

Accuracy of the Banjarmasin prediction score for appendicitis to differentiate complicated and non-complicated appendicitis

Hery Poerwosusanta, PhD¹, Redha Ramadhana Habiby, MD², Ika Kustiyah Oktaviyanti, PhD³, Tjahyo Kelono Utomo, MD⁴, Deddy Rasyidan Yulizar, MD⁵, Edi Hartoyo, PhD⁶

¹Pediatric Surgery Division, Department of Surgery, Faculty of Medicine, Lambung Mangkurat University/Ulin Hospital, Banjarmasin, Indonesia, ²Faculty of Medicine and Health, Lambung Mangkurat University, Banjarmasin, Indonesia, ³Department of Anatomical Pathology, Faculty of Medicine and Health, Lambung Mangkurat University, Banjarmasin, Indonesia, ⁴Department of Surgery, Digestive Surgery Division, Faculty of Medicine and Health, Lambung Mangkurat University, Banjarmasin, Indonesia, ⁵Department of Urology, Digestive Surgery Division, Faculty of Medicine and Health, Lambung Mangkurat University, Banjarmasin, Indonesia, ⁶Department of Pediatrics, Tropic Infection Division, Faculty of Medicine and Health, Lambung Mangkurat University, Banjarmasin, Indonesia

ABSTRACT

Introduction: Acute Appendicitis is typically felt in the right lower abdomen. Despite existing diagnostic methods to differentiate between complicated and non-complicated cases, achieving accurate diagnoses remains challenging. This study highlights the need for a reliable diagnostic tool to improve patient outcomes and inform surgical strategies, demonstrating the accuracy of the Banjarmasin Prediction Score for Appendicitis (BPSA).

Materials and Methods: This observational cross-sectional study involved patients diagnosed with acute Appendicitis at Ulin, Sultan Suriansyah, and Damanhuri Hospital in Banjarmasin, Indonesia. Data were collected through consecutive sampling and analysed using SPSS to ensure robust findings. The collected data were then compared between complicated and non-complicated appendicitis cases to evaluate the diagnostic accuracy of the BPSA and Alvarado scores.

Results: Among the 62 cases evaluated, 28 were classified as non-complicated and 34 as complicated Appendicitis. The BPSA showed a sensitivity of 71.4% and a specificity of 70.6%. The Alvarado score demonstrated lower sensitivity but a higher specificity of 79.4%. There was no significant difference in the Alvarado score ($P > 0.05$), while the BPSA score revealed a significant difference ($P < 0.05$) between complicated and non-complicated Appendicitis. Variations in histamine levels were also noted ($P = 0.002$), further underscoring the efficacy of the BPSA scoring system.

Conclusion: The Alvarado score is key for diagnosing acute Appendicitis, and the BPSA score helps differentiate between complicated and non-complicated cases, enhancing treatment strategies. The study's limitation was confined to a single region and a relatively small sample size, which may affect the generalisability of the findings.

KEYWORDS:

Appendicitis, BPSA Scoring, Alvarado score, Diagnostic tool, Accuracy

INTRODUCTION

Acute abdomen cases account for 7-10% of emergency department visits, with acute Appendicitis being the most common cause. Its prevalence in developed countries is 5 to 50 cases per 100,000 individuals annually, mainly affecting those aged 10 to 30. Appendiceal perforation occurs in 40% of cases, especially in adolescents and individuals over 50.¹ Non-complicated Appendicitis involves mucosal inflammation, while complicated Appendicitis includes perforation and abscess formation, increasing the risk of morbidity and mortality.¹⁻³

The incidence rate of Appendicitis in Indonesia was 134 per 100,000 population. The Indonesian Department of Health reveals that Appendicitis is the fourth most common infectious disease in Indonesia, with 28,949 inpatients and 34,386 outpatients.⁴ Often reported as a typical surgical emergency in Southeast Asia, Appendicitis remains a significant health concern across the region. Understanding its presentation in different local settings is, therefore, essential for optimising care. In Johor, Malaysia, Batu Pahat is the second largest city after Johor Bahru, with a population exceeding 400,000 people. The district Hospital Sultanah Nora Ismail (HSNI) has a total of 1,200 emergency surgeries. About 1/6 of emergency cases are related to appendicitis.⁵

