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Original Article

A Novel and Comprehensive Scoring System (TUST Score) for Diagnosing Acute Appendicitis

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ABSTRACT

Objective: To develop a novel, comprehensive and all-inclusive Scoring System (TUST Score) for the diagnosis of Acute Appendicitis using USG as a routine along with Clinical features and Laboratory Investigations.
Study Design: Prospective Longitudinal Study.
Place and Duration of Study: Department of Surgery, Combined Military Hospital, Tarbela Pakistan, from Sep 2020 to Mar 2024.
Methodology: After their informed consent, 260 patients who fulfilled all criteria of TUST Score for diagnosis of Acute Appendicitis and underwent Appendicectomy with proven diagnosis on Histopathology were included in this study.
Data was entered on a Proforma comprising patient's Demographic Parameters, Clinical Features, Laboratory Investigations, Radiological as well as their Operative Findings and Histopathological Reports.
Results: Out of 260 patients, 150(57.7%) were male while remaining 110(42.3%) were female. Minimum age was 10 years and maximum age 49 years with mean age of 24.15±0.154 years. Sensitivity of TUST Score in diagnosing Acute Appendicitis was 93%, Specificity 85%, Positive Predictive Value96%, Negative Predictive Value 75%, and Diagnostic Accuracy was 91%.
Conclusion: Being comprehensive and all inclusive, TUST Score at a cut-off value of (10/26) is a very useful tool to diagnose Acute Appendicitis and is far better than any other score developed so far.

Keywords: Acute Appendicitis, Diagnosis, Histopathology, Score, Sensitivity and Specificity, TUST, Ultrasonography.

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INTRODUCTION

Abdomen is a Temple of Surprise and despite recent advances in the medical field, Acute Abdomen remains a great challenge to surgeons. Moreover, Acute Appendicitis is one of the commonest surgical emergencies in the world, with 6.7% - 8.6% of the people suffering from it.[1]

If not treated timely, it can cause many serious complications like peritonitis, pelvic abscess and even death. Therefore, its prompt and accurate diagnosis is very important to reduce its morbidity and mortality.[2]

Since only 2/3rd of the patients with Appendicitis present with classical features, as well as the fact that other diseases may mimic this condition, diagnosis of Appendicitis is a challenging undertaking.[3] Therefore, in a significant number of the patients (20-33%) presenting with atypical findings, use of some imaging modality is must to help solve the diagnostic problem.[4]

Majority of Surgeons face a dilemma, between performing an unnecessary Negative Appendicectomy and delaying one, and finally operating when complications occur leading to increased morbidity and mortality. Therefore, Negative Appendicectomy due to early operation and life-threatening complications due to delayed intervention, are some of the drawbacks of Appendicectomy.

Presently, there is no fool proof diagnostic tool for diagnosing acute appendicitis to avoid early unnecessary negative appendicectomy as well as delayed appendicectomy with its associated complications. Many Scoring Systems have evolved to help in this regard. The aim and objective of this study is to develop a Novel Scoring System which is comprehensive and all-inclusive with good Sensitivity, Specificity and Diagnostic Accuracy for timely diagnosis and management of this life threatening condition.

METHODOLOGY

This Prospective Longitudinal Study was carried out in Department of Surgery CMH Tarbela, Pakistan from September 2020 to March 2024. Institutional Review Committee / Hospital Ethical Committee approval was obtained (Vide Letter No. Coy / 1103 - Gen / 15 / 2020, dated: 9th Sept 2020). The Sample Size was calculated by using WHO Sample Size

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Calculator, taking lifetime prevalence of Acute Appendicitis at 6.7% in general population.[5]

