European Journal of Molecular & Clinical Medicine

ISSN 2515-8260 Volume 09, Issue 03, 2022

ORIGINAL RESEARCH

A Comparative Study of Alvarado, Ripasa and Airs Scoring Systems in the Diagnosis of Acute Appendicitis

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ABSTRACT

Background: Acute appendicitis is the most common cause of abdominal emergency in both developed and developing countries, yet its diagnosis remains challenging. Several scoring systems have been developed in order to aid the decision-making process to reach diagnosis of acute appendicitis in the quickest way, which include the Alvarado Score, the AIRS Score, and the RIPASA Score. The current study compares and assesses the utility of the scoring systems in establishing a diagnosis of acute appendicitis, as compared to a final histological report.

Materials and Methods: This was a prospective study conducted at the Department of General Surgery, Rajindra Hospital, Patiala, including 60 patients presenting with right iliac fossa pain for less than 72 hours and were planned to undergo appendectomy, from 2020 to 2021. A structured pre-prepared proforma was used to enter the complete history, clinical examinations, hematological and biochemical investigations, the calculated scores for the Alvarado, RIPASA, and AIRS scoring system, and the histopathological report for each patient. Sensitivity, specificity, accuracy, PPV, and NPV were calculated for Alvarado, RIPASA, and AIRS Scores for the diagnosis of acute appendicitis with histopathologic diagnosis as the gold standard. Receiver operator characteristics (ROC) curve was done, and criterion value was estimated depending on the specificity and sensitivity.

Results: In our series, the RIPASA score had the highest statistical parameters amongst all 3 scores. The sensitivity, specificity, PPV and NPV were 92.45%, 85.71%, 98%, and 60% respectively. It had the highest diagnostic accuracy (91.67%). It was followed by the AIRS scoring system with a sensitivity, specificity, PPV, and NPV of 88.68%, 71.43%, 95.92%, and 45.45% respectively. Its diagnostic accuracy was 86.67%. The Alvarado score had a sensitivity, specificity, PPV, and NPV were 81.13%, 71.43%, 95.56%, and 33.33% respectively. Its diagnostic accuracy was 80%.

Conclusion: It is concluded that the RIPASA Scoring system is a valid and better tool with high discriminating power in the diagnosis of acute appendicitis, and for minimizing unproductive admission and abdominal explorations, especially in Asian ethnicity, as it outperforms the Alvarado and the AIRS Scores in all statistical parameters, as per our study.

Keywords: Appendicitis, RIPASA, AIRS, Alvarado, Scoring System

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INTRODUCTION

Acute appendicitis is one of the commonest causes of pain in the lower abdomen that leads patients to attend the emergency department. Appendicitis is commonest between the ages of 10 and 20 years, but no age is exempted.[1] A male preponderance exists, with a male to female ratio of 1.4:1.[2] It is still one of the commonest abdominal emergencies that demand surgery. Emergency appendicectomy makes up one in ten of all emergency surgeries.[3] First described by Fitz more than 100 years ago,[4] it still remains a difficult diagnosis to establish, and the gold standard to this date is histopathologic examination. The presentation is often not classical, which poses diagnostic challenges in many cases. Quite often the appendix is found to be normal on histopathology, the patient's symptoms being due to other causes.[5] This is particularly challenging among the young, the elderly, and females of reproductive age, where other genitourinary and gynecological conditions can present with signs and symptoms that resemble acute appendicitis.

The diagnosis of acute appendicitis is based on signs & symptoms whose interpretation is sometimes subjective (e.g., anorexia) and varied (e.g., pain perception & referral or migration).[6] Pain starts in the epigastrium or periumbilical area and migrates to the right lower quadrant. It is also associated with anorexia,[7] fever, nausea and vomiting.[6] The commonest sign of acute appendicitis is right lower quadrant tenderness, especially at McBurney's point.[7] Although direct rebound pain is sometimes difficult to elicit, it is one of the specific signs of acute appendicitis. It can be replaced with other indirect signs such as the Rovsing sign. Initial slight temperature elevation is common.[7] A rectal examination does not appear to be a reliable element in the diagnosis of acute appendicitis because of its low diagnostic weight.

