

The Diagnostic Role of Colour Doppler in Acute Appendicitis

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Abstract:

Background: Appendicitis represents one of the most common causes of abdominal pain of adult patients referred to the emergency department. Appendectomy is the most frequent emergency surgery performed worldwide. A clinical decision to operate leads to the removal of a normal appendix in 15-30% of cases and this rate of negative appendectomies can be reduced by observing equivocal cases for a period of time. Graded compression ultrasonography technique is the first line method in diagnosing appendicitis. Detection of hyperemia of appendiceal wall using colour Doppler is gaining attention in the differentiation of enlarged appendix in the absence of acute inflammation from acute appendicitis and even gangrenous appendicitis. Therefore, this study is aimed at assessing the diagnostic accuracy of colour Doppler in acute appendicitis.

Materials and Methods: A cross-sectional clinical study was undertaken in the Department of Surgery in collaboration with the Department of Radiodiagnosis RIMS, Imphal. The total numbers of patients in the study were 102 with clinical signs and symptoms of acute appendicitis and fulfilled the inclusion and exclusion criteria of the study. The patient's symptoms, signs, duration of symptoms, findings of both ultrasound and colour Doppler, intra operative findings are recorded. All appendectomy specimens were examined by a routine protocol in which the ultimate diagnosis was based on histo-pathological result. The result was analysed by using data-based program, descriptive statistics such as mean, standard deviation and percentage. Chi-square test was used for testing significance of the study and $p < 0.05$ was taken as significant.

Results: Sensitivity of colour Doppler was found to be higher than conventional ultrasound while overall specificity of colour Doppler to ultrasound remains same. Curvilinear pattern of Doppler flow is highly specific to acute appendicitis (100%). Accuracy of colour Doppler was 97.08% while that of ultrasound is 95.09%.

Conclusion: Accuracy of colour Doppler is higher than that of conventional grey scale imaging and its combination with ultrasound gives an added advantage of distinguishing between complicated and uncomplicated appendicitis thus helpful in triaging patients with acute appendicitis and deciding best treatment plan.

Key Word: Acute Appendicitis, Colour Doppler, Hyperemia, Ultrasonography.

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I. Introduction

Diagnosing acute appendicitis is not always easy, and the time spent in arriving at diagnosis leads to delayed surgical intervention, which in turn causes related complications. Ultrasonogram (USG) is a cheap, easily available, non invasive and no radiation hazard imaging modality for the diagnosis of acute appendicitis. When a threshold of 6 mm for the outer dimensions of a noncompressible appendix is taken, sensitivity is 100% for appendicitis but specificity is only 68%. When the appendix measures between 6 and 7 mm, demonstration of intramural hyperemia on colour Doppler may be a valuable aid in establishing the diagnosis in borderline cases because there is usually no visualized flow in the normal appendix.

In some instances, the diameter of the appendix may be larger than 6mm without acute inflammation, due to the presence of intraluminal materials like gas, faeces and fluid or mucosal lymphoid hyperplasia secondary to viral gastroenteritis or mesenteric lymphadenitis which mimic appendicitis. To reduce the false positive rate of appendicular diameter criteria other parameters like intraluminal content, periappendiceal changes, mural thickening, preservation of wall layers and increased blood flow in appendiceal wall should be taken into consideration.²

Detection of hyperemia of appendiceal wall using colour Doppler is gaining attention in the differentiation of enlarged appendix in the absence of acute inflammation from acute appendicitis and even gangrenous appendicitis. Doppler examination findings can be summarized as: presence or absence of colour Doppler signals and whether colour flow is normal or increased. In colour Doppler, a curvilinear pattern represents hyperemia, owing to vessels with increased flow, and it has high specificity (94.9%) for appendicitis.³ A suppurative appendicitis showed greater circumferential flow in its wall than a normal appendix. A gangrenous appendicitis is diagnosed when colour Doppler signals disappear with loss of echogenicity in its wall on gray scale.⁴ Colour Doppler provide a simple means to confirm the gray-scale sonography findings, with no appreciable increase in examination time (average, 1-2 minutes) or in cost (when using instruments already equipped for Doppler imaging).⁵

Colour Doppler is found helpful in differentiating between complicated and uncomplicated appendicitis and thus for triaging patients with acute appendicitis. This study is aimed to evaluate the diagnostic accuracy of colour Doppler in acute appendicitis and to assess whether colour Doppler has any advantage over conventional grey scale USG in detecting acute appendicitis.

