Research article

Comparison between the specificity and sensitivity of the RIPASA and Alvarado Scoring systems in the diagnosis of acute appendicitis among patients with complaints of right iliac fossa

Seyed Ashkan Tabibzadeh Dezfuli¹, Reza Yazdani¹*, Mohammadjavad Khorasani² and Seyed Alireza Hosseinikhah³

¹ Assistant Professor, Trauma and Emergency Medicine Research Center, Hormozgan University of Medical Sciences, Bandar Abbas, Iran
² Head of Department of Emergency Medicine, Hormozgan University of Medical Sciences, Bandar Abbas, Iran
³ Emergency Medicine Specialist, Hormozgan University of Medical Sciences, Bandar Abbas, Iran

* Correspondence: Email: ryazdani@hums.ac.ir; Tel: +989123390064.

Abstract: Introduction: Acute appendicitis is one of the common prevalent surgical emergencies. Various techniques, such as Alvarado Score are used for diagnosis it. This study was conducted to compare the Alvarado and RIPASA scoring systems in patients referred to Hospital with complaints of right iliac fossa pain. Methodology: This descriptive-analytic cross-sectional study was conducted in patients over 15 years with abdominal pain referred to emergency room of the Hospital. The data collection form was completed for each patient based on history and examinations and then examined by a surgeon. The pathological specimens were examined and the pathological outcomes of each patient were recorded in the relevant information collection form and finally analyzed. Results: The results for the Alvarado system showed that 42.1%, 29.2% and 28.80% of the patients had a low probability, moderate probability and high probability of appendicitis, respectively. The findings for RIPASA system showed that 19.3% of patients definitely had appendicitis. The sensitivity, specificity, and positive and negative predictive values of Alvarado were 70.18%, 53.95%, 53.33%, and 69.61%, respectively. In contrast, the sensitivity, specificity, and positive and negative predictive values of the RIPASA scoring system were 93.42%, 45.61%, 69.61%, and 83.87%, respectively. Conclusion: On the basis
of the results, the RIPASA scoring system is a better system. Since the best cut-off point is 6 for Alvarado and 7.75 for RIPASA, it is better to use the values as a benchmark for the systems.

**Keywords:** appendicitis; RIPASA; Alvarado

1. **Introduction**

Acute appendicitis is one of the most common surgical emergencies. It has been reported that incidence of appendicitis over a lifetime to be one in seven in the most people [1]. Delayed appendectomy action due to diagnostic accuracy is due to the risk of a perforated inflamed appendix and abdominal cavity infection that in turn increases the death rate [2]. Also for the definitive diagnosis of appendicitis, a pathological examination should be performed [3].

Diagnostic accuracy can be increased by using costly techniques such as ultrasound or tomography. However, these techniques may not be readily available when these are needed [4,5]. So various techniques are used for identifying vague cases and decreasing the negative appendectomy rate, such as some scoring systems [6,7]. The most common scoring system used in Europe and the United States of America is Alvarado Scoring system. This system is commonly used in Western countries. Very low sensitivity and specificity of the scoring system was reported in a population with a completely different ethnic origin and diet [8].

A new scoring system, so called RIPASA, is used for the population of South East Asian [9–11]. This system needs more parameters compared to the Alvarado system that may increase the sensitivity and specificity of the scoring system that ultimately accelerate the diagnosis of appendicitis and prevent negative appendectomy and complications of delayed appendectomy [6]. Symptoms in patients with appendicitis are similar to patients with abdominal pain especially in the early stages that make its diagnosis difficult [12]. Delayed for appendectomy due to performing accuracy experiments is associated to the risk of a perforated inflamed appendix and abdominal cavity and peritonitis infection that may ultimately cause to patient death [2]. For the definitive diagnosis of appendicitis, a pathological examination should be performed [13]. Negative appendectomy is a symptom-based surgery. Diagnostic accuracy can be improved by using techniques such as ultrasound or tomography up to about 20–40% [14–17], but these may not be available when these are needed [4,5]. The different techniques are developed to identify vague cases for reducing the negative appendectomy rate [18], such as number of scoring systems designed to help early diagnosis of acute appendicitis and rapidly managing it [6,9,19,20]. The most common scoring systems used in Europe and the United States of America are Alvarado Score and modified Alvarado Score [7,20]. Scoring in these systems is performed using clinical history, physical examination, and patient tests [21]. The sensitivity and specificity of the Alvarado Score and the modified Alvarado Score have been reported to be 53–88% and 75–80% respectively [7]. However, these systems have a very low sensitivity and specificity in a population with different ethnic origin and diet [8]. Other system is RIPASA that uses more parameters such as age, gender, and duration of symptoms before referral [10].

