

Research Article

Diagnostic Accuracy of Pediatric Appendicitis Score (PAS) and Alvarado Score (AS) Among Children and Adolescents Aged 5 to 18 Years Old Diagnosed with Acute Appendicitis (AA) and Acute Mesenteric Adenitis (AMA) at a Tertiary Hospital in Manila, Philippines from 2018-2023

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Background: Acute appendicitis (AA) is a common cause of acute abdominal pain and surgical emergencies in children. Due to similar clinical presentations, differentiating AA from acute mesenteric adenitis (AMA) can be challenging. The Pediatric appendicitis score (PAS) and Alvarado score (AS) are used to diagnose AA.

Objective: This study aimed to determine the diagnostic accuracy of PAS and AS among patients with AA and AMA.

Methods: A cross-sectional study using chart review was conducted on 157 patients diagnosed with AA (n=87) or AMA (n=70), with a mean age of 12.2 ± 4.0 years. Key symptoms and diagnostic scores were analyzed.

Results: This study revealed significant symptoms associated with AA including migrating pain to the right lower quadrant, fever, tenderness over the right iliac fossa, rebound tenderness, leukocytosis, and neutrophilia. Importantly, patients with AA had higher mean PAS ($6.87 + 1.78$) and AS ($7.16 + 1.58$) than AMA (PAS: $4.62 + 1.61$, AS $5.23 + 1.87$; $p < 0.001$). PAS demonstrated superior diagnostic accuracy over AS using a cutoff of $\geq 7/10$, with better sensitivity, specificity, PPV, and NPV.

Conclusion: PAS was statistically superior to AS in diagnosing AA ($p = 0.049$). PAS is recommended to avoid unnecessary surgical consultations and further imaging.

Keywords: Appendicitis, mesenteric adenitis, child, diagnosis, accuracy, scoring.

Introduction

Acute appendicitis (AA) is one of the most common causes of acute abdominal pain in children and the most common surgical emergency in children.^{1,2,3} Early diagnosis of AA is essential to prevent complications, including appendiceal perforation.^{3,4} Complications caused by unnecessary delay in diagnosis can increase morbidity, mortality, and hospitalization, which contribute to patients' economic and social burdens.⁵

However, accurate clinical diagnosis of AA remains a challenge to physicians, particularly because of its similar clinical presentation with acute mesenteric adenitis (AMA), often making it difficult to differentiate between the two.^{1,2,6}

Definitive diagnosis of AMA is commonly made through imaging studies, either abdominal ultrasound or computed tomography (CT) scan, which show a cluster of three or more lymph nodes measuring >5 mm on

their short axis in the (RLQ) and para-aortic region without an identifiable acute inflammatory process.^{1,6,7} Radiological findings of AA include at least one of the following features: blind-ended non-compressible tube in RLQ, the diameter of appendix >7mm, presence of fecalith, target sign in axial plain, or peri-appendiceal collection.¹

Because AMA is an important clinical mimic of appendicitis in children and has been reported as the most common finding during negative surgical explorations for suspected AA, several scoring systems have been developed and tested to diagnose AA.^{2,8} Pediatric appendicitis score (PAS) and Alvarado score (AS) are the commonly studied and applied clinical scores.^{1,8}

Review of Related Literature

AA is rare among children aged <6 years old, accounting for only <5% of all cases of childhood AA.⁹ Incidence of AA in children increases with age: 1.1/10,000 among children aged 3 to <5 years, 6.8/10,000 among children aged 5 to 9 years, and 19.3/10,000 among children aged 10 to 14 years.⁹ Adolescent children aged 12 to 16 years are at greatest risk for appendectomy.¹⁰

In the Hospital Discharges Registry of the Philippine Pediatric Society, there are 12,750 reported cases of AA and 2,134 cases of AMA from January 2010 to December 2022.¹¹ Among children with AA, most belong to the age group of 10 to 14 years old (5,372), followed by 15 to 18 years old (3,944), then 5 to 9 years old (2,603). Also, among children with AMA, most are aged 5 to 9 years old (850) and 10-14 years old (779).¹¹

AMA is more common during the first decade of life than AA, and it is often preceded by upper respiratory illness (URTI).⁷ Etiologies include viral and bacterial infections, most commonly gram-negative *Yersinia pseudotuberculosis* and *Yersinia enterocolitica*, inflammatory bowel disease, or lymphoma.¹² AMA is characterized by right lower quadrant (RLQ) pain secondary to an inflammatory condition of mesenteric lymph nodes.¹² AMA is self-limiting, and patients are managed with supportive care, including hydration and pain control.^{7,12} Symptoms like abdominal pain usually resolve within 2 to 4 weeks.^{7,13}