Various scoring systems are used for diagnosing Appendicitis, each with different accuracy: the Alvarado score (24% sensitivity, 97% specificity), the Appendicitis Inflammatory Response Score (AIRS) (22% sensitivity, 97% specificity), and the Adult Appendicitis Score (AAS) (53% sensitivity, 93% specificity). These scores' positive predictive value (PPV) ranges from 81% to 82%, but negative appendectomy rates remain high at 18%-19%. Ultrasonography is limited in distinguishing between non-complicated and complicated Appendicitis, showing 81.1% sensitivity and 56.6% specificity.^{6,7} Current scoring systems cannot differentiate between the two types with different treatment strategies.⁸

This article was accepted: 09 October 2025

Corresponding Author: Redha Ramadhana Habiby

Email: redha.ramadhana@gmail.com

Table I: The Alvarado and The Banjarmasin Prediction Score for Appendicitis (BPSA) Score

	Alvarado Score	Banjarmasin Prediction Score for Appendicitis (BPSA)
Migration or relocation of pain from paraumbilical to the right lower quadrant	1	1
Anorexia	1	1
Nausea/vomiting	1	1
Right Lower Quadrant Pain	2	2
Rebound pain	1	1
Increase the temperature > 37,50 C	1	1
Leukocytosis	2	1
Leukocyte shift to the left (>75% neutrophil)	1	1
Neutrophil Lymphocyte Ratio (NLR) > 3	-	1
Free fluid on Ultrasound	-	2
Histamine level > 1 ng/ml	-	1
TOTAL SCORE	10	13

Table II: Bi-variate Analysis Table (Difference Test) between 2 groups

Variable	Complicated Appendicitis (n = 28)	Non-complicated Appendicitis (n = 34)	p-value
Alvarado score, mean (±SD)	7.82 (±1.18)	7.44 (±1.40)	0.987a
BPSA score, mean (±SD)	10.21 (±1.57)	8.65 (±1.70)	0.009a*
Histamine level, mean (±SD)	64.99 (±43.34)	34.89(±34.83)	0.002 a*
Leucocyte, mean (±SD)	16,436.43 (±6,930.98)	13,725.59 (±4,468.32)	0.081 b
NLR, mean (±SD)	12.11 (±8.85)	7.16 (±4.84)	0.012 b*

BPSA = Banjarmasin Prediction Score for Appendicitis; NLR = Neutrophyl-Lympocyt Ratio
 a = Mann-Whitney test; b = T-independent Test; c Categorical data
 *Significance if p-value <0.05

Table III: Bivariate Analysis of Observation groups in the logistic regression test

Variable	Complicated Appendicitis (n = 28)	Non-Complicated Appendicitis (n = 34)	Complicated Appendicitis Crude POR (95%CI)	p-value
Alvarado score, mean (±SD)	7.82 (±1.18)	7.44 (±1.40)	1.260 (0.845-1,879)	0.256
BPSA score, mean (±SD)	10.21 (±1.57)	8,65 (±1.70)	1.831 (1.252-2.678)	0.002*
Histamine level, mean (±SD)	64.99 (±43.34)	34.89(±34.83)	1.000 (0.964-0.995)	0.009*
Leucocyte, mean (±SD)	16.436.43 (±6.930.98)	13.725.59 (±4.468.32)	1.000 (1.000-1.000)	0.075
NLR, mean (±SD)	12.11 (±8.85)	7.16 (±4.84)	1.115 (1.023-1.215)	0,014*

BPSA = Banjarmasin Prediction Score for Appendicitis; NLR = Neutrophyl-Lympocyt Ratio
 *Significance if p-value <0.05

The study aims to demonstrate that combining Alvarado and BPSA scoring can effectively predict and differentiate between non-complicated and complicated appendicitis stages.

