Clinical accuracy of bedside Ultrasonography in the diagnosis causes of acute RIF pain at emergency departments

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Right iliac fossa (RIF) pain is a common clinical ailment in the emergency department. Abdominal Ultrasound (US) is a non-invasive, lively, functional, and secure procedure with zero radiation to patients. Though clinically it is difficult to diagnose its cause, the US is considered the first-line imaging modality used to find the etiology of RIF pain. At the end of this research, the accuracy of the US imaging in the diagnosis of acute RIF pain with respect to the relevant laboratory and clinical findings and intraoperative observations was verified. This is a multi-centered prospective cohort study conducted in three Khartoum State hospitals. One hundred patients with acute RIF pain attending the emergency department were included. The patients were examined by two emergency physicians trained in Ultrasonography. After clinical examination and routine laboratory investigations, a full grid pattern US scan of the abdominal cavity was performed. SPSS statistical software 23.0 version was used for the analysis of the data. The sonographic findings were then compared with the outcome of the surgery. Sensitivity, specificity, accuracy, positive predictive value (PPV), and negative predictive value (NPV) were determined. The incidence of RIF pathologies is common in the third and fourth decades of life (45% and 27%), respectively. Appendicitis and lower ureteric stones were more prevalent in males than females (41.2% and 35.3% vs. 8.2% and 6.1%). The hemorrhagic ovarian cyst was the most etiology of RIF's pain in females compared to appendicitis (34.7% vs. 8.2%). The US diagnostic performance for RIF pathologies had a sensitivity of 88.40%, 77.41% specificity, 89.7% PPV, 75% NPV, the area under the curve (AUC) of 0.82.4, and overall accuracy of 85%. Appendicitis, lower ureteric stones, hemorrhagic ovarian cysts, and pelvic inflammatory disease were the most commonly diagnosed etiologies of RIF's pain. Bedside US proved to have high sensitivity, specificity, and accuracy for diagnosing the pathologies of the RIF.

Keywords: Ultrasound, Right Iliac Fossa pain, Appendicitis, Accuracy, Lower ureteric stone.

INTRODUCTION

Right iliac fossa (RIF) pain is still facing diagnostic challenges. Abdominal pain is considered the third most common reason for patients attending the emergency room. (Gammeri et al.2016, Gudelis et al.2019) The differential diagnosis of this acute RIF pain is not always straightforward. Many conditions might be responsible for pain at this site. (Zhao et al.2020, Endo et al. 2020, Rassi et al.2019)

In literature, RIF pain diagnosis has focused on the principal diagnosis of acute appendicitis (AA), even though there are different reasons for pain at the RIF. (Alfredo 2018) RIF pain can be caused by several pathologies that had been classified into gastrointestinal and genitourinary patterns. These pathologies could be considered in the differential diagnosis of AA. However, acute RIF pain may not be caused by AA alone, specifically in females.

The ultrasound (US) represents the ideal imaging diagnostic modality for the determination of acute

abdominal pain. Its excellent contrast resolution, Doppler usage facility, safety, availability, and non-harmful procedure made the US the first-line investigation in an emergency. (Quigley and Stafrace,2013) Modern advances in US equipment improve the spatial resolution to investigate the appendix and its surrounding tissue. (Roccarina et al.2013)

These advancements have improved the sensitivity and accuracy of the US. The US's sensitivity and specificity are essential for diagnostic accuracy in assessing various pathologies in the RIF. However, this study aims to evaluate the performance of ultrasound at the patient's bedside to characterize the pathologies that cause RIF pain and describe the variation of incidence of these pathologies concerning age and gender.

MATERIALS AND METHODS

Study Design and Settings:
This was a cross-sectional multicenter Khartoum State hospitals at emergency departments (ED) of Alribat University hospital (35 cases), Ombada model hospital (35 cases), and Ibrahim Malik teaching hospital (30 cases) from January to July 2017. Institutional Ethical approval was done before commencing the research by Alzaiem AlAzhari University, Khartoum, Sudan [aau.Rec#11122017]. As this experimental research involves human subjects, Declaration of Helsinki guidelines for protecting patients' health, privacy and safety were followed. Also, all human research procedures were followed in accordance with the ethical standards of the Institutional Committee responsible for the human experimentation with reference to International and National guideline. Written consent was taken from all the study participants after informing the objective and scope, procedures, risks and benefits of the research.

