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ORIGINAL ARTICLE

Performance of Ultrasound in Diagnosis of Medical and Surgical Pediatric Pathologies: Clinical Assessment among Iraqi Children

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ABSTRACT

Background: *In the recent decades, ultrasonography (US) has become widely utilized across various medical specialties for purposes such as diagnosis, monitoring, and procedural guiding. Pediatric sonography plays a crucial role in situations when there are limited resources for diagnostic imaging due to its cost and little infrastructural, maintenance, and resource needs. Ultrasound is ideal for children due to their small size internal organs which are easily accessible by sound waves.*

Objectives: *To assess the utility, performance and role of ultrasound in diagnosis of different pediatric pathologies in both medical and surgical disciplines.*

Patients and Methods: *A prospective study carried out in Basra Maternity and Children Hospital included 295 consecutive child patients of both genders aged between one day and 13 years who were admitted at different wards of the hospital.*

Results: *Abdominal ultrasound performed more frequently in older children in 68.7%. It showed sensitivity of 86.9%, 66.6%, 66.6%, 65.5%, 64.2%, 61.5%, 60%, in diagnosis of gall stones, ascites, pancreatitis, cholecystitis, paralytic ileus, mesenteric lymphadenitis and chronic liver disease, respectively. Renal ultrasound was done in 20.3% of cases, and showed a sensitivity ranged between 48.7% and 76.9% in diagnosis of renal pathologies. Transfontanelle ultrasound done in 13.2% of cases. It showed a sensitivity of 61.5%, 60%, 54.5% in diagnosis of hydrocephalus, intraventricular hemorrhage and subdural effusion. Abdominal ultrasound had a sensitivity ranged between 35.7% to 87.5% in diagnosis of surgical pediatric cases.*

Conclusion: *Ultrasound is useful technique in detection of different pathologies in most body systems among pediatric population with medical and surgical problems*

Keywords: ***Pediatric Pathologies, Diagnosis, Ultrasonography, Performance***

1. INTRODUCTION

Ultrasound refers to the propagation of sound waves through air, fluid, and human tissue mostly in the form of longitudinal waves. The quality of an ultrasonic examination relies on achieving the most resolution feasible through the use of a high transducer frequency, as well as ensuring that the sound waves can penetrate to an appropriate depth (1). In the recent decades, ultrasonography (US) has become widely utilized across various medical specialties for purposes such as diagnosis, monitoring, and procedural guiding (2). Much of the revolutionized uses of US began in the tertiary care centers, however, currently, has adopted in almost all clinical settings, including outpatient clinics and critical care units. This adoption of ultrasonography is driven by the need for faster diagnosis and more efficient use of manpower resources in healthcare. Ultrasonography plays a crucial role in situations when there are limited resources for diagnostic imaging due to its cost and little infrastructural, maintenance, and resource needs. Ultrasound in these contexts yields crucial information that greatly influences patient outcomes and has the potential to revolutionize medical practice (3,4). Similar to how the stethoscope brought about a major change in medicine about two centuries ago, advancements in ultrasound technology now provide a new opportunity to significantly enhance traditional medical practices. Miniaturized and portable ultrasound equipment now enable ultrasound to be used directly on the patient side, allowing for quick evaluation in areas that were previously inaccessible . Ultrasound is particularly suitable for youngsters due to their small size internal organs which are easily accessible by sound waves, resulting in high-quality images. Furthermore, the longer lifespan of potential cancerous growths caused by radiation has led to widespread support for ultrasonography as the preferable initial method of imaging for children, including those being examined at the point of care (5). Different types of ultrasound examination are currently present based on the site of examination and types of examined tissue, the most commonly performed US examination in children is abdominal US as the first line investigation in any suspected abdominal pathology in children as in imaging procedure used to examine the internal organs of the abdomen (6). In urinary system, ultrasound is the first investigation in all children suspected of having any urinary tract abnormality. The findings of the ultrasound will then

