

# The Evaluation of the Sensitivity and Specificity of Ultrasound Examination in Patients With Suspected Acute Appendicitis

Ana Majdawati<sup>1,\*</sup> I Gusti Ayu Putri Anom Sari<sup>2</sup>

<sup>1</sup>Radiology Department of Medical Study Program, Faculty of Medicine Health Sciences, Universitas Muhammadiyah Yogyakarta, Gd. Siti Walidah LT. 3 Kampus Terpadu UMY

<sup>2</sup>The student in Faculty of Medicine Health Sciences, Universitas Muhammadiyah Yogyakarta

\*Ana Majdawati. Email: ana.majdawati@umy.ac.id

## ABSTRACT

**Background:** Acute Appendicitis is inflammation of the appendix, which manifests as pain in the lower right abdomen that can develop into an acute abdomen. This situation can end in the emergency room and require immediate surgical treatment. Ultrasound is the initial choice most often used for the diagnosis of Appendicitis as well as determining whether surgery is needed. **Objective:** To identify the sensitivity and specificity of ultrasound as an imaging modality for the diagnosis of Acute Appendicitis at PKU Muhammadiyah Gamping Hospital in Yogyakarta. The results of this diagnostic test are essential to be used as an evaluation of the radiology skills, the ultrasound modalities used in health services, as well as being useful for improvement. **Method:** This research study is a diagnostic test of ultrasound of suspected Acute Appendicitis with a gold standard. The result emerged from the histopathological tissue from the appendectomy. The research subjects consisted of 72 suspected Appendicitis subjected to ultrasound and continued with appendectomy and histopathological in 2014 - 2017. The sensitivity and specificity values of the ultrasound were calculated, which were useful for evaluating diagnostic services at PKU Muhammadiyah Gamping Hospital, Yogyakarta. **Results:** The number of study subjects was 72, with positive ultrasound results of 52 and a negative ultrasound of 20 samples. The 52 respondents with positive ultrasound consisted of 25 adults and 27 children dominated by males. Twenty samples with negative ultrasound results consisted of 9 adults and 11 children dominated by females. The results of sensitivity and specificity values of ultrasound were 82.7%, 33.33%, and 53% of accuracy. The results of this value can be used as an evaluation of ultrasound in cases of Acute Appendicitis in PKU Muhammadiyah Gamping Hospital, Yogyakarta in Indonesia. **Conclusion:** Ultrasound has a good sensitivity value for the diagnosis of Acute Appendicitis. However, it has a low specificity value. It shows that the ultrasound can be used as a modality for diagnosing Acute Appendicitis, which has a role in screening the diagnosis. Ultrasound cannot be used as a screening for suspected patients with Acute Appendicitis who are entirely normal or in good condition. It will be the researchers' evaluation of the cause of the low specificity value to improve the diagnosis of suspected Appendicitis.

**Keywords:** Acute Appendicitis, ultrasound, sensitivity, specificity, accuracy, histopathology

## 1. INTRODUCTION

Appendicitis is inflammation of the inner lining of the appendix vermiformis and can spread to surrounding organs. Acute Appendicitis is the most common type and requires emergency abdominal surgery. The incidence of acute Appendicitis in lifelong individuals is 7-8% (1.2).

The clinical symptoms of acute Appendicitis begin with severe pain in the lower right abdomen with symptoms of nausea, vomiting, and fever. Patients will experience symptoms improvement of about 80% in less than 48 hours. If the symptoms do not improve more than that duration, it can be suspected of complications in the form of perforation. Patients who have experienced this condition will be taken to the hospital emergency room for an appendectomy (3).

Appendicitis is the most common surgical case. 40% of the emergency cases in the field of abdominal surgery are appendectomy. Appendectomy shows a negative result around 10.6%, especially in women due to the lower right abdominal pain involving gynecological organs. The pain often leads to disorders such as cases of adnexitis, ectopic pregnancy, and tubal ovarian abscess (4). This case was also usually found at PKU Muhammadiyah Hospital, where the researcher worked. The number of cases of acute appendicitis suspected of having an ultrasound examination was an average of 2-3 cases/day or 720 cases/year, 50% of which is abdominal surgery.

