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Evaluation of patients admitted to the emergency department with the suspect of acute renal colic with the modified stone score

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Aim: Renal colic pain is one of the most common agonizing forms of pain that is frequently treated in emergency departments. Computed Tomography (CT), which is used for the detection of kidney stones, is a costly application. Therefore, scoring systems that predict stone have been developed. This study was conducted to investigate the diagnostic accuracy of the modified STONE score to predict stones.
Materials and Methods: Among those who applied to the emergency department with renal colic pain, patients with CT were examined. 337 patients included in the study were divided into two groups as those with and without kidney stones. It was examined whether there was a difference between these two groups in terms of personal, seasonal, laboratory findings and Modified STONE Score.
Results: We found that ureteral stone history, pain duration less than 6 hours, presence of hematuria and nausea/vomiting, CRP value below 0.5 mg/dL, The Modified STONE score above 9, age ≤50 years were factors that increase stone. The Modified STONE score was significantly high in the stone-detected group. When the STONE score is calculated for all patients and divided into three groups (low, moderated, and high modified STONE scores), the prevalence of ureteral stones increases towards the high modified STONE scores group.
Conclusion: We found that the modified STONE score was quite successful in predicting ureteral stones. We determined that emergency physicians can diagnose stones using this score and avoid unnecessary CT. The diagnostic value of this score may increase when nausea/vomiting factor is added.

Keywords: The Modified STONE Score, Urinary Tract Stones, Emergency Departments
Short Title in English: Kidney stone diagnosis with stone score

INTRODUCTION

Renal colic pain is a painful urologic case caused by the presence of stones in the urinary tract. Typically, the pain is blunt, continuous, and excruciating, with abrupt onset at the costo-vertebral angle, radiating to the groin and genitals [1]. Renal colic pain affects more than 1 million patients who visit hospitals due to complaints from it each year [2] Almost half of these patients revisit hospitals within five to seven years after the first visit. More than 70% of kidney stone occurrences are observed in people aged 20 to 50 years, and the incidence in men is about 2 times higher than in women [3-5]. In Turkey, the prevalence of ureteral stones was reported at approximately 14% [6].

Urinalysis, laboratory tests and imaging methods such as ultrasonography (USG) or computed tomography (CT) are used in renal colic. Although USG can accurately detect hydronephrosis and perinephric fluid, it has low sensitivity in showing and locating kidney stones [7]. Non-contrast CT is the gold standard imaging method in the initial diagnosis of patients with ureteral stones [8]. In recent years, CT with a sensitivity of 96.6% and a specificity of 94.9% has been the first-choice method as it can detect any hydroureter, hydronephrosis or ureteral edema associated with the location and size of the stone. [8,9]. Unlike USG, CT exposes patients to high levels of radiation and increases the long-term risk of cancer [10-13]. It is estimated that there are new cancer patients due to unnecessary abdominal and pelvic CT scans [14]. Therefore, various scoring systems such as STONE score, modified STONE score and CHOKAI score have been developed to prevent unnecessary CT use and thus reduce radiation exposure in patients with ureteral stones [15-17]. The STONE score has a sensitivity of 71.7% and a specificity of 64.7%, while the sensitivity and specificity of the Modified STONE score are reported as 87.7% and 70.6% [17]. For this reason, many researchers preferred to use the Modified STONE score.

Although there are many studies on the STONE score in the literature, there are few studies evaluating the modified STONE score. This study was conducted to investigate the diagnostic accuracy of the modified STONE score and its ability to predict the presence of ureteral stones.

MATERIALS AND METHODS

This study was designed as a single-center, retrospective observational study and it was carried out in Bozyaka Training and Research Hospital which has a capacity of 700 beds and an annual average of 200,000 patients. Inclusion criteria for patients were: Applied to emergency department between January 2019 and January 2020, aged 18 and older, had CT scans and diagnosed with renal colic in the emergency department. The person choosing the patient was blind to the study and just did this job. Exclusion criteria for patients were: Being younger than 18 years old, not having a CT scan, having a history of trauma, presence of active malignancy, presence of known renal disease (creatinine > 1.5 mg/dl), patients with unavailable or missing laboratory data, presence of leukocytes in urine microscopy and having fever more than 37.7°C. Demographic data (age, gender, season of application) were retrieved using the hospital information management system database. The diagnosis of patients who came to the hospital with renal colic complaints, was made by anamnesis, physical examination, laboratory findings, abdominal USG and/or abdominal tomography. The patients included in the study were divided into two groups as those with and without ureteral stones. Modified STONE score was used in patients with ureteral stones. The modified STONE score is calculated according to the values: Gender (male-3 points), duration of pain (<6 hours-3 points), presence of hematuria (6 points), previous stone history (2 points), C-reactive protein (CRP: <5 mg)/l-2 points). Afterwards, the patients were divided into three groups as low risk between 0-4 points, medium risk between 5-