PAS and AS are the commonly applied scoring systems to diagnose AA.^{1,8} Both scoring systems utilize clinical history, physical examination, and routine laboratory test results to identify high-risk patients for surgical management. These scoring systems can aid in reducing the time needed for diagnosis and preventing negative appendectomies.^{3,4}

PAS utilize the following criteria: clinical findings (1 point each) including anorexia, nausea or vomiting, migration of pain to RLQ, fever $\geq 38.0\text{C}$, leukocytosis $>10,000$, and neutrophilia $>75\%$; and physical examination findings (2 points each) including RLQ tenderness to cough, percussion, or hopping, and tenderness over right iliac fossa. In AS, symptoms including anorexia, nausea or vomiting, migration of pain to RLQ; signs including of elevated temperature $\geq 37.3\text{C}$, rebound tenderness; and laboratory finding of neutrophils

>75% are scored 1 point each, while presence of RLQ tenderness and leukocytosis >10,000 are scored 2 points each. Obtaining a score of 7 to 10 in either PAS or AS indicates that AA is likely.

Patients with a probability of AA below the test threshold may be discharged without additional diagnostic tests. In contrast, those with a high probability above the treatment threshold may be treated with immediate appendectomy, and those who have an intermediate risk that is between the test and treatment thresholds may undergo imaging or further observation and monitoring.⁸ Imaging studies are usually performed to differentiate between AA and AMA, and AMA is a common finding in imaging studies for patients with clinical suspicion of AA.²

In both PAS and AS scoring systems, anorexia, vomiting, migration of pain to RLQ, and physical examination findings, such as abdominal guarding and direct and rebound tenderness, were all significantly associated with AA than AMA.^{2,6} Patients with AA also had significantly higher white blood cell (WBC) counts and C-reactive protein (CRP) levels.^{2,7} More common signs and symptoms in AMA include fever ranging between 38.0-38.5°C, changes in stool frequency and consistency, pain in the periumbilical region and RLQ, and tenderness in RLQ.^{6,7}

However, each scoring system has different sensitivity and specificity to diagnose acute appendicitis.¹ Some studies have shown that PAS was superior in diagnosing AA in the pediatric population than AS in terms of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy.⁵

A study by Kalu et al. showed that PAS has a sensitivity of 97.5%, specificity of 66.7%, PPV 97.5%, NPV of 66.7%, and diagnostic accuracy of 95.3%.¹⁴ A study by Peyvasteh, on the other hand, showed that AS has a sensitivity of 91.3%, PPV of 87.7%, and NPV of 51.2%.¹⁵ Higher AS scores have also been associated with more severe intra-operative findings and lower negative appendectomy rates.¹⁶ All patients with AS 7-10 had confirmed appendicitis according to histopathology.¹⁵

Significance of the Study

While the clinical diagnosis of AA is typically based on the patient's history, physical examination findings, and routine blood and urine analysis, the use of scoring systems, such as PAS and AS, can significantly enhance diagnostic accuracy. These systems, though not yet universally adopted, have the potential to guide physicians in determining the most appropriate management, thereby reducing the need for unnecessary surgical exploration and appendectomies.

Only patients with equivocal results based on the scoring systems undergo imaging studies to attain a final diagnosis. These procedures also significantly increase hospital costs, which can be a challenge to some patients especially in resource-limited areas.

Hence, this study aimed to identify clinical characteristics that can significantly differentiate AA from AMA and to promote the use of scoring systems for diagnosis and eventually avoid unnecessary surgical consultations and further imaging.

Objectives

General Objective

This study aimed to determine the diagnostic accuracy of PAS and AS among children and adolescents aged 5 to 18 years old diagnosed with AA and AMA at a tertiary hospital in Manila, Philippines from January 2018 to December 2023.

Specific Objectives

- To differentiate patients diagnosed with AA and AMA using clinical characteristics (history, physical examination), laboratory test results, and radiologic findings (e.g., abdominal ultrasound or CT scan)
- To differentiate patients diagnosed with AA and AMA using outcome (surgical or supportive) and histopathologic findings (if applicable)
- To differentiate the scoring risk stratification (PAS and AS) of patients diagnosed with AA and AMA (subgroup analysis)
- To compare the accuracy of clinical parameters, radiologic studies, and scoring systems (PAS and AS) in diagnosing AA and AMA in terms of sensitivity, specificity, PPV, and NPV (subgroup analysis)

Methodology

Study Design

This was a cross-sectional study. Chart review was performed to retrieve relevant clinical characteristics, including the patient's history, physical examination findings, laboratory test results, PAS and AS scores, and initial and final diagnoses. If PAS and AS scores were not indicated in the patient's records, they were calculated retrospectively.

