

Reliability of Ultrasound for Diagnosis of Appendicitis in Children

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How to cite this article:

Harati M, Khalili M, Mohajerzadeh L, Sarafi M, Rafiei Tabatabaei S. Reliability of Ultrasound for Diagnosis of Appendicitis in Children. Iranian Journal of Pediatric Surgery 2022; 8 (2): 133 - 143.

DOI: <https://doi.org/10.22037/irjps.v8i2.38946>

Abstract

Introduction: In the medical world, acute appendicitis is one of the common surgeries. The Aim of this study is determining reliability of ultrasound in acute appendicitis.

Materials and Methods: The ethical code has been gotten in this research firstly .Based on the archives at Mofid Hospital, the list of appendectomy children in a six- months period has been extracted when they used the ultrasound prior to surgery. Demographic data, medical history and findings of appendicitis, even during the surgery, have been recorded using designed questionnaire based on patients' documents. According to the surgeon report, not only have appendicitis patients been operated but also confirmed.

The ultrasound results have been compared with surgical results (as the gold standard). For each of the ultrasound findings, based on SPSS software as has used for analyzing, some parameters have been calculated such as sensitivity index, specificity, positive and negative predictive value, accuracy and area under the ROC curve.

Results: In this study, 111 children with diagnosis of appendicitis have been operated. Based on the ultrasound prior to surgery, 71 patients (64%) with purulent appendicitis showed direct sonographic signs of appendicitis, 11 patients (9.9%) showed indirect signs, 6 patients (5.4%) revealed complicated signs, 7 patients (6.3%) with mesenteric lymphadenopathy and 16 patients (14.4%) negative in ultrasound. Also, according to the final diagnosis after surgery, 105 patients (94.6%) had appendicitis and 6 people (5.4%) were negative for appendicitis. The significant relationship was found between the ultrasound results prior to surgery and the final diagnosis after surgery for patients ($p < 0.05$). The diagnostic value of ultrasound results prior to surgery in order to determine the appendicitis in children undergoing surgery has been revealed by different factors such as sensitivity, specificity, positive predictive value, negative predictive value and accuracy. These factors are at 83.8%, 100%, 100%, 83% and 92.3%, respectively ($p < 0.05$).

Keywords

- Ultrasound
- Appendicitis
- Child

Conclusion: It seems that Ultrasound prior to surgery is the useful method to determine the children appendicitis.

Introduction

Ultrasound technique is usually used to diagnose the appendicitis. Based on different studies, this device has a sensitivity around 71.2% to 99% and specificity in the range of 91.3% to 98.2%. In case of the suspected children by appendicitis, ultrasound is not only cost-effective, but it has been completely diagnostic for this acute disorder, and it has been cited as the first diagnostic method, but its use shouldn't delay the patient's treatment.¹ However, CT scan provides more accurate diagnostic information about acute appendicitis rather than ultrasound with respect to the much higher negative predictive value. In terms of radiation risk especially in children, CT scan has placed the second diagnostic modality after ultrasound.²⁻⁷ In fact, the risks of radiation on children are reported to be almost ten times in comparison with adults.⁸ In addition, MRI is another method to assess and diagnose as used for children based on the literature so accuracy level is same as CT scan.⁹ Also, MRI shows more positive predictive value rather than CT scan with high level of accuracy.¹⁰ It is worth noting that, it is not possible to observe the location of appendicitis in 30-

53% of MRI in children, but the negative predictive value of this method is still reported at the high percentage 99% to 100%.¹¹⁻¹⁴ Ultrasound is still emphasized as an available modality with high diagnostic capability in emergency because of method cost and lack of portable access by MRI. Acute appendicitis is a common surgical emergency disease, so accurate diagnosis helps to reduce the mortality of complications, also during the corona epidemic, the correct diagnosis of appendicitis is a very valuable factor and this issue has been well done regarding the background, therefore based on the literature review, the aim of this study is to investigate the reliability of ultrasound to identify the children appendicitis at Mofid Hospital in Tehran. In this research, the following are examined.

Materials and Methods

In this cross-sectional study, the sampling method was the census technique; the list of appendectomy has been extracted during a six- months period at Mofid Hospital in Tehran for children under ultrasound test before surgery. Positive ultrasound finding appendicitis have been divided into three

groups such as direct sign, indirect sign (table 1) and complicated appendicitis, including phlegmon, abscess and peritonitis. Furthermore, other findings were mesenteric lymphadenopathy and normal ultrasound. Demographic data, medical history and findings of appendicitis even during the surgery have been recorded using designed questionnaire based on patients' documents. According to the surgeon report, not only all appendicitis patients have been operated but also confirmed. The ultrasound results have compared with

surgical results (as the gold standard). SPSS software has used for analyzing and some parameters have calculated such as sensitivity index, specificity, positive and negative predictive value, accuracy and area under the ROC curve. In order to compare the qualitative variables, Chi-square test and Fisher's exact test has used by two groups. In this study, Receiver Operative Characteristics analysis (ROC) has applied. In this context, the diagnostic value has determined, and the sensitivity and specificity has also reported ($P < 0.05$).

