International Clinical and Medical Case Reports Journal
Research Article (ISSN: 2832-5788)

External Validation of the CHOKAI Score for the Prediction of Ureteral Stones

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Citation: *AlQuraini K, Albulushi S, Alfarsi A. External Validation of the CHOKAI Score for the Prediction of Ureteral Stones. Int Clinc Med Case Rep Jour. 2025;4(11):1-8.*

Received Date: 31 October, 2025; **Accepted Date:** 04 November, 2025; **Published Date:** 06 November, 2025

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ABSTRACT

Background: Accurate risk stratification for patients presenting with loin pain is essential to optimize diagnostic imaging and reduce unnecessary radiation exposure. The CHOKAI score is a recently developed clinical prediction tool designed to estimate the probability of ureteral stones without immediate computed tomography (CT) scanning. This study aimed to externally validate the CHOKAI score in an Omani population and compare its diagnostic performance with established scoring systems.

Methods: We conducted a multicenter prospective observational study from November 2020 to September 2021 across three tertiary hospitals in Oman. Adult patients presenting to the emergency department with acute flank, loin or lower abdominal pain were enrolled. Clinical data, urine analysis and point-of-care ultrasonography (POCUS) were collected to calculate the CHOKAI and STONE scores. All patients subsequently underwent CT or alternative imaging for confirmation. Receiver operating characteristic (ROC) analysis was performed to assess diagnostic accuracy, with the area under the curve (AUC), sensitivity, specificity and optimal cut-off points calculated.

Results: A total of 200 patients were included (mean age 39.4 ± 16.1 years), of whom 128 (64.3%) were diagnosed with ureteral stones. The CHOKAI score demonstrated an AUC of 0.831 (95% CI: 0.771–0.880). At the optimal cut-off of >5, sensitivity was 82.0% and specificity was 67.6%. Hydronephrosis was detected in 73.4% of patients on POCUS. While sensitivity was acceptable, specificity fell short of the desired ≥80% threshold.

Conclusion: The CHOKAI score showed moderate diagnostic performance in predicting ureteral stones in the studied population. Although it may assist in identifying high-risk patients, it should not replace confirmatory CT scanning. Integrating the CHOKAI score with clinician expertise and improved ultrasound training may enhance diagnostic accuracy and support more judicious use of imaging.

Keywords: Loin pain; CHOKAI score; Emergency department

INTRODUCTION

Acute renal colic, most often caused by ureterolithiasis, is a common presentation in the emergency department (ED) and is typically characterized by flank, loin or lower abdominal pain symptoms that are often non-specific [1,2]. Non-contrast helical computed tomography (NCCT) has become the gold standard diagnostic modality for ureteral stones due to its high sensitivity and specificity [1,2]. However, repeated CT imaging raises significant concerns regarding cumulative radiation exposure, particularly since ureterolithiasis is a recurrent condition, with relapse rates reported in 15% of patients within one year and 30–50% within ten years [3-7].

To minimize unnecessary radiation exposure, clinical prediction tools have been developed to guide imaging decisions in suspected cases of ureterolithiasis. One such model is the STONE score, proposed by Moore et al [8]. The score incorporates five clinical variables -sex, duration of pain, nausea/vomiting, haematuria and race - to estimate the probability of ureteral stones, categorizing patients into low, intermediate or high-risk groups. While the STONE score demonstrated utility as a screening tool, it has several limitations. Notably, the inclusion of "race" (black vs non-black) as a predictor has been questioned for its limited generalizability across different populations. In addition, the score omits assessment of hydronephrosis, a key ultrasonographic finding commonly used in the initial evaluation of suspected renal colic.

To address these limitations, Fukuhara et al. developed the CHOKAI score, which adds age, prior history of kidney stones and hydronephrosis detected on ultrasonography to the original STONE score components. The CHOKAI score ranges from 0 to 11 points and demonstrated improved diagnostic performance compared with the STONE score in its initial validation study. However, the study's single-center design and significant selection bias, where approximately 80% of eligible patients were excluded, limit the external generalizability of its findings.

