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COMPARATIVE ASSESSMENT OF THE EFFICACY OF COMPUTED TOMOGRAPHY TO ULTRASONOGRAPHY IN SUBJECTS WITH ACUTE APPENDICITIS IN INDIAN SETUP

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ABSTRACT

Background: The most common reason for abdominal surgery in the Indian scenario is attributed to acute appendicitis. Appendicitis is widely assessed with ultrasonography with it being safe, however, it is difficult to be performed on subjects with massive bodies and needs an operator. CT (computed tomography) scans have high accuracy than ultrasonography with accuracy rates of nearly 95%.

Aim: The present study aimed to comparatively assess the efficacy of computed tomography to ultrasonography in subjects with acute appendicitis in an Indian setup.

Methods: The present study assessed 115 subjects with acute appendicitis suspicion. Acute appendicitis was initially assessed using Alvarado scores. Abdominal ultrasonography was then performed. In subjects with unclear or negative ultrasonography results, a CT scan with oral contrast was done. CT and ultrasonography data were reassessed by radiologist experts and a comparison was made with pathology and surgery results. Also, the comparison was made in two groups.

Results: The negative predictive value, positive predictive value, specificity, and sensitivity of CT scans based on the pathology results in subjects with low clinical suspicion were 79.5%, 94.6%, 87.7%, and 81.6% respectively. The negative predictive value, positive predictive value, specificity, and sensitivity of ultrasonography based on the pathology results in subjects with low clinical suspicion were 67.8%, 94.3%, 74.7%, and 63.2% respectively.

Conclusion: The present study concludes that in comparison to abdominal ultrasonography, CT scan has high sensitivity and specificity in subjects with acute appendicitis.

Keywords: Acute appendicitis, computed tomography, CT scan, ultrasound, ultrasonography.

INTRODUCTION

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Acute appendicitis has a high prevalence and affects nearly 7% of the population in their lifetime. The global annual incidence of acute appendicitis ranges from 96% to 100% per 100,00 adult subjects depicting children and adolescents at the highest risk of acute appendicitis. The common cause of emergency abdominal surgery in the Indian scenario is attributed to acute appendicitis which must be differentiated from the abdominal pain caused by other sources. The abdominal pain diagnosis in nearly 2% to 10% of the subjects is complicated by the delayed cases of inflammatory mass and perforation.[1]

The diagnosis of acute appendicitis is made with the combined use of radiography, laboratory assessment, physical examination, and history intake. With these diagnosis measures, it is considered that more than 90% of the subjects can be accurately and quickly diagnosed for acute appendicitis including the elderly subjects where generalized abdominal pain is seen with leukocytosis in place of localized pain and postmenopausal women where other gynecological conditions can mimic the acute appendicitis.[2]

It is also seen that hospital cost, perforation morbidity, and negative appendectomy rate can be decreased by 15% using radiographic imaging in subjects with clinical suspicion of acute appendicitis. In cases of unclear diagnosis with conventional radiography, other imaging modalities such as CT scans are used depicting that imaging is beneficial in subjects as the typical symptoms of acute appendicitis are absent in nearly half of the subjects with acute appendicitis. Also, nearly 1/3rd of subjects with acute appendicitis are afebrile until perforation and have normal counts of WBCs (white blood cells). Scans are useful in these conditions.[3]

Among, radiographic techniques, ultrasonography is widely available and is considered as safe with high accuracy of 70% to 98%. However, it poses a challenge in subjects with massive bodies and is operator-dependent. Ultrasonography use has controversy, whereas, CT scan has high accuracy rates of 93% to 98%. CT scan has drawbacks of being high-cost, issues of potential contrast material, and high radiation exposure. Previously, the 3 main methods of CT scan used were focused appendiceal CT with rectally administered contrast media, oral and/or intravenous contrast media, and abdominal and pelvic CT without contrast. However, recent data depicts that the first imaging test in acute appendicitis should be an abdominopelvic CT scan.[4]

