นิพนธ์ต้นฉบับ

The role of ultrasonography in the diagnosis of acute appendicitis.

Kaesorn Vajarpongse*
Laddawa Vajragupta* Chanvit Tanphiphat**
Wanchat Loaprasert* Wuttichai Tanapongsathorn*

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A prospective real-time ultrasonographic study of the abdomen was performed in 109 patients with suspected acute appendicitis. The criteria for ultrasonographic diagnosis of acute appendicitis included visualization of the appendix with a diameter of 7 mm or more and wall thickness of greater than 2 mm. The demonstration of periappendiceal or pericecal fluid collection with or without visualization of the appendix were indicative of ruptured appendicitis or appendiceal abscess.

Seventy-eight patients were proven to have acute appendicitis by surgery and histologic examination. Ultrasonography was found to have sensitivity of 93 percent, specificity of 93.5 percent and overdll accuracy of 93.6 percent. Fifty-eight of 63 patients with unruptured appendicitis were correctly disgnosed by ultrasonography. All 15 patients with ruptured appendicitis and appendiceal abscess were correctly diagnosed.

Ultrasonography helped to exclude acute appendicitis in 29 out of 31 patients, and led to a correct alternative diagnosis in 14 patients.

In conclusion real-time ultrasonography is a useful diagnostic procedure in the patients suspected of having acute appendicitis.

Reprint request : Vajarpongse K, Department of Radiology, Faculty of Medicine, Chulalongkorn University, Bangkok 10330, Thailand
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* Department of Radiology, Faculty of Medicine, Chulalongkorn University.
** Department of Surgery, Faculty of Medicine Chulalongkorn University.

เกษร วัชรพงศ์, ลัดดาวัลย์ วัชรคุปต์, ชาญวิทย์ ตันติ์พิพัฒน์, วันชาติ เล้าประเสริฐ, วุฒิชัย ธนาพงศ์ธร, การใช้อัลตราซาวด์วินิจฉัยไส้ติ่งอักเสบ. จุฬาลงกรณ์เวชสาร 2533 สิงหาคม ; 34 (8) : 577-586

การศึกษาแบบไปข้างหน้า (Prospective study) ของผลการตรวจอัลตราซาวด์ของช่องท้อง ในผู้ป่วยจำนวน 109 ราย ที่สงสัยเป็นไส้ติ่งอักเสบ พบว่าอัลตราซาวด์สามารถวินิจฉัยไส้ติ่งอักเสบที่ไม่มีการทะลุได้ถูกต้อง 58 รายจาก 63 ราย สามารถวินิจฉัยไส้ติ่งอักเสบที่มีการทะลุ (ruptured appendicitis) รวมทั้งที่มีการเกิดฝีร่วมด้วย (appendical abscess) ได้ถูกต้องทั้งหมดจำนวน 15 ราย

นอกจากนี้อัลตราซาวด์ยังช่วยวินิจฉัยโรคที่ให้อาการใกล้เคียงกับไส้ติ่งอักเสบได้ถูกต้อง 11 ราย ได้แก่ ถุงน้ำดีอักเสบ 3 ราย ไตอักเสบ 4 ราย ความผิดปกติของมดลูกและรังไข่ 3 ราย และลำไส้กลืนกัน (intussusception) 1 ราย

จากการศึกษาดังกล่าวอัลตราซาวด์ sensitivity 93 % และมีความแม่นยำ 93.6 % จึงมีประโยชน์ในการวินิจฉัยไส้ติ่งอักเสบในรายที่อาการแสดงไม่ชัดเจนและช่วยวินิจฉัยแยกโรคที่มีอาการคล้ายคลึงกัน

Acute appendicitis remains one of the most frequent causes of abdominal surgical emergency. Appendectomy is considered the most appropriate treatment due to a low mortality rate of 0.2-0.8 percent[1]. An increased mortality rate of up to 15 percent has been observed in patients over 70 years of age which is mainly attributed to delay in diagnosis and thus treatment[1]. A high rate of appendiceal rupture from delayed diagnosis and surgical intervention was found in patients less than 18 year old and over 50 years old.[1-3] The complication rate of appendectomy in ruptured appendicitis has been reported as high as 48 percent.[4]

The diagnosis of acute appendicitis may not be difficult in cases with typical clinical symptoms and signs. Major factors contributing to the delay in diagnosis are the presence of atypical symptoms and signs, in the very young and elderly patients.[4] Symptom and signs of acute appendicitis may be closly mimicked by nonsurgical diseases, such as mesenteric adenitis and gynecologic disorders in women.

