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Study of the combination of Alvarado score and Ultrasonography in diagnosing acute appendicitis

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Abstract
Acute appendicitis is a common surgical emergency with a lifetime risk of about 6 - 7%. Appendicectomy is the treatment of choice. A delay in the diagnosis and management can lead to complications such as appendicular rupture, abscess and peritonitis. In the current era of evidence based medicine, negative appendicectomies are not acceptable. The Alvarado score is in use since a long time for the diagnosis of acute appendicitis. Ultrasound is the first line investigation used in case of suspected acute appendicitis. Various studies have shown that Alvarado score or Ultrasonography individually, is insufficient diagnostic tools. Some studies have shown that their diagnostic efficacy is increased when used in combination with one another. This prospective comparative study carried out in 100 patients with a clinical suspicion of acute appendicitis proves that the combination of Alvarado score and Ultrasonography is a better diagnostic tool, compared to either of the two, alone.

Keywords: Acute appendicitis, Alvarado score, Ultrasound, Diagnostic efficacy

Introduction
Acute appendicitis is a common surgical emergency [1]. Around 6 - 7% of the general population is believed to have appendicitis in their lifespan [1, 2]. Appendicectomy is the treatment of choice. Inspite of its high prevalence rates, the diagnosis remains challenging as the symptoms overlap with many other surgical and non-surgical conditions. In a case of suspected acute appendicitis, the main decision that has to be made is whether the patient has to be operated or not.
A delay in the diagnosis and management can lead to complications such as appendicular rupture, abscess and peritonitis [3, 4]. Perforation can occur in about 35% of the cases [5]. So, surgeons worldwide have widely accepted a negative appendicectomy rate of 20 to 40% [6].
There are various drawbacks with negative appendicectomies, such as exposing the patient to the risks of the surgical procedure, socio-economic burden in the form of hospital expenses, lost working days and declined productivity [7]. Recently, few studies have reported a higher risk of acute myocardial infarction being related to appendicectomy and tonsillectomy done before the age of 20 years[8]. There is also an increase in the use of appendix as a conduit in urinary tract and biliary tract reconstruction in modern surgery [9, 10, 11]. So, there is an increasing need to preserve the normal appendix.
Various clinical, biochemical and radiological methods such as Alvarado scoring system, C-reactive protein (CRP) values, Total leucocyte count (TLC), Ultrasonography (USG), Computed Tomography (CT), Magnetic Resonance Imaging (MRI) are used in the diagnosis of acute appendicitis.
Alvarado scoring system uses patient symptoms, clinical signs and laboratory values to determine the possibility of acute appendicitis. Studies have shown that Alvarado score has more specificity than sensitivity, a high positive predictive value [12, 13]. Some studies have also shown that Alvarado score alone is an inadequate diagnostic tool [14].
Ultrasound (USG) has well-established direct and indirect signs for acute appendicitis diagnosis [15]. Investigations like CT, MRI are expensive. Even though CT has the highest sensitivity and specificity [12], there is risk of radiation exposure. Ultrasonography has a comparatively lower sensitivity and specificity [12], but it has the advantages of being faster, not using contrast material and zero radiation exposure [12]. So, ultrasonography is the most common modality used in the diagnosis of acute appendicitis.

Studies in the past have proven that the diagnostic efficacy of Alvarado score and Ultrasonography can be increased by using them in combination with each other, or with other investigations such as CRP [16, 17].
In this study, the efficacy of the combination of Alvarado score and Ultrasonography in diagnosing acute appendicitis was studied.

Materials and Methods

It is a prospective cross-sectional comparative study carried out in JSS Hospital, Mysuru on 100 patients admitted under the department of General Surgery with suspected acute appendicitis. The required history and blood investigation reports were collected, Alvarado score calculated. An Alvarado score of 7 or more was considered diagnostic in this study. Ultrasound abdomen and pelvis was done and reports collected. The patients were followed up and the details of their surgery, histopathology reports were collected. Histopathological report of acute appendicitis was considered as the gold standard. The efficacy of Alvarado score and Ultrasound in diagnosing acute appendicitis was studied separately and in combination and the results tabulated.

Results and Discussion

In this study, majority of the study population (36%) belonged to the age group of 21 to 30 years, 36.4% in males, 35.6% in females. The mean age of the study population was 33.6 years. 55% of the study population was males, 45% females.
The most common presenting symptom was pain abdomen, which was present in 100% of the study population. Localised Right Iliac Fossa (RIF) pain was present in 70% of the study population, whereas the classical migrating pain was seen in only 14% of the study population. Nausea or vomiting was present in 55% of the study population, anorexia in 57% and fever in 25%.
RIF tenderness was present in 95% of the study population, rebound tenderness over RIF was present in 17% of the individuals, localized guarding and rigidity was present in 11% of the study population.
Only 36% of the study population had leucocytosis. (Higher limit taken as 11,000 cells/cu.mm of blood). 38% of the study population had a left shift.
In this study involving 100 patients with suspected acute appendicitis, histopathological examination was positive for acute appendicitis in 62 patients, i.e., 62%.
Of the 100 patients involved in the study, 68% underwent laparoscopic appendicectomy, 32% underwent open appendicectomy.
In this study, Alvarado score has a sensitivity - 35.48%, specificity - 92.11%, positive predictive value (PPV) - 88%, negative predictive value (NPV) - 46.67% and a diagnostic accuracy of 57%. [With 95% Confidence Interval] This is in accordance with other similar studies [18, 19].

