

External Validation of the STONE Score, a Clinical Prediction Rule for Ureteral Stone: An Observational Multi-institutional Study

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Study objective: The STONE score is a clinical decision rule that classifies patients with suspected nephrolithiasis into low-, moderate-, and high-score groups, with corresponding probabilities of ureteral stone. We evaluate the STONE score in a multi-institutional cohort compared with physician gestalt and hypothesize that it has a sufficiently high specificity to allow clinicians to defer computed tomography (CT) scan in patients with suspected nephrolithiasis.

Methods: We assessed the STONE score with data from a randomized trial for participants with suspected nephrolithiasis who enrolled at 9 emergency departments between October 2011 and February 2013. In accordance with STONE predictors, we categorized participants into low-, moderate-, or high-score groups. We determined the performance of the STONE score and physician gestalt for ureteral stone.

Results: Eight hundred forty-five participants were included for analysis; 331 (39%) had a ureteral stone. The global performance of the STONE score was superior to physician gestalt (area under the receiver operating characteristic curve=0.78 [95% confidence interval {CI} 0.74 to 0.81] versus 0.68 [95% CI 0.64 to 0.71]). The prevalence of ureteral stone on CT scan ranged from 14% (95% CI 9% to 19%) to 73% (95% CI 67% to 78%) in the low-, moderate-, and high-score groups. The sensitivity and specificity of a high score were 53% (95% CI 48% to 59%) and 87% (95% CI 84% to 90%), respectively.

Conclusion: The STONE score can successfully aggregate patients into low-, medium-, and high-risk groups and predicts ureteral stone with a higher specificity than physician gestalt. However, in its present form, the STONE score lacks sufficient accuracy to allow clinicians to defer CT scan for suspected ureteral stone. [Ann Emerg Med. 2015;■:1-10.]

Please see page XX for the Editor's Capsule Summary of this article.

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INTRODUCTION

Background

Pain from a kidney stone is a common reason for US emergency department (ED) visits, accounting for more than 1 million visits annually.¹⁻³ Although most patients are discharged after an evaluation and symptomatic treatment, approximately 10% require inpatient admission.^{1,4,5} Individuals who are unable to pass their stone may continue to experience pain, vomiting, and urinary symptoms, and ultimately require a urologic intervention.⁶ The STONE score is a recently derived clinical prediction rule designed to aid clinicians to evaluate the risk of ureteral stone and important alternative diagnoses for patients with suspected nephrolithiasis.⁶ The STONE score is calculated as a weighted

sum of 5 categorical predictors; the points for each predictor are based on the estimated coefficients from a regression model constructed to predict the presence of a ureteral stone. Patients were classified into low-, moderate-, and high-score groups with corresponding outcome probabilities of ureteral stone and important alternative diagnoses. Patients with a high score had an 89% probability of ureteral stone and a 1.6% probability of alternative diagnosis; those with a low STONE score had a 9% probability of ureteral stone (the probability of alternative diagnosis was not reported in this group). In accordance with these outcome probabilities, the authors concluded that patients with a high STONE score could potentially receive ultrasonography, reduced-dose computed tomography (CT), or no further imaging. However, the authors did not report the sensitivity and specificity of the STONE score, which are important test characteristics of the decision rule, as opposed

Editor's Capsule Summary*What is already known on this topic*

The STONE score is a clinical decision rule to risk-stratify urolithiasis.

What question this study addressed

Can the STONE score be used to rule in stones such that computed tomography (CT) scanning is unnecessary?

What this study adds to our knowledge

In this validation study of 845 adults receiving CT scanning for suspected urolithiasis, using a high-risk score rather than CT to rule in urolithiasis identified 53% of stones while falsely suggesting stones in 13% of patients without calculi. Furthermore, one of the score's 5 core elements failed to predict urolithiasis.

How this is relevant to clinical practice

This independent assessment found the STONE score to be an inaccurate tool to defer CT scanning and identified one of its core elements as invalid.

to the positive predictive value, which is heavily influenced by the prevalence of the outcome in the original study population.^{7,8} A clinical decision rule that seeks to rule in ureteral stone should have an excellent specificity.⁶⁻¹¹

Importance

Abdominal CT has become the most frequently used imaging test for suspected kidney stone because of its perceived superior diagnostic accuracy and ability to identify important alternative diagnoses, such as appendicitis and diverticulitis.^{4,12-17} Despite a significant increase in the use of CT scans for patients with suspected kidney stone, there has been no demonstrable improvement in patient outcomes.¹⁸⁻²⁰ A recent national survey described a 10-fold increase in CT use during 1996 to 2007 for suspected kidney stone, without associated increases in kidney stone diagnoses, important alternative diagnoses, or hospitalization of kidney stone patients.²⁰ Furthermore, abdominal CT entails radiation exposure with attendant cancer risk, is associated with increased ED length of stay, and contributes to increasing annual care cost for acute nephrolithiasis, estimated in excess of \$5 billion.²¹⁻²⁵ If the STONE score is found to identify patients with ureteral stone with sufficient accuracy without relying on further imaging, it could significantly improve the evaluation of patients with suspected nephrolithiasis.^{7,9,26,27}

Goals of This Investigation

We sought to determine whether the STONE score could be used to safely decrease CT scan use in patients with suspected nephrolithiasis. Using data from a recently completed multicenter randomized trial comparing CT scan to ultrasonography for patients with suspected nephrolithiasis, we determined the discrimination, calibration, and test characteristics of the STONE score to predict ureteral stone. In addition, we compared the test characteristics of the STONE score to those of unstructured physician gestalt. We hypothesized that a high STONE score (10 to 13) would have sufficient specificity to diagnose ureteral stone and allow clinicians to defer CT scan in patients with suspected nephrolithiasis.

MATERIALS AND METHODS**Study Design and Setting**

To evaluate the STONE score, we conducted a secondary analysis using data from a recently conducted randomized comparative effectiveness trial, the Study of Ultrasonography Versus Computed Tomography for Suspected Nephrolithiasis.¹⁹ The randomized trial was conducted at 15 academic EDs across the United States between October 2011 and February 2013. Details of the participating EDs have been reported.²⁸ Briefly, the participating sites were academic EDs with emergency medicine residencies and emergency ultrasonography fellowships across the United States, with representation from a number of settings: urban, rural, university based, and safety net hospitals. The sites varied by size, annual census, and patient population served. This randomized trial was performed with institutional review board approval at each site and informed consent was obtained from all participants. This current study was performed with institutional review board approval at the University of California, San Francisco.

Selection of Participants

Adult participants with suspected kidney stones that required imaging (determined by an attending emergency physician) were randomly assigned to receive point-of-care ultrasonography, radiology ultrasonography, or CT as their initial imaging test. Patients were excluded from enrollment if they were pregnant, at high risk of an important alternative (non-kidney stone) diagnosis, had received a kidney transplant, required dialysis, had a known solitary kidney, or weighed more than 129 kg if men or 113 kg if women. The STONE score consists of 5 demographic and clinical variables collected during the ED visit: sex, race, nausea or vomiting, duration of pain symptoms, and

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