direct further investigations, such as congenital hydronephrosis, obstruction of urinary tract, duplicated ureter, multicystic dysplastic kidney, and many other urinary abnormalities (7,8). Doppler assessment of the renal vessels is an important examination particularly in renal transplant, suspected renal vein thrombosis, renal artery stenosis, renal tumors, hypertensive disorders (9–11). Ultrasound imaging of the scrotum is the primary imaging method used to evaluate disorders of the testicles and the surrounding tissues in children to identify any mass (cystic or solid), assessment of outcomes of scrotal trauma, causes of testicular pain/swelling and looking for undescended testis (12,13). Also pediatric sonography is utilized in prenatal postnatal diagnosis of hydrocephalus, a myelomeningocele or meningocele and anencephaly (14,15). Furthermore, sonography has a significant role in the evaluation of head, neck and spine in childhood for the detection and assessment of intraventricular hemorrhages. On the other hand, transcranial Doppler of the blood velocity in the terminal portion of the internal carotid and the proximal portion of the middle cerebral artery can play important role in prevention of strokes in cases with sickle cell disease (16). Previous studies and literatures proved the significant role and wide utilization of sonography in pediatric population as it has high performance and accuracy in both early detection and diagnosis of different pathologies as well as follow up and screening for certain diseases and pathologies. The role of pediatric sonography can begin at prenatal stage and continued to later pediatric age. Therefor we aimed to assess the utility , performance and role of ultrasound in diagnosis of different pediatric pathologies in both medical and surgical disciplines.

2. METHODOLOGY

This was a prospective clinical study conducted at Al-Basra Maternity and Children Hospital during a period of 18 months. We included children under 13 years who were admitted to different wards of the hospital; neonatal care unit (INICU), emergency ward, surgical wards and general pediatric wards.

Inclusion criteria:

1. Children at 1 day – 13 years of age.
2. Both genders
3. Iraqi nationality

4. Resident in Basra

Exclusion criteria:

1. Children with critical medical or surgical conditions
2. Unconscious child
3. Children who were referred from other hospital
4. Children whose parents/guards did not consent to participate in the study.

Study population:

All children aged one day to 13 years who were admitted to different wards of our hospital

Study sample and sampling technique:

The study included a total of 295 children who met the inclusion criteria. They were selected using consecutive purposive convenient sampling method.

Data collection:

Data were collected using a data collection sheet (questionnaire) consisted of four sections; the first for the demographic characteristics of the participant children ; the second for clinical findings, the third for the laboratory investigations and findings and the fourth section for the ultrasound findings. Data were collected through a full history taking and thorough clinical examination. Clinical presentations were reported including the abdominal pain, abdominal distension, fever, vomiting, bowel motion (diarrhea/constipation), signs and symptoms related to the urinary tract and renal diseases, convulsions, jaundice, level of consciousness and other presenting features.

Study protocol:

1. **Ultrasound examination**

Ultrasound examination was requested for all children for assessment of different systems according to the presenting symptoms; gastrointestinal, renal and central nervous systems All requests were performed by specialist pediatricians (the authors) supported by the short hidtory for each case with reporting of main symptoms and signs like abdominal pain, distention, vomiting, jaundice, burning micturation or neurological symptoms like convulsion, irritability or others symptoms (medical problems). For surgical problems, abdominal ultrasound was requested for suspected surgical problems (like appendicitis, intussception, intestinal obstruction etc...). Abdominal and renal ultrasound was requested

for masses and other related lesions. Ultrasound results were assessed by specialist expert radiologists at the department of diagnostic radiology in our hospital.

Sonographic equipment used

Ultrasound examinations were conducted using high resolution transducers i.e. linear array transducer of 7.5-10MHz for deep organs (i.e. liver, spleen, kidney etc...) and curvilinear transducer of 3.5 5.0MHz.forsuperficial and small organs (i.e., thyroid, fontanel etc.).

2. Other radiological and laboratory data

Radiological finding (other than ultrasound) like CT scan, MRI, Barium studies, IVP, CXR, plain abdominal x-ray ware sent for some patients according to their needs to confirm the diagnosis; these results were recorded.

Some patients needed some investigations, like CBC, blood film, ESR, liver function test, renal function test, urinary test(GUE, urine culture, etc….), bone marrow aspiration and biopsy, these investigations were recorded to reach for final diagnosis.

