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Original Research Paper

General Surgery

"ROLE OF COMPUTED TOMOGRAPHY AND ULTRASONOGRAPHY IN THE DIAGNOSIS OF ACUTE APPENDICITIS" : A MULTI-CENTRE EXPERIENCE

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ABSTRACT Acute appendicitis is one of the most common cause of acute abdomen that warrants emergency surgery.Inspite of widespread use of advanced laboratory markers, the diagnosis of appendicitis can be difficult. Different markers like WBC count and CRP have been investigated in various studies for their role in the diagnosis of acute appendicitis. Traditionally, the diagnosis of acute appendicitis is mainly based on history, findings at physical examination, and results of laboratory tests. The rate of negative findings for appendicitis at laparotomy or laparoscopy based on these parameters may be as high as 50%. For the past two decades investigators have considered CT and sonography to be accurate imaging techniques for detecting acute appendicitis.The Aims and objective is to determine the diagnostic accuracy of non-enhanced computed tomography (NECT) and ultrasonography (USG) in acute appendicitis and To find out whether the negative appendectomy rate can be lowered down by combining the findings of non-enhanced computed tomography (NECT) and ultrasonography (USG). In conclusion, non enhanced computed tomography and ultrasonography are complimentary to one another in the diagnosis of acute appendicitis. Non-enhanced computed tomography has a higher accuracy rate when compared with ultrasound of abdomen. Negative appendectomy rate can be lowered down by combiningthe findings of non-enhanced computed tomography (NECT) and ultrasonography (USG).

KEYWORDS : Acute appendicitis, Appendix, USG,NECT

INTRODUCTION

Acute appendicitis is one of the most common cause of acute abdomen that warrants emergency surgery.[1,2]Inspite of widespread use of advanced laboratory markers, the diagnosis of appendicitis can be difficult. Different markers like WBC count and CRP have been investigated in various studies for their role in the diagnosis of acute appendicitis.[3,4,5] Various studies have emphasized that increased leukocyte count and CRP supports the diagnosis of acute appendicitis.[6] The lifetime risk of developing appendicitis in western scenario is 8.6% for males and 6.7% for females, with the highest incidence in between second and third decades.[7] Although most of the times diagnosis of acute appendicitis is made clinically, later on it can be supported by various radiological and biochemical investigations, findings may not always be typical, in which case the establishment of diagnosis becomes difficult. This classical practice is currently being abandoned by most surgeons as negative appendectomy are no longer considered acceptable. They carry a substantial morbity, increase hospital cost[8,9,10]and may be avoided by using preoperative radiological imaging.[11]

Traditionally, the diagnosis of acute appendicitis is mainly based on history, findings at physical examination, and results of laboratory tests. The rate of negative findings for appendicitis at laparotomy or laparoscopy based on these parameters may be as high as 50%.[12,13] On the other hand, a delay in the diagnosis and treatment of appendicitis may increase the potential risk of a complicated clinical course.[14]

For the past two decades investigators have considered CT and sonography to be accurate imaging techniques for detecting acute appendicitis. Helical CT has reported sensitivities of 70–100% and specificities of 91–99%.[15,16]Sonography has reported sensitivities of 75-90% and specificities of 86-100%.[17,18]

Sonography examinations were performed using the graded compression technique described by Puylaert.[19] On sonography, the primary criterion to establish the diagnosis of acute appendicitis was direct visualization of the inflamed appendix: a concentrically layered, small, sausagelike structure found at the point of tenderness. The classic appearance is an incompressible appendix with a diameter of 6 mm or larger and echogenic incompressible periappendicular inflamed fat with or without an appendicolith.

