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

Abeysinghe G.B1, Tennakoon S. U. B1,2, Fahim H.M1, Bandara R.M.S.N1, Dassanayake G.K1, Dissanayake D.M.A.H1

1District General Hospital, Matale, Sri Lanka
2Department of community medicine, Faculty of Medicine, Peradeniya, Sri Lanka

Keywords: Alvarado score; appendicitis; cutoff; sensitivity; specificity

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

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
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
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 1985 [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**             |              |                        |                          |         |
| Male                | 176 [100]    | *21.1 [13.1]           | *22.2 [10.9]             | **0.53  |
| Female              | 56 [100.0]   | 37 [57.8]              | 27 [42.2]                |         |
| **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                  | 54 [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 [35.0]                | 0.014   |
| No                  | 4 [100.0]    | 0 [0.0]                | 4 [100.0]                |         |
| **Rebound tenderness**|         |                        |                          |         |
| Yes                 | 53 [100.0]   | 62 [58.4]              | 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                 | 55 [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]                 | <5 0.001|
| No                  | 91 [100.0]   | 91 [100.0]             | 0 [0.0]                  |         |
| **CRP**             |              |                        |                          |         |
| Yes                 | 47 [100.0]   | 46 [57.9]              | 1 [2.1]                  | <5 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]

| Appendicitis Diagnosed based on Alvarado score > 7 | Histological diagnosis of Appendicitis | Predictive values |
|---------------------------------------------------|---------------------------------------|-------------------|
| Yes                                               | 52 [62.7%] *                         | 60 [100%] *PPV = 85% |
| No                                                | 31 [37.3%] **                        | 81 [91.0%] *NPV = 72% |
| Total                                             | 83 [100%]                             | 172               |

* A cutoff of 7 provides a **Sensitivity 62.7%, Positive Predictive value 85% and Negative 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        | 93.6            |
| 4.5           | **89.2**    | 12.4            |
| 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%, Positive Predictive value 86% and Negative Predictive 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 | Item                  | Cronbach's Alpha if Item Deleted |
|-------------|-----------------------|----------------------------------|
| 0.64        | Migrating pain        | 0.62                             |
|             | Vomiting/Nausea       | 0.66                             |
|             | Fever                 | 0.69                             |
|             | Loss of appetite      | 0.59                             |
|             | RIF tenderness        | 0.65                             |
|             | Rebound tenderness    | 0.56                             |
|             | WBC>10000             | 0.46                             |
|             | Neutrophilia          | 0.49                             |

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.
All authors disclose no conflict of interest. The study was conducted in accordance with the ethical standards of the relevant institutional or national ethics committee and the Helsinki Declaration of 1975, as revised in 2000.

References

1. Okobia MN, Osime U, Aligbe JU. Acute appendicitis: review of the rate of negative appendectomy in Benin city. Nig J Surg.1999;6:1–5.
2. Ergul E. Importance of family history and genetics for the prediction of acute appendicitis. Internet J Surg.2007;10:2.
3. Hoffmann J, Rasmussen, OO. Aids in the diagnosis of acute appendicitis. Br J Surg.1989;76[8]:774-79.
   Doi:10.1002/bjs.1800760803
4. Field S, Morrison I. The Acute Abdomen. In: Sutton D [eds]: Textbook of Radiology and Imaging.7th edition. Churchill Livingstone,2003:685.
5. Jahn H, Mathiesen FK, Neckelmann K, Hovendal CP, Bellstrom T, Gottrup F. Comparison of Clinical Judgment and Diagnostic Ultrasonography in the Diagnosis of Acute Appendicitis: experience with a score-aids diagnosis. Eur J Surg.1997;163[6]:433-443. https://doi.org/10.1186/isrctn56471730
6. Kulik DM, Uleryk EM, Maguire JL. Does this child have appendicitis? A systematic review of clinical prediction rules for children with acute abdominal pain. J Clin Epidermiol. 2013;66[1]:95-104. DOI:10.1016/j.jclinepi.2012.09.004
7. Andersson RE. Meta-analysis of the clinical and laboratory diagnosis of appendicitis. Br J Surg.2004;91[1]:28-37. Doi:10.1002/bjs.4464
8. Reilly BM, Evans AT. Translating clinical research into clinical practice: impact of using prediction rules to make decisions. Ann Intern Med.2006; 144[3], 201-209. Doi: 10.7326/0003-4819-144-3-200602070-00009
9. Alvarado AMD. A practical score for the early diagnosis of acute appendicitis. Ann Emerg Med.1986;15 [5]:557-564. Doi:10.1016/S0196-0644(86)80993-3
10. Spiegel DA, Gosselin RA. Surgical services in low-income and middle-income countries. Lancet.2007;370:1013–1015. Doi:10.1016/s0140-6736(07)61457-3
11. Alvarado A. A practical score for the early diagnosis of acute appendicitis. Ann Emerg Med.1986;15[5]:557–564.
   Doi:10.1016/s0196-0644(86)80993-3
12. Ohle R, O'Reilly F, O'Brien KK, Fahey T, Dimitrov BD. The Alvarado score for predicting acute appendicitis: a systematic review. BMC Medicine.2011;9[1];139-146 doi:10.1186/1741-7015-9-139
13. Chong CF, Thein A, Ahamed MAJ, Tin A, Tripathi S, Ahmad MA. Evaluation of the RIPASA score: a new scoring system for the diagnosis of acute appendicitis. Brunei. Int Med J.2010;6[1]:17-26.
14. Kalan M, Talbot D, Culniffe WJ, Rich AJ. Evaluation of the modified Alvarado score in the diagnosis of acute appendicitis: a prospective study. Ann R Coll Surg. 1994;76[6]:418–419.
15. Bujang, M. A., Adnan, T. H., Requirements for Minimum Sample Size for Sensitivity and Specificity Analysis, Journal of Clinical and Diagnostic Research. 2016 Oct, Vol-10[10]: YE01-YE06, DOI: 10.7860/JCDR/2016/18129.8744
16. Cortina, J. M. [1993]. What is coefficient alpha? An examination of theory and applications. Journal of applied psychology, 78[1], 98
17. Thomas GT. Interpreting diagnostic test [Internet]. [University of Nebraska Medical Center]: Available from: http://gim.unmc.edu/dxtests/Default.htm.
18. Mallick KK, Yin EYN. Alvarado score in Diagnosing Acute Appendicitis. IOSR-JDMS.2014 Jan;13[1]:71-74
19. Kong V, Van Der Linde S, Aldous C, Handley J, Clarke, D. The accuracy of the Alvarado score in predicting acute appendicitis in the black South African population needs to be validated. Can J Surg.2014; 57[4]:121-125. Doi: 10.1503/cjs.023013
20. Khan I, ur Rehman A. Application of Alvarado scoring system in diagnosis of acute appendicitis. J Ayub Med CollAbbottabad 2005;17[3:41-44.
21. Ohmann C, Yang Q, Franke C. Diagnostic scores for acute appendicitis. Abdominal Pain Study Group. Eur J Surg.1995;161[4]:273-281.
22. Gilmore OJA, Jones D, Yang Q. Appendicitis and mimicking conditions. Lancet.1975;11:421–424. DOI: 10.1016/S0140-6736[75]90841-7.
23. Thabit MF, Al An sari HM, Kamoona BR. Evaluation of modified Alvarado score in the diagnosis of acute appendicitis at Baghdad teaching hospital. The IPM Jur.2012;11:675-683.