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Research Article

The Role of Intravenous Urography in the Evaluation of Hydronephrosis: A Cross-Sectional Study

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Abstract

Background: Hydronephrosis is one of the diseases that causes dilation in the calices and pelvis of the kidney. It is considered one of the most difficult conditions to diagnose in urology. The study estimated the effectiveness of imaging methods, ultrasound (US), intravenous urography (IVU), and computed tomography (CT), for detecting the severity of hydronephrosis in adult patients.

Methods: The study was a cross-sectional study carried out at Ghazi Alhariri Hospital in Baghdad, Iraq, from January 2024 to December 2024 with 100 patients diagnosed with hydronephrosis. Pregnant women, patients with renal failure, and patients allergic to the contrast were excluded. The results were analyzed with chi-square, Kruskal-Wallis tests, and binary logistic regression for risk factors for hydronephrosis ($p < 0.05$).

Results: The results showed that the mean age of patients was 39.0 ± 0.9 years, and females and males were 60% and 40%, respectively. A high relationship between imaging techniques and hydronephrosis groups ($P = 0.000$). The three imaging techniques have proven their efficiency in diagnosing advanced cases of hydronephrosis, despite there being no relationship between these three methods ($p = 0.233$). Moreover, the results showed that there is a relationship between the severity of hydronephrosis with age and past urolithiasis, but there is no relationship between the disease and the patient's sex.

Conclusions: The three imaging methods have proven their efficiency in diagnosing hydronephrosis grades, but ultrasound is preferred as a preliminary examination, and IVU techniques should be avoided as much as possible due to the possibility of side effects resulting from them.

Keywords: Ultrasound, Intravenous urography, Computed Tomography, hydronephrosis, grade

Introduction

Hydronephrosis, a distension in the renal pelvis and calyces that occurs due to obstruction in the urinary flow, causes more clinical complications that affect renal function and overall health [1]. Causes of this disease can belong to a variety of reasons, like age and urolithiasis [2-3]. It is further classified into grades that reveal the degree of pelviureteric junction (UPJ) obstruction [4]. Nevertheless, a high evaluation and grading of hydronephrosis are important to make a good guide for treatment and to detect the outcomes [5]. The accuracy of imaging techniques is important for high assessment of hydronephrosis grades and causes. Ultrasound (US), intravenous urography (IVU), and computed tomography (CT) are the most common imaging techniques that are used [6]. Diagnosis is essential for planning the treatment, US, CT, and IVU are the most used techniques, development of CT scan helped the doctor to diagnose the disease more accurately [7-9]. Ultrasound is non-invasive technique, useful as a first examination imaging modality, which can evaluate changes in renal morphology [10]. In the past, intravenous urography (IVU) was used as a gold test, but over time it was replaced by other tests due to the side effects that occur after injection with contrast agents [11]. Currently, renal CT has developed into a broadly adopted modality that has a high value in diagnostic accuracy [12-13]. The study's goal was to evaluate the relationship between ultrasound (US), intravenous urography (IVU), and computed tomography (CT) with hydronephrosis grades in adult patients.

Materials and Methods

Patient Population

A cross-sectional study was carried out from January to December 2024 at Ghazi Alhariri Hospital for Specialized Surgeries, Baghdad, Iraq. One hundred adult patients with hydronephrosis were consecutively included from the outpatient department of urology. Patients aged between 18 and 60 years with clinical documentation of hydronephrosis according to ultrasound were selected. Exclusion criteria included patients with signs of renal failure (high serum creatinine and low glomerular filtration rate), known allergies to iodine-based contrast agents, and pregnant women.

Clinical Evaluation

All patients were clinically evaluated by taking the medical history for each patient, including physical examination and assessing symptoms such as pain, renal colic, hematuria, and urinary tract infections. Renal function tests such as (creatinine and estimated Glomerular Filtration Rate [eGFR]) were also performed. Ultrasound was performed as a preliminary examination to assess symptoms and determine the severity of the disease.