The CT criteria for acute appendicitis were an enlarged appendix (7mm in outer diameter), periappendicular fatty infiltration and a thickened appendiceal wall enhancement.[12]

Ultrasound is safe, easily accessible, and, mostimportant, does not use ionizing radiation. When the USresult is equivocal a CT should be carried out. A negativeUS result does not justify a complementary CT. Patientswith an equivocal clinical diagnosis and a negative US forappendicitis, can safely be re-evaluated during a hospitaladmission or at the outpatient clinic the next day. In case ofnon-visualization of the appendix during US in children,appendicitis can be safely ruled out if there are no secondarysigns of appendicitis.[20]

Patients with non-visualization of the appendix on US or normal scans, are at significantly lower risk for appendicitis, either perforated or nonperforated.[21]Knowledge of the identified CT findings like the presence of appendiceal wall enhancement, intraluminal air in appendix, a coexistent

inflammatory lesion, and appendiceal wall thickening may improve diagnostic accuracy for acute appendicitis in patients with equivocal CT findings.[22]

Rapid and accurate diagnosis is important because extension of the period between onset of symptoms and start of the surgical procedure may increases the rate of complications i.e. appendicular abscess, appendicular perforation, which may results in sepsis and even death. In addition, the ratio of patients undergoing appendectomy with a normal histopathological investigation result (negative appendectomy) ranges between 5% and 42%.[23] The morbidity of these patients who are operated on despite the absence of acute appendicitis is thus increased. The rate of clinical diagnosis of acute appendicitis is approximately 85%.[24] To support the clinical diagnosis of acute appendicitis and to reduce the frequency of unnecessary appendectomy, the importance of laboratory investigations like white blood cell counts(WBC), C-reactive protein (CRP), USG and computed tomography etc, has been investigated in various studies.[25,26] Although most studies demonstrate positive correlation between leukocytosis, elevated CRP with USG and Computed tomography for acute appendicitis, these tests are not always confirmatory. The use of ultrasonography (USG) as a diagnostic tool for appendicitis has been widely accepted. The sensitivity, specificity, positive predictive value, negative predictive value and accuracy rate of ultrason ography was 71.2%, 83.3%, 97.4%, 25% and 72.4%, respectively.[25,26] Computed tomography is considered as gold standard investigation for diagnosis of appendicitis.

However, because of radiation exposure during CT, recent studies have suggested performing initial sonography and limiting CT in evaluation of patients with acute abdominal pain.[27,28] Unfortunately, the precise utility of sonography in the initial assessment of patients with suspected acute appendicitis is still widely debated.[29] Therefore, some clinicians prefer performing CT for diagnosis or exclusion of acute appendicitis.

Acute appendicitis continues to be a challenging diagnosis. Although there are many parameters that have been developed, yet the diagnosis of acute appendicitis still remains a dilemma in a large proportion of cases inspite of the various laboratory investigation. Preoperative radiological imaging using ultrasonography (USG) and computed tomography (CT) has gained popularity as it may offer a more accurate diagnosis than a classical evaluation.

Thus the purpose of our study is to determine the accuracy of computed tomography and ultrasonography in the diagnosis of patients suspected of having acute appendicitis. Attempt was made to find out whether the negative appendectomy rate can be lowered down by combining the findings of computed tomography and ultrasonography.

AIMS AND OBJECTS

1. To determine the diagnostic accuracy of non-enhanced computed tomography (NECT) and ultrasonography (USG) in acute appendicitis.
2. To find out whether the negative appendectomy rate can be lowered down by combining the findings of non-enhanced computed tomography (NECT) and ultrasonography (USG).

MATERIALS AND METHODS

Study design: Cross sectional study.

Study setting: The study was carried out in the Department of Surgery in collaboration with Department of Radio-diagnosis and Department of Pathology, in Dr. Ram Manohar Lohia Institute Of Medical Sciences , Prasad Institute Of Medical Sciences & Hospital, Lucknow and Autonomous State Medical College, Basti, Uttar Pradesh ,for a period of 27 months with effect from January 2019 to March 2021. All Patients who attended surgery OPD or emergency ,was clinically diagnosed to have acute appendicitis.

INCLUSION CRITERIA:

All patients who was clinically diagnosed to have acute appendicitis and who underwent ultrasonography and computed tomography at Department of Surgery.

EXCLUSION CRITERIA:

1. Patient who was not willing to participate in this study.
2. Patient of appendicular lump or abscess.
3. Patient previously treated conservatively for appendicitis.
4. Pregnant women.
5. Patient less than 18 yrs.
6. Patients recognized to have any co-morbidity like heart disease, psychiatric illness and diabetic.
7. Patients who are Immuno compromised and on steroids therapy.