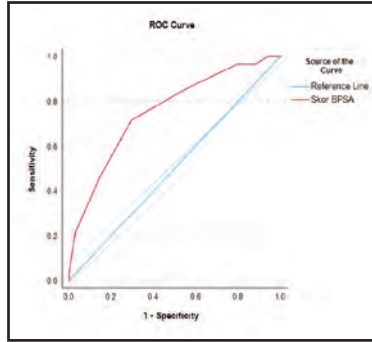
MATERIALS AND METHODS

This observational cross-sectional study evaluates how clinical findings, scoring systems, inflammatory markers, histamine levels, ultrasound results, surgical findings, and anatomical pathology effectively differentiate between non-complicated and complicated Appendicitis. The study included patients aged five and older with acute Appendicitis at Ulin, Sultan Suryansyah, and Damanhuri Hospitals in Banjarmasin, Indonesia. We analysed secondary data without intervention, excluding pregnant patients and those with non-assessable appendices, autoimmune diseases, comorbidities, malignancies, or chronic conditions.

Patients were selected using consecutive sampling, in which all eligible subjects presenting during the study period and meeting the inclusion and exclusion criteria were enrolled

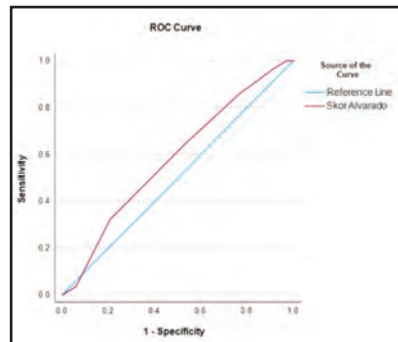
until the required sample size was reached. This method was chosen to ensure feasibility within the available study period, minimise selection bias by including every eligible patient in sequence, and reflect the real-world distribution of cases in the participating hospitals. The minimum sample size was calculated based on a cross-sectional study design, resulting in 23 subjects per group.⁹

All acute Appendicitis patients underwent evaluation based on clinical signs, scoring systems, laboratory markers, ultrasound findings, histamine levels, and surgical results. The Alvarado and BPSA scoring considered indicators such as pain migration, anorexia, nausea/vomiting, right lower quadrant pain, rebound tenderness, fever (temperature > 37.5°C), leucocytosis, a left shift in leukocyte count (>75% neutrophils), a neutrophil-to-lymphocyte ratio (NLR) > 3, fluid accumulation on Ultrasound, and blood histamine levels > 1 ng/ml (Table I). A radiology specialist performed the Ultrasound using standardised hospital protocols to minimise variability. To control potential observer bias, all Ultrasound findings were reviewed and confirmed by a senior



Positive if Greater Than or Equal To a	Sensitivity	1-Specificity	Specificity	Youden index
4:00	1.000	1.000	0.000	0.000
5:50	1.000	.941	0.059	0.059
6:50	0.964	.882	0.118	0.082
7:50	0.964	.794	0.206	0.170
8:50	0.857	.559	0.441	0.298
9:50	0.714	.294	0.706	0.420
10:50	0.464	.147	0.853	0.317
11:50	0.214	.029	0.971	0.185
12:50	0.036	.000	1.000	0.036
14:00	0.000	.000	1.000	0.000

Fig. 1: A. BPSA Sensitivity Curve. B. Sensitivity and Specificity of BPSA Score. The cut-off point for the area under the curve (AUC) is recorded in the table above. This conversion is based on the Youden Index. The highest value obtained is 0.42. The sensitivity of the BPSA score test is 71.4%, while its specificity is 70.6%.



Positive if Greater Than or Equal To a	Sensitivity	1 - Specificity	Specificity	Youden Index
3.00	1	1	0.000	0.000
4.50	1	0.971	0.029	0.029
5.50	0.964	0.912	0.088	0.052
6.50	0.857	0.765	0.235	0.092
7.50	0.643	0.529	0.471	0.114
8.50	0.321	0.206	0.794	0.115
9.50	0.036	0.059	0.941	-0.023
11.00	0	0	1.000	0.000