Diagnostic Methods

Ultrasound was done using a convex probe (3.5 MHz) (Toshiba SSA-790A, Tokyo, Japan). The proposed ultrasonic examination of the renal pelvis and kidneys, then ureterovesical junctions (UVJ) from the full urinary bladder. First, hydronephrosis detection and degree assessment were performed by ultrasound. ASTM STD method results per ASTM E2875 were used for the standard imaging method following ultrasound-based findings; IVU was performed in patients with a standardized imaging protocol. Patients were well hydrated before the procedure and were pre-medicated whenever necessary to prevent complications. For IVU, patients were administered an oral purgative in the evening prior, and after acquisition of a plain abdominal film, An intravenous iodinated contrast medium was administered as a weight-based bolus injection, and serial radiographic images were obtained (5, 10, and 20 min post-injection). To determine the underlying cause of hydronephrosis, a CT scan was employed, as it is the gold standard modality of imaging for detailed anatomical and pathological information. CT was obtained in respiratory hold from the kidneys to the pubic symphysis using a toshiba aquilion multi detector helical scanner with 64 slices and the following settings: Pitch 6; Scan duration; beam collimation 5 mm × 1.25 traverse resilience ~20s, followed by curved MPR (Multi-Planar Reconstruction) centered at the ureter of the symptomatic side, on a workstation by a trained CT technologist, to perform the reconstruction. Manual selection of a point in the middle of the ureteric lumen on serial axial images allowed visualization of the renal collecting system from the level of the renal pelvis to the urinary bladder. Images were independently reviewed by four radiologists, all experienced at the time of this study in urological imaging for renal pelvis dilation, calyceal effacement, and parenchymal thinning.

Data Collection and Variables

Data were collected using structured case forms. The main variables included patient information, including age, sex, and history of urolithiasis; clinical symptoms; total imaging techniques (US, IVU, CT) grades of hydronephrosis severity; and type of the disease (unilateral vs. bilateral).

Quality Control

To ensure the validity and reliability of imaging and clinical data, all radiographic images were independently double-read by four radiologists blinded to clinical outcomes. Any inconsistencies were resolved by consensus. Double-verification protocols were employed during data entry to minimize transcription errors.

Ethical Considerations

Ethical approval was obtained from the Training and Human Development Center at Educational Medical City, Ministry of Health, Baghdad, with reference number 32602 on December 28, 2023. All participants gave written informed consent after receiving a thorough study description, its objectives, and the risks associated with intravenous contrast media. Participants' data and personal information were kept confidential.

Statistical Analysis

The data were analyzed by using the SPSS program (version 22), with a p-value of < 0.05 considered statistically significant. The data obtained from the outpatient urology department were compared with ultrasound, IVU, and CT results using descriptive statistical analysis to determine the variables of the study. The chi-square test was used to assess the relationship between imaging methods and type of hydronephrosis, as well as to determine the ability of these techniques to identify the severity of hydronephrosis using the Kuskill-Wails test. History of urolithiasis, sex, and age these factors were studied with hydronephrosis by using binary logistic regression analysis with computed tomography as gold standard test.

Results

Patient demographics

The study included 100 patients with hydronephrosis. The mean age was 39.0 ± 0.9, and

the range was 44.0, with 60% being females and 40% being males. The demographic factors, such as sex, age, and history of urolithiasis, coincided with the findings that resulted from US, IVU, and CT. The hydronephrosis can be assessed by evaluating the performance of these imaging techniques.

Imaging techniques and hydronephrosis types

The current study made a comparison between the imaging modalities (US, IVU, and CT) to diagnose hydronephrosis. Table 1 shows unilateral and bilateral hydronephrosis distribution among these imaging modalities. Ultrasound indicated that unilateral hydronephrosis was 47%, while bilateral was 3% of cases. Generally, unilateral and bilateral cases were distributed equally (P=0.000). The intravenous urography (IVU) technique indicated that unilateral hydronephrosis was 47% and bilateral only 1%. The same strong finding (P = 0.000) is revealed for all distributions. While in the computed tomography (CT) technique, unilateral hydronephrosis was 47%, and bilateral hydronephrosis was 4%. Once again, all distribution is indicative of an acceptable outcome (P=0.00). The relationship between hydronephrosis type and imaging method used for each imaging technique was (P=0.000) for all imaging modalities. This indicate that all imaging techniques has a high effect on the identification of unilateral and bilateral hydronephrosis.