RESULTS AND OBSERVATION

The present study consist of 82 patients who attended surgery OPD or casualty in the Department of General Surgery, DR RML-IMS, Prasad institute of medical sciences & Hospital and Autonomous state medical college,Basti, uttar Pradesh was clinically diagnosed to have acute appendicitis. during the study period i.e January 2019 to March 2021 with clinical diagnosis of acute appendicitis and undergoing emergency appendectomy. Type of the study was a cross sectional study and relevant information were elicited in the predesigned interview schedule, prepared for the purpose.

AGE DISTRIBUTION:

Table 1 : Age distribution of the respondents

Age group	Frequency	Percentage
19-20	13	15.9
21-30	22	26.8
31-40	15	18.3
41-50	23	28.0
51-60	5	6.1
61-70	2	2.4
>70	2	2.4
Total	82	100.0

Table 1 shows majority of respondents were from the age group 41-50 years (28%) followed by 21-30 years (26.8%). Mean age of the patients in this study was35+15.2 year.

SEX DISTRIBUTION:

Table 2 :Sex distribution of the respondents

SEX	Frequency	Percentage
MALE	35	42.7
FEMALE	47	57.3
Total	82	100.0

Table 2 shows majority of the respondents were female accounted for 57.3% of cases while the male accounted 43.1%.

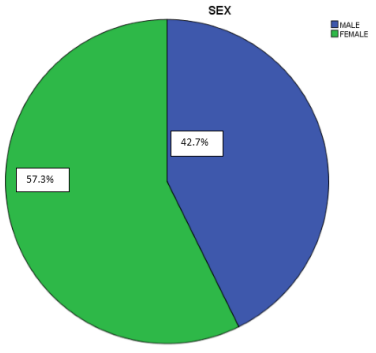

Fig 1. Pie chart showing sex distribution of the respondents

RELIGION

Table 3: Religion distribution of the respondents

Religion	Frequency	Percentage
HINDU	56	68.3
MUSLIM	14	17.1
CHRISTIAN	12	14.6
Total	82	100.0

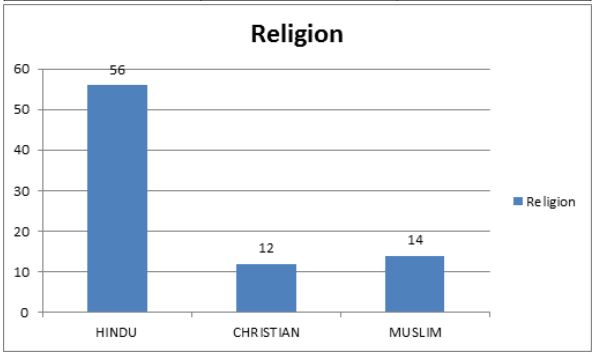

Fig 2. Bar diagram shows distribution of respondents by religion

Table 3: shows majority of the patients were found to be Hindu (68.3%) followed by Muslim (17.1%) and lastly Christian (14.6%).

SOCIO-ECONOMIC STATUS :

Table 4: Socioeconomic distribution of the respondents

Frequency	Percentage	Socio-economic status
HIGH CLASS	13	15.9
MIDDLE CLASS	47	57.3
LOW CLASS	22	26.8
Total	82	100.0

Table 4: shows most of patients were from middle socio-economic status (57.3%) followed by low class (26.8%) followed by high class (15.9).

SYMPTOMS AND SIGN PRESENTATION :

Table 5: distribution of the respondents with initial site of pain

Initial site of pain	Frequency	Percentage
RIF	24	29.3
SUPRAPUBIC	19	23.2
PERIUMBILICAL	39	47.6
Total	82	100.0

Table 5: shows the frequency of patients with the initial site of pain. Most of patients had initialsite in periumblical area (47.6%) followed by right iliac fossa pain (29.3%) andsuprapubic (23.2%).

