**ความถูกต้องแม่นยำของการตรวจวินิจฉัยไส้ติ่งอักเสบโดยการเอกซเรย์คอมพิวเตอร์โดยไม่ฉีดสารทึบรังสีในโรงพยาบาลพัทลุง**

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**บทคัดย่อ**

ไส้ติ่งอักเสบเฉียบพลันเป็นสาเหตุส่วนใหญ่ของอาการปวดท้องเฉียบพลันที่ต้องการรักษาโดยการผ่าตัด การวินิจฉัยภาวะไส้ติ่งอักเสบเฉียบพลันจะใช้อาการ อาการแสดง การตรวจร่างกาย และผลการตรวจทางห้องปฏิบัติเบื้องต้น ได้แก่ ผลเลือด และผลการตรวจปัสสาวะ ปัจจุบันการตรวจเอกซเรย์คอมพิวเตอร์ได้ถูกนำมาใช้ในผู้ป่วยที่มีอาการ การตรวจร่างกายและผลการตรวจทางห้องปฏิบัติไม่ชัดเจน โดยการตรวจเอกซเรย์คอมพิวเตอร์จะตรวจก่อนและหลังฉีดสารทึบรังสี แต่มีผลเสียคือ สารทึบรังสีมีราคาแพง ผู้ป่วยมีโอกาสแพ้สารทึบรังสี และผู้ป่วยได้รับปริมาณรังสีมากขึ้น ผู้วิจัยจึงต้องการศึกษาความแม่นยำของการตรวจเอกซเรย์คอมพิวเตอร์โดยไม่ฉีดสารทึบรังสีในการวินิจฉัยผู้ป่วยที่สงสัยไส้ติ่งอักเสบแบบเฉียบพลัน การวิจัยนี้ทำการศึกษาย้อนหลังในผู้ป่วยอายุมากกว่าหรือเท่ากับ 15 ปี จำนวน 310 คน ที่มีอาการสงสัยไส้ติ่งอักเสบและได้รับการส่งตรวจเอกซเรย์คอมพิวเตอร์ของโรงพยาบาลพัทลุงตั้งแต่ มกราคม 2566 ถึง ธันวาคม 2566 โดยเก็บข้อมูลจากเวชระเบียน (PTL-HOS) คือ เพศ อายุ และภาพเอกซเรย์คอมพิวเตอร์ ได้แก่ size and wall thickness of appendix, appendicolith, periappendiceal fat stranding and abscess และความผิดปกติอื่นๆที่พบ โดยเปรียบเทียบกับผลทางพยาธิวิทยาซึ่งเป็น gold standard ในการวินิจฉัยไส้ติ่งอักเสบ

ผลการศึกษา ผู้ป่วยจำนวน 108 คนถูกวินิจฉัยไส้ติ่งอักเสบทางพยาธิวิทยา การตรวจเอกซเรย์คอมพิวเตอร์โดยไม่ฉีดสารทึบรังสีมี accuracy 97.1%, sensitivity 94.7%, specificity 98.5%, positive predictive value 97.3% และ negative predictive value 97.0%

สรุป การตรวจเอกซเรย์คอมพิวเตอร์โดยไม่ฉีดสารทึบรังสีมีความถูกต้องแม่นยำในการวินิจฉัยไส้ติ่งอักเสบ

**คำสำคัญ**: เอกซเรย์คอมพิวเตอร์ช่องท้อง, ไส้ติ่งอักเสบ

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**Accuracy of Non-Contrast Enhanced CT in The Diagnosis of Acute Appendicitis in Phatthalung Hospital**

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**Abstract**

Background: Acute appendicitis is the most common acute abdominal condition requiring surgery. The diagnosis of acute appendicitis is usually based on clinical signs, symptoms and results of a simple laboratory examination. Computerized tomography (CT) is indicated for investigation in patients with atypical clinical manifestations of appendicitis. Routine contrast-enhanced computed tomography (CECT) increases cost and morbidity. However, many authors defend its use to assure a higher efficacy. A retrospective study was performed among 310 patients with suspected appendicitis but equivocal clinical manifestation and laboratory examination between January 2023 and December 2023 from medical records (PTL-HOS) and CT images from Picture Archiving and Communication System (PACS). CT diagnosis was made by: presence of an abnormal appendix, appendicoliths, periappendiceal fat stranding, periappendiceal abscess and absence of signs that may lead to other diagnosis. The findings were correlated with surgical histopathology which being the gold standard for confirmation of appendicitis.