Imaging techniques and hydronephrosis grading

Grades of hydronephrosis classified as severe, moderate, and mild these grades were demonstrated on CT, IVU, and US techniques. In Figure 1 the data are shown as horizontal bars for each imaging technique, indicating the level of severity. The hydronephrosis grades in CT scans were severe (48%), moderate (29%), and mid (23%). The results founded that CT scan has the ability to diagnose advanced cases of the disease, as the highest hydronepherosis grades was determined by CT. In IVU, the grades were severed (47%), moderate (27%), and mild (26%). It also had a considerable proportion of severe grades, close to grades followed in CT; but, in ultrasound technique moderate and mild cases had the same cases number (24%) which is more distributed as a compared to CT, but US identify the largest group of severe hydronephrosis (49%), which mean that US used as an alternative technique for high grade conditions. The three imaging modalities demonstrated all grades of hydronephrosis particularly sever grade Therefore, these imaging modalities are considered effective techniques in identifying the disease at all its grades. Severe grades were identified frequently, indicating the importance of imaging modalities in the diagnosis particularly patients with symptoms of hydronephrosis. Therefore, this graph illustrates CT, IVU, and US grades, all these imaging techniques able to diagnose this disease and the results were similar across all imaging techniques. In addition, the study assessed the relative efficiency of three imaging modalities US, IVU, and CT as shown in Table 2 which illustrate the evaluation of the mean ranks of each method as measured by the Kruskal–Wallis test. The CT scan achieved the highest mean rank 161.03, demonstrating its high effectiveness in diagnosing the disease, especially in severe cases as shown in Figure 2. Ultrasound revealed a moderate preference (mean rank 152.48) which mean that ultrasound is a valuable and useful technique in evaluating the disease, as it is real- time examination and non-invasive, but it is less efficient than the CT scan as shown in Figure 3. IVU was ranked lower (138.00). This result comes from the fact that IVU is an invasive examination as well as for the side effects that may result from the use of the contrast medium as shown in Figure 4. Furthermore, the development of non-invasive imaging modalities reduces the use of IVU examination. The imaging methods are arranged hierarchically, with CT scanning having the highest value, indicating its ability to identify the disease. However, ultrasound considered necessary as an initial imaging technique of the disease. On the other hand, the low ranking of IVU confirm the need to use modern imaging techniques with better effectiveness and fewer side effects. Chi-Square value being (2.910) indicates that there is no great difference between the imaging methods. (Asymptotic Significance) p-value=0.233 indicates there is no significant difference between the imaging methods. Although the mean ranks suggested differences in perception of effectiveness.

Risk factors for hydronephrosis

Table 3 shows different types of effects present in the diagnosis of hydronephroses, using CT as the gold standard. The results indicated that history taking about hydronephrosis predictors such as age, sex, and history of urolithiasis and tests to diagnose hydronephrosis such as ultrasound (US) and intravenous urography (IVU) have a predictive role, too. The negative coefficient for age suggested that with increasing age, hydronephrosis decreases. More precisely, for each one-year increase in age, the odds of hydronephrosis

