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ORIGINAL ARTICLE / ÖZGÜN ARAŞTIRMA MAKALESİ

The Role of the Speed Bump Sign Model for Diagnosing Acute Perforated Appendicitis in the Emergency Department

Acil Serviste Akut Perfore Apandisit Tanısında Hız Kasis Bulgusu Modelinin Rolü

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ABSTRACT

Aim: Diagnostic strategies for acute appendicitis (AA), including physical examination, imaging, and laboratory analyses, remain challenging due to variable presentations. The speed bump sign (SBS), evaluating pain during transit, has been explored as a diagnostic indicator. Our study aimed to validate SBS and introduced an emergency department (ED)-based speed bump model (SBS-m) for diagnosing perforated appendicitis (PA).

Material and Methods: Adult patients presenting with suspected acute appendicitis (AA) were enrolled. A speed bump model assessed the SBS-m. Positive SBS responses indicated heightened pain upon the rear wheelchair wheel's speed bump contact, while negative responses indicated no pain change. SBS and SBS-m were subsequently compared.

Results: AA was diagnosed in 100 (82%) of 122 suspected cases. For diagnosing AA, SBS showed 81.4% sensitivity (95% CI: 72.3 - 88.6), while SBS-m had 82% sensitivity (95% CI: 73.1 - 88.9). Both tests displayed 100% sensitivity and NPV (95% CI: 76.8 - 100) in distinguishing PA from non-perforated AA.

Conclusion: The SBS and SBS-m exhibit high sensitivity in diagnosing PA with minimal false negatives, suggesting their potential as valuable tools for PA exclusion.

Keywords: Acute appendicitis, perforated appendicitis, speed bump sign, diagnostic accuracy

ÖZ

Amaç: Fizik muayene, görüntüleme ve laboratuvar analizleri dahil olmak üzere akut apandisit (AA) tanısına yönelik stratejiler, değişken klinik bulgular nedeniyle güçlükler içermektedir. Transit sırasında ağrı artışını değerlendiren "hız kasisi bulgusu" (*Speed Bump Sign, SBS)* tanısal bir gösterge olarak araştırılmıştır. Bu çalışmanın amacı, SBS'nin geçerliliğini değerlendirmek ve perfore apandisit (PA) tanısında kullanılmak üzere acil servis (AS) temelli bir hız kasisi modeli (SBS-m) geliştirmektir.

Gereç ve Yöntemler: Akut apandisit (AA) ön tanısı ile acil servise başvuran erişkin hastalar çalışmaya dâhil edildi. SBS-m değerlendirmesi, modifiye edilmiş fiziksel bir hız kasisi modeli kullanılarak gerçekleştirildi. Tekerlekli sandalyenin arka tekerleği hız kasisinden geçerken karın ağrısında artış olması pozitif SBS yanıtı, ağrıda değişiklik olmaması ise negatif yanıt olarak kabul edildi. SBS (anamneze dayalı) ve SBS-m (model temelli) testleri tanısal performans açısından karşılaştırıldı.

Bulgular: Toplam 122 şüpheli olgunun 100'ünde (%82) AA tanısı doğrulandı. AA tanısında SBS'nin duyarlılığı %81,4 (GA %95: 72,3–88,6), SBS-m'nin duyarlılığı ise %82 (GA %95: 73,1–88,9) olarak bulundu. Her iki test de PA'yı perforasyonsuz AA'dan ayırt etmede %100 duyarlılık ve negatif prediktif değer (GA %95: 76,8–100) gösterdi.

Sonuç: SBS ve SBS-m, PA tanısında yüksek duyarlılık ve minimum yanlış negatif sonuç göstererek PA'nın dışlanmasında değerli araç olarak potansiyelini ortaya koymuştur.

Anahtar Kelimeler: Akut apandisit, perfore apandisit, hız kasisi bulgusu, tanısal doğruluk

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Introduction

Acute appendicitis (AA) is a common abdominal emergency with nonspecific symptoms including pain, nausea, fever, and elevated inflammation markers. Delayed surgical intervention increases risks of complications, including perforation, peritonitis, sepsis, and mortality (1-3). Perforated appendicitis (PA) significantly affects postoperative outcomes, raising complications such as obstruction, abscess, and infection. This heightened morbidity prolongs stays and costs, with PA patients 2.34 times more likely to die after surgery (4). Early, accurate diagnosis of acute perforated appendicitis is crucial for prompt surgical intervention and overall morbidity reduction (5).