Sample size:
Sample size for this study was calculated using G power 3.1 software. Considering an alpha of 0.05, a power of 0.80, the calculated effect size was 0.51, with a required sample of 79 patients.

Procedure:
One hundred patients (100) who attended the ED with acute RIF's pain were recruited using a convenient sampling method. Patients who were clinically diagnosed with acute abdominal complaints underwent the US in the study center. Special consideration was given to proper confidentiality. Patients with cholecystitis, kidney stones, hepatic masses and previous pelvic surgery were excluded from the study. All the findings in the right iliac region were included in the study at the time of examination. Collected information were recorded in the department ultrasonography report template and data are available for authors and can be exchanged with the readers by corresponding author only after obtaining the permission and approval from the journal publisher and chief editor.

Final diagnosis
The final diagnosis was the etiologic diagnosis of RIF, which would be surgical or medical pathology. After the surgeon's examination and susceptibility to pathologies found at the RIF, preoperative routine Lab tests were conducted. A clinician or surgeon who was blinded to the ultrasound results examined the samples. The outcome of the surgical operations was compared to the sonography findings to determine the sensitivity and specificity of the pelvic US. Consequently, the performance of the US compared to the performance of clinical-laboratory investigation for the diagnosis of surgical pathology.

Sonographic technique
The patients were instructed to be fasting when they attended the emergency ED. They were examined using the diagnostic ultrasound machine AL PINION model: ECUBE7, manufactured in china supported with a transabdominal probe of 3,5 to 5MHz. The second US machine was a Sonoscape portable, model A5, manufactured in China, endowed with a 3.5 to 5 MHz transabdominal probe.

Expert Sonologists using a 3.5 MHz convex (transducer for adults and 5 MHz for slim patients) examined the participants at the ED. Color Doppler was applied to differentiate cystic and vascular lesions, specifically for appendicitis and cystic ovarian lesions. The patients were scanned in supine positioning, and if there was abdominal tenderness, a pillow might be placed under the knees. For investigating the appendix, the transducer was placed in a transverse position supported with deep graded compression (mild to moderate) to eliminate the bowel gas and decrease the distance between the probe and the appendix. This compression allows visibility of iliac vessels and the psoas muscle, as the appendix lies anterior to these structures. The protocol should include the entire female pelvis with right lower quadrant pain and scanning the lower ureter of all patients with a normal appendix. The gain was adjusted with the transducer placed from the midline across the abdomen to the right. Transverse and longitudinal scans were repeated at different levels until the right side had been scanned along with the whole abdomen. On the longitudinal planes, appendicitis is characterized as a fluid-filled, non-compressible tube-like structure with a blind end and its diameter exceeding 6 mm (figure 1). In the axial plane, it has a target appearance with a fluid-filled echogenic center (figure 2). On the other hand, the hemorrhagic ovarian cyst appears as a hypoechoic round structure containing echogenic non-homogenous clots with thick serous fluid at the center.
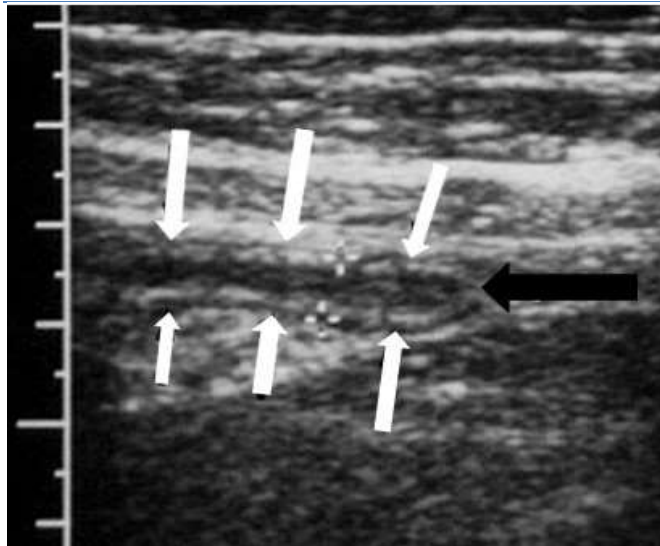
Figure 1: Longitudinal sonogram of an inflamed appendix taken with graded compression demonstrates mild dilation (white arrows) with preserved multilayered appearance of bowel. Note the blind end appearance of the appendix (black arrow).