diagnosis are lower (1 - 0.606). The reason for the decrease in the rate of hydronephrosis with age may be due to anatomical differences in older people or as a result of diseases resulting from cancerous diseases. The p-value for the significance level (p = 0.002) indicates that age is a statistically significant predictor. The sex coefficient (males, females) is positive, indicating a slight increase in the odds of hydronephrosis for males compared to the female population, although this effect is not significant (p = 0.480). Having a male gender increases the chance of hydronephrosis by 22.1%, as shown by an odds ratio of 1.221, but the confidence interval includes 1. Therefore, gender is not considered a major factor influencing the diagnosis of the disease based on CT as the gold standard. A history of urolithiasis is a significant independent predictor of hydronephrosis (P = 0.000) and (odds ratio = 33.115), which means patients with a history of kidney stones have a greater than 33 times probability of having hydronephrosis compared with people who do not have a history of kidney stones. This means that taking the patient's medical history is very important in assessing the patient's clinical condition. Ultrasound results have shown that hydronephrosis can be strongly predicted by yielding an odds ratio of 20.085 (P = 0.000). Ultrasound is considered a primary diagnostic tool based on high probability, as it has the ability to diagnose the disease more than 20 times. similarly, IVU had a significant relationship with hydronephrosis (P = 0.000) with an odds ratio of 12.182. Thus, IVU gives a high possibility of correct diagnosis, but it is lower than US.

Table 1: Imaging methods and hydronephrosis types

Imaging methods	Hdronephrosis type		p-value
Ultrasound (US)	Unilateral	Bilateral	0.000
Unilateral	47 (47%)	0(0%)	
Bilateral	3(3%)	50(50%)	
Total No. (%)	50 (50%)	50(50%)	
Intravenous Urography (IVU)			0.000
Unilateral	47 (47%)	0(0%)	
Bilateral	1(1%)	52(52%)	
Total No. (%)	48(48%)	52(50%)	
Computed Tomography (CT)			0.000
Unilateral	47 (47%)	0(0%)	
Bilateral	4(4%)	49(49%)	
Total No. (%)	51(51%)	49(49%)	

Table 2: Comparing the grades of hydronephrosis among the Imaging methods (US, IVU, CT)

Grades	Imaging methods	Sample size (N)	Mean Rank
	Ultrasound	100	152.48
	IVU	100	138.00
	CT	100	161.03
	Total	300	
Test Statistics		Value	
Chi-Square		2.910	
Degrees of Freedom (df)		2	
Asymptotic Significance (p-value)		0.233	

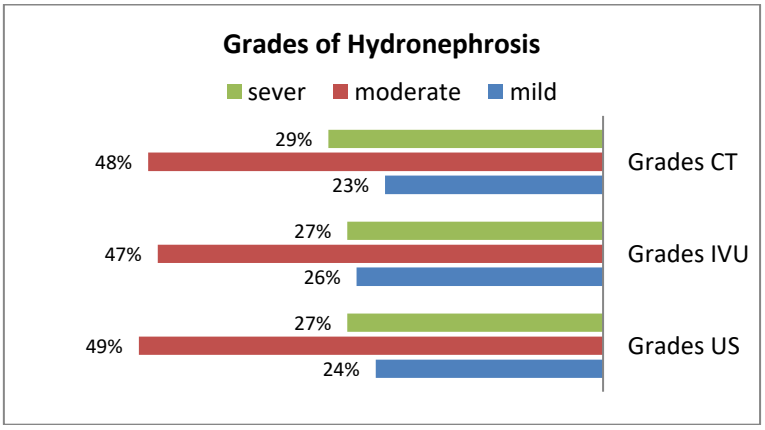

Figure 1: Distribution of grades of hydronephrosis among the imaging methods (CT, IVU, US)