Results: Non-contrast enhance CT in 108 patients had 97.1% accuracy, 94.7% sensitivity, 98.5% specificity, 97.3% positive predictive value and 97.0% negative predictive value.

Conclusions: Non-contrast enhanced CT presents a similar overall accuracy.

**Keywords:** Computerized tomography, non-contrast enhanced CT, appendix, acute appendicitis

**Introduction**

Acute abdomen is a life-threatening condition requiring prompt diagnosis and often emergency surgery. Acute appendicitis is the most common cause of acute abdomen[1-2] with an estimated lifelong risk of 8.6% among men and 6.7% among women.[3] Further, acute appendicitis is the most common acute abdominal condition requiring surgery.[4-5]

The diagnosis of acute appendicitis usually based on clinical signs and symptoms with results of simple laboratory examination.[6] The typical presentation begins with anorexia, nausea, vomiting, periumbilical pain due to irritation of visceral nerves then localizes to the right lower quadrant. Alvarado clinical scoring system comprises the basis of eight predictive clinical factors to improve the accuracy of physicians' clinical assessments in diagnosing acute appendicitis.[5,7] This Alvarado scoring system produces a maximum total score of 10 points and includes clinical symptoms (migration = 1, anorexia = 1, nausea and vomiting = 1), signs (tenderness in right lower quadrant = 2, rebound pain = 1, elevate of temperature = 1) and laboratory findings (leukocytosis = 2 and shift of the leukocyte to the left = 1).[2] Summary of the 2020 update of the WSES Jerusalem guidelines suggested clinical scores alone (e.g., Alvarado score, AIR score, and the new Adult Appendicitis Score) are sufficiently sensitive to exclude acute appendicitis, accurately identifying low risk patients and decreasing the need for imaging and the negative appendectomy rates among such patients.[8] That mean they recommend the use of clinical scores to exclude acute appendicitis and identify intermediate risk patients needing imaging diagnostics.

Ultrasonography (US) is safe and widely available, although it's operator-dependent and difficult for people with massive bodies. Computed tomography (CT) scans are more accurate than US, with a 93 - 98% accuracy rate[9] versus 82.4 - 85%.[10-11] US can be used as a primary imaging modality to avoid the disadvantages of CT.[12]

CT is indicated for investigation among patients with atypical clinical manifestations of appendicitis to reduce negative appendectomy.[13-16] CT has several advantages due to its high sensitivity/specificity,[1,17] short examination times,[1,17] secondary findings,[14,18] optimal treatment planning, good visualization of anatomy and high availability. Contrast-enhanced CT has been demonstrated to facilitate in the diagnosis of acute appendicitis and showed 90 - 98% accuracy.[4,6,19-20] The routine rectal and intravenous administration of contrast medium for detecting acute appendicitis exhibits high efficacy, however, its disadvantages including the high cost from expansive nonionic contrast medium for intravenous administration (1000 to 1500 THB per case) and high morbidity from increased doses of radiation exposure (two-time scans), risk of contrast-induced acute kidney injury and adverse reaction of contrast medium. The routine contrast-enhanced CT have been widely used in acute appendicitis although the prior studies such as Malone et al[21] or D'Ippolito et al[22] revealed the accuracy of non-contrast enhance CT were similar to those obtained with contrast-enhanced CT. The objective of this study was to evaluate the accuracy of non-contrast enhanced CT diagnosing acute appendicitis by comparing results of CT with surgical and pathology reports in Phatthalung hospital, to increase confidence of non-contrast enhanced CT study in diagnosing acute appendicitis. This study was based on the hypothesis that if non-contrast enhanced CT had high accuracy to diagnose acute appendicitis, the major advantages are relatively low cost,

decreased doses of radiation (only one-time scan), decrease risk of contrast-induced acute kidney injury and adverse reaction of contrast medium.

