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Original Research Article

Evaluation of RIPASA versus modified ALVARADO score in the diagnosis of acute appendicitis

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ABSTRACT

Background: The diagnosis of Acute Appendicitis is mostly clinical through different scores; comparative assessment of Raja Isteri Pengiran Anak Saleha Appendicitis (RIPASA) score against modified ALVARADO score for the diagnosis of Acute Appendicitis would reveal the better score for clinical use.
Aims and Objective: Evaluation of RIPASA score against modified ALVARADO score as a diagnostic score for Acute Appendicitis.
Materials and Methods: A prospective study was conducted on all cases of suspected Appendicitis at a tertiary center from January 2021 to June 2022. Each patient was scored by both RIPASA and modified ALVARADO scores and Histopathological report for Appendicitis was taken as the gold standard. Both the scores were evaluated for their diagnostic ability.
Results: 80 patients with suspected Acute Appendicitis with a mean age of 21.36years and with female predominance were scored by both RIPASA and modified ALVARADO scores. Sensitivity, specificity, Positive and Negative predictive values, Positive and Negative likelihood ratio, and area under ROC curve for RIPASA score (at 7.5 cutoff) were 94.74, 82.61, 93.10, 86.36, 5.45, 0.06 and 0.93; corresponding values for modified ALVARADO score (at 7.0 cutoff) were 59.65, 82.61, 89.47, 45.24, 3.43, 0.49 and 0.89 respectively. Both the scores had positive correlation when diagnosing an Acute appendicitis patient.
Conclusion: RIPASA Score (at 7.5 cut-off) is a better diagnostic tool than modified ALVARADO Score (at 7 cut-off) due to better sensitivity, Positive and Negative predictive values, and higher area under the fitted ROC curve.

1. Introduction

Despite its high prevalence, diagnosing acute appendicitis is a challenge because it is mainly based on presenting symptoms, physical examination findings and basic laboratory investigations all of which raise a high index of suspicion but often are not diagnostic individually.[1] Chronic medication use in the elderly and changes in pain tolerance with age may lead to differences in physical examination findings and blood parameters between age groups, and the differences in diagnostic parameters, making the diagnosis of acute appendicitis more difficult.[2] It has been estimated that the diagnosis of Acute Appendicitis is missed at a rate of 3.8-15% for children and 5.9-23.5% for adults during management in Emergency Department.[3] Although medical diagnostic tools and imaging technology has developed tremendously, yet the diagnosis of Acute Appendicitis is

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often missed. So, the clinical examination results in a suspicious patient are still depended upon and because not one symptom or sign helps us conclusively diagnose Acute Appendicitis, we depend on several scoring systems which have been suggested to have a role in diagnosing Appendicitis.

Alvarado (MANTRELS) scoring system was first described in 1986 and has been the most popular scoring system to diagnose Acute Appendicitis.[4] The original Alvarado score describes a possible total of 10 points, but those medical facilities that are unable to perform a differential white blood cell count, are using a Modified Alvarado Score with a total of 9 points.[5] Several other scoring systems were subsequently reported like Pediatric Appendicitis score, Tzanaki score, Lintula score, Eskelinen score, Ohmann score, Fenyo-Lindberg score, Christian score, Adult Appendicitis score, AIR score, Nigam Score and Raja Isteri Pengiran Anak Saleha Appendicitis (RIPASA) scores.[6–12] Different investigators have shown advantages of using a particular scoring system over the other in their work. The RIPASA scoring system has been reported to have better sensitivity and specificity for Asian and middle-eastern population.[6,7] We have been using the Alvarado scores for the diagnosis of Acute Appendicitis for a long time but had a significant number of negative appendicectomies and missed a few appendicitis cases which got complicated later. So, a prospective study was conducted at our center to compare the scores of Alvarado and RIPASA in patients suspected to have acute appendicitis and were compared against the positive biopsy report of Acute Appendicitis taken as the gold standard.

