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Research Article

The Association Between Hounsfield Bladder Urine in Non-Contrast CT Scan and Positive Urine Culture for Identification of Urinary Tract Infection

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Abstract

Introduction: This study aims to examine Hounsfield bladder urine in a non-contrast CT scan with positive urinary culture to diagnose urinary tract infections in patients referred to Ayatollah Taleghani and Labbafinezhad Hospital in Tehran.

Method: The present research is a cross-sectional study to specify the correlation of urine bladder urine in non-contrast CT scans with positive urinary culture to diagnose urinary tract infection in patients referred to Ayatollah Taleghani and Labbafinezhad Hospital in Tehran in 2022. Patients who were hospitalized with complaints of urinary symptoms and acute abdominal pain, according to laboratory criteria, were diagnosed with a urinary tract infection and underwent a CT scan of the abdomen without injection, were included in the study. The required information in the field of Hounsfield number determination was obtained through radiological studies. Part of the necessary information was obtained from patients' files and from radiological studies.

Result: One hundred nine patients participated in this research; 52 (47.7%) were women. The mean age of the patients was 55.82 ± 17.60 years. Fifty-three people (48.6%) had positive urine culture. The average attenuation value in cases with positive culture was -7.37±5.66, and in cases with negative culture was 8.22±5.00 (P=0.0001). According to ROC curve analysis, the attenuation value's calculated cutoff point for predicting the urine culture's positivity was -3. Therefore, for predicting the positivity of urine culture, the sensitivity rate of the attenuation value was about 82.1%, and the specificity was 81.1% (AUC: 0.91, P-value<0.0001). Forty-three patients with an attenuation value less than negative 3 had positive Urine culture (P=0.0001). The neutrophil average was 73.50±16.38 in patients with attenuation value ≤− 3 and 68.25±12.58 in patients with attenuation value >−3 (P=0.010). Also, the relationship between the distribution of attenuation value with a negative cutoff value of 3 and the distribution of positive and negative cultures of patients was significant (P=0.0001). Also, the relationship between the distribution of attenuation value with a negative cutoff value of 3 and the distribution of leukocyte esterase in the patients was significant (P=0.002).

Conclusion : The measurement of attenuation in the specific bladder area can be a valuable tool in diagnosing urinary tract infections with high accuracy without incurring extra costs. Additional investigations are required to verify the outcomes.

Keywords: Urinary tract infection (UTI), Hounsfield scale, CT scan, urine culture.

Introduction

UTI is a prevalent infectious disease with a high financial cost. The gold standard for diagnosing UTI is urine culture. However, it takes a long to obtain the consequences, so doctors should depend on some blood and urine examinations for critical diagnosis [1-3]. Another method to diagnose UTI is dipstick tests, which are comfortable and quick to perform. A review study shows that the dipstick test for detecting lactoesterase (LE) and urinary nitrite. Diagnosing or ruling out UTI is appropriate when both

results are interpreted together. However, if the dipstick is positive for only one of the above, the results will not be valid, and more tests are required for these patients [4-8]. Microscopic examination of urine is another diagnostic method that requires more time and money than dipstick tests but is faster and cheaper than urine culture [9]. The combination of dipstick tests with microscopic examination can be used to diagnose or rule out UTIs. However, if the result of the total tests is uncertain, then the microscopic examination is positive for pyuria, bacteriuria, and other tests. If negative, a urine culture will be required for diagnosis [10].

Routine imaging is not necessary for diagnosing UTLs. However, imaging techniques are used in complicated UTLs, such as in patients with diabetes, severe signs, immunocompromised patients, and those resistant to antibiotic treatment [15-22]. A non-contrast CT scan is not only an effortless and fast method to diagnose the cause of the obstacle, but it may also supply helpful diagnostic data. Employing CT, body cavities and the weakening of tissues and fluids can be estimated quantitatively and standardly in the Hounsfield unit. The Hounsfield unit measure is usually conducted in clinical preparation to specify the configuration of kidney stones and hardness, anticipate the result of stone management, and distinguish malignant from benign kidney tumors [10-14]. Studies are related to the Hounsfield unit on the content of fluids collected in body cavities [4, 5]. Hounsfield scales are measured and reported in various clinical applications [4].