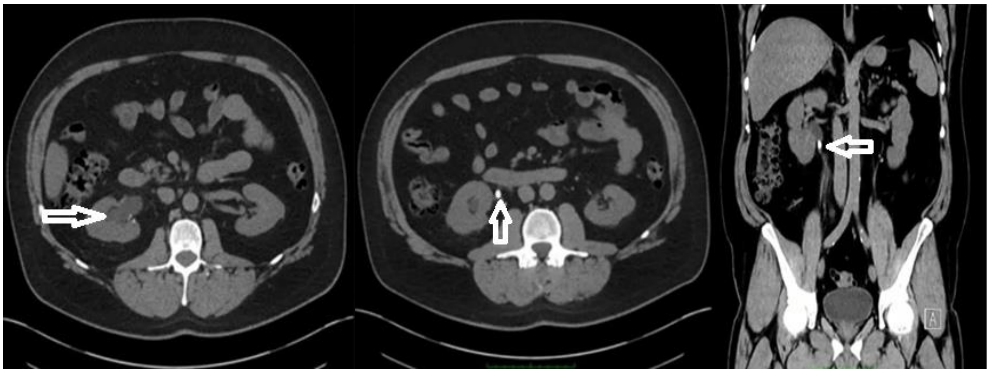

Figure 2: CT scan images with axial and coronal section show the right kidney dilated as a compared with the left kidney indicated mild hydronephrosis due to stone appear in ureteroplevic junction

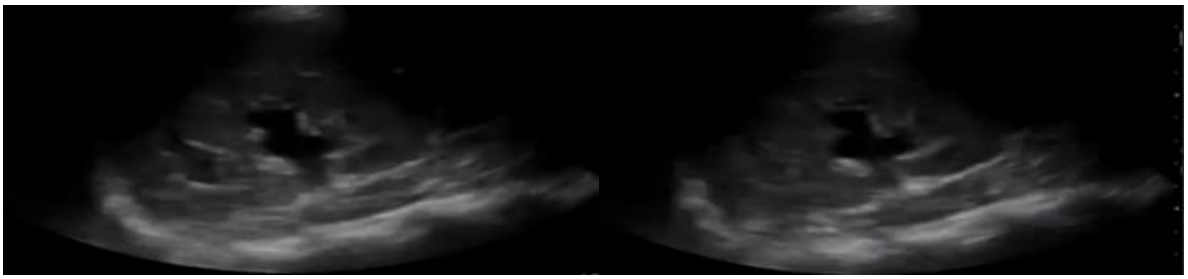

Figure 3: Ultrasound images for patient with right renal colic with mild hydronephrosis with renal pelvis dilated