II. Material And Methods

Study Design: Cross sectional study

Study Location: The study was carried out in Department of Surgery in collaboration with Department of Radiodiagnosis, Regional Institute of Medical Sciences (RIMS) Imphal, Manipur.

Study Duration: August 2017 to July 2019

Sample size: 102 patients.

Subjects & selection method: The study population consisted of patients above 18 years of age presented to Surgery OPD/ Casualty with right lower abdominal pain suggestive of acute appendicitis.

Inclusion criteria:

All patients above 18 years of age who were admitted to the surgical ward of the Regional Institute of Medical Sciences, Imphal with clinical features suggestive of acute appendicitis and underwent emergency appendectomy.

Exclusion criteria:

- Patients previously treated for appendicitis
- Appendicular lump/peritonitis
- Pregnancy
- Immunocompromised patients
- Patients not giving consent for study

Procedure methodology

After obtaining a written consent, a total of 102 consecutive patients satisfying both inclusion and exclusion criteria diagnosed with acute appendicitis clinically and appendix visualized in ultrasound with Doppler consenting for surgery were recruited for this study. Clinical history, physical examination and laboratory results were recorded for all patients. USG of whole abdomen and colour Doppler of appendix was performed on all study patients.

Patients confirmed with either ultrasound or colour Doppler to have acute appendicitis were posted for emergency appendectomy after obtaining consent and with antibiotic prophylaxis. Appendectomy is performed in a standard fashion, intra operative findings are recorded in the proforma and appendectomy specimen is subjected to HPE. Post operatively patients are managed with IV fluids and supportive care and enteral feeding started whenever bowel movements were appreciated. Immediate post-operative complications are recorded and treated in routine manner.

Patients were routinely followed up after 2 weeks post-operative or early as needed and assessed for delayed complications with HPE reports.

Hyperemia of the appendix measured by colour Doppler and ultrasound findings were correlated with the histopathology results.

Statistical analysis

All the data was entered in a proforma and data analysis was performed using SPSS software 21 version (IBM Corp., Armonk, NY, United States).

Sociodemographic variables were expressed in descriptive statics like frequency and mean. Association between HPE and ultrasound of appendix, HPE and colour Doppler findings, Surgical Site Infection (SSI) and colour Doppler, SSI and faecolith were analysed by chi square test. P value <0.05 was taken as significant.

III. Result

Majority of patients presented were between 41-50 years with slight female preponderance and belonging to middle class family. Pain in right lower abdomen and tenderness in Mc Burney's point were present in all patients.

Ultrasound and Doppler features:

In this study, majority of patients had diameter of appendix detected by ultrasound was 8mm (27.5%). Minimal cut off value for sonological positive appendicitis was 6mm and was seen in 19.6% of study population. Largest diameter of appendix recorded by ultrasound in this study is 18mm. Ultrasound of abdomen focusing to diagnose acute appendicitis also showed indirect features like fat stranding in 92 patients (90.2%) and periappendiceal collection in 25 patients (24.5%).

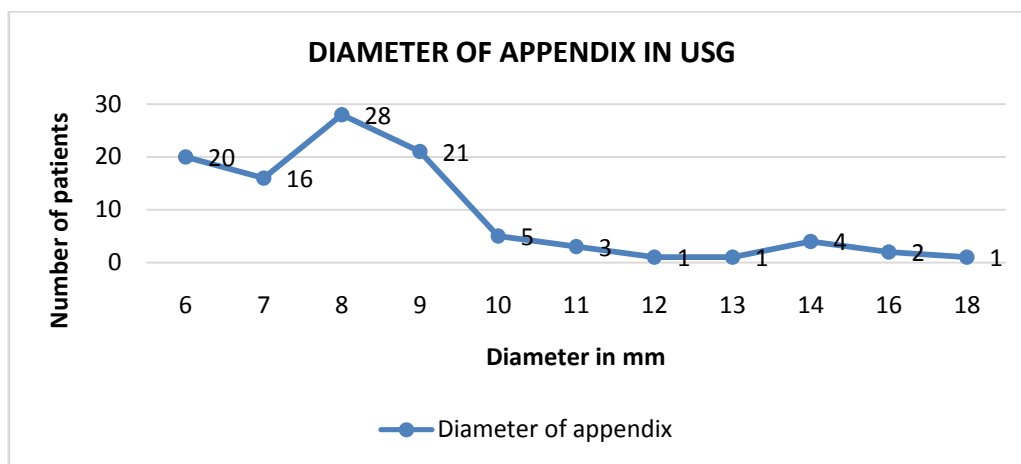


Figure 1: Line diagram showing number of patients and diameter of appendix in ultrasound

Doppler pattern:

In this study, most of the study population showed curvilinear pattern in Doppler indicating hyperemia of appendix (56.9%). Punctate pattern in Doppler was noticed in 29 patients (28.4%) and 14.7% of study population was showing no Doppler signals on appendix.