This study aims to examine Hounsfield bladder urine in a non-contrast CT scan with positive urine culture to diagnose UTIs in patients referred to Ayatollah Taleghani and Labbafinezhad Hospital in Tehran.

Methods

This observational study, a cross-sectional analytical (case-control) study, investigates the relationship of Hounsfield urine in the CT scan without contrast with positive urinary culture for the diagnosis of UTLs in patients referred to Ayatollah Taleghani and Labbafinezhad Hospital in Tehran from May 2022 to August 2023.

After collecting the names of the people hospitalized with complaints of acute abdominal pain and urinary symptoms, the people who underwent three examinations, including microscopic examination of urine by dipstick and urine culture and CT scan of the abdomen without contrast, were included in the study and the CT scan Without contrast, at the level of the trigone of the bladder, the Hounsfield number of the urine inside the bladder is calculated by drawing a converging elliptical area inside the bladder that includes all the urine inside the bladder and the bladder wall is placed outside it, and calculating the skin distance. The Hounsfield number of urine is calculated from the mentioned area. Then, the patients are allocated into groups based on negative and positive urine cultures. The correlation of the Hounsfield number with various parameters, including fever, white blood cell count, and neutrophil count, is measured.

Inclusion criteria:

Patients referred to the emergency room of Ayatollah Taleghani and Labbafinezhad Hospital.

For patients who came with acute abdominal pain and dysuria, the following three procedures were performed at the same time: Microscopic examination of urine, including dipstick tests urine culture, Abdominal CT scan without injection and the bladder volume of patients should be between 150 and 600 cc.

Exclusion criteria:

Patients who have a urinary catheter (D-J, nephrostomy, and Foley catheter)

People who only have CT with intravenous contrast.

People with insufficient bladder volume.

Patients who have errors (artifacts) in imaging (such as orthopedic prostheses)

Positive urine cultures other than Ecoli (including staph, Klebsiella, and Proteus) and positive urine cultures Ecoli less than 100,000.

The technical parameters of taking a CT scan from patients are that the patient was supine with 1.5 mm thick CT-scan images. The model of Taleghani Hospital was a Siemens somatom scope 16-slice scanner. The model of Labbafinezhad Hospital was Siemens Sensation (Siemens Healthneers, Erlangen, Germany) 64 slice scanner.

Statistical analysis

SPSS-26 analyzed the data. The Kolmogorov-Smirnov test was utilized to assess the normality of variable distribution. In the case of normal data distribution, T-test and Mann-Whitney were used. A ROC test was utilized to determine the cut-off point. The significance level of differences was supposed to be $P<0.05$.

Results

The study included 109 eligible patients, 52 (47.7%) were female and 57 (52.3%) were male. The average age of all cases was 55.82 ± 17.60 years. 56 people (51.7%) had negative urine culture and 53 people (48.6%) had positive urine culture.

There was no difference in gender and age distribution among patients with positive and negative cultures (P>0.05) (Table 1). The average pH in cases with positive culture was 5.34±0.53; in cases with negative culture, it was 5.65±0.72, which was significant (P=0.010). Neutrophil mean in cases with positive culture was 75.13±15.69, and in cases with negative culture was 66.71±12.56, which was significant (P=0.002). Also, the mean attenuation value in cases with positive culture was -7.37±5.66, and in cases with negative culture was 5.00±8.22 (P=0.0001) (Table 1).

There was a significant association between nitrite and leukocyte esterase distribution in cases with negative and positive cultures (P=0.001).