In order to prevent the complications associated with delayed appendectomy a negative appendectomy rate of 20-25 percent is generally accepted by surgeons.[1,4-9] Prior to high resolution real-time ultrasound, non-invasive imaging enabling direct visualization of the inflamed appendix was not available. The first reported case of ultrasonic demonstration of an inflamed appendix in a leukemic child which led to the proper management was by Deutsch and Leopold.[10] Subsequent reports on the sonographic evaluation of appendicitis involving both retrospective and prospective studies with varying degrees of acuuracy were published.[11-16] The purpose of this prospective study is to determine the diagnostic accuracy of ultrasonography and its effect on the care of patients thought to have acute appendicitis in a Bangkok teaching hospital.

SUBJECTS AND METHODS

From August 1988 to December 1989, 109 patients who were diagnosed on clinical grounds to have possible acute appendicitis, ruptured appendicitis and appendiceal mass were examined by high resolution real-time ultrasound at the; Chulalongkorn Hospital. The series included 50 male and 59 female patients ranging in age from 4 to 77 years (mean age 31 years). All ultrasono graphic studies were carried out using a 5 MHz linear array transducer (Aloka SSD 256 and Aloka SSD 620). The technique of graded compression as described by Puylaert[11] was used in this study. The transducer was first placed at the most painful area pointed out by the patient. Compression by the transducer was gradually increased until all intestinal gas and fluid were expressed from the cecum and ascending colon. If the inflamed appendix could not be demonstrated, transverse scanning was initiated in the lateral right mid abdomen just above the umbilicus, and continued caudally to the right lower quadrant with gradually increasing pressure on the transducer. Sonographic visualization of the cecal tip, iliopsoas muscle and iliac vessels were useful landmarks to identify the appendix (Fig. 1). If the inflamed appendix could not be visualized the entire abdomen and pelvis were examined to look for an alternative diagnosis.

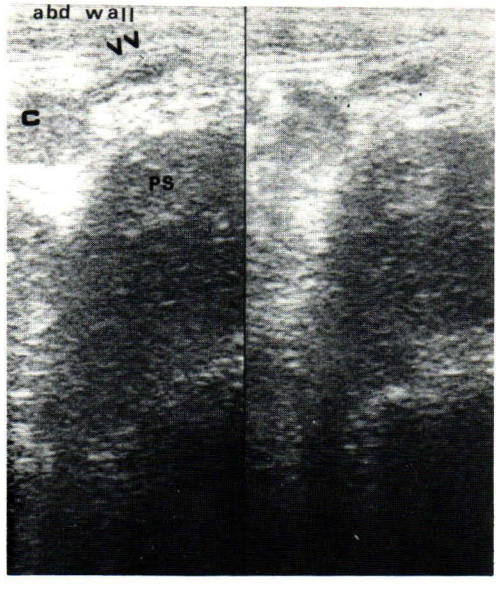

Figure 1. Sonographic landmarks of the appendix
The appendix (VV) is located in RIQ between the anterior abdominal wall and iliopsoas muscle (PS)

The ultrasonographic criteria for the diagnosis of acute appendicitis included one or more of the following

1. Visualization of the inflamed appendix
2. Demonstration of periappendiceal fluid collection
3. Presence of appendicolith

The ultrasonographic appearance of the inflamed appendix was a non compressible blind-end tubular structure usually located at the cecal tip (Fig. 2). In the transverse scan it had a "target-like" appearance which consisted of a hypoechoic fluid or pus distended lumen, a huperechoic ring representing mainly mucosa and submucosa, and an outer hypoechoic ring representing the muscularis (Fig. 3a and 3b). The outer ring should be 7 mm or greater in diameter and hypoechoic wall over 2 mm in thickness. The mural thickness visualized on ultrasonography varied greatly and corresponded to the various macromorphologic transformation of the appendiceal wall. In the case of gangrenous appendicitis a detailed layering of the largely hypoechoic thickened appendiceal wall frequently could not be identified. In addition, there was a zone of increased echogenicity which was probably due to mesenteric or omental covering over the inflamed appendix (Fig. 4), and points to transmural inflammation and a periappendiceal inflammatory reaction.

