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Value of ultrasound in the assessment of acute abdomen in the pediatric age group

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Abstract

Background & objectives: Acute abdominal pain in pediatric age groups is the most common presentation in an emergency room. The study aimed to diagnose cases of pediatric acute abdomen based on the ultrasound findings and determine the value of ultrasound in decision making.

Methods: A cross-sectional prospective study was conducted in the Raparin hospital in Erbil city/Iraq from Feb 2021 to June 2022. A convenience sampling method was used, and 200 patients who complained of acute abdominal pain were included in the study. The questionnaire was designed for data collection. A specialist pediatrician clinically examined the children; investigations were done then referred to the radiology department for an ultrasound examination.

Results: The ages of the involved cases ranged from one month to 15 years. Among them, 56.0% were males compared to 44.0% females, with a male to female ratio of 1.27:1. Regarding provisional clinical diagnosis of the patients, 60.0% presented with gastrointestinal problems among them, 39.2% had Gastroenteritis, 28.3% had appendicitis, 5.8% intestinal obstruction, 4.2% appendicular mass, 1.7% perforated appendix with the same percentage for intussusception, 23.0% suffered from mesenteric lymphadenitis, 7.0% had genitourinary symptoms and 6.0% were presented with non-specific symptoms. There was a highly significant association between the management plan and the surgical outcome of the cases, where the ultrasound was diagnostic among the majority (95.3%) of the operated patients.

Conclusions: Ultrasound helped in earlier diagnoses of acute abdominal conditions and reduced radiation exposure to the pediatric age group.

Key words: Acute abdomen; Children; Emergency room; Ultrasound.

Introduction

Acute abdominal pain in pediatric age groups can be “defined as syndrome induced by a wide different variety of pathological conditions and is the most common presentation in an emergency room. It is a broad spectrum of surgical, medical, and gynecological disorders. Some cases do not need surgical interventions like gastroenteritis, constipation, and functional digestive problems. However, other conditions require emergency surgery because of their life-threatening risks. It constitutes 50% of admission to the emergency room.[1] There may be distension, rebound rigidity, guarding of the abdominal wall, and diffuse tenderness on examination. Young children cannot express themselves; therefore, diagnosis is difficult. Moreover, cases of acute abdomen in different age groups among pediatric patients will have other etiologies, laboratory findings, and ultrasound images. There are seasonal variations among the acute abdomen in pediatric age groups due to the high incidence of infections in the rainy season.[2] Some studies classified acute abdominal conditions in children into

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traumatic and non-traumatic based on the etiologies.[3] Acute appendicitis is the most common cause of acute abdomen. The presentation in adults is right lower quadrant pain, but there are different signs in children. The bowel sounds will be absent in children, but the "psoas", "Rovsing" signs, and "obturator", will be positive.[4] The laboratory tests lacked accuracy in diagnosing acute appendicitis; therefore, the ultrasound is considered the first-line approach in investigating cases. The incidence of appendicitis varies between males to females. The gastrointestinal emergency among children and neonatal patients causes a dilemma for pediatricians and is usually presented with characteristic ultrasound features. The diagnosis of painful abdominal conditions is challenging, especially in children. Taking history from a child is a difficult task, and many extra-abdominal causes make it difficult to reach a diagnosis.Using ultrasound made it easy to get the diagnosis and manage the patients accordingly. Abdominal pain could be acute appendicitis, hypertrophic pyloric stenosis, and intussusceptions. X-rays of the abdomen in cases of intussusception may be undiagnostic, while the ultrasound features are "pseudo-kidney sign", "sandwich sign", and "hair-fork-sign".[6] In appendicitis, the US features are the presence of "appendicolith foci", "blind-ended tubular structure", "uncompressible"[7] and "fluid-filled".[8] Among the features of pyloric stenosis are the "nipple sign", "double-track sign, and "doughnut sign". Girls between 11 and 15 may present with gynecological causes for acute abdominal pain (10%). The most common are "Graafian follicle" rupture and torsion of ovarian cysts.[9] Gall bladder diseases form about 0.5% of the cases, and intestinal obstruction was reported in girls below two years of age as studies revealed.[9] This study aimed to diagnose cases of acute abdomen based on the ultrasound findings and determine the value of ultrasound as an instrument in decision making. Specific objectives were to find the frequency of acute abdominal cases by ultrasonography in the emergency room, the diagnostic accuracy of ultrasound among pediatric age groups, and the role of ultrasound in the intervention pathway steps.