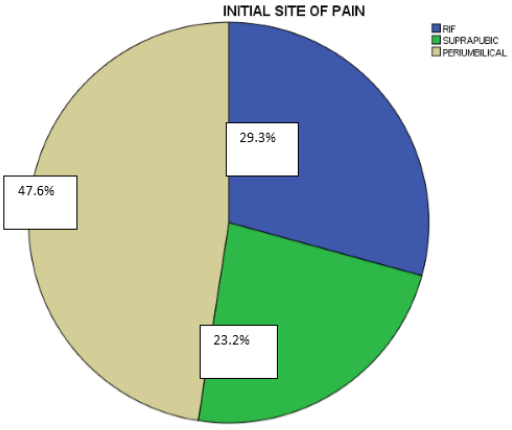

Fig 3. Pie chart showing distribution of the patients according initial site of pain

Table 6: Symptoms distribution of the respondents

SYMPTOMS	FREQUENCY	PERCENTAGE
SHIFTING PAIN	58	70.7
ANOREXIA	75	91.5
NAUSEA/VOMITING	78	95.1
FEVER	17	20.7
DYSURIA	38	46.3
DIARRHEA	7	8.5

Table 6 shows the frequency of respondents presented with shifting right iliac fossa pain, anorexia, nausea/vomiting, fever, dysuria and diarrhoea. Its evident that most of patients had nausea/vomiting (95.1%) and Anorexia (91.5%) shifting right iliac fossa pain (70.7%).

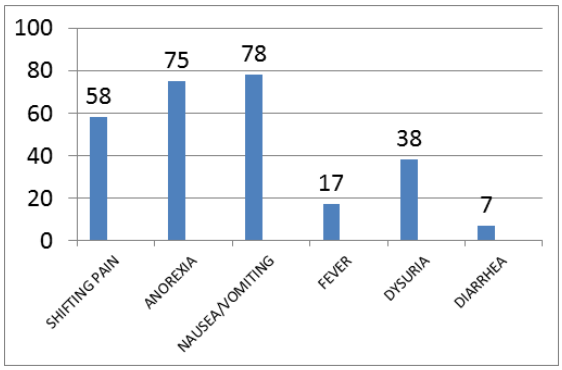

Fig 4. Bar diagram showing distribution of respondents by symptoms.

Table 7 : distribution of the respondents according to clinical sign

SIGN	FREQUENCY	PERCENTAGE
REBOUND TENDERNESS	73	89
LOCALIZED GUARDING	32	39
ROVSING SIGN	33	40
COPE PSOAS	9	11
COPE OBTURATER TEST	4	4.9
ELEVATED TEMPERATURE	14	17

Table 7, shows that most of the patients in our study had rebound tenderness in RIF (89%) followed by Rovsing sign (40%), localized guarding (39%). Fever was present in 17%,Cope psoas 11% and Copeobturater test 4.9%.

DISTRIBUTION ACCORDING TO CLINICAL SIGN

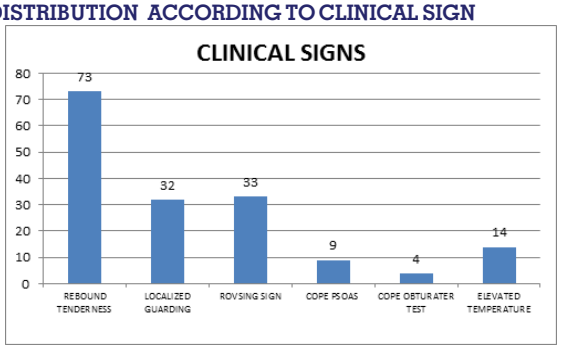

Fig5. Bar diagram showing distribution of the patients according to sign

Table 8: Showing diameter of appendix in USG

Diameter of appendix in USG(mm)	Frequency	Percentage
0	8	9.8
5	1	1.2
6	10	12.2
7	13	15.9
8	21	25.6
9	16	19.5

10	6	7.3
11	3	3.7
12	1	1.2
13	1	1.2
14	2	2.4
Total	82.0	100%

Majority of patients in our study have diameter of appendix detected by ultrasound to be 8mm(25.6%). Minimal cut off value for sonological positive appendix was 6mm and it was detected in 73 patients. Largest diameter of appendix in this study was 14mm.

Table9 : USG Appendix visualisation distribution of the respondents

USG OF APPENDIX	Frequency	Percentage
VISUALISED	74	90.2
NOT VISUALISED	8	9.8
Total	82	100.0

Table 9: In our study in 90.2% of cases USG was able to visualised appendix whereas appendix was not visualised in 9.8% cases.

