Assessing The Diagnostic Accuracy Of Alvarado And Tzanaki Scores For Acute Appendicitis: A Comparative Study

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Abstract:

Background: One of the leading causes of sudden abdominal pain is acute appendicitis, which also happens to be the most common surgical illness in emergency departments. Acute appendicitis continues to be a significant cause of morbidity in the population and can also manifest as diffuse peritonitis in an advanced stage if diagnosis is delayed. Various scoring systems are used in diagnosing it such as Alvarado, Tzanaki, RIPASA, AIR and AAS. Effectiveness of one scoring system over the other is a potential field of research.

Materials and Methods: A prospective observational cohort study was conducted to include 100 patients with acute appendicitis who presented to the emergency room of VMMC and Safdarjung Hospital, New Delhi, between January 2022 and January 2023. The objective of the study is to assess the diagnostic accuracy of Tzanaki score and Alvarado Score in acute appendicitis, and their role in reducing negative appendicectomy rates. All patients were scored as per the Alvarado and Tzanaki scoring systems pre-operatively, after necessary clinical, biochemical and radiological examinations. The data entry was done in the Microsoft Excel spreadsheet. The independent t-test, Fisher's exact test and The DeLong et al. test were used. For statistical significance, a p-value of less than 0.05 was considered statistically significant.

Results: The mean age of presentation in our study was 31 years (31.07 +/- 15) with highest frequency of presentation in third decade (33%), followed by second decade (29%, p=0.18). Out of 100 patients, there were 45 (45%) male and 55 (55%) female patients (p=0.68). The mean Alvarado score is 7.8 and median is 8. The mean Tzanaki score is 11.92 and median is 12 (p<0.01). The area under curve (AUC) for Alvarado score is 0.653, while AUC for Tzanaki score is 0.858. Using the DeLong et al. test, difference between area under curve (AUC) was 0.205 with standard deviation of 0.103 (p=0.045). In our study, the total Alvarado score had 70.53% sensitivity, 60% specificity, 97.10% positive predictive value (PPV), 9.7% negative predictive value (NPV) and a diagnostic accuracy of 70%. The total Tzanaki score had 91.58% sensitivity, 80% specificity, 98.9% positive predictive value (PPV), 33.3% negative predictive value (NPV) and a diagnostic accuracy of 91%. Therefore the Tzanaki score outperformed the Alvarado score.

Conclusion: Tzanaki score is a superior diagnostic coring system for acute appendicitis than the Alvarado score, with better diagnostic accuracy and reasonably low negative appendectomy rate.

Key Word: appendix, mc burney's point, tzanaki score, alvarado score, DeLong test.

I. Introduction

Appendicitis refers to an inflammation of the vermiform appendix's internal lining that can progress to affect the whole organ. One of the leading causes of sudden abdominal pain is acute appendicitis, which also happens to be the most common surgical illness in emergency departments[1]. This disorder affects 7% of the population throughout their entire lifespan. It most frequently appears in adolescence and the twenties, with a 3:2 male-to-female ratio. Acute appendicitis continues to be a significant cause of morbidity in the population and can also manifest as diffuse peritonitis in an advanced stage if diagnosis is delayed[2]. Uncertain of its exact function, the appendix is a pouch-like structure located at the beginning of the large intestine. The blockage of the vermiform appendix's lumen is the main cause of its inflammation. Acute appendicitis is divided into four subtypes from a pathological perspective: catarrhal, phlegmonous, gangrenous, and perforated. This classification reflects the disease's evolutionary stages[3]. The primary and most frequent early sign of acute appendicitis is pain in the abdomen around the umbilicus, with 75% of patients experiencing a typical shift in pain from the periumbilical to the right iliac fossa. Depending on the site of the appendix in relation to the cecum, pain can sometimes be

reported in various other places. This is very often accompanied by nausea, vomiting, anorexia, fever, and chills. As the condition worsens, these symptoms typically get worse[4]. In most cases, the diagnosis of acute appendicitis is clinical. In around 80% of instances, a clinical examination aids in the diagnosis of acute appendicitis. Imaging and laboratory testing are needed to assist with diagnosis when there is ambiguity after a clinical assessment[5].

