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ORIGINAL PAPERS

ROLE OF MULTI-DETECTOR COMPUTED TOMOGRAPHY IN ASSESSING ANATOMICAL SITE VARIATION OF APPENDIX IN PATIENTS WITH APPENDICITIS

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ABSTRACT

Introduction: The appendix is a blind-ended tubular structure arising from the cecum with diameter of less than 6 mm. Acute appendicitis (AA) is considered as a common disease in young patients and may occur in any age. The use of biochemical markers and urine analysis may lack specificity for AA diagnosis. Thus, the aim is to assess the feasibility of multi-detector computed tomography (MDCT) in diagnosing and differentiating kinds of appendicitis.
Methods: 121 consecutive patients (8.30% female, 91.70% male), with a mean age of 23.86 ± 10.86 years who were operated on for the suspicion of AA, were included in this study. Recruited patients were classified as false negative (FN) group and true positive (TP) group based on lab result and both clinical decision, symptoms and MDCT findings. Mann-Whitney U test was used to compare whether there is a difference in the dependent variable for two independent groups (FN and TP). A two-sided p-value > 0.05 was considered significant.
Results: There was a statistical difference has been observed between the FN and TP groups (p=0.005) with respect to white blood (WBC) counts. However, those groups were not statistically different from each other (p=0.16) as a function of appendix diameter. There was a linear relation between WBC counts and appendix diameter > 10 mm.
Conclusion: MDCT is highly accurate in diagnosing acute appendicitis. US is a "first-pass" recommended approach in diagnosing acute appendicitis. Appendix diameter greater than 10 mm is linearly correlated with white blood cell counts.
Key words: MDCT, Acute appendicitis, Diagnostic accuracy, White blood cells, radiology

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INTRODUCTION

The appendicitis is a common disorder in the digestive system that is caused by obstruction of appendiceal lumen and led to retention of intralumenal fluid and venous congestion in addition to necrosis and infection and consequently causes different complications including follicular bronchiolitis, fecolith, stricture, foreign bodies, parasitic infection or tumour [1].
Acute appendicitis (AA) has high prevalence and affecting both juvenile and young adults with a peak incidence in the second and third decades of life and AA could also occur across all ages.
The lifetime risk of developing AA is reported to be within 8.6% to 6.7% for men and women respectively [2], while men are more vulnerable to AA compared to women by 150% [3]. Additionally, AA has high rate of morbidity and mortality if untreated [4].
Yet, the treatment of AA is straightforward if accurately diagnosed, however, its symptoms are not AA specific and overlap with so many other illnesses [5]. Therefore, the diagnosis of AA remains a challenge and the negative appendectomy rate reaches 33% [6], with incorrect diagnosis of AA of about 20% in general population and around 40% in women during reproductive age [4], [7], [8].
In response to the difficulty of the accurate diagnosis of AA to limit misdiagnosis of AA and negative appendectomy rates as aside to physical investigations, laboratory blood and urine investigation has been considered and there has been several biomarkers utilized to assist in differentiating AA from non-inflammatory causes of acute abdominal pain. This includes white blood cells, C-reactive proteins, absolute neutrophil count, inter-

lukin-6 in addition to other newly utilized biomarkers [5], in combining the first two biomarkers was reported to increase the accuracy in paediatric population[9]. The use of biochemical markers in addition to clinical scoring systems for AA are ruled out in diagnostic decision due to complete lack of specificity and therefore, they may only be utilized as a guide.

Imaging modalities such as ultrasound (US), magnetic resonance imaging (MRI) and computed tomography (CT) are playing an important role in diagnosing AA, its complication and suggesting alternate diagnosis in appropriate cases.

Using US is lower in cost and safer imaging modality; however, the sensitivity and specificity of US was reported to be 69% and 81% respectively, thus, US did not add value over physical examination [10].

