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ORIGINAL ARTICLE

Concordance of diagnostic tests, ultrasound of urinary tract versus non-contrast CT in urolithiasis in a four-level center in Bogotá, Colombia

Concordancia de pruebas diagnósticas, ultrasonido de vías urinarias vs. TC sin contraste en urolitiasis en un centro de cuarto nivel en bogotá, colombia

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Abstract

Objective: *In the approach and diagnosis of urinary stone disease, computed tomography (CT)-scan with a focus on the urinary tract is the gold standard. However, renal ultrasonography may be more cost-effective and faster in some settings. Renal ultrasonography has been considered as an alternative in the emergency protocols of some institutions and studies. The objective of this research is to make a study of diagnostic concordance between urinary tract ultrasound and non-contrast CT in a fourth-level center in Bogotá.* **Method:** *Retrospectively, a base is developed with a sample of all the patients who were taken to non-contrast CT and renal ultrasound at the same time for a clinical course suggestive of stone disease. All patients between the period January 2011 and December 2015 with both tests were selected. Data were collected from each of the official reports. A Cohen's Kappa test was performed to evaluate the diagnostic concordance between the variables used.* **Results:** *A sample of 269 patients who underwent simultaneous non-contrast CT and renal ultrasound was collected. Diagnosis of lithiasis was 80.3% CT-KUB versus 44.03% US kappa = 0.29. The kappa value for the size of the largest stone diagnosed between the two images was 0.458. For the location of the largest stone diagnosed between the two images, it was 0.54. For obstruction and degree of obstruction, the kappa correlation value between images was 0.42. Finally, for the number of stones, the kappa correlation value was 0.37.* **Conclusion:** *Non-contrast CT should be the imaging of choice considering its diagnostic values.*

Keywords: *Urolithiasis. Non-contrast computed tomography. Urinary tract ultrasound. Diagnostic tests.*

Resumen

Objetivo: *En el abordaje y diagnóstico de la urolitiasis, la tomografía computarizada (TC) con enfoque en el tracto urinario es el método de referencia. Sin embargo la ultrasonografía renal podría ser más costo-efectiva y rápida en algunos entornos. La ultrasonografía renal se ha considerado como una alternativa en los protocolos de emergencia de algunas instituciones. El objetivo es evaluar la concordancia diagnóstica entre la ecografía y la TC sin contraste en un centro de cuarto nivel.* **Método:** *Se desarrolló una base de datos con una muestra de todos los pacientes que fueron llevados a TC sin contraste y ecografía renal por un cuadro clínico sugestivo de urolitiasis. Se seleccionaron todos los pacientes entre enero de 2011 y*

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diciembre de 2015 que se sometieron a ambas pruebas. Se recopilaron datos de cada uno de los informes oficiales. Se realizó una prueba de kappa de Cohen para evaluar la concordancia diagnóstica entre las variables utilizadas. **Resultados:** *Se recopiló una muestra de 269 pacientes que se sometieron simultáneamente a TC sin contraste y ecografía renal. El diagnóstico de urolitiasis con TC fue del 80.3 vs. 44.03% con ultrasonido, con un valor de kappa de 0.29. Para el tamaño del cálculo más grande el valor kappa fue de 0.458 y el valor kappa para ubicación del cálculo más grande fue de 0.54. La obstrucción y grado de obstrucción tuvieron un valor kappa de 0.42. El número de cálculos tuvo un valor kappa de 0.37.* **Conclusiones:** *La TC sin contraste es la prueba de imagen de elección.*

Palabras clave: *Urolitiasis. TC sin contraste. Ultrasonografía. Pruebas diagnósticas.*

Introduction

In the approach and diagnosis of ureteral stone, tomography with a focus on the urinary tract is the gold standard[1]. However, urinary tract ultrasound (USut) may become more accessible, fast, and cost-effective in emergency settings. Ultrasound has the above advantages, as well as the absence of exposure to ionizing radiation[2]. USut has been considered as an alternative in the emergency protocols of some institutions and studies[3-7]. These have described the ability of ultrasound to diagnose both radiolucent and radio-opaque stones, renal inflammation, urethral obstruction associated with hydronephrosis, and the presence of ureteral jets.

Ultrasound is operator dependent and has always represented a challenge for the surgeon in terms of reliability. Considering that the initial diagnostic image has a great impact on the initial therapeutic decision, it is considered of great relevance to describe the concordance between ultrasound and the gold standard, non-contrast computed tomography (CT), in the emergency setting at a high complexity center in Bogota, Colombia.

Methods

Study design, population, and objectives

A retrospective, descriptive, observational, and cross-sectional study was designed. A retrospective design is considered for a pilot survey conducted in the emergency department of the study institution where emergency physicians did not have in their diagnostic imaging protocols to request both diagnostic images.