2. Materials and Methods

2.1. Study design, population and setting

A prospective study was conducted in the department of surgery at a tertiary hospital from January 2021 to June 2022. All patients fulfilling the inclusion criteria and admitted for the evaluation and management as a suspected case of Acute Appendicitis in the department of surgery were included in the study after taking informed consent. Patients were pre-informed about the procedure and all its possible complications beforehand, according to the declaration of Helsinki. They were also told about their inclusion in the study and the methodology adopted.

2.2. Inclusion criteria

Patients presenting with acute pain in right iliac fossa (suggestive of acute appendicitis and undergoing appendectomy).

2.3. Exclusion criteria

1. Appendicular lump
2. Paediatric patients (Children less than 10 years of age) were not included in the study.
3. Other causes of acute right iliac fossa pain like ruptured ectopic pregnancy, twisted/ruptured ovarian cyst, pelvic inflammatory disease, ureteric colic, Meckel's diverticulitis, intussusceptions, pyelonephritis diagnosed pre or per-operatively.

2.4. Parameters studied

1. Score according to the ALVARADO System.
2. Score according to the RIPASA System.
3. Histopathological reports.

Histopathological confirmation or non-confirmation of Acute Appendicitis was taken as the gold standard against which both the scores were compared.

2.5. Study tools

Modified ALVARADO Score chart (Table 1) and RIPASA score chart (Table 2) were the study tools used in this study. Equipment required for laboratory investigations (complete hemogram and urinalysis), Imaging study, Ultrasound (USG) & histopathology were also needed and for this the departments of pathology, biochemistry and radiology were involved.

All these 80 patients were scored by both Alvarado and RIPASA scoring and subjected to surgery. Post-surgery, the result of the histopathological examination (HPE) of the specimen from the Appendicular tissue was considered as evidence of whether Appendicitis was present or not. Specimen showing features suggestive of Acute Appendicitis were considered to have the disease and those not showing the features were not considered to have the disease. RIPASA Scores at 7.5 cut-off and Alvarado scores at 7 cut-offs were used to draw 2x2 contingency table for diagnostic tests and presence or absence of disease. Data thus collected was analyzed.

Table 1: Modified ALVARADO score

Variable	Score
Symptoms	
Pain migratory to RIF	1
Anorexia	1
Nausea and vomiting	1
Sings	
RIF tenderness	2
Rebound tenderness	1
Fever	1
Laboratory	
Leukocytosis	1
Maximum Score	9

RIF, right iliac fossa.

Table 2: RIPSA scoring system

1	**Demography**	**Score**
	Female	0.5
	Male	1
	Age <39.9 years	1
	Age >40 years	0.5
2	**Symptoms**	
	RIF pain	0.5
	Pain migration to RIF	0.5
	Anorexia	1
	Nausea & vomiting	1
	Duration of symptoms <48 hrs.	1
	Duration of symptoms >48 hrs.	0.5
3	**Signs**	
	RIF tenderness	1
	Guarding	2
	Rebound tenderness	1
	Rovsing sign	2
	Fever >37° C <39° C	1
4	**Investigation**	
	Raised WBC counts	1
	Negative urine analysis	1
5	**Additional score**	
	Non Asian	1
	Total Score	17.5

RIF: Right Iliac Fossa; **WBC:** white Blood Cell.

2.6. Statistical analysis

Demographic data was analyzed using the Microsoft excel tools and Vassar stats. Online Vassar Stats was used to calculate the sensitivity, specificity, positive and negative predictive values, and the likelihood ratios of these two scoring methods as diagnostic tests. Receiver operating characteristics curve and area under this curve was calculated using the online tool for ROC curve. Fischer's exact test (modified Chi square test) was used to analyze the Alvarado scores against HPE results and RIPASA scores against HPE results. Social Science statistics tool was also used to calculate sample size and plot tables and charts. For correlation statistics and scatter plot with line of best fit, Vassar stats and online Alcula tools were used.