The use of radiological methods, including CT scans, ultrasound (US), and point-of-care ultrasound, has enhanced the diagnosis of abdominal emergencies such as AA (1,6). Increased use of radiological tools reduced perforation rates (7). However, despite improved accuracy, CT scans pose limitations such as missed cases, high radiation exposure, and increased healthcare costs. (8). Various scoring systems have emerged due to inadequate symptom sensitivity in AA diagnosis. Despite physical exams, labs, scoring systems, and imaging, many pathological results revealed histologically normal appendices (9). Therefore, research on new markers and methods to diagnose AA continues (10,11).

Speed bumps, typically 4-5 cm high and 25 cm deep, have a long-standing role in speed reduction, often in 50 km/h zones (12). Clinical research suggests their potential in AA diagnosis, focusing on heightened pain during passage. However, prior studies relied solely on history (SBS), lacking physical verification. Our study innovatively introduced a speed bump model (SBS-m), assessing its diagnostic relevance for AA and PA, while also comparing it to historical SBS. The speed bump sign (SBS) is a simple, history-based clinical test where patients are asked if they experienced an increase in abdominal pain when passing over speed bumps en route to the hospital. The underlying principle is that peritoneal irritation, as seen in AA, is exacerbated by jarring movements, making the test a potential indicator of intra-abdominal pathology. While the SBS has shown some diagnostic utility in differentiating appendicitis from other causes of abdominal pain, it remains subjective and dependent on patient recollection, without any physical examination component. (13-15).

Accordingly, this study aimed to investigate the diagnostic performance of both SBS and the newly developed SBS-m model for the detection of AA and PA.

Material and Methods

For the study, permission was obtained from the University of Health Sciences Samsun Training and Research Hospital Clinical Research Ethics Committee (Protocol code: SBUSEAH-KAEK-2020/1/2, Date: 30/01/2020). Our study was conducted following the Declaration of Helsinki, Good Clinical Practices, and Good Laboratory Practices. An informed consent form was obtained from each patient participating in the study.

Study Characteristics and Patient Selection

Our study was planned as a prospective, descriptive and analytical study. Adult Patients (over 18 years) who were admitted to the University of Health Sciences Samsun Training and Research Hospital, Department of Emergency Medicine with symptoms of abdominal pain between January 2020 and September 2020 and were clinically considered to have AA were included in our study. AA and PA were definitively diagnosed via post-surgical histopathology. Our primary focus (SBS and SBS-m for PA) used these reports as reference. In the secondary analysis (SBS and SBS-m for AA), a multifaceted reference test incorporated pathology, radiological imagery, and follow-up data. For non-surgical cases, diagnosis drew from anamnesis, exams, labs, radiology, consultations, and clinical follow-ups. Patients under 18 years of age, those with active acute infections, known autoimmune diseases, malignancies, or musculoskeletal conditions significantly affecting gait were excluded from the study. Additionally, patients who had undergone blood transfusions within the last three months were excluded, as transfusion-related immunomodulation and potential inflammatory marker alterations could confound the diagnostic accuracy of laboratory tests and clinical assessments used in the study. Similarly, patients with known hematological disorders, such as anemia (hemoglobinopathies, hemolytic anemia), thrombocytopenia, leukemia, or other bone marrow-related pathologies were excluded due to their propensity to alter baseline inflammatory parameters and pain perception, potentially biasing both laboratory findings and clinical interpretation of the SBS.

Patients unable to ambulate (walk) independently were also excluded from participation. This exclusion was essential because the Speed Bump Test (SBS-m) simulates the mechanical jostling experienced during vehicular movement over a speed bump, which mimics the aggravation of peritoneal irritation seen in conditions like appendicitis. Since the index test involves controlled mobility (wheelchair traversal over a physical bump), patients who are permanently non-ambulatory or unable to tolerate such movement (due to neurological deficits, severe orthopedic impairments, or critical illness) would not experience the diagnostic stimulus in a physiologically relevant manner. Additionally, non-ambulatory status itself may introduce alternative sources of abdominal pain or discomfort unrelated to appendiceal pathology, thus confounding test results. Therefore, the accuracy and safety of the test necessitated exclusion of patients who could not safely undergo this physical maneuver. Following these criteria, 122 emergency department (ED) patients suspected of AA participated, all providing written informed consent after study explanation.