To establish the ideal equilibrium between under- and over-diagnosis in patients with acute appendicitis, an efficient scoring system might serve as a beneficial guiding tool. The surgeon's experience plays a vital part in accurate clinical evaluation. Although diagnostic techniques such as Computed Tomography (CT) have a high degree of diagnostic value, their application tends to be restricted in environments with limited resources. In emergency situations, the practice of scoring in addition to the clinical examination can significantly boost the accuracy of the diagnosis[6]. There are numerous scoring systems, but studies have not been able to establish which is superior. Various scoring systems include the Alvarado scoring system, the Tzanaki scoring system, the Raja Isteri Pengiran Anak Saleha Appendicitis (RIPASA) scoring system, the Appendicitis Inflammatory Response (AIR), the Adult Appendicitis Score (AAS), and the appendicitis scoring system. The Alvarado score is the most widely used and evaluated scoring system, but its sensitivity and specificity are only beneficial for excluding appendicitis cases, but not for deciding which cases necessitate surgery[7]. Acute appendicitis is frequently diagnosed using the Alvarado scoring system. It is composed of signs, symptoms, and inflammatory markers. A score of 7 or above out of 10 is deemed to be acute appendicitis and necessitates immediate surgical intervention. Its sensitivity and specificity are, respectively, 70-90% and 87-92%[8]. Clinical examination, ultrasonography, and inflammatory indicators are all combined in the Tzanaki scoring system. A diagnosis of acute appendicitis requiring surgical intervention is defined as having a score of 8 or above. It has a 95.4% sensitivity, 97.4% specificity, and 96.5% accuracy rate[9]. The purpose of this study was to determine the effectiveness of the Tzanaki and Alvarado scoring systems in the diagnosis of acute appendicitis and to lower the rate of negative appendectomies.

II. Material And Methods

A prospective observational cohort study was conducted to include 100 patients, aged more than 12 years, with acute appendicitis who presented to the emergency room of VMMC and Safdarjung Hospital, New Delhi, between January 2022 and January 2023. This study was reviewed and approved by Institutional review board (IRB) - VMMC and Safdarjung Hospital, New Delhi.

Study Design: Prospective open label observational study

Study Location: This was a tertiary care teaching hospital based study done in Department of General Surgery, at VMMC and Safdarjung Hospital, New Delhi, India.

Study Duration: January 2022 to January 2023.

Sample size: 100 patients.

Sample size calculation: The study of Shashikala V, et al[1] observed that sensitivity and specificity of Tzanakis score was 79.62% and 83.3% respectively and of Alvarado score was 61.9% and 50.0% respectively. Taking these values as reference, the minimum required sample size with desired precision of 15%, 80% power of study and 5% level of significance is 95 patients. To reduce margin of error, total sample size taken is 100.

Subjects & selection method: A prospective observational cohort study was conducted to include 100 patients, aged more than 12 years, with acute appendicitis who presented to the emergency room of VMMC and Safdarjung Hospital, New Delhi, between January 2022 and January 2023.

Inclusion criteria:
All patients above age of 12 diagnosed with acute appendicitis undergoing appendectomy.

Exclusion criteria:
1. Pregnant females
2. Appendicular abscess
3. Appendicular mass
4. Peritonitis

Procedure methodology:
All patients were subjected to a detailed clinical history and examination. A thorough abdominal examination was performed, with special emphasis on eliciting tenderness in the right iliac fossa and rebound tenderness. Later, relevant biochemical investigations were sent, including a complete blood count (CBC), a liver function test (LFT), a kidney function test (KFT), and serum electrolytes (SE). All patients were subjected to a radiological investigation - USG whole abdomen. All patients were scored as per the Alvarado and Tzanaki scoring systems pre-operatively. The decision to perform an appendicectomy was based on clinical findings assessed by the senior surgeon. All eligible patients underwent an emergency open appendicectomy under spinal

anesthesia. Intraoperative findings were noted, with special mention regarding the appearance of the appendix. Postoperatively, a comparison of the Tzanaki and Alvarado scoring systems and the histopathology of the appendix of the same patient was done.

