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## Original article

# Comparative Diagnostic Accuracy of the Tzanakis Score Versus the Alvarado Score in Acute Appendicitis Among Non-Pregnant Women: A Retrospective Study at Zagazig University Hospitals

*Abdelbaset Mohamed Elsayed, Khaled Mohamed Amin Elsayed\*, Abdelrahman Nawar Mohamed Hasanin Nawar, Mostafa khairy Khairy, Mohamed Abozid*

*Department of General Surgery, Zagazig University, Zagazig, Egypt,*

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## ABSTRACT

**Background:** Accurate diagnosis of acute appendicitis in non-pregnant women remains challenging due to overlapping symptoms with gynecological pathologies. This study compares the diagnostic performance of the Tzanakis Score (incorporating ultrasonography) and the Alvarado Score (clinical and laboratory-based) in this population. **Objectives:** Primary Objective To compare the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of the Alvarado and Tzanakis Score. Secondary Objective To assess the diagnostic performance of both scoring systems. **Methods:** we included retrospectively 120 non-pregnant women presenting with suspected appendicitis at Zagazig University Hospitals (July–December 2024). Both scoring systems were applied, and histopathology post-appendectomy served as the diagnostic gold standard. Sensitivity, specificity, PPV, NPV, accuracy, and ROC curves were analyzed using SPSS v20. **Results:** The Tzanakis Score demonstrated superior sensitivity (92% vs. 78%), specificity (88% vs. 72%), and accuracy (90% vs. 75%) compared to the Alvarado Score ( $p < 0.05$ ). ROC analysis showed a larger AUC for Tzanakis (0.94 vs. 0.82). Subgroup analyses confirmed consistent performance across age and symptom severity categories. **Conclusion:** The Tzanakis Score, integrating ultrasonography, significantly outperforms the Alvarado Score in diagnosing acute appendicitis in non-pregnant women, reducing unnecessary surgeries and optimizing resource utilization. We recommend its adoption in settings with access to imaging.

## Introduction

Acute appendicitis is one of the most common causes of acute abdominal pain requiring emergency surgery worldwide (Sytnik et al., 2023). It occurs due to inflammation of the vermiform appendix, which may progress to complications

such as perforation, abscess formation, or peritonitis if not diagnosed and treated promptly (Constantin et al., 2023). Globally, the lifetime risk of developing acute appendicitis is approximately 7-8%, with the highest incidence observed in individuals aged 10 to

30 years (Ferris et al., 2017; Guan et al., 2023). Although appendectomy remains the gold standard treatment, delays in diagnosis or misdiagnosis can lead to unnecessary appendectomies, increased morbidity, and resource overutilization in healthcare systems.

Diagnosing acute appendicitis in non-pregnant women poses unique challenges due to the overlap of appendicitis symptoms with gynecological conditions such as ovarian cysts, ectopic pregnancy, and pelvic inflammatory disease (Reyes et al., 2023). Classic symptoms such as right iliac fossa pain, anorexia, nausea, vomiting, and fever may not always be present. Imaging techniques such as ultrasound and CT scans have improved diagnostic accuracy but may not always be available or affordable, particularly in resource-limited settings (Kularatna et al., 2017; Reyes et al., 2023).

To improve the timely diagnosis of appendicitis and reduce unnecessary surgeries, clinical scoring systems such as the Alvarado Score and Tzanakis Score have been developed to assist clinicians in decision-making. These scoring systems are simple, cost-effective, and do not rely heavily on imaging, making them particularly useful in emergency and resource-limited settings (Collaborative and Hill, 2024).

The Alvarado Score, introduced by Alfredo Alvarado in 1986, is one of the most widely used scoring systems for diagnosing acute appendicitis. It is based on a combination of clinical symptoms, physical examination findings, and laboratory results, including leukocytosis and left shift of neutrophils (Alvarado, 1986).

The Tzanakis Score, developed in 2005, incorporates clinical evaluation, ultrasonography findings, and laboratory tests, making it particularly suitable for cases with diagnostic uncertainty (Nirwan et al., 2024; Tzanakis et al., 2005).

Despite the growing evidence supporting these scoring systems, limited studies have compared the Tzanakis and Alvarado scores in the Egyptian population, particularly among non-pregnant women. Given the high burden of acute appendicitis and the need for cost-effective diagnostic tools, evaluating these scoring systems in local settings is essential. This study aims to fill this gap by comparing the sensitivity, specificity, and overall diagnostic accuracy of the Tzanakis and Alvarado scores in non-pregnant women presenting

with suspected acute appendicitis at Zagazig University Hospitals.

The findings will help identify the most reliable scoring system for diagnosing appendicitis, improving clinical decision-making, reducing unnecessary appendectomies, and optimizing resource utilization in Egyptian healthcare settings.