Population

A non-randomized non-probabilistic sampling was performed in a fourth level of complexity institution in Bogotá, Colombia. All data are collected from medical records and the surgical database of the institution, filtering patients by diagnosis code (N20.1 ICD10 International Classification of Diseases) and filtered by emergency admission. The inclusion criteria applied to the patients resulting from the search were that the patients were admitted to the emergency department for the main reason for consultation associated with renoureteral colic, urinary tract infection, or another symptom suggestive of ureterolithiasis. Exclusion criteria included pregnancy, patients with another type of diagnostic imaging at the time of consultation, post-operative patients with urological pathology including lithiasis, and patients with no official radiology report of both images. Patients with previously diagnosed concomitant nephrolithiasis were not excluded from the study.

All patients who met the criteria from January 2011 to December 2015 were collected (5 years).

Patient characteristics

The characteristics of the patients were age, sex, and main symptom of the reason for consultation. Body mass index or weight was not collected due to feasibility at the study institution and existing data in the pilot medical records.

Diagnostic imaging characteristics in a high complexity institution

The fourth level of complexity center has the following diagnostic instruments that were used in the diagnostic images of the sample; a Toshiba multislice tomograph with 64 detection channels (Tokyo, Japan) where images were taken with a full bladder, with the patient in supine decubitus, with slices every 3 mm, without contrast medium. The radiation dose protocol determined by the study hospital was followed for all imaging. The standard ultrasonography equipment used; new generation ultrasound, Toshiba Nemio 20, (Tokyo, Japan) evaluates the urinary tract in multiple anatomical planes. Transducers are used according to the patient's habitus to optimize penetration and image resolution.

Characteristics of the diagnostic imaging protocol time and interpretation.

Diagnostic images were requested, acquired, and interpreted in the context of a diagnostic suspicion in the emergency setting. They were subsequently interpreted by a radiologist or senior radiology resident; the images were kept at the discretion of the two readers. Both images were requested in a period and taken no longer than 24 h; however, there is no data on the time between acquisition and reading between one image and another. The physicians in charge of interpreting and reading the images had the possibility to read the patient's medical history, symptoms, and initial approach, as well as history. It was hardly impossible to control that the reading was performed by the same person in the case of each of the diagnostic imaging modalities.

Spontaneous revision of passage and surgery was performed between images.

Study intervention and parameters collected

They are collected in a systematized database, using categorical variables for the variables of interest described.

Diagnosis of ureteral lithiasis, it corresponds to the diagnosis of lithiasis located in the ureter as a conclusion of the diagnostic image.

Laterality, it was defined as the laterality of the diagnosed stone, in case of being present on both sides, the bilateral category was considered.

Stone size, the maximum size of the largest stone in any plane, and four categories were determined, based on the American Urological Association's stratification of ureteral stone passage. < 5 mm, 5 and 10 mm, 10 mm-20 mm and > 20 mm.

Location, defined as the location of the largest stone, three categories were identified: distal or middle ureter, proximal ureter, or upper pole and lower pole.

Obstruction, presence or absence of obstruction, taking into account that there is no interchangeable validated classification system for obstruction between non-contrast CT and ultrasound, it was decided to demonstrate the presence of obstruction between both images. Yes as the diagnosis of hydronephrosis and no if the diagnosis was not mentioned in the report.

Number of stones were counted on a scale of three categories: one stone, two stones, and three stones or more.

Statistical analysis

Over the entire sample, the individual variables of the patients are described by frequency distribution and those of interest by categories of the diagnostic images.

Table 1. Interpretation of the *kappa Cohen* coefficient

Value of K	Strenght of agreement
< 0.00	Bad
0.00-0.20	Poor
0.21-0.40	Weak (fair)
0.41-0.60	Moderate (acceptable)
0.61-0.80	Good
0.81-1	Very good

If the variables do not have a normal distribution, the analysis is performed by percentile distribution. If they have a normal distribution, t-test and Shapiro–Wilk test are used to confirm distribution. A concordance test with Cohen's Kappa coefficient was performed to determine operative conclusions between categorical variables of the diagnostic tests: ultrasound versus non-contrast CT. Table 1 shows the values referenced for interpretation of the kappa cohen coefficient[8]. All statistical calculations were performed in STATA 14 (data analysis and statistical software)[9]. A $p < 0.05$ was considered significant. The corresponding author has full access to the data analysis and takes responsibility for the integrity of the data and its veracity.

Ethical aspects

This study was submitted to an established protocol and presented to an Ethics Committee of the fourth-level hospital where the study was carried out. It was not necessary to take informed consent from each patient. Moreover, the risk was considered less than the minimum according to resolution 8430 of the Colombian Ministry of Health. The project was registered and converted into a clinical study.