Figure 2: Transverse sonogram of an inflamed appendix taken with graded compression demonstrates Target sign (white arrow) with increased thickness and preserved multilayered appearance.

Statistical analysis

Data were analyzed using SPSS version 23 (IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.). Qualitative data were presented as frequencies and percentages. A Chi-square test was used to find the association of age and gender with the RIF sonographic findings. To assess the diagnostic value of ultrasound, two-by-two tables and the Receiver Operating Characteristic (ROC) was applied to create the sensitivity, specificity, accuracy, PPV, and NPV. In all analyzes, the significance level was regarded to be <0.05.

RESULTS

A total of 100 patients who attended the ED complaint of RIF pain were examined by ultrasound. They were 49 (49%) females and 51 (51%) males; the mean age was 28.86 ± 10.06 years (table 1).

Table 1: Socio-demographic characteristics of the study population.

Variable	No.	Percentage	Significance
Gender			
Males	51	51%	.935
Females	49	49%	
Occupation			
Employee	38	38	
House wives	27	27	
workers	25	25	.004
students	8	8	
Others	2	2	
Age *Mean=28.86± 10.060 years*			
First decade	15	15%	
Second decade	45	45%	
Third decade	27	27%	< 0.001
Fourth decade	7	7%	
Fifth decade	6	6%	

They were employees 38 (38%), homemakers 27 (27%), workers 25 (25%), and 8 (8%) were students. RIF pathologies' prevalence was the most frequent in the second decade, 45 (45%) and third decade 27 (27%).

The sonographic investigation revealed that appendicitis was positive in 25 (25%), lower ureteric stone 21 (21%), ovarian cyst 17 (17%), and PID was positive in 10 (10%) of the cases. There was only one case of ovarian torsion (Figure 3).
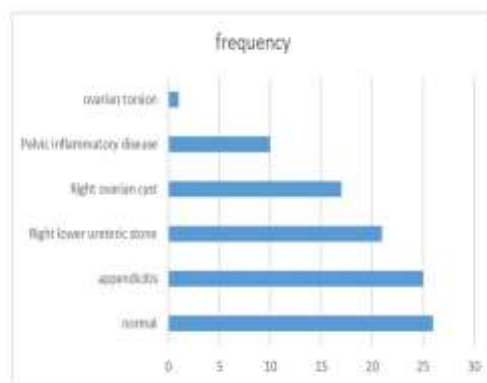
Figure 3: Distribution of diagnosed sonographic findings at the right iliac fossa among patients with RIF's pain.

In comparison, the leading cause was a hemorrhagic

ovarian cyst in females, and PID and the incidence were 17 (34.7%) and 10 (20.4%), respectively. Appendicitis and lower ureteric stones were significantly higher in males than females, as shown in Table 2. Therefore, the incidence of RIF's pathologies was significantly different with gender (p-value=0.001).

Table 3 summarizes the incidence of RIF's pathologies according to the age groups. There was a significant association between age and the RIF sonographic findings (p-value = 0.001). RIF pathologies'

prevalence was more common in 20-29 years (45 %) than in the other age groups. Appendicitis and right lower ureteric stone were the most frequent in this age group (20-29 years old); 15(33.3%) vs. 13 (28.9%) respectively. Age has a significant association with the incidence of RIF pathologies (P-value = 0.001). The leading cause of RIF's pain in males was appendicitis, counted 21 (41.2%), and lower ureteric stone 18 (35.3%), respectively.

Table 2: Correlation between gender and sonographic findings

Sono-graphic Findings	Gender		Correlation Coefficient	P-value
	Males No. (%)	Females No. (%)		
Normal	12 23.5%	14 28.6%	0.34	0.001
Appendicitis	21 41.2%	4 8.2%		
Lower ureteric stone	18 35.3%	3 6.1%		
Ovarian cysts	0 0.0%	17 34.7%		
Pelvic inflammatory disease	0 0.0%	10 20.4%		
Ovarian torsion	0 0.0%	1 2.0%		
Total	51	49		

