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The comparison of two prediction models for ureteral stones: CHOKAI and STONE scores

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1. Introduction

Renal colic is an emergency symptom characterized by sudden onset of intense pain secondary to urinary stone disease. It is the most common urologic disease of patients seeking help in the emergency department (ED) [1]. The overall prevalence of urinary stone disease is reported as 14% in Turkey [2]. In the United States, over 1 million patients are examined and treated for renal colic every year [3].

Use of unenhanced helical computed tomography (CT) is recommended for diagnosis of kidney stone disease due to its high sensitivity and specificity [4]. In the United States, more than 1.5 million CT scans are carried out yearly for suspected kidney stones [5].

Scoring systems have been developed for patients presenting to the ED with renal colic in order to reduce average time spent in the ED and reduce exposure to radiation. Moore et al. developed the STONE scoring system, comprised of 5 variables (sex, pain duration, ethnic origin, nausea-vomiting, hematuria) resulting in a score between 0 and 13 points. Scores ranging from 0 to 5, 6–9, and 10–13 represent a low, medium, and high risk of kidney stones respectively. In STONE scoring system's prospective validation, in patients with a score between 10 and 13, thus belonging to the high risk group, 88.6% were found to have a ureteral stone while only 1.6% received an alternative major diagnosis [6]. Fukuhara et al. developed the CHOKAI scoring system based on a Japanese population, comprised of seven variables (nausea-vomiting, hydronephrosis, hematuria, history of renal stones, sex, age, duration of pain). This system also scores patients from 0 to 13 points. In the study patients were seperated into two risk groups according to respective optimal cut-off values; CHOKAI score suggestive of high probability (6–13), and low probability (0–5). 98.6% of patients with CHOKAI scores ≥6 were found to have ureteral stones [7].

Our study aimed to compare and contrast the diagnostic accuracy of STONE and CHOKAI scores in patients presenting to the ED with flank pain.

2. Materials and methods

2.1. Study design and selection of patients

The study facility was a 150-bed urban hospital with an annual ED census of approximately 216,000. The institutional review board approved the analysis and issued a waiver of consent (Ethics Committee Ruling number: 2019/8–4).

We retrospectively reviewed the medical records of patients who visited the ED for flank pain between January 2019 and October 2019. Of these patients, those who were ≥ 15 years of age and had a urinalysis, ultrasonography (US) and CT scan available were included in the study. Patients with abnormal vital signs (high fever, hypotension), malignity history, urinalysis revealing leukocytes and C-reactive protein (CRP) concentrations ≥6 mg/L, and/or no US, CT, or urinalysis available were not included in the study. The definitive diagnosis of ureteral stone was made by a radiology specialist's analysis of CT scans. STONE and CHOKAI scores were calculated after diagnosis of urinary sytem stone was certain (Table 1) [6,7].

2.2. Statistical analysis

In summarizing the data obtained from the study, descriptive statistics were tabulated for continuous variables as mean ± standard deviation or median and quartile width, depending on the distribution. Categorical variables were summarized as numbers and percentages. The normality test of numerical variables was checked with the Kolmogorov Smirnov test. Independent Samples t-test was used when the laboratory parameters showed normal distribution according to the presence of the producing stone, and the Mann Whitney *U* test was used in cases where there was no normal distribution. The superiority of CHOKAI and STONE scores in detecting ureteral stones was examined by Receiver operating characteristic (ROC) curve analysis. In addition, the cut-off value was determined for each score. Spearmen Rho Correlation coefficient was used to evaluate the correlation between CHOKAI and STONE scores and laboratory parameters. With the MedCalc Statistical Software Trial version (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2015) program, using the DeLong method and Youden's index; The optimal cut-off value, 95% confidence interval [CI], area under the curve (AUC), positive likelihood ratio (LR+), and negative likelihood ratio (LR−) were calculated. Statistical analyzes

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Table 1
CHOKAI and STONE score calculation [5,6]