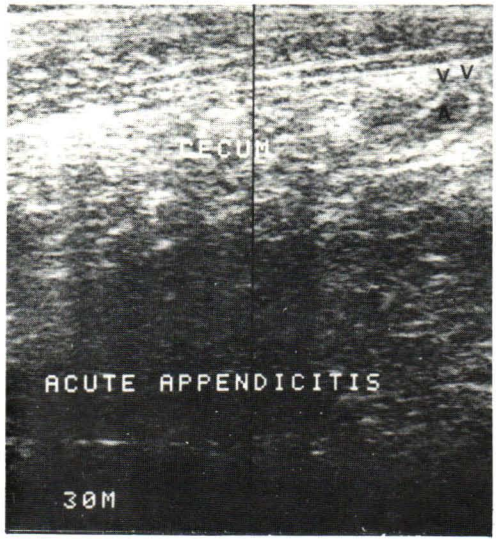

Figure 2. The inflamed appendix (VV) appears as a blind-end tubular structure located at tip of cecum

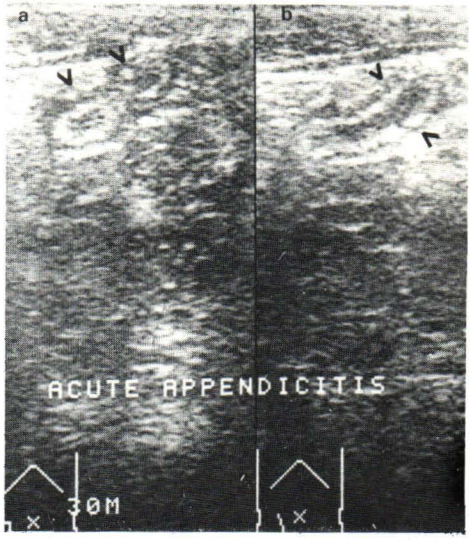

Figure 3. a. The transverse acan of the appendix had the target-like appearance (arrow heads). The inner most hypoechoic layer represent distended lumen containing pus, the middle echogenic layer represent inflamed submucosa, the outer hypechoic layer represent edematous mural wall thickness.
b. The longitudinal scan demonstrates layers of appendix corresponding to transverse scan.

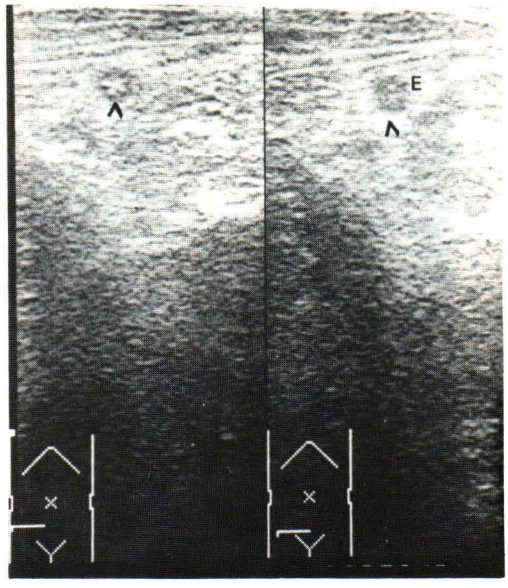

Figure 4. Transverse sonogram of RLQ reveals echogenic halo (E) surrounding the appendix (arrow head). This may be mesentric or omental covering

Appendicoliths were seen as an intraluminal foci of high amplitude echoes with acoustic shadowing (Fig. 5a and 5b).

In cases of ruptured appendicitis or abscess, the rate of visualizaation of the inflamed appendix was lower than in unruptured appendicitis[12] due to the overlying bowel ileus. Therefore the presence of periappendiceal fluid associated with a thick-walled cecum and terminal ileum were considered suggestive of acute appendicitis (Fig. 6a and 6b). All patients that had a positive ultrasonographic findings of acute, as well as those with clinical features of acute appendicitis or other surgical conditions underwent surgery. Operative fingings and histologic examination of all removed appendices were obtained for evaluating the accuracy of ultrasonography.