These parameters affect the sensitivity and specificity of the Alvarado system for the diagnosis of acute appendicitis [6]. Therefore, these parameters in patients suspected of appendicitis and their
effect on diagnostic accuracy has been studied in several studies [23–26]. This study was for first
time was conducted in Iran as an Asian country and the data can be used for Iran and it’s beside
countries. This study was conducted aimed at comparing the Alvarado and RIPASA scoring systems
in patients referred to hospital in Bandar Abbas with complaints of right iliac fossa pain.

2. Methodology

This prospective study was lasted for 6 months and compared the Alvarado and RIPASA
scoring systems in patients referred to hospital in Bandar Abbas with complaints of right iliac fossa
pain during the second half of 2017. Ethical approval for conducting the study was granted by the
Hormozgan University of Medical Sciences Review Ethics Committee at Bandar Abbas, Iran (Ethics
code: HUMS.REC.1396.150).

The statistical population of this descriptive-analytic cross-sectional study consisted of patients
with complaints of right iliac fossa pain. Out of this population, all patients over 15 years with
abdominal pain who were hospitalized in emergency room of hospital in Bandar Abbas and were
willing to participate in the study were included. The data collection form was completed for each
patient, based on history and examinations. Then each patient was examined by a surgeon. The
appendectomy was performed on the basis of the clinical opinion of the surgeon. The pathological
specimens were examined in the laboratory of hospital in Bandar Abbas. Then, the pathological
outcomes per patient were recorded in the relevant information collection form.

Inclusion criteria included informed consent of the patient for participating in the study. Patients
who did not want to participate in the study and did not complete the written consent were excluded.
Other exclusion criteria were skin pigmentation, nail polish, venous pulse, severe anemia (hb < 5),
vascular dislocation, low blood pressure, and fever that disrupt the pulse oximetry. The laparoscopic
was conducted.

We analyzed the data by the Statistical Package for Social Sciences 23.0 for Windows (SPSS
Inc., Chicago, IL, United States). Our findings were reported as mean and investigated within a 95%
reliance and at a level of P < 0.05 significance. The Kolmogorov-Smirnov test was used for
investigation of normal distribution of the quantitative data. Predicted negative appendicectomy rates
for both scores were calculated and compared using Chi-square test for statistical analysis and all the
variables were analyzed by unpaired student’s t-test. In addition, receiver operating curve (ROC) at
the optimal cut-off threshold scores for the RIPASA score was achieved by Stats Direct statistical
software version 2.7.2 (Stats Direct Ltd, Cheshire, UK 2008).

3. Results

In the current study, 212 patients with complaints of abdominal pain in the right iliac fossa were
examined that 133 patients (62.7%) underwent appendectomy.

The mean age was 28.3 ± 4.8 years. Of these, 56% were male. Alvarado score was calculated
for each patient. Scores less than 5, between 5 and 7 and higher 8 were considered as low probability,
moderate probability and high probabilities of appendicitis, respectively. Accordingly, 42.1% of the
patients had a low probability, 29.2% had a moderate probability and 28.8% had a high probability
of appendicitis.
Also, RIPASA score was calculated for each patient. Scores less than 5, between 5 and 7, 7.5 and 11.5 and more than 11.5 were considered as very low, low probability, high probability and definitive probabilities, respectively. Accordingly, 12.3% of patients definitely had appendicitis.