In identifying whether appendectomy is needed, several examinations are necessary to be conducted to diagnose acute appendicitis. The examinations are essential to determine the severity of appendicitis or complications occurred (5). Ultrasonography is one of the imaging

modalities of the last decade widely used with a variety of considerations that ultrasound is an accessible, mobile, non-invasive, and relatively inexpensive examination. Although it is known that ultrasound has lower sensitivity and specificity values than CT-Scan, this tool is preferred as it has several advantages, as mentioned previously (6-9). Several studies that have been carried out show the results of ultrasound diagnostic tests as a diagnostic modality for acute appendicitis, which has values that vary from low to high, namely sensitivity and specificity of 60-95%. As it depends on many factors that influence, the researchers would like to conduct this research to obtain an essential diagnostic value used as an evaluation to make improvements to the factors, especially in radiology services at PKU Muhammadiyah Gamping Hospital, Yogyakarta, Indonesia (6, 9,10).

## 2. MATERIAL AND METHOD

This study utilized a diagnostic test design of the ultrasound compared to the results of the histopathological examination as a gold standard by determining the sensitivity and specificity values using a 2x2 table. The data used were secondary data taken at PKU Muhammadiyah Gamping Hospital, Yogyakarta Indonesia.

Inclusion criteria in this study were patients with clinical Appendicitis of all ages whose histopathological and ultrasound results were both positive and negative. Meanwhile, the exclusion criteria were no available ultrasound or histopathological data, both in the medical record and a picture of the disease other than acute Appendicitis. Examples of excluded diseases are malignancy, gynecological disease, infection of other organs, or the presence of diseases of the urinary system.

Research subjects who met the inclusion and exclusion criteria were 72, with a percentage of 40 males and 32 females. The dominant age group was 4-10 years old, who were 28 patients in this study. Samples obtained were grouped into a positive histopathological result and a negative histopathological result and positive ultrasound and negative ultrasound with detailed ultrasound criteria as follows: 1). lumen diameter > 6mm, 2). Lack of compressibility, 3). thickening of the appendix wall, 4). appendicolith, 5). increasing blood flow in the appendix wall on Doppler staining, 6). peri-enteric hyperechoic fat, 7). caecum wall thickening > 5mm, 8). hyperechoic mucosa and muscular layer of the appendix lumen, 9). extra-luminal appendicolith, and 10). free fluid around the appendix.

A positive ultrasound result would be shown if there were at least 2 of the criteria above, with the mandatory criterion no. 1 or 2. Meanwhile, the negative ultrasound result was shown if no results were found that met the criteria mentioned above or if the appendix could not be visualized, and there were no other diseases. The histopathological criteria were as follow; histopathology is considered positive if one of the criteria is obtained, namely edema and appendix wall congestion, polymorphonuclear neutrophil infiltration (PNI), transmural (either limited by mucosa or already penetrating the epithelium), and intramural abscess

or granulocyte cell congestion. Furthermore, it is considered negative if one of the criteria is found, that will be categorized as another appendix abnormality, namely fibrous obliteration, and lymphoid hyperplasia.

The determination of the sample based on the data in the medical record of the ultrasound and histopathological examination was carried out by radiology and histopathology specialists with a kappa value of > 7, respectively, and utilized interobserver assessment methods. The ultrasound examiner and histopathology were separated from each other and had no connection (blinding).

The independent variables in this study were positive and negative ultrasound results. Meanwhile, the dependent variables were positive histopathological results and negative histopathology results. Upon the data collection, the characteristics of the sample data was grouped. The criteria for diagnostic test variables were consolidated into a 2x2 table and was proceeded to calculate the sensitivity and specificity values according to the applicable formula.

## 3. SAMPLE SIZE OF THE RESEARCH

$$n = Z_{\alpha/2} \text{ Sen } (1 - \text{sen}) = 1,962 \times 0.75 \times 0.25$$

$$d2P = 0,102 \times 0.0001$$

$$= 72,03$$

$$= 72 \text{ samples}$$

### 3.1. Research Result

The results were obtained from secondary medical record data from 72 suspected Appendicitis that met the inclusion and exclusion criteria in 2014-2017 at PKU Muhammadiyah Gamping Hospital, Yogyakarta, Indonesia. Medical record data contained ultrasound results with several assessment criteria and appendectomy histopathology results. Some of the data obtained are shown in tables 1, 2, 3, and 4 below.