MRI and CT imaging modalities are with higher specificity and sensitivity for diagnosing AA, where the sensitivity and specificity are reaching 98% for CT modality [11]–[13], whereas the sensitivity was found to be 91.8% and the specificity was 97.9% for MRI [14]. The advantages of CT over MRI are including the cost of MRI and the limited availability in addition to the scan time of MRI that is longer (up to 30 min) compared to CT scan time (up to 2 sec) [15].

The aim is to assess the feasibility of multi-detector computed tomography (MDCT) in diagnosing and differentiating kinds of appendicitis.

METHODS

121 consecutive patients (8.30% female, 91.70% male), with a mean age of 23.86 ± 10.86 years, who were operated on for the suspicion of appendicitis in king Khalid Hospital-Hail-Saudi Arabia; from January 2021 to December 2021 were recruited in this current study. Multi-detectors-CT (MDCT) examination was conducted on recruited patients using both 64-detector-row CT scanner after injecting an intravenous contrast medium and US. The images of MDCT were attained during the "portal venous phase," including the area from the symphysis pubis and the dome of the diaphragm. Lab information for blood and urinary were obtained including white blood cell counts and color of urine for all recruited patients. Counts of WBC of 11,000 (11K) per microliter (/µL) is used as a cutoff point in this study as it is the upper limit of normal WBC counts in K per µL for the laboratory in our hospital.

Recruited patients were classified as a false negative (FN) group and true positive (TP) group based on lab result and both clinical decision, symptoms and MDCT and US findings.

The protocol for this retrospective study was approved by the Ethics Committee of King Khalid Hospital and Ha'il University with the requirement for informed consent being waived due to the retrospective design of this study.

Mann-Whitney U test was used to compare whether there is a difference in the dependent variable for two independent groups (FN and TP). A two-sided p-value > 0.05 was considered significant.

RESULTS

10 females with averages age of 18.45±11.45 years old and 111 males with averages age of 28.91±10.25 years old were included in this study. Participants were classified into two groups based upon the blood test reading and both MDCT and US findings, based on different imaging features including appendix diameter, wall thickness of appendix, appendicolitis and *heterogeneous fat* stranding, by two Radiologists.

These two groups are TP who have a result of WBC greater than 11 k/ µL and positive in both MDCT findings and Ultrasound in the diagnosis of AA, and FN for those who have blood result that is < 11 k/µL and positive in both MDCT findings and Ultrasound in the diagnosis of AA.

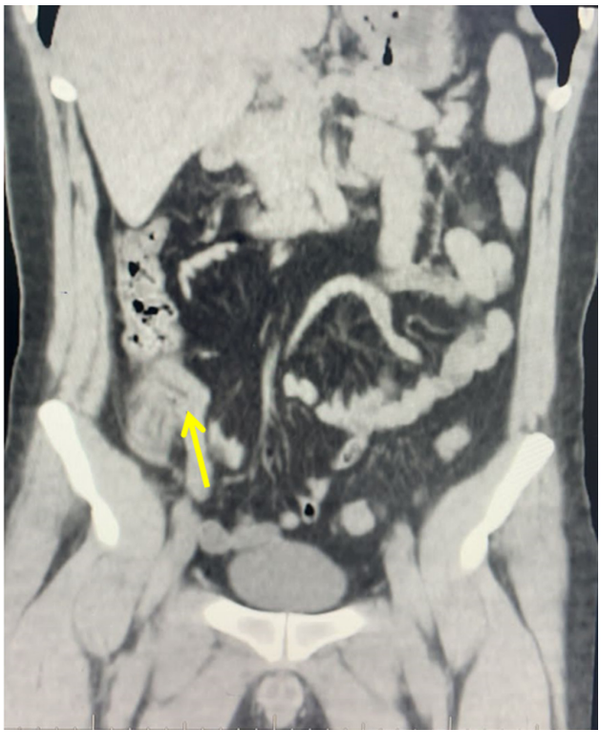

Fig. 1. A coronal reformation of MDCT for 23-years old male, is showing a mildly dilated appendix having adjacent fat stranding.