Table 1. Alvarado score.

| Alvarado                | Frequency | Percent (%) |
|-------------------------|-----------|-------------|
| Low probability         | 89        | 42.1%       |
| Moderate probability    | 62        | 29.2%       |
| Highly probability      | 61        | 28.8%       |
| Total                   | 212       | 100.0%      |

Table 2. RIPASA score.

| RIPASA                  | Frequency | Percent (%) |
|-------------------------|-----------|-------------|
| Unlikely                | 41        | 19.3%       |
| Low possibility         | 63        | 29.7%       |
| High possibility        | 82        | 38.7%       |
| Definitive              | 26        | 12.3%       |
| Total                   | 212       | 100.0%      |

The results showed that 62.7% of patients underwent appendectomy. Accordingly, 37.3% of the patients did not undergo histologic and pathological examination for diagnosis of appendicitis. Of the patients who underwent appendectomy, 76 patients (57.1%) had positive and 42.8% had negative pathology responses.

Table 3. Histological results.

| Histology   | Frequency | Percent (%) |
|-------------|-----------|-------------|
| Not done    | 79        | 37.3%       |
| Positive    | 76        | 35.8%       |
| Negative    | 57        | 26.9%       |
| Total       | 212       | 100.0%      |

Accordingly, the results of two scoring systems were compared in terms of definitive results from the pathological examination.

Accordingly, the sensitivity, specificity, and positive and negative predictive values were calculated for the two scoring systems.

The sensitivity of the Alvarado scoring system was 53.95% and its specificity was 70.18%. Positive and negative predictive values of Alvarado were 70.69% and 53.33%, respectively. In contrast, the sensitivity, specificity, and positive and negative predictive values of the RIPASA scoring system were 93.42%, 45.61%, 69.61%, and 83.87%, respectively.
Table 4. Comparison of PIPASA and Alvarado scores by pathology results.

| Histology          | Positive | negative |
|--------------------|----------|----------|
|                    | Count    | Row (N%) | Count    | Row (N%)|
| **Alverado**       |          |          |          |          |
| Low probability    | 5        | 23.8%    | 16       | 76.2%    |
| Moderately probable| 30       | 55.6%    | 24       | 44.4%    |
| High probability   | 41       | 70.7%    | 17       | 29.3%    |
| **Ripasa**         |          |          |          |          |
| Unlikely           | 1        | 100.0%   | 0        | 0.0%     |
| Low possibility    | 4        | 13.3%    | 26       | 86.7%    |
| High possibility   | 48       | 62.3%    | 29       | 37.7%    |
| Definitive         | 23       | 92.0%    | 2        | 8.0%     |

Table 5. Sensitivity, specificity, and positive and negative predictive values of RIPASA and RIPASA scoring systems.

| Histology          | Alvarado (P/N) | RIPASA (P/N) |
|--------------------|----------------|--------------|
|                    | Positive  | Negative | Positive | Negative |
| **Histology**      | Frequency | Percent (%) | Frequency | Percent (%)|
| Positive           | 41       | 70.7%     | 71       | 69.6% |
| Negative           | 35       | 46.7%     | 17       | 29.3% |
| **Sensitivity (CI 95 %)** | 53.95% | (42.13–65.45) | 93.42% | (85.31–97.83) |
| **Specificity (CI 95 %)** | 70.18% | (56.60–81.57) | 45.61% | (32.36–59.34) |
| **Positive predictive Value (PPV) (CI 95 %)** | 70.69% | (57.27–81.91) | 69.61% | (59.71–78.33) |
| **Negative predictive Value (NPV)** | 53.33% | (41.45–64.95) | 83.87% | (66.27–94.55) |

The ROC curve was plotted for these two scoring systems.

![Figure 1. ROC curve for Alvarado and RIPASA scoring systems.](image-url)
Subsequently, the area under the curve of these two scoring systems was calculated and the results were compared with each other.

The area under the curve for the Alvarado scoring system was 0.662 and it was 0.739 for the RIPASA scoring system. Given the principle that the closer number is to one, more reliable is the scoring system, the RIPASA scoring system with a significant P-value of less than 0.001 is considered to be a better technique. Also, the best cut-off point is 6 for Alvarado and 7.75 for RIPASA. The results also indicate that if the number 7.75 is considered as an interpretation benchmark for RIPASA scoring system, its sensitivity is 81.58% and the specificity is 54.39%.

