International Journal of PharmTech Research
CODEN (USA): IJPRIF, ISSN: 0974-4304, ISSN(Online): 2455-9563
Vol.12, No.04, pp 70-76, 2019

Accuracy of Findings of Ultrasound (USG) Examination in Pediatric Patients with suspected Appendicitis with Intraoperative Findings

Hari Irawan[1]*, Erjan Fikri[2], Elvita Rahmi Daulay[3]

[1]Department of Surgery, Faculty of Medicine University of Sumatera Utara/ Haji Adam Malik Hospital-Medan, Indonesia
[2]Division of Pediatric Surgery, Department of Surgery, Faculty of Medicine University of Sumatera Utara/ Haji Adam Malik Hospital-Medan, Indonesia
[3]Department of Radiology, Faculty of Medicine University of Sumatera Utara/ Haji Adam Malik Hospital-Medan, Indonesia

Abstract : Background & Objectives: Unspecified lower abdominal pain might confuse clinicians in diagnosing pediatric appendicitis. Ultrasonography, as an initial affordable tool, has been learned its role in reducing unnecessary appendectomy. This study aimed to determine the accuracy of ultrasonography in pediatric acute appendicitis and its correlation to intraoperative findings, confirmed by histopathology results. The result would verify other study experience.

Methods : The study was a diagnostic study which retrospectively review the children who underwent an ultrasound study for suspected appendicitis in pediatric surgery division of Haji Adam Malik Hospital and Universitas Sumatera Utara Hospital, Medan, North Sumatera between January 2014 until March 2019. We determined the accuracy along with sensitivity and specificity results of Ultrasonography (USG) using calculated formula. The comparation between ultrasonography results and intraoperative findings was analyzed using Chi Square test or its alternative.

Results : Among the 32 patients, male and female were almost equal in 1:1 ratio, with mean age of 14.06 (±3.98) years old. Twenty-six patients were positively diagnosed as appendicitis using ultrasonography. Only two patients have no appendicitis based on intraoperative findings, confirmed by histopathology results. There is a statistically significant difference between ultrasonography findings and histopathology results (p=0,03). We obtained the accuracy of ultrasonography in predicting appendicitis was 87.5%, with 86.7% sensitivity and 100% specificity.

Conclusion : Our results compare favorably with alternative studies, however indicate the potential for improvement in accuracy of image, with a future study incorporating new ways of categorizing ultrasound findings presently being undertaken.

Hari Irawan *et al* /International Journal of PharmTech Research, 2019,12(4): 70-76.

DOI: http://dx.doi.org/10.20902/IJPTR.2019.120410

Introduction

The diagnosis of acute lower abdominal pain in children in children is a challenge for the surgeon. Acute appendicitis is the most common cause of acute abdomen. Diseases similar to acute appendicitis are acute gastrointestinal and gynecological diseases. This paper reviews the ultrasound findings of acute appendicitis in children with a focus on imaging instructions for specific diagnoses. This has an impact on diagnostic accuracy and intraoperative management.

In the pediatric population, appendicitis is the most frequent in the second decade and rarely occurs in children under the age of 2 years (Sivit CJ; 2004). The classic clinical presentation is the onset of acute abdominal pain originating from the periumbilical region and migrating to the right lower quadrant. Abdominal distention and tenderness in the abdomen can be found if there is obstruction or intestinal perforation. About one third of children with appendicitis have atypical clinical signs and symptoms (Kaneko K; 2004). In adolescent women, in particular, gynecological disorders can cause acute lower abdominal pain that resembles appendicitis.

Ultrasonography is the imaging modality most often used in the evaluation of children suspected of appendicitis. The importance of ultrasonography in the management of appendicitis in children is able to help distinguish appendicitis from other abdominal and pelvic abnormalities that resemble appendicitis (Sivit CJ; 2001). About a quarter to one-third of children referred for sonographic evaluation of suspected appendicitis will have the condition and a quarter to a third of children will have another diagnosis, usually gastrointestinal and gynecological diseases, which are found on ultrasonography (Siegel MJ; 1991). Many children These children, nearly one third to half, will experience abdominal pain disappearing before a specific diagnosis is made (Sivit CJ; 2001). Other intra-abdominal diseases with acute appendicitis are gastroinestinal diseases and acute gynecological abnormalities (Siegel; 1991). Thus, the entire abdomen and pelvis should be examined in children who have a normal graded compression check from the right lower quadrant and there is no evidence of appendicitis by ultrasonography.