The sensitivity and specificity of abdominopelvic CT are 94% and 95% as reported. Higher accuracy is seen in CT scans compared to ultrasonography in the assessment of the normal appendix. A normal CT scan shows an inflamed appendix of diameter >6mm, appendiceal wall enhancement, and appendiceal wall thickening following infusion of the contrast media. The contrast air presence in the lumen of the appendix rules out appendicitis. CT scan is a reliable modality for differentiating appendicitis from most other gynecological conditions keeping a challenge on the use of ultrasonography in females.[5] The present clinical study aimed to comparatively assess the efficacy of computed tomography to ultrasonography in subjects with acute appendicitis in an Indian setup.

MATERIALS AND METHODS

The present cross-sectional clinical study was aimed to comparatively assess the efficacy of computed tomography to ultrasonography in subjects with acute appendicitis in an Indian setup. The study assessed subjects visiting the Department of Radiodiagnosis, Nalanda Medical

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College, Patna, Bihar with abdominal pain suspicious of acute appendicitis. Written and verbal informed consent was taken from all the subjects before study participation.

The inclusion criteria for the study were subjects having acute abdominal pain, from both genders, the age range of 16-60 years, referred to the emergency department, and willing to participate in the study. The exclusion criteria were subjects having other systemic diseases, immunocompromised subjects, having symptoms for <72 hours, subjects aged <16 years, and subjects who did not give informed consent for study participation.

The final sample size was taken as 115 subjects that fulfilled the inclusion criteria; After final inclusion, detailed history was taken from all the study subjects along with the demographic data concerning gender and age. All subjects were then subjected to comprehensive clinical examination and the samples were collected for the laboratory tests. Depending on the observations, an initial diagnosis was made.

After an initial assessment, Alvardo scores were used to diagnose acute appendicitis. A score of 1-4 ruled out acute appendicitis, whereas, a score of 7 or more confirmed the diagnosis of acute appendicitis. A score of 5-6 suggested watching the subject if further testing was needed. The present stud included only the subjects with Alvarado scores of ≥ 7.[6]

A radiologist, an expert in the field, performed abdominal ultrasonography on all the subjects. After ultrasonography, a diagnosis was made and the treatment was started. On ultrasonography, diagnostic criteria for appendicitis were dilated appendix with >6mm diameter and other positive findings including periodical fluid, hyperemic appendiceal walls, appendicolith, echogenic peri-appendicular fat, and/or abscess. The report of ultrasonography was reported as not visualized, positive, or negative for acute appendicitis.

In cases where ultrasonography reports were unclear or negative, a CT scan was done with oral contrast. The results of the CT scan were reported by the radiologists. The diagnosis of appendicitis on CT scan was made with appendix having lumen >6mm with other positive findings including phlegmon, appendicolith, peri-appendicular fat stranding, abscess, or cecal wall thickening. The radiologist performing CT reported the results to be positive or negative for appendicitis.

The CT and ultrasonography data were then reassessed by another radiologist, an expert in the field, and a comparison was made with the final diagnosis of the subject in case of pathology and surgery results.

The data gathered were analyzed statistically using SPSS software version 25.0 (IBM Corp., Armonk, NY, USA) along with Fisher's exact test, Chi-square test, and Student t-test. The data were expressed as mean and standard deviation. The significance level was kept at $p<0.05$.

RESULTS

During the present study, a total of 180 subjects presented with abdominal pain raising the concern and suspicion of acute appendicitis, and were further referred for examination. Among 121 subjects that underwent surgery, in 4 subjects the pathological data were missing and were not included in the present study. In 2 subjects, further, Alvarado's scores were <7 and were also excluded from the study. The final sample size for the study was 115 subjects. The mean age of

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the study subjects was 26.7±9.8 years and were in the age range of 16-60 years. There were 54.78% (n=63) males and 45.21% (n=52) females in the present study.