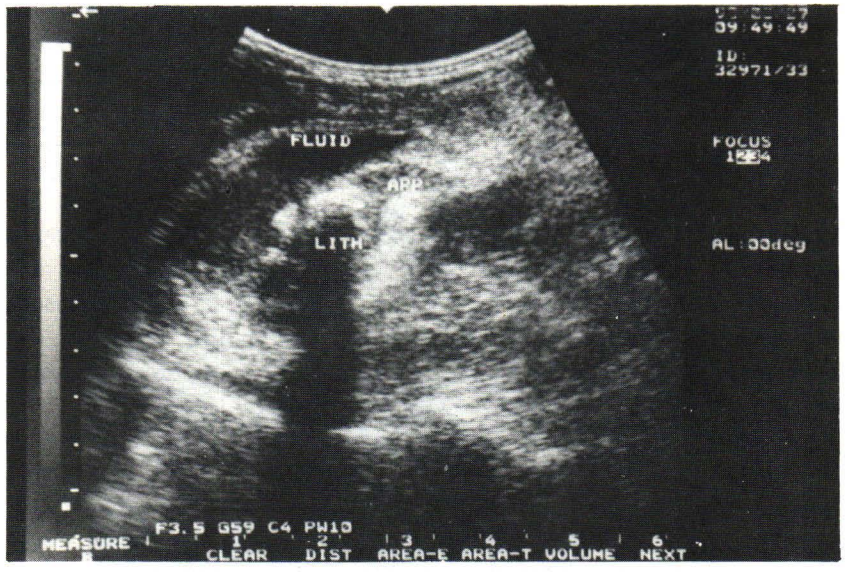

Figure 5. a. An oblique sonogram of the right lower quadrant reveals appendicolith (lith) appears as a strong echo with acoustic shadow, in the proximal end of the appendix (app). Loculated fluid anterior to the appendix is present.

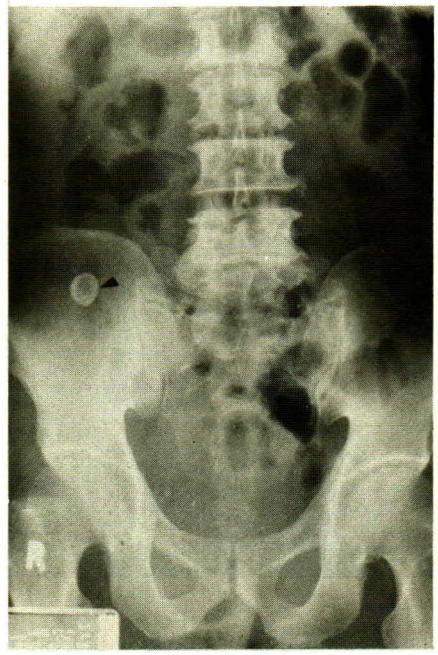

Figure 5. (Cont'd)

b. Abdominal radiograph in the same patient shows appendicolith (arrow) in right lower quadrant with mild degree of small bowelileus.