Creation of the Speed Bump Model and Index Test

In our study, a modified speed bump measuring 97 cm in length, 13 cm in width, and 2 cm in height was used. Adjusting for the wheelchair's rear wheel height (20 cm), the speed bump's height was reduced by about a third (the exact ratio of speed bumps to vehicle tires). The speed bump was fixed in the ED corridor to mitigate variable speed effects and patient discomfort. Starting with the wheelchair's front wheel, the test involved the rear wheel passing over the bump, with the clinician holding the chair. Seat belts were secured before each test, ensuring consistency. The same investigator conducted all tests, which were positive if pain

increased upon the wheel passing over the bump and negative if pain remained unchanged or decreased (Figure 1). The test wasn't repeated for patient comfort.

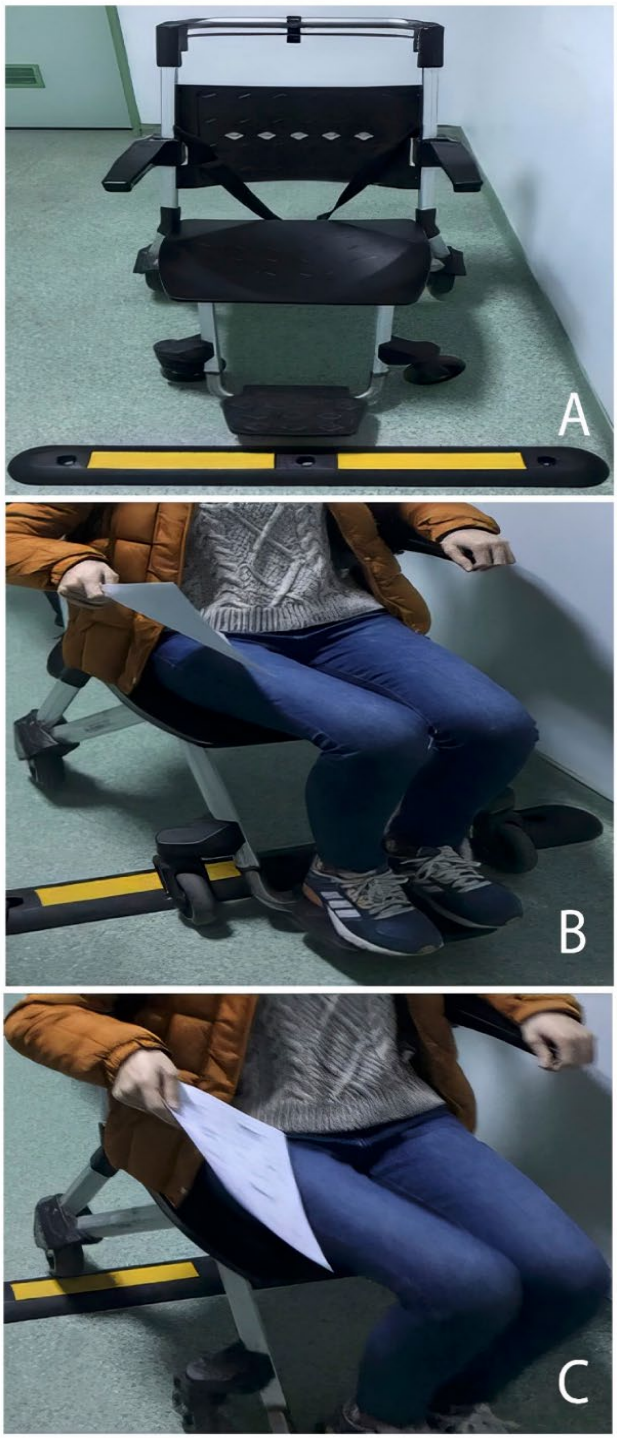

Figure 1. Demonstration of the Speed Bump Sign Model (SBS-m) used for diagnostic evaluation in the emergency department. **(A)** A standard manual wheelchair and a modified speed bump were used in the study. **(B)** Starting position before the maneuver. **(C)** Execution of the test as the rear wheels of the wheelchair pass over the speed bump, during which the pain response is assessed for positivity.

Study Design

Following patient selection, comprehensive data collection was conducted as detailed below. Patient data encompassed demographics, symptoms, physical findings, vitals, radiological images (USG and CT), and lab parameters including leukocyte count, neutrophil percentage, and count. A pre-intervention questionnaire explored transportation route, speed bump experience, pain severity, and onset time (SBS). All first-time ED admissions for suspected AA underwent SBS-m evaluation by the same investigator. Surgical cases relied on pathology reports for AA and PA diagnoses.