3. Comparison of findings:

Ultrasound findings were compared to final diagnoses that based on clinical, laboratory, and radiological data.

4. Distribution of patients

The patients were sub-grouped according to their age into three sub-groups:

- Neonates (< 1 month)
- Infants (1-12 months)
- Children (older than 12 months)

Statistical analysis:

Data were entered managed and processed using the statistical package for social sciences (SPSS) version 27.

Variables were presented according to their types; Scale (quantitative) variables presented as mean, standard deviation (SD) and range. Categorical (qualitative) variables presented as frequency and simple percentage. Scale variables were compared using parametric statistical tests; student's t test and ANOVA. Categorical variables compared using chi-squared test and Fisher's exact test when each was applicable. The validity of ultrasound was estimated using the validity parameters; sensitivity, specificity, accuracy, positive predictive value (PPV) and

negative predictive value (NPV). All these parameters were calculated using the standard equations and based on the original standard 2 x 2 table as followed:

Table 1. Standard 2 x 2 table for calculation of validity parameters

Variable		Final diagnosis		Total
		Positive	Negative	
Ultrasound	Positive	TP	FP	TP+FP
	Negative	FN	TN	TN+FN
Total		TP+FN	TN+FP	TP+FP+TN+FP
Sensitivity = TP / TP + FN				

TP: True positive, FP: False positive, FN: False negative, TN: True negative

All statistical tests were applied at a level of significance of (P. value) of ≤ 0.05 to be considered as significant, while P. value of ≤ 0.01 as highly significant

3. RESULTS

A total of 295 child patients enrolled in this study of them 56 (18.9%) aged < 1 month, 122 (41.4%) aged 1 – 12 months and the remaining 117 (39.7%) were older than 12 months – 13 years. Males were relatively dominant and contributed for 52.2%. Patients from center (urban) areas were 104 (35.3%). Regarding type of ultrasound, abdominal type performed in 96 case, surgical for 84 cases, renal 60 cases, Transfontanelle 39 cases and for masses in 16 cases, (**Table 2**). Moreover, abdominal ultrasound was more frequently performed in older children, (68.8%), (P<0.01). For surgical cases ultrasound was performed more frequently in cases aged 1-12 months, (41.7%) with no statistical significant difference,(P>0.05). Renal ultrasound performed more frequently in infant age group, (53.3%), (P<0.01). Transfontanelle US performed more frequently in neonate age group, (P<0.05). For suspected masses, US was performed in 10 neonate cases (62.5%) which was significantly more frequent than other age groups, (P<0.05), (**Table 3**). Regarding the sex, there was statistically significant difference (P<0.05) in renal and suspected masses. Regarding the sensitivity of ultrasound in diagnosis of different abdominal pathologies, higher sensitivity of 86.9%, reported in detection of gallstone, in other pathologies US had a sensitivity ranged

between 60% to 69.8%, (**Table 5**). As shown in (**Table 6**), ultrasound was excellent sensitive for detection of congenital PUJ obstruction, (Sensitivity =100%) and Congenital renal cyst (Sensitivity =100%), for Renal stone (sensitivity= 76.9%), for other renal pathologies, sensitivity ranged between 48.7% and 61.7%, (**Table 6**). Sensitivities of ultrasound in diagnosis of different neurological pathologies are shown in (**Table 7**), where US was relatively more sensitive for Hydrocephalus (61.5%). For surgical pathologies, US was highly sensitive for most surgical pathologies, (**Table 8**). In diagnosis of masses, US showed sensitivity ranged between 66.6% for Neuroblastoma and 80% for Wilms tumor, (**Table 9**).