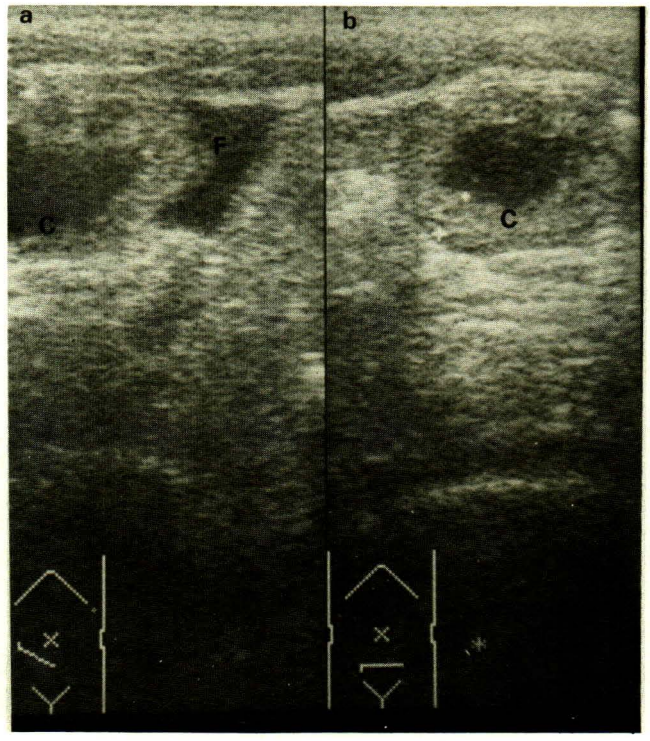

Figure 6a. Oblique sonogram and 6b. transverse sonogram in patient with ruptured appendicitis reveals fluid (F) surrounding the tip of thick walled cecum (C). Unidentified appendix.

RESULTS

Seventy-eight of 109 patients had a final diagnosis of acute appendicitis. Sixty-three patients had unruptured appendicitis, 10 patients had ruptured appendicitis and 5 had appendiceal abscess.

Table 1 shows the results of ulttrasonography in all the patients studied. In 63 cases with unruptured appendicitis, 58 inflamed appendices were visualized with diameters varying from 7 to 18 mm, mean 10 ∓ 1 SD. The appendical wall had a thickness ranging from 2 to 5 mm. The inflamed appendix could not be demonstrated in 5 patients (Table 2).

TABLE 1. Results of Sonography in 109 patients with Suspected Appendicitis.

	No. of patients	Sonography			
		True+ve	true−ve	False+ve	False−ve
Unruptured appendicitis	63	58	-	-	5
Ruptured appendicitis	10	10	-	-	-
Appendiceal abscess	5	5	-	-	-
Non appendicitis	31	-	29	2	-
Total	**109**	**73**	**29**	**2**	**5**

TABLE 2. Incidence of Visualized Appendix by Ultrasonography

	No. of patients	US+ve	US−ve
Unruptured appendicitis	63	58	5
Ruptured appendicitis	10	8	2
Appendiceal abscess	5	3	2
Total	**78**	**69**	**9**

In the 10 patients with ruptured appendicitis, the appendix was visualized together with the presence of fluid collection in the periappendiceal and pericecal areas in 8 cases. In the other two patients, the appendix was not visualized but fluid collection was present in the right lower quadrant.

Appendicoliths were present in 2 of 5 cases with appendiceal abscess. The sonographic findings in appendiceal abscess ranged from almost echo-free liquid to the presence of heterogeneous echogenic masses (Fig. 7).

Table 3 lists the final diagnoses in cases of non-appendicitis, 17 of these 31 patients in whom ultrasonographic findings were indicative of nonappendicitis, were verified to have normal appendices at surgery. The other 14 patients improved with medical treatment. A false positive sonographic diagnosis of acute appendicitis occurred in 2 patients, one of whom had pelvic inflam matory disease (PID) and the other periappendicitis with lymphoid hyperplasia. The diameters of the appendices were 7 mm and 10 mm respectively.

In this series ultrasonography has an accuracy of 93.6 percent, a sensitivity of 93.3 percent, specificity of 93.5 percent, positive predictive value of 97.5 percent and negative predictive value of 85.3 percent (Table 4).

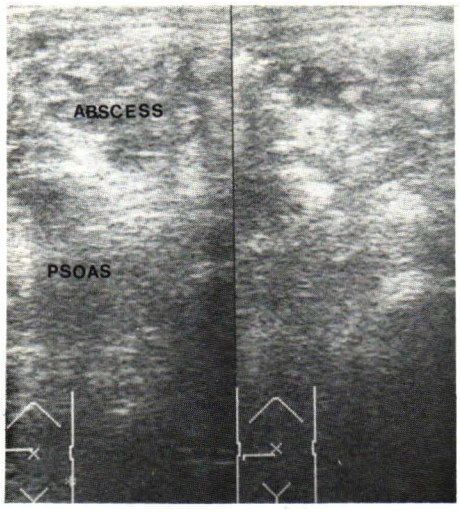

Figure 7. Sonogram of right lower quadrant in patient with appendiceal abscess shows the heterogeneous echogenic mass with non demonstrable appendix.

TABLE 3. Final Diagnosis in Nonappendicitis.