Study Population and Setting

Children and adolescents aged 5 to 18 years old presenting to the emergency department of a tertiary hospital in Manila, Philippines with acute abdominal pain and initially diagnosed with AA or AMA from January 1, 2018 to December 31, 2023 were included in this study.

Inclusion and Exclusion Criteria

Patients included in this study were children and adolescents aged 5 to 18 years old presenting to the emergency department of a tertiary hospital in Manila, Philippines with acute abdominal pain and initially diagnosed with AA or AMA from January 1, 2018, to December 31, 2023.

Patients excluded in this study were those who came in the ER with imaging results before a clinical examination and diagnosis can be made, with known gastrointestinal diseases or previous abdominal surgeries, and with final diagnoses aside from AA or AMA.

Sampling Technique

This study utilized purposive sampling, wherein all eligible patients were included based on the inclusion criteria. A list of all eligible patients was obtained from the emergency department logbook and pediatric department census. Patients' charts were retrieved from the Medical Records section for review and data collection.

Sample Size Estimation

A minimum of 157 patients were required for this study based on 0.821 AUC value of PAS score in diagnosing AA in children.¹⁴ This computation also accounted for 5% level of significance and 12% desired width of the confidence interval.

Data Extraction

Data collection was performed by the principal investigator from June to September 2024. The following data were obtained from the hospital information system, medical charts, emergency department logbooks, and pediatric department census, and were recorded in Data Extraction Forms: age, sex, duration of abdominal pain, presence of URTI within the last 2 weeks prior consult or admission; symptoms including anorexia, nausea or vomiting, migration of pain to RLQ, signs including RLQ tenderness to cough, percussion, or hopping, tenderness over the right iliac fossa, and rebound tenderness; laboratory findings including WBC count and neutrophil percentage; PE findings including Rovsing sign, Psoas sign, Obturator sign, guarding; imaging findings (e.g., abdominal ultrasound, CT scan); outcomes including surgical or supportive management; histopathology findings (e.g., non-suppurative, suppurative, gangrenous, or perforated appendix); and PAS and AS scores.

Data Encodement

Data collected that were classified as demographic and clinical profile included numerical variables: age (years) and duration of abdominal pain (hours), and categorical variables: sex, presence of URTI within the last 2 weeks prior to consult or admission, symptoms including anorexia, nausea or vomiting, migration of pain to RLQ, signs including RLQ tenderness to cough, percussion, or hopping, tenderness over the right iliac fossa, and rebound tenderness; laboratory findings including WBC count and neutrophil percentage; PE findings including Rovsing sign, Psoas sign, Obturator sign, and guarding.

Outcomes of patients were classified as either surgical or supportive management, and histopathologic findings were classified into non-suppurative, suppurative, gangrenous, or perforated appendix. Abdominal ultrasound and CT scan findings were classified as either with or without radiologic diagnosis of AA or AMA. PAS and AS scores were obtained and stratified according to risk: PAS 1-3 (unlikely appendicitis), 4-6 (cannot definitely rule in or rule out appendicitis), 7-10 (likely appendicitis); AS 1-4 (unlikely appendicitis), 5-6 (possible appendicitis), 7-10 (likely appendicitis).

Table 1. Demographic and clinical profile of patients aged 5-18 years old diagnosed with AA and AMA at a tertiary hospital in Manila, Philippines from January 1, 2018 to December 31, 2023

Parameters	Total (N=157) Frequency (%)	AA (n=87, 55%) Frequency (%)	AMA (n=70, 45%) Frequency (%)	<i>p-value</i>
Age, years (mean ± SD)	12.2 ± 4.0	12.7 ± 4.2	11.6 ± 3.8	0.098
Age group				0.065
5 to 9 years old	49 (31.2)	25 (28.7)	24 (34.3)	
10 to 14 years old	57 (36.3)	27 (31.0)	30 (42.9)	
15 to 18 years old	51 (32.5)	35 (40.2)	16 (22.9)	
Sex				0.300
Male	70 (44.6)	42 (48.3)	28 (40.0)	
Female	87 (55.4)	45 (51.7)	42 (60.0)	
Duration of abdominal pain, hours (mean ± SD)	40.1 ± 41.5	38.5 ± 38.3	42.1 ± 45.4	0.594
URTI within last 2 weeks	42 (26.8)	12 (13.8)	30 (42.9)	< 0.001
PAS*/AS** components				
Symptoms				
Anorexia	70 (45.2)	40 (47.1)	30 (42.9)	0.601
Nausea or vomiting	92 (58.6)	52 (59.8)	40 (57.1)	0.740
Migration of pain to RLQ	68 (43.3)	45 (51.7)	23 (32.9)	0.018
Signs				
Fever	49 (31.2)	34 (39.1)	15 (21.4)	0.018
RLQ tenderness to cough, percussion, or hopping	148 (94.3)	85 (97.7)	63 (90.0)	0.079
Tenderness over the right iliac fossa*	67 (42.7)	55 (63.2)	12 (17.1)	< 0.001
Rebound tenderness**	74 (49.7)	51 (63.8)	23 (33.3)	< 0.001
Laboratory findings				
Leukocytosis				
WBC >10,000	119 (78.3)	80 (94.1)	39 (58.2)	< 0.001
WBC count (mean ± SD)	14.1 ± 4.8	15.6 ± 4.4	12.3 ± 4.7	< 0.001
Neutrophilia				
Neutrophils >75%	98 (64.5)	69 (81.2)	29 (43.3)	< 0.001
Neutrophil count (mean ± SD)	76.1 ± 14.4	82.1 ± 8.7	68.5 ± 16.4	< 0.001
Other signs:				
Rovsing sign	25 (16.7)	19 (22.9)	6 (9.0)	0.023
Psoas sign	41 (27.3)	27 (32.5)	14 (20.9)	0.141
Obturator sign	50 (33.3)	34 (41.0)	16 (23.9)	0.027
Guarding	32 (21.2)	24 (28.6)	8 (11.9)	0.013

