Original Article

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Radiology Section

Computed Tomography Scan for Minimising the Rate of Negative Appendectomy in Patients Suffering from Acute Right Lower Abdominal Pain

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ABSTRACT

Introduction: Diagnosis and management of right lower abdominal pain which is frequently due to appendicitis, is still a subject of continuous study. The correct diagnosis will decrease the frequency of negative surgery with a decline in days of hospital stay and leads to the direction of health funds towards the proper target.

Aim: To evaluate the efficiency of Computed Tomography (CT) scan in diagnosing the patients presenting with acute pain at the lower right abdominal quadrant and its chance for diminishing the rate of negative appendectomy in these patients.

Materials and Methods: This study included 238 consecutive patients suffering from acute pain in the right lower abdominal quadrant. All patients underwent clinical, laboratory, and radiological evaluation. The abdominal Ultrasonography (USG), and then a CT done in all cases. Laparoscopy was not available in our emergency operating theatre, so diagnostic laparoscopy was not possible and laparotomy was done for the 238 patients as they had a suspicion of the need for surgical intervention. The harvested specimens sent for histological examination. We excluded from our study the patients who were generally stable with mild or no abdominal manifestations, as well as with the negative USG and/or CT, they kept for 48 hours under observation and then discharged on symptomatic treatment, contact number for communicating in cases of recurrent symptoms, and follow-up in the outpatient clinic. Data were collected and statistically analysed.

Results: Appendectomy performed in 238 cases, out of them 105 were males and 133 were females. Considering histopathological diagnosis as the gold standard, preoperative CT showed a significantly higher test validity characters in comparison to the abdominal USG and clinical examination with a sensitivity of 94.3%, a specificity of 91%. On the other hand, USG showed a sensitivity rate of 77.4%, a specificity rate of 76%. Clinical examination showed a sensitivity rate of 74.8%, a specificity rate of 69.6%.

Conclusion: The preoperative CT for patients suffering acute pain in the lower right abdominal region; is highly recommended in suspicious cases and it diminishes the rate of unnecessary laparotomies when the diagnostic laparoscopy is not possible as well as it improves the true positive surgical rate.

Keywords: Acute abdomen, Negative laparotomy, Preoperative

INTRODUCTION

Acute appendicitis is the commonest cause of acute abdominal emergencies all over the world. The incidence of acute appendicitis around 89/100,000 annually [1], the lifetime risk of getting an attack of acute appendicitis about 7-8% [2]. Despite being a disease that dates from early history, diagnosis and suggested lines of management for right lower abdominal pain which mostly due to appendicitis still a subject of continuous development. The attainment of correct diagnosis irrespective of the cost of procedures used, could decrease the consumption of resources through reduction of the frequency of negative surgery with its consequences as a decline in days of hospital stay and permit the direction of health funds towards the proper target [1-3].

The typical manifestations of acute appendicitis are (peri-umbilical pain shifting to the right iliac fossa, anorexia, and nausea). However, the diagnosis of acute appendicitis is not continuously clear clinically and range from 37% to 53%. The drawbacks of the wrong diagnosis, missing appendicitis and delay of operations are severe and dramatic and may include

the following sequel: gangrenous appendicitis, perforation with peritonitis or abscess formation, increase the duration of hospital stay, the cost elevated, and the incidence of early and delayed complications markedly amplified with increases in patient's morbidity and mortality [1,4,5].

Improvement of radiological tools and progress in the estimation of new inflammatory markers allows higher incidence of early diagnosis and proper management of acute appendicitis, but the rate of early detection for complicated and/or unusually presented appendicitis is still inadequate [3,6,7]. On the other hand, in the past, negative appendectomy has been considered acceptable at the rates of 20%-25% and as high as 40% in women. The size of the problem of negative appendectomy is much greater in special situations as abnormal presentation, abnormal site of pain, in pregnant ladies and in children [8,9]. In general, females showed a higher rate of negative appendectomy due to different gynaecological problems, which can confuse the diagnosis of appendicitis. Also, pregnancy is an important cause for acute abdomen and thus, resulting in high rate of negative laparotomy [2,10]. In the present study, we are trying to share our efforts helping to minimise the problem of negative appendectomy in patients suffering acute right lower abdominal pain when diagnostic laparoscopy is not available.