Other supportive examination of the abdomen, which is simple, but rarely can diagnose appendicitis. Its main role is to assess the potential complications associated with acute inflammation, namely intestinal obstruction and perforation.

Computed Tomography (CT) scans play a role in obese patients and they complain of abdominal pain that cannot tolerate compression-graded sonographic techniques. CT scan is also useful in patients with suspected perforated appendicitis and periappendiceal abscess, because it helps to make a diagnosis and determine whether percutaneous abscess drainage can be done safely. There is agreement that imaging techniques improve both of these clinical scenarios, because of the potential for early diagnosis and high sensitivity (CT, MRI) and specificity (USG, CT, MRI) (Humes DJ; 2006).

A recent study showed that increasing pre-operative imaging use in patients with acute appendicitis saves costs and reduces Negative Appendectomy Rate (NAR) (Boonstra; 2014).

Poortman et al. Conducted a research at the Department of Surgery, St. Elisabeth Hospital Tilburg, Tilburg, Netherlands in 2009 recommending a diagnostic model of graded compression USG appendicitis as the initial imaging modality followed by CT scan examination. This model was applied to a relatively small group of patients in this study, it was found that ultrasound examination dramatically increased sensitivity (100%), specificity (85%), and accuracy (92%), and gave an 8% Negative Appendectomy Rate and no appendicitis missed. These results are similar to those in the study of Poortman et al. (sensitivity of 100%, specificity of 86%, and Negative Appendectomy Rate of 8%), Ramarajan et al. (99% sensitivity, 91% specificity, and 7% Negative Appendectomy Rate), and Thirumoorthi et al. (sensitivity 94.2%, specificity of 97.5%, Appendectommy negative appendicitis Rate 1.8%, and Appendicitis missed 0%).

Currently at other institutions Ultrasonography (USG) studies of appendicitis have been carried out in children with intraoperative findings and confirmed by histopathological examination results, so the researcher intends to examine whether there is a relationship between ultrasonography (USG) in pediatric appendicitis and intraoperative findings and confirmed by histopathological examination at H. Adam Malik General Hospital and North Sumatra University Hospital Medan to prove whether the accuracy of the diagnosis of acute appendicitis in children with Ultrasound (USG) examination at RSUP H. Adam Malik and University of North

Sumatra Hospital Medan is as accurate as other institutions, so that it can be verified An ultrasound at H. Adam Malik Hospital and University of North Sumatra Hospital Medan is similar to an ultrasound examination in another hospital in diagnosing pediatric appendicitis

Methods

The study was a diagnostic study which retrospectively review the children who underwent an ultrasound study for suspected appendicitis in pediatric surgery division of Haji Adam Malik Hospital and Universitas Sumatera Utara Hospital, Medan, North Sumatera between January 2014 until March 2019. We determined the accuracy along with sensitivity and specificity results of Ultrasonography (USG) using calculated formula. The comparation between ultrasonography results and intraoperative findings was analyzed using Chi Square test or its alternative.

All patients with appendicitis <18 years old. who had done ultrasonography (USG) and appendectomy surgery were included

Results

A total of 32 subjects were included in this study. The characteristics of the subjects in this study are shown in table 1, based on sex, girls had more appendicities as many as 17 people (53.1%) compared to 15 boys who suffered appendicitis (46.9%). Based on the age of children who suffer from appenditis on average 14 years old.Based on the results of the ultrasound obtained as many as 26 people (81.3%) children suffering from appendicitis while the results of histopathological examination as many as 30 people (93.8%) children suffer from appendicitis.

