Comparisons of the RIPASA score with the ALVARADO and Paediatric Appendicitis Scores for the diagnosis of acute appendicitis in paediatric patients

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ABSTRACT

Introduction: Appendicitis is a common surgical emergency and diagnosis is usually straight forward. However, negative appendicectomy is still a problem. Several appendicitis predictive scores have been developed. To prospectively compare the RIPASA score with the Alvarado score and Pediatric Appendicitis score (PAS) for the diagnosis of acute appendicitis in pediatric patients presenting with right iliac fossa pain. **Materials and Methods:** Sixty-two pediatric patients aged between 1 years and 18 years old, presenting with RIF pain recruited to the Prospective study comparing RIPASA and Alvarado score were included for analysis. The RIPASA score, Alvarado score and PAS were derived during admission. Receiver operating curve (ROC), sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), diagnostic accuracy and likelihood ratios for all three clinical scoring systems (CSSs) were derived. **Results:** The optimal cut-off threshold score derived for RIPASA score, Alvarado score and PAS were 7.5, 7.0 and 6.0 respectively. At their respective optimal cut-off threshold score, the sensitivity, specificity, PPV, NPV and diagnostic accuracy of the RIPASA score were 96.7%, 84.4%, 85.3%, 96.4% and 90.9%, 70.0%, 84.4%, 80.8%, 75.0% and 82.0% for Alvarado score, and 70.0%, 75.0%, 72.4%, 72.7% and 81.0% for PAS respectively. The likelihood ratio for the RIPASA score at optimal cut-off threshold was 5.8, which was higher than the Alvarado score or PAS. The predicted negative appendicectomy rate for the RIPASA score (14.7%) was lower than the observed rate (25%), Alvarado score (19.2%) and PAS (27.5%). **Conclusion:** The RIPASA score at a cut-off threshold score of 7.5 is a better CSSs for diagnosing acute appendicitis in children, than the Alvarado score or PAS.

Keywords: Alvarado score, RIPASA score, Paediatric Appendicitis Score, Likelihood ratios, sensitivity, specificity

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INTRODUCTION

Acute appendicitis is one of the most common surgical emergencies encountered in the Accident and Emergency Department with an in-

cidence of 1.5-1.9 per 1000 population. [1] In children, the incidence has been reported to increase at an average of rate of 0.5 cases/100,000 population/year, with a lifetime cumulative incidence of 9.0%. [2] Over 80% of patients who undergo emergency appendicectomy are below 40 years of age and more than half of this is in the paediatric age group. [3]

Although acute appendicitis usually present with the classical signs and symptoms of right lower quadrant pain, nausea or vomiting and fever, these can be very subtle in the paediatric population. Coupled with difficulty in eliciting signs, particularly in the younger age group, makes identifying appendicitis in the paediatric population challenging. The resulting delay in making an accurate diagnosis of acute appendicitis, leads to higher rates of perforation, over 50-86% in those younger than five years of age with its associated morbidity and mortality. [4]

Clinical scoring systems (CSSs) have been developed to aid clinicians in stratifying patients into low, intermediate or high-risk groups for acute appendicitis and to provide the appropriate management strategies based on their risk categories. [5–12] Of these, the Alvarado score and Paediatric Appendicitis score (PAS) have been evaluated extensively in paediatric population with sensitivity and specificity ranging from 70-100% and 60-90% respectively depending on the chosen cut-off threshold value. [5, 12]

The RIPASA score, also known as the Raja Isteri Pengiran Anak Saleha Appendicitis score, named after the hospital where it was developed, is the newest CSSs. The RIPASA score was reported to have a sensitivity, specificity and accuracy of 98%, 81.3% and 91.8% respectively, evaluated in a population with a mean age of 25 years. [6, 13]

This study aimed to compare the RIPASA score with both the Alvarado score and PAS for the diagnosis of acute appendicitis in a paediatric population.

MATERIALS AND METHODS

Patient population: This study is a subgroup analysis of the original prospective study comparing the RIPASA score with the Alvarado score conducted from November 2008 to June 2009. [6] The inclusion criteria for this study analysis were all patients aged 18 years or below, presenting with RIF pain, suspected to be acute appendicitis. Patients above the age of 18 years old presenting with non-RIF pain and those who have been admitted previously for other complains but who subsequently developed RIF pain during their admission episodes were excluded from the study. Ethical approval to conduct the study was granted by the Medical and Health Review Ethics Committee at RIPAS Hospital.