Patients and methods

A prospective study was conducted in Raparin hospital in Erbil city/Iraq from Feb 2021 till June 2022. After ethical approval from Hawler Medical University/ College of Medicine, A cross-sectional convenience sampling method was used, and 200 patients who complained of acute abdominal pain (patients will usually present with sudden abdominal pain for more than six hours in previously healthy patients) were included in the study. The questionnaire was designed for data collection. A specialist pediatrician clinically examined the children, and investigations were done then referred them to a radiology department for an ultrasound examination. We approached each patient's parent, assured confidentiality, and informed verbal consent was taken. Those children who needed admission were admitted to the pediatric department, and a detailed investigation, examination, and ultrasound were performed. We collected the data through direct interviews with parents. The data included age, duration of the pain, gender, and history of previous episodes. The patients were divided by age groups, using the same categorization used by Baker.[10] Neonates, from birth to 2 months; infancy from 3 months to 12 months; 1-5years preschoolers; middle childhood from 6 to 11 years; early adolescence from 12-18 years.[10, 11] The child was asked to show the site of the pain.[12] Accordingly, a direct and focused ultrasound examination was done; a radiology specialist thoroughly examined the liver, spleen,

pancreas, appendix, gallbladder, intestine, kidneys, urinary bladder, uterus &ovaries. The 3.75 MHz (convex) and 7.5 MHz (linear) transducers from voluson E6 of GE health care are used. The quality of images was assessed and then examination by color Doppler ultrasound was done to assess organ perfusion.[13, 14] We reviewed the ultrasound images to reach the final diagnosis. X-ray findings, laboratory results, and type of treatment received, whether surgical or medical, were included in the data collection. Exclusion criteria included children with a previous history of the same abdominal pain and children with a history of trauma and cancer case. Statistical analysis is done based on the difference in the site of pain, laboratory results, ultrasound images, and management of the patients were all included in the analysis. The SPSS program (Statistical Package of social science version 25) was used. Chi-square and Fisher's exact were calculated, and a p-value ≤ 0.05 was considered significant.

Results

In this cross-sectional study, 200 children with acute abdomen were involved; their ages ranged from one month to 15 years with a mean± SD of 6.868± 3.634 years. Among them, 56.0% were males compared to 44.0% of females, with a male to female ratio of 1.27:1 Figure (1) and (2)

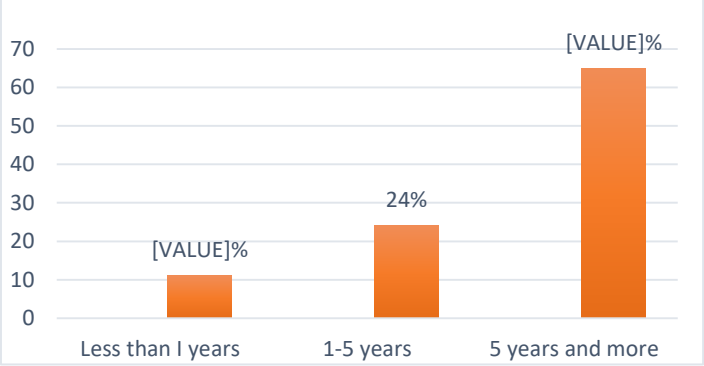

Figure (1): Age groups of the patient

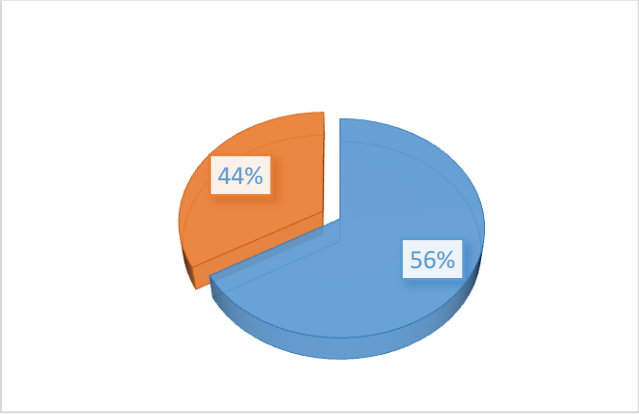

Figure (2): Gender of the patients

Regarding provisional clinical diagnosis of the patients, 60.0% were presented with gastrointestinal problems, 23.0% suffered from mesenteric lymphadenitis, 7.0% had genitourinary symptoms, and 6.0% were presented with non-specific symptoms Table (1).