In 23.47% (n=27) subjects, negative results were seen on ultrasonography for appendicitis, and in 6.08% (n=7) subjects, ultrasonography reports were suspicious of appendicitis, in these 29.56% (n=34) subjects abdominal CT was done with no intravenous contrast material injection. These CT scans were considered positive when there were inflammatory alterations around the cecum and appendix and there was an increase in the density, formation of phlegmon or abscess with appendicitis appearance, expansion of intestinal arches and cecum in the RLQ area, thickening in arches of the small intestine and cecum wall, and presence of gas or fluid in the peri-appendicular region.

In pathological findings, an enlarged intestine was seen with an increased thickness of cecum of more than 5mm, and a transverse diameter of more than 2.5 cm was seen. In cases where no acute appendicitis evidence was seen on the CT scan along with no pathologic changes in pelvic or abdominal organs, the results were taken as positive. In 24 subjects, favorable CT findings were seen for acute appendicitis and the confirmed diagnosis was made with post-appendectomy pathological testing.

On assessing the association between CT scan results and ultrasonography, it was seen that in subjects that underwent CT scans, 3 false negative and 1 false positive result were seen. It was seen that on CT, the retrocausal appendix and reduced peritoneal fat were visible. It was noted that false-negative results and the absence of appendicitis symptoms were attributed to a lack of adequate fat around the appendix and cecum and the anatomic position of the appendix and cecum. These subjects benefitted from a more comprehensive assessment using a CT scan with an injection of the contrast material. The mean age of subjects with negative appendectomy was 26.4±7.9 years and with positive appendectomy was 26.4±9.4 years. The age difference was statistically non-significant with p=0.43. Also, no significant difference was seen in female and male subjects with negative appendectomy with p=0.26. In 89.56% (n=103) study subjects, pathology verified the presence of appendicitis, and the appendicitis diagnosis was challenged by 10.43% (n=12) pathology as shown in Table 1.

Negative predictive value, positive predictive value, specificity, and sensitivity based on the pathology results are summarized in Table 2. The negative predictive value, positive predictive value, specificity, and sensitivity of CT scans based on the pathology results in subjects with low clinical suspicion were 79.5%, 94.6%, 87.7%, and 81.6% respectively. The negative predictive value, positive predictive value, specificity, and sensitivity of ultrasonography based on the pathology results in subjects with low clinical suspicion were 67.8%, 94.3%, 74.7%, and 63.2% respectively. Depending on the ultrasonography and CT assessment depending on the gender of the study subjects, the negative predictive value, positive predictive value, specificity, and sensitivity of ultrasonography in male subjects based on pathology were 77.5%, 61.3%, 96.3%, and 83.1% respectively. the negative predictive value, positive predictive value, specificity, and sensitivity of CT scans in male subjects based on pathology were 100%, 89.6%, 81.2%, and 100% respectively. In female subjects, the results of the CT scan were completely consistent with

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the results of the pathology, and negative predictive value, positive predictive value, specificity, and sensitivity of ultrasonography were 100%, 93%, 84.1%, and 100% respectively as depicted in Table 2. Figure 1 shows coronal and axial CT section of inflamed appendix and Figure 2: distal view and inflamed appendix [diameter 10 mm]

DISCUSSION

In the present study, a total of 180 subjects presented with abdominal pain raising the concern and suspicion of acute appendicitis, and were further referred for examination. Among 121 subjects that underwent surgery, in 4 subjects the pathological data were missing and were not included in the present study. In 2 subjects, further, Alvarado's scores were <7 and were also excluded from the study. The final sample size for the study was 115 subjects. The mean age of the study subjects was 26.7±9.8 years and were in the age range of 16-60 years. There were 54.78% (n=63) males and 45.21% (n=52) females in the present study. These data correlated with the studies of Podda M et al[7] in 2021 and Moris D et al[8] in 2021 where authors assessed appendicitis subjects following the Alvarado scores utilized in the present study and assessed subjects with demographic data comparable to the present study.