Data Analysis

Descriptive statistics were used to summarize the demographic and clinical characteristics of the patients. Frequency and proportion were used for categorical variables, and mean and standard deviation (SD) were used for normally distributed continuous variables. Independent Sample T-test and Fisher's Exact/Chi-square test were used to determine the difference of mean and frequency, respectively, between patients with and without AA or AMA.

Subgroup analysis was done for patients with complete data for the components of PAS and AS scoring systems. The Area under the receiver operating characteristics (ROC) curve as well as its diagnostic parameters

determined the diagnostic accuracy of PAS and AS scoring systems to discriminate a clinical outcome, AA or AMA. All statistical tests were two tailed test. Shapiro-Wilk test was used to test the normality of the continuous variables. Missing values were neither replaced nor estimated. Null hypotheses was rejected at 0.05 α -level of significance. Microsoft Excel and STATA 13.1 were used for data management and analysis, respectively.

Ethical Issues

Prior to the conduct of this study, approval from the Institutional Review Board (IRB) and Ethics Committee was obtained. There were no foreseen ethical issues in the conduct of this study. Moreover, the principal investigator is Good Clinical Practice (GCP) certified.

Data collected from the chart review were stored on Google Drive, which only the principal investigator and research advisers had access to. Encoded data were stored in a password-protected laptop and were not printed nor distributed. Data was only shared with the statistician for data analysis. Completed forms will be kept in the online database for a maximum of 5 years from study completion and will then be deleted.

The principal investigator has no conflict of interest with any institution. There were no patient-related compensations, reimbursements, or entitlements.

Data Privacy

Permission to obtain and review patients' charts from the medical records was also obtained from the Medical Director, Medical Records Head, Data Privacy Officer, and Department of Pediatrics Chair.

Only the principal investigator and research advisers had access to the collected and encoded data that were stored on Google Drive. Privacy and confidentiality were ensured at all times. No personal identifiers such as name, date of consultation or admission, and patient number were recorded in the data collection forms. Instead, each patient was assigned a unique study code.

Results

A total of 259 pediatric patients presented to the emergency department of a tertiary hospital in Manila, Philippines with acute abdominal pain and were initially diagnosed with AA or AMA from January 1, 2018 to December 31, 2023. All patients were screened for eligibility. The following were excluded from the study: 4 who were aged <5 years old, 16 with no available medical records, 26 with no consent to use the information for research purposes, and 56 who had other final diagnoses (i.e., acid-related disease, urinary tract infection, acute gastroenteritis, food intolerance, functional constipation, or fecal stasis or impaction).

Among 157 patients included in the study, 87 (55%) had AA as the final diagnosis, and 70 (45%) had AMA (*Table 1*). Most patients were female (85%) and belonged to the 10-to-14-year-old age group (36.3%). Mean age of patients was 12.2 ± 4.0 years old (12.7 ± 4.2 for AA; 11.6 ± 3.8 for AMA). There was no significant difference in the duration of abdominal pain among patients with AA compared with those with AMA ($38.5 \pm$

38.3 vs 42.1 ± 45.4 hours; $p=0.594$). More patients with AMA had a history of URTI within the last 2 weeks (42.8% vs 13.8%; $p<0.001$).