Table 10:USG feature of acute appendicitis:

USG feature	frequency	percentage
fat standing	48	58.5%
collection	13	15.9%

Table 10, shows that majority of the patients in this study,ultrasound showsfat standing was present 58.5% but collection was found only in 15.9%.

Table 11: CT scan Appendix visualisation

Frequency	Percentage	CT scan of Appendix
VISUALISED	81	98.8
NOT VISUALISED	1	1.2
Total	82	100.0

Table 11, shows that majority of patients in this study, appendix was visualised in CT scan 81(98.8%) whereas it was not visualised in 1(1.2%) patient.

Table 12: CT scan- periappendicular inflammatory changes

Periappendicular inflammatory changes	Frequency	Percentage
PRESENT	75	91.5
ABSENT	7	8.5
Total	82	100.0

Table 12 shown that most of patient (91.5%) haveperia ppendicular inflammatory changes in CT scan.

Table 13: Post operative complication

POST OP COMPLICATIONS	FREQUENCY	PERCENTAGE
PYREXIA	9	11
PARALYTIC ILEUS	8	9.8
SSI	26	31.7

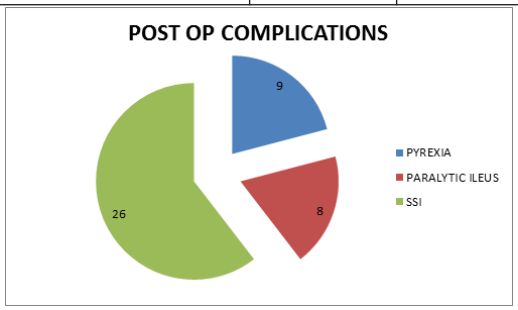

Fig6 :Pie chart showing distribution of post operative complication

Table 13, shows that in this study, surgical site infection 26(31.7%) was most common post operative complication followed by pyrexia 9(11%) cases and paralytic ileus 8(9.8%) cases.

Histopathology report:

Table 14 :Histopathological reports

Histopathology report	Frequency	Percentage
NORMAL APPENDIX	10	12.2%
ACUTE APPENDICITIS	72	87.8%
Total	82	100.0%

Table 14 shows that after HPE examination 72(87.8%) of the patients had acute appendicitis and 10(12.2%) of the patients had normal appendix.

Table 15: Combined Accuracy of USG and histopathological report

Inference of USG accuracy with histopathology report			
INFERENCE OFUSG ACCURACY	HPR		Total
	NORMAL APPENDIX	ACUTE APPENDICITIS	
Acute appendicitis	5	61	66
Normal	5	11	16
Total	10	72	82

p value : 0.021

On statistical analysis, in 66 of the 82 patients, ultrasound shown sign of acute appendicitis, out of 66 patients 5 cases was diagnosed as normal appendix by histopathology. At the same time ultrasound failed to detect 11 cases of acute appendicitis which was confirmed by histopathology.The accuracy rate, Sensitivity, specificity, positive predictive value and negative predictive value of ultrasound respectively are 80.4%, 84.7%, 50%, 92.4% and 31.2%.This association between accuracy of ultrasound and histopathology of appendix was found to be statistically significant with p value of 0.021.

Table 16: Combined accuracy of CT scan and histopatho logical report distribution of the respondents

Inference of CT accuracy with histopathology report			
INFERENCE OF CT ACCURACY	HPR		Total
	NORMAL APPENDIX	ACUTE APPENDICITIS	
Acute appendicitis	4	71	75
Normal	6	1	7
Total	10	72	82

p value 0.001

In this study, 75 of the 82 cases CT scan shown the sign of acute appendicitis, out of 75 patients, 4 cases diagnosed as normal appendixby histopathology. CT scan failed to identify one case which turned out to be acute appendicitis inhisto pathological examination report.The accuracy rate, sensitivity, specificity, positive predictive value and negative predictive value of CT scan respectively 93.9%, 98.6%, 60%, 94.6% and 85%.

This association between accuracy of CT scan and histopathology of appendix was found to be statistically significant with p value of 0.001.