9 points, and high risk between 10-16 points. In addition, as in the study of Kim et al. [16], we determined the optimum cut-off value for MSS as 10. According to this cut-off value, we divided them into two groups as MSS positive and MSS-negative. The accuracy rate in the prediction of ureteral stones was examined in all groups.

Statistical methods:

SPSS 26.0 (IBM Corporation, Armonk, New York, United States) program was used in the analysis of variables. Whether the data were suitable for normal distribution was evaluated with the Shapiro-Wilk test. Independent-Samples T test was used together with Bootstrap results to compare two independent groups with each other according to quantitative data. Mann-Whitney U test was used in conjunction with Monte Carlo results. Pearson Chi-Square test was tested with Monte Carlo Simulation technique to compare categorical variables with each other. Column ratios were compared with each other and expressed according to Benjamini-Hochberg corrected p-value results. Odds ratio with 95% confidence intervals was used to compare patients with and without a risk factor. In order to determine the causal relationship of the presence of ureteral stone with explanatory variables, logistic regression test was tested with the Enter method. Sensitivity and specificity ratios were analyzed by Receiver Operating Curve (ROC) curve analysis to determine the relationship between the real classification and the classification calculated with the cut off values according to the modified stone score, age and CRP variables. Quantitative variables were shown in the tables as mean (standard deviation) and median (percentile 25/percentile 75), and categorical variables as n (%). Variables were analyzed at 95% confidence level, and p value less than 0.05 was considered statistically significant.

RESULTS

Of 1165 patients admitted to the emergency department with suspected acute renal colic, 337 met the inclusion criteria (Figure 1).

In this study, the median (percentile 25/percentile 75) age was 41 (33/52) and the number of male patients was 226 (67.1%). Pain duration was less than six hours in 59.3% of the patients, and it was accompanied by nausea and/or vomiting in 55.5%. Those with a history of ureteral stone in the past were 41.2%. The most common laboratory finding was hematuria with 70.0%. According to CT scan findings, ureteral stones were detected in 237 (70.3%) patients. History of ureteral stone, pain duration less than 6 hours, presence of hematuria, CRP value below 0.5 mg/dL, and STONE score above 9 were significantly more common in the group with ureteral stones ($p<0.001$). In addition, a statistically significant difference was found in the stone-detected group compared to the stone-free group in terms of age (≤50) and the presence of nausea and/or vomiting ($p=0.011$, $p=0.008$). While the median (min/max) value of the modified STONE score was 12 (11/14) in the stone-detected group, it was 4.5 (3 / 6) in the other group, and the difference between the groups was statistically significant ($p <0.001$). No significant difference was found between the groups in terms of leukocyte count (<12.000 cells/mL), BUN (<26 mg/dL) value and creatinine (<1.2 mg/dL) value, the time for application to hospital and gender ($p> 0.05$) (Table 1), (Figure 2). Logistic regression test revealed that 3 factors were statistically significant ($p<0.001$): Age≤50 (Odds Ratio=5.542), presence of nausea and vomiting (Odds Ratio=6.83), Modified STONE Score>9 (Odds Ratio=100.048) were associated with the incidence of renal stone (Table 2).

According to the modified STONE score, 233 (69.1%) patients were in the high risk group, 56 (16.6%) patients in the moderated risk group, and 48 (14.2%) patients in the low risk group.

The prevalence of ureteral stones was 227/233 (97.4%) in the high-risk group, 10/56 (17.8%) in the moderated-risk group, and 0/48 (0%) in the low-risk group. As we move from the low risk group to the high risk group, the prevalence of ureteral stones increases (Figure 3).

When the modified STONE score (MSS) cut-off value was accepted as 10, those with MSS 9 and below were called MSS-negative, those with MSS 10 and above were called MSS-positive. The relationship between the diagnosis of renal stones and the diagnosis of alternative diseases between these two groups is shown in Figure 4.

Alternative diagnoses according to ureteral stone prevalence and Modified STONE score categories are shown in Table 3.