Variables		CHOKAI score	STONE score
Age	<60 years	1	–
	≥60 years	0	–
Sex	Male	1	2
	Female	0	0
Duration of pain	<6 h	2	3
	6–24 h	0	1
	>24 h	0	0
Nausea or Vomiting	Vomiting	1	2
	Nausea	1	1
	Absent	0	0
Urinary stone history	Yes	1	–
	No	0	–
Hydronephrosis	Yes	4	–
	No	0	–
Hematuria	Positive	3	3
	Negative	0	0
Race	Black	–	3
	Non-black	–	0
Total score		/13	/13

were performed using the program Jamovi project (2019), Jamovi (Version 1.0.1) [Computer Software], (Retrieved from https://www.jamovi.org). Significance level was taken into account as 0.05 (p-value) in statistical analysis.

3. Results

A total of 609 patients were retrospectively analyzed. Of these, 239 patients were found to fit the inclusion criteria and were subsequently included in the study (Fig. 1).

Patients' demographical and clinical characteristics as well as laboratory findings are summarized in Table 2. The mean age of the patients was 39.4 ± 6.3, while 160 were male and 79 were female. Seventy-seven patients presented with nausea, while 20 experienced vomiting. The mean CHOKAI and STONE scores of the patients were 8.2 ± 3.0 and 8.1 ± 2.5, respectively. Patients' median CHOKAI score was 9.0 [6.0–11.0], while median STONE score was 8.0 [6.0–10.0]. Final diagnoses of the patients, CHOKAI and STONE scores according to diagnoses, invasive procedures, and outcomes are displayed in Table 3. In the 39