MATERIALS AND METHODS

This prospective study was implemented in the General Surgery Department, Benha University Hospital in Egypt and King Saud Hospital in Saudi Arabia from January 2016 until January 2018. After approval of the study protocol by the local Ethical Committee and obtaining a fully informed written patients consent. The study included 238 consecutive patients came to ED suffering from acute pain in the right lower abdominal quadrant. Patient selection was done in a consecutive manner without any one's individual decision with a clear inclusion and exclusion criteria.

Sample size = $z^2xp(1-p)/e^2N$

N=Population size; e = Margin of error; z = z-score; and e is the % into a decimal form (example, 3% = 0.03).

Patients suffering from non-traumatic abdominal acute pain at the right lower quadrant that necessitates hospital admission and they were diagnosed as acute appendicitis were included in the study. Patients who had or became stable with the negative USGand/or CT, patient's inability to offer informed consent, patients <18 years of age and > 60 years old, pregnant females, any contraindication for the contrast agents, patients involved in another drug or device study and patients with the remarkable psychiatric problem were excluded from the study.

All included patients underwent a complete medical history and a comprehensive clinical examination. History of pain, nausea and/or vomiting, fever, change in the bowel habits, urinary symptoms, gynaecological problems, and history of previous similar manifestations was undertaken. Clinical signs in the form of tenderness, rebound tenderness, and special clinical signs were determined. Blood samples sent to a laboratory for Complete Blood Count (CBC), Erythrocyte Sedimentation Rate (ESR), C-Reactive Protein (CRP) and full routine investigations as well as a pregnancy test for all females in the childbearing period. The probable clinical diagnosis was determined depending on the clinical and laboratory data.All enrolled patients, underwent an abdominal USG and then scanning with multidetector row CT (HiSpeed Advantage; GE Medical Systems, Milwaukee, Wis). Scans were taken at 5-mm section thickness. The contrast material (Omnipaque 300, GE Healthcare) was injected intravenously (150 mL at a rate of 5 mL/Sec).

Patients who had a clinical suspicion for the need of surgical interference were managed emergently after correction of general condition particularly if there is fever or dehydration. On the other hand, the patients who had or became stable with the negative USG and/or CT were continued under observation in the Emergency Department (ED) upto 24 hours and then cleared and they excluded from our study. Harvested specimens (the appendix) sent to the laboratory for histopathological examination, which is the gold standard investigation for comparison of diagnostic accuracy.

STATISTICAL ANALYSIS

Collected data presented as mean±SD, numbers, ranges, and ratios. Results analysed using Wilcoxon's ranked test for unrelated data (Z-test) and Chi-square test (χ^2 test) for numerical data. Sensitivity and specificity of the diagnostic modalities as predictors for negative laparotomy were assessed via the Receiver Operating Characteristic (ROC) curve analysis judged by the Area Under the Curve (AUC) and Regression analysis (Stepwise method). Statistical analysis completed by the SPSS (version 21.0 for Windows; SPSS Inc., Chicago, Illinois, USA) statistical package.

RESULTS

The study included 238 consecutive patients presented to the ED with a picture suggestive of acute abdomen. All patients underwent surgical exploration, including; 164/238 (69%) patients had emergency surgery and 74/238 (31%) had surgery within 48 hours of hospitalisation. There were 105/238 (44%) males and 133/238 (56%) females with mean age of 34.4±7.5 years. Patients' demographic, constitutional and clinical data at the time of presentation are shown in [Table/Fig-1].

The postoperative histopathological findings confirmed the

positive diagnosis of acute appendicitis in 159/238 patients (66.8%), while in 79 cases (33.2%), the appendix was histopathologically free (non inflamed appendix).

Preoperative clinical diagnosis depending on presenting symptoms, objective findings and laboratory data, defined 143/238 patients as having an acute abdominal condition, mostly acute appendicitis. Among these cases, the postoperative histopathological results confirmed only 119/143 (83.2%) as an inflamed appendix (true positive). The preoperative USG defined 142/238 patients as having acute appendicitis. Among these cases, the postoperative histopathological results confirmed only 123/142 (86.6%) as an inflamed appendix (true positive). On the other hand, preoperative abdominal CT-scan defined 159/238 patients as having acute appendicitis. Among these cases, the

Data	Strata	Findings
Age (years)		27.4±7.5 (19-45)
Gender	Males	105 (44%)
	Females	133 (56%)
Body mass index (BMI)		30.6±2.4 (26.1-35.8)
Presenting symptoms	Pain	186(78%)
	Fever	45 (19%)
	Nausea	209 (88%)
	Vomiting	36 (15%)
	Diarrhea	5 (2%)