A white blood count above 10,000/cu.mm is a valuable finding in acute appendicitis. A differential white count with a shift to the left (i.e., neutrophils of more than 75%) is also a useful indicant in acute appendicitis. C-reactive protein test is a non-specific test that detects an inflammatory process only, which is positive in acute appendicitis. Often, urinalysis is also necessary to exclude urological causes of right iliac fossa pain.[8] If the urine shows abundant red cells it may point to a ureteral calculus and further evaluation is necessary.

Transabdominal sonography is used as an imaging modality in patients with suspected appendicitis because it rapidly helps distinguish patients with appendicitis that require computed tomography or surgery from those with a normal appendix.[9] However, the diagnosis of acute appendicitis is often difficult, even for the experienced examiner.[10] Initial reliance on ultrasound has become more guarded recently because of moderate sensitivity (86%) and specificity (81%),[11] limiting its diagnostic ability.[12] Radiological modalities like Computed Tomography (CT) imaging have a high sensitivity and specificity for the definite diagnosis of acute appendicitis, but, its indiscriminate use may lead to detection of early low-grade appendicitis & unnecessary appendicectomies, and substantially increased health care costs.[13] The use of these diagnostic modalities causes further delays in diagnosis and surgery. Hence, the diagnosis of acute appendicitis still depends to a large extent on clinical judgments, which involve the synthesis of a large amount of clinical data, aided by surgical experience.

A quick and correct diagnosis of acute appendicitis leading to early appendicectomy and avoidance of complications arising from perforations can be difficult at times. If the symptoms are vague, the diagnostic process takes longer, thus delaying surgery, which increases the possibility of complications. On the other hand, hasty surgery without an

accurate diagnosis leads to negative appendectomy, increasing the morbidity of treatment. An equivocal diagnosis of acute appendicitis is thus controversial, as some advocate early surgical exploration on wide indications hoping to prevent perforation, with an associated high frequency of negative explorations as an acceptable trade-off, while others propose early exploration in patients with obvious disease and active observation of patients with an equivocal diagnosis, which gives fewer negative explorations without increasing the number of perforations.[14]

A negative appendicectomy is a surgery performed for a preoperative diagnosis of appendicitis that results in a normal histopathology specimen.[15] A normal appendix is often removed to reduce future diagnostic dilemmas. The practice of using clinical parameters alone in diagnostics leads to a false positive diagnosis (negative appendectomy) rate in the range of 15-30%. The rate of such unnecessary laparotomies is even higher (35-45%) in women of childbearing age, because of the female pelvic organs and complications of pregnancy in this group.[16] The negative exploration is not innocuous and carries a morbidity that has been estimated as high as 15%.7 In the past 2 decades, the negative appendectomy rate has been relatively constant with a slight decline after 2000.[11] An additional benefit of improved diagnostic accuracy is the lower perforation rate that coincided with the decrease in negative laparotomies.[17] This high rate can be decreased by careful and accurate diagnosis of appendicitis thus preventing the progression to perforation and peritonitis. CT reduces the NAR but routine CT is unnecessary to maintain a NAR below 3% and for male patients, a positive Alvarado score suffices.[18,19]

A large number of clinical scoring systems for acute appendicitis are available to the surgeon. The Alvarado scoring system is the most widely known and the best performing system. This scoring system was developed in western countries, and multiple studies have reported low sensitivity and specificity when it is applied to a population with a different ethnic origin and diet.[20,21] Both the Alvarado and modified Alvarado scores lack parameters that are important determinants in the diagnosis of acute appendicitis, such as age, gender, and the duration of symptoms. It was constructed based on a retrospective review, but it is supposed to be used on patients with suspicion of appendicitis. Because of the difference in the spectrum of disease between these groups of patients, the scoring weights may be biased.[22] The variables were selected without any appropriate mathematical model to help in the identification of variables possessing an independent diagnostic value and in the determination of their weights in the scoring system. Finally, discriminating capacity is lost because of the dichotomization of the variables.