It was seen that in 23.47% (n=27) subjects, negative results were seen on ultrasonography for appendicitis, and in 6.08% (n=7) subjects, ultrasonography reports were suspicious of appendicitis, in these 29.56% (n=34) subjects abdominal CT was done with no intravenous contrast material injection. These CT scans were considered positive when there were inflammatory alterations around the cecum and appendix and there was an increase in the density, formation of phlegmon or abscess with appendicitis appearance, expansion of intestinal arches and cecum in the RLQ area, thickening in arches of the small intestine and cecum wall, and presence of gas or fluid in the peri-appendicular region. These findings were similar to the studies of Pogorelic Z et al[9] in 2020 and Jeon BG et al[10] in 2019 where the negative ultrasonography results were found positive on the CT scan.

The study results showed that in pathological findings, an enlarged intestine was seen with an increased thickness of the cecum of more than 5mm, and a transverse diameter of more than 2.5 cm was seen. In cases where no acute appendicitis evidence was seen on the CT scan along with no pathologic changes in pelvic or abdominal organs, the results were taken as positive. In 24 subjects, favorable CT findings were seen for acute appendicitis and the confirmed diagnosis was made with post-appendectomy pathological testing. These results were consistent with the findings of Karul M et al[11] in 2014 and Zisman A et al[12] in 2022 where a CT scan revealed similar findings as seen in the subjects of the present study.

It was seen that for the association between CT scan results and ultrasonography, it was seen that in subjects that underwent CT scans, 3 false negative and 1 false positive result was seen. It was seen that on CT, the retrocaecal appendix and reduced peritoneal fat were visible. It was noted that false-negative results and the absence of appendicitis symptoms were attributed to a lack of adequate fat around the appendix and cecum and the anatomic position of the appendix and cecum. These subjects benefitted from a more comprehensive assessment using a CT scan with an injection of the contrast material. The mean age of subjects with negative appendectomy was

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26.4±7.9 years and with positive appendectomy was 26.4±9.4 years. The age difference was statistically non-significant with p=0.43. Also, no significant difference was seen in female and male subjects with negative appendectomy with p=0.26. In 89.56% (n=103) study subjects, pathology verified the presence of appendicitis, and the appendicitis diagnosis was challenged by 10.43% (n=12) pathology. These results were in agreement with the studies of Teng TZJ et al[13] in 2021 and Fu J et al[14] in 2021 where a similar association was reported in the findings of CT scan and ultrasonography as seen in the present study.

The study results showed that the negative predictive value, positive predictive value, specificity, and sensitivity of CT scans based on the pathology results in subjects with low clinical suspicion were 79.5%, 94.6%, 87.7%, and 81.6% respectively. The negative predictive value, positive predictive value, specificity, and sensitivity of ultrasonography based on the pathology results in subjects with low clinical suspicion were 67.8%, 94.3%, 74.7%, and 63.2% respectively. Depending on the ultrasonography and CT assessment depending on the gender of the study subjects, the negative predictive value, positive predictive value, specificity, and sensitivity of ultrasonography in male subjects based on pathology were 77.5%, 61.3%, 96.3%, and 83.1% respectively. the negative predictive value, positive predictive value, specificity, and sensitivity of CT scans in male subjects based on pathology were 100%, 89.6%, 81.2%, and 100% respectively. In female subjects, the results of the CT scan were completely consistent with the results of the pathology, and negative predictive value, positive predictive value, specificity, and sensitivity of ultrasonography were 100%, 93%, 84.1%, and 100% respectively. These results were in line with the findings of Leung B et al[15] in 2019 and Kilkenny J et al[16] in 2022 where high sensitivity and specificity of CT scan was reported by authors in their studies as reported by the results of the present study.

CONCLUSION

Considering its limitations, the present study concludes that in comparison to abdominal ultrasonography, CT scan has high sensitivity and specificity in subjects with acute appendicitis. The present study recommends that a CT scan shall be performed in every negative case of ultrasonography to confirm acute appendicitis as it is highly accurate in the majority of the subjects.