A coronal reformation of MDCT (Fig. 1) is showing a mildly dilated appendix (with a relatively thick wall; 3 mm) and having adjacent fat stranding.

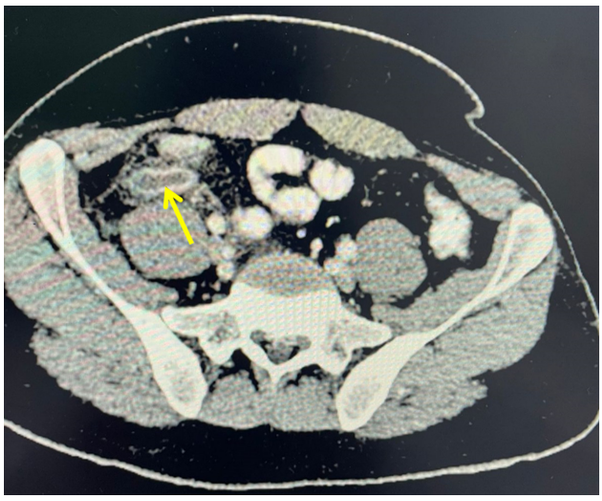

Fig. 2. An axial reformation of MDCT for 44-years old male with wall enhancement is shown appendiceal dilatation (arrow).

An axial reformation of MDCT (Fig. 2) with wall enhancement shown appendiceal dilatation (arrow) with a measure of around 12 mm in thickness (at its maximum).

An axial reformation of MDCT (data not shown) is demonstrating acute ruptured appendicitis, this male patient had an elevated white blood cell count (18.2 K/µL).

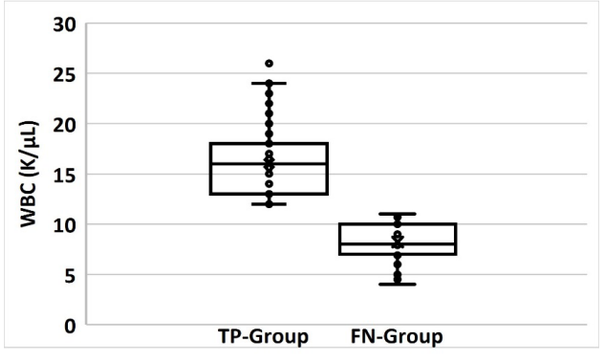

Fig. 3. Box plot of WBC counts in TP and FN groups.

TP group was with WBC count of 16.04 ± 3.60 K/µL (mean ± STD), while in FN group, the WBC count was 8.22 ± 1.86 K/µL (mean ± STD).
The difference (shown as box plot in Fig3) was statistically significantly different between TP and FN groups (p-value = 0.0046).
However, for the diameter of appendix in the two groups (shown as box plot in Fig4), the difference was not statistically significant (p-value = 0.1563).

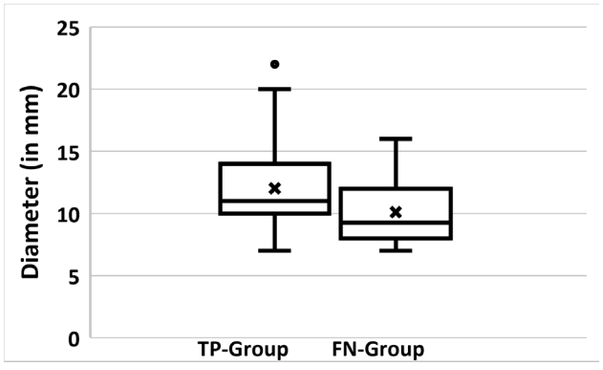

Fig. 4. Box plot of Diameter of appendix in TP and FN groups.

The diameter was 12.07 ± 3.05 mm (mean ± STD) and 10.1 ± 2.41 mm (mean ± STD) for TP and FN groups respectively.