Given the variability in demographic and clinical profiles across populations, external validation of the CHOKAI score in diverse settings is essential before its broader clinical implementation. In Oman, for instance, the "race" component of the STONE score is not applicable, further emphasizing the potential utility of a modified and externally validated prediction tool. Therefore, this study aimed to externally validate the CHOKAI score in patients presenting to Omani EDs with suspected ureteral stones, assess its diagnostic accuracy compared to NCCT findings and explore its potential role in optimizing imaging strategies.

MATERIALS AND METHODS

Study design and Setting

This multicentre prospective observational study was conducted from November 2020 to September 2021 across three tertiary hospitals in Oman: Royal Hospital, Sohar Hospital and Al-Nahda Hospital. The study included adult patients presenting to the emergency department (ED) with acute flank, loin or lower abdominal pain

suspected to be due to ureterolithiasis. The study protocol was approved by Research and Ethical Review & Approval Committee Ministry of Health, Sultanate of Oman.MoH/DGPS/CSR/PROPOSAL APPROVED/53/2020. Written informed consent was obtained from all participants or their guardians before enrolment.

Participants

Inclusion criteria were:

- Age ≥18 years.
- Presentation to the ED with acute flank, loin or lower abdominal pain.

Exclusion criteria were:

- Declining to participate in the study.
- Abnormal vital signs at presentation (body temperature >38°C or systolic blood pressure <90 mmHg).
- Lack of approval or consent.

Data Collection

Before the study began, all participating physicians and nurses received standardized training on study procedures, data collection forms and ultrasound techniques. Eligible patients were identified by the treating physicians or nurses based on presenting symptoms and initial assessments. A structured questionnaire was administered to collect duration of pain, presence of nausea or vomiting, previous history of kidney or upper ureteral stones, demographic and clinical characteristics.[1,2] Following a physical examination, all patients underwent urine dipstick testing or standard urinalysis to detect haematuria.

Point-of-Care Ultrasonography (POCUS)

Hydronephrosis was assessed using point-of-care ultrasonography (POCUS) with a curvilinear probe. POCUS was performed by trained emergency physicians, ultrasonographically experienced clinicians or medical interns. When performed by less experienced operators, all findings were reviewed by an emergency physician. The presence or absence of hydronephrosis was recorded by the primary examiner.

Confirmatory imaging and Diagnosis

Non-contrast helical CT (NCCT) served as the reference standard for definitive diagnosis, given its high sensitivity and specificity for ureteral stones.[1,2] When NCCT was not performed, kidney-ureter-bladder (KUB) radiography or ultrasound findings by experienced emergency physicians or urologists were accepted, particularly if stones were visualized at the pelviureteric junction. The final diagnosis was made by the treating emergency physician or, when indicated, in consultation with a urologist.

Score calculation

After establishing the final diagnosis, the CHOKAI and STONE scores were calculated for all patients. The CHOKAI score ranges from 0 to 11 points and incorporates seven variables: age, sex, pain duration, nausea or

vomiting, history of renal stones, presence of haematuria and hydronephrosis on ultrasonography.[6,5] The STONE score, for comparison, includes sex, pain duration, nausea/vomiting, haematuria and race. Scores were recorded in a dedicated form along with the final diagnostic findings for subsequent analysis. The CHOKAI score criteria are summarized in (Table 1).

Table 1: CHOKAI Score Components and Assigned Values.

Parameter	Score
Age < 60 years	1
Age ≥ 60 years	0
Male	1
Female	0
Pain duration < 6 hours	2
Pain duration 6-24 hours	0
Pain duration > 24 hours	0
Nausea	1
Vomiting	1
None (nausea/vomiting)	0
History of renal stones (Yes)	1
History of renal stones (No)	0
Hydronephrosis on ultrasound (Yes)	1
Hydronephrosis on ultrasound (No)	0
Hematuria (Yes)	3
Hematuria (No)	0

Outcome measures

The primary outcome was the diagnostic accuracy of the CHOKAI score, assessed by the area under the receiver operating characteristic (ROC) curve (AUC). The secondary outcome was determination of the optimal cut-off score for predicting ureteral stones, defined by the point maximizing both sensitivity and specificity. Sensitivity, specificity, positive likelihood ratio (LR+) and negative likelihood ratio (LR–) were calculated at this cut-off.