Sample Size Estimation

Perforated appendicitis rates varied in previous reports (4.4% to 39.7%) (15,16). To safely exclude PA, we aimed for SBS-m sensitivity of ≥98%. Assuming 20% perforation rate and targeting 98% sensitivity within a 95% CI, we estimated needing 66 AA cases. Previous SBS studies noted average AA rates of 67% (13,15,17-19). Accounting for this and 20% drop-out, the sample size was 122.

Statistical Analysis

Statistical analysis utilized SPSS version 15.0 (Chicago, USA). Normality was assessed visually (histograms, probability graphs) and analytically (Kolmogorov-Smirnov, Shapiro-Wilk tests). Descriptive stats included mean and SD for normally distributed numerical data, median (IQR: interquartile ranges) for non-normally distributed data, and numbers/percentages for nominal data. Independent t-tests compared normally distributed variables, while Mann-Whitney U tests assessed non-normally distributed ones. Chi-square test used for nominal data. For analysis of diagnostic performance, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (PLR), negative likelihood ratio (NLR), and accuracy were reported. $p<0.05$ indicated significance.

Results

The mean age of the 122 patients was 30 years (IQR: 18–70), with 48 (39%) females and 74 (61%) males. Most 94 (92.6%) arrived via personal or public transport, while 4 (5.8%) used a land ambulance and 1 (0.8%) an air ambulance. One patient arrived on foot. Thus, 118 patients were included for SBS calculation, as two couldn't recall speed bump pain, one came on foot, and one used air ambulance. The median symptom duration was 33 (range, 2-120) hours. Demographics, transportation, vitals, symptoms, exams, and radiological findings were summarized in Table 1.

Of the 122 patients suspected of appendicitis, 100 (82%) had appendicitis. The vast majority of patients (95.9%) required hospitalization, and 91.8% ultimately underwent surgical intervention. Among surgical patients, 14 (12.5%) had perforated appendicitis. The findings observed in 10 patients whose appendicitis diagnosis was excluded by non-surgical imaging methods and who did not undergo surgery are shown in Table 2. Histopathological details for surgical patients, and findings for 10 patients with excluded appendicitis diagnosis are summarized in Table 1-2.

Patients with appendicitis 100 (82%) were compared with patients diagnosed without appendicitis. 22 (18%). The leukocyte count (p=0.004), neutrophil count (p=0.022), and serum neutrophil percentage (p=0.017) were significantly higher in patients with AA than in patients with non-appendicitis. However, no significant differences were observed between the two groups in other sociodemographic and clinical characteristics (Table 1).

	AA (+) (n=100)	AA (-) (n=22)	*p*
Age (year)	30 (18-70)¶	33.5 (19-51)¶	0.512†
Female, n (%)	37 (37)	11 (50)	0.259*
Transportation to the hospital, n (%)			
Land ambulance	4 (4.0)	3 (13.6)	
Air ambulance	1 (1.0)	-	
Walking	1 (1.0)	-	0.406#
Private/public vehicle	94 (94)	19 (86.4)	
Symptom duration, hours	30 (2-120)¶	40.5 (2-96)¶	0.233†
Body temperature (°C)	36.5 ± 0.4§	36.6 ± 0.7§	0.241‡
Nausea, n (%)	73 (73)	15 (68.2)	0.648*
Anorexia, n (%)	58 (58)	13 (59.1)	0.925*
Vomiting, n (%)	36 (36)	6 (27.3)	0.435*
Localization of pain, n (%)			
RLQ	79 (79)	19 (86.4)	0.561#
Pain migration	18 (18)	2 (9.1)	0.524#
Widespread pain	14 (14)	1 (4.5)	0.302#
Outside the RLQ	8 (8)	2 (9.1)	1.000#
Guarding, n (%)	29 (29)	4 (18.2)	0.301*
Rebound tenderness, n (%)	65 (65)	19 (86.4)	0.050*
Leukocyte count, $10^3/\mu L$	13.4 ± 4.4§	10.5 ± 3.2§	***0.004***‡
Neutrophil count, $10^3/\mu L$	10.1 (2.0-23.7)¶	7.3 (2.3-15.4)¶	***0.004***†
Serum neutrophil percentage	77.3 (41.5-91.6)¶	70.8 (48.7-88.4)¶	***0.023***†
Alvarado score	6.5 ± 1.6§	5.9 ± 1.4§	0.101‡
Alvarado <7 points, n (%)	41 (41.0)	14 (63.6)	0.053*
Alvarado ≥7 points, n (%)	59 (59.0)	8 (36.4)	