Of the 200 patients recruited, only 62 patients were aged 18 years and below, satisfied the study inclusion and exclusion criteria. Demographics of these 62 patients are shown in table 1.

Both the RIPASA and Alvarado scores for these 62 paediatric patients were extracted from the original study database. All 15 parameters for the original RIPASA score were used despite the fact that all study participants were below the age of 18 years and were given a score of 1. The decision to do so

Table 1: Paediatric patients' demographic.

	Total
Male : Female	28:34
Mean Age (years)	12.9 ± 3.6
Ultrasound investigations (%) Female (%) Male (%)	15 (24.2) 10 (66.7) 5 (33.3)
Total emergency appendicectomy	40 (64.5)
Confirmed histology for acute appendicitis	30 (48.4)
Negative histology for acute appendicitis	10 (16.1)
Observed negative appendicectomy rate (N=40)	10 (25)
Perforated Appendix (%)	5 (16.7)
Mean hospital stay (Range) days	4.0 ± 1.4 (1-8)
Post-operative complications (%) Superficial wound infection Bowel obstruction	4 (7.5) 3 (4.8) 1 (1.6)
Number of patients discharge alive	62 (100)

was to standardised the RIPASA score form for both paediatric and adult patients and to maintain the cutoff threshold of 7.5. The 8 parameters for PAS were obtained from the patients' database and the total score derived for each of the 62 patients. The total PAS scores were then used for comparison with both the RIPASA score and Alvarado score.

Statistical Analysis: All data were presented as mean ± standard deviation for continuous variables and percentage for proportion. Receiver operating curve (ROC) at the optimal cut-off threshold score of 7.5 for the RIPASA score, 7.0 for the Alvarado score and 6.0 for PAS were derived using PASW statistical software (PASW for Windows, Version 18.0. Chicago: SPSS Inc.). Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and diagnostic accuracy at the reported optimal cut-off threshold scores were also derived from the ROCs for all three appendicitis CSSs. Predicted negative appendicectomy rates for all three appendicitis CSSs were also calculated and compared using Chi-square test for statistical analysis. Likelihood ratios for all three Appendicitis CSSs were also derived. A separate group analysis for children aged 12 years and below was also performed to derive the sensitivity, specificity, accuracy, PPV, NPV and likelihood ratios in younger children.

RESULTS

Mean age of the group was 12.9 ± 3.6 years with a male to female ratio of 28:34. Ultrasound investigations were performed in only 15 out of 62 (24.2%) patients with 66.7% performed in female patients (Table 1).

Forty patients underwent emergency appendicectomy based on the surgeons' clinical judgments. Out of these, only 30 cases were confirmed histologically for acute appendicitis, of which five cases (17.2%) had perforated appendicitis (Table 1). Ten cases were negative for acute appendicitis and histology specimen showed normal appendix in nine patients and periappendicitis (a condition characterised by inflammation which was localised to the serosa only) in one patient, indicating a negative appendicectomy rate of 25.0%. The mean duration of hospital stay was 4.0 ± 1.4 (range: 1 to 8) days.

Three out of 40 (7.7%) patients who underwent emergency appendicectomy, developed post-operative complications as shown in Table 1. All 62 patients were discharged alive.

Table 2 showed the distribution of the 62 paediatric patients in 4 groups, according to the RIPASA score at cut-off threshold score of 7.5, Alvarado score at cut-off threshold of 7.0 and PAS at cut-of threshold of 6.0. The

Table 2: Distribution of patients according 4 groups of true positive, false positive, true negative and false negative for all 3 appendicitis scores.