For the calculation of the sample size, search was done for similar studies done in the past in English literature to look for the effect size for the difference between RIPASA and Alvarado scoring. In one such study by Chisthi et al. sensitivity and specificity for RIPASA reported was 0.95 and 0.80 approximately.[7] Considering a prevalence of 0.20 for Acute Appendicitis, confidence level of 0.95, precision of 0.10, sample size for sensitivity was 92 and that for specificity was 77 using online sample size calculator. Considering a dropout rate of 10%, final sample size was 103. However, during the study period only 80 patients could be enrolled.

3. Ethical Approval

Consent was taken from the institutional ethics committee (Memo no. 68/ANMMC, dated 14/01/2021) for conducting this study.

4. Results

Total of 80 patients were evaluated during this period Females (71.3%) outnumbered males (28.7%).

Mean age of patients included in this study was 21.36years with a wide range of age from 10years to 43years. 62.50% of cases were in the age group of 11-20 years of age, followed by 21-30 years of age (25%).

Confirmation of Acute Appendicitis on histopathology (HPE) was considered as the gold standard to judge whether the patient was suffering from Acute Appendicitis or not. In all, 57 (71.25%) cases showed evidence of Acute Appendicitis on HPE while 23 (28.75%) cases had negative report for Acute Appendicitis. Those having positive HPE report were truly suffering from the disease while those having negative report were considered not to be suffering from the disease.

4.1. Findings on RIPASA scoring

Considering RIPASA score ≥7.5 as evidence of Acute Appendicitis clinically, cases were divided into 'RIPASA+ve' or 'RIPASA-ve'. 58 patients (72.5%) were RIPASA positive, while 22 (27.5%) were RIPASA negative. (Table 3) shows further sub-categorization of the patients into 'low possibility' (LP), 'high possibility' (HP) and 'diagnosed' (D) cases as per their RIPASA scores.

Sub-categorization of cases depending upon the RIPASA and modified ALVARADO scores is shown in Table 3.

4.2. Comparing RIPASA scores with Histopathological outcomes

Considering the patients with evidence of Acute appendicitis on HPE to be having the disease and those without evidence on HPE to not having the disease, RIPASA scores were assessed as diagnostic test. (Table 4) shows the 2x2 contingency table for RIPASA score and the evaluation of RIPASA score as a diagnostic score against modified ALVARADO score.

4.3. Findings on modified ALVARADO scoring

Considering modified ALVARADO scores≥7 as diagnostic of Acute Appendicitis clinically, cases were divided into 'ALVARADO+ve' or 'ALVARADO-ve'. 38 cases (47,5%) were 'ALVARADO+ve' and 42 cases (52.5%) were 'ALVARADO -ve'. (Table 3) further shows the subcategorization of patients into 'low possibility', 'high possibility' and 'Diagnosed' cases depending upon their modified ALVARADO scores.

Table 3: Subcategorization of cases depending upon the RIPASA and modified ALVARADO scores

Subcategorization - RIPASA Scores			**ALVARADO scores Subcategorization – modified**		
RIPASA Score range	Diagnostic Possibility group	Frequency	ALVARADO Score range	Diagnostic Possibility group	Frequency
<7.5	LP	22	5-6	LP	18
7.5-12	HP	53	6-7	HP	55
>12	D	5	>8	D	7

LP- Low possibility; HP- High possibility; D-Diagnosed

Table 4: Comparison of the two scores (2X2 tables for the two scores)

HPE(Disease)→ RIPASA Scores ↓	**Disease present**	**Disease absent**	**Total**	**HPE (Disease)→ ALVARADO Scores**	**Disease present**	**Disease absent**	**Total**
≥7.5(+)	54	4	58	≥7(+)	34	4	38
<7.5(-)	3	19	22	<7(-)	23	19	42
Total	57	23	80	Total	57	23	80

Table 5:

Parameter	**RIPASA (at7.5)**	**Modified ALVARADO (at 7)**
Sensitivity (%)	94.74	59.65
Specificity (%)	82.61	82.61
Positive predictive value (%)	93.10	89.47
Negative predictive value (%)	86.36	45.24
Positive Likelihood Ratio	5.45	3.43
Negative Likelihood Ratio	0.06	0.49
Accuracy	91.25%	66.25%
Fitted ROC Curve area	0.93	0.89
Negative Appendectomy rate (False positive cases)	6.95	10.53%

4.4. Comparing modified ALVARADO scores with Histopathological outcomes

Considering the patients with evidence of Acute appendicitis on HPE to be having the disease and those without evidence on HPE to not having the disease, modified ALVARADO scores were assessed as diagnostic test and a 2x2 contingency table as shown in (Table 4) was created.

Analyzing modified ALVARADO scores as a diagnostic test and HPE as the gold standard for disease detection, the sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio and negative likelihood ratio is summarized in (Table 5).

So, modified ALVARADO scores have low sensitivity (59.65%), high specificity (82.61%), high positive predictive value (89.47) but poor negative predictive value (45.24) as diagnostic score.

4.5. Receiver operating characteristic (ROC) Curve for RIPASA SCORE and modified ALVARADO

(Figure 1) demonstrates the two ROC curves and depicts a higher area under the curve in the case of RIPASA (at 7.5 cutoff) compared to modified ALVARADO score (at 7 cutoff).

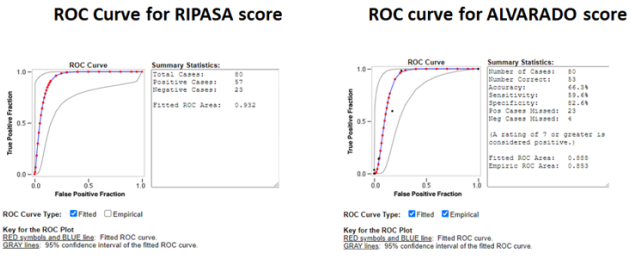

Figure 1: ROC curves for the two scores

4.6. Correlation between RIPASA and ALVARADO scores

Positive Correlation between the two scores has been summarized in (Figure 2).