The Appendicitis Inflammatory Response Score (AIRS) 14 includes inflammatory markers which have been shown to have a high discriminating power,[23] and are graded instead of being dichotomous, and the biomarker variables are divided into intervals. Weighted ordered logistic regression analysis was used to construct the scoring system. It identifies variables with an independent predicting capacity and helps obtain the variables' scoring weights. Three diagnostic test zones are defined: one zone with a high sensitivity to identify the patients that can be safely discharged with an outpatient follow-up, one zone with a high specificity to identify patients who need to be operated upon, and an indeterminate group of patients who need additional diagnostic workup. It works better in the pediatric population because the variables scored are easy to apply to children.[24]

To develop an appendicitis scoring system that is more applicable to the Southeast Asian region, in 2010, the Raja Isteri Pengiran Anak Saleha Appendicitis (RIPASA) score was introduced by Chong et al. which was shown to have higher specificity and sensitivity and an overall higher diagnostic accuracy than the Alvarado score, particularly when applied to Asian popoulations.[8,25] The parameters included in the new appendicitis scoring system consisted of age, gender, RIF pain, the migration of pain to the RIF, nausea and vomiting,

anorexia, the duration of symptoms, RIF tenderness, guarding, rebound tenderness, Rovsing's sign, fever, elevated white cell count, negative urinalysis and a foreign NRIC included as an additional parameter because of the high probability of acute appendicitis seen in foreign nationals presenting with RIF pain.[8]

Thus, management of patients with suspected acute appendicitis is still challenging and the optimal management algorithm is still being debated even after the introduction of CT, USG, and diagnostic laparoscopy. Currently, the histopathologic examination is considered to be the gold standard to diagnose appendicitis. The Alvarado, RIPASA, and AIRS scores are amongst the most popular scoring systems for acute appendicitis, devised to mitigate the challenges faced in the diagnosis of acute appendicitis. The current study compares the diagnoses based on the Alvarado, AIRS, and RIPASA scoring systems with those obtained from histopathology after appendectomy and evaluates several predictive diagnostic values, as few such studies exist in the current world literature.

Aims and Objectives

The present study has been attempted to assess the diagnostic accuracy of the Alvarado Scoring System, Acute Inflammatory Response score & RIPASA scoring system among the patients presenting with acute right iliac fossa pain at Rajindra Hospital and Government Medical College, Patiala, with the diagnosis of Acute Appendicitis.

MATERIALS & METHODS

This was a prospective study conducted at the Department of General Surgery, Rajindra Hospital, Patiala, including 60 patients presenting with right iliac fossa pain for less than 72 hours and were planned to undergo appendectomy, from 2020 to 2021. Patients with documented appendicular perforation or lump, or pain >72 hours duration were excluded from the study. A structured pre-prepared proforma was used to enter the complete history, clinical examinations, hematological and biochemical investigations, the calculated scores for the Alvarado, RIPASA, and AIRS scoring system, and the histopathological report for each patient. Data collected were entered into a Microsoft Excel 365 Spreadsheet. All the statistical calculations were done using (Statistical Package for the Social Science) SPSS 21version (SPSS Inc., Chicago, IL, USA) statistical program for Microsoft Windows. Data was described in terms of range; mean ±standard deviation (± SD), median, frequencies (number of cases), and relative frequencies (percentages) as appropriate. For comparing categorical data, the Chi-square ($\chi 2$) test was performed and an exact test was used when the expected frequency is less than 5. Sensitivity, specificity, accuracy, PPV, and NPV were calculated for Alvarado, RIPASA, and AIRS Scores for the diagnosis of acute appendicitis with histopathologic diagnosis as the gold standard. Receiver operator characteristics (ROC) curve was done, and criterion value was estimated depending on the specificity and sensitivity. The area under curve (AUC) was measured. A probability value (p-value) less than 0.05 was considered statistically significant.