**Table 1.** Primary Data of Research Subjects

No	Information	Frequency / amount		p value
		account	percentage	
1	Gender			
	Male	38	52,78 %	P. 0,000
	Female	34	47,22%	
2	Age			
	Adult (> 18 years)	25	34,72%	P. 0,939
	Children (<18 years)	47	65,28%	
3	The Ultrasound Result			

Positive Ultrasound	52	72,22%	<i>P.</i> 0,213
	29	40,28%	
- Male	11	15,28%	
- Female	18	25,00%	
	23	31,94%	
- Male	18	25%	
- Female	5	6,94%	
Negative Ultrasound	20	27,78%	<i>P.</i> 0,213
	9	12,50%	
- Male	4	5,56%	
- Female	5	6,94%	
	11	15,28%	
- Male	5	6,95%	
- Female	6	8,33%	

**Table 2. Results of Ultrasound Examination**

No	Information	Frequency / amount	
		number	percentage
1	Positive ultrasound	52	73,24%
	- Lumen diameter > 6 mm	18	25,35%
	- Lumen diameter > 6 mm; lack of compressibility	19	26,76%
	- Lumen diameter > 6 mm; thickening of the appendix wall	3	4,22%
	- Lumen diameter > 6 mm; appendicolith	1	1,41%
	- Lumen diameter > 6 mm; pericentric hyperechoic fat	3	4,22%
	- Lumen diameter > 6 mm; hyperechoic mucosa and lumen muscle layer	4	5,63%
	- Lumen diameter > 6 mm; free fluid around the appendix	4	5,63%
2	Negative ultrasound	20	26,76%
	- The unvisualized appendix	20	26,7%

**Table 3. Results of Histopathological Examination**

No	Information	Frequency / amount	
		number	percentage
Histopathology results			
	Positive histopathology	30	41,67 %
	- edema / congestion	25	
	- PMN infiltrate	29	
	- Intramural abscess	2	
	- A granulocyte cell	15	
	Negative histopathology	42	58,33 %
	- Fibrous obliteration	14	
	- Lymphoid hyperplasia	28	

**Table 4. Ultrasound Examination Diagnostic Test Results With Histopathological Examination**

No	Examination Category	Estimation (95% CI), %		
		Sensitivity	Specificity	Accuracy
1	Ultrasound for Acute Appendicitis	82,7%	33,33%	53%

In this study, a total of 72 sample data consisted of 38 males (52,78%) and 34 females (47,22%). Based on age groups, the age of children (< 18 years) is 47 (65,28%) and adult (> 18 years) is 25 (34,72%) (Table 1). Table 1 shows that there is a significant relationship between gender and histopathology of Acute Appendicitis ( $p: 0,000$ ). The age of Appendicitis was not significantly related to histopathology results ( $p: 0,939$ ). Based on the ultrasound results, the most common image findings widened of the lumen diameter > 6mm (25,35%), and lack of compressibility (26,76%). Positive ultrasound was found in 52 (73.24%), while negative ultrasound was 20 (26,76%) (Table 2). There was no significant relationship between the results of the ultrasound and the results of histopathology (Table 1).

In the 30 positive histopathology results (41,67%), the most common features are PMN infiltrates, which showed 29 (96,67%) and edema, which showed 25 (82.7%). The most common negative histopathological picture found was lymphoid hyperplasia (66.67%) (Table 3). The ultrasound diagnostic test results compared to the results of the histopathological examination showed that the sensitivity was 82.7%, specificity was 33.33%, and accuracy was 53% (table 4).

## 4. DISCUSSION

In this study, positive ultrasound data were more common in males than females. Some references mention that epidemiologically the incidence of Acute Appendicitis is more common in males who are less than 14 years old. Ultrasound results are more sensitive to identify appendix inflammation in children (5,8,12). This study revealed that appendicitis mostly occurred at the children's age. It is in line with the results of other studies showing that the incidence of Appendicitis mainly occurred in the children's period ranging from 10 to 18 years old (9).

Negative ultrasound results are more common in female patients, especially children. This incident is related to the anatomical structure of the female organs showing that there are gynecological and urinary organs, namely the ureter, in the lower right quadrant area. The risk of urinary tract infections (UTI) in women manifests as pain from the ureter occurring in the right lower quadrant of the abdomen (11,13).

The positive histopathology results showed that a considerable amount of PMN infiltration and edema cells were found in males. In terms of pathophysiology and anatomical location, the nature of the male appendix is longer and located in the pelvis; thus, the appendix is easily inflamed due to obstruction, which results in acute inflammation. Reactions in the form of edema and infiltration of PMN cells into tissues and mucosa are the initial reaction forms of infection and inhibition of the appendix lumen (14).