These results were compared by drawing the ROC curve indicating that RIPASA with a P-value of less than 0.001 is a better technique.

4. Discussion

Acute appendicitis is known as one of the most usual surgical emergencies that junior doctors are encountered it. It is difficult to make a rapid and precise diagnosis for acute appendicitis. Some radiological tests such as computed tomography are broadly used and have high sensitivity (94%) and specificity (95%) for diagnosing acute appendicitis [27]. However, using a rapid and accurate diagnosis for acute appendicitis is difficult. Some practices, such as computed tomography are not economic and increase patients cost. Computed tomography not only increases costs, but may also delay emergency appendicectomy [9]. Some scoring systems such as Alvarado and the Modified Alvarado scoring are used to help a precise diagnosis of acute appendicitis in the fastest and cheapest status [20]. The systems help junior doctors for selecting emergency appendicectomy and/or conservative management [20]. The RIPASA is other scoring system that is known as a beneficial, rapid diagnostic system for acute appendicitis that only needs the patient’s demographics such as age, gender and nationality, and/or a clinical history (such as anorexia, nausea and vomiting and clinical examination [9]. Scoring systems do not increase costs for patients, because the systems need only patient’s demographics. The systems will not additional costs for clinical trials and these are thus economic methods for detecting appendicitis. In addition, the systems do not use apparatus with side effects; these can be accepted as safe systems.

The results of this study showed that the RIPASA scoring system is preferred. The sensitivities for RIPASA and Alvarado were 93.42% and 53.95%, respectively. The results show that RIPASA has more sensitivity. In contrast to our findings, previous studies have reported 83.01% and 81.00% for sensitivity of RIPASA and Alvarado, respectively [28]. The sensitivity for Alvarado scoring had significant difference with our findings (81% vs. 53.95%). The differences were due to studied populations. Previous studies have shown that although Alvarado scoring has good sensitivity and specificity in western population, but it has low sensitivity (50% to 59%) and specificity (23% to 94%) in Asian or oriental populations [29–31]. In the current study, we investigated Asian populations and our findings are in agreement with previous studies [29–31]. Parallel to our findings, Chong et al. [9] reported sensitivity of 97.50% for RIPASA scoring system that is closed to our findingd (93.42% vs. 97.50%). Higher sensitivity in RIPASA compared to Alvarado could be also due to more parameters in this method, because the RIPASA score uses more parameters that are not present in the Alvarado scoring, including age, gender and the duration of symptoms prior to presentation [32,33]. The results showed that specificities of RIPASA and Alvarado systems were 70.18% and 45.61%, respectively. The results showed that if the patient is not suffering from appendicitis, Alvarado will be negative in a
larger number of patients. The specificities of RIPASA in studied by Dr. Chong, Dr. Nanjundia, Dr. Karan, Dr. Boot, and Dr. Malik were 85.3\%, 90.5\%, 77\%, 93\% and 69.86\% respectively, which were far higher than the calculated value in this study [23–26]. Sensitivity and specificity values should be higher than 80\% [34,35]. The results showed that sensitivity and specificity in Alvarado scoring was lower than 80\% and it thus has not enough sensitivity and specificity. The low sensitivity of the Alvarado technique and its high level in the RIPASA technique in this study suggests that in the case of appendicitis, RIPASA is better scoring compared to Alvarado for diagnosis of acute appendicitis. This issue was significantly different in the present study than Ardam’s study [28].