The Alvarado scoring system involves eight parameters and a total score of 10. (Table no. 1)[1]. Patients were graded into three subgroups based on the Alvarado score. (A). Appendicitis least likely: Score 1 to 4; (B). Appendicitis likely: Score 5 to 7; (C) Appendicitis: Score 8 to 10. The Tzanaki scoring system involves four parameters and a total score of 15. (Table no. 2)[2]. Patients were graded into two subgroups based on the Tzanaki score. (A). No Appendicitis: Score less than or equal to 8; (B). Appendicitis: Score more than 8.

Table no. 1: Components of Alvarado Scoring System

ALVARADO SCORING SYSTEM	
<u>Symptoms</u>	SCORES
1. Migratory pain	1
2. ANOREXIA	1
3. Nausea and Vomiting	1
<u>Signs</u>	
4. Tenderness in RIF	2
5. Rebound Tenderness	1
6. Fever(>37.5ºC)	1
<u>Lab Reports</u>	
7. Raised WBC (>11000 / cm3)	2
8. Shift of WBC to left	1
TOTAL	10

Table no. 2: Components of Tzanaki Scoring System

TZANAKI SCORE		
COMPONENTS	PRESENT	ABSENT
1. Presence of right lower abdominal tenderness	4	0
2. Raised WBC (>12000 / cm3)	2	0
3. Rebound tenderness	3	0
4. Positive ultrasound scan findings of Appendicitis	6	0
TOTAL	15	

Statistical analysis:

The presentation of the categorical variables was done in the form of numbers and percentages (%). On the other hand, the quantitative data with a normal distribution were presented as the means ± SD (standard deviation), and the data with a non-normal distribution were presented as the median with the 25th and 75th percentiles (interquartile range). The data normality was checked using the Kolmogorov-Smirnov test. In cases where the data was not normal, we used non-parametric tests.

The following statistical tests were applied for the results:
1. The association of the variables, which were quantitative in nature, was analysed using an independent t test.
2. The association of the variables, which were qualitative in nature, was analysed using Fisher's exact test, as at least one cell had an expected value of less than 5.
3. The receiver operating characteristic curve was used to find the cut-off points of the total Alvarado score and the total Tzanaki score for predicting appendicitis. Sensitivity, specificity, positive predictive value, and negative predictive value were calculated. The DeLong et al. test was used for the comparison of the area under the curve of the Alvarado score and the Tzanaki score for predicting appendicitis[10].

The data entry was done in the Microsoft Excel spreadsheet, and the final analysis was done with the use of the Statistical Package for Social Sciences (SPSS) software, SPSS 28.0. For statistical significance, a p-value of less than 0.05 was considered statistically significant.

III. Result

The mean age of presentation in our study was 31 years (31.07 +/- 15), with highest frequency of presentation in third decade (33%), followed by second decade (29%, p=0.18) (Table no. 3). Out of 100 patients, there were 45 (45%) male and 55 (55%) female patients (p=0.68). All patients were scored as per the Alvarado scoring system pre-operatively, as shown in the table (Table no. 4). The most common finding in our study was anorexia (n=97, 97%), followed by right iliac fossa tenderness (n=91, 91%) and nausea (n=87, 87%) (p=0.204). Patients were graded into three subgroups based on the Alvarado score (Table no. 5). (A). Appendicitis least

likely: n=1 (1%), (B). Appendicitis likely: n=30 (30%), (C) Appendicitis: n=69 (69%). The mean score is 7.8 and median is 8 (Table no. 5).