Table-I: TUST Score

Serial No	Parameters	Score
1	**Age (10 - 49 yrs)**	
	>40 years	0
	≤40 years	1
2	**Gender**	
	Female	0
	Male	1
3	**Abdominal Pain**	
	Right Lower Quadrant	1
	Migratory	1
4	**Intensity of pain**	
	Mild/Moderate	0
	Severe	1
5	**Duration of pain**	
	>48 hours	0
	≤48 hours	1
6	**Additional symptoms**	
	Anorexia	1
	Nausea/Vomiting	1
	Fever	1
7	**Palpation**	
	Tenderness	1
	Rebound Tenderness	1
	Guarding	1
8	**Urinary symptoms**	
	Present	0
	Absent	1
9	**Gynaecological Complaints**	
	Present	0
	Absent	1
10	Rovsing Sign	1
11	**Other Signs**	
	Baldwin and Cope's Sign etc	1
12	**Bowel Sounds**	
	Present	0
	Absent	1
13	**Total Leukocyte Count(x10)**	
	≤11.0	0
	>11.0	1
14	**Neutrophil Count (%)**	
	≤75	0
	>75	1
15	**CRP (mg/L),**	
	≤6	0
	>6	1
16	**Urine R/E**	
	RBCs/Pus Cells +ve	0
	RPCs/Pus Cells -ve	1
17	**Pregnancy Test**	
	Negative	0
	Positive	1
18	**Ultrasound Findings**	
	Not visible: Grade 0: 52	-
	<6 mm: Grade 1: Zero	0
	>6 mm: Grade 2: 208	1
	Fecolith: Grade 3: 26	1
	Free fluid: Grade 4: 234	1
	*Mass / Phlegmon: Grade 5: 26	1
	SCORE	26
	Operative Findings	(May have >1 findings)
	Grade 1	Normal Looking
	Grade 2	Inflamed
	Grade 3	Gangrenous / Perforated
	Grade 4	Free Fluid
	Grade 5	Mass/Abscess
	Histopathological Findings	
	Grade 1	Normal
	Grade 2	Inflamed
	Grade 3	Gangrenous/Perforated (Complicated)

This study comprised 260 patients who fulfilled all criteria of TUST Score shown in Table-I for diagnosis of Acute Appendicitis and underwent Appendicectomy with proven diagnosis on Histopathology.

Inclusion Criteria: Patients between 10 to 50 years of age presenting with right lower quadrant abdominal pain of less than 3 days duration, suspected to have Acute Appendicitis who fulfilled all criteria for TUST Score and had undergone Emergency Appendicectomy as the primary procedure were included in the study, after their informed consent.

Exclusion Criteria: Patients with a right iliac fossa mass or previous history of urolithiasis or pelvic inflammatory disease and pregnant women, children below 10 years of age, elderly patients above 50 years and those with any of the missing parameters of TUST Score, like Urine R/E, Pregnancy Test, CRP and USG as well as those undergoing Interval Appendicectomy were excluded from the study.

TUST Score was calculated for every patient who was diagnosed with Acute Appendicitis and underwent Appendectomy with proven histopathological examination.

All Ultrasound Examinations were performed by a Senior Consultant Radiologist with 10 years plus Post - fellowship Experience on a modern and state-of-the-art Machine (TOSHIBA Xario XG, SSA - 680A, Color Doppler Ultrasound System, Manufactured June, 2010. Made in Japan).

On ultrasonography, a blind ending, a peristaltic, noncompressible tubular structure in the right iliac fossa (RIF) with a thickened wall and widened diameter (>6mm) with increased peri-appendicular fat echogenicity or free intraperitoneal fluid or presence of appendicolith, were suggestive of Acute Appendicitis. USG image of one of our patients with Acute Appendicitis is depicted in Figure-1.

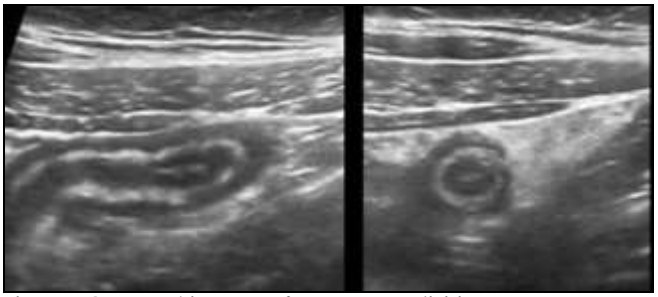

Figure-1: Sonographic Image of Acute Appendicitis (A peristaltic, non-compressible, blind-ending tube (appendix) with >6mm outer diameter and >3mm wall thickening)

Open Appendicectomy was performed in all our patients with histopathology of resected specimens as gold standard for final diagnosis. Conservative non-operative management was not done in any patient. Per-operative Photograph of a patient undergoing Open Appendicectomy is shown in Figure-2.

Figure-2: Operative Findings

Data was entered on a Proforma comprising patient's Demographic Parameters, Clinical Features, Laboratory Investigations, Radiological as well as their Operative Findings and Histopathological Reports. Statistical Package for Social Sciences (SPSS) Version 26 was used for data analysis. Quantitative variables with normal distribution were expressed as Mean±SD and qualitative variables were expressed as frequency and percentages. Diagnostic parameters were calculated using a 2x2 contingency table Sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy were determined by using the standard formulae.