	TRUE POSITIVE			FALSE POSITIVE			TRUE NEGATIVE			FALSE NEGATIVE		
Variables	**RIPASA >7.5**	**ALVARADO >7.0**	**PAS>6.0**	**RIPASA >7.5**	**ALVARADO >7.0**	**PAS >6.0**	**RIPASA <7.5**	**ALVARADO <7.0**	**PAS <6.0**	**RIPASA <7.5**	**ALVARADO <7.0**	**PAS <6.0**
Sample Size	29	21	21	5	5	8	27	27	24	1	9	9
Male : Female	15:14	9:12	10:11	1:4	0:5	3:5	12:15	12:15	10:14	0:1	6:3	5:4
Mean Age (years)	11.0±3.3	10.4±3.1	10.3±3.0	13.4±4.8	13.4±4.8	13.6±4.4	14.7±2.6	14.7±2.6	15.7±2.4	17	13.1±3.7	13.4±3.8
Total Score	10.4±1.9	7.9±0.9	8.6±0.7	10.0±1.6	8.2±1.1	10.3±3.0	5.8±0.8	4.2±1.3	4.6±0.5	6.0	5.1±1.0	4.7±0.5

RIPASA score correctly classified 29 (96.7%) patients confirmed with histological acute appendicitis to the high probability group (RIPASA score >7.5) compared with 21 (70.0%) patients with the Alvarado score >7.0 and PAS >6.0 (Table 2). All three scoring system correctly classified 27 (84.4%), 27 (84.4%) and 24 (75.0%) of patients without acute appendicitis into the True negative group with scores <7.5 for the RIPASA score, <7.0 for the Alvarado score and <6.0 for PAS respectively. The nine patients missed by both the Alvarado score and PAS were classified wrongly into the false negative group (Alvarado score <7.0; PAS <6.0). This was significantly more than those wrongly classed as false negative by the RIPASA score (Table 2: Alvarado Score, p=0.02; PAS, p=0.01). There was no difference in mean age among all four groups (p>0.05). The mean total RIPASA scores for each group is shown in Table 2.

At the optimal cut-off threshold score of 7.5 for the RIPASA score, the calculated sensitivity and specificity were 96.7%% and 84.4%, compared with 70.0% and 84.4% for Alvarado score (optimal cut-off threshold of 7.0) and 70.0% and 75.0% for PAS (optimal cut-off threshold of 6.0) respectively. The PPV and NPV for both the RIPASA score were 85.3% and 96.4%, compared with 80.8% and 75.0% for the Alvarado score and 72.4% and 72.7% for PAS respectively (Table 3).

The diagnostic accuracy were 90.0% (Table 3, 95% CI: 82.9%-98.8%) for the RIPASA score, 82.0% (Table 3, 95% CI: 71.1%-92.9%) for Alvarado score and 81% (Table 3, 95% CI: 70.1%-91.9%) for PAS. This meant a difference of area under the curve of 8.0% between the RIPASA and Alvarado (Figure 1, p=0.08), and a difference of 9% between the RIPASA and PAS (Figure 1, p=0.02), the latter which was statistically significant. The difference of 8% between RIPASA and Alvarado equates to a total of 9 (14.5%) patients with confirmed histological acute appendicitis who were missed diagnosed by the Alvarado score (Table 2). Similarly the difference of 9% between the RIPASA and PAS equates to

Table 3: Sensitivity and Specificity analysis of all 3 appendicitis scoring systems in paediatric patients.

A: Sensitivity and Specificity Analysis of Appendicitis Scoring Systems in Paediatric Patients

Appendicitis Scores	Sensitivity		Specificity		PPV		NPV		Accuracy		Likelihood Ratio (Weighted by prevalence)		Negative Appendicectomy rate
	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Positive	Negative	
RIPASA	96.7%	80.9-99.8%	84.4%	66.5-94.1%	85.3%	68.2-94.5%	96.4%	79.8-99.8%	90.9%	82.9-98.8%	5.80	0.04	14.7%
Alvarado	70.0%	50.4-84.6%	84.4%	66.5-94.1%	80.8%	60.0-92.7%	75.0%	57.5-87.3%	82.0%	71.1-92.9%	4.20	0.33	19.2%
PAS	70.0%	50.4-84.6%	75.0%	56.2-87.9%	72.4%	52.5-86.6%	72.7%	54.2-86.0%	81.0%	70.1-91.9%	2.63	0.38	27.5%

B: Sensitivity and Specificity Analysis of Appendicitis Scoring Systems in Paediatric Patients aged 12 years and below.