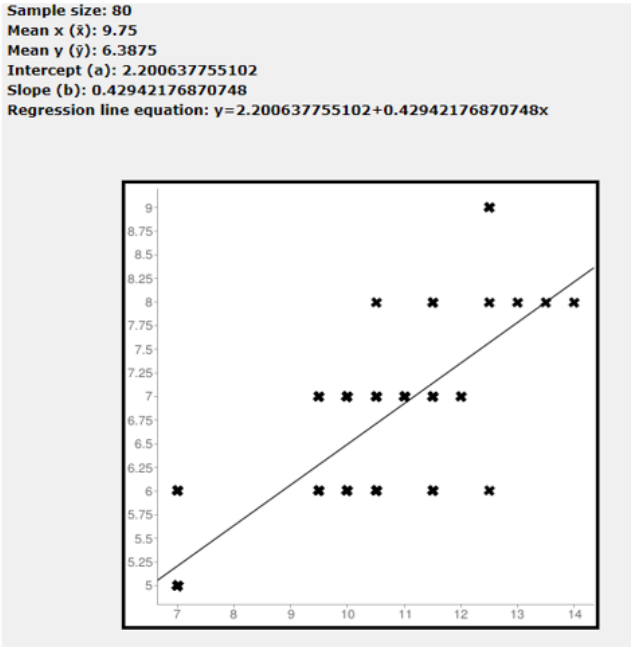

Figure 2: Positive correlation between the two scores

5. Discussion

Surgery for an acutely inflamed appendix constitutes one of the commonest surgical emergencies constituting approximately one in ten of all emergency abdominal surgeries in several series.[8,9] Clinical diagnosis of the condition still plays the most important role in providing prompt relief from pain and lessening the chances of complications by facilitating timely surgery. This may at times be difficult and may often lead to situations where there is a dilemma about appropriate management. Radiological modalities such as computed tomography (CT) imaging further aid in making a definite diagnosis and have been reported to have high sensitivity (94%) and specificity (95%) for diagnosing acute appendicitis.[10] This implies the benefits of CT scan as a diagnostic modality and as a result in most large hospitals, it is now a routine to request for CT imaging in all patients suspected of acute appendicitis.[10,11] This practice unfortunately inflates the cost of healthcare substantially. Moreover, it is not available at many centres in developing countries and the process of arranging for CT imaging may further delay emergency appendectomy. The use of CT scans in such scenario may lead to the detection of early low-grade appendicitis and unnecessary appendectomies in a condition that would otherwise have resolved spontaneously with antibiotics therapy.[12]

The scoring systems which are a mixed blend of symptom scores, sign scores and laboratory findings' scores increase the probability of detection of Acute Appendicitis when compared to their individual components. At the same time, they are simple to be practiced, do not cause undue delay, or add to the cost of management. The most popular ALVARADO score, which was developed in 1986, is a simple additive scoring system to help in the diagnosis of acute appendicitis.[4] It has stood the test of time but although it showed very good sensitivity and specificity when applied in Western population, several subsequent studies have shown its limitations when applied in an Asian or Oriental population.[13,14] Therefore, a new extensive, simple additive scoring system called the RIPASA score has been developed, that consists of 14 fixed parameters that are unique to our population setting. All these parameters are easily obtainable from good clinical history, examination, and investigations.

In our study, a sample size of 80 seemed adequate. Females outnumbered males, constituting 71.3% of study population. This was not due to any bias and possibly could be attributed to chance occurrence. Being conducted in the department of General surgery, only one patient was in the 'less than 10years' group while the age group 11-20 years was the one which was found to be the most affected. If more pediatric patients would have been accommodated by collaborating with the Department of Pediatric surgery, a more representative sample would have been possible. This is an important limitation of our study but because it was conducted in the department of Surgery, only older children and adults were included. Even then, a wide range of age was seen from 10years to 43 years.

Chong et al. in a retrospective study, reported that the RIPASA score had better sensitivity (88%) and specificity (67%) than the ALVARADO score (sensitivity 59%, specificity23%) in Asian population. In our study, the RIPASA scores were considerably better than the modified ALVARADO score in correctly diagnosing acute appendicitis. While both RIPASA and modified ALVARADO scores had comparable specificity, sensitivity, positive and negative predictive values; positive likelihood ratio and diagnostic accuracy of RIPASA scores were significantly better than the corresponding modified ALVARADO scores. When considering the diseased population, RIPASA scores outperformed modified ALVARADO scores in detecting them; also, the possibility that a high score on RIPASA scoring was diseased (i.e., the positive predictive value) was better. As against this, the negative predictive value of RIPASA was also better compared to the modified ALVARADO group. The difference in diagnostic accuracy alone of the two scores was 25% which is statistically significant. Fitted ROC curve area (which signifies how better a diagnostic test is) was significantly more in the case of RIPASA (at 7.5) compared to Alvarado score (at 7). All these establish the superiority of RIPASA Scores when compared to modified ALVARADO scores in this study. This may be because the RIPASA scores are better suited for Asian and eastern ethnic groups. This also implies for the Indian population as this

study has been conducted on Indian patients. Similar has been the observation of other researchers.[15–22]