RESULTS

A total number of 260 patients were included in the study. Age ranged from 10 - 49 years (mean 24.15±10.15) Out of 260 patients, 150(57.7%) were male while remaining 110(42.3%) were female. Typical features of RIF pain / migratory nature were found in 100-160 patients (38.46–61.53%). Duration of pain was <48 hours in 160(61.53%) and >48 hours in 100(38.46%) patients. TLC was raised (>11,000 / Cmm) in 160(61.53%) and within normal limits in 100(38.46%) cases. Out of 260 cases Appendix was not picked up by USG in 52(20.00%) and was visualized in 208(80.00%) cases. 259 Appendices were found to be inflamed on histopathology out of 260(99.61%).

True positive, False positive, False negative and True negative cases along with validity of TUST score are shown in Table-II.

Table-II: Validity of TUST Score

TUST Score	Based on Histopathology as Gold Standard		
	Disease +ve	Disease –ve	Total
Positive	192 (TP)	8 (FP)	200
Negative	15 (FN)	45 (TN)	60
	207	53	260

Sensitivity= 192(TP)/192(TP) +15(FN)= 0.927 (ALL DISEASE +VE)
Specificity= 45(TN)/45(TN)+8(FP)= 0.849 (ALL DISEASE -VE)
Positive Predictive Value (PPV)= 192 (TP)/192(TP)+8(FP)= 0.96
Negative Predictive Value (NPV)= 45(TN)/45(TN)+15(FN)= 0.75
Diagnostic Accuracy= 192(TP)+45(TN)/260 (ALL PATIENTS)= 0.911

Table-III: Comparison of Different Scoring Systems

Parameters	Alvarado Score (%age)	USG alone (%age)	Tzanaki's Score (%age)	TUST Score (%age)
Sensitivity	94.1%	80.0%	91.9%	93.0%
Specificity	33.3%	60.0%	85.1%	85.0%
Positive Predictive Value	88.8%	93.3%	93.6%	96.0%
Negative Predictive Value	50.0%	30.0%	81.6%	75.0%
Diagnostic Accuracy	85.0%	77.5%	89.9%	91.0%

DISCUSSION

The findings of our study show that the novel TUST Score at a cut-off value of (10/26) is a very useful tool to diagnose Acute Appendicitis and has comparative diagnostic significance as compared to any other score.

Many studies show that 20% cases of Appendicitis are misdiagnosed and Negative Appendectomy rate ranges between 5%-46%. A 15-20% NAR (Negative Appendicectomy Rate) is generally acceptable, but it may be disturbingly as high as 46 % in young ovulating women where clinical features may mimic gynecological diseases. Therefore, to avoid serious consequences of Missed Appendicitis, early and accurate diagnosis is must.[6]

Although many attempts have been made to improve the Diagnostic Accuracy of Acute Appendicitis, yet there is a very high incidence of Negative Appendectomy as well as risk of perforation (10-30%) because of delayed Operation. Therefore, we need to strike a balance between Early Negative Appendicectomy (which is not without complications) and Delayed Operation with associated Morbidity and Mortality).[7]

This diagnostic dilemma led to development of numerous Scores to help in diagnosis of Acute Appendicitis. Since 1980, many Scoring Systems have been developed, RAMA - AS (Ramathibodi Appendicitis Score),[8] Christian, Izbicki, RIPASA[9] (Raja Isteri Pangiran Anak Saleha), Fenyo, Tzanaki's,

Andersson & Andersson (AIR: Appendicitis Inflammatory Response:) Score,[10] Alvarado/ Modified Alvarado (by Kalan & Colleagues),[11] Sammalkorpi (AAS: Adult Appendicitis Score), Samuel[12] (PAS: Paediatric Appendicitis Score), Lintula, Eskelinen, Ohmann, , Karaman Score and Shabir's SMART - LAB Score (Sonography. Migratory RIF Pain, Anorexia, Rebound tenderness, Tenderness, Leucocytosis, Acute Phase Protein (CRP) and Serum Bilirubin).[13–16]

The Alvarado Score was the 1st one to be described in 1986 and is in use since then, the last being Shabir's Score described in 2022. Majority of these Scoring Systems are mainly based on clinical presentation which makes the diagnosis difficult for some patients, such as the elderly, the diabetics and the children.[12-14]

Ultrasound is a helpful modality and is being used in Tzanaki's and Shabir's Score, both are combination of physical examination, laboratory and sonographic evaluation. But they omit some Symptoms, (e.g., Pain in the RIF, its Migratory Nature & Nausea / vomiting in Tzanaki Score and Urine R/E & Pregnancy Test in Shabir's Score). Similarly, un like our study all other Scores disregard many important parameters, e.g., USG in RIPASA Score, CRP & USG in Alvarado Score and Clinical Tests (Rovsing's and other Signs) in almost all the Scores.[14-16]