Appendicitis Scores	Sensitivity		Specificity		PPV		NPV		Accuracy		Likelihood Ratio (Weighted by prevalence)		Negative Appendicectomy rate
	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Positive	Negative	
RIPASA	100%	80.0-100%	75%	35.6-95.5%	90.0%	69.4-98.4%	100%	51.7-100%	82.8%	0-100%	10.00	0.00	NA
Alvarado	80.0%	55.7-93.4%	75%	35.6-95.5%	88.9%	63.9-98.1%	60.0%	27.4-86.3%	73.1%	48.7-97.6%	8.00	0.67	NA
PAS	85.0%	61.1-96.0%	62.5%	25.9-89.8%	85.0%	61.1-96.0%	62.5%	25.9-89.8%	72.5%	47.3-97.7%	5.67	0.60	NA

Footnote: comparison between the 3 scoring systems and observed negative appendicectomy rate, $p>0.5$

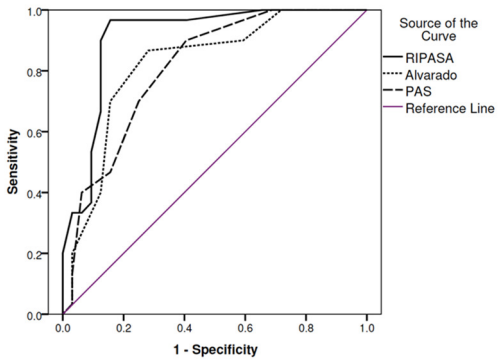

Fig. 1: Receiver operating curves for the three clinical scoring systems.

(19.4%) patients who were incorrectly diagnosed by PAS, of which nine were confirmed histological acute appendicitis but categorised into the low risk group (PAS ≤5.0, Table 2).

The predicted negative appendicectomy rates for the RIPASA, Alvarado and PAS scores were 14.7%, 19.2% and 27.5% respectively, which was not statistically significant from the observed rate or between the scoring systems (Table 3: $p>0.05$). For the RIPASA score, these equates to a 10.3% reduction in negative appendicectomy rate from the observed rate of 25% (Table 1).

The likelihood ratios weighted for prevalence for the three scores are shown in Table 3. Paediatric patients presenting with RIF pain with a RIPASA score of >7.5 are 5.8 times likely to have acute appendicitis, compared with a likelihood ratio of 4.2 for the Alvarado score and 2.6 for PAS. Similarly paediatric patients presenting with RIF pain with a RIPASA score of <7.5, have a likelihood ratio of 0.04 of having acute appendicitis, compared with 0.33 for Alvarado score <7.0 and 0.38 for PAS <6.0.

For paediatric patients aged 12 years

or younger, the sensitivity, specificity, PPV, NPV and accuracy for the three scores are shown in Table 3. Again in this group, the RIPASA score performed better than both Alvarado score and PAS, with a much higher positive sensitivity (100%), NPV (100%) and likelihood ratio (10.0) for the RIPASA score >7.5, with a negative likelihood ratio of zero for score <7.5.

DISCUSSION

We have previously evaluated and compared our RIPASA score with the Alvarado score for the diagnosis of acute appendicitis in the general population, consisting of mainly young adults. [6, 13] We confirmed that the RIPASA score performed significantly better than the Alvarado score in this population. Although our original study also included a paediatric population, the final outcome of the study was evaluated as a whole. This study now specifically looked at the performance of the RIPASA score in our paediatric population and compares it to the Alvarado and PAS scores.

This study results again confirmed that the RIPASA score is a better scoring system for the diagnosis of acute appendicitis in a paediatric population, compared to the Alvarado or PAS scoring systems. The RIPASA score achieved higher sensitivity, specificity, PPV, NPV, accuracy as well as likelihood ratios than either Alvarado or PAS. In our study, PAS consistently performed lower in terms of diagnosing acute appendicitis than the Alvarado and RIPASA score. Both the Alvarado and PAS missed diagnosed nine patients who had acute appendicitis and categorised them into a low risk group. This may lead to a delay in making an accurate diagnosis as well as making a definite decision for emergency appendicectomy in these nine patients, thus predisposing these patients to higher risk of perforated appendicitis and its associated higher morbidity and mortality rate.

When confronted with a paediatric patient presenting with right iliac fossa pain and a RIPASA score >7.5, the doctor can be 5.8 to 10 times certain of making an accurate diagnosis of acute appendicitis and hence make the necessary clinical decision according to our RIPASA score clinical guidelines as shown in Table 5, which is to refer on to the oncall surgeon or prepare the patient for emergency appendicectomy.