Table no. 3: Distribution of age(years) of study subjects

Age(years)	Frequency	Percentage
13-20	29	29.00%
21-30	33	33.00%
31-40	16	16.00%
41-50	10	10.00%
51-60	6	6.00%
61-70	6	6.00%
Mean ± SD	31.07 ± 15	
Median (25th-75th percentile)	27(20-37.25)	
Range	13-70	

Table no. 4: Distribution of Alvarado score components of study subjects

Alvarado score components	Frequency	Percentage
Pain migration		
0	56	56.00%
1	44	44.00%
Anorexia		
0	3	3.00%
1	97	97.00%
Nausea		
0	13	13.00%
1	87	87.00%
RIF tenderness		
0	09	09.00%
2	91	91.00%
Rebound tenderness		
0	65	65.00%
1	35	35.00%
Fever(>37.5ºC)		
0	17	17.00%
1	83	83.00%
Raised WBC (>10x10⁹/l)		
0	17	17.00%
2	83	83.00%
Shift of WBC to left		
0	14	14.00%
1	86	86.00%

Table no. 5: Total Alvarado score of study subjects

Total Alvarado score	No Appendicitis (n=5)	**Appendicitis Present (n=95)**	Total	**P value**
Appendicitis least likely {1-4}	0 (0%)	**1 (1.05%)**	1 (1%)	
Appendicitis Likely {5-7}	3 (60%)	**27 (28.42%)**	30 (30%)	**0.204***
Appendicitis {8 to 10}	2 (40%)	**67 (70.53%)**	69 (69%)	
Mean ± SD	6.6 ± 1.52	**7.86 ± 1.38**	7.8 ± 1.41	
Median (25th-75th percentile)	7 (5-8)	**8 (7-9)**	8 (7-9)	
Range	5-8	**4-10**	4-10	**0.059†**
† Independent t test, * Fisher's exact test				

All patients were scored as per the Tzanaki scoring system pre-operatively, as shown in the table (Table no. 6). The most common finding in our study was positive USG finding of appendicitis (n=93, 7%), followed by right lower abdominal tenderness (n=91, 91%) (p<0.01). Patients were graded into two subgroups based on the Tzanaki score (Table no. 7). (A). No Appendicitis: Score less than or equal to 8 (n=12, 12%); (B). Appendicitis: Score more than 8 (n=88, 88%). The mean score is 11.92 and median is 12 (p<0.01). (Table no. 7). Every appendicectomy specimen was subjected to histopathological examination. Appendicitis was present in 95 specimens (95%), while absent in 5 (5%).

Table no. 6: Distribution of total Tzanaki score components of study subjects.

| Total Tzanaki score components	Frequency	Percentage
Presence of right lower abdominal tenderness		
0	9	9.00%
4	91	91.00%
Raised WBC(>12⁹/l)		
0	17	17.00%
2	83	83.00%
Rebound tenderness		
0	65	65.00%
3	35	35.00%
Positive ultrasound scan findings of Appendicitis		
0	7	7.00%
6	93	93.00%

Table no. 7: Total Tzanaki score of study subjects

Total Tzanaki score	No Appendicitis (n=5)	Appendicitis present(n=95)	Total	P value
<=8	4 (80%)	8 (8.42%)	12 (12%)	
>8	1 (20%)	87 (91.58%)	88 (88%)	0.0006*
Mean ± SD	8 ± 2.45	12.13 ± 2.14	11.92 ± 2.32	
Median (25th-75th percentile)	8 (6-8)	12 (12-13)	12 (12-13)	
Range	6-12	6-15	6-15	<.0001†
† Independent t test, * Fisher's exact test				

The receiver operating characteristic curve was used to find the cut-off points of the total Alvarado score and the total Tzanaki score for predicting appendicitis (Image no. 1). The area under curve (AUC) for Alvarado score is 0.653, while AUC for Tzanaki score is 0.858. The DeLong et al. test was used for the comparison of the area under the curve[10]. The difference between area under curve (AUC) is 0.205 with standard deviation of 0.103 (p=0.045). ((Table no. 8). In our study, the total Alvarado score had 70.53% sensitivity, 60% specificity, 97.10% positive predictive value (PPV), 9.7% negative predictive value (NPV) and a diagnostic accuracy of 70%. The total Tzanaki score had 91.58% sensitivity, 80% specificity, 98.9% positive predictive value (PPV), 33.3% negative predictive value (NPV) and a diagnostic accuracy of 91%. (Table no. 9). The Tzanaki score outperformed

the Alvarado score. Therefore, using the Tzanaki score while treating acute appendicitis lowers the likelihood of a negative appendectomy when compared to Alvarado score.