**Objective**

This study aimed to establish the accuracy of non-contrast enhanced CT diagnosing acute appendicitis by comparing results of CT with surgical and pathology reports.

**Methodology**

**Study design and patient**

This retrospective study, reviewed retrospective data from January - December 2023 among 310 adult patients (>15-year-old) with suspected appendicitis. They had lower, usually right -sided, abdominal pain without history of appendectomy and in whom the diagnosis was not obvious. After equivocal clinical manifestation and laboratory examination and they underwent unenhanced abdominal CT between January 2023 and December 2023.

**Imaging Technique**

CT examinations were performed on a CT 128-slice scanner (Philips Incisive). The patients were scanned in the supine position from the kidney level to the symphysis pubis with 1- and 5 -mm thickness axial images without IV contrast material administration. Coronal and sagittal reconstructions in 1 mm. were obtained.

**Pathological Technique**

The tissue had processed using the formalin-fixed paraffin-embedded (FFPE) technique to create paraffin blocks, which were sectioned at 3 microns by a microtome. The sections were stained with routine Hematoxylin and Eosin (H&E). Positive finding for acute appendicitis was presence of neutrophilic infiltration into appendiceal wall (muscularis propria).

**Data collection**

Patient records were retrieved from hospital database (PTL-HOS) and Picture Archiving and Communication System (PACS) including age, sex, clinical presentation, diagnosis, treatment, pathology report and medical imaging.

**Image Interpretation**

Imaging retrospective review was done by single blind technique. A single radiologist with 16 years' experience performed all measurements and separate interpreted the CT criteria while blinded to the postoperative notes, pathology results and clinical follow up to conclude appendicitis or normal. Imaging diagnoses based on CT findings were compared with surgical (and histopathology) results and clinical follow-up. If no surgery was conducted and the patients' symptoms had resolved, this was recorded as a true-negative finding on non-contrast enhanced CT. CT parameters evaluation were size of the appendix, appendiceal wall thickness, appendicoliths, periappendiceal fat stranding and abscess.[6, 22] The diameter of the appendix was measured at the greatest portion of the visible appendix on axial scans. If the appendix was not seen, the appendix was traced in coronal or sagittal reformat images. The caliber of the normal appendix should not exceed 6 mm.[1,23] Appendiceal wall thickness was measured to determine its maximum thickness. The wall thickness of the normal appendix should total less than 2 mm.[1]

Appendicolith was defined as a high attenuation structure within the appendix. Appendiceal fat stranding was defined as increased attenuation of peri-appendiceal fat which can be ill-defined, reticular or linear. Appendiceal abscesses were defined as fluid collected in the appendicular region with or without internal gas.

**Statistical Analysis**

After collecting the study data, they were entered in the Epicalc package in R Program, Version 4.2.1 (R Foundation for Statistical Computing, Vienna, Austria) to clean and calculate data and display the results into accuracy, sensitivity, specificity, positive predictive value, negative predictive value and prevalence.

**Ethic consideration**

This research was approved by the Human Subjects Ethics and Research Committee, Phatthalung hospital, no.21/2567 approved date 05 August 2024. There was no commercial fund support and the author declared no conflict of interest.