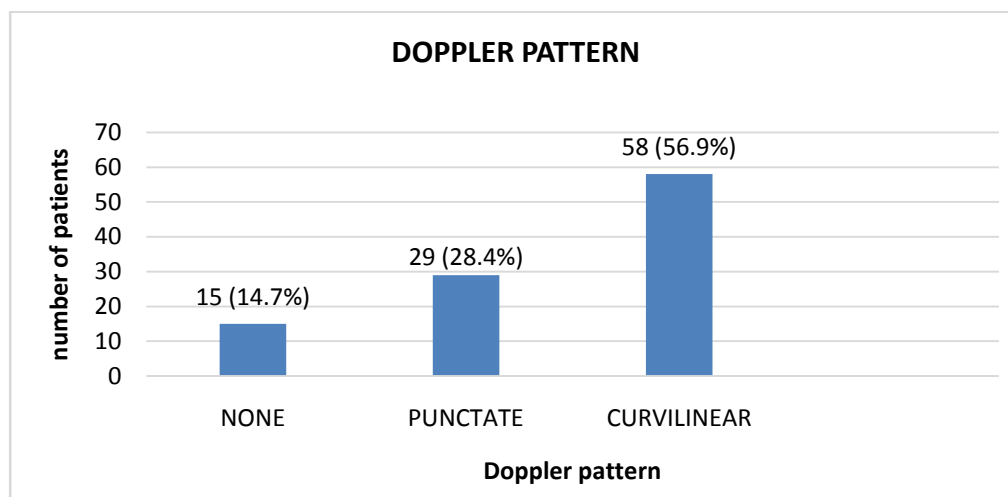


Figure 2: Bar diagram showing distribution according to Doppler pattern

All patients in this study underwent emergency appendectomy and findings are noted. Early lump is noted in 15 patients (14.7%) and dense adhesions were present with caecum and surrounding structures in 40 patients (39.2%). Faecolith was noted in 24 patients (23.5%).

Appendix was only mildly inflamed in 5 patients (4.9%), moderately inflamed in 48 patients (47.1%), highly inflamed with friable appendix in 41 patients (40.2%). Gangrenous appendicitis was noted in 3 patients (2.9%) and appendix was perforated in 5 patients (4.9%). Appendicular abscess was noted in 4 patients (3.9%). 13 patients (12.7%) developed pyrexia in post operative period due to thrombophlebitis (9 patients), urinary tract infection (2 patients) and residual collection in 2 patients.

Paralytic ileus was seen in 12 patients (11.8%) which was resolved by conservative management. 35 patients (34.3%) developed surgical site infection, which was managed by regular dressing, antibiotics according to culture and sensitivity and secondary suturing.



Fig 3: Curvilinear pattern in colour Doppler

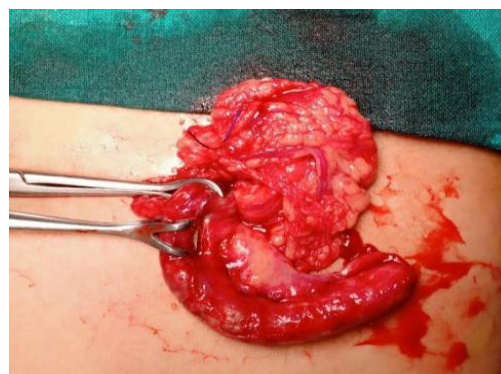


Fig 4: Highly inflamed appendix intraoperatively

Histopathology report:

On HPE examination of appendectomy specimens, 56.9% of the patients had appendicitis with peri appendicitis, 29.4% had acute appendicitis, 8.8 % had necrotizing appendicitis, 4.9% with subacute appendicitis/normal.