Table 1 Characteristics of Research Subjects

Characteristics	n=32
Gender, n (%)	
Male	15 (46,9%)
Female	17 (53,1%)
Age (Year), Mean±S.D	14,06±3,983
Ultrasound Results (USG), n(%)	
Appendicitis	26 (81,3%)
Not Appendicitis	6 (18,8%)
Overview of histopathology	
Appendicitis	30 (93,8)
Not Appendicitis	2 (6,3%)

Relationship between Ultrasound (USG) Examination and Intraoperative findings

The used analysis test was an alternative test from chi square, namely Fisher Exact test because the data distribution did not meet the chi square test requirements. Based on the analysis test used, it was found that there was a relationship between USG results and significant intraoperative findings from histopathological features with a value of $p < 0.05$ ($p = 0.030$)

Table 2 Accuracy of USG Results and Intraoperative Findings of Childhood Appendicitis

		Histopathology Findings n(%)		**Total**	***P****
		Appendicitis	**Not Appendicitis**		
Ultrasonografi (%)	Appendicitis	26 (86,7%)	0 (0,00%)	26 (81,3)	0,030
	Not Appendicitis	4 (13,3%)	2 (100%)	6 (18,8%)	
	Total	30 (100%)	2 (100%)	32 (100%)	
Sensitivity (%) Specificity (%) Accuracy (%) PPV (%) NPV (%)	86.7 99 87.5 99 33.3				
**Fisher Exact test*					

From the results of ultrasonography (USG), 86.7% sensitivity and specificity> 99% were obtained. Accuracy of ultrasonography in diagnosing appendicitis was found to be 87.5%. False positive results from ultrasound were not found in this study. False negatives were found in two cases (6.65%). Positive predictive value reaches> 99% and negative predictive value is 33.3%

Discussion

High specificity (99%) of all studies shows that ultrasound is a useful test to rule out the presence of appendicitis, even with relatively low diagnostic results, identifying appendices 40.7% of the time. Similarly, the LR (LR - = 0.13) calculated from this study is sufficient to potentially influence the path of doctor's decision making. This is reflected in the negative appendectomy rate of 13.3%, with 4 negative appendectomy performed. False negative results due to ultrasound findings in the appendix appear lymphoid hyperplasia, causing dilatation of the appendix lumen and an increase in the appendix diameter, so that it is considered positive because of enlarged diameter.

Because this study is retrospective, a binary diagnosis model is used, where doubtful findings (appendices) are integrated into positive or negative findings. These results reflect the potential limitations of ultrasound to confirm or rule out the diagnosis of appendicitis, because the appendix is not always sonographically identified. The difference in visualization ability of each operator that was not assessed in this study is thought to have a role in identifying univocal findings or unusual images.

Sensitivity (86.7%) and specificity (> 99%) in the study showed a significant association between USG findings and histopathological results resembling those of other centers but these results were considered not yet capable of including findings that were still vague. This shows the need for developing a systematic approach in visualizing the appendix.

One limitation of this study is the missing data, especially for visualization evidence from the appendix through ultrasound and a complete description of the appendix, such as diameter and compressibility. To limit selection bias, all eligible studies were included, and there was no control over the experience of staff conducting ultrasound examinations.

Conclusion

Compared to alternative studies, our study shows similarities in results. Ultrasound can be useful as an initial diagnostic tool that is quite accurate and specific in diagnosing appendicitis in children. It is necessary to improve the accuracy of images in further studies and systematic approaches to visualize appendicitis findings in children