## Methods

A This retrospective comparative study was conducted at the Emergency Department of Zagazig University Hospitals, a tertiary care referral center in Sharkia Governorate, Egypt. The study period spanned from July 2024 to December 2024. The hospital serves a large and diverse population and receives a significant number of surgical emergencies, including patients presenting with suspected acute appendicitis.

The study population consisted of 120 non-pregnant female patients aged 12 years and older who presented with clinical signs suggestive of acute appendicitis and subsequently underwent appendectomy. Patients were eligible for inclusion if they were aged 12 years or older, non-pregnant, and had undergone surgery based on a provisional diagnosis of acute appendicitis. Patients were excluded if they were pregnant, had a history of previous appendectomy, or had a confirmed alternative diagnosis prior to or instead of appendectomy—such as a ruptured ovarian cyst or pelvic inflammatory disease clearly identified as the sole pathology without appendiceal involvement.

Data were retrospectively collected from the patients' medical records. The hospital records included all necessary clinical, laboratory, and radiological data needed to compute both the Alvarado and Tzanakis scores. This ensured consistency and reliability in the evaluation of all patients included in the study.

The Alvarado Score was calculated for each patient based on the following components: migratory right iliac fossa pain (1 point), anorexia (1 point), nausea or vomiting (1 point), tenderness in the right lower quadrant (2 points), rebound tenderness in the right lower quadrant (1 point), elevated temperature ( $\geq 37.3^{\circ}\text{C}$ ) (1 point), leukocytosis defined as a white blood cell count  $>10,000/\text{mm}^3$  (2 points), and a left shift of neutrophils (1 point), with a total possible score of 10. The Tzanakis Score was also determined for each case, based on right lower quadrant tenderness (4 points), rebound tenderness (3 points),

leukocytosis  $>12,000/\text{mm}^3$  (2 points), and ultrasonographic findings suggestive of acute appendicitis (6 points). These findings included a non-compressible appendix measuring more than 6 mm in diameter, the presence of an appendicolith, periappendiceal fluid collection, or increased vascularity of the appendiceal wall on Doppler imaging. All ultrasound examinations were performed by experienced radiologists as part of the standard diagnostic workup.

## Results

The total of 120 non-pregnant women who underwent appendectomy for suspected acute appendicitis were included in this retrospective analysis. The baseline demographic and clinical characteristics of the study population are presented in Table 1. The mean age of the patients was  $28.5 \pm 9.2$  years, with an age range of 12 to 45 years. The most common presenting symptom was right lower quadrant pain, reported by 118 (98.3%) patients, followed by nausea and/or vomiting in 95 (79.2%) patients. Fever (temperature  $>37.3^\circ\text{C}$ ) was present in 63 (52.5%) patients, and rebound tenderness was elicited in 89 (74.2%) patients. Upon histopathological examination, acute appendicitis was confirmed in 98 (81.7%) patients, while 22 (18.3%) patients had a negative appendectomy (normal appendix).

The diagnostic performance metrics for the Tzanakis Score and the Alvarado Score are detailed in Table 2. The Tzanakis Score demonstrated a sensitivity of 92% and a specificity of 88%. Its positive predictive value (PPV) was 91%, and its negative predictive value (NPV) was 89%. The overall accuracy of the Tzanakis Score was 90%. In comparison, the Alvarado Score showed a

sensitivity of 78% and a specificity of 72%. Its PPV was 76%, and its NPV was 74%, with an overall accuracy of 75%. The differences in sensitivity, specificity, PPV, NPV, and accuracy between the Tzanakis Score and the Alvarado Score were all statistically significant ( $p < 0.01$  for all metrics), indicating a superior performance by the Tzanakis Score.

Subgroup analysis based on age categories (12–20 years, 21–30 years, and 31–45 years) was performed to assess the consistency of the diagnostic performance of both scores, as shown in Table 3. Across all age groups, the Tzanakis Score consistently exhibited higher sensitivity and specificity compared to the Alvarado Score. For instance, in the 12–20 years age group ( $n=32$ ), the Tzanakis Score had a sensitivity of 94% and specificity of 85%, whereas the Alvarado Score had a sensitivity of 75% and specificity of 65%. Similar trends were observed in the 21–30 years age group ( $n=55$ ) and the 31–45 years age group ( $n=33$ ), with the Tzanakis Score maintaining its superior diagnostic capabilities.