Fig. 2: A. Alvarado Sensitivity Curve. B. Sensitivity and Specificity of Alvarado Score. The cut point of the area under the curve (AUC) is obtained in the table above with a conversion of the Youden Index. The highest value obtained is 0.115. The sensitivity value of the Alvarado score test is 32.1%, and its specificity is 79.4%

radiology specialist who was not involved in the initial scan and was blinded to the patient's histamine results and surgical findings. Histamine levels were measured in patient serum using the FineTest® Human Histamine ELISA Kit (Cat. No.: EH2552).¹⁰

Data analysis was used for SPSS version 26.0, reporting as frequencies and percentages for categorical data and as

means and standard deviations for numerical data. We assessed data distribution using the Kolmogorov-Smirnov test and one-way ANOVA, Levene's test for homogeneity. For non-normally distributed data, we applied transformations with power transformations (exponents more significant than 1), inverse, log10, and square root to correct non-normality and non-homogeneity. The Bivariate Analysis difference test used the Mann-Whitney and Independent T-

test, and the logistic regression test results show a statistically significant relationship between the components of the BPSA scoring. The ROC curve was utilised to assess sensitivity and specificity. Data were transformed using the Youden index table, seeking the highest cut-off value.¹¹

RESULTS

Subject Characteristics

This study analyses 62 cases of Appendicitis, including 28 complicated and 34 non-complicated cases. The gender distribution shows 34 males and 28 females, reflecting a balanced ratio. Patients' ages range from 5 to 67 years, with an average of 30. Most cases were treated in major hospitals in Banjarmasin, Indonesia: Ulin (37 patients), Damanhuri (24 patients), and Sultan Suriansyah (1 patient). Four patients were excluded due to positive pregnancy tests.

Comparison Test

Statistical comparison showed no significant difference in Alvarado scores between complicated and non-complicated appendicitis. In contrast, the BPSA score, histamine levels, and NLR were significantly higher in complicated cases (Table II). These findings are critical for enhancing diagnostic criteria and treatment strategies.

The logistic regression test results show a statistically significant relationship between the components of the BPSA scoring, which causes a substantial difference between complicated and non-complicated Appendicitis, with a possibility of 1.831 times greater. Histamine level ($p=0.009$) is the most influential component in distinguishing the two types of Appendicitis (Table III).

BPSA Score Sensitivity and Specificity Test

The area under the curve established a cut-off value of 0.42 (Figure 1). The BPSA scoring demonstrated a sensitivity of 71.4% and a specificity of 70.6% (Table IV), highlighting an impressive capacity for accurate identification. (95% CI : 1,252-2,678)

Alvarado Score Sensitivity and Specificity Test

The area under the curve cut-off value was determined to be 0.115 (Figure 2). The Alvarado scoring demonstrated a sensitivity of 32.1% and a specificity of 79.4% (Table 5). This strong performance underscores the reliability of the Alvarado score in clinical assessments. (95% CI : 0,845-1,879)

DISCUSSION

The BPSA score significantly outperforms the Alvarado score regarding sensitivity, boasting a rate of 71.4% compared to just 31.2%. The heightened sensitivity makes it especially adept at detecting complicated Appendicitis, an area where the Alvarado score often falls short, leading to a concerning number of false negatives. The key to the BPSA's effectiveness is incorporating vital parameters, including the Neutrophil-to-Lymphocyte Ratio, Histamine levels, and free fluid observed in ultrasound imaging. Despite its limitations, the Alvarado score holds a notable advantage in specificity, with rates of 79.4% versus 70.6%. This higher specificity is crucial for accurately identifying non-complicated Appendicitis,

enhancing the negative rate. Therefore, while the Alvarado score remains necessary for diagnosing Appendicitis, it should be seamlessly paired with the BPSA score to classify cases as complicated or non-complicated accurately. Using both scores strategically can influence patient management, guiding therapeutic decisions, incision designs, and choices between minimally invasive or conventional surgery. This scoring system is vital in optimising postoperative care and improving patient outcomes.⁶

Previous studies indicate that NLR values greater than 7, mainly those exceeding 12, can effectively differentiate between complicated and non-complicated cases. The immunological response to perforation is both aggressive and systemic. Neutrophils, as innate immune system components, work to eliminate bacteria. In contrast, lymphocytes, part of the adaptive immune system, tend to decrease in circulation as they migrate to infected tissues. Overall, NLR serves as an easily applicable parameter.¹²⁻¹⁴