**Result**

Of 310 patients with suspected appendicitis and who underwent non-contrast enhanced abdominal CT, the median age was 40.5 years old (range 15 - 99), majority were females (70.3%). One hundred and thirty-four patients (43.2%) had an appendectomy. Of these, 114 patients (36.8%) presented acute appendicitis. In twenty patients who had negative pathology of appendicitis, were diagnosed acute diverticulitis (3 patients), acute pelvic inflammatory disease (2 patients), right ureteric stone (1 patient), dermoid cyst (1 patient) and other conditions (13 patients). One hundred and seventy-six patients (56.8%) were kept for observation and treated nonoperatively. They were discharged from the hospital with other diagnoses of nonspecific gastrointestinal- conditions (17 patients, 5.5%), KUB stone or infection (12 patients, 3.9%), gynecologic condition (10 patients, 3.2%) and other conditions (137 patient, 44.2%).

**Imaging outcomes**

One hundred and fourteen patients had surgery and pathologically proved appendicitis. Non-contrast enhanced CT scans were positive for appendicitis among 111 patients; 108 patients consistent with final diagnosis on the basis of surgery and pathologic examination (true positive), dissimilar result among three patients were false positive in which two patients received a diagnosis of diverticulitis and one patient received a diagnosis of pelvic inflammatory disease. Non-contrast enhanced CT scans were negative for appendicitis among 199 patients; 193 patients were similar to diagnosis on the basis of clinical follow-up (true negative) and disparate among six patients (false negative) which five patients were early appendicitis, one patient was early appendicitis coinciding with right ureteric stone.

Six false negative patients presented early appendicitis. One patient had coincidence with the right ureteric stone. The appendix size in these six false negative patients were 5.4 to 8.3 mm. All of them had no peri-appendiceal fat stranding, thickened appendiceal wall, appendicolith, appendiceal abscess or phlegmon.

Three false positive patients did not undergo appendectomy. Two patients had diverticulitis and one patient had acute pelvic inflammatory disease for which symptoms were resolved by medical treatment, these cases were considered to be false-positive CT results.

Non-contrast enhanced CT had an accuracy of 97.1%, a sensitivity of 94.7% and a specificity of 98.5%. Results obtained by comparison of CT diagnosis with surgical pathology results and clinical follow-up illustrated in Tables 1.

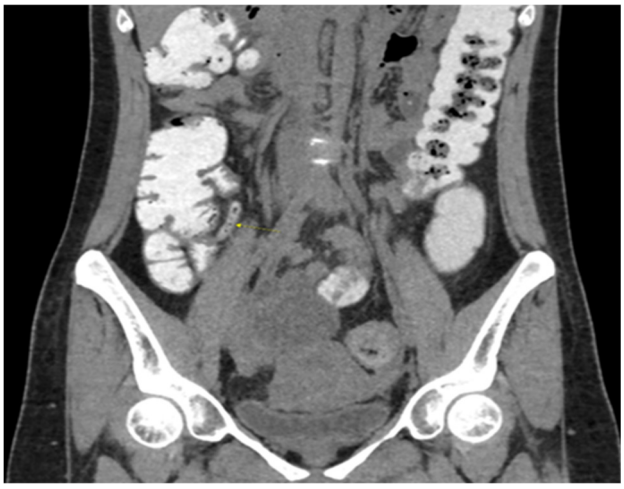
**Table 1 Accuracy of non-contrast enhanced CT in the diagnosis of acute appendicitis (N = 310)**

| CT diagnosis | Final diagnosis (pathologic or clinical follow up) | | |
|---|---|---|---|
| | Appendicitis | Normal | Total |
| Appendicitis | 108 | 3 | 111 |
| Normal | 6 | 193 | 199 |
| Total | 114 | 196 | 310 |

| | |
|---|---|
| True positive = 108 | Accuracy = 97.1% (95% CI 94.6% to 98.7%) |
| True negative = 193 | Sensitivity = 94.7% (95% CI 88.9% to 98.0%) |
| False positive = 3 | Specificity = 98.5% (95% CI 95.6%, 99.7%) |
| False negative = 6 | Positive predictive value = 97.3% (95% CI 92.3% to 99.4%) |
| | Negative predictive value = 97.0% (95% CI 93.6 to 98.9%) |

**Size of appendix:** The diameter of the appendixes among 310 patients varied in size from 2.7 to 16.9 mm, median was 5.7 mm. One hundred and sixty-nine patients had their size of appendix less than or equal to 6 mm and the surgical pathology result confirmed normal appendix in 168 patients. Only one patient had an appendix size 5.7 cm, but the surgical pathologic result diagnosed early acute appendicitis. The negative predictive value was 99.4%.

