Alvarado score in predicting acute appendicitis among patients presenting to a secondary care unit in Sri Lanka: a new cut-off value

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Abstract

Introduction

The commonest abdominal emergency in high and low-income countries is acute appendicitis. The lifetime risk is about 7%. The young age group is more susceptible, but none of the age groups is immune. As symptoms of acute appendicitis overlap with a few other conditions, accurate diagnosis is difficult. The objectives were to evaluate the sensitivity and specificity of the Alvarado score in the diagnosis of acute appendicitis among patients presenting with abdominal pain suggestive of acute appendicitis among Sri Lankan patients.

Materials and Methods

This was a validation study to determine the use of the Alvarado score for predicting the diagnosis of acute appendicitis at a General Hospital in the Central Province of Sri Lanka. All patients who were admitted to surgical units of General Hospital Matale with suspected acute appendicitis and undergoing appendicectomy were the study population.

Results

A total of 178 patients were recruited for the study of which 83 were histologically confirmed cases and while 89 were not confirmed. The recommended Alvarado score cutoff of 7 returns a sensitivity of 62.5% and a specificity of 91%. On the other hand, a cut-off value of 4.5 provides a sensitivity of 89.2% and a specificity of 86.5%. This cutoff value increased the Negative Predictive Value to 89.5% from 72% whereas the Positive Predictive Value did not change.

Conclusions

An Alvarado Score cut off value of 4.5 provides a sensitivity of 89.2% and a specificity of 86.5% compared to 62% and 91% respectively at the recommended cutoff value of 7. Since calculating decimals is not practical with the score we suggest

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lowering the cutoff of the Alvarado score to 5 for patients in Sri Lanka.

Introduction

The commonest abdominal emergency in high and low-income countries is acute appendicitis [1]. The lifetime risk is about 7% [2]. The young age is more susceptible but none of the age groups is immune. As symptoms of acute appendicitis overlap with a few other conditions, an accurate diagnosis of the condition is difficult. Various other factors such as late presentation and partial treatment make the diagnosis more challenging. Hence investigations may be needed to support the clinical diagnosis [3]. None of the available investigations is 100% diagnostic [4].

Apart from C-reactive protein and white blood cell count the other commonly used investigation modality is ultrasound scan; which is freely available but highly operator dependent in the diagnosis of acute appendicitis [5]. Contrast-enhanced, thin-section computed tomography scanning is the imaging modality of choice in achieving a diagnosis and detecting complications in acute appendicitis, with high specificity. But it is not freely available in our set up. Due to the above facts, many clinicians have proposed the use of clinical predictive rules [CPR] to enhance the clinical diagnosis of acute appendicitis. [6,7]. This CPRs utilise important symptoms, signs and test results in an attempt to quantify the probability of the disease being present [8]. CPR would allow junior medical officers to decide to either transfer or not transfer the patient to a better-equipped centre when they receive a patient with abdominal pain of which the aetiology is not clear. The Alvarado Score is the most used CPR in the diagnosis of Acute Appendicitis. Alvarado score, which was suggested by Alford Alvarado in 1986, consists of eight predictive factors to help in the early diagnosis of acute appendicitis [9]. The score is based on four symptoms, two signs and one laboratory investigation which translate to a total score of 10 points [Table 1]. Based on this score, three groups of patients are identified [10, 11].

I score more than seven - appendicitis confirmed

ii   score of five and six – to be observed

iii   score less than four- acute appendicitis is unlikely and

other causes of abdominal pain to be conceded

The Alvarado score was developed in 1986 as a diagnostic tool [12. 13. 14]. Surgeons have found that this score is a sensitive diagnostic tool for the diagnosis of acute appendicitis, but many researchers have found that the Alvarado score has poor accuracy in Asian populations [13, 14]. The score is well calibrated in men but tends to be over predictive in females [14]. This was a study to assess the sensitivity and specificity of the current recommended ALVARDO score cutoff and to determine an appropriate cut off point of Alvarado score for predicting the diagnosis of Acute Appendicitis for Sri Lankan patients seeking health care at Matale General Hospital.