RESULTS

The present study was conducted in the Department of Surgery, Rajindra Hospital, Patiala, amongst 60 cases of acute appendicitis, during 2020-21. The following results were observed. Patients from the 3rd and the 4^{th}decades of their lives predominated our study population. Maximum patients were from the 20-30 years age group (n=19, 31.6%) followed by the 31-40 years age group (n=16, 26.6%). The mean age was 33 years, the standard deviation was 14.1 years and the median age was 31. 20 patients (33%) were female and 40 (67%) were male. The sex ratio (M: F) was 2:1.

The commonest symptom was Right Iliac Fossa pain (n=60, 100%), followed by anorexia (n=54, 90%), nausea and vomiting (n=50, 83%), and pain migration (n=48, 80%). The duration of the symptoms was <48 hours in 24 patients (40%) and >48 hours in the remaining 36 patients (60%). Tenderness in their right iliac fossa was the most common sign (n=58, 97%), followed by guarding (n=55, 91%), fever (n=37, 62%), rebound tenderness (n=21, 35%), and Rovsing's sign (n=14, 23%). Guarding was found to be statistically significant (p=0.006). The TLC was elevated in 39 (65%) patients. 48 patients (80%) showed a shift to the left, i.e., an increase in neutrophil counts. The mean neutrophil count was 80.95%. The qCRP was raised in 59 patients (98.3%) The mean qCRP was 40.23. 83% patients had a negative urinalysis report. On statistical analysis, the TLC (p=0.045), and negative urinalysis was significant (p=0.011). 53 (88.3%) patients were diagnosed with appendicitis on histopathology. 7 patients were found to have a normal appendix on histopathology. Thus, our overall negative appendectomy rate (NAR) was 11.6%.

Table 1: Confusion matrix for the Alvarado Scoring System

		HPE		**Total**	**p-value**
		Appendicitis (n=53)	**Appendicitis Absent (n=7)**		
Alvarado Score	>7	43	2	45	0.003
	0-7	10	5	15	

Table 2: Confusion matrix for the RIPASA scoring system

		HPE		**Total**	**p-value**
		Appendicitis (n=53)	**Appendicitis Absent (n=7)**		
RIPASA score	> 7.5	49	1	50	0.0001
	< 7.5	4	6	10	

Table 3: Confusion matrix for the AIRS Scoring System

		HPE		**Total**	**p-value**
		Appendicitis (n=53)	**Appendicitis Absent (n=7)**		
AIRS score	5-12	47	2	49	0.001
	0-4	6	5	11	

Table 4: Comparison of all 3 scoring systems

Statistic	**Alvarado Score (>7)**	**RIPASA Score (>7.5)**	**AIRS score (>4)**
Sensitivity	81.13%	92.45%	88.68%
Specificity	71.43%	85.71%	71.43%
Positive Predictive Value	95.56%	98.00%	95.92%
Negative Predictive Value	33.33%	60.00%	45.45%
Accuracy	80.00%	91.67%	86.67%

The sensitivity of Alvarado score (cut-off>7) was 81.13%, specificity was 71.43%, positive predictive value was 95.56% and negative predictive value was 33.3%. Its diagnostic accuracy was 80% and it was significant on statistical comparison with histopathology (p=0.003) The negative appendectomy rate for the Alvarado scoring system was 3.3%. The sensitivity of RIPASA score (cut-off>7.5) was 92.45%, specificity was 84.71%, positive predictive value was 98% and negative predictive value was 60%. Its diagnostic accuracy was 91.67% and it was highly significant on statistical comparison with histopathology (p=0.0001) The negative appendectomy rate for the RIPASA scoring system was 1.6%. The

sensitivity of the AIRS score was 88.68%, specificity was 71.43%, positive predictive value was 95.92% and negative predictive value was 45.45%. Its diagnostic accuracy was 86.67% and it was significant on statistical comparison with histopathology (p=0.001). The negative appendectomy rate was 3.3%.