Table (1): Provisional clinical diagnosis of the patients on admission

Diseases	Frequency	%
Non-specific	12	(6.0)
GIT problems	120	(60.0)
Mesenteric lymphadenitis	46	(23.0)
Genitourinary	14	(7.0)
Hepatobiliary	5	(2.5)
Gynaecological	3	(1.5)
Total	200	100.0

Concerning the site of abdominal pain among the patients, 42.5% suffered from right iliac fossa pain, 35.5% had generalized abdominal pain, and 16.5% had central abdominal pain Table (2).

Table (2): Site of the abdominal pain during admission

Site of abdominal pain	Frequency	(%)
Generalized	71	35.5
Central	33	16.5
Right iliac fossa pain	85	42.5
Upper right	4	2.0
Loin pain	4	2.0
Left iliac fossa pain	1	0.5
Suprapubic	2	1.0
Total	200	100.0

Among the main gastrointestinal presentations of the patients, 39.2% presented with gastroenteritis, 28.3% with a cute appendicitis, 5.8% with intestinal obstruction, and 4.2% of them showed signs of appendicular mass. Table (3).

Table (3): Clinical Gastrointestinal presentation of the patients on admission

Diseases	Frequency	(%)
Appendicitis	34	28.3
Appendicular mass	5	4.2
Perforated appendix	2	1.7
Gastroenteritis	47	39.2
Intestinal obstruction	7	5.8
Intussusception	2	1.7
Suspected appendicitis	22	18.3
Pancreatitis	1	0.8
Total	120	100.0

Regarding the duration of the abdominal pain, around 52.0% had 1-2 days, 36.5% had less than one day, and the other 11.5% had three days or more Figure (3).

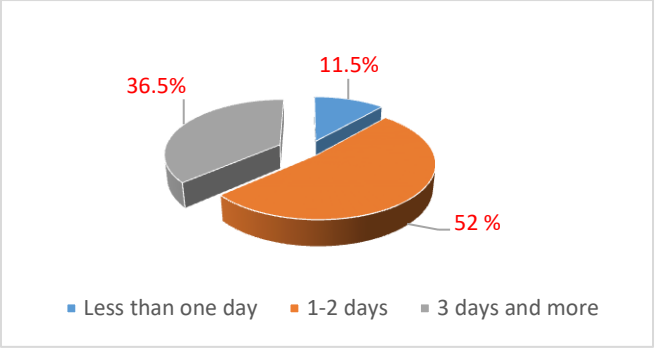

Figure (3): Duration of pain in days

The main abdominal ultrasound finding of the patients was normal in 35.5%, 24.5% showed mesenteric lymphadenitis, 12.0% showed acute appendicitis, and 10.5% showed dilated loops due to gastroenteritis Table (4). About the management plan of the patients, 74.5% were treated with medications, 23.5% underwent surgery, and only 2.0% had not required any treatment Figure (4).

Table (4): Ultrasound findings of the patients

Findings	Frequency	(%)
Normal	71	35.5
Appendicitis	24	12.0
Gastroenteritis	21	10.5
Intussusception	4	2.0
Mesenteric adenitis	49	24.5
Renal stone	4	2.0
Intestinal obstruction	5	2.5
Perforated appendix	2	1.0
Appendicular mass	4	2.0
Cystitis	8	4.0
Pancreatitis	1	.5
Cholecystitis	4	2.0
Torsion ovary	3	1.5
Total	200	100.0

There was a highly significant statistical association (P= 0.001) between the management plan and the surgical outcome of the cases, where the ultrasound was diagnostic among the majority (95.3%) of the operated patients Table (5).