Table 1: ultrasound findings of appendicitis

Direct	Indirect/ secondary
*Closed loop observation as incompressible *Target sign without peristalsis *Appendicolith *Dilated tubular Lesion(6mm<)	*Pericecal fat and Prominent Echogenic periappendiceal fat *Free fluid

Results

In this study, 111 children with diagnosis of appendicitis have operated by surgeon. All patients were more than 5 years old 66 boys (60%) and 45 girls (40%). **Figure 1**

shows the maximum prevalence around 100 to 150 months (35.1%). Ultrasound was positive for 88 patients (79.3%) when 71 patients (64%) with direct sonographic

signs, 11 patients (9.9%) with indirect signs and 6 patients (5.4%) with complication signs, phlegmon, abscess, etc. Furthermore, 7 patients (6.3%) with mesenteric lymphadenopathy and 16 patients (14.4%) as normal have reported prior to surgery (See **Table 2**). After surgery, based on the final diagnosis, 105 patients (94.6%) had appendicitis and 6 patients (5.4%) had negative appendicitis. Among 6 patients with negative appendicitis, 4 patients had normal

preoperative ultrasound and 2 patients had mesenteric lymphadenopathy that have reported in **Table 3**. The diagnostic value of ultrasound results prior to surgery in order to determine the appendicitis in children undergoing surgery has revealed by different factors such as sensitivity, specificity, positive predictive value, negative predictive value and accuracy. These factors are at 83.8%, 100%, 100%, 83% and 92.3%, respectively ($p < 0.05$).

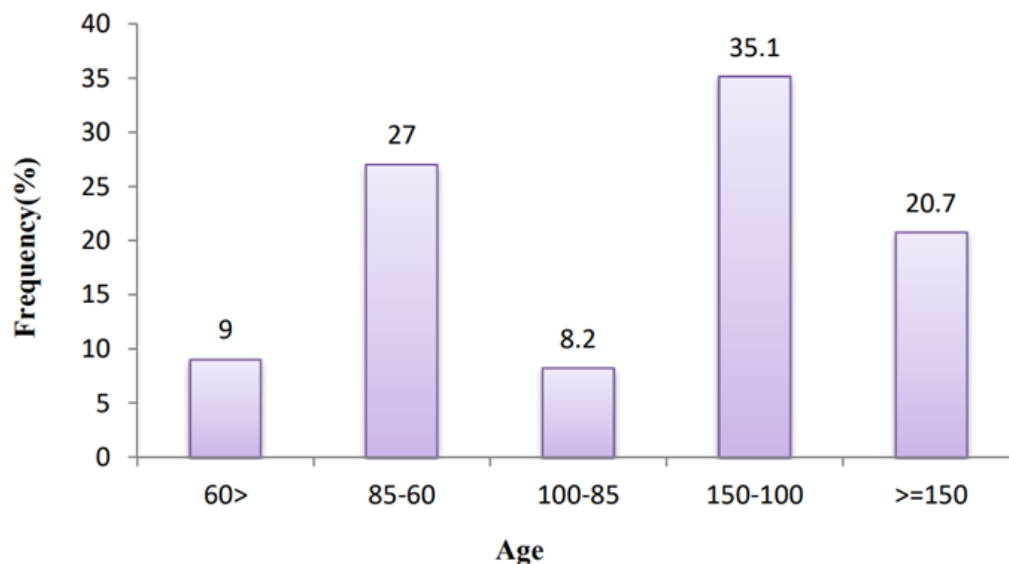


Figure 1: Distributed of the Patient's age during the study

Table 2: Ultrasound results prior to surgery for patients

Ultrasound prior to surgery	Frequency	Percentage
Direct	71	64
Indirect	11	9.9
Complicated appendicitis	6	5.4
Mesenteric lymphadenopathy	7	6.3
Negative appendicitis	16	14.4

Table 3: Frequency value and Comparison of ultrasound results for prior to and after surgery

Results prior to surgery	Final diagnosis after surgery		p-value
	Negative appendicitis	Positive appendicitis	
Direct	0 (0%)	71 (67.6%)	< 0.001
Indirect	0 (0%)	11 (10.5%)	
Complicated appendicitis	0 (0%)	6 (5.7%)	
Mesenteric lymphadenopathy	2 (33.3%)	5 (4.8%)	
Negative appendicitis	4 (66.7%)	12 (11.4%)	

Based on patient's result as distributed in **Table 3**, there is a significant relationship

between the results of ultrasound before surgery and the final diagnosis after surgery ($p < 0.05$).