Table 2. Baseline demographic characteristics and types of performed ultrasound of the studied group

Variable		No.	%
Age	< 1 month	56	18.9
	1 - 12 months	122	41.4
	> 12 months - 13 years	117	39.7
Sex	Male	154	52.2
	Female	141	47.8
Residence	Center	104	35.3
	Periphery	191	64.7
Type of Ultrasound	Abdominal	96	32.5
	Surgical	84	20.3
	Renal	60	13.2
	Transfontanelle	39	28.5
	For masses	16	5.4
Total		295	100.0

Table 3. Distribution of types of ultrasound according to age of patients

Type of Ultrasound	Age						Total	P. value
	< 1 month		1 - 12 months		> 12 months			
	No.	%	No.	%	No.	%		
Abdominal	0	0.0	30	31.3	66	68.8	96	< 0.01 hs
Surgical	24	28.6	35	41.7	25	29.8	84	>0.05 ns
Renal	8	13.3	32	53.3	20	33.3	60	< 0.01 hs
Transfontanelle	24	61.5	15	38.5	0	0.0	39	< 0.05 sig
Masses	0	0.0	10	62.5	6	37.5	16	< 0.05 sig
Total	56	18.90	122	41.4	117	39.7	295	-

hs: highly significant, ns: not significant , sig: significant

Table 4. Distribution of types of ultrasound according to sex of patients

Type of Ultrasound	Sex				Total	P. value
	Male		Female			
	No.	%	No.	%		
Abdominal	45	46.9	51	53.1	96	>0.05 ns
Surgical	50	59.5	34	40.5	84	>0.05 ns
Renal	24	40.0	36	60.0	60	<0.05 sig
Transfontanelle	22	56.4	17	43.6	39	>0.05 ns
Masses	13	81.2	3	18.8	16	<0.01 hs
Total	154	52.2	141	47.8	295	

hs: highly significant, ns: not significant , sig: significant

Table 5. Sensitivity of ultrasound in diagnosis of different abdominal pathologies

Pathology	Total cases	Ultrasound		Sensitivity
		Diagnosed	Undiagnosed	
Gallstone	23	20	3	86.9%
Ascites	9	6	3	66.6%
Pancreatitis	3	2	1	66.6%
Cholecystitis	29	19	10	65.5%
Paralytic ileus	14	9	5	64.2%
Mesenteric Lymphadenitis	13	8	5	61.5%
Chronic liver disease	5	3	2	60.0%
Total	96	67	29	69.8%

Table 6. Sensitivity of ultrasound in diagnosis of different renal pathologies

Pathology	Total cases	Ultrasound		Sensitivity
		Diagnosed	Undiagnosed	
Renal stone	13	10	3	76.9%
UTI	39	19	20	48.7%
Congenital PUJ obstruction	6	6	0	100.0%
Congenital renal cyst	2	2	0	100.0%
Total	60	37	23	61.7%

Table 7. Sensitivity of ultrasound in diagnosis of different neurological pathologies

Pathology	Total cases	Ultrasound		Sensitivity
		Diagnosed	Undiagnosed	
Hydrocephalus	13	8	5	61.5%
Intra ventricular hemorrhage	15	9	6	60.0%
Subdural effusion	11	6	5	54.5%
Total	39	23	16	58.90%

Table 8. Sensitivity of ultrasound in diagnosis of different surgical pathologies

Pathology	Total cases	Ultrasound		Sensitivity
		Diagnosed	Undiagnosed	
Duodenal atresia	8	7	1	87.5%
Intussusception	14	12	2	85.7%
Pyloric stenosis	12	10	2	83.3%
Perforated viscous	5	4	1	80.0%
Jejunal atresia	9	7	2	77.7%
Volvulus	9	7	2	77.7%
Complicated Appendicitis	13	8	5	61.5%
Non complicated Appendicitis	14	5	9	35.7%
Total	84	60	24	71.4%

Table 9. Sensitivity of ultrasound in diagnosis of different masses

Pathology	Total cases	Ultrasound		Sensitivity
		Diagnosed	Undiagnosed	
Wilms tumor	5	4	1	80.0%
Lymphoma	7	5	2	71.4%
Neuroblastoma	3	2	1	66.6%
Abdominal hematoma	1	1	0	-
Total	16	12	4	75.0%