Diagnosi	No of patients	US+ve	US−ve
Acute cholecystitis	2	2	0
Chronic cholecystitis	1	1	0
Diverticulitis	2	0	2
Amebiasis	2	2	0
Duodenal ulcer	1	0	1
Ileo-cecal tuberculosis	1	1	0
Intussusception	1	1	0
Acute PID	2 (false)	1	1
Ruptured endometrioma	1	1	0
Twisted ovarian cyst	1	1	0
Acute pyelonephritis	4	4	0
Gastroenteritis	5	0	5
Lymphoid hyperplasia	1 (false)	1	0
Unknown causes	7	0	7
Total	**31**	**15**	**16**

TABLE 4. Diagnostic Value of Real-time Sonography in Suspected Appendicitis.

	No. of patients	Sonography				
		Accuracy	Sensi-tivity	Speci-ficity	PV+	PV−
Kastrup et al. (11)	46	87	83	94	96	76
Abu-Yousef et al. (14)	68	90	80	94	91	89
Jeffrey et al. (12)	90	91	83	95	89	92
Puylaert et al. (13)	111	0	75	100	0	0
Schwerk (15)	532	95.7	88.5	98	94.5	96.3
Present study	109	93.6	93.3	93.5	97	85

DISCUSSION

From this prospective study, ultrasonographic diagnosis of acute appendicitis was correct in 75 out of 78 cases. The test had accuracy of 93.6 percent which was comparable with other reports[10,13,14,17] (Table 4).

Five patients had false negative sonographic diagnoses of acute appendicitis. There were two possible reasons for this. Firstly the location of the inflamed appendix was retrocecal in 4 cases and subhepatic in one case. Secondly obesity and bowel ileus may have contributed to the non-visualization of the inflamed appendix.

The two false positive sonographic diagnoses were due to our criteria requiring the diameter of the appendix to be 7 mm or more for the diagnosis of acute appendicitis. One young woman with acute PID had an appendix of 7 mm in diameter, which was normal histologically. Another case with histologic diagnosis of lymphoid hyperplasia had an appendix of 10 mm in diameter. This false positive interpretation seem to support the reports by Jeffrey, Abyu-Suf and others[11,12,14] which claimed that a normal appendix could be visualzied by high resolution real-time ultrasound. However there were no normal appendix of diameter greater than 6 mm in their series. Puylaert[10,13] did not visualize normal appendix by ultrasonography and emphasized that visualization of the appendix alone was the sole criterion for diagnosis of acute appendicitis. This observation has also been noted by Birnholtz. Jeffrey stated that mural thickness of acute appendicites is 3 mm or greater but the criteria for the mural thickness of the normal appendix have not been established.

Our series provided a correct ultrasonographic diagnosis of ruptured appendicitis and appendiceal abscess in all 15 patients, although the appendix was not directly visualized in 4 cases. The apparently sensitivity of 71 percent in demonstrating the appendix did not affect the plan of management since the ultrasonographic diagnosis was met by the other criteria and the clinical findings in these patients also dictated an emergency operative intervention.

Sonographic examination helped to exclude acute appendicitis in 29 of 31 patients, in whom 17 were proven by surgery. Although acute or subacute appendicitis could not be completely ruled out in the other 14 patients, operation was unnecessary since they were all improved by medical treatment alone. Diagnostically recent sonographic findings were established in 11 patients which included 3 cholecystitis, 4 acute pyelonephritis, 3 gynecologic disorders and one intussusception of Meckel's diverticulum.

CONCLUSION

This study like the other studies, had a specificity of 93.5 percent, a sensitivity of 93 percent, positive predictive value of 97 percent, negative predictive value of 85 percent and overall accuracy of 93.6 percent However, even if ultrasonography can visualize the inflamed appendix in a high percentage of patients and may suggest alternative diagnoses in a significant number of cases, ultrasonic non visualization of the appendix alone dose not entirely exclude acute appendicitis. Therefore a combination of clinical findings and ultrasonographic would help to improve preoperative diagnostic accuracy.

In conclusion, real-time ultrasonography has an important role in patients with suspected acute appendicitis, especially those with atypical symptoms and signs, and fertile women who may harbore gynecologic conditions mimicking appendicitis. The negative appendectomy rate would also besofely reduced if ultrasonographic and clinical findings were combined in patient management.

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