The RIPASA score is a useful, rapid diagnostic tool for acute appendicitis, especially in the settings of emergency, as it requires only the patient's demographics (age, gender and nationality, which are all available on registration), a good clinical history (RIF pain, migration to RIF, anorexia, nausea and vomiting), clinical examination (RIF tenderness, localized guarding, rebound tenderness, Rovsing's sign and fever) and two simple laboratory investigations (raised white cell count and negative urinalysis performed at triage, which is defined as an absence of red and white blood cells, bacteria and nitrates). Thus, in an emergency setting, the on duty Medical Officer can take a decisive action upon seeing patients with RIF pain, by referring those with a RIPASA score ≥ 7.5 to the on-call surgical team for admission; as against this, patients with a RIPASA score < 7.0 can either be observed in the ward or sent home with advice for observation. The use of a numerical score also improves the working relationships between the on-duty emergency medical officer and the on-call surgeon, since any patient with a RIPASA score ≥ 7.5 needs to be admitted. With its high sensitivity (94.74%) and NPV (86.36%), the RIPASA score can also help to reduce unnecessary and expensive radiological investigations such as routine CT imaging, thus further helping to reduce annual healthcare expenditure and time. The 14 fixed parameters can be easily and rapidly obtained in any population setting by taking a complete history, and conducting a clinical examination and two simple investigations. In majority of the patients, a quick decision can be made about a referral to an on-call surgical team – whether to discharge or observe further. The option of having additional parameters makes the RIPASA score more flexible and adaptable to different geographical regions. In terms of healthcare cost savings, the use of RIPASA score may help to reduce unnecessary inpatient admissions and expensive radiological investigations. It has previously been hypothesized that in view of ethnicity and dietary habit, the Modified ALVARADO score per se may not be as predictable in the South Asian population as in the Western World[13,14,21]. On the other hand, the RIPASA score has been hypothecated to be directly applicable in the South Asian population.[23] Frountzas et al. in his meta-analysis of randomized trials comparing the two scores concluded that although RIPASA had better sensitivity but due to low specificity, additional means were needed for accurate diagnosis.[24] The current study put this perspective in comparison, by specific statistical tools available (ROC). Analysis of the collected data revealed that a modified ALVARADO score of 7 was more consistent with the operative and histopathological findings. Higher and lower cut-offs affect area under ROC curve. This translates into a significant patient population receiving conservative treatment in case a score of 7 is taken as the cut-off point. On the other hand, the RIPASA score specifies a cut off score of 7.5 for accepting an operative approach; this again involves the area under ROC curve which is highest when cut-off for RIPASA is 7.5.

An important role of the scoring systems and the diagnostic tests is to prevent unnecessary Appendectomies in cases where Appendix is not inflamed; that is they should be able to lessen negative Appendectomies. With RIPASA Scoring this was in 6.9% of the cases while it was in 10.53% of the cases in modified ALVARADO scoring. So, RIPASA Scores fared better in preventing unnecessary Appendectomies.

Correlation analysis between the two scores showed a strong positive correlation between the two scores suggesting that in most of the cases, both scores correlated well.

5.1. Limitations and strengths of the study

Limitations of this study are the limited number of cases, non-inclusion of children less than 10 years of age and comparison with other similar scores for appendicitis. Similar studies on larger patient population would further validate the results obtained in this study. The inclusion of Pediatric patients also would present a broader perspective and bring out stronger evidence. RIPASA scores can be compared with other contemporary scores to further improve these scoring systems for a rationale use. Despite these limitations, this study brings forth the comparative data for the two scores in a developing country like ours and the evidence for the use of RIPASA scores in lieu of modified ALVARADO scores in patients with suspicion of Appendicitis.

6. Conclusion

Scoring systems for Acute Appendicitis are indispensable in the emergency scenario. They help in the prevention of negative appendectomies and guide management in cases of diagnostic dilemmas. RIPASA Scores (at 7.5 cut-off) are a better diagnostic tool compared to modified ALVARADO Scores (at 7 cut-off) due to better sensitivity and positive and negative predictive values and higher area under the fitted ROC curve.

7. Authors' Contribution

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, data analysis, and interpretation, or all these areas. All authors took part in drafting, revising, or critically reviewing the article and gave final approval of the version to be published.

8. Source of Funding

None.

9. Conflict of Interest

None.

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