**1A axial image**



**1B Coronal image**

**Figure 1: Normal appendix**

A 27-year-old female patient with acute abdominal pain and clinically suspected appendicitis. Non-contrast enhanced CT scan with rectal contrast administration was obtained. A (axial image) and B (coronal image); The normal appendix (arrow) is clearly seen. It has thin wall with air and contrast-filled lumen. Its size is 4.9 cm. No appendicolith or peri-appendiceal fat stranding is demonstrated.

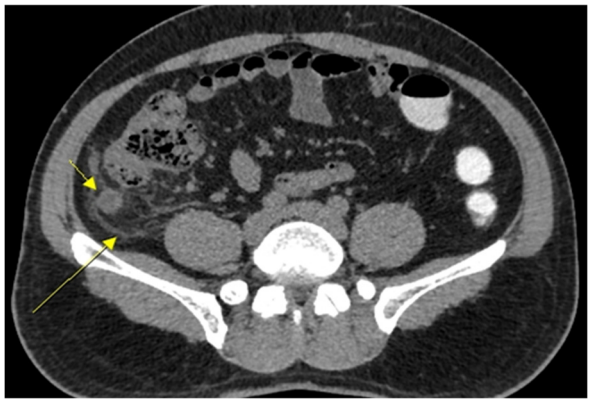


**Figure 2: Enlarged appendix**

Non-contrast enhanced CT in a 48-year-old male patient with acute appendicitis. The axial image showed enlarged appendix (short arrow) with wall thickening and adjacent inflammatory changes (arrow). The appendix was measured at 13.6 mm.

**Appendiceal wall thickness**: Among 179 patients with wall thickness under 2 mm, seven patients had surgical pathology result diagnosed acute appendicitis.

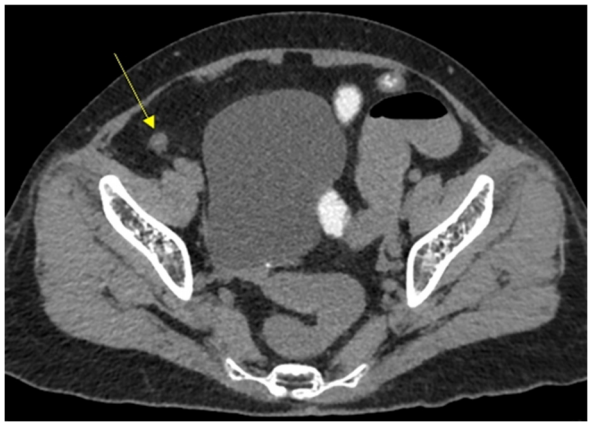


**Figure 3: Wall thickening**

Non-contrast enhanced CT in a 64-year-old female patient with acute appendicitis. The axial image showed enlarged appendix with wall thickening (arrow). The appendiceal wall is measured at 0.2 mm in thickness.

**Appendicoliths:** The Appendicoliths were found in 28 patient (9%), 22 patients presented confirmed acute appendicitis, six patients presented normal appendix.