Table 1: Participants' information regarding urine culture

Items		Negative	Positive	P-value
Age, years		53.21±17.96	58.58±16.95	0.112
Sex	Female	(%42.9) 24	0.297	0.297
	Male	(%57.1) 32	(%47.2) 25	
PH		5.65±0.72	5.34±0.53	0.010
SG		1017.35±6.76	1019.60±5.21	0.074
The length of the area of assessment in the skin (mm)		49.20±17.10	53.64±20.33	0.312
WBC (103/mm3)		9.18±5.75	11.50±10.73	0.137
Neutrophil (103/mm3)		66.76±12.56	75.13±15.69	0.002
Bladder attenuation value		5.00±8.22	-7.37±5.66	<0.001
Leukocyte esterase	Negative	(%98.2) 55	0.0001	<0.001
	+1	(%1.8) 1	(%15.1) 8	
	+2	(%0.0) 0	(%20.8) 11	
	+3	(%0.0) 0	(%3.8) 2	
Nitrite	Negative	(%100.0) 56	(%60.4) 32	<0.001
	Positive	(%0.0) 0	(%30.2) 16	

According to the ROC curve analysis, the attenuation value's calculated cutoff point for forecasting the urine culture's positivity was -3. The Attenuation value's rate for forecasting the positivity of urine culture was about 82.1%, and the specificity was 81.1% (AUC: 0.91 p < 0.001) (Figure 1). All 43 cases with an attenuation value less than negative 3 had positive urine culture (P=0.0001) (Figure 2).

The neutrophil average in cases with Attenuation value ≤−3 was 73.50±16.38, and in patients with Attenuation value >−3 was 68.25±12.58, which was significant (P=0.010). The relationship between the distribution of attenuation value with a negative cut-off value of 3 and the distribution of positive and negative cultures of patients was statistically significant. Also, the relationship between the distribution of attenuation value with a negative cut-off value of 3 and the distribution of leukocyte esterase in patients was significant (P=0.002). There was no difference in age, gender, PH, SG, WBC distance from the skin surface, and attenuation value with the negative cutoff value of 3 (P>0.05) (Table 2).

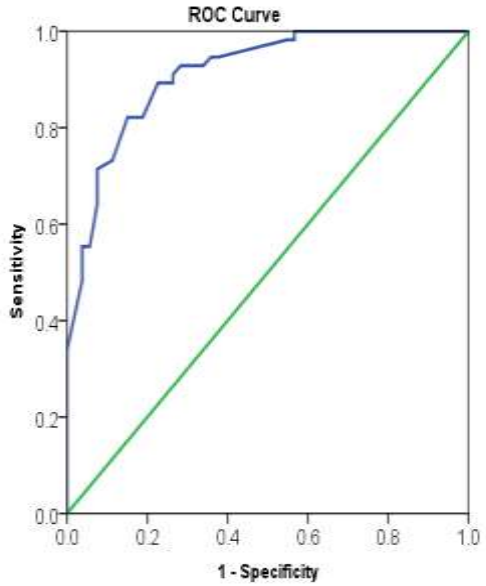

Figure 1: ROC curve analysis, (AUC: 0.91 p < 0.001)

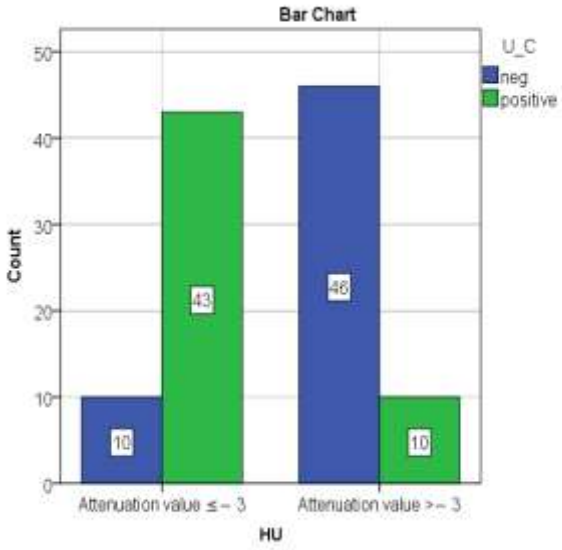

Figure 2: Distribution of attenuation value with a negative cut-off value of 3 with the distribution of positive and negative cultures of patients