The most common presenting signs and symptoms of patients with either AA or AMA were RLQ tenderness ($n=148$, 94.3%) and nausea or vomiting ($n=92$, 58.6%), respectively (Table 1). This study showed that the migration of pain to RLQ (51.7% vs 32.9%; $p=0.018$), fever (39.1% vs 21.4%; $p=0.018$), tenderness over the right iliac fossa (63.2% vs 17.1%; $p<0.001$), rebound tenderness (63.8% vs 33.3%; $p<0.001$), leukocytosis $>10,000$ (94.1% vs 58.2%; $p<0.001$), and neutrophilia $>75\%$ (81.2% vs 43.3%; $p<0.001$) were significantly associated with AA than AMA ($p < 0.05$). Mean WBC count was significantly higher among patients with AA than those with AMA (15.6 ± 4.4 vs 12.3 ± 4.7 ; $p < 0.001$). Mean neutrophil count was also significantly higher among patients with AA (82.1 ± 8.7 vs 68.5 ± 16.4 ; $p < 0.001$). Other physical examination findings significantly associated with AA than AMA were the Rovsing sign (22.9% vs 9.0%; $p=0.023$), Obturator sign (41.0% vs 23.9%; $p=0.027$), and guarding (28.6% vs 11.9%; $p=0.013$).

Table 2. PAS and AS risk stratification of patients aged 5-18 years old diagnosed with AA and AMA at a tertiary hospital in Manila, Philippines from January 1, 2018 to December 31, 2023

Scoring risk stratification	Total (N=142) Frequency (%)	AA (N=76, 54%) Frequency (%)	AMA (N=66, 46%) Frequency (%)	<i>p-value</i>
PAS score (mean ± SD)	5.82 ± 2.04	6.87 ± 1.78	4.62 ± 1.61	< 0.001
1-3	24 (16.9)	2 (2.6)	22 (33.3)	< 0.001
4-6	61 (43.0)	25 (32.9)	36 (54.6)	
7-10	57 (40.1)	49 (64.5)	8 (12.1)	
AS score (mean ± SD)	6.26 ± 1.97	7.16 ± 1.58	5.23 ± 1.87	< 0.001
1-4	13 (9.1)	0	13 (19.7)	< 0.001
5-6	58 (40.9)	28 (36.8)	30 (45.4)	
7-10	71 (50.0)	48 (63.2)	23 (34.9)	

Only 78 of 87 patients with AA and 62 of 70 with AMA had outcomes available in their medical records, hence eligible for the subgroup analysis. Nine patients with AA were excluded from the subgroup analysis for the following reasons: two discharged against medical advice (DAMA), four transferred to hospital of choice (THOC), and three with no operation record or histopathology report. Similarly, eight patients with AMA were excluded due to discharge against medical advice. Most patients with AA were found with a suppurative appendix (40.5%), followed by a ruptured appendix (25.3), gangrenous appendix (16.5%), congestive appendix (11.4%), and non-suppurative appendix (5.1%). All patients (100%) with AMA received only supportive management.

Among 87 patients with AA who underwent surgery, only 52 had available histopathology reports in their medical records. Most of them had findings consistent with the diagnosis of appendicitis: acute suppurative appendicitis with peri appendicitis (40.4%), acute gangrenous appendicitis with peri appendicitis (34.6%), acute congestive appendicitis with peri appendicitis (5.8%), and chronic appendicitis with peri appendicitis (3.8%). Eight patients (15.4%) were found to have lymphoid hyperplasia, which is usually seen in cases of AMA.

Of the 157 patients, 15 had incomplete data of the components for PAS and AS scoring systems, hence only 142 (76 AA, 66 AMA) were included in the subgroup analysis (Table 2). The missing components mainly were the presence or absence of rebound tenderness and CBC results. Compared to patients with AMA, those with AA had significantly higher mean PAS (6.87 ± 1.78 vs 4.62 ± 1.61 ; $p < 0.001$) and AS scores (7.16 ± 1.58 vs 5.23 ± 1.87 ; $p < 0.001$). The majority of patients with AA (64.5%) had PAS scores 7-10, while 54.6% of patients with AMA had PAS scores 4-6. Additionally, most patients with AA (63.2%) had AS scores 7-10, while 45.4% of patients with AMA (45.4%) had AS scores 5-6.