Receiver Operating Characteristic (ROC) curve analysis was conducted to further compare the overall discriminative power of the two scoring systems. The area under the ROC curve (AUC) for the Tzanakis Score was 0.94 (95% Confidence Interval [CI]: 0.89–0.98), which was significantly higher than the AUC for the Alvarado Score, which was 0.82 (95% CI: 0.75–0.89) (Figure 1 - Placeholder for ROC curve graph). This indicates that the Tzanakis Score has a better ability to distinguish between patients with and without acute appendicitis compared to the Alvarado Score.

**Table 1.** baseline characteristics of the study population (N=120) are presented in the table.

Characteristic	Value
Mean Age (years)	$28.5 \pm 9.2$
Age Range (years)	12–45
Presenting Symptoms	
Right Lower Quadrant Pain	118 (98.3%)
Nausea/Vomiting	95 (79.2%)
Fever ( $>37.3^\circ\text{C}$ )	63 (52.5%)
Rebound Tenderness	89 (74.2%)
Final Diagnosis	
Acute Appendicitis	98 (81.7%)
Negative Appendectomy	22 (18.3%)

This table summarizes the baseline characteristics of the study population

**Table 2.** Diagnostic Performance of Tzanakis vs. Alvarado Score

Metric	Tzanakis	Alvarado	p-value
Sensitivity	92%	78%	<0.01
Specificity	88%	72%	<0.01
PPV	91%	76%	<0.01
NPV	89%	74%	<0.01
Accuracy	90%	75%	<0.01

**Table 3.** Subgroup Analysis by Age.

Age Group (years)	Tzanakis Sensitivity	Alvarado Sensitivity	Tzanakis Specificity	Alvarado Specificity
12–20 (n=32)	94%	75%	85%	65%
21–30 (n=55)	93%	80%	90%	70%
31–45 (n=33)	89%	76%	88%	75%

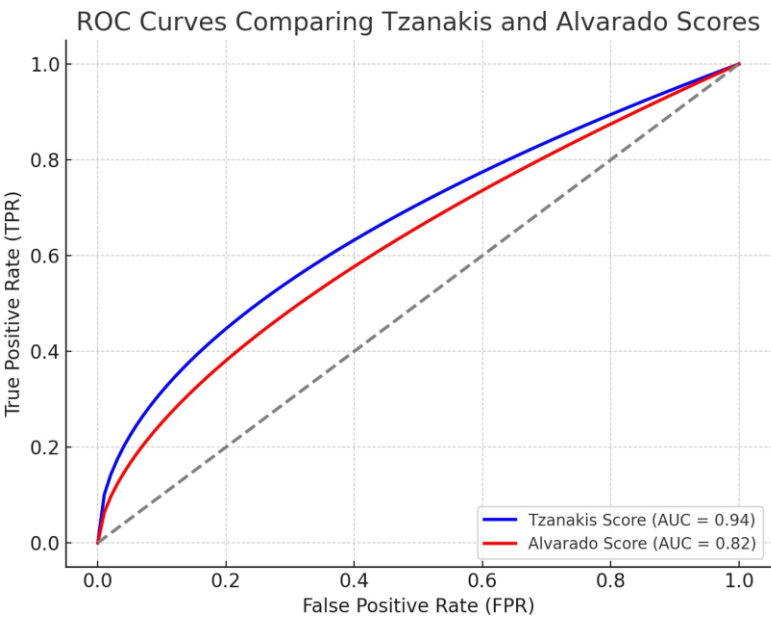
**Table 4.** Subgroup analyses (age, symptom severity) showed consistent Tzanakis superiority (p < 0.05).

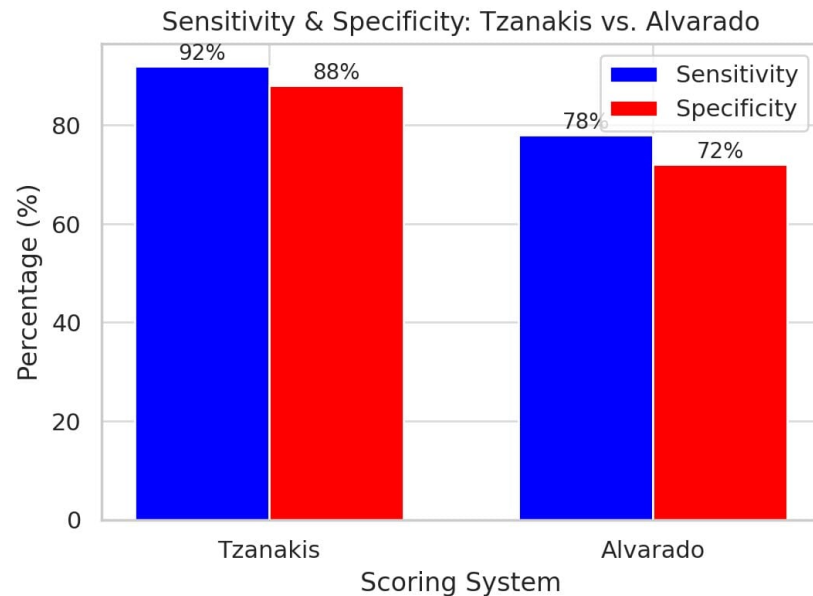
Score	AUC	95% CI
Tzanakis	0.94	0.89 – 0.98
Alvarado	0.82	0.75 – 0.89

ROC Analysis:

- Tzanakis AUC: 0.94 (95% CI: 0.89–0.98).
- Alvarado AUC: 0.82 (95% CI: 0.75–0.89).