Table 17: Combined CT accuracy and USGaccuracy distribution of the respondents

		INFERENCE OF CT ACCURACY		Total
		YES	NO	
INFERENCE OF USG ACCURACY	YES	64	2	66

	NO	11	5	16
TOTAL	75	7	82	

P value :0.003

In this study, CT scan accurately diagnosed 75 cases of acute appendicitis and 7 cases not able to diagnosed, out of 7 cases 2 case accurately diagnosed by ultrasound. Ultrasound accurately diagnosed 66 cases of acute appendicitis and not able to diagnosed 16 cases out of which 11 cases turn out acute appendicitis by CT scan.

This association between accuracy of ultrasound and CT scan to diagnosed acute appendicitis was found to be statistically significant with p value of 0.003.

DISCUSSION

Acute appendicitis is the most common indication for emergency abdominal surgery in patients presenting with acute abdominal pain at the emergency department (ED), with over 250.000 patients being operated for presumed appendicitis in the United States each year.[8] Traditionally, acute appendicitis has always been a clinical diagnosis based on patient history, physical examination, and laboratory testing. An active strategy with a low exploration threshold for patients with suspected appendicitis was regarded as good practice.

This classical practice is currently being abandoned by most surgeons as negative appendectomyare no longer considered acceptable. They carry a substantial morbidity, increase hospital cost[8,9,10]and may be avoided by using preoperative radiological imaging.[11]

OzkanS et al[31] reviewed 74 patients and concluded that the Alvarado score and USG are not sufficient on their own for making the decision for surgery in patients with acute appendicitis with difficult diagnosis. Compared to these, CT has been determined to have a higher accuracy rate and lower incidence of negative laparotomy. In cases presenting to the emergency department, by taking detailed medical history, performing a careful physical examination and with the laboratory findings, and taking into consideration thepossibility of perforated appendicitis as well as of negative laparotomy; CT scan seems to be more effective and efficient investigated tool in acute appendicitis with difficult diagnosis.

Our study investigated role of ultrasound and CT scan in diagnosis of acute appendicitis. The study was designed to find out sensitivity, specificity, positive predictive value and negative predictive value ultrasound and CT scan in diagnosis of acute appendicitis.

In the study conducted by Demircan et al, with 85 patients, the mean age was 33.5 ± 12.8 years. 55.3% (47) of the patients were males and 44.7% (38) were females.[36] In the study conducted by Dikicier et al, 48% of the cases (n = 139) were males, 52% were (148) females and the mean age was 31.5.[37] In our study number of female 57.3%(47) was higher than male 42.7%(35). Male to female ratio was 1:1.3. In our study females were more commonly affected than males. The mean age of the patients in our studuyis 35.74yrs and standard deviation of 15.29yrs. Most of the patients of acute appendicitis were in age group of 41 – 45yrs (28%) followed by 21-30 year (26.8%). Cumulative patients below 50 yrs of age constituted major no. of patients (89%).

In our study, the patients age was in agreement with that of literature and female gender have higher incidence.

The maximum number of patient, in our study were Hindus (68.3%) followed by Muslims (17.1%) and Christians (14.6%).

In a study carried out by Mentes et al, in 22 cases (27.5%), there was no pain radiation to the right lower quadrant and in 70% of cases, there was right lower quadrant tenderness, out of which 75% of cases have rebound tenderness, and the Rovsing's sign was positive in 66% of the cases.[38] Which is consistent with findings in our study except for Rovsing's sign which was positive in only 40% of cases in our study.

In our study, the appendix was not visualised on US in 8 patients. Non-visualised appendix in all these patients were abnormal at surgery and proven as acute appendicitis on HPE report, thus non-visualisation of the appendix on US does not exclude appendicitis.

In our study, the false negative rate of 13% was very high compared to the previous series in which the false negative rate was 4.5-5%.[12,19,39,40] The false negative ratein the study of Poortman et al was 21%.[32] The high false negative results in our study could be due to the unfavourable location of appendix (retrocaecal or high location), obese patients and excessive bowel gas.