Table 1: Efficacy of Alvarado score (Cutoff- 7) as a diagnostic tool for acute appendicitis

Parameter	Estimate	Lower – Upper 95% CIs
Sensitivity	35.48%	(24.74, 47.92)
Specificity	92.11%	(79.2, 97.28)
Positive predictive value	88%	(70.04, 95.83)
Negative predictive value	46.67%	(35.82, 57.84)
Diagnostic accuracy	57%	(47.22, 66.27)
Likelihood ratio of a positive test	4.495	(1.989 – 10.16)
Likelihood ratio of a negative test	0.7005	(0.6638 – 0.7392)

In this study, Ultrasonography has a sensitivity - 79.03%, specificity - 50%, positive predictive value (PPV) - 72.06%, negative predictive value (NPV) - 59.38% and a diagnostic accuracy of 68%. [With 95% Confidence Interval]

Table 2: Ultrasound as a diagnostic tool for acute appendicitis

Parameter	Estimate	Lower – Upper 95% CIs
Sensitivity	79.03%	(67.36, 87.32)
Specificity	50%	(34.85, 65.15)
Positive predictive value	72.06%	(60.44, 81.32)
Negative predictive value	59.38%	(42.26, 74.48)
Diagnostic accuracy	68%	(58.34, 76.33)
Likelihood ratio of a positive test	1.581	(1.411 – 1.771)
Likelihood ratio of a negative test	0.4194	(0.3253 – 0.5406)

In this study, combination of Alvarado score and Ultrasonography (atleast 1 positive) showed a sensitivity - 88.71%, specificity - 44.74%, positive predictive value (PPV) - 72.37%, negative predictive value (NPV) - 70.83% and a diagnostic accuracy of 72%. [With 95% Confidence Interval]

Table 3: Combination of Alvarado score and Ultrasonography in the diagnosis of acute appendicitis (atleast 1 positive)

Parameter	Estimate	Lower – Upper 95% CIs
Sensitivity	88.71%	(78.48, 94.42)
Specificity	44.74%	(30.15, 60.29)
Positive predictive value	72.37%	(61.42, 81.16)
Negative predictive value	70.83%	(50.83, 85.09)
Diagnostic accuracy	72%	(62.51, 79.86)
Likelihood ratio of a positive test	1.605	(1.456 – 1.77)
Likelihood ratio of a negative test	0.2524	(0.1654 – 0.385)

In this study, combination of Alvarado score and Ultrasonography (both positive) showed a sensitivity - 25.81%, specificity - 97.37%, positive predictive value (PPV) - 94.12%, negative predictive value (NPV) - 44.58% and a diagnostic accuracy of 53%. [With 95% Confidence Interval]

Table 4: Combination of Alvarado score and Ultrasonography in the diagnosis of acute appendicitis (Both positive)

Parameter	Estimate	Lower – Upper 95% CIs
Sensitivity	25.81%	(16.55, 37.88)
Specificity	97.37%	(86.5, 99.53)
Positive predictive value	94.12%	(73.02, 98.95)
Negative predictive value	44.58%	(34.36, 55.28)
Diagnostic accuracy	53%	(43.29, 62.49)
Likelihood ratio of a positive test	9.806	(0.9713 – 99.01)
Likelihood ratio of a negative test	0.762	(0.7292 – 0.7963)

Combination of Alvarado score and Ultrasonography (atleast one positive) has proven to be effective in the diagnosis of acute appendicitis as it has a higher sensitivity, higher negative predictive value and a higher diagnostic accuracy. When both USG and Alvarado score are positive, the specificity is increased.
A study by Patel Vivek *et al*. also showed that Alvarado score and Ultrasonography used together was more effective in the diagnosis of acute appendicitis than when used separately [18].

Table 5: Rate of negative appendicectomies and missed appendicitis

Criteria for appendicectomy	Negative appendicectomy	Missed appendicitis (Total HPE positive- 62)	Number of appendicectomies
Clinical suspicion	38%		100
Alvarado score (>=7)	12%	40	25
USG findings (s/o appendicitis)	27.94%	13	68
Atleast 1 positive	27.63%	7	76
Both positive	5.8%	46	17

In this study, clinical suspicion was taken as the criteria for surgery, there was a negative appendicectomy rate of 38%. If the decision for surgery had been made based on an Alvarado score of more than or equal to 7, the negative appendicectomy rate would have been 12% with 40 cases of missed appendicitis. The negative appendicectomy rates are comparable with similar studies which have negative appendicectomy rates of 13.3%, 15.6%, 16.2% and 14.3% respectively [17, 20, 21, 22[.

If the decision for surgery had been made based on Ultrasonography suggestive of acute appendicitis, the negative appendicectomy rate would have been 27.94% with 13 cases of missed appendicitis.

If atleast one of the two being positive was taken as the criteria for surgery, the negative appendicectomy rate would have been 27.63% with 7 cases of missed appendicitis. If both Ultrasound and Alvarado score being positive was taken as the criteria for surgery, the negative appendicectomy rate would have been 5.8% with 46 cases of missed appendicitis.

About 17 negative appendicectomies could have been prevented if both negativity was considered as a criteria to defer surgery, with 7 cases of missed appendicitis.

Conclusion

From the present study, it may be concluded that a combination of Alvarado score and Ultrasonography is a better diagnostic tool in diagnosing acute appendicitis when compared to either Alvarado score or Ultrasonography separately. The combination can decrease the need for unnecessary radiological investigations and also decrease the rate of negative appendicectomies.

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