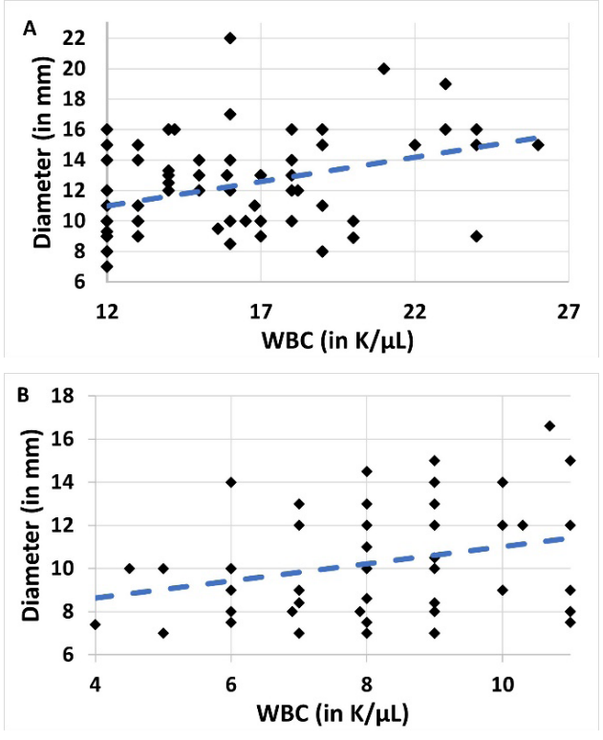

Fig. 5. Scatter plot of WBC counts and the diameter of appendix for TP group (A) and FN group (B).

There was a linear increase of appendix diameter as a function of WBC counts for both groups (Fig.5) for TP group (A) and FN group (B).

DISCUSSION

The appendix is a blind-ending tubular structure arising from the cecum with diameter of ≤ 6 mm. However, if the diameter > 6 mm, making AA diagnosis is with high sensitivity and specificity approaching 93% [16], [17]. Other imaging findings such as the presence of appendicoliths and the presence of intraluminal gas may also be considered for the diagnosis of acute Appendicitis. All the confirmed cases of Appendicitis

in this current study were having maximum diameter of appendix that is greater than 6 mm; 11.21 ± 2.95 mm (mean ± STD).

There were a significant difference of WBC counts in comparison of TP and FN groups. Normal WBC counts below a cutoff point of 11 K/ μL were recorded for 51 patients (42%). This may explain that although WBC counts is one of the most used laboratory tests for the diagnosis of AA and it is the earliest indicators of inflammation in AA. However, WBC counts is not a specific marker, and it may be elevated in patients with other inflammatory conditions [5]. Additionally, Other study demonstrated that WBC counts were not well correlated with CT-determined AA [18]. Therefore, normal WBC counts do not preclude AA as it is also demonstrated elsewhere [19].

The maximum diameter of appendix was not statistically significant between TP and FN groups based on WBC counts with p-value of 0.1563. However, there was a linear increase of WBC counts with respect to the maximum diameter of appendix and particularly for diameter > 10 mm. This has been also confirmed elsewhere [20].

Despite the debate over the carcinogenic risk of radiation exposure from CT, and by considering that appendicitis is a common disease with vast majority of patients who are adolescents and young adults with average life expectancies. A "first-pass" recommended approach is by using US.

This study has some limitations. The age of recruited patients was varied from 72 years old down to 7 years old and WBC count can vary with age [21]. Other biomarkers rather than WBC counts were not included. Thus, by combining other biomarkers, such as C-reactive protein and leukocyte particle count may reduce the negative rates [22].

CONCLUSION

Multidetector computed tomography is highly accurate in diagnosing acute appendicitis. US is a "first-pass" recommended approach in diagnosing acute appendicitis. Appendix diameter greater than 10 mm is linearly correlated with white blood cell counts.