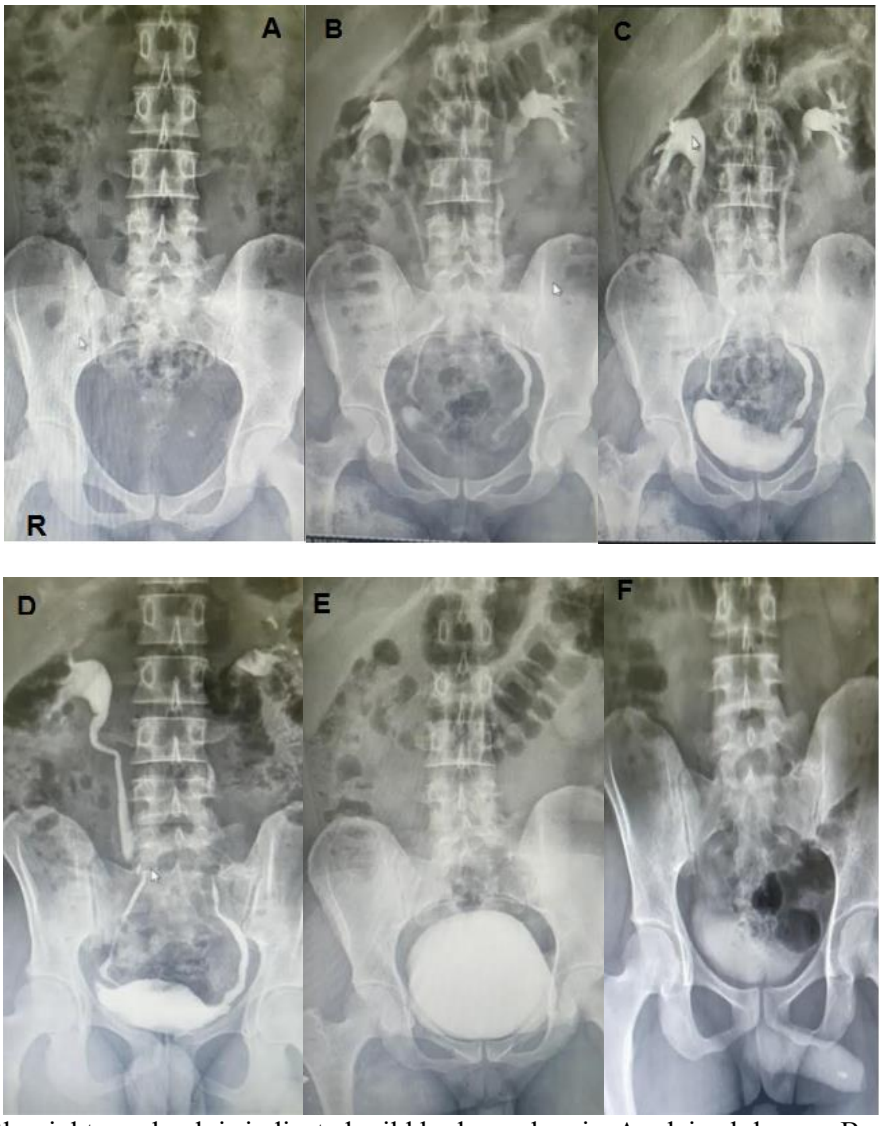

Figure 4: IVU show the right renal pelvis indicated mild hydronephrosis. A. plain abdomen, B. after 5 minute, C. After 10-minute, D. After 20 minutes prone view, E. After full bladder, F. After empty bladder prone view

Table 3: Factors influencing the risk of hydronephrosis through imaging methods and CT scan as a gold standard test

Variable	Between	S.E.	Wald	df	Sig.	Exp (B)	95% C.I. for Exp (B)	
							Lower	Upper
Age	-0.500	0.150	10.000	1	0.002	0.606	0.450	0.820
Sex	0.200	0.300	0.500	1	0.480	1.221	0.700 -	2.150
History of Urolithiasis	3.500	0.600	33.000	1	0.000	33.115	12.000 -	90.500
US Hydronephrosis	3.000	0.500	36.000	1	0.000	20.085	9.000 -	45.000
IVU Hydronephrosis	2.500	0.450	25.000	1	0.000	12.182	5.500 -	27.000

Rates of complications of IVU and other adverse events

Intravenous urography was performed, and the side effects were very small; only 2% of patients had mild pain and nausea, and there were no severe side effects, like nephropathy due to contrast. This means that this examination can be performed within the established protocols, thus reducing the side effects that may occur.