Sample size calculation

Sample size was determined based on an anticipated AUC of 0.8 from prior literature, with a 95% confidence interval (CI) width of ±0.05, calculated using the method of Hanley and McNeil. The required minimum sample size was 99 patients.

Statistical analysis

Continuous variables were summarized as mean ± standard deviation (SD) and categorical variables as counts and percentages. ROC analysis was performed to calculate AUC and determine the optimal cut-off point. Statistical significance was set at $p < 0.05$.

RESULTS

A total of 200 patients met the inclusion criteria. The mean age was 39.4 ± 16.1 years and 128 patients (64.3%) were diagnosed with ureteral stones based on confirmatory imaging.

POCUS revealed hydronephrosis in 146 patients (73.4%), while 53 patients (26.6%) showed no evidence of hydronephrosis. CHOKAI score categories were as follows: mild (0–4 points) in34 patients (17.1%), moderate (5–8 points) in 125 patients (62.8%) and severe (9–11 points) in 40 patients (20.1%)

Receiver operating characteristic (ROC) analysis showed an area under the curve (AUC) of 0.831 (95% CI: 0.771–0.880; $p < 0.0001$) for the CHOKAI score in detecting ureteral stones.

At the optimal cut-off score of >5, the sensitivity was 82.0% (95% CI: 74.3–88.3), specificity was 67.6% (95% CI: 55.5–78.2) and the Youden Index was 0.496

Among the 71 patients without ureteral stones, 36 (50.7%) were correctly classified as below the cut-off. Among the 128 patients with ureteral stones, 100 (78.1%) were correctly classified as above the cut-off. CT scan results showed that 64.3% of patients had positive findings for ureteral stones, while 35.7% had negative findings. Timing of CT imaging varied, with 24% performed after one week and 53% after two weeks from ED presentation, potentially influencing stone detection rates (Figure 1). The diagnostic performance characteristics at the optimal cut-off are presented in (Table 2).

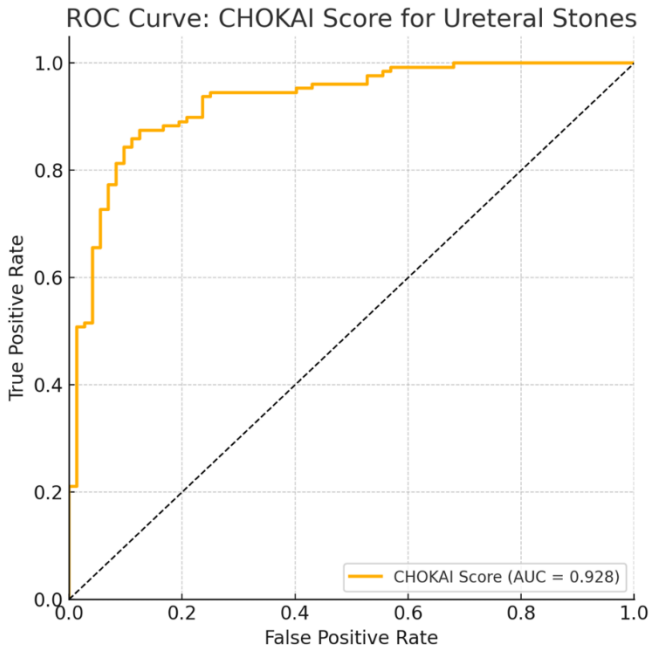

Figure 1: Receiver Operating Characteristic Curve of the CHOKAI Score.

ROC curve showing the diagnostic performance of the CHOKAI score for predicting ureteral stones, with an AUC of 0.831 (95% CI: 0.771–0.880) (Table 2).