Table 1. Comparison of sociodemographic, clinical, and imaging characteristics of patients with and without appendicitis
RLQ: Right Lower Quadrant, Median (min-max), §: Mean ± SD, ¶: Median (IQR), †: Mann-Whitney U test, ‡: T test for independent groups, *: Chi-square test, #: Fisher Exact test

While the Alvarado score appeared marginally higher among AA patients (6.5 ± 1.6) compared to others (5.9 ± 1.4), this difference did not reach statistical significance (p=0.10). The probability of AA was 30% in those with an Alvarado score of 1-4, 66% in those with 5-6 points, and 93% in those with 7-10 points. For this reason, “7 points” was frequently preferred as the threshold value in previous studies (20). Accordingly, this threshold value was used in our study, and it was observed that the Alvarado score was 7 points or higher in 59% of those with AA and 36.4% of those without AA (p=0.045) (Table 1).

Diagnostic characteristics of SBS-m and SBS are summarized in Table 3. For diagnosing AA, SBS showed 81.4% sensitivity (95% CI: 72.3 - 88.6), while SBS-m had 82% sensitivity (95% CI: 73.1 - 88.9). Both tests displayed 100% sensitivity and NPV (95% CI: 76.8 - 100) in distinguishing PA from non-perforated AA (Table 3). In our study, with high false positive rates (19.4% - 19.6%) and very low positive likelihood ratios (PLR 0.9, 95% CI: 0.8 - 1.1), SBS and SBS-m showed limited "ruling in" ability. SBS and SBS-m have a very low false negative rate and high sensitivity in the diagnosis of perforated appendicitis. Therefore, it may be useful in excluding acute perforated appendicitis. However, both have only mediocre diagnostic performance for patients with suspected AA; this indicates that it cannot be used for ruling out or in when used alone. In summary, in diagnosing PA, they demonstrated excellent "ruling out" performance due to zero false negatives.

Discussion

Our findings demonstrated that SBS and SBS-m are highly sensitive tools for ruling out PA in suspected AA cases. However, their limited specificity restricts their diagnostic utility for general AA classification.

Diagnosis	Histopathologic Features/Definitive Diagnosis	n (%)
AA (+) (n=100)		
	Acute appendicitis	59 (48.4)
	Acute gangrenous appendicitis	30 (24.6)
	Acute suppurative appendicitis	8 (6.6)
	Plastron appendicitis	2 (1.6)
	Acute necrotizing appendicitis	1 (0.8)
AA (-) (n=22)		
Surgery (+)		
(n=12)	Lymphoid hyperplasia	6 (4.9)
	Diverticulitis	2 (1.6)
	Neuroendocrine tumor	2 (1.6)
	Chronic appendicitis	1 (0.8)
	Meckel diverticulitis perforation	1 (0.8)
Surgery (-)		
(n=10)	Ovarian cyst rupture	2 (1.6)
	Chronic atrophic gastritis	1 (0.8)
	Lymphadenitis	1 (0.8)
	Pelvic inflammatory disease	1 (0.8)
	Subileus	1 (0.8)
	Terminal ileitis	1 (0.8)
	Dermoid cyst	1 (0.8)
	Chronic active colitis	1 (0.8)
	Chronic duodenitis	1 (0.8)

Table 2. Final diagnosis and histopathologic features of patients with suspected appendicitis.
AA: Acute appendicitis

Timely diagnosis of AA is crucial, yet remains challenging due to its nonspecific clinical presentations, necessitating exploration of adjunct diagnostic tools such as SBS. Swift diagnosis of AA is vital due to the link between delayed surgery and higher rates of complications and mortality. The challenge in clinical diagnosis arises from the nonspecific and varying presentations of AA. Various methods, including history, physical examination, lab tests, and imaging, are used for diagnosis. Yet, even with these approaches, AA can still be misdiagnosed. As such, the search for novel diagnostic methods continues (21-26). One such method is the SBS, which is based on patients' perception of increased pain while passing over speed bumps en route to the hospital. Similar to our findings, previous SBS studies showed high sensitivity but low specificity (12,14,18-21). Our study introduced SBS-m, which evaluated the diagnostic performance for patients with perforated appendicitis (PA) in the ED setting for the first time.