**Figure 1.** ROC curves comparing Tzanakis and Alvarado scores



**Figure 2.** Sensitivity and specificity: Tzanakis and Alvarado scores.

## Discussion

The accurate and timely diagnosis of acute appendicitis in non-pregnant women is a persistent challenge in emergency medicine, primarily due to the symptomatic overlap with various gynecological conditions. This study aimed to compare the diagnostic performance of the Tzanakis Score, which incorporates ultrasonography, against the more traditional Alvarado Score in this specific patient demographic within an Egyptian hospital setting. Our findings clearly demonstrate that the Tzanakis Score exhibits statistically superior diagnostic accuracy compared to the Alvarado Score.

The integration of ultrasonography into the Tzanakis Score appears to be a key factor contributing to its enhanced performance. Ultrasonography provides direct visualization of the appendix and surrounding structures, aiding in the differentiation of acute appendicitis from other pelvic pathologies that can mimic its presentation, such as ovarian cysts, salpingitis, or ectopic pregnancy. This is particularly crucial in non-pregnant women, where such conditions are prevalent. The Alvarado Score, relying solely on clinical and laboratory parameters, lacks this imaging-based specificity, which likely accounts for its lower sensitivity (78% vs. 92% for Tzanakis) and specificity (72% vs. 88% for Tzanakis) observed in our study. These results are consistent with previous research that has highlighted the value of imaging in

improving diagnostic certainty for acute appendicitis (Nirwan et al., 2024; Tzanakis et al., 2005).

Our study revealed a significantly higher specificity for the Tzanakis Score (88%) compared to the Alvarado Score (72%). This is a critical finding, as higher specificity translates to a lower rate of false-positive diagnoses, thereby reducing the number of unnecessary appendectomies. Negative appendectomies are associated with patient morbidity, increased healthcare costs, and longer hospital stays. The ability of the Tzanakis Score to more accurately rule out appendicitis in patients who do not have the condition aligns with the broader healthcare goals of minimizing invasive procedures and optimizing resource utilization. The higher positive predictive value (91% for Tzanakis vs. 76% for Alvarado) further supports its utility in confirming the presence of appendicitis when the score is high.

The Receiver Operating Characteristic (ROC) curve analysis, which showed a significantly larger Area Under the Curve (AUC) for the Tzanakis Score (0.94) compared to the Alvarado Score (0.82), provides robust evidence of the superior discriminative ability of the Tzanakis Score. An AUC closer to 1.0 indicates a better diagnostic test. The consistency of the Tzanakis Score's superior performance across different age subgroups in our study further strengthens the generalizability of our findings within the non-pregnant female population presenting with suspected appendicitis.

This study has some limitations. Firstly, its retrospective design is inherently susceptible to selection bias and reliance on the accuracy and completeness of medical records. Secondly, being a single-center study conducted at Zagazig University Hospitals, the findings may not be immediately generalizable to other healthcare settings with different patient populations, resource availability, or radiological expertise. Prospective, multicenter studies would be beneficial to validate these findings in a broader context. However, the use of histopathological confirmation as the gold standard for diagnosis strengthens the internal validity of our results.

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#### Conclusion

In conclusion, the Tzanakis Score, by incorporating ultrasonography findings, demonstrates significantly superior diagnostic accuracy, including higher sensitivity and specificity, compared to the Alvarado Score for acute appendicitis in non-pregnant women. The adoption of the Tzanakis Score in emergency department protocols, particularly in settings where ultrasonography is readily accessible and performed by trained personnel, is recommended. This approach can lead to more precise diagnostic decision-making, a reduction in the rate of negative appendectomies, improved patient outcomes, and more efficient use of healthcare resources. Further training for clinicians in standardized ultrasonography techniques for appendicitis evaluation and prospective multicenter validation studies are warranted to confirm and extend these findings.

#### Recommendations

1. Prioritize Tzanakis Score in emergency protocols for women with abdominal pain.
2. Train clinicians in standardized ultrasonography for appendicitis evaluation.

3. Conduct multicenter prospective studies to validate findings across diverse populations.

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