Area under the Alvarado ROC is 0.765. The cut-off score for maximum sensitivity and specificity is 6.5, which is less than the original cut-off value of 7. Similarly, the area under the RIPASA ROC is 0.833, and maximum sensitivity and specificity are seen at a cut-off of 7.3, which is approximately equal to the original cut-off of 7.5. The area under the AIRS ROC is 0.770, and the maximum sensitivity and specificity are encountered at a cut-off of 4.5, which is a little higher than the original scoring cut-off of 4. Statistical analysis revealed all AUCs to be statistically significant. The RIPASA ROC AUC is highly significant (p=0.004) Hence, all 3 scoring systems are helpful in the diagnosis of acute appendicitis, but the RIPASA scoring is superior amongst the three, as per our series.

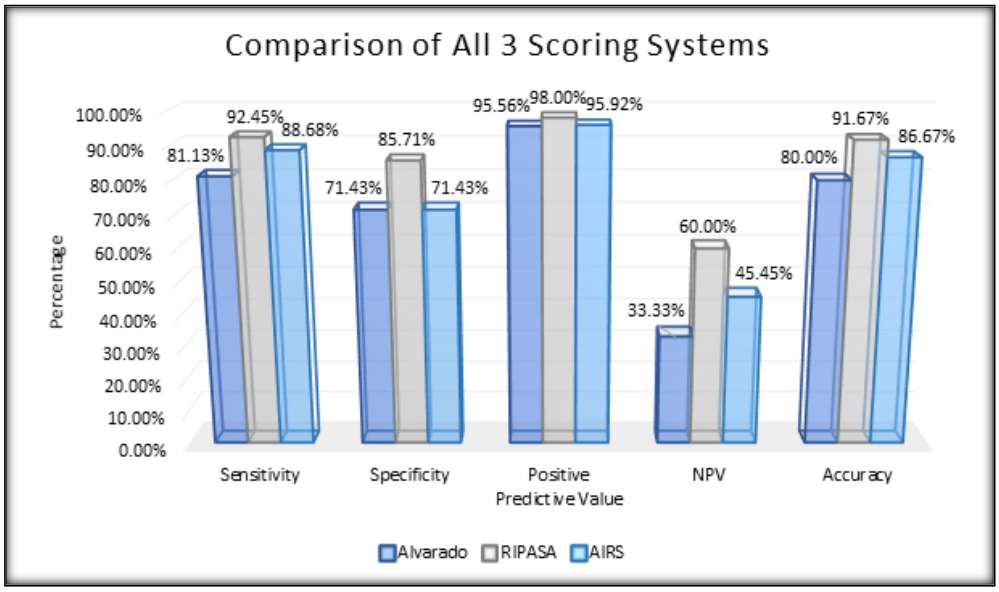

Figure 1: Comparison of Alvarado, RIPASA, and AIRS Scoring Systems

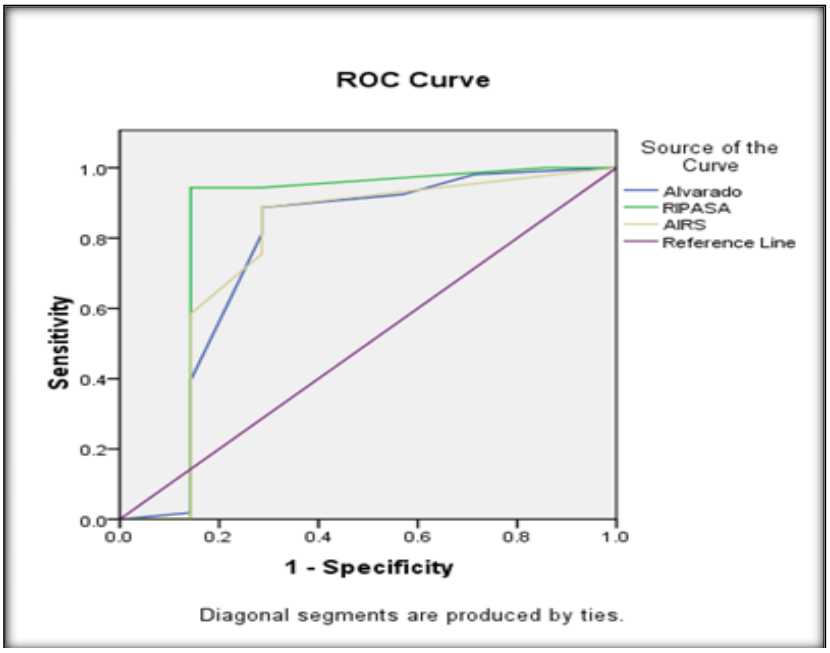

Figure 2: Receiver Operator Characteristic Curve

DISCUSSION

Acute appendicitis is one of the commonest surgical emergencies, and appendectomy is one of the commonest surgical procedures performed by general surgeons all around. Delayed diagnosis of acute appendicitis can lead to a perforated appendix, and is hazardous for the patient, while a wrong diagnosis leads to a negative appendectomy. The diagnosis of acute appendicitis remains challenging, particularly for inexperienced surgeons. The diagnosis is primarily clinical, as radiologic investigations such as the CT scan may lead to an increase in unnecessary appendectomies, are costlier, and delay appendectomy as they consume time. Similarly, USG is an operator dependent modality and has lower sensitivity (86%) and specificity (81%).[11] Thus, one has to rely on scoring systems for the diagnosis of acute appendicitis, many of which are available to surgeons. The present study was conducted in the Department of Surgery, Rajindra Hospital, Patiala, amongst 60 cases of acute appendicitis, to compare Alvarado, RIPASA, and AIRS scoring systems.

The demographic profile of our series is consistent with most studies from India. Gopalam & Konidala reported a mean age of 34 years, while Singla et al described a mean age of 25.7 years. Both studies had a male predominance in their study population.[26,27]