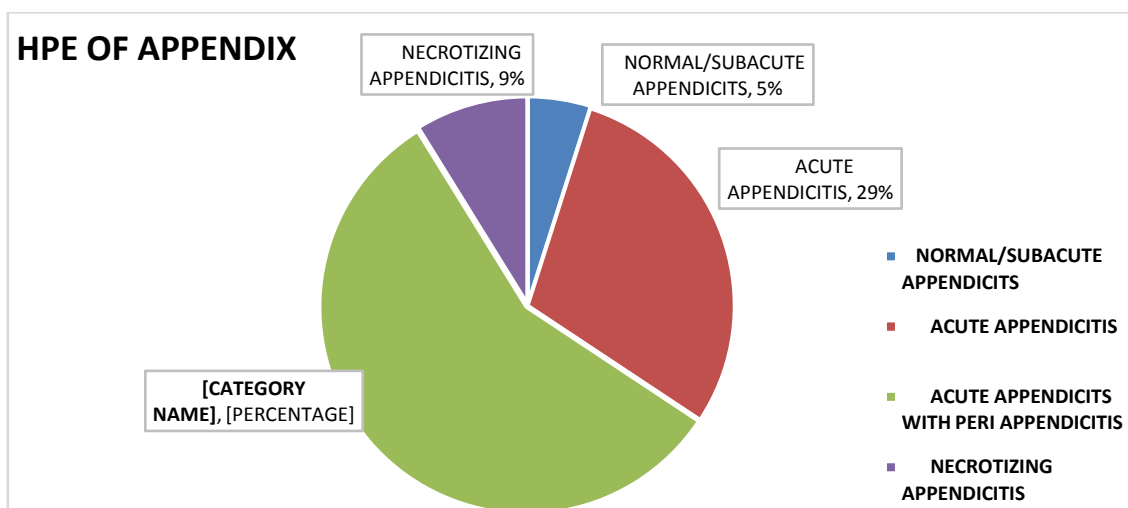


Fig 5: Pie chart showing the distribution of respondents based on HPE reports.

Association between ultrasound of appendix and HPE report:-

Table No 1: Ultrasound Diagnosis and HPE report

USG Diagnosis	HPE Report				Total
	Sub Acute Appendicitis	Acute Appendicitis	Acute Appendicitis With Peri Appendicitis	Necrotizing Appendicitis	
Acute Appendicitis	2	29	56	9	96
Not Appendicitis	3	1	2	0	6
Total	5	30	58	9	102

P Value-0.001

From the statistical analysis, it is seen that ultrasound accurately diagnosed 94 cases of acute appendicitis and excluded 3 cases which are not acute appendicitis in HPE.

At the same time ultrasound failed to detect 3 cases of appendicitis which was diagnosed by Doppler and over diagnosed 2 cases as acute appendicitis which turned out to be normal in histopathology. However, the association between ultrasound diagnosis and HPE reports were found to be statistically significant with chi square of 27.81 and P value of 0.001.

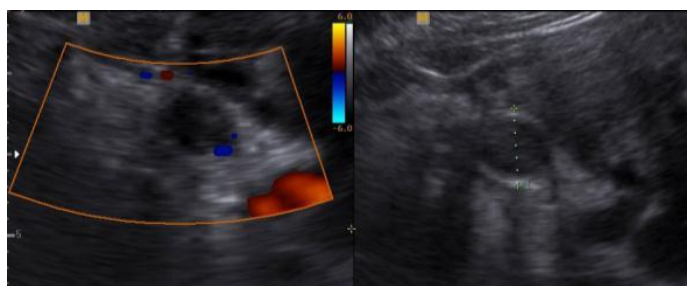


Fig 6: Doppler showing absent signals of appendix >1cm diameter Fig 7: Gangrenous appendicitis intra op

It was found that Sensitivity of ultrasound in this study is 96.9% while specificity is 60%. Accuracy of ultrasound in this study was found to be 95.09%. Positive predictive value of ultrasound to diagnose acute appendicitis is 97.9% while negative predictive value is 50%.

ASSOCIATION BETWEEN ACCURACY OF COLOUR DOPPLER AND HPE OF APPENDIX:

Table No 2: Colour Doppler pattern and HPE Report

Colour Doppler Pattern	HPE Report				Total
	Sub Acute	Acute Appendicitis	Acute Appendicitis With Peri Appendicitis	Necrotizing Appendicitis	
None	3	1	4	7	15
Punctate	2	20	7	0	29
Curvilinear	0	9	47	2	58
Total	5	30	58	9	102

P Value-0.001

We can see from the table that punctate pattern is seen acute appendicitis and curvilinear pattern of Doppler is mainly with severe form of appendicitis and almost not seen in normal or subacute appendicitis. Doppler signals were absent in 3 cases of subacute appendicitis whose corresponding diameter is ultrasound is 6mm and in 7 cases of necrotizing appendicitis with corresponding diameter >7mm. This association is found to be significant as p value is <0.05.