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CONFLICT OF INTEREST

None.

REFERENCES:

1. Mostbeck, G., E. J. Adam, M. B. Nielsen, M. Claudon, D. Clevert, C. Nicolau, C. Nyhsen, and C. M. Owens, "How to diagnose acute appendicitis: ultrasound first," Insights Imaging, vol. 7, no. 2, pp. 255–263, Apr. 2016, doi: 10.1007/S13244-016-0469-6/FIGURES/4.
2. Huang, T.-H., Y. C. Huang, and C.-W. Tu, "Acute appendicitis or not: Facts and suggestions to reduce valueless surgery," 2013, doi: 10.1016/j.jacme.2013.10.003.
3. Humes, D. J. and J. Simpson, "Acute appendicitis," BMJ, vol. 333, no. 7567, pp. 530–534, Sep. 2006, doi: 10.1136/BMJ.38940.664363.AE.
4. Weyant, M. J., S. R. Eachempati, M. A. Maluccio, D. E. Rivadeneira, S. R. Grobmyer, L. J. Hydo, and P. S. Barie, "Interpretation of computed tomography does not correlate with laboratory or pathologic findings in surgically confirmed acute appendicitis," Surgery, vol. 128, no. 2, pp. 145–152, Aug. 2000, doi: 10.1067/MSY.2000.107422.
5. Shogilev, D. J., N. Duus, S. R. Odom, and N. I. Shapiro, "Diagnosing Appendicitis: Evidence-Based Review of the Diagnostic Approach in 2014," West. J. Emerg. Med., vol. 15, no. 7, p. 859, 2014, doi: 10.5811/WESTJEM.2014.9.21568.
6. Lee, S. L., A. J. Walsh, H. S. Ho, W. H. Schwesinger, J. L. Grosfeld, J. Kuhn, K. W. Millikan, and E. T. Peter, "Computed Tomography and Ultrasonography Do Not Improve and May Delay the Diagnosis and Treatment of Acute Appendicitis," Arch. Surg., vol. 136, no. 5, pp. 556–562, May 2001, doi: 10.1001/ARCHSURG.136.5.556.
7. Tzanakis, N. E., S. P. Efstathiou, K. Danulidis, G. E. Rallis, D. I. Tsioulos, A. Chatzivasiliou, G. Peros, and N. I. Nikiteas, "A new approach to accurate diagnosis of acute appendicitis," World J. Surg., vol. 29, no. 9, pp. 1151–1156, Sep. 2005, doi: 10.1007/S00268-005-7853-6/METRICS.
8. Amalesh, T., M. Shankar, and R. Shankar, "CRP in Acute Appendicitis — Is It a Necessary Investigation?," Int. J. Surg., vol. 2, no. 2, pp. 88–89, May 2004, doi: 10.1016/S1743-9191(06)60050-2.
9. Fawkner-Corbett, D., G. Hayward, M. Alkhmees, A. Van Den Bruel, J. M. Ordóñez-Mena, and G. A. Holtman, "Diagnostic accuracy of blood tests of inflammation in paediatric appendicitis: a systematic review and meta-analysis," BMJ Open, vol. 12, no. 11, p. e056854, Nov. 2022, doi: 10.1136/BMJOPEN-2021-056854.
10. Giljaca, V., T. Nadarevic, G. Poropat, V. S. Nadarevic, and D. Stimac, "Diagnostic Accuracy of Abdominal Ultrasound for Diagnosis of Acute Appendicitis: Systematic Review and Meta-analysis," World J. Surg., vol. 41, no. 3, pp. 693–700, Mar. 2017, doi: 10.1007/S00268-016-3792-7/METRICS.
11. Kim, H. Y., J. H. Park, S. S. Lee, W. J. Lee, Y. Ko, R. E. Andersson, and K. H. Lee, "CT in Differentiating Complicated From Uncomplicated Appendicitis: Presence of Any of 10 CT Features Versus Radiologists' Gestalt Assessment," AJR. Am. J. Roentgenol., vol. 213, no. 5, pp. W218–W227, 2019, doi: 10.2214/AJR.19.21331.