Table 3: Cross-tabulation between age groups and sonographic findings

| Age groups	The Sonographic findings							P-value
	normal	appendicitis	lower ureteric stone	Pelvic inflammatory disease	Ovarian cyst	Ovarian torsion	Total	
10-19 years	8 53.3%	3 20.0%	2 13.3%	0 0.0%	2 13.3%	0 0.0%	15 53.3%	0.001
20-29 years	5 11.1%	15 33.3%	13 28.9%	3 6.7%	8 17.8%	1 2.2%	45 100.0%	
30-39 years	4 14.8%	6 22.2%	3 11.1%	7 25.9%	7 25.9%	0 0.0%	27 100.0%	
40-49 years	7 100.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	7 100.0%	
50-59 years	2 33.3%	1 16.7%	3 50.0%	0 0.0%	0 0.0%	0 0.0%	6 33.3%	
Total	26 26.0%	25 25.0%	21 21.0%	10 10.0%	17 17.0%	1 1.0%	100 100.0%	

Table 4 summarizes the cross-tabulation of surgical outcomes and sonographic findings. Surgical operations and the US revealed that 61 cases confirmed diagnosis of RIF pathologies while 24 true negatives with significant confidence (p-value <0.001).

Table 4: Cross-tabulation of surgical outcomes and sonographic findings

Surgical findings	Sonographic findings		Total
	Normal	**abnormal**	
present	7	61	68
absent	24	8	32
Total	31	69	100
P –value< 0.00, chi=42.59			

The analysis of the level of performance of U/S in the diagnosis of RIF's pain shows that the level of sensitivity, specificity, and accuracy highly determines the differential diagnosis of RIF's pathologies. The accuracy of sonography of the RIF's pathologies was 85%, sensitivity 88.4%, and specificity was 77.41%. Its positive predictive value (PPV) was 89.7%, and its negative predictive value (NPV) was only 75% (Table 5). The area under the receiver operating (ROC) curve [AUC] = 0.88, P < 0.001) which indicates high sensitivity (Figure 4).
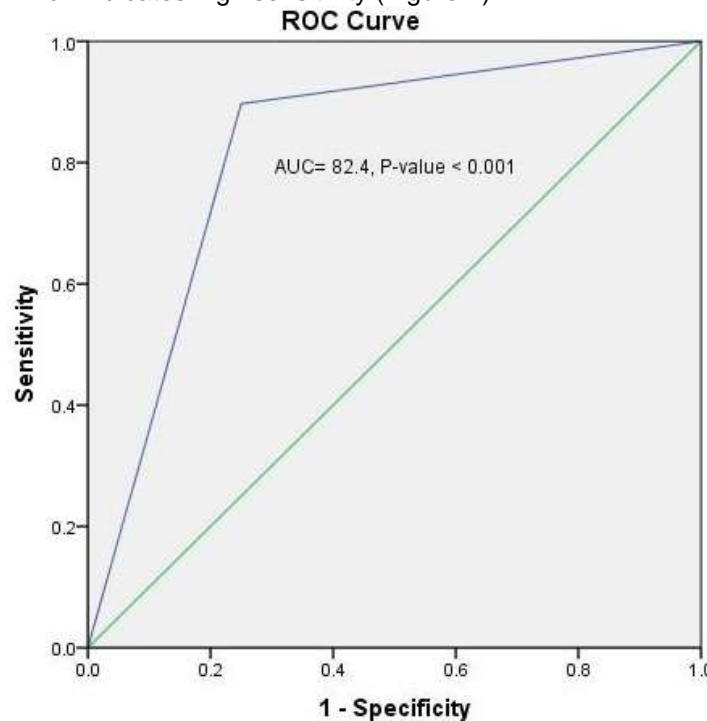
Figure 4: ROC curve shows the sensitivity and specificity of sonography compared with the surgical outcomes for the RIF pathologies.

Table 5: Performance of B-ultrasound for characterization of causes of right iliac fossa pain in the emergency departments.

Findings	Value
Sensitivity	**88.40%**
Specificity	**77.41%**
Accuracy	**85%**
Positive predictive value (PPV) (%)	**89.7%**
Negative predictive value (PPV) (%)	**75%**

DISCUSSION

Acute RIF pain is the central point that confuses the surgeons, urologists, nephrologists, gastroenterologists, gynecologists, and internists.[9] Most of the previous studies have diagnosed RIF pain as appendicitis. (Florin et al.2014, Pinto et al.2013, Karabulut et al. 2019)This study characterized various pathologies that cause pain in the RIF in patients who attended the ED. The study found that AA and lower ureteric stones were the most common cause of RIF pain. The sensitivity of US is high for detecting pathologies of RIF.