References

1. Abel WG, Allen PD. Acute appendicitis in children. Ann. Surg. 1950; 132: 1093–102.
2. AcadEmerg Med. 2017 May;24(5):523-551. doi: 10.1111/acem.13181. Review.
3. Ahmed MJ: Incidental acute focal appendicitis in incidentally removedvermiform appendices. WVMedJ 1966;62:151-154.
4. AlSalem AH, Qureshi ZS, Qaisarudin S, et al: Is acute appendicitis different in patients with sickle cell disease? Pediatr SurgInt 1998;13:265-267.
5. Appendiceal diameter as a predictor of appendicitis in children: improved diagnosis with three diagnostic categories derived from a logistic predictive model. Eur Radiol.
6. Baldisserotto M ,Marchiori E . Accuracy of noncompressive sonography of children with appendicitis according to the potential positions of the appendix . AJR Am J Roentgenol 2000 ; 175 (5): 1387 – 1392.
7. Benabbas R, Hanna M, Shah J, Sinert R. Diagnostic Accuracy of History, Physical- Examination, Laboratory Tests, and Point-of-care Ultrasound for Pediatric Acute- Appendicitis in the Emergency Department: A Systematic Review and Meta-analysis.
8. Boonstra PA, van Veen RN, Stockmann HB (2014) Less negative appendectomies due to imaging in patients with suspected appendicitis. SurgEndosc
9. Bull WT. On the surgical management of typhlitis and perityphlitis.Trans. Am. Surg. Assoc. 1888; 6: 389–418.
10. Butler C: Surgical pathology of acute appendicitis. Hum Pathol1981;12:870-878
11. Carr NJ, Montgomery E: Patterns of healing in the appendix: The morphologic changes in resolving primary acute appendicitis and a comparison with Crohn's disease. Int J Surg Path01 1994;21:23-30
12. Chidmat IN. Hubunganlamanyanyeridengantipehistopalogiappendikspadaappendisitisakutdewasa. Medan :Departemen Bedah FK-USU / RSUP H.Adam Malik , 2005.
13. Cohen B, Bowling J, Midulla P et al. (2015) The non-diagnostic ultrasound in appendicitis: is a non-visualized appendix the same as a negative study? J Pediatr Surg. doi:10.1016/j.jpedsurg. 2015.03.012
14. Cope Z. A History of the Acute Abdomen. London: Oxford University Press, 1965.
15. Copland J. A Dictionary of Practical Medicine. London: Longman, Brown, Green, Longmans, & Roberts, 1858.
16. Coyne SM, Zhang B, Trout AT (2014) Does appendiceal diameter change with age? A sonographic study. Am J Roentgenol 203: 1120–1126
17. Craig S. Acute Appendicitis. eMedicine from Web MD 2005 ; 1 - 21.
18. Cutler ER. Eleven cases of operation for appendicitis. Boston Med. Surg. J. 1889; 120: 554–6.
19. Ellis H. Appendix and Appendectomy.In : Schwartz. Maingot's Abdominal Operation .10th ed. USA : Prentice Hall International , 1997 ; 1197 - 227.
20. Estey A, Poonai N, Lim R (2013) Appendix not seen: the predictive value of secondary inflammatory sonographic signs. PediatrEmerg Care 29:435–439
21. Fitz R. Perforating inflammation of the vermiform appendix, with special reference to its early diagnosis and treatment.Am. J. Med. Sci. 1886; 92: 321–46.
22. Göya C, Hamidi C, Okur MH et al. (2014) The utility of acoustic radiation force impulse imaging in diagnosing acute appendicitis and stage its severity. DiagnIntervRadiol 20:453–458
23. Groves A. All in a Day's Work: Leaves From a Doctor's Case-Book. Toronto: McMillan Publishing Company, 1932; 20–1.
24. Hayden CK Jr, Kuchelmeister J, Lipscomb TS.Sonography of acute appendicitis in childhood: perforation versus nonperforation. J Ultrasound Med 1992; 11: 209-216
25. Herd ME, Cross PA, Dutt S: Histological audit of acute appendicitis. J ClinPathol 1992;45:456-458
26. Humes DJ, Simpson J (2006) Acute appendicitis. BMJ 333: 530–534
27. Incesu L, Yazicioglu AK, Selcuk MB, Ozem N (2004) Contrast enhanced power-Doppler US in the diagnosis of acute appendicitis. Eur J Radiol 50:201–209
28. Kaneko K, Tsudo M. Ultrasound-based decision making in the treatment of acute appendicitis in children. J Pediatr Surg. 2004;39:1316–20. [PubMed]
29. Kim BS, Choi GM, Kim SH, Park JK, Kim K, Kang HW, Kang KS. Usefulness of the inner hypoechoic band of the vermiform appendix as ultrasonographic criteria for the diagnosis of acute appendicitis in children. J Korean RadiolSoc 2007; 57: 483-488