Materials and methods

This was a validation study conducted at General Hospital Matale Sri Lanka. The study population was all consecutive patients who were admitted with suspected acute appendicitis to the surgical units of the General Hospital Matale Sri Lanka for appendicectomy. The study was carried out between the 1st of October 2016 to 31st of March 2017.

The target was 178 cases and controls [89 histologically confirmed cases of acute appendicitis and 89 histologically confirmed non-appendicitis controls] that had undergone appendicectomy to detect a 90% sensitivity and a specificity, assuming 50% confirmed cases among the suspected, at a power of 80% [15]. All consecutive patients, meeting inclusion and exclusion criteria. Exclusion criteria were patients presenting with predominant urological and gynaecological symptoms and right iliac fossa mass. Data were collected by an interviewer-administered questionnaire and a data sheet by medical officers of the surgical unit. Data on socio-demographics of the patient and symptoms, signs and investigations about eight factors of Alvarado score were recorded. Relevant investigation results and post-operative histological findings were obtained from the bed head tickets. Alvarado score was calculated for each patient. The final diagnosis of "appendicitis" was based on histology [gold standard] for this study. Data were entered into SPSS version 16 which was used to analyze data. Clinical features and demographics were compared between the cases and controls and Cronbach's alpha was calculated to assess the internal consistency of the tool. The sensitivity and specificity of the Alvarado score were calculated. ROC curves were used to assess criterion validity where the "cases/controls" variable was the state variable, and the Alvarado score was the test variable. Coordinate points of the ROC were generated together with the curve. Written informed consent was obtained from the individuals before recruitment after explaining the purpose and the procedures of the study. For patients between 13 to 16 years, proxy consent was obtained.

Ethical clearance for the study was obtained from the Ethical Clearance Committee of the Faculty of Medicine, Peradeniya, Sri Lanka, a body which is recognized by the Forum of Ethical Clearance Committees of Asia and the Pacific.

The Alvarado score did not influence the management of the patient. The diagnosis of acute appendicitis was made on the decision of the Consultant Surgeon for management purposes. Confidentiality of data was ensured, and no individually identifiable data was exposed to a third party.

Results

A total of 178 consecutive patients were recruited for the study. 6 were dropped due to incomplete data. Of the 172 participants with complete data who were included in the sensitivity and specificity analysis, 83 were histologically confirmed [cases] and 89 were negative for appendicitis [controls] [Table 2]. No statistically significant difference in the mean age or the sex composition between the cases and the controls were observed [Table 2]. A higher proportion of cases were found to be positive for all symptoms, signs, and laboratory investigations except fever. The Cronbach's alpha value was 0.63 and deleting items would not improve the value significantly [Table 5].

Sensitivity and specificity at a cut-off of 7: The cross-tabulation and the sensitivity and specificity calculation indicate that a cut-off of 7 provides a sensitivity of 62.5% and a specificity of 91% [Table 3]. Although the specificity is highly appropriate a sensitivity of 62.5% is not acceptable for a screening test. Apart from a low sensitivity the Negative Predictive Value [NPV] too was found to be low [72%].

Therefore, the sensitivity and the specificity of the test were calculated at different cutoff values of the Alvarado score [Table 4]. A cut off value of 4.5 provides a sensitivity of 89.2% and a specificity of 86.5%. This cutoff value increased the NPV to 89.5% [data are not shown] whereas the Positive Predictive Value was the same as for a cutoff of 7 which was an acceptable 86%. The ROC curve calculations indicated an area under the curve of 0.85 which was significant at the 95% confidence level [Figure 1].