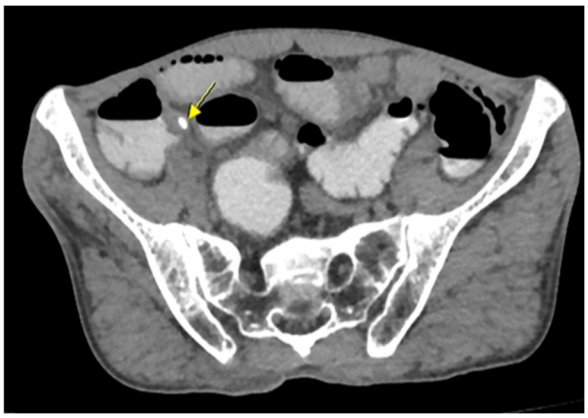


**Figure 4: Appendicolith**s

Non-contrast enhanced CT in a 48-year-old male patient with acute appendicitis. The axial image showed appendicolith (arrow) in appendiceal lumen.

**Peri-appendiceal fat stranding:** The peri-appendiceal fat stranding was found among 100 patients and a total of 114 patients had confirmed acute appendicitis.

**Figure 5: Peri-appendiceal fat stranding**

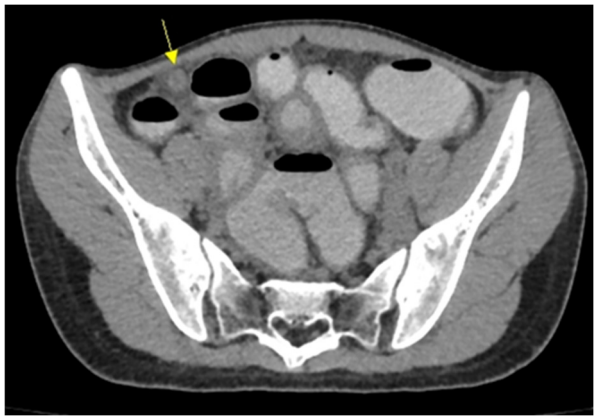
Non-contrast enhanced CT in a 39-year-old male patient with acute appendicitis. The axial image showed enlarged appendix (short arrow) with peri-appendiceal fat stranding (arrow).

**Peri-appendiceal abscess:** Four patients from 310 patients had a peri-appendiceal abscess and were confirmed for acute appendicitis. The positive predictive value was 100%.

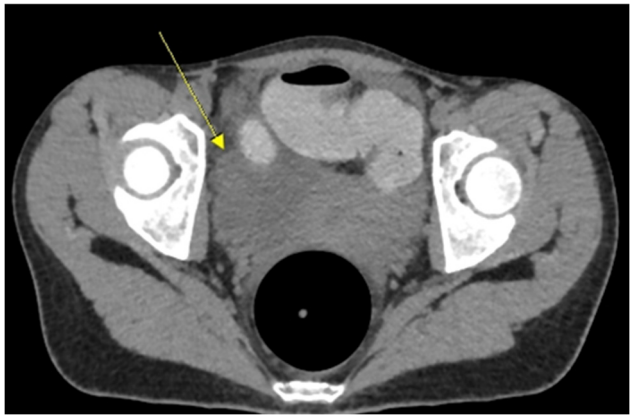
**Figure 6: Peri-appendiceal abscess**

Non-contrast enhanced CT in an 18-year-old female patient with acute appendicitis. A: The axial image showed enlarged appendix with wall thickening (short arrow) and peri-appendiceal fat stranding. B: The image of lower level showed turbid fluid collection (long arrow). Surgical exploration had proved that it was abscess.

The presence of peri-appendiceal fat stranding (36.1%), enlarged appendiceal caliber more than 6 mm (45.5%) and thickening of appendiceal wall (42.3%); these three parameters were strongly suggesting appendicitis by accuracy about 91.6, 90.6 and 90.0%, respectively. (Table 2)