12. Pickhardt, P. J., E. M. Lawrence, B. D. Pooler, and R. J. Bruce, "Diagnostic performance of multidetector computed tomography for suspected acute appendicitis," Ann. Intern. Med., vol. 154, no. 12, pp. 789–796, 2011, doi: 10.7326/0003-4819-154-12-201106210-00006.
13. Randen, A., S. Bipat, A. H. Zwinderman, D. T. Ubbink, J. Stoker, and M. A. Boermeester, "Acute Appendicitis: Meta-Analysis of Diagnostic Performance of CT and Graded Compression US Related to Prevalence of Disease1," https://doi.org/10.1148/radiol.2483071652, vol. 249, no. 1, pp. 97–106, Oct. 2008, doi: 10.1148/RADIOL.2483071652.
14. Kave, M., F. Parooie, and M. Salarzaei, "Pregnancy and appendicitis: A systematic review and meta-analysis on the clinical use of MRI in diagnosis of appendicitis in pregnant women," World J. Emerg. Surg., vol. 14, no. 1, pp. 1–14, Jul. 2019, doi: 10.1186/S13017-019-0254-1/FIGURES/11.
15. Figueiro Longo, M. G., C. Jaimes, F. Machado, J. Delgado, and M. S. Gee, "Pediatric Emergency MRI," Magn. Reson. Imaging Clin. N. Am., vol. 30, no. 3, pp. 533–552, Aug. 2022, doi: 10.1016/j.mric.2022.05.004.
16. Benjaminov, O., M. Atri, P. Hamilton, and D. Rappaport, "Frequency of Visualization and Thickness of Normal Appendix at Nonenhanced Helical CT1," https://doi.org/10.1148/radiol.2252011551, vol. 225, no. 2, pp. 400–406, Nov. 2002, doi: 10.1148/RADIOL.2252011551.
17. De Jesús, O., A. Espejo, M. E. Moreno Mejía, L. Heber, and U. Guerrero, "Review Articles Acute Appendicitis: imAging findings And current ApproAch to diAgnostic imAges Apendicitis AgudA: hAllAzgos rAdiológicos y enfoque ActuAl de lAs imágenes diAgnósticAs".
18. Kim, H. C., D. M. Yang, C. M. Lee, W. Jin, D. H. Nam, J. Y. Song, and J. Y. Kim, "Acute appendicitis: relationships between CT-determined severities and serum white blood cell counts and C-reactive protein levels," Br. J. Radiol., vol. 84, no. 1008, p. 1115, Dec. 2011, doi: 10.1259/BJR/47699219.
19. Er, S., B. Çomçalı, A. Soykurt, B. C. Yüksel, and M. Tez, "Diagnosis of Appendicitis in Patients with a Normal White Blood Cell Count; A Cross-Sectional Study," Bull. Emerg. Trauma, vol. 6, no. 2, p. 128, Apr. 2018, doi: 10.29252/BEAT-060207.
20. Burak, K., A. Ali, C. Hamza, B. Katipoğlu, A. Aygun, and H. Cinar, "The effect of appendix diameter on perforation in acute appendicitis cases Akut apandisit olgularında apandiks çapının perforasyona etkisi," pp. 392–397, 2019, doi: 10.7197/223.vi.567892.
21. Bain, B. J., "Guide., Blood cells: a practical guide," John Wiley Sons, 2021.
22. Haentjens, L., L. Coussement, and M. Vuylsteke, "Value of ultrasound and computed tomography in the diagnosis of acute appendicitis with histopathology as gold standard," https://doi.org/10.1080/00015458.2022.2136050, 2022, doi: 10.1080/00015458.2022.2136050.

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