88.3% (n=53) patients were diagnosed with appendicitis on histopathology. Thus, our negative appendectomy rate (NAR) was 11.6%7 and the patients were found to have a normal appendix on histopathology. This correlates well with studies by Singla et al (10%) and Nanjundaiah et al (10.6%).[12,27] Chong et al had a NAR of 16.3%,[25] while Memon et al describe NAR of up to 20%.[28]

The Alvarado scoring system has a high validity when applied to western populations, but, when it was applied to Asian populations, it revealed a moderately lower specificity and sensitivity. Bolivar-Rodriguez et al,[29] in their study obtained a higher sensitivity for the Alvarado score (97.2%), while Karami et al,[30] and Patil et al,[31] reported the sensitivities to be 78.41% and 78.6% respectively. Lower sensitivities were reported by Chishti et al,[32] and Dezfuli et al,[33] i.e., 64.4% and 53.9%, respectively. Patil et al,[31] and Karami et al,[30] obtained a very high specificity for the Alvarado score (100%), while lower specificities were obtained by Chishti et al,[32] (58.82%) and Bolivar-Rodriguez et al,[29] (27.6%) The specificity in our series correlated well with that of Dezfuli et al (70.18%).[33]

The RIPASA scoring system which was exclusively designed for use with Asian populations, is broader and simpler and consists of seventeen items and an additional parameter. Negative urinalysis was included in the original RIPASA score study to exclude urinary causes of RIF pain, as 60% of the original authors' hospital (RIPAS Hospital, Brunei) general surgical admissions were urological in nature.8 Our sensitivity for the RIPASA score correlates well with those of Karami et al,[30] (93.18%), Dezfuli et al (97.2%),[33] while that of Bolivar-Rodriguez et al was higher (97.2%).[29] Lower sensitivities were described by Chong et al (87.78%) and Chishti et al (87.78%).[25,32] It correlates well with that obtained by Chong et al,[8] in their 2011 comparative study (81.3%). The specificities obtained by Karami et al,[30] and Chishti et al,[32] were 91.6% and 76.47% respectively, while much lower sensitivities were obtained by Chong et al,[25] (67%), Dezfuli et al33 (45.61%), and Bolivar-Rodriguez et al (27.6%).[29] Chong et al,[25] in their 2011 study reported the diagnostic accuracy of RIPASA to be 91.8%.