The results also showed that if the number 7.75 is considered as an interpretation benchmark for RIPASA scoring system, its sensitivity is 81.58\% and the specificity is 54.39\%. The positive predictive values of RIPASA and Alvarado systems were calculated to be 69.61\% and 70.69\%, respectively. These two values were very close for the two techniques. It means that if two techniques suggest the possibility of appendicitis, the final result will be positive with a relatively same probability. In contrast to our findings, the positive predictive values of RIPASA were reported to be 97.4\%, 98.89\%, and 94.8\%, respectively in previous studies [23]. The negative predictive values for RIPASA and Alvarado systems were 83.87\% and 53.33\%, respectively. The results are consistent with the results of previous studies that reported the negative predictive values of RIPASA to be 95.57\% and 91.8\%, respectively [23,36]. Dr Chong and their colleague [22] performed a prospective study and showed that optimal cut-off threshold score of 7.5 derived from the ROC, the sensitivity, specificity, PPV, NPV and diagnostic accuracy of the RIPASA score were 98.0\%, 81.3\%, 85.3\%, 97.4\% and 91.8\%, respectively. They also showed that at the cut-off threshold score of 7.0 for the Alvarado score, the sensitivity, specificity, PPV, NPV and diagnostic accuracy were 68.3\%, 87.9\%, 86.3\%, 71.4\% and 86.5\%, respectively. However, in the current study, cut-off of 6 was optimum. The differences for cut-off could be attributed to sample size. It was reported that with a sample size of > 300 patients as reported in our development phase of the RIPASA score, a predicted negative appendicectomy rate of 6.9\%, a significant reduction of 9.3\% was obtained [29]. A higher value in the RIPASA scoring system suggests that if the probability of appendicitis is low for the patient according to the scoring system, the patient will be less likely to have appendicitis.

5. Conclusion

In sum, the RIPASA scoring is commonly a much better diagnostic scoring system for acute appendicitis versus Alvarado scoring, with higher sensitivity in the Iranian population. The parameters in this scoring system can be simply obtained by completing history, and conducting a clinical examination and two simple investigations. With regards to economic dimension, the use of RIPASA scoring can decrease unnecessary inpatient admissions and expensive radiological investigations.

Acknowledgment

The study is funded by Hormozgan University of Medical Sciences, Bandar Abbas, Iran. All authors contributed toward data analysis, drafting and revising the paper and agreed to be responsible for all the aspects of this work.
Conflict of interest

The authors declared no conflict of interest.

References

1. Ohle R, O’Reilly F, O’Brien K, et al. (2011) The Alvarado score for predicting acute appendicitis. *BMC Med* 9: 139.
2. Omundsen M, Dennett E (2006) Delay to appendicectomy and associated morbidity: a retrospective review. *ANZ J Surg* 76: 153–155.
3. Malik MU, Connelly TM, Awan F, et al. (2017) The RIPASA score is sensitive and specific for the diagnosis of acute appendicitis in a western population. *Int J Colorectal Dis* 32: 491–497.
4. Doria AS, Moineddin R, Kellenberger CJ, et al. (2006) US or CT for diagnosis of appendicitis in children and adults? A meta-analysis. *Radiol* 241: 83–94.
5. Pham VA, Pham HN, Ho TH (2009) Laparoscopic appendectomy: an efficacious alternative for complicated appendicitis in children. *Eur J Pediatr Surg* 19: 157–159.
6. Nanjundaiah N, Ashfaqe M, Venkatesh SH, et al. (2014) A comparative study of RIPASA score and Alvarado score in the diagnosis of acute appendicitis. *J Clin Diagn Res* 8: 3–5.
7. Baidya N, Rodrigues G, Rao A, et al. (2007) Evaluation of Alvarado score in acute appendicitis: a prospective study. *Int J Surg*. Available from: http://www.ispub.com/journal/the-internetjournal-of-surgery/volume-9-number-1/evaluation-of-alvaradoscore-in-acute-appendicitis-a-prospective study.html#sthash.0YNMiNlc.dpbs.
8. Kalan M, Talbot D, Cunliffe WJ, et al. (1994) Evaluation of the modified Alvarado score in the diagnosis of acute appendicitis: a prospective study. *Ann R Coll Surg Engl* 76: 418–419.
9. Gilmore OJ, Browett JP, Griffin PH, et al. (1975) Appendicitis and mimicking conditions. A prospective study. *Lancet* 2: 421–424.
10. Aydin S, Fatihoglu E, Ramadan H, et al. (2017) Alvarado Score, Ultrasound, and CRP: How to Combine Them for the Most Accurate Acute Appendicitis Diagnosis. *Iran J Radiol* 14: 56255.
11. Ebell MH (2008) Diagnosis of appendicitis: part II. Laboratory and imaging tests. *Am Fam Physician* 77: 1153–1155.
12. Yu J, Fulcher AS, Turner MA, et al. (2005) Helical CT evaluation of acute right lower quadrant pain: part I, common mimics of appendicitis. *Am J Roentgenol* 184: 1136–1142.
13. van Breda Vriesman AC, Puylaert JBCM (2006) Mimics of appendicitis: alternative nonsurgical diagnoses with sonography and CT. *Am J Roentgenol* 186: 1103–1112.
18. Reilly BM, Evans AT (2006) Translating clinical research into clinical practice: impact of using prediction rules to make decisions. *Ann Intern Med* 144: 201–209.