While the imaging results were completely normal in 59 (17.5%) of 100 (29.7%) patients who do not have ureteral stones according to CT scans, pathologies other than ureteral stones were detected in 41 (12.2%) patients. Other pathologies include alternative diagnoses such as acute appendicitis, acute cholecystitis, acute pancreatitis, ovarian cyst rupture, renal infarction, GI perforation, etc. (Table 4).

DISCUSSION

This study demonstrated the applicability of the Modified STONE score in the Turkish population in patients admitted to the emergency department with suspected acute renal colic. Ureteral stones were detected at a rate of 97.4% in the group with a high modified STONE score This result was similar with the rate of 98% found in the study of Kim et al. [16].

History and physical examination findings are very important in patients presenting to the emergency department, but emergency physicians can use scoring systems as a complementary tool. It was showed in our study that the Modified STONE score had a high sensitivity in detecting ureteral stones. Patients with a high modified STONE score are more likely to have ureteral stones. For this reason, patients can be diagnosed without the CT, USG or extra consultation. Thus, rapid discharge of the patient from the emergency department can be planned. For this reason, we think that this scoring system can be preferred by emergency physicians and will reduce the workload and additional cost.

In our retrospective study, 1165 patients with suspected acute renal colic were screened and 598 patients had CT scans. CT imaging method was used in 51.3% of the patients in our own clinic. The rate of CT imaging in our clinic was similar to the rate found in the study of Kim et al. [16].

In our study, the prevalence of ureteral stones was 70.3% whereas in the study conducted by Kim et al. in South Korea, the prevalence of ureteral stones was 79% [16]. In Turkey, the prevalence of ureteral stones varies between 49-84% [17-19].

The modified STONE score included the variables male sex, pain duration less than six hours, previous ureter stone history, presence of hematuria, and C-reactive protein (CRP) less than 0.5 mg/dL [16]. In our study, all these parameters were the same as the other study findings except gender [16,17] Among the patients included in our study, 226 patients (67.1%) were male. While male gender was an important risk factor compared to females in other studies [16,17], although a high rate of male patients was included in our study, the difference was statistically not significant (p=0.07). Since there is no obstetrics and gynecology department in our hospital, female patients in our region often apply to the emergency departments of other hospitals in the region when they are ill. Therefore, the number of male patients could be higher in our hospital.

Although male gender was a risk factor according to the modified STONE score, it was not a risk factor in our study. This may be a difference seen in our society.

In our study, the prevalence of ureteral stones was 227/233 (97.4%) in the high-risk group, 10/56 (17.8%) in the intermediate-risk group, and 0/48 (0%) in the low-risk group. The prevalence of alternative diagnosis is increasing from the high-risk group to the low- and intermediate-risk group. In the alternative diagnosis group, the prevalence was found to be 39.6% (19/48) for the low risk group, 32.1% (18/56) for the medium risk group, and 1.7% (4/233) for the high risk group. These findings also showed similarities as in the study of Kim et al. [16].

We found the alternative diagnosis rate to be 12.1% in patients who applied to our emergency department with the suspicion of acute renal colic. In similar studies, the rate of alternative diagnosis varies between 10% and 22.1% [20-22]. The higher rate of alternative diagnosis in other countries compared to our country can be explained by the more widespread use of CT imaging.

As in the study of Kim et al., we determined the optimum cut-off value for MSS as 10 [16], and according to this cut-off value, two groups were designated as MSS positive and MSS-negative. The MSS positive group corresponds to the high-risk group and includes patients with a modified STONE score of 10 or more. The prevalence of ureteral stones in the MSS positive group was 97.4% in our study, while it was 98.0% in the study of Kim et al. [16].

In our study, important alternative diagnoses were found to be 1.7% in the MSS positive group. These diagnoses were diverticulitis, inguinal hernia, enterocolitis and pelvic inflammatory disease. In the study of Kim et al., the rate of significant alternative diagnosis in the MSS positive group was 1.9% [16] which was similar to the result in our study. On the other hand, the rate of significant alternative diagnosis in the MSS negative group was found to be 35.6% in our study. In the study of Kim et al., this rate was 23.5% [16]. Therefore, it can be said that advanced imaging methods are necessary for patients in the MSS negative group.

It is known that acute renal colic pain is more common in young adult men and often recurs [3-5]. Therefore, young patients have frequent admissions to the emergency department. There are studies which showed that patients are exposed to high levels of radiation with CT and this increased the risk of cancer, particularly in younger patients compared to the elderly [23]. In addition, unnecessary IT requests both increase the length of stay in the emergency department and cause additional costs. As seen in our study and other studies, MSS positivity largely detects ureteral stones, and it can be said that additional imaging methods other than ultrasound can be abandoned.