The AIR scoring system is another clinical criterion for AA diagnosis well known in validation studies during the last decade. It uses graded variables that can be objectively applied, and the score was constructed using weighted ordered logistic regression, comprising variables chosen using appropriate mathematical models. The sensitivity of AIRS score in our series correlated well with that of Andersson et al (89.1%),[34] Patil et al,[31] Saha et al (89.9%),[35] Scott et al (90%),[36] and Bolivar-Rodriguez et al,[29] (91.9%) while higher sensitivities of 97.7% and 93% were reported by Chishti et al,[32] and de Castro et

al.[24]Karami et al,[30] and Sudhir & Sekhar,[37] reported lower sensitivities of 78.4% in their studies. Patil et al,[31] reported the specificity of the AIRS score to be 100%. The specificity of the AIRS score at a cut-off of 4 was much higher in the series of Karami et al (91.6%),[30] Bolivar-Rodriguez et al (89.5%),[29] and Sudhir & Sekhar (89%).[37] The lowest specificity reported was by Chishti et al (29.41%).[32]

Table 5: Sensitivity, Specificity, PPV and NPV of Alvarado, RIPASA and AIRS scoring systems by various authors

Scoring System	Study	Year	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Alvarado	Present Study	2021	81.13	71.43	95.56	33.3
	Karami et al	2017	78.41	100	100	38.71
	Bolivar-Rodriguez et al	2018	97.25	27.6	83.3	72.7
	Chishti et al	2020	64.4	58.82	89.23	23.81
	Dezfuli et al	2020	53.9	72.18	70	53.3
RIPASA	Present Study	2021	92.45	84.71	98	60
	Chong et al	2011	98	81.3	81.3	97.4
	Nanjundaiah et al	2014	96.2	90.5	98.9	73.1
	Singla et al	2016	95.6	80	97.7	66.7
	Karami et al	2017	93.18	91.67	98.8	64.7
	Bolivar-Rodriguez et al	2018	97.2	27.6	88.8	90
	Chishti et al	2020	87.78	76.47	95.18	85.98
	Dezfuli et al	2020	93.4	45.61	69.61	83.3
AIRS	Present Study	2021	88.6	71.43	95.92	45.45
	De Castro et al	2012	93	85	79	95
	Karami et al	2017	78.41	91.67	98.57	36.67
	Patil et al	2017	89.9	63.6	-	-
	Saha et al	2018	89.9	63.6	95.23	43.75
	Bolivar-Rodriguez et al	2018	91.9	89.5	96.7	56.7
	Chishti et al	2020	97.78	29.41	88	71.43
	Andersson et al	2021	96.1	43	-	99

In our series, the sensitivity and specificity of the RIPASA score were significantly better than the other 2 scoring systems. It had the highest diagnostic accuracy, and the maximum area under the ROC (0.833) and the RIPASA ROC AUC is highly significant (p=0.004). It was followed by the AIRS scoring system with a sensitivity of 88.68%. The Alvarado score showed the lowest sensitivity amongst the 3 scores. The specificity of both the AIRS and the Alvarado scores were lower, at 71.43%. Thus, both AIRS and Alvarado score were comparably less suitable for ruling in the diagnosis when applied to our population. This compares favorably with that of Karami et al,[30] who stated that the RIPASA score is superior to the AIRS and Alvarado score, and is in contrast to that of Bolivar-Rodriguez et al and Chisthi et al,[29,32] who concluded that the AIRS score is superior to RIPASA and Alvarado scoring systems. However, it is worthwhile to note that the study by Bolivar-Rodriguez was done in a western population.[29]

CONCLUSION

It is concluded that the RIPASA Scoring system is a valid and better tool with high discriminating power in the diagnosis of acute appendicitis, and for minimizing unproductive admission and abdominal explorations, especially in Asian ethnicity, as it outperforms the

Alvarado and the AIRS Scores in all statistical parameters, as per our study. The surgeon can perform a quick diagnosis on encountering a patient with acute appendicitis, with a score >7.5 suggesting a need for appendectomy. However, further studies are required with larger sample sizes, as very few studies comparing all three scoring systems exist.

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