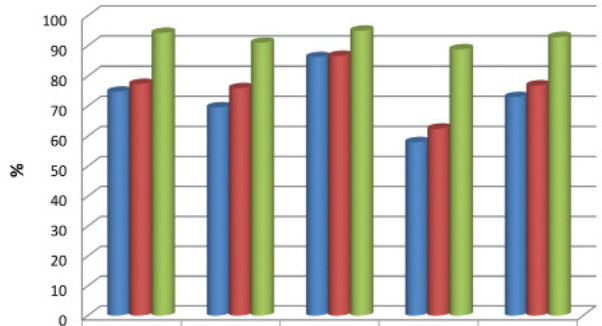
[Table/Fig-1]: patients' demographic data.
Data are presented as mean ± SD & numbers; ranges & percentages are in parenthesis

Histopathological			Clinical	USG	CT-scan
Positive	True	238	119	123	150
	False		24	19	8
Negative	True		55	60	71
	False		40	36	9

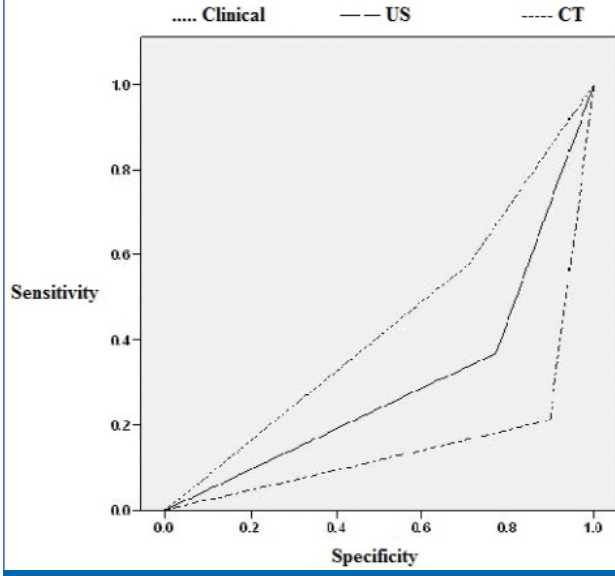
[Table/Fig-2]: Patients' distribution according to the clinical and radiological diagnosis of acute appendicitis in comparison with histopathological diagnosis.

postoperative histopathological results confirmed 150/159 (94.3%) as an inflamed appendix (true positive) [Table/Fig-2].

Considering histopathological diagnosis as the gold standard, preoperative CT showed a significantly higher test validity characters in comparison to the abdominal USG and clinical examination with a sensitivity of 94.3%, a specificity of 91%, PPV of 95%, NPP of 88.8%, and an accuracy rate for diagnosis 92.9%. On the other hand, USG showed a sensitivity rate of 77.4%, a specificity rate of 76%, PPV of 86.6%, NPP of 62.5%, and an accuracy rate for diagnosis 76.9%. Clinical examination showed a sensitivity rate of 74.8%, a specificity rate of 69.6%, PPV of 86.2%, NPP of 58%, and an accuracy rate for diagnosis 73% [Table/Fig-3].



[Table/Fig-3]: Test validity characters of the clinical, US, and CT diagnosis of acute appendicitis as the cause of acute abdomen.



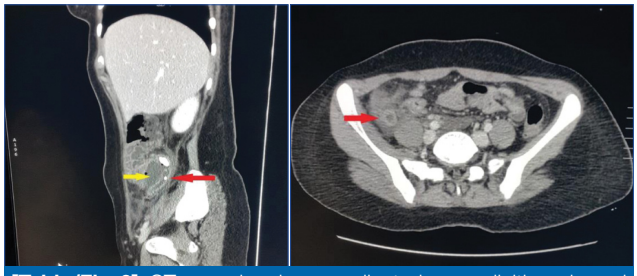
[Table/Fig-4]: The ROC curve analysis of the sensitivity of clinical diagnosis, USG scanning and CT imaging for prediction of negative appendectomy.

Using ROC curve for evaluating the predictability of clinical diagnosis, USG diagnosis and CT imaging as a predictor for a negative diagnosis showed that both USG and CT imaging are significant sensitive predictors for negative appendectomy [Table/Fig-4]. Moreover, regression analysis defined preoperative CT as the best predictor for negative appendectomy [Table/Fig-5].