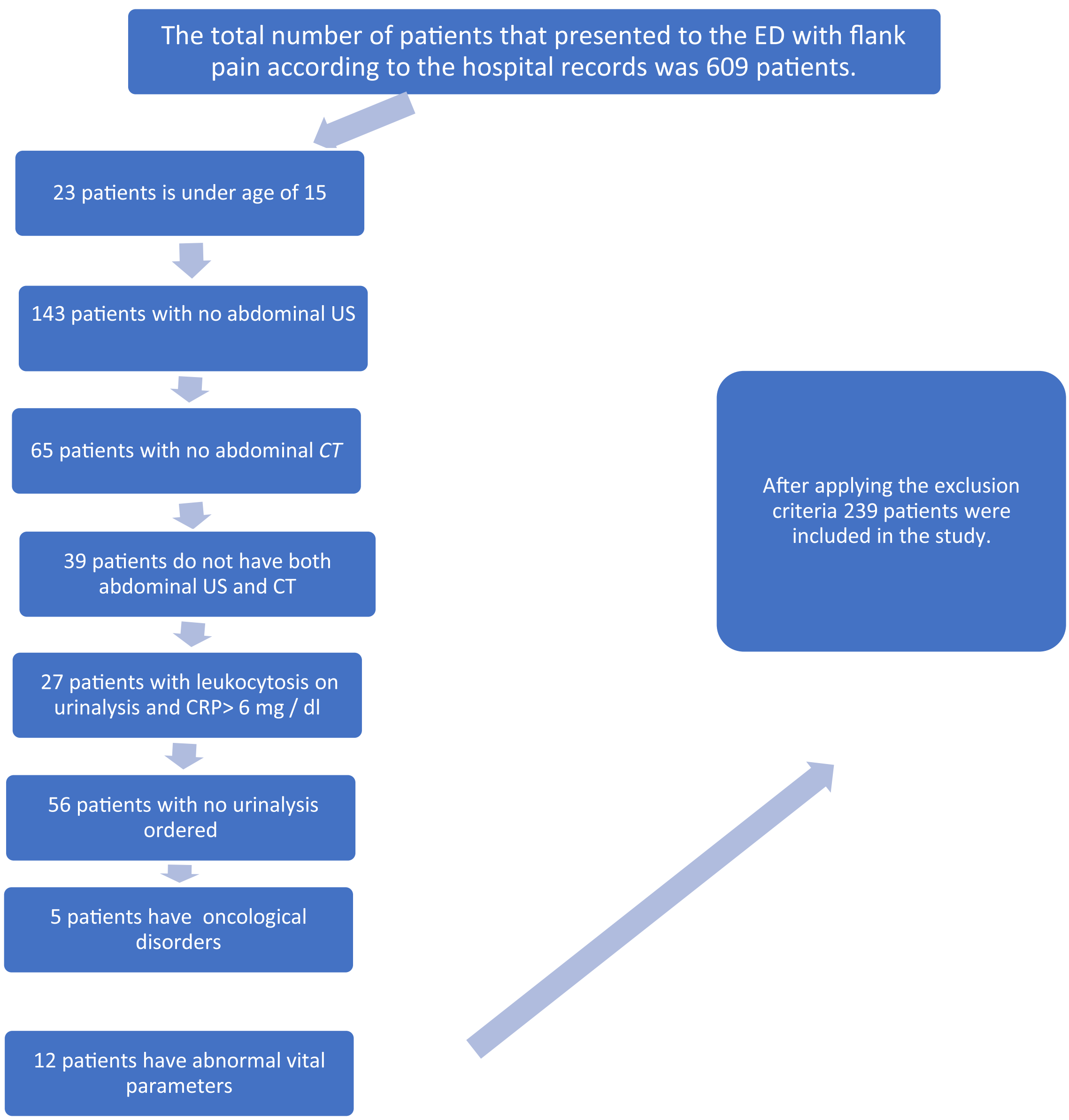

Fig. 1. Patients flow diagram.

(16%) patients that received a diagnosis other than ureteral stones, non-urological interventions were applied.

Table 4 shows the relationship between the presence of kidney stones and scores. While 159 of the patients with a positive STONE score have kidney stones, 167 of the patients with a positive CHOKAI score have kidney stones, and only 1 patient has an alternative diagnosis.

CHOKAI and STONE scores' respective advantages as well as their sensitivity, specificity, LR+ and LR- were calculated and displayed in Table 5. In the ROC curve analysis carried out according to this data, CHOKAI score was found to be superior to STONE score in a statistically significant manner (Fig. 2, $p = .006$). Furthermore, CHOKAI's sensitivity, specificity, LR+ and LR- in predicting ureteral stone was found to be 83%, 94.9%, 16.27 and 0.18, respectively while CHOKAI score's cut-off value was found to be >6 (AUC = 0.945, (95% [CI]: 0.908–0.970, $p < .001$). Finally the STONE scoring system with a cut-off value of >6 (AUC = 0.860, (95% [CI]: 0.810–0.901, $p = .004$) showed a sensitivity of 79.5%, specificity of 84.6%, LR+ of 5.16 and LR- of 0.24.

4. Discussion

Defining clear safety criteria for discharge, as well as outlining time intervals for discharge or committing patients to inpatient treatment is of utmost importance in ED. For this reason, doctors working in the ED use a multitude of medical scoring, criteria, and classification systems. These resources provide important clinical guidance to doctors in predicting outcomes, patients' perspective risks, and circumstances as well as diagnosing patients accurately [8]. In our study, we compared the utility of CHOKAI and STONE scoring systems in patients presenting with flank pain and found that CHOKAI was a superior system compared to STONE. In addition, 39 of the patients included in the study had an alternative diagnosis other than ureteral stones. Almost all of these alternative diagnoses would have been identified by the CHOKAI score and the STONE score (except for one patient with bladder cancer with a STONE score >6).

The STONE scoring system devised by Moore et al. uses a combination of sex, duration of pain, ethnic origin, hematuria, and nausea-vomiting and gives a maximum score of 13 points. According to this, patients are separated into three groups according to risk; low (0–5), medium (6–9), and high (10−13). According to this system, patients with high scores may be diagnosed using methods other than CT, or low dose CT may be considered as an alternative. Conversely, patients with low scores should be considered for alternative diagnoses [6].

The STONE scoring system has been investigated through external validation studies in the literature [9]. Wang et al. conducted a validation study in which they compared STONE score and physician gestalt performance in predicting presence of ureteral stones. The authors of the study found that STONE was superior to physician gestalt in terms of specificity [10]. In the patients included in our study, the vast majority (83.7%) were found to have ureteral stones. We attributed this to physician gestalt, but since our study did not compare physician gestalt with scoring systems we were unable to compare our results with Wang and colleagues' research.