Discussion

Hydronephrosis is one of the reasons for renal dysfunction; it is considered one of the direct causes of renal dysfunction and consequently kidney failure. Therefore, early diagnosis of the disease is considered one of the important things. Early diagnosis of the disease reduces the consequences that may occur to the patient if the correct diagnosis is delayed [14]. The study indicated a relationship between the hydronephrosis type and imaging techniques, which is consistent with another study [15], finding that imaging has a highly effective role in assessing the disease. Ultrasound is considered one of the tests that must be performed as a preliminary examination for the disease, due to its ability to diagnose the disease, as it has the ability to evaluate the anatomical structures and identify any damage that may occur in the tissue. The CT scan results showed that the highest infection rate was in severe cases, followed by moderate and mild cases. These results were consistent with other studies, which indicated that the CT scan can diagnose severe cases because it is able to clearly evaluate the anatomical details of the kidney, and this helps in diagnosing the disease and its impact on the kidney structure, such as obstruction of the urinary tract as a result of hydronephrosis [16]. IVU results were very close to the CT scan results. This means that IVU has the ability to diagnose the disease and evaluate its grades, despite its side effects, as it requires a contrast medium and has a side effect on the patient. It has been observed that IVU is trustworthy, but it may not be as sensitive as CT in detecting subtle anatomical changes [17]. Severe hydronephrosis was observed in 49% of patients by ultrasound, while moderate and mild hydronephrosis were found in 24% and 24% of cases, respectively. Ultrasound is considered one of the primary imaging devices due to its primary and effective role in diagnosing the disease at any stages, as ultrasound is considered one of the safest imaging devices [18]. The results show that CT is positioned at the very top position with a mean rank of 161.03, indicating its high-resolution imaging and its complete assessment features. This is consistent with other studies that highlight CT as the one that provides the most anatomic details and is indispensable for the diagnosis of severe disease [19]. The ranking of CT is related to its effectiveness in demonstrating renal diseases, particularly hydronephrosis, because the urinary tract and peri-nephric area are better delineated by CT than by US, and IVU [20]. The CT scanner is considered one of the useful technique in diagnosing diseases because it is a non-invasive fast technique. All of these things make the CT scanner superior to other imaging modalities in diagnosing diseases [21]. The ultrasound had 152.48 level of predilection; this percentage was moderate because ultrasound has many benefits as a real, non-invasive examination. Ultrasound has limitations in some complex cases due to difficult-to-diagnose lesions. US is an important technique that used as a preliminary assessment and follow-up of congenital anomalies, but it does not reach the ability of computed tomography technique in diagnosing the complex stages of hydronephrosis [22]. The mean rank for IVU (138.00) was the lowest, this decrease is a result of the use of the contrast agents and its side effects [23]. In addition, new non-invasive imaging modalities such as MRI, as well as improved ultrasound capability, now provide a direct alternative to IVU. There are risks of complications and the invasive nature of IVU, hence, we recommend safer alternatives such as ultrasound [24]. Although the results show an indication of a difference in mean ranks, it is not statistically significant at the 5% level. This finding is important because it shows that, at least in

clinical practice, the potential preferences for CT over US and IVU may not translate to a superiority in diagnostic efficiency. This means that all three imaging techniques have the ability to diagnose the disease, but each technique has a specific benefit. The study represents several significant relationships between several predictors and the incidence of hydronephrosis when CT is used as the gold standard test. It was found that older age was statistically significantly correlated with a reduced incidence of hydronephrosis (P = 0.002). However, Age is not one of the causes of hydronephrosis, as there is no relationship between age and the incidence of the disease, despite the existence of some studies that have proven that advancing age is one of the causes leading to the occurrence of the disease [25]. Likewise, hydronephrosis can affect people at any age, as it may occur as a result of a congenital obstruction that occurred during fetal development [26]. While the study has found greater frequency of hydronephrosis in women aged 20-60 may be due to pregnancy and gynecological malignancies [27], compared to our non-significant association between sex and hydronephrosis, the present study excluded these patients (pregnancy and gynecological malignancies). On the other hand, hydronephrosis in men aged over 60 is often attributed to prostatic causes [28]. The study proved that a history of urolithiasis is one of the causes of hydronephrosis. This is consistent with the study that proves that kidney stones are one of the causes of the disease resulting from obstruction in the urinary tract [29]. There is a positive relationship between the diagnosis of the disease and ultrasound and intravenous urograpghy. This indicates that both devices have the ability to diagnose the disease and determine the best method of treatment, and CT is also used as a standard of measurement for these criteria and could be detected as the gold standard test, which means that CT is well known to have high sensitivity for hydronephrosis and be able to detect hydronephrosis and assess the grades of hydronephrosis [30]. In contrast, CT has high efficiency for diagnosing the disease, since CT gives precise anatomical detail of the kidney and the severity of the disease [31].

Conclusions

The study proved the effectiveness of the three imaging modalities (US, IVU, and CT) in diagnosing the stages of hydronephrosis, but the CT scan had the advantage in diagnosing severe grade cases. This does not mean that there is no importance for the other imaging modalities. On the contrary, the ultrasound is considered one of the techniques that must be used to examine the disease, as it is a real examination. Intravenous urography is also useful in diagnosing the stages of the disease, but IVU has disadvantages, as the contrast medium has many side effects. Therefore, it is recommended to reduce this examination. In addition, the study showed that age and history of urolithiasis with the disease have a relationship with the occurrence of the disease, while sex does not affect the incidence rate.

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