In our study, we detected ureteral stones in 67.4% (233/347) of the patients with MSS positive. In the study of Kim et al., this rate was 64.2% [16]. Accordingly, it can be interpreted that using MSS can reduce the use of CT method by 60-70%, and thus reduce the risk of cancer due to radiation.

Our study has some limitations. The sample size was relatively small and it was a retrospective study. In addition, the generalizability of the findings is limited as it is a single-center study. The results may differ from region to region or country to country due to differences such as geographical conditions, socioeconomic level, eating and drinking habits that may affect the symptom of acute renal colic. Our study was only for a part of the Turkish population. The results of this study should be supported by multicenter studies that can cover all regions of the country or studies covering different countries. Only patients who underwent CT imaging in the

MSS evaluation were examined. However, other imaging methods are also frequently used in our country. These limitations should be considered in future research.

CONCLUSION

With this study, we found that the Modified STONE score is quite successful in predicting ureteral stones. By using this score, emergency physicians will safely reduce the overuse of CT, the costs, and the length of stay in the emergency room. We think that when factors such as nausea and/or vomiting are added to this score, its diagnostic value may increase. The sensitivity and specificity of the modified STONE score should be supported by more extensive studies.

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Table 1. Comparison of demographic data, laboratory findings, Modified Stone Score findings of patients with and without ureteral stone

	Total	Patients without stone	Patients with stone	p
	(n=337)	(n=100)	(n=237)	
Age, median(q1/q3)	41 (33 / 52)	43 (35 / 56)	40 (32 / 50)	**0.011** [u]
Gender, n(%)				0.077 [c]
Female	111 (32.9)	40 (40.0)	71 (30.0)	
Male	226 (67.1)	60 (60.0)	166 (70.0)	
Season, n(%)				0.354 [c]
Autumn	73 (21.7)	21 (21.0)	52 (21.9)	
Winter	87 (25.8)	30 (30.0)	57 (24.1)	
Spring	69 (20.5)	15 (15.0)	54 (22.8)	
Summer	108 (32.0)	34 (34.0)	74 (31.2)	
Pain duration, n(%)				**<0.001** [c]
<6	200 (59.3)	25 (25.0)	175 (73.8) [A]	8.5 (4.9-14.5) [OR]
>6	137 (40.7)	75 (75.0) [B]	62 (26.2)	
Nausea, vomiting, n(%)				**0.008** [c]
No	150 (44.5)	56 (56.0) [B]	94 (39.7)	1.9 (1.2-3.1) [OR]
Yes	187 (55.5)	44 (44.0)	143 (60.3) [A]	
Stone story, n(%)				**<0.001** [c]
No	198 (58.8)	82 (82.0) [B]	116 (48.9)	4.7 (2.7-8.4) [OR]
Yes	139 (41.2)	18 (18.0)	121 (51.1) [A]	
Hematuria, n(%)				**<0.001** [c]
No	101 (30.0)	83 (83.0) [B]	18 (7.6)	59.4 (29.2-120.7) [OR]
Yes	236 (70.0)	17 (17.0)	219 (92.4) [A]	
Creatinine, mean (SD.)	1.1 (0.2)	1 (0.2)	1.1 (0.2)	0.485 [t]
BUN, median(q1/q3)	31 (25 / 37)	30.5 (24 / 40)	31 (25 / 37)	0.893 [u]
Urea, median(q1/q3)	66.34 (53.5 / 79.18)	65.27 (51.36 / 85.6)	66.34 (53.5 / 79.18)	0.893 [u]
CRP, median(q1/q3)	0.4 (0.2 / 3.7)	1.6 (0.3 / 7.25)	0.4 (0.2 / 2.8)	**<0.001** [u]
WBC, median(q1/q3)	9.47 (7.59 / 12.07)	9.775 (7.57 / 13.22)	9.43 (7.61 / 11.39)	0.155 [u]
Stone Score, median(q1/q3)	11 (7 / 13)	4.5 (3 / 6)	12 (11 / 14)	**<0.001** [u]
Age, n(%)				**0.011** [rc]
>50	91 (27.0)	37 (37.0) [sp]	54 (22.8)	AUC (SE): 0.588 (0.034)
≤50	246 (73.0)	63 (63.0)	183 (77.2) [ss]	
CRP, n(%)				**<0.001** [rc]
>0.4	146 (43.3)	63 (63.0) [sp]	83 (35.0)	AUC (SE): 0.668 (0.031)
≤0.4	191 (56.7)	37 (37.0)	154 (65.0) [ss]	
Stone Score, n(%)				**<0.001** [rc]
≤9	104 (30.9)	94 (94.0) [sp]	10 (4.2)	AUC (SE): 0.971 (0.011)
>9	233 (69.1)	6 (6.0)	227 (95.8) [ss]	