Table 4: Determination of diagnostic value and sensitivity value, specificity, positive and negative predictive value, accuracy and curve area under the ROC for Preoperative ultrasound results in the diagnosis of appendicitis in children under surgery.

Sensitivity	Specificity	Accuracy	Negative predictive value	Positive predictive value	Curve area ROC	p-value
83.8%	100%	84.7%	83%	100%	0.919	< 0.001

As can be seen in **Table 4**, the diagnostic value of ultrasound results prior to surgery is a significant factor to diagnose

appendicitis in children undergoing appendicitis surgery ($p < 0.05$).

Discussion

A significant relationship has been found between the ultrasound results prior to surgery and the final diagnosis after patient's surgery. The diagnostic value of ultrasound results prior to surgery with sensitivity, specificity, positive predictive value, negative predictive value and accuracy is 83.8%, 100%, 100%, 83.1%, 92.3% respectively in order to determine appendicitis in children undergoing surgery.

In this study, both factors such as sensitivity and specificity show the in good agreement with the results as obtained in other studies and indicate that ultrasound specificity impact is higher than sensitivity. Also, most of the patients had direct

ultrasound sign (64%). Direct ultrasound signs have the highest sensitivity and specificity in comparison with to other categories. Moreover, if the ultrasound is positive, it is completely a positive predictive value with 100% and indicates the presence of appendicitis. overall, it seems Ultrasound is so useful prior to the surgery. Limchareon et al on 2014 evaluated 428 patients with suspicious appendicitis who undergone ultrasound exam. The appendix was identified in 270/428 cases (63.1%). The overall sensitivity was 71.2%, specificity 97.7%, positive predictive value 88.1%, negative predictive value 93.4%, accuracy 92.6%. The specificity (47.1%), negative

predictive value (61.5%), and accuracy (76.3%) were significantly lower in patients undergone surgery. The efficacy of US between the sexes and age groups showed no significant difference, except the lower positive predictive values in the younger age group. They found that the effectiveness of ultrasound for the diagnosis of appendicitis in children is high enough so used as a first-choice imaging method to reduce some indexes such as complications, hospitalization and negative appendectomy rates. In this study only direct signs of appendicitis in ultrasound were evaluated and secondary signs or complicated cases were not considered.¹⁵ Kitar et al on 2019 also was at good agreement with the present study. They understood that the acute appendicitis can diagnose in children using ultrasound method usefully and accurately that leads to a significant reduction of negative appendectomy without increasing the number of CT scans.¹⁶ Pedram et al. (2019), was successful to study evaluation of the diagnostic accuracy of ultrasound in children's acute appendicitis. Based on their findings, sensitivity 58% and specificity 68% in ultrasound technique has exposed. The positive and negative

predictive values were 77% and 46%, respectively. Moreover, curve area was 0.853, which indicates a moderate accuracy for test.¹⁷ Furthermore, Ghani et al on 2022 also shows the convergence study as well. One hundred children with suspected appendicitis under ultrasound has been tested, 23 children had appendectomy. Based on pathology, appendicitis has confirmed in 20 cases. In general, ultrasound had sensitivity 74% and specificity 92%.¹⁸ In other study, Ashjaei et al on 2022 also demonstrate the convergence results with this research, 108 children between 1-15 years old suspected appendicitis were enrolled in the study, based on sonographic findings, 67.7% had appendicitis criteria, 13.9% had perforated appendicitis and 18.5% had normal appendix. On the other hand, there were acute appendicitis in 63.9% of patients, perforated appendicitis in 12% and normal appendix in 8.3% in surgical reports. Sensitivity of incompressible appendicitis, appendicolith, maximal outer diameter (MOD) above 6 mm, round (target) appendix was 98.68%, 28.04%, 94.74%, 68.42%, respectively. Specificity of incompressible appendicitis, appendicolith, MOD above 6 mm, round

appendix was 64.71%, 96.15%, 64.71%, and 94.12%, respectively. Overall sensitivity and specificity of US in appendicitis were 97.56% and 69.23%, respectively.¹⁹ Finally, according to the findings in this study and previous studies, it seems to be that using ultrasound before surgery is useful and beneficial in order to determine children appendicitis.

Conclusion

In our study diagnostic value of ultrasound prior to surgery is high especially for specificity and positive predictive which are the highest in comparison to other studies.

According to above findings ultrasound is a useful method to determine appendicitis in suspected cases in pediatric.

Ethical Consideration

This study was approved by Institutional Ethics Committee of Shahid Beheshti University of Medical Sciences and the approval ID is IR.SBMU.MSP.REC.1401.17.

Acknowledgment

Not Applicable

Funding/Support

Not Applicable

Conflict of interests

There are no conflicts of interest.

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