The present study found that appendicitis and lower ureteric stone were the most common causes of pain in the RIF, and the incidence was higher in the second and third decades of life. In agreement with this result, Coward et al. studied the prevalence of appendicitis over time and found 30.6% in the age group of 18-30 years and 26.1% in the age group of 32-47 years. (Shogilev et al.2014) Furthermore, in developed countries, the peak incidence was between 10 and 30 years old. (Coward et al. 2016, Ilves,2014) Therefore, the prevalence of acute appendicitis may more likely be found at a younger age.

The current study shows that appendicitis was more prevalent in males than in females. In agreement with this finding, Wilasrusmee et al. reported that acute appendicitis was more prevalent in males than females. (Viniol et al.2014) Additionally, Alshebromi studied acute appendicitis prediction and found that one-third of the patients were females, which meant males' incidence was high. (Wilasrusmee et al. 2017)

The present study found that lower ureteric stone is the second cause of RIF pain. In agreement with this finding, Ramachandran et al. reported that ureteric stone was the second cause of RIF pain.(Alshebromi et al.2019) The study estimated that the incidence was higher in males than females. Similar to this result, it was reported that the incidence of renal stones in developed countries was 10% for men and 3% for women. (Ramachandran et al.2018) This result is in agreement with our study. In contrast, Mathiyalagen et al. reported

that females had a significant risk for renal stones more than females. (Nirumand et al. 2018) These results indicate that the gender difference in the prevalence of renal stones was controversial.

The study assessed the accuracy, sensitivity, specificity, PPV, NPV for whole findings of the RIF. It was observed that the diagnostic accuracy of the US varied was high (85%) for the pathologies diagnosed in the RIF. The overall sensitivity was 88.4%, specificity 77.41%. Similar to these results, Fanny evaluated the performance of ultrasound for acute appendicitis and reported a sensitivity of 82% and NPV of 93%. (Mathiyalagen et al.2017) Another study reported an NPV of 98.7% of the US for AA, approximately near to our findings.(Löfvenberg et al.2016) However, the US's reported sensitivity was variable (67–100%).(Sheikh et al.2017, Kaiser et al.2002, Doria et al. 2006)

In agreement with our findings, Xia et al. studied the localization of ureteric calculi and found that the ultrasound's sensitivity was high (91%) for distal ureteric stone. (Trout et al.2012) On the other hand, Ather et al. studied the US's diagnostic accuracy compared to unenhanced computerized tomography and found that the US's sensitivity was 81%. 9Xia et al.2020)

The current study found that right ovarian hemorrhagic cysts were the common pathology that causes RIF pain in females. In agreement with this finding, Ahmed and Al-Najjar reported that ovarian cysts were the second RIF lesion.(Ather et al. 2004) A previous study said that the US could accurately characterize about 90% of ovarian masses and reported a sensitivity of 88% for characterizing ovarian malignancies. (Ahmed and Al-najjar.2020) It is well established that the US is very accurate and sensitive for characterizing all gynecological masses.

In general, pelvic US is a reliable method in diagnosing various pathologies at the RIF, which causes severe pain in the emergency departments. Accordingly, the pain at RIF may not always be appendicitis, especially the reproductive women in whom the hemorrhagic cysts were the most common prevalent. The US had sensitivity and specificity, and it should be used as an excellent diagnostic tool in emergency departments to avoid undue surgical interventions.

Limitation of the study

The main limitation of this study is that there is a possibility of bias as the study subjects were not chosen randomly and there were no blind assessors. In few cases of surgical interventions, the findings were not completely reported. Further studies with a larger sample size to confirm the initial results of this study.

CONCLUSION

This study signifies the role of Ultrasound in characterizing and diagnosing various pathologies that cause acute RIF pain. Appendicitis, lower right ureteric stone, hemorrhagic ovarian cysts, and PID were the most common etiologies of RIF pain in the emergency. US proves a high sensitivity, specificity, and accuracy to characterize the pathologies, which cause acute RIF pain in an emergency. This characterization is essential to avoid undue surgical interventions and for better treatment and management.

CONFLICT OF INTEREST

The authors report that there are no conflicts of interest in this work. There is no financial support or sponsorship for this research.

AUTHOR CONTRIBUTIONS

QTA contributed to study design and literature search. MG and MB definition of intellectual content. MTA and ARA edited and reviewed the manuscript. AS and FA prepared the manuscript. AG and BA data acquisition. All authors read and approved the final version.

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