4. DISCUSSION

Ultrasound is a safe, non-invasive investigation which is found to be acceptable to children for both isolated and repeated examination. Ultrasound may also be helpful in the decision for surgical conservative treatment and a first stage imaging method for patients with acute abdominal symptoms and provides accurate diagnosis. It is also a valuable tool for monitoring acute and chronic intestinal diseases and gives additional information to endoscopic and radiological examinations (17). However, role and performance of ultrasound in pediatric population still need further evaluation hence we conducted this

prospective study aiming to assess the utility , performance and role of ultrasound in diagnosis of different pediatric pathologies in both medical and surgical disciplines in Basra Maternity and Children Hospital . The present study included a total of 295 pediatric patients of both genders aged between one day and 13 years. We demonstrated that referred cases from peripheral areas were more frequent than those from the center; 64.7% vs. 35.3%, respectively. This may be due to inadequate primary health care setting, unavailability of ultrasound or radiologist in the peripheral areas, villages and towns around the center. Similar findings also reported in Jordan by Massadeh et al,(18). In the present study, abdominal ultrasound was performed in 32.5% of cases and was more frequently performed in older children. This could be attributed to the fact that GIT problems were observed more in older children, these findings agreed that reported by Gale et al. from the United States (19). In the current study, the sensitivity of ultrasound in diagnosis of GIT problems was found to be 86.9% for gallstones, for other GIT problem we found lower sensitivity rate ranged between 60% to 66.6% . Tsai et al. (20) from United States documented a sensitivity of 82% in diagnosis of cholecystitis. Other studies showed higher sensitivity rates (21,22) than we did. This study had demonstrated that renal ultrasound was done in 20.3% of cases for different problems like renal stones ,UTI ,congenital PUJ obstruction and renal cysts, it was significantly related to age group being more in infancy where these problems are more prominent in this age group, also renal ultrasound was done more in females , this can be explained by higher prevalence of urinary tract infections in females (23). The sensitivity of ultrasound was 76.9% In diagnosis renal stones, in a study conducted by Roberson et al. US produced a sensitivity of 66.7% in detection of nephrolithiasis (24). Previous study showed that in detection of ureteral calculi US had a low sensitivity of only 12.8% based on direct visualization of the calculi (25). We found that ultrasound sensitivity was 48.7% in diagnosis of UTI (upper and lower) , which was close to that found by Alshamsam et al. in Saudi Arabia (26) who documented a sensitivity of 50%. Our finding was higher than that reported in earlier study conducted by Mahant et al. who found a sensitivity of 40% (27). The difference may be related to including lower UTI in our study and variation in the diagnostic ultrasound systems, additionally, possible cause of an undetectable UTI by ultrasound include inadequate preparation which may be more difficult in children than adult. In our

study ultrasound detected all of the congenital PUJ obstruction and congenital renal cyst, giving a sensitivity of 100%, this was not unexpected due to nature of these pathologies. Ucar et al. stated that ultrasound was 100% sensitive in PUJ obstruction (28). Dias et al. reported that ultrasound had significant higher diagnostic accuracy and sensitivity in diagnosis of fetal renal abnormalities (29). Vester et al. showed in their study a good sensitivity for US in detection of congenital renal cysts (30). Regarding neurological problems , transfontanelle ultrasound was performed in 13.2% of total cases most of them in their first year of life. We found that US had a sensitivity of 61.5%, 60% and 54.5% for diagnosis of hydrocephalus, intra ventricular hemorrhage and subdural effusion, respectively. However, our findings were relatively higher than the findings of Eze and Enukegwu from Nigeria who reported a sensitivity of 56.7% in detection of hydrocephalus(31). Our findings was similar to what was found by Yikilmaz et al from Turkey (32) and lower than that reported by Alves et al. in Brazil (33). Our analysis revealed that US was good diagnostic tool in different surgical pathologies such as duodenal atresia, intussusception, pyloric stenosis, perforated viscous, jejunal atresia, and volvulus with a sensitivity ranged between 77.7% and 87.5%, for complicated appendicitis, US had a sensitivity of 61.5% and for non-complicated appendicitis it had a sensitivity of 35.7%. Our finding was lower than that found by Himeno et al. in Japan (sensitivity was 93%) (34). This difference could be explained by using different techniques, removal of intestinal gas by slow compression using a 7.5 MHz probe is believed to facilitate depiction of the appendix, in addition to difference in facilities, specialist pediatric sonographers were present in Japanese study . Possible causes of an undetectable appendix include masking by intestinal gas (Air-filled dilated bowel loops from the a dynamic ileus may hide from the view), and location of the appendix deep in the abdomen or above the cecum, inexperienced hands. Generalized peritonitis hampers graded compression, which may account for low score in appendiceal perforation. Another pitfall in advanced appendicitis where there is secondary wall thickening of the ileum. Often the ileal thickening is more prominent and conspicuous on ultrasound than the underlying inflamed appendix. Factors influencing false negative diagnosis of acute appendicitis include retrocaecal position of the appendix and when caecum is filled with gas and faeces was adequate, compression is not possible and pelvic appendices were missed due to dense omental adhesion covering the