Image no. 1: Comparison of area under curve of Total Alvarado score and Total Tzanaki score for predicting appendicitis.
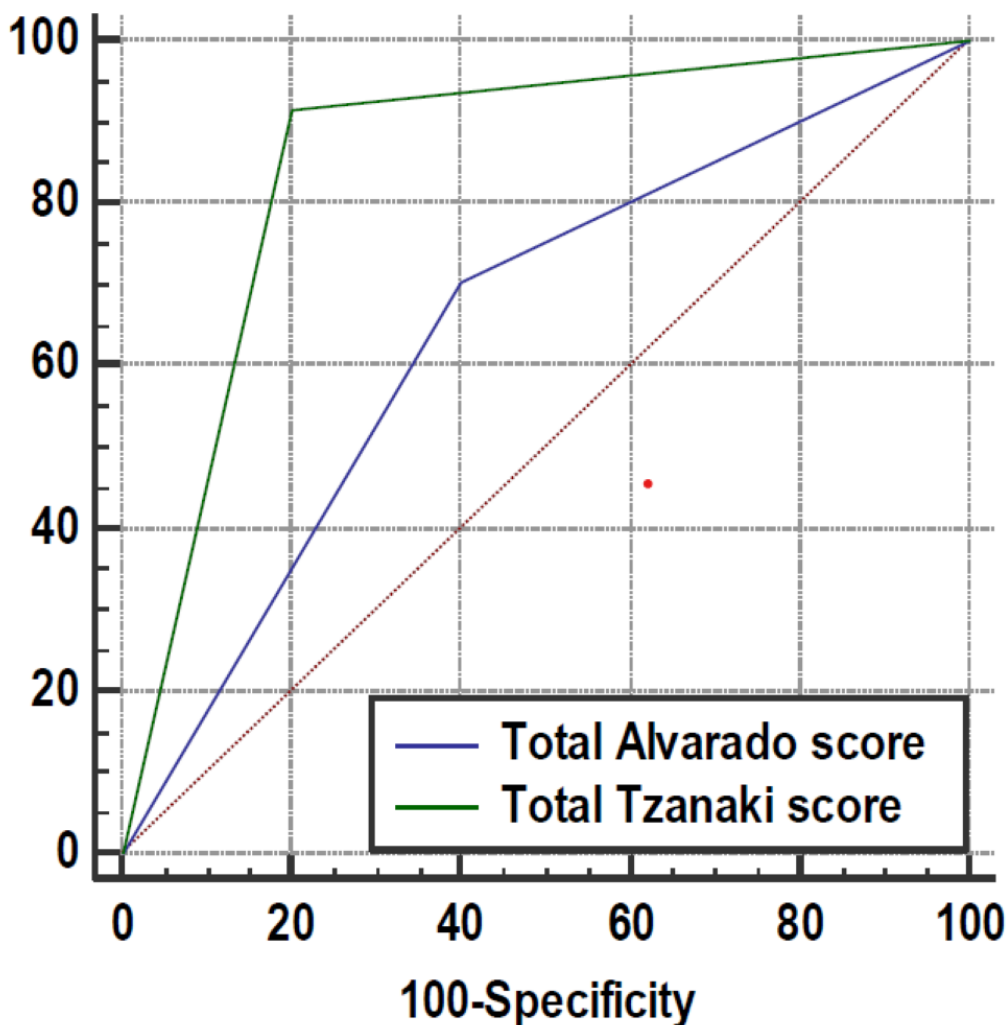
Table no. 8: DeLong et al test