Meanwhile, the negative histopathology results showed that lymphoid hyperplasia was more dominant in pediatric patients, both female and male. It is related to the nature of the children's appendix, where the amount of lymphoid in the appendix is considerable until the age of adolescence and the body's immune system in children prone to disease. Inflammation of the appendix causes enlarging lymphoid organs (12,14,15).

82.7% of sensitivity shows that the ability of ultrasound in diagnosing acute suspected Appendicitis in patients is good. It indicates that the ultrasound device can differentiate appendix inflammation with the criteria mentioned above in patients experiencing pain and lower right abdominal pain caused by Acute Appendicitis. The sensitivity of a diagnostic test is influenced by several factors, such as well-trained operators, operators' sufficient experiences in handling cases, the quality of ultrasound modalities, patients' conditions such as obesity, poor patient coordination due to pain that disrupts the examination, the presence of air around the appendix that interferes with appendix visualization, as well as appendix location (6, 7,16). The sensitivity value in this study is quite good (82.7%), which is indicated by the appendix diameter > 6 mm and the lack of compressible, which has a high percentage of positive ultrasound results followed by the results of histopathology. Ultrasound examination is a first-line diagnostic examination in suspected Appendicitis in children (17).

The specificity value of 33.33% indicates that the ability of the ultrasound device to detect acute Appendicitis in healthy or asymptomatic patients is poor. This small value of specificity increases the incidence of false negatives and requires careful consideration from PKU Muhammadiyah Gamping Hospital, Yogyakarta, Indonesia. An evaluation needs to be carried out to identify the most significant causal factors to be followed up with improvements that will give a good specificity value. Some references mentioning the increasing values of ultrasound sensitivity, specificity, and accuracy are greatly influenced by the skills of the examiner. Furthermore, the ultrasound examiner is greatly influenced by the examination techniques that not all of them can practice properly. Some of the methods utilized are gradual compression techniques, especially in the hidden appendix position and the condition of patients with the abdominal thickness that interferes with the examination (obesity) (5).

The low specificity and accuracy in this study can also be caused by patients' factors. 50% of the study sample is the age of the children period, where ultrasound examination in children requires different techniques. Children tend to be less cooperative; thus, the examiner often has difficulty in conducting an ultrasound examination with the recommended procedures to be able to visualize the appendix accurately. The examiner or radiologist is recommended to conduct ultrasound technique training, for instance, paying attention to the high-frequency transducer used, which is linear with a frequency of 7-10 MHz. Besides, other training programs can be in the form of positioning the patient correctly, for instance, supine and left lateral decubitus position, conducting ultrasound technique with multilevel compression and manual posterior compression, managing proper patient preparation, including filling the bladder, making the pediatric patients calm and comfortable (18, 19).

In addition to the factors mentioned above, the other critical factor is the availability of adequate ultrasonography tools for ultrasound Appendicitis. It is manifested in a device with proper specifications, a high-frequency transducer, as well as a comfortable and friendly ultrasound space, especially for children.

## 5. CONCLUSION

Based on the data of the research, it can be concluded that the sensitivity, specificity, and accuracy of USG from 72 data from PKU Muhammadiyah Gamping Hospital, Yogyakarta, Indonesia, were 82.7%, 33.33%, and 53%, respectively. USG sensitivity showed a good value and the ability to enforce acute appendicitis. Meanwhile, the specificity of USG in this study showed a low value, which indicated that ultrasonography at PKU Muhammadiyah Gamping hospital could increase the incidence of false-negative in diagnosing acute appendicitis in healthy or asymptomatic patients. Compared to the sensitivity value, the low specificity value was caused by several false negatives that cannot be controlled, namely patients' factors (calming pediatric patients with good cooperation between

radiologists and parents), specialized and trained techniques from radiologists in ultrasound examination in children, a comfortable and friendly examination room for pediatric patients, and a suitable ultrasound device with a high-frequency transducer. The evaluation conducted by the researchers during this study could contribute and evaluate the improvement of radiology services for patients, especially for Appendicitis cases.

