wa mtoto/mlezi: Nimepewa nafasi ya kukuuliza maswali ambayo yanahusu utafiti huu na mtoto wangu, masuali yamejibiwa kikamilifu.

Naelewa kwamba sio lazima nihusike katika utafiti huu, na pia naweza kubadili nia yangu kuhusu kuendelea kushiriki.

Ahsante sana kwa ushirikiano wako.

Tarehe

File ya mtoto/numbari ya x-ray

Nathibitisha kwamba mzee wa mtoto amefahamu na kukubali kushiriki katika utafiti huu.

Daktari Salim Ismail

Sahihi

Tarehe