**(A) Axial view**



**(B) Axial view of lower level**

**Figure 6: Peri-appendiceal abscess**

**Table 2 Efficacy of parameters used in non-contrast enhanced CT in the diagnosis of acute appendicitis**

| CT parameter | ACU | SENS | SPEC | PPV | NPV |
|---|---|---|---|---|---|
| Size of appendix > 6 mm | 90.6 | 99.1 | 85.7 | 80.1 | 99.4 |
| Wall thickness ≥ 2 mm | 90.0 | 93.9 | 87.8 | 81.7 | 96.1 |
| Appendicolith | 68.4 | 19.3 | 96.9 | 78.6 | 67.4 |
| Fat stranding | 91.6 | 87.7 | 93.6 | 89.3 | 92.9 |
| Abscess | 64.5 | 3.5 | 100 | 100 | 64.1 |
| Total | 97.1 | 94.7 | 98.5 | 97.3 | 97.0 |

ACU - Accuracy SENS - Sensitivity SPEC - Specificity
PPV - Positive predictive value NPV - Negative predictive value

## Discussion

Acute appendicitis is a common emergency surgical presentation. The gold standard treatment is surgery. Like any surgical procedure, appendicectomy is associated with complications. Negative appendicectomy can occur, and its incidence is 15 to 39%.[24-26] Of 310 patients with acute abdominal pain and atypical clinical manifestations of appendicitis, who underwent non-contrast enhanced abdominal CT in Phatthalung hospital, 134 patients had surgery and were defined negative appendectomy by pathological report among 20 patient (14.9%) which lower incidence of negative appendectomy as compare to the patients without pre-operative CT scan in prior study (25.8% - 27.8%).[24-26]

The results of this study were accuracy 97.1%, sensitivity 94.7% and specificity, 98.5% of non-contrast enhanced CT that were high accuracy to assess patients with clinical manifestations of acute appendicitis that confirmed by Malone et al[21] and D'Ippolito et al.[22] They obtained results that unenhanced CT were similar to those obtained with enhanced CT (accuracy = 92%[21] and 93%[22], sensitivity = 87%[22] - 91%[21] and specificity = 97%[22] - 100%[21]). The diameter exceeding 6 mm of appendix was an insufficient basis for a diagnosis of acute appendicitis. Among 114 patients with pathological proved appendicitis had diameter exceeding 6 mm in 113 patients. The inflammatory changes involving the thickened wall of appendix or fat stranding adjacent to the edematous inflamed appendix were high accuracy and common findings in acute appendicitis. These CT parameters including size of appendix > 6 mm, wall thickness > 2 mm and presence of fat stranding had high accuracy, sensitivity, specificity, positive predictive value and negative predictive value to diagnose acute appendicitis.

The presence of an appendicolith within the enlarged and thickened wall of appendix was useful finding due to high specificity, but it was not common finding, which only 28 patients had appendicolith (prevalence of 9%). Detection of appendicolith without enlarged appendix and inflammatory changes was an insufficient basis for a diagnosis of acute appendicitis. The appendiceal abscess was found in only 4 patients, but specificity and positive predictive value were 100%.

Additional data from this study revealed non-contrast enhanced CT was useful to detect renal and ureteric stones that also common problems in acute abdominal pain, visceral fat and position of cecum and appendix were influenced interpretation of CT scan. The obese patients had more visceral fat, made it easier to detect appendix. Therefore, slender young patients who had little retroperitoneal and mesenteric fat, resulted to be more difficult to diagnose. Malposition of the cecum or a low-lying cecum in the anatomic pelvis can also cause misinterpretation. The examination is well tolerated even by very sick patients.

## Conclusion

Non-contrast enhanced CT during preoperative diagnosis of appendicitis in Phatthalung hospital demonstrates high accuracy (97.1%), high sensitivity (94.7%), high specificity (98.5%) as other reports in the literature using

contrast-enhanced CT.[4,6,9,17-20,27-29] The examination is well tolerated even by very sick patients, less expensive and essentially less of risk as compare to contrast enhanced CT due to rapidity, only one time of radiation exposure, no risk and no cost from contrast medium. The study concludes that unenhanced CT is an accurate examination in patients with atypical clinical manifestations of appendicitis.

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