Table 3. Diagnostic accuracy of clinical parameters, radiologic findings, and scoring systems in differentiating AA and AMA among patients aged 5-18 years old at a tertiary hospital in Manila, Philippines from January 1, 2018 to December 31, 2023

	TP (n)	FP (n)	TN (n)	FN (n)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Clinical diagnosis (n=140)								
AA	56	17	46	21	72.7	73.0	76.7	68.7
AMA	33	10	67	30	52.4	87.0	76.7	69.1
Radiologic diagnosis (abdominal ultrasound or CT scan) (n=59)								
AA	18	2	1	3	85.7	33.3	90.0	25.0
AMA	23	1	5	6	79.3	83.3	95.8	45.5
Scoring system (n=125)								
PAS $\geq 7/10$ for AA	43	3	54	25	63.2	94.7	93.5	68.3
AS $\geq 7/10$ for AA	37	18	43	27	57.8	70.5	67.3	61.4

Among 140 patients (78 AA, 62 AMA) with outcomes available in their medical records, AA was the clinical diagnosis for 73 patients, 56 of whom had a final diagnosis of AA. In contrast, 17 had a final diagnosis of AMA based on surgical outcome and histopathology report (Table 3). On the other hand, AMA was the clinical diagnosis for 43 patients, 33 of whom had a final diagnosis of AA while 10 eventually underwent surgical management and had final diagnosis of AA based on the histopathology report. Clinical diagnosis of AA has higher sensitivity than that of AMA (72.7% vs 52.4%), but lower specificity (73.0% vs 87.0%).

Moreover, only 38% (59 of 157) of patients underwent additional radiologic imaging, 24 of whom had AA and 35 patients had AMA (AA: 1 had ultrasound, 23 had CT scan; AMA: 15 had ultrasound, 20 had CT scan) (Table 3). Among patients with AA, 20 had ultrasound or CT scan findings consistent with AA, while among patients with AMA, 24 had ultrasound and CT scan findings consistent with AMA. The most common ultrasound and CT scan findings among patients with AA were prominent-sized appendix ≥ 0.7 cm, fluid-filled appendix, presence of an enlarged base, periappendiceal fat stranding, or appendicolith. Among patients with AMA, multiple mesenteric lymph nodes in the RLQ, measuring 0.5 to 0.6cm, were noted in the imaging studies. Imaging evaluation improved the diagnostic sensitivity for both AA and AMA, 85.7% and 79.3%, respectively.

Among patients with PAS $\geq 7/10$ (n=46), 43 had a final diagnosis of AA, while among patients with AS $\geq 7/10$ (n=55), only 37 had a final diagnosis of AA (Table 3). PAS has higher diagnostic accuracy than AS for AA using

a cutoff of $\geq 7/10$ in terms of sensitivity (63.2% vs 57.8%), specificity (94.7% vs 70.5%), PPV (93.5% vs 67.3%), and NPV (68.3% vs 61.4%).

Figures 2 and 3 show the ROC curves for PAS (in blue) and AS (in red) scores in diagnosing AA and AMA, respectively. Among patients with AA, the PAS score has an area under the curve (AUC) of 0.8239, which indicates a good level of discrimination (closer to 1 is ideal). In contrast, the AS score has an AUC of 0.7668, which shows fair discrimination, though lower than the PAS score (Figure 1). Among patients with AMA, the PAS and AS scores have AUC of 0.1761 and 0.2332, respectively, which indicate a poor level of discrimination (Figure 2). The p-value of 0.049 suggests a statistically significant difference between the two scoring systems in the diagnosis of AA and AMA (Figures 2 and 3).

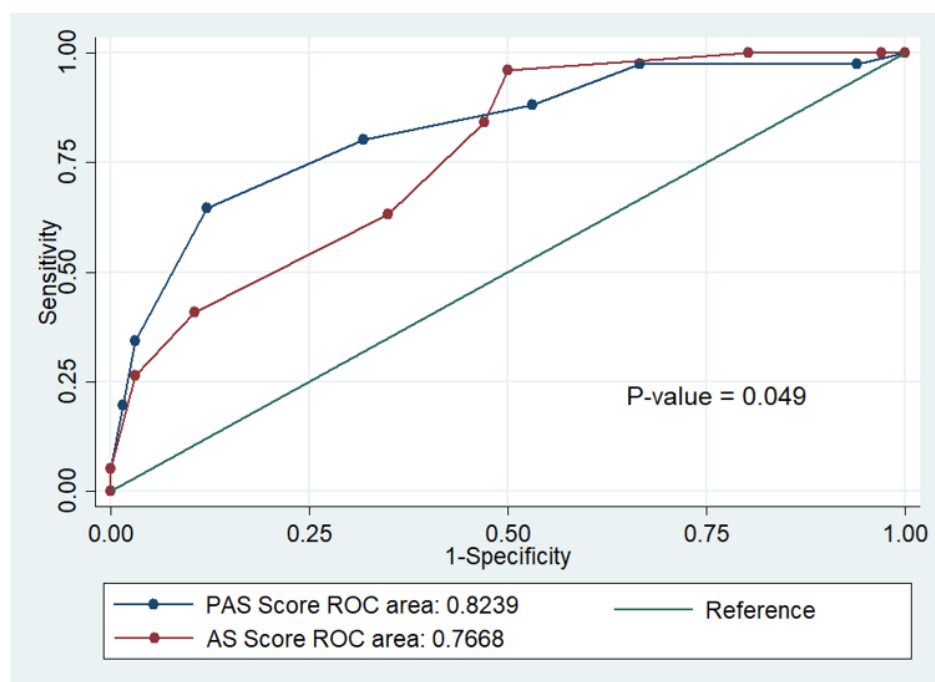


Figure 1. ROC cutoff point for diagnosis of AA using the PAS vs. AS scores among patients aged 5-18 years old at a tertiary hospital in Manila, Philippines from January 1, 2018 to December 31, 2023