The SBS was first described in Golledge et al.'s study in 1996, which reported 80% sensitivity, 52% specificity, and 64% accuracy in diagnosing AA in 100 patients with right iliac fossa pain (18). In the meta-analysis conducted by Andersson et al., the effectiveness of clinical and laboratory methods in diagnosing AA was evaluated (22). The meta-analysis assessed the patients with increased pain during movement rather than the SBS and reported a PLR of 1.24 and an NLR of 0.49. Our results were correlated with these studies.

In the study by Ashdown et al. (2012), involving 101 patients, a sensitivity of 97% and a negative predictive value (NPV) of 90% were reported for diagnosing possible appendicitis (12). Interestingly, Helen Ashdown and her UK team received the '2015 Ig Nobel Award for Diagnostic Medicine' (at Harvard University in Cambridge) for demonstrating the effectiveness of speed bumps in ruling out appendicitis. Haider et al. (3 years later) and Eid et al. (2020) similarly reported high sensitivities (97%, 97%, and 90.5%, respectively) for the SBS in diagnosing AA in their studies (14,19). In contrast, our study found a lower sensitivity. A meta-analysis by Ling Wang et al. (2022) included four studies (343 patients) on the role of SBS in AA diagnosis, yielding a pooled sensitivity of 0.94 and a specificity of 0.49, with a diagnostic odds ratio of 14.1. However, this meta-analysis exhibited high heterogeneity (I2: 79.43) and relied on patient recall. Discrepancies in results could arise from differences in patient exposure to speed bumps during transportation and varying disease prevalence.

While the SBS is fundamentally a reflection of peritoneal irritation, its clinical significance appears particularly pronounced in AA compared to other etiologies. In our study, cases such as ovarian cyst rupture, terminal ileitis, diverticulitis, and Meckel's diverticulum perforation also involve localized peritoneal irritation; however, these conditions often present with less consistent symptomatology regarding movement-induced pain. Appendicitis, especially in its suppurative, gangrenous, or perforated forms, typically causes localized and progressive peritoneal inflammation that amplifies with dynamic abdominal stress, such as vehicular bumps. Conversely, peritoneal irritation from ruptured ovarian cysts or terminal ileitis may not consistently provoke pain responses to external jolts, possibly due to differences in lesion location, depth of irritation, or peritoneal involvement extent. Literature similarly indicates that the SBS's predictive utility diminishes in non-appendiceal conditions; Golledge et al. and Ashdown et al. observed that while SBS showed high sensitivity for appendicitis, its specificity suffered due to positive responses in other causes of abdominal pain (12,18). However, these non-appendiceal cases accounted for only a minor fraction of false positives, suggesting that the intensity and nature of peritoneal irritation in AA produce a more reliable SBS response. Therefore, while SBS may not distinguish among all causes of peritoneal irritation, its robust sensitivity for appendiceal pathology, particularly perforated appendicitis, supports its value in rapid clinical triage.

	TN	FN	TP	FP	Sensitivity*	Spesificity *	PPV *	NPV *	PLR *	NLR *	Accuracy *
Acute Appendicitis (n=100) & Other Diagnoses											
SBS	2	18	79	19	81.4 (72.3 - 88.6)	9.5 (1.2 - 30.4)	80.6 (77.9 - 83.1)	10.0 (2.7 - 30.7)	0.9 (0.8 - 1.1)	1.9 (0.5 - 7.8)	68.6 (59.5 - 76.9)
SBS-m	2	18	82	20	82.0 (73.1 - 88.9)	9.1 (1.1 - 29.2)	80.3 (77.7 - 82.8)	10.0 (2.7 - 30.8)	0.9 (0.8 - 1.1)	1.9 (0.5 - 7.9)	68.8 (59.8 - 76.9)
Perforated Appendicitis & Non-perforated Appendicitis											
SBS	18	0	14	65	100 (76.8 - 100)	21.6 (13.4 - 32.1)	17.7 (16.1 - 19.4)	100	1.2 (1.1 - 1.4)	0.0	32.9 (23.8 - 43.3)
SBS-m	18	0	14	68	100 (76.8 - 100)	20.9 (12.9 - 31.1)	17.0 (15.6 - 18.7)	100	1.2 (1.1 - 1.4)	0.0	32.0 (23.1 - 42.1)
Perforated Appendicitis & Other Diagnoses											
SBS	2	0	14	19	100 (76.8 - 100)	9.5 (1.2 - 30.4)	42.4 (39.1 - 45.8)	100.0	1.1 (1.0 - 1.3)	0.0	45.7 (28.8 - 63.3)
SBS-m	2	0	14	20	100 (76.8 - 100)	9.0 (1.1 - 29.2)	41.1 (38.0 - 44.4)	100.0	1.1 (1.0 - 1.3)	0.0	44.4 (27.9- 61.9)