Results

Population and patient characteristics

A total of 4748 patient records were reviewed from January 2011 to December 2015 that met our inclusion criteria, of these, only 269 were requested, interpreted, and had an in-hospital report with the characteristics described in materials and methods, for both diagnostic images. Of these 269 patients, 139 (51.6%) were female and 130 (48.33%) were male. The age distribution did not have a normal distribution, so the median was

36 years, with an interquartile range between 27 and 48 years. The majority of patients (46.09%) were in the range between 41 and 60 years in rank analysis. Most of the patients 93.31% presented renoureteral colic as their main clinical manifestation. Table 2 describes the variables associated with the characteristics of the sample.

Characterization and ureterolithotomy by ultrasonography and non-contrast CT

Table 3 characterizes the variables resulting from the interpretation of diagnostic images in each of the imaging modalities.

For the diagnosis of urolithiasis, while 80.66% of the cases were diagnosed with ureterolithiasis of any characteristics by non-contrast CT; only 44.03% of the ultrasounds had a diagnosis of ureterolithiasis. As for stone size, for the < 5 mm category, it was reported in 29.63% of non-contrast CT versus 16.67% USut; for the 5-10 mm category, there was less absolute difference with 50.93% in the non-contrast CT versus 55.88% in the USut; in the 10-20 mm category, the distribution was 17.13% in the non-contrast CT versus 22.55% in the USut; and finally, in the > 20 mm category, the distribution was 2.31% in non-contrast CT versus 4.90% in USut. Regarding laterality, while 31.65% of the stones were right for the non-contrast CT, 42.94% were right for the USut. Bilaterality was diagnosed and characterized in 43.58% of non-contrast CT with a diagnosis of ureterolithiasis and only in 20.16% of USut with a diagnosis of ureterolithiasis.

Regarding location, the largest absolute differences were found between the distal and middle ureter category 55.92% for non-contrast CT versus 34.58% for USut as well as the lower pole category 10.90% of non-contrast CT versus 28.04% of USut. The presence of obstruction was present in 71.69% of the non-contrast CT versus 77.63% of the ultrasounds.

In the number of stones, the greatest absolute difference was seen in the presence of one stone, which for non-contrast CT was present in 44.04% of the cases, while in ultrasound, it was present in 62.86% of the cases, ensuring the underdiagnosis of the lithiasic mass, in number; however, a tendency to overestimate the lithiasic mass in diameter was found.

Table 2. Population characteristics

Sex	n (%)
Female	139 (51.67)
Male	130 (48.33)
Age, year	
< 20	33 (12.26)
21-40	124 (46.09)
41-60	94 (34.94)
61-80	18 (6.69)
> 80	0 (0.0)
Median: 36 years p25 27 p75 48	
Clinical manifestations	
Pyeloureteral colic	251 (93.31)
UTI	8 (2.97)
Other	10 (3.72)

UTI: urinary tract infection.

Table 3. Diagnostic results non-contrast CT/ultrasound

Variables	Non-contrast CT (%)	Ultrasound (%)
Urolithiasis diagnosis		
Yes	217 (80.66)	118 (44.03)
No	52 (19.33)	143 (53.36)
Stone size		
< 5 mm	64 (29.63)	17 (16.67)
5-10 mm	110 (50.93)	57 (55.88)
> 10 < 20 mm	37 (17.13)	23 (22.55)
> 20 mm	5 (2.31)	5 (4.90)
Laterality		
Right	69 (31.65)	52 (12.91)
Left	54 (24.77)	47 (37.90)
Bilateral	95 (13.585)	25 (20.16)
Location		
Distal and middle ureter	118 (55.92)	37 (34.58)
Proximal ureter-upper pole	70 (33.17)	39 (36.15)
Lower pole	23 (10.90)	30 (28.01)
Presence of obstruction		
Yes	157 (71.69)	118 (77.63)
No	59 (26.91)	32 (21.05)
Number of stones		
1	96 (11.01)	66 (62.86)
2	60 (27.52)	16 (15.21)
> 3	62 (28.44)	23 (21.90)

CT: computed tomography.