Table 2: Participants' information regarding HU

Items		Attenuation value >– 3	Attenuation value ≤– 3	P-value
Age, years		55.42±19.36	56.24±15.72	0.810
Sex	Female	(%44.6) 25	(%50.9) 27	0.510
	Male	(%55.4) 31	(%49.1) 26	
PH		5.61±0.66	5.38±0.62	0.067
SG		1018.41±6.93	1018.49±5.24	0.800
The length of the area of assessment in the skin (mm)		49.12±17.44	54.13±20.31	0.170
WBC (103/mm3)		9.22±5.42	10.34±10.30	0.474
Neutrophil (103/mm3)		68.25±12.58	73.50±16.38	0.010
Bladder attenuation value		(82.2) 46	(%81.2) 43	<0.001
Leukocyte esterase	Negative	(%92.9) 52	(%66.0) 35	0.002
	+1	(%1.8) 41	(%15.1) 8	
	+2	(%3.6) 2	(%17.0) 9	
	+3	(%1.8) 1	(%1.9) 1	
Nitrite	Negative	(%91.1) 51	(%79.2) 42	0.106
	Positive	(%8.9) 5	(%20.8) 11	

Discussion

This study aims to examine Hounsfield bladder urine in a non-contrast CT scan with positive urinary culture to diagnose UTIs in patients referred to Ayatollah Taleghani and Labbafinezhad Hospital in Tehran in 2022. Therefore, a significant correlation between the Hounsfield urine bladder number in the CT scan of the abdomen without injection and the positive urine culture was determined in this study. Meaningful communication in the timely diagnosis of patients with worse general conditions and more comprehensive treatment measures can reduce the mortality rate and the resulting financial burden. 109 patients included in this study, 56 of whom had a negative urine culture, and 53 had a positive urine culture. The average attenuation value was higher in cases with positive cultures than in cases with negative cultures. There was a significant relationship in nitrite and leukocyte esterase distribution in cases with negative and positive cultures. The

calculated cutoff point of the attenuation value for predicting the positivity of the urine culture was -3. The attenuation value's sensitivity rate for determining of urine culture was about 82.1%, and the specificity rate was 81.1%. The neutrophil mean in patients with attenuation value ≤−3 was higher than in patients with attenuation value >−3. Also, the relationship between the distribution of attenuation value with a negative cutoff value of 3 and the distribution of positive and negative cultures of patients was statistically significant. The relationship between the distribution of attenuation value with a negative cutoff value of 3 and the distribution of leukocyte esterase in the patients was statistically significant.

In the study of Basmaci et al. [4] investigated the diagnostic value of CT scan in predicting positive urine culture of the bladder based on the Hounsfield scale, information on 58 patients was collected. The outcomes of this research revealed that the average attenuation value in positive and negative cultures was -6 and 12. Based on the cut-off value of attenuation value, the sensitivity for determining urine culture positivity was 93%, with 100% specificity. All 26 cases with an attenuation value <-1 had a positive urine culture, whereas only 2 out of 32 cases with an attenuation value >-1 tested positive for a urine culture. Basmaci et al.'s findings [4] were akin to the current study, and the marginal variance could be attributed to the disparity in study populations due to limited research in this area and small sample sizes in previous studies. Further studies in different populations should be conducted to confirm the results. The possible mechanism leading to the negative attenuation value of bladder urine with UTI is not precise. It can result from bacteria interfering with compounds in the urine or the bacteria's capabilities [4-7].

Although UTI is a widespread disease, there are still some problems in the diagnosis of UTI that cause difficulties for doctors. The ideal test should be available quickly, cheaply, and accurately. Certain urinary tract infections can have no symptoms or show unusual signs and symptoms [10-14]. Due to these factors, doctors have few tests to diagnose a UTI. Urine is chemically analyzed using a dipstick test. These dry sticks react to identify particular gravity and the existence of nitrites, urine pH, protein, LE, and peroxidase in urine. Finding LE protein in urine suggests the existence of neutrophils and, therefore, pyuria. LE can be identified by using the esterase technique on white blood cells. Nevertheless, there is a high occurrence of false positives caused by contamination with vaginal flora bacteria. The presence of nitrites quickly indicates the presence of bacteria in urine. Various types of bacteria, such as Klebsiella, E. coli, and Proteus, can change nitrate into nitrite. Nonetheless, bacterial species such as Enterococcus, Pseudomonas, and S. saprophyticus do not produce nitrite, resulting in a negative nitrite test despite their presence in urine cultures [19-20].