Discussion

While the classic signs and symptoms of AA are only present in 60% to 70% of cases, and its clinical presentation is similar to that of AMA, the diagnosis of AA can be significantly improved with a thorough history and physical examination conducted by physicians.^{1,2,6,17}

In this study, most patients with AA were aged 10 to 14 years old (31.0%) and 15 to 18 years old (40.2%). This was consistent with the data of Hospital Discharges Registry of the Philippine Pediatric Society, which showed highest incidence of AA among children aged 10 to 14 years old and 15 to 18 years old.¹¹ History of recent URTI, within the past 2 weeks, was often seen in patients with AMA than those with AA (42.8% vs 13.8%; $p < 0.001$). The result of this study was similar to that of Pokhrel's study which showed that significantly more patients with AMA had history of URTI within the last 2 weeks (58.8% vs 97%, $p < 0.05$).¹

Similarly, other studies had also shown that the following signs and symptoms were significantly associated with AA than AMA: nausea (89.9% vs 65.8%, $p < 0.05$) or vomiting (61.8% vs 34.3%, $p < 0.05$), migration of pain to RLQ (87.1% vs 2.9%, $p < 0.05$), rebound tenderness (83.9% vs 5.9%, $p < 0.001$) and abdominal guarding (74.2% vs 17.6%, $p < 0.001$), and higher WBC counts (15.82 vs 10.16, $p < 0.001$) and percentage of neutrophils (78.90 vs 65.45, $p < 0.001$).^{1,2,6} Clinical diagnosis of AA has higher sensitivity than that of AMA (72.7% vs 52.4%), but lower specificity (73.0% vs 87.0%). Similarly, Toorenvliet et al showed sensitivity of 88% vs 21% and specificity of 83% vs 96%.²

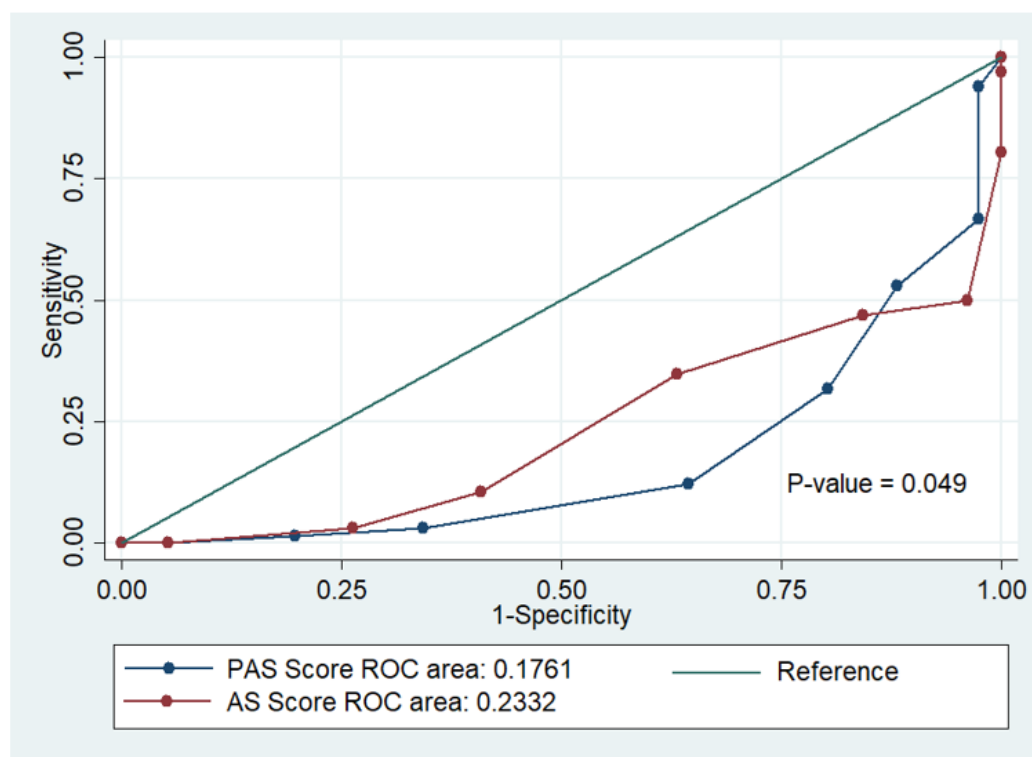


Figure 2. ROC cutoff point for diagnosis of AMA using the PAS vs. AS scores among patients aged 5-18 years old at a tertiary hospital in Manila, Philippines from January 1, 2018 to December 31, 2023