Some studies depend only on Ultrasonography which can miss a very significant number of Appendicitis cases. According to a study by Ambreen et al. Sensitivity of Ultrasound was found to be 80% and that of Alvarado Score 94.1%. Specificity with Ultrasound was 60% whereas it was 33.3% in Alvarado Score. Diagnostic Accuracy was 77.5% with USG and 85% with Alvarado Score. Therefore, both are complementary and need to be used together to reduce NAR (Negative Appendicectomy Rate) thus supporting the need for a comprehensive and all inclusive Score (like, TUST Score).[17]

We have devised a novel Scoring System (TUST Score) for diagnosing Acute Appendicitis. It is a very unique and comprehensive score in the sense that it is all inclusive and adds Ultrasonography to other Parameters, i.e., Symptoms, Signs and Laboratory investigations. All parameters carry 0-1 point with total Score being 26 as shown in Table-I. A Sore of 10/26 is diagnostic of Acute Appendicitis. Interestingly, the word TUST literally means a tuft or bunch or cluster because in this novel score, a number of parameters including clinical features, laboratory investigations and sonographic findings are grouped together. The Acronym TUST also indicates the Initials of names of the Three Authors (Tariq, Uzma, Saqib) along with the Place (Tarbela) where this study was carried out.

No doubt, a wide range of tools are available for diagnosing Acute Appendicitis, They present high sensitivity and specificity, but have some limitations. CT scan is considered as the best diagnostic tool for Appendicitis, but ionizing radiation risk, limited availability and high cost are its major disadvantages.[18-20]

Laparoscopy is very useful in the diagnosis and management of lower abdominal pain, but is invasive and costly along with anesthesia risk and high rate of negative appendectomies. Moreover, complication rate is almost the same in both inflamed and normal appendix, making the patient's management further complex.[21]

However, Ultrasonography is an inexpensive, readily available and non-invasive method with an Accuracy Rate of upto 71% - 90% for the diagnosis of Acute Appendicitis. It also helps in ruling out other causes of Acute Abdomen but it is Operator dependent. At the same time, Patient Factors (obesity, appendix position, fasting status and bowel gases etc.) and Machine Factors can also limit its utility.

Despite advances in Pathology and Radiology, the Negative Appendectomy still remains a possibility in patients presenting with right iliac fossa pain. The NAR ranges between 16.8% and 31.9%, with a mean NAR of 26.7% or 18.3% after a positive ultrasound scan which is worryingly high. Therefore, being complementary, Clinical and radiological imaging/ USG must be used simultaneously.[22]

A total of 260 patients were included in our study, out of which 250 patients (96.15%) were <40 years of age along with Male predominance (n=150/260: 57.7%) which is comparable to another study conducted by Rohan Qamar *et al*.[23]

In this study, 259/260(99.9%) cases were confirmed positive on histopathology, giving the overall Negative Appendectomy Rate of 0% which is in contrast to 33.1% and 14.7% reported in other studies. The Negative Appendectomy Rate with Tzanaki Score is 7%. The reason for very low (almost Zero) Negative Appendectomy rate in our study is because of this unique (TUST) Scoring System which is all inclusive.

Our study revealed that TUST Score has 93% Sensitivity, 85% Specificity, 96% Positive Predictive

Value, 75% Negative Predictive Value and 91% Diagnostic Accuracy, whereas they are 91.9%, 85.1%, 93.6%, 81.6% and 89.9% respectively in Tzanaki's Score for diagnosing Acute Appendicitis.[24,25] If Tzanaki Score >8, there is 96% chance of Acute Appendicitis whereas, if TUST Score ≥10, there is 99.62% (almost 100%) chance of Acute Appendicitis. Therefore, TUST Score has far better Sensitivity, Specificity and Diagnostic Accuracy than any other score (using Ultrasonography as a routine) because all the USG Scans were done by the same Senior Consultant Radiologist and on the same state-of-the-art USG Machine thus eliminating the Operator and Machine Factors.

CONCLUSION

Being comprehensive and all inclusive, TUST Score at a cut-off value of (10/26) is a very useful tool to diagnose Acute Appendicitis and has comparative diagnostic significance as compared to any other score.

LIMITATIONS OF STUDY

1. It is humanly impossible to get all USGs done by the same Senior Consultant Radiologist (as practised in this study), especially in a Tertiary Care Hospital with heavy workload. However, this limitation can be overcome, to some extent, by engaging many Senior Consultant Radiologists with same experience.

2. Any Score must be simple and effective but TUST Score is little complex.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

GRT & SUR: Data acquisition, data analysis, critical review, approval of the final version to be published.

UR: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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