Diagnostic concordance between ultrasonography and non-contrast CT

The results of the diagnostic test concordance test are shown in table 4. Interpretations and statistical analysis were made based on the Cohen kappa value. For the diagnosis, the concordance had a kappa coefficient of 0.29, which is interpreted as weak or fair. In terms of the size of the stone, the coefficient between the two diagnostic imaging modalities was 0.45, which is

Table 4. Concordance of diagnostic variables between non-contrast CT/ultrasound

Diagnostic variables	Concordance (%)	Expected match (%)	Kappa	SE
Urolithiasis diagnosis	61.57	45.64	0.2929	0.034
Stones size	66.00	37.21	0.4585	0.066
Laterality	67.21	30.73	0.5267	0.577
Location	68.87	32.28	0.5403	0.063
Presence of obstruction	79.87	65.21	0.4213	0.076
Number of stones	58.65	33.51	0.3782	0.062

CT: computed tomography.

interpreted as moderate or acceptable. As for laterality, the kappa coefficient was 0.52, which is interpreted as moderate. It was also the location with a Cohen's kappa value of 0.54. The presence of obstruction had a concordance coefficient of 0.42, which is moderate. Moreover, the number of stones resulted in a concordance coefficient of 0.37 which is weak.

Discussion

The approach to the lithiasis mass at the time of diagnosis of ureterolithiasis in the emergency setting is relevant and has an impact on decision-making in the management and treatment of the patient. Non-contrast CT remains the gold standard because of its operational variables; however, to decrease radiation some protocols and studies have proposed urinary tract ultrasonography. In studies of diagnostic tests comparing the operative performance of USut in comparison with non-contrast CT as the gold standard, it has been determined that this has a low sensitivity of 54% and specificity of 91%[10]. Other studies with the same design propose a decrease in sensitivity associated with stones smaller than 3 mm, recommending smaller operative differences above this value[11]. Some authors propose additional advantages of ultrasonography in pediatric patients, for lower radiation dose, as well as for patients with non-obstructive hydronephrosis[12]. This study also seeks to propose the diagnostic concordance of the variables associated with the diagnosis, taking into account that without a correct characterization, a second diagnostic image would be necessary. Regarding the fact that the non-diagnostic concordance is weak, it should not be considered as a first choice for diagnostic imaging. Its sensitivity is low, and much of the approach would subsequently be erroneous.

With respect to the diagnostic variables evaluated, stone size was considered to have a moderate correlation, however with a tendency to overestimate stone size in diameter stones in general. Previous studies have shown these results with urolithiasis diagnoses, with an overestimation in stones between 0 and 10 mm and a downward estimation in stones larger than 20 mm[10]. These estimates could lead to inadequate management decisions specifically in patients between 6 and 8 mm and values in the gray zone such as 10-15 mm. Fowler et al. describe an average overestimation of 1.5 mm (SD 0.7 mm)[13]. There are studies that propose a lower rate of surgical interventions; however, these lack internal validity and a control group[14].

With respect to laterality, the concordance coefficient resulted in a moderate interpretation. In our study, there was a tendency to underestimate the bilaterality of ureterolithiasis. It has also been described that the operative variables of ultrasonography decrease with right laterality[15].

In terms of the number of stones, the agreement was weak, which could be correlated with the overestimation of diameter. However, there is no significant evidence in this study to ensure such correlation. It can be affirmed that there is a tendency for a lower number of stones in ultrasonography compared to non-contrast CT.

Conclusion

Non-contrast CT should be the imaging of choice considering its diagnostic values. Emergency protocols must be optimized, considering the low sensitivity of ultrasound and the increase in false negatives, patients will require secondary studies and other diagnostic aids. It is important to note that in many centers, ultrasound is the preferred initial investigation for renal colic either due to cost considerations or when CT scans are

not feasible. As demonstrated in our study, ultrasound is the second-best imaging option and can be utilized when CT is not available.

This publication contributes to the literature by providing precise diagnostic reference values for the interpretation of the described image methods.

Limitations

Limitations found in the study are its retrospective nature, and the inability to control the interpreter of the images in each modality or by a single observer, or controllable observers. Experience levels and operating conditions dependent on ultrasound will be a limiting factor for studies associated with this diagnostic imaging. Techniques and experiences of sonographers may cause measurements and observations to vary significantly, but we cannot state with certainty the impact of this factor. In conditions of ultrasound, interpretation in the context and decision-making in lithiasis should be considered carefully and always be critical with the values in diameter and laterality. The number of stones is not a variable that we recommend assessing by ultrasound. Ultrasound should not be the first-line diagnostic and decision-making study, as long as non-contrast CT is available despite the radiation risk. The diagnostic and characterization features of the lithiasic mass are moderate and limited.

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Conflicts of interest

The authors declare no conflicts of interest.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained approval from the Ethics Committee for analysis and publication of routinely acquired clinical data and informed consent was not required for this retrospective observational study.

Use of artificial intelligence for generating text. The authors declare that they have not used any type of generative artificial intelligence for the writing of this manuscript nor for the creation of images, graphics, tables, or their corresponding captions.

Ethics approval and consent to participate

Ethics was approved by Comité Central.

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