Table 2: ROC Analysis of the CHOKAI Score for the Diagnosis of Ureteral Stones

CHOKAI score	AUC (95% CI)	Cut-off	Sensitivity (95% CI)	Specificity (95% CI)	LR +	LR -	Youden's index
	0.831 (0.771 - 0.880)	>5	82.03 (74.3 - 88.3)	67.61 (55.5 - 78.2)	2.53	0.27	0.496

DISCUSSION

In this multicentre external validation study, the CHOKAI score demonstrated moderate diagnostic performance for predicting ureteral stones among patients presenting to the emergency department (ED) with flank or loin pain. The area under the receiver operating characteristic curve (AUC) was 0.831, with acceptable sensitivity (82.0%) but relatively lower specificity (67.6%) at the optimal cut-off of >5 points [6,7]. Our findings suggest that the CHOKAI score may serve as a useful screening tool; however, it has limitations when used as a stand-alone method to defer confirmatory imaging [6].

Hydronephrosis as a key predictor

Hydronephrosis detection emerged as a critical factor in the CHOKAI score, contributing 1 of 11 points. In our cohort, 73.4% of patients exhibited hydronephrosis, consistent with prior studies emphasizing its diagnostic importance in ureteral stones. However, ultrasonography is inherently user-dependent and diagnostic accuracy varies with operator experience. Some scans in our study were performed by medical interns or non-fellowship-trained physicians, potentially affecting precision. To mitigate this, all findings by less experienced operators were reviewed by trained emergency physicians and targeted training improved overall accuracy.

POCUS is a useful tool for predicting ureteral stones; however, hydronephrosis as an isolated finding on US does not reliably predict stones and combining POCUS with clinical prediction scores, such as in the STONE PLUS study, improves diagnostic performance.

Timing of confirmatory imaging

Another factor influencing results was the delay in CT imaging. For 24% of patients, CT was performed more than one week after ED presentation and for 53%, CT was done after two weeks. This delay may have led to spontaneous stone passage, contributing to false-negative findings and underestimation of CHOKAI score performance[4]. Despite this, our findings suggest that patients with CHOKAI scores ≥6 points still require CT confirmation, whereas scores of 0-5 points could potentially allow clinicians to defer CT imaging, as none of these patients were ultimately diagnosed with ureteral stones [2,3,5].

Comparison with previous studies

The original CHOKAI study reported superior diagnostic accuracy compared with the STONE score, attributed in part to the inclusion of hydronephrosis as a predictive variable [6]. Our study supports this finding but highlights that operator variability and timing of imaging may reduce specificity in real-world ED settings. While CHOKAI shows promise for stratifying patients and optimizing imaging strategies, it should not replace confirmatory radiological tests, particularly in patients with persistent or severe symptoms [2,4].

Clinical implications

The CHOKAI score may assist clinicians in prioritizing high-risk patients for early CT imaging while potentially deferring imaging for low-score patients, reducing cumulative radiation exposure and ED length of stay [2,5,6]. However, appropriate training in POCUS is essential to maximize score accuracy and ensure reliable detection of hydronephrosis.

This study has several limitations. First, it included only Omani patients, which may limit the generalizability of the CHOKAI score to other populations [6]. Second, ultrasonography was performed by operators with varying levels of experience, including medical interns and non-fellowship-trained physicians, potentially reducing diagnostic precision despite review by experienced emergency physicians. Third, delayed confirmatory CT imaging in many cases- 24% after one week and 53% after two weeks- may have led to spontaneous stone passage and underestimation of sensitivity [4]. Additionally, we did not directly compare the CHOKAI score with the STONE score in this population, which could provide further insight into its relative utility [6]. Despite these limitations, the study has notable strengths, including its multicentre design, prospective data collection and real-world ED setting, which enhance the applicability and relevance of the findings to routine clinical practice [6,7].

CONCLUSIONS

The CHOKAI score demonstrated moderate diagnostic accuracy for predicting ureteral stones in patients presenting with loin pain in the Omani emergency department setting, achieving good sensitivity but only fair specificity at the optimal cut-off of >5. While it may serve as a useful adjunct in risk stratification and imaging prioritization, it should not replace confirmatory CT scanning. Incorporating CHOKAI scoring into a structured diagnostic pathway - combined with clinician judgment, timely imaging and enhanced ultrasound training- could help optimize resource use while minimizing unnecessary radiation exposure. Further prospective, multicentre studies in diverse populations are warranted to refine and validate its clinical utility.

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