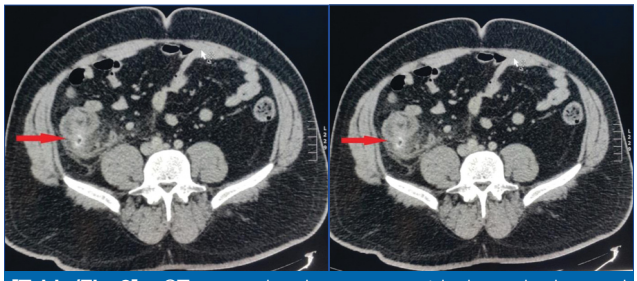
Modalities	β	T	p-value
Clinical diagnosis	0.072	1.023	>0.05
USG scanning	0.062	0.319	>0.05
CT imaging	0.688	10.172	<0.001

[Table/Fig-5]: Regression analysis of diagnostic procedures as the best predictor for prediction of negative laparotomy.

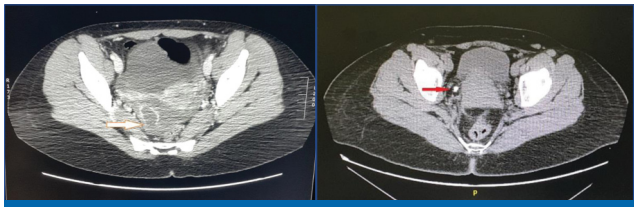
The CT-scan diagnosed a variety of cases of complicated appendicitis [Table/Fig-6]. Besides diagnosing cases of uncomplicated appendicitis [Table/Fig-7], CT imaging defined one case of cancer caecum forming a mass mimicking appendicular mass on USG examination. Moreover, CT diagnosed cases of inflammatory bowel disease at the terminal ileum that was clinically mimic acute appendicitis [Table/Fig-8]. CT showed one case of caecal diverticulitis that was diagnosed before by the USG as complicated appendicitis [Table/Fig-9]. Abdominal CT-scans defined a variety of different intra-abdominal/gynaecological insults that lead to acute abdominal pain in the right lower quadrant; complicated right ovarian cyst [Table/Fig-10], disturbed ectopic pregnancy, right tubo-ovarian abscess, and Pelvic Inflammatory Disease (PID). Three cases had impacted lower end right ureter [Table/Fig-11].



[Table/Fig-6]: CT-scan showing complicated appendicitis: enlarged appendix with enhanced thickened wall and a dilated lumen containing 2 faecoliths (red arrow) and a peri-appendicular fluid collection containing pocket of air indicating beginning of abscess formation (yellow arrow).
[Table/Fig-7]: CT-scan showing non complicated appendicitis; inflamed appendix with thickened and enhanced wall as well as a dilated lumen (red arrow).



[Table/Fig-8]: CT-scan showing asymmetrical marked mural thickening of the cecum (red arrow) and terminal ileum with mesenteric lymphadenopathy, indicating inflammatory bowel disease in a patient suffering acute pain in the right iliac fossa.
[Table/Fig-9]: CT-scan showing cecal diverticulum with surrounding fat stranding (diverticulitis) (arrow). This case diagnosed previously in the USG as complicated appendicitis.



[Table/Fig-10]: CT-scan showing complicated right ovarian cyst in patient suffering acute right side abdominal pain, laparoscopy exploration revealed hemorrhagic right side ovarian cyst.
[Table/Fig-11]: CT-scan showing impacted stone at the distal end of the right ureter (red arrow) in a patient came with a picture mimic acute appendicitis.

DISCUSSION

Acute appendicitis can be diagnosed by medical history and clinical examination, however, typical clinical findings and laboratory results may be absent in about 20-30% at the time of presentation, and even when they are present in the early stage, can mimic other intra-abdominal conditions and the diagnosis of acute abdomen can be difficult [11].

Radiological studies, for example USG, CT or MRI may be essential to decrease the rate of negative appendectomy [12]. Sometimes there is a role for diagnostic laparoscopy in diagnosing the acute abdominal insults mostly in female patients.

When we advise one of the imaging studies, the potential exposure to radiation and patients' age should be taken into consideration. A precise balance of risk benefit ratio is important. The routine use of preoperative CT-scan has been established to be associated with lower rates of negative appendectomy [13]. On the other hand, there is increasing proves that spontaneous improvement of uncomplicated AA is common and that imaging studies can result in increased diagnosis of benign conditions and avoidance of unnecessary surgeries [14].