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TABLES

Variable		**Appendectomy positive**		**Appendectomy negative**		**p-value**
		n	**%**	**n**	**%**	
CT scan (n=34)	**Positive**	24	96	1	4	**<0.001**
	Negative	3	33.3	6	66.66	
Ultrasonography (n=115)	**Positive**	77	95.06	4	4.93	0.09
	Negative	27	79.41	7	20.58	

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Table 1: Relationship between results of CT scan and ultrasonography in positive and negative appendectomy

Variable	CT scan	Ultrasonography
Negative predictive value	79.5%	67.8%
Positive predictive value	94.6%	94.3%
Sensitivity	87.7%	74.7%
Specificity	81.6%	63.2%

Table 2: Comparative assessment negative predictive value, positive predictive value, specificity, and sensitivity of CT scan and ultrasonography

ATLAS

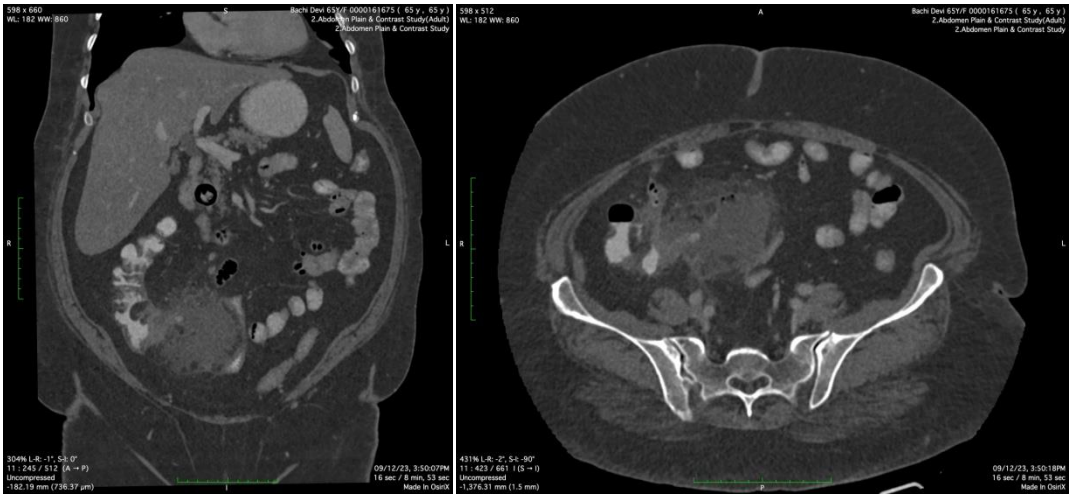

Figure 1: Axial and coronal image of necrotizing acute appendicitis with localized perforation

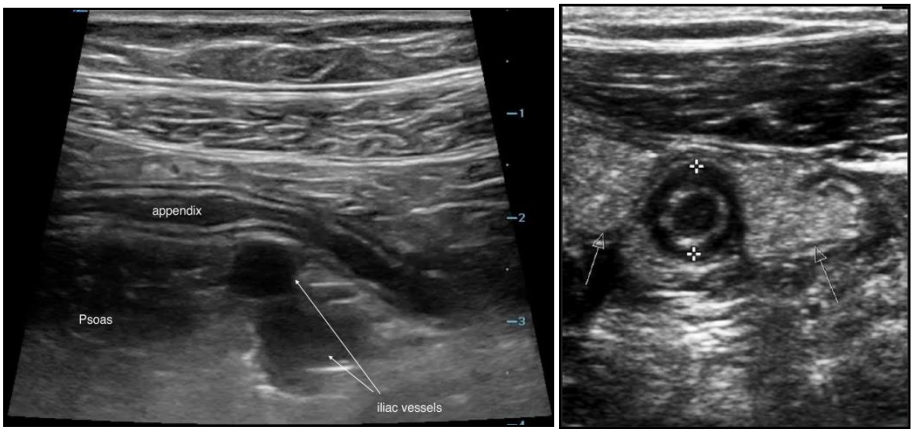

Figure 2: distal and frontal view of necrotizing acute appendicitis [diameter 10mm]