19. Ohmann C, Yang Q, Franke C (1995) Diagnostic scores for acute appendicitis. Abdominal Pain Study Group. *Eur J Surg* 161: 273–281.

20. Alvarado A (1986) A practical score for the early diagnosis of acute appendicitis. *Ann Emerg Med* 15: 557–564.

21. Eskelinen M, Ikonen J, Lipponen P (1994) Contributions of history-taking, physical examination, and computer assistance to diagnosis of acute small-bowel obstruction. A prospective study of 1333 patients with acute abdominal pain. *Scand J Gastroenterol* 29: 715–721.

22. Chong CF, Thien A, Mackie AJ, et al. (2011) Comparison of RIPASA and Alvarado scores for the diagnosis of acute appendicitis. *Singapore Med J* 52: 340–345.

23. Karan M, Kumar Mukesh M, Atul K, et al. (2015) Significance of ripasa scoring system in diagnosis of acute appendicitis. *Int J Healthcare Sci* 3: 4–10.

24. Walczak D, Pawiłczak D, Zółtaszek A, et al. (2015) The value of scoring systems for the diagnosis of acute appendicitis. *Pol J Surg* 87: 65–70.

25. Butt M, Chatha S, Ghumman A, et al. (2014) RIPASA Score: A New Diagnostic Score for Diagnosis of Acute Appendicitis. *J Coll Physicians Surg Pak* 24: 894–897.

26. Liu W, Qiang J, Xun SR (2015) Comparison of multislice computed tomography and clinical scores for diagnosing acute appendicitis. *J Int Med Res* 43: 341–349.

27. Terasawa T, Blackmore CC, Bent S, et al. (2004) Systematic review: computed tomography and ultrasonography to detect acute appendicitis in adults and adolescents. *Ann Int Med* 141: 537–546.

28. D’Souza N, Nugent K (2016) Appendicitis. *Am Fam Physician* 93: 142–143.

29. Al-Hashemy AM, Seleem MI (2004) Appraisal of the modified Alvarado Score for acute appendicitis in adults. *Saudi Med J* 25: 1229–1231.

30. Khan I, ur Rehman A (2005) Application of alvarado scoring system in diagnosis of acute appendicitis. *J Ayub Med Coll Abbottabad* 17: 41–44.

31. Jang SO, Kim BS, Moon DJ (2008) Application of alvarado score in patients with suspected appendicitis. *Korean J Gastroenterol* 52: 27–31.

32. Abdeldaim Y, Mahmood S, Mc Avinghey D (2007) The Alvarado score as a tool for diagnosis of acute appendicitis. *Ir Med J* 100: 342–342.

33. Saidi HS, Chavda SK (2003) Use of a modified Alvorado score in the diagnosis of acute appendicitis. *East Afr Med J* 80: 411–414.

34. Kurklu C, Karabulut K, Aygen E, et al. (2013) Appendicitis scores may be useful in reducing the costs of treatment for right lower quadrant pain. *Ulus Travma Acil Cerrahi Derg* 19: 13–19.

35. Konan A, Hayran M, Kılıç YA, et al. (2011) Scoring systems in the diagnosis of acute appendicitis in the elderly. *Ulus Travma Acil Cerrahi Derg* 17: 396–400.

36. Singla A, Singla S, Singh M, et al. (2016) A comparison between modified Alvarado score and RIPASA score in the diagnosis of acute appendicitis. *Updates Surg* 68: 351–355.

© 2020 the Author(s), licensee AIMS Press. This is an open access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0)