Supported by Camacho-Cruz et al. and Sahbaz et al., this study concluded that leucocyte counts do not significantly differentiate between complicated and non-complicated Appendicitis. Additionally, the ratios of neutrophils showed no significant difference between the two groups. Therefore, leucocyte and neutrophil counts cannot be relied upon as diagnostic tests for acute Appendicitis. Elevated leucocyte levels are non-specific, exhibit low sensitivity, and may also increase in other infections, failing to distinguish between complicated and non-complicated Appendicitis.^{15,16} Another study corroborated these results, indicating that higher leucocyte counts were significant in patients with complicated Appendicitis. An increased leucocyte count is often observed in complicated and uncomplicated Appendicitis. That is because individual differences in immune responses, influenced by factors like age, immune status, and the duration of symptoms, cause WBC counts to fail to differentiate the sensitivity and specificity to distinguish between the degree of Appendicitis. They need other parameters to reveal Appendicitis.^{15,17}

Several studies have shown varying sensitivity and specificity of Ultrasound. Identifying the appendix in non-complicated Appendicitis is often a challenge. Free fluid on Ultrasound is an accurate indicator of complicated Appendicitis.⁶

Research demonstrates that mastocytosis and mast cell degranulation can differentiate between complicated and uncomplicated Appendicitis, consistent with our findings of higher levels in complicated cases. Mast cells interact with the enteric nervous system via the production of nerve growth factor (NGF) and promote inflammation, potentially accelerating progression to perforated Appendicitis.¹⁸ While direct mast cell analysis cannot occur pre-surgery, histamine—chiefly produced by these cells—can serve as a valuable alternative for pre-surgical assessment. These inflammatory processes help explain the superior sensitivity and specificity of the BPSA score observed in our study.¹⁹

This study had several limitations. It was conducted in a single region, which may limit its generalizability. The sample size was relatively small, and there was no blinding

in the assessment process, introducing potential observer bias. In addition, possible variability in laboratory measurements could have influenced the results. For future research with larger samples across multiple centres, applying blinding protocols and standardising laboratory methods are essential to strengthen the findings and ensure the reliability of BPSA scoring.

CONCLUSION

The Alvarado score is crucial for diagnosing acute Appendicitis, followed by the BPSA score to differentiate between complicated and uncomplicated Appendicitis, paving the way for improved treatment and management strategies. Clinically, this combination can improve decision-making for surgical intervention and reduce unnecessary delays. Future research should involve larger, more diverse, multicentre populations to validate these findings and assess the consistency of BPSA performance. Further studies comparing BPSA with other diagnostic scores, such as AIRS and AAS, are also warranted to establish its relative diagnostic accuracy.

ACKNOWLEDGMENTS

We thank all patients and families for their study participation, especially Mohammad Bakhriansyah, MD, M.Kes., M.Med.Ed., M.Sc., PhD, and Angga Setya Budi, MD, for improving the manuscript.

ETHICAL APPROVAL

The Commission of Health Research Ethics, the Faculty of Medicine and Health, Universitas Lambung Mangkurat, Banjarmasin, Indonesia, declared this study ethically feasible. (No. 031/KEPK-FK ULM/EC/II/2023)