Krajewski S et al., reported that the negative appendectomy rate was 8.7% when using CT compared with 16.7% when using the clinical evaluation only with a significantly lower rate of negative appendectomy in the era of CT in comparison with the pre-CT era, they concluded that a routine pelvic abdominal CT should be done in all patients suffering pain in the right lower abdominal quadrant with suspected appendicitis, this can diminish the frequency of unnecessary surgical interference without increasing the morbidity [13]. These data go in hand with our reported figures that revealed a high accuracy rate of CT scan (92.9%) in diagnosing cases of right iliac fossa pain when compared with the accuracy of the USG and clinical examination which is 76.9% and 73% respectively. Of course, in the absence of the facility of diagnostic laparoscopy, the CT study will lead to avoidance of unnecessary surgery. In the same way, Petroianu, found that the improvements in radiological tools lead to reductions in the false positive or negative acute appendicitis diagnosis [15]. In experienced hands, USG may have a 90% sensitivity with a specificity greater than 90%. However, in his study, CT has reported a sensitivity of about 95% and specificity over 95% that exceed our findings.

Also, Kontopodis N et al., agrees with our results and they mentioned that for adult patients coming with clinical manifestations of acute appendicitis, the specificity and sensitivity of pelvi-abdominal CT were higher than those of the USG, with better performance when CT scan was done with IV contrast [16].

In order to avoid the risk of high radiation dose and the use of intravenous contrast material, Poletti PA et al., [17] & Petroianu A et al., [15] evaluated an idea of mixing the USG and low-dose unenhanced CT with oral contrast in the evaluation of acute appendicitis, to diminish the need for conventional CT and they found that the planned algorithm achieved a high sensitivity as well as specificity for diagnosis of acute appendicitis, while decreasing the necessity for standard CT and accordingly restricting exposure to radiation and to the IV contrast material. In supporting the accuracy of CT scan in the diagnosis of the acute abdominal conditions, a recent study compared between CT and magnetic resonance imaging (MRI), Kinner S et al., [18] and Repplinger M et al., [19] found in their study that in adolescents and young adults, the diagnostic sensitivity and specificity of CT and (MRI) are very similar for the diagnosis of acute appendicitis.

Bhangu A et al., discussed a case with right-sided acute loin pain, abdominal USG was negative for appendicitis, renal stones or hydro-nephrosis, after discharge, the patient came again one week later in the ED and an abdominal CT with IV contrast was done and showed perforated appendicitis [20].This supports our results that revealed a high diagnostic accuracy of CT scan compared to abdominal USG (93.8 and 71.7%, respectively). In a trial to study the patient's factors that affect the result of the imaging study Abo Alyssa M et al., tried to define the relationship between patients' body mass index (BMI) and the accuracy of abdominal USG and CT scan for patients suffering acute abdominal pain, they found that the sensitivity and specificity of CT are excellent for diagnosis of acute appendicitis irrespective of the BMI [21]. This data agrees with our results; however, they found that the sensitivity of USG decreased with increasing the BMI over 35 kg/m^2.

Regarding the differential diagnosis of acute abdominal pain in our study; CT scans defined 20 cases of gynaecological emergencies which were misdiagnosed depending on USG examination. Moreover, CT imaging confirmed a rare caseof acute caecal diverticulitis without abscess formation that was diagnosed before as complicated appendicitis by the abdominal US. One case of cancer caecum forming a mass mimicking appendicular mass on USG examination was diagnosed on CT imaging. These data provide an additional advantage for preoperative CT which may modify the surgical decision. In line with these findings, Purysko O et al., [22] and Park JH et al., [23] goes with our findings and documented that multidetector CT is an extremely useful noninvasive method for diagnosis and identifications of all emergent pathological conditions at the right lower abdominal quadrant such as appendicitis and as well as the less common diseases including inflammatory, malignant, and miscellaneous disorders. D'Souza N et al., in their retrospective study that included 531 patients concluded that the negative appendectomy rate is still very high and leads to an additional economic burden. And they agree with us and advised that routine CT imaging of cases with suspected appendicitis would decrease the frequency of negative appendectomy from 20% to 5%, as well as could result in money savings and a more precise and superior service for our patients [24]. Broader scale studies are required for evaluation of cost-benefit of bearing in mind preoperative CT as a routine diagnostic procedure.

CONCLUSION

Preoperative CT for patients with acute right lower abdominal pain is mandatory in most cases in order to reduce the negative appendectomy rate and improves the true positive surgical rate. Moreover, preoperative CT could help to identify the differential diagnosis of the underlying pathology and so can modify the surgical decision.

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