Management guidelines for patients presenting with RIF pain suspected of acute appendicitis based on the total RIPASA score.

Total RIPASA Score	Management Guidelines
<5.0	Probability of acute appendicitis is unlikely, observe child in A&E dayward and repeat score after 1-2 hours, if reducing score, discharge and review in Paediatric or General/Paediatric Surgery clinic. If increasing score, treat according to score level.
5.0-7.0	Low probability of acute appendicitis, observe in A&E dayward and repeat scoring after 1-2 hours or perform radiological investigations (abdominal ultrasound) to rule out acute appendicitis. If reducing score, discharge and review in Paediatric or General/Paediatric Surgery clinic . If increasing score or no change, child may need admission for observations, discussed with surgeon on-call or paediatrician on-call.
7.5-11.5	Probability of acute appendicitis high, refer child to on-call surgeon or Paediatric surgeon for admission and repeat score in 1-2 hours time. If remain high, prepare patients for appendicectomy procedure. In female child above age of 12 years, suggest perform radiological investigations such as an abdominal ultrasound investigations to rule out gynaecological causes of RIF pain.
>12	Definite acute appendicitis, refer to surgeon on-call or Paediatric surgeon on-call for admission and appendicectomy. Keep NBM and start intravenous fluid. Start appropriate antibiotics based on institutional antibiotic guidelines.

The observed negative appendicectomy rate of 25% in our paediatric patients is also much higher than our previously reported rate of 19.4% in the older population. [13] This is because in children, there are a multitude of pathologies that can mimic acute appendicitis and present with central abdominal pain or right iliac fossa pain such as mesenteric adenitis, pneumonia, constipation etc. Younger age group and female gender have been shown to be independent predictors of higher negative appendicectomy rate. [14, 15] Using the RIPASA score, we were able to reduce the negative appendicectomy rate to a predicted rate of 14.7%, which is a 10.3% reduction from the observed rate of 25%. This equates to four children out of a hundred who will be spared from unnecessary appendicectomy (Tables 1 and 3). The negative appendicectomy rate achieved by the RIPASA score is also the lowest among the three CSSs. PAS unfortunately achieved negative appendicectomy rate, which was much higher than the observed rate of 25%, meaning that by using PAS as a CSSs, more children may be subjected to unnecessary appendicectomy (Table 3).

Our study also confirmed that the RIPASA score is a better CSSs for diagnosing acute appendicitis in younger children aged 12 years or less, achieving sensitivity and NPV of 100% each. With a RIPASA score of >7.5, a child aged 12 years of less, presenting with right iliac fossa pain, the attending physician or surgeon can be 10 times more certain of a diagnosis of acute appendicitis. The RIPASA score is also twice more powerful as a CSSs for diagnosing acute appendicitis than PAS.

Using the RIPASA score can also provide an added benefit in terms of communication between doctors, particularly between the Accident and Emergency doctors and surgeons. In our unit, the RIPASA score has made communication easier and quicker between our Accident and Emergency Department colleagues with the oncall surgical team. With a RIPASA score >7.5, the oncall surgical team are more willing to accept and admit the patient without the constant argument that can occurred between the Accident and Emergency doctors and surgeons.

There are other CSSs for diagnosing acute appendicitis but we chose to compare the RIPASA score with Alvarado and PAS scoring systems, as these two are the most commonly used diagnostic scores for acute appendicitis in children. [7–11]

There are limitations in our study and the foremost is the fact that this is a subgroup analysis of our previous larger study. Hence the sample size is smaller. Despite that, our study was able to show that the RIPASA score was definitely much better than the Alvarado or PAS in accurately diagnosing acute appendicitis.

In conclusion, the RIPASA score as a diagnostic scoring system for acute appendicitis in the paediatric group, aged 18 years or below and definitely in the children younger than 12 years of aged, is better and more accurate than either the Alvarado or PAS. Using the RIPASA score, more children will be accurately and rapidly diagnosed, allowing for quick decision making in terms of surgical intervention for those who required it and not delaying surgery which may lead to a higher

rate of perforated appendicitis. Unlike the Alvarado and PAS, with the RIPASA score, fewer children will be missed diagnosed and sent home.

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