REFERENCES

- Di Saverio S, Podda M, De Simone B, Ceresoli M, Augustin G, Gori A, et al. Diagnosis and treatment of acute appendicitis: 2020 update of the WSES Jerusalem guidelines. *World J Emerg Surg* 2020; 15: 32.
- Atema JJ, Van Rossem CC, Leeuwenburgh MM, Stoker J, Boermeester MA. Scoring system to distinguish uncomplicated from complicated acute appendicitis. *Br J Surg* 2015; 102(8): 979-90.
- Nanjundaiah N, Mohammed A, Shanbhag V. A comparative study of RIPASA score and Alvarado score in the diagnosis of acute appendicitis. *J Clini Diagn Res.* 2014; 8(11): NC03-5.
- Salim J, Agustina F, Maker JJR. Pre-Coronavirus disease 2019 pediatric acute appendicitis: risk factors model and diagnosis modality in a developing low-income country. *Pediatr Gastroenterol Hepatol Nutr* 2022; 25(1): 30-40.
- Bahari NB, Salekan K, Shariffuddin FNA, Misni MN, Bahari NB, Abu Bakar H, et al. Incidence of retrocaecal acute appendicitis at the Hospital Sultanah Nora Ismail (HSNI) Batu Pahat. *Batu Pahat*; 2021 Mar.
- Bom WJ, Scheijmans JCG, Salminen P, Boermeester MA. Diagnosis of uncomplicated and complicated appendicitis in adults. *Scand J Surg* 2021; 110(2): 170-9.
- Frountzas M, Stergios K, Kopsini D, Schizas D, Kontzoglou K, Toutouzias K. Alvarado or RIPASA score for diagnosis of acute appendicitis? A meta-analysis of randomized trials. *Int J Surg* 2018; 56: 307-14.
- Yazar AS, Erdoğan S, Şahin C, Güven Ş. Reliability of ultrasonography and the Alvarado scoring system in acute appendicitis. *Turk J Pediatr* 2018; 60(2): 173-9.
- Bujang MA, Sapri FE. An application of the runs test to test for randomness of observations obtained from a clinical survey in an ordered population. *Malays J Med Sci* 2018; 25: 146-51.
- Wuhan Fine Biotech Co., Ltd. FineTest Human Histamine ELISA Kit [Internet]. Wuhan: Fine Biotech; [cited 2025 Aug 15]. Available from: <https://www.fn-test.com>
- Poerwosusanta H, Gunadi, Noor Z, Oktaviyanti IK, Mintaroem K, Pardjianto B, et al. The effect of laparoscopy on mast cell degranulation and mesothelium thickness in rats. *BMC Surg* 2020; 20: 133.
- Zhang Q, Zhao H, Wang F, Li W, Zhang P. Diagnostic value of laboratory parameters for complicated appendicitis: a two-center study. *Biomed Rep* 2024; 20(5): 44.
- Mekrugsakit N, Tullavardhana T. The Value of Complete Blood Count Parameters in predicting complicated acute appendicitis: a prognostic accuracy study. *Arch Acad Emerg Med.* 2023;11(1).
- Hajibandeh S, Hajibandeh S, Hobbs N, Mansour M. Neutrophil-to-lymphocyte ratio predicts acute appendicitis and distinguishes between complicated and uncomplicated appendicitis: a systematic review and meta-analysis. *Am J Surg* 2020; 219(1): 154-63.
- Camacho-Cruz J, Padilla PO, Sánchez DG, Mongui DM, Hoyos LK, Porras ML, et al. Outcomes of acute appendicitis in patients younger than age 4: a descriptive study. *Ann Pediatr Surg* 2022; 18: 48.
- Şahbaz NA, Bat O, Kaya B, Ulukent SC, İlkgül Öz, Özgün MY, et al. Lökosit sayısı ve nötrofil oranlarının non-komplike apandisit tanısında ve komplike apandisitlerin belirlenmesinde klinik önemi. *Ulus Travma Acil Cerrahi Derg* 2014; 20(6): 423-6.
- Lobo S, Felizes A, Nogueira P, Gonçalves M. Can C-reactive protein and white blood cell count predict complicated appendicitis in children? *Int Surg* 2023; 107(1): 38-42.
- Poerwosusanta H, Gunadi G, Gunawan P, Fauzi AR, Budi AS, Poerwosusanta AR, et al. Mast cell essential roles: will it be a novel tool for differentiating the severity of pediatric appendicitis? *Open Access Maced J Med Sci.* 2022; 10(A): 812-6.
- Arredondo Montero J, Rico-Jiménez M, Pérez Riveros BP, Fernández Atuan R, Pakkasjärvi N, Krishnan N, et al. Role of type I hypersensitivity reaction in the development of overall and uncomplicated acute appendicitis: a systematic review and meta-analysis. *Curr Probl Surg.* 2024; 61(3): 101816.