Variable	Value
Difference between areas	0.205
Standard Error	0.103
95% Confidence Interval	0.00391 to 0.407
P value	0.0457

Table no. 9: Receiver operating characteristic curve of Total Alvarado score and Total Tzanaki score for predicting appendicitis

Variables	Total Alvarado score	Total Tzanaki score
Area under the ROC curve (AUC)	0.653	0.858
Standard Error	0.125	0.101
95% Confidence interval	0.551 to 0.745	0.774 to 0.920
P value	0.221	0.0004
Sensitivity (95% CI)	70.53% (60.3 - 79.4%)	91.58% (84.1 - 96.3%)
Specificity (95% CI)	60% (14.7 - 94.7%)	80% (28.4 - 99.5%)
PPV (95% CI)	97.1% (89.9 - 99.6%)	98.9% (93.8 - 100.0%)
NPV (95% CI)	9.7% (2.0 - 25.8%)	33.3% (9.9 - 65.1%)
Diagnostic accuracy	70.00%	91.00%

IV. Discussion

The three teniae coli merge near the base of the cecum, where the appendix is located. The appendix's position varies, despite its base being fixed. The retrocaecal, pelvic, and retrocolic positions are the most frequent ones. The ligament of Treves connects the appendix to the terminal ileum, which is situated 2.5 cm inferior to the ileocecal valve. The mesoappendix, which extends from the mesentery, houses the appendix's vascular supply[3]. The occlusion of the appendiceal lumen is the primary cause of acute appendicitis. One of the most prevalent acute illnesses causing abdominal pain in the emergency room is appendicitis. The highest incidence occurs in the second and third decades of life, with rates being lower in children under the age of four and gradually declining in individuals over the age of thirty. However, the risk of mortality is highest at the oldest and youngest ages[11]. A vague periumbilical pain that gradually radiates to the right lower quadrant at McBurney point over the course of a few hours is the "classic" presentation of acute appendicitis. This is owing to the fact that appendiceal tip inflammation leads to peritoneal irritation and progresses from midgut visceral pain brought on by the appendix's "hollow viscus" distention to somatic parietal discomfort. Atypical presentations are possible due to variable position of appendix. Patients with the appendix in the retrocaecal position typically experience pain in their flanks or back, while those with the appendix in the pelvic position might suffer from pain in the suprapubic area and those with the appendix in the retro-ileal position might encounter testicular pain as a result of irritation of the spermatic artery and ureter. This typically goes hand in hand with anorexia, the urge to defecate, occasional nausea, vomiting, diarrhoea, and fever. Murphy's Triad is a set of symptoms including pain, vomiting, and fever. A number of signs are described in acute appendicitis such as Mc Burney's sign, Blumberg sign (Rebound tenderness), Rovsing's sign, Cope's obturator sign, Psoas sign and pointing sign[12].

A non-compressible, non-peristaltic, tubular structure with a blind end and a diameter of 6 mm or more is a sign of acute appendicitis on ultrasonography (USG). An appendicolith produces an acoustic shadow. Its specificity varies from 81% to 98%, while the sensitivity is said to be between 71% and 94%. For individuals, such as pregnant women and children, for whom it is preferable to reduce radiation exposure, ultrasound may be the imaging test of choice[13]. The sole surgical treatment for an uncomplicated appendicitis is an appendectomy, which can be performed using a variety of techniques, including open surgery, robotic surgery, traditional laparoscopy, and single incision laparoscopy. Ochsner Sherren's regimen, comprising IV fluids, IV antibiotics, and close monitoring of the size of the lump, is initially used to handle appendicular lump patients conservatively. The treatment for appendicular abscess is drainage. Numerous studies have been conducted worldwide to examine the sensitivity and specificity of the available clinical scoring systems in the diagnosis of acute appendicitis in order to lower the negative appendectomy rates[1]. When compared to the Tzanaki scoring system, the Alvarado scoring system contained more characteristics, but it excludes imaging, which is now an essential element of diagnosis and is readily accessible. The Tzanaki scoring system gives imaging greater significance while awarding ultrasonography six points. Various studies have studied role of Alvarado scoring system in diagnosis of Acute appendicitis (Table no. 10) [3,8,14-17]. The system of scoring was explained by Alvarado in 1986. As evidenced by numerous studies, the Alvarado scoring system has proved effective in early identification of acute appendicitis in patients with the pre-operative clinical diagnosis of appendicitis. It also helped to lower the incidence of negative appendectomy[1]. Small sample size is a common drawback of most of these studies. In our study, the Alvarado score had a diagnostic accuracy of 70%, a sensitivity of 70.53%, a specificity of 60%, a positive predictive value (PPV) of 97.1% and a negative predictive value (NPV) of 9.1%.