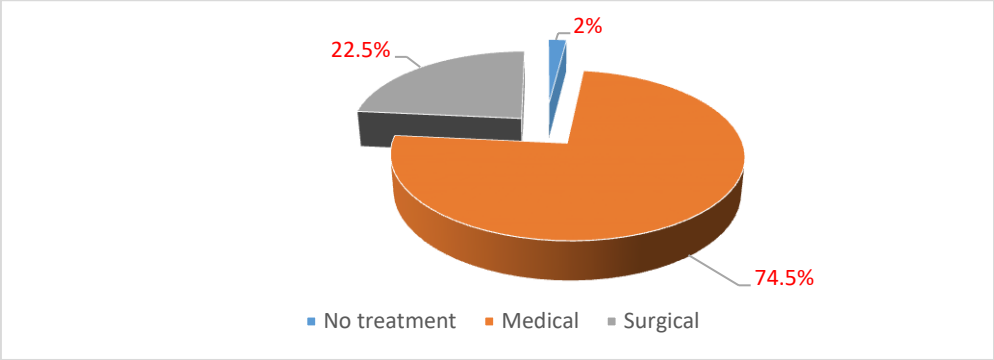

Figure (4): Management plan of the patients

Table (5): Association of the management plan to the surgical outcome of the patients

Variables	Management plan			p value*
	No treatment	Medical	Surgical	
Value in surgical cases				0.001
Non-diagnostic	4 (2.7)	141(95.9)	2 (1.4)	
Diagnostic	0 (0.0)	2 (4.7)	41(95.3)	
Supportive	0 (0.0)	0 (0.0)	4 (100.0)	
False-negative	0 (0.0)	6 (100.0)	0 (0.0)	

*: Fischer's exact test

Table (6): Distribution of the studied sample by sensitivity, specificity, positive predictive value, and negative predictive value

Cases	Sensitivity	Specificity	*PPV	**NPV
Acute cholecystitis	52%	80%	83%	45%
Acute appendicitis	85%	97%	92.5%	86%
Appendicular mass	96%	93%	85%	88%
Intestinal obstruction	89.7%	93.0%	87.8%	84.3%
Renal stone	67%	77%	82%	87%
Intussusception	80.7%	52.7%	81.8%	50.88%
Cystitis	87.1%	98.1%	94.4%	95.4%
Perforated appendix	42.2%	90.4%	45.8%	89.0%
Ovarian torsion	79%	76%	69%	70%

***PPV:** Positive predictive value ****NPV:** Negative predictive value

Discussion

Ultrasound is an irreplaceable imaging technique in the assessment of pediatric acute abdominal pathologies; it can bring an immediate evaluation of acute abdominal conditions without the need for sedation or contrast in skilled hands.[6] One study done by Banerjee R, Prasad A, Gupta S reviewed acute abdomen in non-traumatic cases in the emergency department 68.7% had inflamed acute appendicitis followed by intussusception 41.9%,[1]our study reported lower figures for acute appendicitis12% and intussusception 2%. The low rates reported could be due to the design & time of the study. Imaging cases at an early stage will help in reducing morbidity and mortality.[5] Ultrasound is beneficial in diagnosing young patients with ovarian torsion and appendicitis due to the non-ionizing nature of this technique.[15]The liver, spleen, kidneys, gallbladder, and bowel all could be examined by ultrasound, and no contraindications were found for this technique. It requires a trained radiologist for the interpretation of scanning images. In the current study, ultrasound was diagnostic in 95% of surgical cases and supportive in 100 %. In the study of Shiraz in Iran among children with acute appendicitis (5 -15 years), ultrasound's diagnostic accuracy (48%) was moderate.[16]In our current study, 2 % of cases were diagnosed with acute cholecystitis by ultrasound.A study conducted at Columbia University Hospital[17] concluded that ultrasound is not very accurate (negative predictive value was 48%) in diagnosing cases of acute cholecystitis, and other supportive laboratory tests (elevated neutrophil count) with positive Murphy's signs give more accurate results. Our study revealed similar findings. In this study, 1.5% were diagnosed with torsion of ovaries with a sensitivity rate of 79% in which two of them had oophorectomies and one case saved & detorsion done. A study in Switzerland reported 21% of ovarian torsion among children with acute abdomen after an ultrasound.[18] Investigations revealed that the anatomy and perfusion of the ovaries could be evaluated by ultrasound. Ultrasound is the best modality for diagnosing adnexal mass.The ultrasound sensitivity for diagnosing ovarian torsion was 74%.[19] Interpretation of results in the current study showed that 17% (34 out of 200) were diagnosed with acute appendicitis clinically, and the rate lowered (24 out of 200, 12%) after scanning. Ultrasound changed the management plan by 5% (10 out of 200) for acute appendicitis and reduced the rate of unnecessary operations. This result was consistent with that reported previously by other researchers. In an African study, the surgery was planned in 45% of cases based on clinical diagnosis only. However, after doing the