Attenuation values in non-contrast CT scans may also distinguish the kind and substances of ascites. In a research examined intra-abdominal ascites using non-contrast computed tomography to recognize cases with bladder rupture through ascites calculation. It was discovered that the level of ascites in bladder rupture was notably lesser compared to intestinal ischemia and gastrointestinal perforation [21].

In the study of Yuruk et al. [5] in Turkey, the results of which were published in July 2016, in order to decide the investigative value of CT scan in differentiating hydronephrosis from pyonephrosis based on the Hounsfield scale, the information on 105 patients was examined and based on that, it was determined that Hounsfield in cases with pyonephrosis are higher than cases with hydronephrosis. Goldman et al. (2004) showed the diagnostic value of CT scans in cases of obstructive urolithiasis based on the Renal Hounsfield scale. The information of 145 cases was examined, and the Hounsfield number in the three upper, middle, and lower bridges of the kidney parenchyma was calculated, and the average value was determined for each kidney. The Hounsfield number of the kidney on the side where there was lithiasis was lower than the kidney on the opposite side, and the difference of Hounsfield between the two kidneys was more significant than and equal to 5 with 61% sensitivity and 100% diagnostic specificity [7].

Nonetheless, imaging techniques are employed for complex UTIs in individuals with weakened immune systems, patients with diabetes, those experiencing severe symptoms, and individuals who do not respond to antibiotic treatment. Erdogan and colleagues (2020) examined Hounsfield unit values on non-contrast CT scans of the renal pelvis to differentiate between pyonephrosis and hydronephrosis in enlarged urinary organizations. By conducting Renal Pelvis Hounsfield Unit measurements on non-contrast CT scans, they

determined that distinguishing between pyonephrosis and hydronephrosis can be done promptly and at no extra expense. Basmaci et al.'s (2019) research assessed the ability of HU in renal pelvic urine to predict the presence of positive renal pelvic urine culture in obstructive urinary systems. They stated that HU values were notably reduced in the positive culture cases, regardless of the occurrence of pyonephrosis [6].

An essential limitation of this research is the retrospective data review, and a prospective study is suggested to confirm and re-examine the results.

Based on the outcomes of the current study and the lack of sufficient studies, it is necessary to conduct more studies in this field. Of course, with the outcomes of the current research, CT imaging cannot be suggested for the identification of UTI. However, in cases with an acute incident possibly linked to urinary tract signs and a non-contrast CT scan is requested, detailing the attenuation level can offer important insights regarding a potential UTI diagnosis for the clinician. This is due to the attenuation value provides greater accuracy rate than standard urine test parameters.

Conclusion

The measurement of attenuation in the specific bladder area can be a valuable tool in diagnosing urinary tract infections with high accuracy without incurring extra costs. Additional investigations are required to verify the outcomes.

Acknowledgments

Not applicable.

Conflict of Interest Disclosures

There are no conflicting interests listed by the authors.

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Not applicable.

Authors' Contributions

SHL, PD, MJ, AA, SB and FSJ contributed to the design and draft of the research and data collection, accomplished the data analysis, revised the all data and wrote the text. All authors approve and read the text version final

Ethical Statement

The Shahid Beheshti University of Medical Sciences ethics committee confirmed the proposal of this research (Code: IR.SBMU.MSP.REC.1402.069). All experiments were performed in accordance with relevant guidelines and regulations such as the Declaration of Helsinki and the patients signed the informed consent form and agreed to be published.

Declaration of Generative AI and AI-assisted technologies

None.

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