In our study the vast majority of patients presented with nausea or vomiting (59.4%). Kim et al. conducted an external validation study on the STONE scoring system and subsequently replaced the nausea-vomiting variable with history of ureteral stone and low CRP (<0.5 mg/dL), creating the modified STONE score. They found that the modified STONE score's diagnostic performance was higher than the original STONE score [11].

Literature shows that cumulative radiation exposure increases cancer risk and that young patients in particular are at higher risk than older patients [12,13]. In our study, 66.5% of patients with a positive STONE score had kidney stones, while 69.8% of patients with a positive CHOKAI score had kidney stones. The reduction in CTs will be at least 66%, which is a definite benefit of using both scores, although this benefit is not much different between the two scoring systems.

Due to the fact that patients presenting to the ED tend to be younger and these complaints are often recurrent. Hence physicians developed new clinical scoring systems in order to reduce reliance on CT for diagnosis [14,15]. Fukuhara et al. developed the CHOKAI scoring system of which one of the variables is evidence of hydronephrosis on US, equal

Table 2
Demographic and clinical characteristics of the patients.

Variables	
Age, years (mean ± SD)	39.4 ± 16.3
Gender, n (%)	
Male	160 (66.9)
Female	79 (33.1)
Nausea and Vomiting, n (%)	
Absent	142 (59.4)
Nausea	77 (32.2)
Vomiting	20 (8.4)
Onset of Pain, n (%)	
<6 Hours	89 (37.2)
6–24 Hours	71 (29.7)
>24 Hours	79 (33.1)
Hydronephrosis, n (%)	200 (83.7)
Stone, n (%)	200 (83.7)
Right	108 (45.2)
Left	120 (50.2)
Localization, n *(%)*	
Distal ureter	142 (71)
Mid ureter	26 (13)
Proximal ureter	32 (16)
Stone Size, mm (mean ± SD*)*	6.3 ± 2.5
Hematuria, n (%)	
Present	91 (38.1)
Absent	148 (61.9)
History of Stone, n (%)	
Absent	144 (60.3)
Present	95 (39.7)
CHOKAI Score, pts (*mean* ± SD)	8.2 ± 3.0
STONE Score, pts (*mean* ± SD)	8.1 ± 2.5

Table 3
Final diagnosis, patient interventions and outcomes

Final diagnosis	n (%)	CHOKAI Score	STONE Score
Ureteral stone	200 (83.7)	9.1 ± 2.4	8.7 ± 2.2
Ureteropelvic Stenosis	20 (8.4)	4.8 ± 1.9	5.1 ± 2.2
Myalgia	7 (2.9)	2.6 ± 1.5	5 ± 2.2
Ovarian Cysts	2 (0.8)	2	6
Cholecystitis	2 (0.8)	2	5
Urinary tract infection	2 (0.8)	2	4
Urinary bladder cancer	1 (0.4)	5	9
Orchitis	1 (0.4)	2	5
Appendicitis	1 (0.4)	2	5
Segmental Artery Stenosis	1 (0.4)	4	5
Ureteral obstruction due to cervical cancer	1 (0.4)	6	6
Ovarian Torsion	1 (0.4)	2	6
Patient Interventions	N		
Ureteroscopic Stone Fragmentation	119		
Medical Treatment	80		
Follow-up	16		
Pyeloplasty	4		
Appendectomy	1		
Oophorectomy	1		
Cystoscopy	1		
Cholecystectomy	2		
Extracorporeal Shock Wave Lithotripsy	13		
Other Surgical Intervention	2		
Outcomes	N		
Admission	143		
Discharge	96		

Table 4
The relationship between the presence of kidney stones and scores

	Presence of kidney stone	
	Present	Absent
STONE > 6	159	6
STONE ≤ 6	41	33
CHOKAI > 6	167	1
CHOKAI ≤ 6	33	38

Table 5
ROC analysis according to CHOKAI and STONE scores at diagnosis of ureteral stone

	CHOKAI score (>6)	Stone score (>6)
AUC	0.945	0.860
Sensitivity	0.830	0.795
Specificity	0.949	0.846
95% CI	0.908–0.970	0.810–0.901
p value	**<.001**	**.004**
CHOKAI vs STONE Scores p-value	**0.006**	
LR+	16.27	5.16
LR−	0.18	0.24

AUC, Area Under The Curve; CI, Confidence Interval; LR+, Positive Likelihood Ratio; LR−, Negative Likelihood Ratio. Bold denotes the p value.