[u] Mann Whitney U test(Monte Carlo), [c] Pearson Chi-Square Test(Monte Carlo), [OR] Odds Ratio (%95 Confidence Interval), [rc] Roc (Receiver Operating Curve) Analysis (Honley&Mc Nell - Youden index J), AUC: Area under the ROC curve, q1: percentile 25, q1: percentile 75, [A] Significance according to the "patients without stones" group, [B] Significance according to the "patients with stones" group

Table 2. Odds Ratio for age, presence of nausea and vomiting, and Modified Stone Score

	B	SE.	P	Odss Ratio	Odss Ratio 95% C.I.	
					Lower	Upper
Age (≤50)	1,712	0,459	**<0.001**	5,542	2,253	13,631
Nausea, vomiting	1,921	0,341	**<0.001**	6,830	3,504	13,315
Modified Stone Score(>9)	-4,606	0,547	**<0.001**	100,048	34,230	292,418

Dependent variable: Presence of stones, Prediction rate of patients with stones=96.2, Prediction rate of patients with non-stones=83, Overall accuracy: 92.3, P Model<0.001

Multiple Logistic Regression (Method = Enter), C.I. :Confidence interval, B: regression coefficients, SE: Standard error

Table 3. Alternative diagnoses in patients according to modified STONE score categories

	Low risk (n= 19)	Moderate risk (n= 18)	High risk (n= 4)	Total (n= 41)
Acute Appendicitis	1	-	-	1
Cholelithiasis	2	2	-	4
Newly Detected Malignancy	2	1	-	3
Acute Pyelonephritis	2	2	-	4
Acute Cholecystitis	1	1	-	2
Ovarian Cyst	1	2	-	3
Enterocolitis	1	-	1	2
Inguinal Hernia	-	2	1	3
Ureteropelvic Stenosis	-	1	-	1
Renal Infarction	-	1	-	1
Ovarian Cyst Rupture	1	-	-	1
Pelvic inflammatory Disease	-	-	1	1
GIS Perforation	1	1	-	2
Endometriosis	-	1	-	1
Thoracolumbar Spondylosis	1	-	-	1
Acute Pancreatitis	-	1	-	2
Angiomyolipoma	1	-	-	1
Paraganglioma	1	-	-	1
Hydatid Cyst of the Liver	1	-	-	1
Appendicolith	-	1	-	1
Diverticulitis	-	1	1	2
Adrenal Adenoma	1	1	-	2
Aortic Syndrome	1	-	-	1
Pneumonia	1	-	-	1

Table 4. Alternative diagnoses in patients without ureteral stones

	n	%
Patients having stone	237	70,3
Patients not having stone and not being detected any diseases	59	17,5
Patients not having stone but being detected alternative diseases	41	12,2
Cholelithiasis	4	1,2
Pyelonephritis	4	1,2
Inguinal Hernia	3	0,9
Ovarian Cyst	3	0,9
New Malignancy	3	0,9
Diverticulitis	2	0,6
Enterocolitis	2	0,6
Gastrointestinal Perforation	2	0,6
Cholecystitis	2	0,6
Adrenal Adenoma	2	0,6
Angiomyolipoma	1	0,3
Aortic Syndrome	1	0,3
Appendicitis	1	0,3
Appendicolith	1	0,3
Endometriosis	1	0,3
Hydatid Cyst of the Liver	1	0,3
Ovarian cyst rupture	1	0,3
Pancreatitis	1	0,3
Paraganglioma	1	0,3
Pelvic Inflammatory Disease	1	0,3
Pneumonia	1	0,3
Renal Infarction	1	0,3
Thoracolumbar Spondylosis	1	0,3
Ureteropelvic Stenosis	1	0,3

Figure 1. Flow diagram of the study

Figure 2. Roc curves about Modified Stone Score, age and CRP level of the patients.

Figure 3. Comparison of patients with low, moderated and high modified STONE scores in terms of detection of ureteral stones and alternative diagnoses

Figure 4. Comparison of patients with positive and negative modified STONE scores in terms of detecting ureteral stones and alternative diagnoses