30. Kottmeier PK. Appendicitis. In: Welch K, Randolph J, Ravitch M, O'Neil J, Rowe M, editors. Pediatric surgery. Chicago: YearBook Medical, 1986: 989-995
31. Lamps LW. Appendicitis and infections of the appendix.SeminDiagnPathol 2004; 21: 86-97
32. Lee JH, Jeong YK, Hwang JC, et al. Graded compression sonography with adjuvant use of a posterior manual compression technique in the sonographic diagnosis of acute appendicitis. Am J Roentgenol 2002;178(4):863-868.
33. Lowe LH, Penney MW, Scheker LE, Perez R, Jr, Stein SM, Heller RM, et al. Appendicolith revealed on CT in children with suspected appendicitis: How specific is it in the diagnosis ofappendicitis? AJR Am J Roentgenol. 2000t;175:981–4. [PubMed]
34. Lubis R.Pengaruhjumlahnetrofildalammenentukantindakanappendektomiakut.Medan : Departemen Bedah FK USU / RSUP H.Adam Malik , 1998
35. Masoomi H, Mills S, Dolich MO et al. Comparison of outcomes of laparoscopic versus open appendectomy in children: data from the Nationwide Inpatient Sample (NIS), 2006–2008. World J. Surg. 2012; 36: 573–8.
36. McIlrath DC. Kelainanbedah appendix vermiformisdan diverticulum meckel. Dalam :Sabiston Buku Ajar Ilmu Bedah. Jakarta : EGC , 1994 ; 1– 13.
37. Mirilas P, Skandalakis JE. Not just an appendix: Sir Frederick Treves. Arch. Dis. Child. 2003; 88: 549–52.
38. Nonneoplastic diseases of the appendix. In: Fenoglio-Preiser CM, Noffsinger AE, Stemmermann GN, Lantz PE, Isaacson PG, editors. Gastrointestinal pathology: an atlas and text. 3rd ed. Philadelphia: Lippincott Williams and Wilkins, 2008: 497-498
39. Park NH, Park CS, Lee EJ, Kim MS, Ryu JA, Bae JM, Song JS. Ultrasonographic findings identifying the faecal-impacted appendix: differential findings with acute appendicitis. Br J Radiol 2007; 80: 872-877
40. Park NH, Song SY, Lee EJ, Kim MS, Park CS, Oh HE, Yang GS. Characteristic sonographic appearance of normal appendix in children: inner hypoechoic band without folding. J Korean RadiolSoc 2004; 51: 663-667
41. Patriquin HB, Garcier JM, Lafortune M, Yazbeck S, Russo P, Jequier S, Ouimet A, Filiatrault D. Appendicitis in children and young adults: Doppler sonographic-pathologic correlation. AJR Am J Roentgenol 1996; 166: 629-633
42. Peña BM , Taylor GA . Radiologists' confidence in interpretation of sonography and CT in suspected pediatric appendicitis .AJR Am J Roentgenol2000 ; 175 (1): 71 – 74 .
43. Pieper R, Kager L, Nasman P: Clinical signiticance of mucosal inIIammation of the vermiform appendii. Ann Surg 1983;197:368-374
44. Pledger G, Stringer MD. Childhood deaths from acute appendicitis inEngland and Wales 1963–97: observational population based study. BMJ 2001; 323: 430–1.
45. Pledger HG, Buchan R. Deaths in children with acute appendicitis.BMJ 1969; 4: 466–70.pseudomyxoma peritonei.SeminDiagnPathol 1996; 13:3 14-325
46. Poortman P, Oostvogel HJ, Bosma E, et al. Improving diagnosis of acute appendicitis: results of a diagnostic pathway with standard use of ultrasonography followed by selective use of CT. J Am Coll Surg. 2009;208(3):434–441.
47. Puylaert JB (1986) Acute appendicitis: US evaluation using graded compression. Radiology 161:691–695
48. Quigley AJ, Stafrace S (2013) Ultrasound assessment of acute appendicitis in paediatric patients: methodology and pictorial overview of findings seen. Insights Imaging.doi:10.1007/s13244-013-0275-3
49. Quillin SP, Siegel MJ, Coffin CM. Acute appendicitis in children: Value of sonography in detecting perforation. AJR Am J Roentgenol. 1992;159:1265–8.
50. Rabah R. Pathology of the appendix in children: an institutional experience and review of the literature. PediatrRadiol 2007; 37: 15-20
51. Ramarajan N, Krishnamoorthi R, Barth R, et al. An interdisciplinary initiative to reduce radiation exposure: evaluation of appendicitis in a pediatric emergency department with clinical assessment supported by a staged ultrasound and computed tomography pathway. AcadEmerg Med. 2009;16(11):1258–1265.
52. Rettenbacher T, Hollerweger A, Macheiner P, Rettenbacher L, Frass R, Schneider B, et al. Presence of absence of gas in the appendix: Additional criteria to rule out or confirm acute appendicitis – evaluation with US. Radiology. 2000;214:183–7.