Nicolaos E. Tzanakis first employed the Tzanakis scoring system in 2005 at the Medical School of Athens University in Greece. A combination of clinical evaluations, elevated leucocyte count, and ultrasonography is a part of Tzanaki's scoring method[2]. Various studies have studied the role of Tzanaki scoring system in diagnosis of Acute appendicitis (Table no. 11)[1,3,5,11,17]. The Tzanaki scoring system has a better accuracy, sensitivity, specificity, PPV and NPV in most studies. Patients with a Tzanaki score more than 8 are more likely to have acute appendicitis. In our study, 88% of the participants had a Tzanaki score above 8. The Tzanaki score had a diagnostic accuracy of 90%, a sensitivity of 91.58%, a specificity of 80%, a positive predictive value of 98.9%, and a negative predictive value of 33.3%. Giving a greater importance to USG findings, the Tzanaki score seems to be more reliable than Alvarado score in current day healthcare. Our study has some limitations, including the fact that there are only 100 patients in it, that USG imaging is operator-dependent, allowing for inter-observer variations in results. Based on the findings of this study, we propose that Tzanaki score be taken into account while treating acute appendicitis because it lowers the likelihood of a negative appendectomy when compared to Alvarado score.

Table no. 10: Studies on Alvarado Score

ALVARADO SCORE					
STUDY	SENSITIVTY %	SPECIFICITY %	PPV %	NPV %	ACCURACY %

1. Maghrebi H, et al [14]	81.25	-	74.28	-	-
2. Memon ZA, et al [15]	93.50	80.60	92.30	83.30	89.80
3. Jalil A, et al [16]	66.00	81.00	96.00	29.00	-
4. Anupriya R, et al [3]	36.21	66.67	84.00	117.78	41.43
5. Brigand C, et al [17]	76.00	75.00	97.20	21.4	-
6. Malla BR, et al [8]	73.00	67.00	97.20	21.42	-

Table no. 11: Studies on Tzanaki Score

TZANAKI SCORE					
STUDY	SENSITIVTY %	SPECIFICITY %	PPV %	NPV %	ACCURACY %
1. Lakshminarasimhaiah A.K, et al [11]	85.49	71.43	98.80	15.15	85.00
2. Anupriya R, et al [3]	65.52	100	100	37.50	71.43
3. Brigand C, et al [17]	86.90	75.00	97.50	33.30	-
4. Shashikala V, et al [1]	79.62	83.30	97.72	31.25	-
5. Sigdel GS, et al [5]	91.48	66.66	-	-	90.00

V. Conclusion

Acute appendicitis is a frequent surgical emergency. Acute appendicitis is still diagnosed clinically, but when the clinical signs remain ambiguous, grading systems aid in the diagnosis and can lower the likelihood of negative appendectomy. In our study, the Tzanaki score greatly outperformed Alvarado score in terms of sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy. The Tzanaki scoring system is a promising tool for accurately diagnosing acute appendicitis with reasonably low negative appendectomy rate. In conclusion, the Tzanaki score is currently a considerably superior diagnostic scoring system for acute appendicitis than the Alvarado score.

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