Discussion

This study was conducted to evaluate the sensitivity and specificity of the Alvarado score in detecting acute appendicitis cases presenting to the surgical unit at a secondary care centre in central Sri Lanka. The tool returned a Cronbach's alpha value of 0.63 which is considered an acceptable level indicating the adequacy of internal consistency [16]. It was found that at a cut-off of 7 [9] as recommended by the developers of the tool, the sensitivity was unacceptably low at 62.7% but the specificity was high at
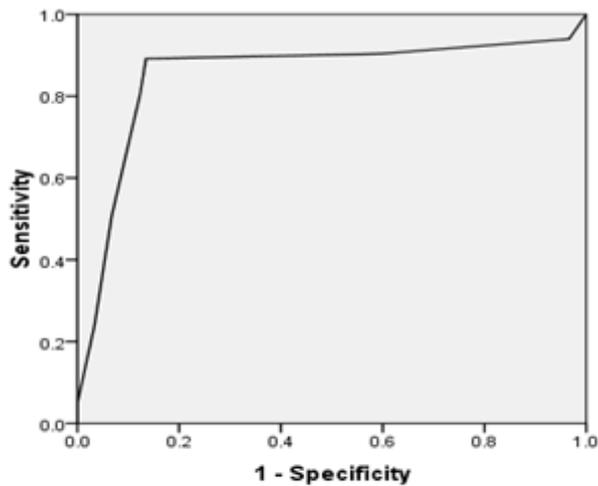
Diagonal segments are produced by ties.

Figure 1. ROC curve of Alvarado score
Area under the curve 0.85, P value <0.001

Table 1. Alvarado score calculation: symptoms, signs and laboratory investigations and the weights allocated to each if positive

Category	Symptom/sign/investigation	Score if positive
Symptom	Migrating pain	1
	Nausea/vomiting	1
	Anorexia	1
	Fever	1
Signs	RIF tenderness	2
	Rebound tenderness	1
Laboratory results	Leukocytosis	2
	Left shift	1
Total		10

*Alford Alvarado 1986 [9]

Table 2. . Age, sex, symptoms, signs and laboratory investigations comparison between cases and controls

		*Total N [%]	Cases N [%] *Mean [SD]	Controls N [%] *Mean [SD]	P value
Age		176 [100]	*21.1 [13.1]	*22.2[10.9]	**0.53
Sex	Male	79 [100.0]	51 [64.6]	28 [35.4]	#0.488
	Female	86 [100.0]	51 [59.3]	35 [40.7]	
Migrating pain	Yes	28 [100.0]	27 [96.4]	01 [3.6]	#<0.001
	No	148 [100.0]	78 [52.7]	70 [47.3]	
Vomiting/nausea	Yes	112 [100.0]	68 [60.7]	44 [39.3]	#0.706
	No	64 [100.0]	37 [57.8]	27 [42.2]	
Fever	Yes	100 [100.0]	56 [56.0]	44 [44.0]	#0.319
	No	74 [100.0]	47 [63.5]	27 [36.5]	
Loss of appetite	Yes	104 [100.0]	78 [75.0]	26 [25.0]	#<0.001
	No	72 [100.0]	27 [37.5]	45 [62.5]	
RIF tenderness	Yes	172 [100.0]	105 [61.0]	67 [39.0]	*0.014
	No	4 [100.0]	0 [0.0]	4 [100.0]	
Rebound tenderness	Yes	63 [100.0]	62 [98.4]	1 [1.6]	#<0.001
	No	109 [100.0]	39 [35.8]	70 [64.2]	
WBC>10000	Yes	74 [100.0]	74 [100.0]	0 [0.0]	#<0.001
	No	101 [100.0]	30 [29.7]	71 [70.3	
Neutrophilia	Yes	65 [100.0]	65 [100.0]	0 [0.0]	#<0.001
	No	109 [100.0]	38 [34.9]	71 [65.1]	
UFR	Yes	8 [100.0]	7 [87.5]	1 [12.5]	#$ 0.001
	No	91 [100.0]	91 [100.0]	0 [0.0]	
CRP	Yes	47 [100.0]	46 [97.9]	1 [2.1]	#$ 0.414
	No	31 [100.0]	31 [100.0]	0 [0.0]	