In our study, of the three patients in whom the appendix was considered normal on CT, one patient had an appendix measuring 6mm with no associated surrounding inflammation, appendices were abnormal at surgery and found to have acute appendicitis on histopathology report. Thus the false negative rate was 1.2%, as comparable to previous series in which false negative ratevaried from 1% to 10%.[16,17,33-35,41]

The sensitivity of USG in acute appendicitis has been reported as 81-88% and the specificity has been reported as 78-84%.[42] In the study conducted by Wilson, et al., the accurate diagnosis rate of USG was determined as 71-97%, the sensitivity as 76-96%, and the specificity as 47-94%. [43] Orr, et al., found the sensitivity of USG in acute appendicitis as 85% and the specificity as 92%.[44] In the study of Reich et al, the sensitivity of USG was determined as 68%, and the PPV was determined as 94%.[45] In the prospective study by Poortman, et al. followed-up with suspicious acute appendicitis with the sonography and the CT, they found out that the sensitivities of CT and sonography were 76 and 79%, respectively; the specificities were 83 and 78%, respectively; and the accuracy rates were 90 and 87%, respectively.[32] While our USG results were consistent with the results of above study. Our USG accuracy rate, sensitivity, specificity and positive predictive value was 80.4%, 84.7%, 50% and 92.4%. The reason for the lower specificity of the USG may be due to the different evaluations of the patients by different radiologists with different experiences.

The sensitivity and the accuracy rates of CT imaging with contrast vary between 96 98% and 93-98%, respectively. The reported sensitivity and accuracy rates for enhanced imaging without contrast varies between 87-90% and 93-97%, respectively.

In another study conducted by Ozkan et al, the sensitivity, specificity, positive predictive value, negative predictive value and accuracy rate of CT was reported as 97.2%, 62.5%, 92.1%, 83.3% and 90% respectively.[31] The sensitivity, specificity, PPV, NPV, and accuracy rates of CT in our study were found to be in agreement with the previous studies.

In our study, accuracy rate of CT scan(93.9%) was found to be more than accuracy rate of USG(84.7%) to diagnosed acute appendicitis and it was statistically significant (p value = 0.003).

In acute appendicitis cases, it is important to reach an early and accurate diagnosis before the complications occur. The objective is to reduce the rate of negative appendectomy without increasing the perforation rate.

While early surgical interventions performed to prevent complications have resulted in negative laparotomies in 8-30% of the cases, interventions that are performed late in order to wait for the clinical picture to fully settle, lead to an increase in the rate of perforated appendicitis.[46] In our study, negative appendectomy were determined in 12.1% of the cases.

In the study of Reich et al, 10% of the cases in whom the USG findings were found to be compatible with appendicitis, resulted in negative laparotomies.[45] In the study conducted by Parks et al, the negative laparotomy rate was reported as 5% for USG, 4.3% for CT, and 12.2% for physical examination.[47] In another study conducted by Pickhardt et al, the negative laparotomy rate for CT was determined to be 7.5%.[48]

In our study, the negative appendectomy rates were 5.3% which was consistent with the literature for CT and the rates were determined to be high for USG which was 7.5%.

It is observed that CT has begun to be used more commonly in the diagnosis of acute appendicitis, due to high sensitivity, specificity, and accuracy rates and observed to have reduced the negative appendectomy rates. For this reason, the choice of CT is on an increasing trend in the diagnosis of acute appendicitis.

However because of its higher cost factor, longer time taken for preparation, exposure to ionizing radiation and limited availability, CT scan is till now not preferred as the first choice of investigation in the diagnosis of acute appendicitis.

CONCLUSION

In conclusion, non enhanced computed tomography and ultrasonography are complimentary to one another in the diagnosis of acute appendicitis.

Non-enhanced computed tomography has a higher accuracy rate when compared with ultrasound of abdomen. Negative appendectomy rate can be lowered down by combiningthe findings of non-enhanced computed tomography (NECT) and ultrasonography (USG).

In our study found that sensitivity, specificity and accuracy rate for CT scan to diagnosed appendicitis was 98.6%, 60% and 93.9% respectively.

In this study sensitivity, specificity and accuracy rate for USG to diagnosed acute appendicitis was 84.7%, 50% and 80.4% respectively.

USG may be used first in patients who are suspected of having appendicitis, but a USG examination with negative findings should not lead to a dismissal of the diagnosis. CT scans should be used judiciously, CT recommendations should be reserved for cases in which sonographic results are suboptimal or indeterminate.

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