appendix. Inadequate preparation of patient causes an undetectable appendix (35). We found that sensitivity of ultrasound for intussception diagnosis was 85.7% which was lower than that for another study done by Cina etal in Iran who found a sensitivity of 92.5% (36), this can be explained by difference in techniques of examination of intussception. Pyloric stenosis was found to be diagnosed with sensitivity of 83.3% which was lower than that for other study done in Iran by Alehossein et al, (37) who found a sensitivity of 96%. It is important to note that pylorospasm may mimic hypertrophic pyloric stenosis and the sonographer may make a false-positive diagnosis. Infants who are premature, small and underweight may have pyloric stenosis in the presence of measurements that are below those quoted in the series (38). Sensitivity of ultrasound in diagnosis of volvulus waas77.7% while it was 94% in another study done by Nguyen et al. (39). Other surgical problems like jejunel atresia, duodenal atresia and volvulus were observed to be diagnosed with sensitivity similar to other study done in India by s. Suri et al. (40)(sensitivity was 83%), which demonstrated significance of ultrasound in diagnosis of intestinal obstruction (40). It was found that abdominal or renal ultrasound was used to diagnose masses in 5.4% of cases which was more among infants (the results was statistically significant), this may be related to including Wilms tumour more among males. Sensitivity of ultrasound in diagnosis of Wilms tumor was 80% in our study, while Japanese study published in 2005 done by Tama et al. showed a higher sensitivity of (98.3%) of contrast enhanced ultrasound for the diagnosis of hypovascular renal tumors, but the number of cases is small making less precise comparison. Small number of cases in each tumor was not adequate for calculation of the sensitivity.

5. CONCLUSIONS

Ultrasound is useful technique in detection of different pathologies in most body systems among pediatric population with medical and surgical problems. In renal pathologies, ultrasound showed high sensitivities in diagnosis of congenital anomalies like congenital PUJ and renal cyst but low sensitivity in diagnosis of renal stone and UTI. Abdominal ultrasound, had higher sensitivity in diagnosis of gall stones but low sensitivity in other problems like cholecystitis, mesenteric lymphadenitis, paralytic ileus and ascites. The sensitivity was low in diagnosis of hydrocephaly, intraventricular hemorrhage and subdural effusion. In surgical

cases the sensitivity of ultrasound was good in duodenal atresia , intussusception, pyloric stenosis, perforated viscous jejunel atresia, volvulus, while ultrasound was low sensitive in complicated appendicitis and non-complicated appendicitis. Abdominal and renal masses were diagnosed with low sensitivity. Low sensitivity test for diagnosis of most problem was related to inadequate preparation for patient according to their examination, short time of examination and improper pediatric ultrasonography measures. We recommend adequate preparation of child before examination For better performance of sonographers it is needed to increase number of ultrasound machines in all pediatric units especially emergency unit, providing training course of sonographers including using Doppler ultrasound, knowledge about pediatric sonographic measurements, and consuming enough time and using appropriate procedure. However, further studies are still highly suggested, particularly multiple center studies.

Ethical Approval:

All ethical issues were approved by the author. Data collection and patients enrollment were in accordance with Declaration of Helsinki of World Medical Association , 2013 for the ethical principles of researches involving human. Signed informed consent was obtained from each participant and data were kept confidentially.

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