Table 3. Diagnostic value of the SBS and SBS-m in AA and PA.
*; (95% Confidence Interval), PPV: Positive predictive value, NPV: Negative predictive value, PLR: Positive likelihood ratio, NLR: Negative likelihood ratio, SBS: Speed Bump Sign (anamnesis), SBS-m: Speed Bump Sign - model, TN: True Negative, FN: False Negative, TP: True Positive, FP: False Positive.

Our study introduced a standardized SBS-m approach to ensure consistency across all patients. In contrast to prior studies that rely on patient recall, our method mitigates potential variability arising from diverse speed bump characteristics, vehicle types, and memory lapses. Additionally, the SBS-m eliminates these issues and maintains standardization. Notably, our study is the first to assess the diagnostic accuracy of SBS and SBS-m, particularly in cases of PA.

In conclusion, our findings highlight that while the SBS and the SBS-m cannot reliably confirm or exclude AA due to their limited diagnostic accuracy, they offer a highly sensitive method for ruling out PA in emergency department settings. By standardizing the assessment with SBS-m and minimizing recall bias, this approach ensures consistent evaluation of dynamic peritoneal irritation. Thus, SBS-m may serve as a rapid, low-resource adjunct in the initial triage of suspected PA cases, aiding clinicians in prioritizing surgical intervention and potentially reducing associated morbidity.

Limitations

Our study included 122 patients, of whom 14 had perforated appendicitis. This relatively small sample size may have affected the diagnostic accuracy of SBS and SBS-m for distinguishing AA cases from negative ones. However, our primary focus was on investigating diagnostic accuracy in PA cases, making this limitation less significant. Furthermore, our study's sample size matched the predetermined target population. Secondly, a single researcher conducted SBS-m tests to ensure reliability, although patients were aware of the test. We addressed standardization of wheel and bump sizes, using a common ratio to enable realistic simulation. While the diagnostic methods varied (112 pathology reports, 10 radiological imaging and follow-up data), our primary aim was to assess SBS and SBS-m for PA, which relied on formal pathology reports. Thus, this limitation had minimal impact on our study's primary objective.

Another limitation is the selection of the comparison group. In this study, patients with abdominal pain who were ultimately not diagnosed with appendicitis were used as the control group. However, several of these patients (22 individuals) had alternative diagnoses that could also cause peritoneal irritation, such as pelvic inflammatory disease, gastroenteritis, and urinary tract infections. These conditions may present with clinical and laboratory findings similar to appendicitis, potentially influencing the diagnostic accuracy of the evaluated tests. Comparing the appendicitis group with a healthy control group without abdominal pain could have provided a clearer distinction and enhanced the diagnostic power of the SBS and SBS-m. This design choice may have limited the study's ability to fully differentiate the diagnostic performance of these tests in excluding appendicitis among patients without any peritoneal irritation.

Conclusion

The SBS and SBS-m have high sensitivity in the diagnosis of perforated appendicitis with a very low false-negative rate. Thus, it may be a significant tool for excluding acute

perforated appendicitis. However, both of them have only a mediocre level of diagnostic performance for patients suspected with AA, indicating that they cannot be solely relied upon for definitive AA diagnosis.

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Authors' Contribution: M Yorgun: Conceptualization; Methodology, investigation, data curation, formal analysis;, project administration, visualization, writing – original draft (lead); writing – review & editing.**M Yücel:** Data curation, investigation, visualization, writing – original draft (supporting). **MG:** Critical review, validation, writing – review & editing (supporting). **M Yadigaroğlu:** Formal analysis, software, visualization. **ŞC:** Investigation, data curation, resources. **HT:** Data curation, supervision. All authors reviewed and approved the final version submitted for publication.

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