** students' t test   # chi-square   WBC- white blood cell count   UFR- urine full report
CRP- c-reactive protein $ invalid due to more than 25% cells with expected count less than 5

Table 3. Appendicitis diagnosis based on the recommended cutoff value of Alvarado Score of 7 against the gold standard [Histological diagnosis]

		Histological diagnosis of Appendicitis		Total	Predictive values
		Yes	No		
Appendicitis Diagnosed based on Alvarado score > 7	Yes	52 [62.7%] *	8 [9%]	60 [100%]	ᵃPPV = 86%
	No	31 [37.3%]	81 [91.0%] **	112 [100%]	ᵇNPV= 72%
Total		83 [100%]	89 [100%]	172	

A cutoff of 7 provides a *Sensitivity 62.7%, **specificity 91.0%, ᵃPositive Predictive value 86% and ᵇNegative Predictive Value 72%, for diagnosis of Appendicitis

Table 4. Sensitivity and 1-specificity of the Alvarado score at different Cut off values for screening of acute appendicitis

Cut off value	Sensitivity	1 - Specificity
1.0	100.0	100.0
2.5	94.0	96.6
3.5	90.4	59.6
4.5	*89.2*	13.5
5.5	80.7	12.4
6.5	62.7	09.0
7.5	50.6	06.7
8.5	24.1	03.4
9.5	04.8	00.0

A cutoff of 4.5 provides a Sensitivity 89.2%, specificity 86.5%, aPositive Predictive value 86% and bNegative Preditive Value 89.5 for diagnosis of Appendicitis

Table 5. Cronbach's alpha value of the Alvarado score and the item wise analysis of the value if item deleted

Total	value
Cronbach's alpha	0.64
Item	Cronbach's Alpha if Item Deleted
Migrating pain	.62
Vomiting/Nausea	.66
Fever	.69
Loss of appetite	.59
RIF tenderness	.66
Rebound tenderness	.56
WBC>10000	.46
Neutrophilia	.49

91.0%, for the patients evaluated. The PPV too was acceptable at 86.0%. In contrast, for Iraqi patients in Bagdad, the cutoff value of 7 provided a sensitivity of 89.6% and 92.3% with a positive predictive value was 98.7% and a negative predictive value of 57.4% in both males and females respectively [17]. One other study from the Asian region too reports high sensitivity and positive predictive values but low specificity at a cutoff of 7 [18]. Khan and Rehman have reported a Positive Predictive Value of 84% at a cutoff of 7 [19].

Although surgeons have found that this score is a sensitive screening tool for acute appendicitis [17–20] researchers have reported that the Alvarado score has poor accuracy [11–13,21]. The score was found to be well-calibrated in men but tended to be over predictive in females [13]. Some studies have shown that a cutoff of 7 does not suit all demographics and specific cutoff points may be required for males and females, adults and children, as well as for different ethnic groups [7,13,20]. Some studies have indicated that a cutoff of 6 to be appropriate for all patients and both girls and boys under 16 years as well [20,22]. On the other hand, this finding reinforces the fact that the place of Alvarado score in the clinical management of acute appendicitis cases may not be clear [11]. The unsuitability of the Alvarado score for Bangladeshis has been demonstrated as well [23]. In the current study, a cutoff of 4.5 returned the best sensitivity and specificity [89.2 and 86.5 respectively]. This finding is closer to values that were mentioned in the systematic review by Ohle and others where cutoff values of 5 and 7 were evaluated and 5 was reported as acceptable [11]. An area under the curve of 0.85 of the ROC indicates a test that is acceptable as values above 0.7 are considered appropriate [17].

Conclusions

The Alvarado score is a reliable and valid CPR. A cutoff score of 4.5 is suggested as the best for the participants of this study. Since 4.5 is not a practically possible score due to the nature of it we suggest 5 as the cutoff for Sri Lankan patients. Multicenter studies would identify if the score can be generalized to Sri Lankans.

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