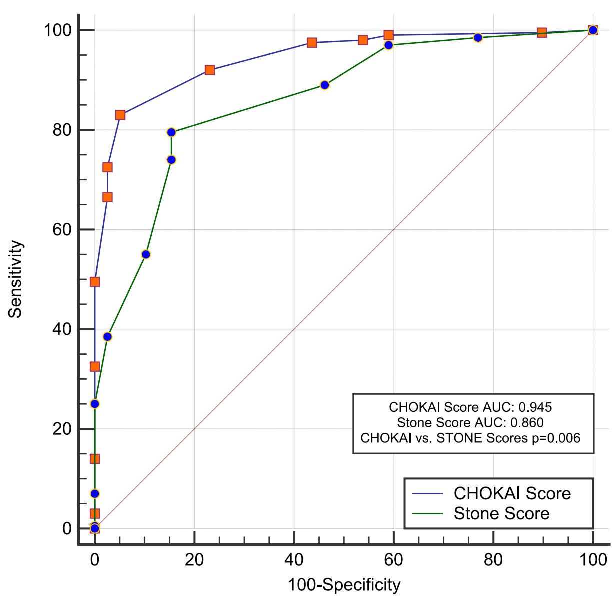

Fig. 2. Receiver operating characteristic curves of the STONE and CHOKAI score.

to 4 points. In their study, CHOKAI's sensitivity was found to be 0.911, while specificity was 0.941. According to these results, CHOKAI was found to be superior to STONE (sensitivity 0.823, specificity 0.824) [7]. Our study corroborated these results, with CHOKAI showing superior performance (sensitivity 0.83, specificity 0.949).

A study conducted recently in Turkey externally validated STONE, modified STONE, and CHOKAI's performance, finding that STONE, modified STONE, and CHOKAI scoring systems' specificity and sensitivity values were 64.71%, 71.70%; 70.59%, 87.74%; and 66.67%, 90.57% respectively [16]. This research attained similar results to ours, with researchers advising revision of the "ethnic origin" parameter, and that this parameter is of limited use in population where that are little or no caucasians.

Limitations.

This study had a few limitations. Firstly, it was designed as a single-center study and was conducted retrospectively. The fact that CT is the gold standard for ureteral stone diagnosis, as well as the fact that US is used in the scoring systems that we contrasted in the study necessitated the exclusion of many patients, significantly decreasing our sample size. Furthermore, the experience and skill of the physician carrying out US imaging may lead to varying results [17].

In conclusion, this study conducted on a Turkish population found that in terms of value in diagnosing ureteral stone, the CHOKAI system was superior to STONE. Despite this, more studies are required in order to establish effectiveness in a wider range of settings.

Credit author statement

All authors had access to the manuscript at every stage of the preparation. They approved the upload of the manuscript all together.

Author contributions

Initials of the contributing authors were listed in brackets after the relevant parts of the research: Literature search (RA, CS, EK), study design (EK, RA, CS), legislative applications (RA, CS), data collection (CS, EK), supervision and quality control (EK, RA), statistical advice (EK, RA), statistical data analysis (EK, CS, RA), data interpretation (RA, EK), drafting the manuscript (RA, EK, CS). All authors were involved in the writing and critical revision of the manuscript and approved the final version. RA and EK take responsibility for the paper as a whole.

Availability of data and materials

The authors agree to the conditions of publication including the availability of data and materials in our manuscript.

Informed consent

The need for informed consent was waived.

Ethical approval

This study was approved by the local ethics committee (Ethics Committee Ruling number: 2019/8-4).

Human rights

The principles outlined in the Declaration of Helsinki have been followed.

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Declaration of Competing Interest

Authors declare that they have no conflicts of interest.

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