53. Robins Sl. Appendix in pathologic basis of disease. 3rd ed. London : WB Saunders , 1984 ; 874 - 7.
54. Ross MJ, Liu H, Netherton SJ et al. (2014) Outcomes of children with suspected appendicitis and incompletely visualized appendix on ultrasound. AcadEmerg Med 21:538–542
55. Rowe M, Grosfeld JL, Coran AG. Essensial of Pediatric Surgery.Toronto : Mosby , 1995 ; 579 – 85.
56. Russel RCG, Wiliams NS. The vermiform appendix. In : Bailey & Love's Short Practice of Surgery. 23rd ed. New York : Oxford University Press Inc , 2000 ; 1076 - 92.
57. Safruddin. Sistemskordalammendiagnosaappendisitisakut. Medan :DepartemenBedah FK-USU / RSUP H.Adam Malik, 1999.
58. Semm K. Endoscopic Appendectomy.Endoscopy. 1983;15;5-64.
59. Siegel M. Female pelvis. In: Siegel MJ, editor. Pediatric Sonography. 4th ed. Philadelphia: Lippincott Williams and Wilkins; 2010. pp. 509–53
60. Siegel M. Female pelvis. In: Siegel MJ, editor. Pediatric Sonography. 4th ed. Philadelphia: Lippincott Williams and Wilkins; 2010. pp. 509–53.
61. Siegel MJ, Carel C, Surratt S. Ultrasonography of acute abdominal pain in children.JAMA. 1991;266:1987–9.
62. Simonovský V. Normal appendix: is there any significant difference in the maximal mural thickness at US between pediatric and adult populations? Radiology 2002; 224: 333-337
63. SivitCJ . Imaging the child with right lower quadrant pain and suspected appendicitis: current concepts .PediatrRadiol2004 ; 34 (6):447 – 453 .
64. Sivit CJ. Imaging the child with right lower quadrant pain and suspected appendicitis: current concepts. PediatrRadiol. 2004;34:447–53. [PubMed]
65. Sjamsuhidayat R, De Jong W. Usus, KolondanAnorektum. Dalam :Buku Ajar IlmuBedah. Jakarta :Penerbit Buku Kedokteran EGC , 1997 ; 865 - 75.
66. Soda K, Nemoto K, Yoshizawa S, Hibiki T, Shizuya K, Konishi F. Detection of pinpoint tenderness on the appendix under ultrasonography is useful to confirm acute appendicitis. Arch Surg. 2002;136:1136–40. [PubMed]
67. Stephenson J, Snoddy WT: AppendiceaJ lesions: Observation in 4000 appendectomies. Arch Surg 1961;83:661-666
68. Styrud J, Eriksson S, Nilsson I, Ahlberg G, Haapaniemi S, Neovius G, Rex L, Badume I, Granström L. Appendectomy versus antibiotic treatment in acute appendicitis. a prospective multicenter randomized controlled trial. World J Surg 2006; 30: 1033-1037
69. Thirumoorthi AS, Fefferman NR, Ginsburg HB, Kuenzler KA, Tomita SS. Managing radiation exposure in children – reexamining the role of ultrasound in the diagnosis of appendicitis. J Pediatr Surg. 2012;47(12):2268–2272.
70. Trout TA, Towbin AJ, Fierke SR, Zhang B, Larson DB (2015)Appendiceal diameter as a predictor of appendicitis in children improved diagnosis with three diagnostic categories derived from a logistic predictive model. EurRadiol
71. UchidaJ: Electron microscopic study of microfoldcells (M cells) in normal and infkuned human appendix. Gastroenterol Japonica 1988;23:251-262
72. Van RandenA, Bipat S, Zwinderman AH, Ubbink DT , Stoker J , Boermeester MA .Acute appendicitis: meta-analysis of diagnostic performance of CT and graded compression US related to prevalence of disease . Radiology 2008 ; 249 (1): 97 – 106.
73. Way LW. Appendix.In : Way LW, Doherty GM. ed. Current Surgical Diagnosis and Treatment . 11th ed. London : McGraw-Hill , 2003 ; 668 - 72.
74. Wiersma F, Srámek A, Holscher HC. US features of the normal appendix and surrounding area in children. Radiology 2005; 235: 1018-1022.

*****