ultrasound surgery rate was reduced by 25% and scanning managed to change the intervention method by 20%.[20]The study of Children's Hospital in Sheffield, UK, reported a 92% rate for a positive ultrasound confirmed by histopathology.[21] Ultrasound is an excellent investigation modality for diagnosing appendicitis and other pathological conditions in the appendix. According to previous studies, diagnosis of acute appendicitis cases with ultrasound by a skilled physician will reduce the rate of unnecessary operations by 20-25%.[22]The diagnostic accuracy of ultrasound was between 87-96% for acute appendicitis.[23] The use of ultrasound was evaluated in many studies for diagnosing acute renal pain. Among patients with acute abdominal pain, 97% were diagnosed with renal stones by ultrasound with the use of the color doppler in the United Arab Emirates study.[24]While in this study, 2% (4 out of 200) presented with lion pain, and the same cases were diagnosed by ultrasound with renal stones. The accuracy of ultrasound in detecting renal stones was 100%. Many intestinal conditions were diagnosed in the current study by ultrasound like acute appendicitis. The sensitivity, specificity, positive, and negative predictive values were 85%, 97%, 92.5%, and 86% respectively. Using ultrasound in diagnosing bowel diseases reported a sensitivity of 93.3%[25] in one study. The study in Italy reported higher figures for sensitivity, specificity, positive predictive value, and negative predictive value (89.7%, 93.0%, 87.8%, and 84.3%).[26]The ultrasound successfully diagnosed children's bowel conditions. The low fat in the abdominal wall and peritoneum made visualization easier.[26] On clinical bases, 23.5% (47 out of 200) were identified with gastroenteritis in the current study. The ultrasound scanning was normal at 13%; after evaluation by scanning, the intestinal fluid-filled dilated loop, and increased peristalsis with normal wall thickness were detected in 10.5% (21 out of 200) only, and the length of the bowel made visualization of the entire bowel difficult; therefore, other diagnostic methods were used as studies revealed.[26,27]The Children's Hospital of Philadelphia investigated the thickness of the intestinal wall in a group of gastroenteritis patients, and a statistically significant difference was found. Although the finding was not specific, the ultrasound still could be a valuable tool in assessing gastroenteritis. The factors that should be emphasized in scanning gastroenteritis are wall thickening, fluid level, mobility of the intestine, and lumen contents.[27]Although most of the cases presented to the emergency room were self-limiting, surgical conditions were also diagnosed.[28] The intussusception was diagnosed clinically in 1% (2 out of 200), and the scanning evaluation revealed 2% (4 out of 200). A study in Children's Mercy Kansas City Hospital in the USA diagnosed 6.3% of intussusception among surgical conditions.[28]The study of NHS foundations general hospital in the UK diagnosed 1% (1 out of 100) with intussusception among screened pediatric patients with right iliac fossa pain.[29] On admission, the intestinal obstruction was diagnosed in 3.5% (7 out of 200), and after scanning patients with ultrasound, the rate decreased to 2.5% (5 out of 200). The x - rays in the current study showed dilated loops, fluid level, and air under the diaphragm in intestinal obstruction in perforated cases. The study in the USA reported a lower figure (1.3%) for intestinal obstruction after ultrasound evaluation.[28]Appendicular mass diagnosed by ultrasound was 2.0% (4 out of 200.) The mass contained bowel loops and omentum; this result was in line with other earlier studies. A retrospective study in maternity and child hospital in Egypt diagnosed 48 cases with an appendicular mass. The ultrasound confirmed all cases, and the appendicular mass was formed by bowel loops, omentum with no pus in

87.5%, 10.4% had pus, and the abscess was detected in 2.08%.[30]

Conclusions

In the current study, ultrasound helped in earlier diagnoses of acute abdominal conditions. It reduces the morbidity and mortality of acute abdominal pathologies and decreases the rate of unnecessary operations. A significant change in the management plan was noticed after using ultrasound, lowering the financial expenses by reducing unnecessary admission.

Conflicts of interest

The author reports no conflicts of interest.

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