PAS and AS scoring systems are practical and reliable methods for diagnosing AA.¹⁷ These scoring systems, by effectively utilizing clinical history, physical examination, and laboratory test results to identify high-risk patients for surgical management, eventually prevent excessive or unwarranted use of ultrasound or CT scans, allow more rapid surgical evaluation among patients with suspected AA, and avoid the potential delay of management.^{3,4,18,19}

Imaging studies are not routinely done because they are costly and have been shown to add minimal information except for cases with complications.¹⁹⁻²¹ Imaging studies, although done on only 38% of the patients included in this study primarily due to financial constraints, showed an improvement in the diagnostic sensitivity for both AA and AMA to 85.7% and 79.3%, respectively. CT scan improves accuracy in diagnosing AA but also results in exposure to ionizing radiation. As a result, ultrasound has been utilized more frequently, but it also has limitations, including being operator-dependent.^{18-19,21}

Patients with AA had significantly higher mean PAS (6.87 ± 1.78 vs 4.62 ± 1.61 ; $p < 0.001$) and AS scores (7.16 ± 1.58 vs 5.23 ± 1.87 ; $p < 0.001$) than those with AMA. These results were similar to those of Mandeville's study, which showed mean PAS and AS scores of 7.6 and 7.2, respectively, among patients with AA, and 5.6 and 5.2, respectively, among patients with AMA ($p < 0.001$).¹⁸ Moreover, more patients with higher PAS and AS scores had a final diagnosis of AA.

In this study, PAS was shown to be superior to AS in diagnosing AA in the pediatric population with sensitivity 63.2% vs 57.8%, specificity 94.7% vs 70.5%, PPV 93.5% vs 67.3%, and NPV 68.3% vs 61.4% at cutoff of $\geq 7/10$. Other studies also had shown that PAS has sensitivity 90.0%-96.9%, specificity 70.0%-89.0%, PPV 77.0%-96.81%, and NPV 53.8%-94.0%, while AS has sensitivity 70.0-89.2%, specificity 42.9%-71.0%, PPV 81.0-95.1%, and NPV 33.3%-56.0%.^{1,2,5,22,23}

The ROC curves, shown in Figures 2 and 3, evaluate the diagnostic ability of PAS and AS scoring systems in distinguishing between AA and AMA by plotting sensitivity (true positive rate) against specificity (false positive rate). Both scoring systems have points above the reference line (green line), which indicates that they are better than random chance at predicting outcomes. Higher AUC values suggest better performance in distinguishing between AA and AMA. PAS has a higher AUC than the AS scoring system (0.8239 vs 0.7668; $p = 0.049$), which suggests better overall predictive accuracy in diagnosing AA. With a p-value of 0.049, PAS is statistically superior to AS in diagnosing AA (*Figure 1*).

Conclusion

The clinical diagnosis of AA is based on the patient's history, physical examination findings, and routine blood and urine analysis. Significant symptoms associated with AA included migration of pain to RLQ, fever, tenderness over the right iliac fossa, rebound tenderness, leukocytosis, and neutrophilia. Most patients with AA had a suppurative appendix.

Using either PAS or AS scoring systems increases diagnostic accuracy and guides physicians to determine appropriate management. Patients with AA had higher mean PAS and AS scores than those with AMA. PAS was statistically superior to AS in diagnosing AA in terms of sensitivity, specificity, PPV, and NPV. Routine use of PAS is recommended to avoid unnecessary surgical consultations and further imaging in the pediatric population.

Limitations and Recommendations

Retrospective medical record review was performed in this study, hence data gathered was based only on chart documentation, and incomplete documentation may have had an effect on the analysis of diagnostic accuracy of the two scoring systems. Other limitations of the study include use of a single center for data collection and relatively small sample size.

A prospective multicenter study with a larger number of patients is recommended to establish the generalizability of the findings from this study. Diagnostic accuracy of each clinical parameter may be obtained. Furthermore, an association of C-reactive protein (CRP) with diagnosis of AA and surgical outcome of patients with AA may also be included in other studies. Inflammatory markers such as WBC and CRP have been shown to aid in the diagnosis of AA.²⁴ CRP level of ≥ 40 is associated with suppurative appendicitis, while CRP 100 to 150 suggests possible perforated or gangrenous appendicitis.²⁵

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