## AUTHORS' CONTRIBUTIONS

First author data collection, makes statistical analysis, and prepare manuscripts, the second author preparation and licensing of hospital data retrieval, data collection and data entry

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## REFERENCES

- [1]. Sandy, C. & Barry E, B. Appendicitis: Practice Essentials, Background, Anatomy. (2015).
- [2]. Gomes, C. A. et al. Acute Appendicitis: proposal of a new comprehensive grading system based on clinical, imaging, and laparoscopic findings. World journal of emergency surgery. 2015; WJES 10, 60.
- [3]. Zarandi, N. P. & al, P. et. Accuracy of Surgeon's Intraoperative Diagnosis of Acute Appendicitis, Compared with the Histopathology Results. Bull Emerg Trauma. 2015; 22, 15–2115.
- [4]. Shrestha, R., Ranabhat, S.R., Tiwari, M. Histopathologic analysis of appendectomy specimens. Journal of Pathology of Nepal. 2012; Vol 2, 215-219.
- [5]. Most beck, G. et al. How to diagnose acute appendicitis: ultrasound first. Insights into Imaging. 2015; 7, 255–263.
- [6]. Subash, K. C., De, A., Pathak, M. & Sathian, B. Diagnostic Role of Ultrasonography in Acute Appendicitis: A Study at a Tertiary Care Hospital. American Journal of Public Health Research. 2015; 23–28 (2015).
- [7]. George, T., N, R. B. K., Thomas, P. T. & George, T. Reliability of ultrasonography in the diagnosis of acute Appendicitis. 2016; 3, 59–61.
- [8]. Jade, R. & Muddebihal, U. M. Modified Alvarado Score and its Application in the Diagnosis of Acute Appendicitis. International Journal of Contemporary Medical Research. 2016; 343, 2393–915.
- [9]. Shrestha A, Khadka H, Poudel B, Basnet RB, Basnet SB. Accuracy of Ultrasound in the Diagnosis of Acute Appendicitis and Correlation with Histopathology. Nepalese Journal of Radiology. 2018; 8(2):13–9.
- [10]. Prasad V.N, Chhetri P.K. Ultrasonography in Acute Appendicitis. Journal of College of Medical Science-Nepal. 2017; 13(1): 203-206.
- [11]. Lin, K. et al. Epidemiology and socioeconomic features of Appendicitis in Taiwan: a 12-year population-based study. World Journal of Emergency Surgery 1–13 (2015). DOI:10.1186/s13017-015-0036-3.
- [12]. Almaramhy, H. H. Acute Appendicitis in young children less than 5 years : a review article. Italian Journal of Pediatrics 1–9 (2017). DOI:10.1186/s13052-017-0335-2.
- [13]. Mardan M.A.A, Mufti T.S, Khattak I.U, Chilkunda N, Alshayeb A.A, Mohammad A.M, et al. Role of Ultrasound in Acute Appendicitis. J Ayub Med Coll Abbottabad. Jul-Sep 2007;19(3):72-9.
- [14]. Yadav, D. D. H., Kulkarni, D. M. P., Sulhyan, D.. K. R. & Barodawala, D. S. M. Histopathological Study of Lesions of the Appendix. International Journal of Health Sciences and Research, 2017; 7: 90–95.
- [15]. Elfaedy O, Benkhadoura M, Elshaikhy A, Elgazwi K. Impact of routine histopathological examination of appendectomy specimens on patient management: a study of 4012 appendectomy specimens. Turkish Journal of Surgery. 2019; 35(3):196–201.
- [16]. Mynalli S, Biradar BN, Braggs AV, Basti RS. Combined Use of High-Resolution Ultrasonography and Ripasa Score in Acute Appendicitis to Reduce Negative Appendectomy Rate. 2018;3(1):5.
- [17]. Khan U, Kitar M, Krichen I, Maazoun K, Ali Althobaiti R, Khalif M, et al. To determine the validity of ultrasound in predicting acute Appendicitis among children keeping histopathology as a gold standard. Annals of Medicine and Surgery. 2019;38:22–7.
- [18]. Reddan T, Corness J, Harden F, Mengersen K. Improving the value of ultrasound in children with suspected appendicitis: a prospective study integrating secondary sonographic signs. 2019; Ultrasonography 38(1).
- [19]. Reddan T, Corness J, Harden F, Mengersen K, Harden F. Ultrasound of pediatric appendicitis and its secondary sonographic signs: providing a more meaningful finding. 2016; 59 J Med Radiat Sci 63.
- [20]. Sayed A.O, Zeidan N.S, Fahmy H.A. Diagnostic reliability of pediatric appendicitis score, ultrasound, and low dose computed tomography scan in children with suspected acute appendicitis. Therapeutics and Clinical Risk Management 2017; 13 847–854.