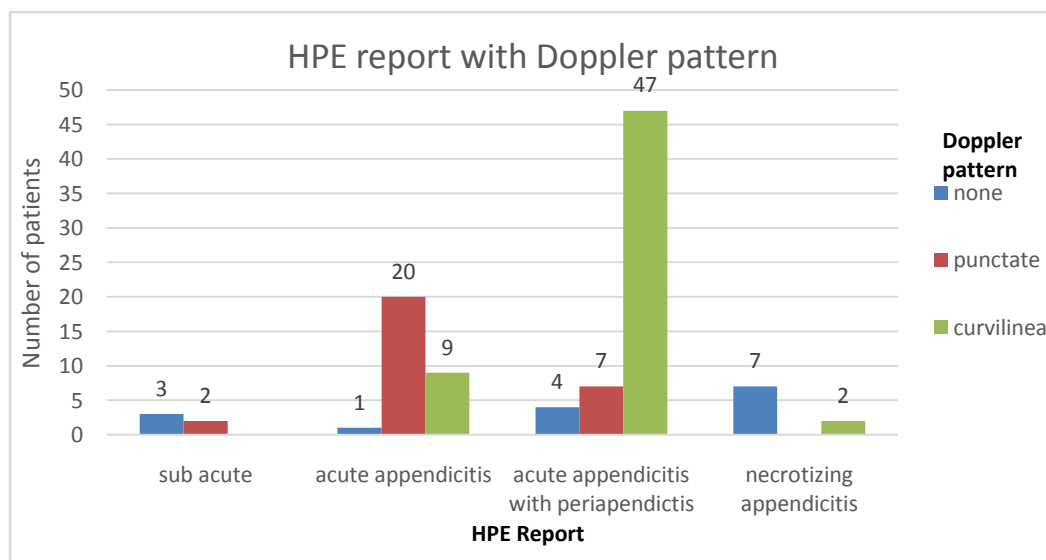


Figure 8: bar diagram showing relation between HPE report and Doppler Pattern

In this study, Doppler of appendix accurately identified 96 cases with acute appendicitis and excluded 3 cases, as not appendicitis histopathologically.

It failed to identify one case which turned out to be acute appendicitis intra operatively and histopathologically. Doppler of appendix over diagnosed 2 cases as acute appendicitis while intra operative and histopathologically turned out not to be acute appendicitis.

From this study, the sensitivity of colour Doppler to diagnose acute appendicitis is found to be 98.9% while specificity remain same as that of ultrasound (60%). But on individually assessing the specificity of each pattern, curvilinear pattern is found to be more specific (100%) and accurate (85.7%) than punctate (40%) and

absent blood flow(40%). Accuracy of colourDoppler was found to be 97.05% which is higher than that of conventional grey scale ultrasound. Positive predictive value of colourDoppler was found to be 96.9% while it shows higher negative predictive value than ultrasound (66.6%) which denotes the ability to rule out acute appendicitis and thus avoid a negative appendectomy.

Accuracy of colourDoppler compared to ultrasound:
Table No 3: comparison between ultrasound and colourDoppler

Parameter	Ultrasound	Colour Doppler
Sensitivity	96.9%	98.9%
Specificity	60%	60%
Accuracy	95.09%	97.05%
Positive Predictive Value	97.9%	96.9%
Negative Predictive Value	50%	66.6%

This table above shows that colourDoppler is more sensitive but equally specific as ultrasound. Accuracy of colourDoppler was found to be 97.05% Negative predictive value of colourDoppler is higher than ultrasound which implies that addition of colourDoppler helps to rule out acute appendicitis and thus reduce the rate of negative appendectomy.

Factors associated with incidence of SSI:

From the study it was noticed that there is a significant association between presence of appendicolith and surgicalsite infection(SSI). SSI was noted in 19 cases out of 24 with faecolith.

From this study it was found that presence of SSI is mostly seen with curvilinear pattern of colour Doppler which, from earlier results related to complicated appendicitis like perforation or gangrenous appendicitis. This association was found to be statistically significant with P value <0.005

While correlating incidence of SSI with intra op findings, it was found that highly inflamed and gangrenous appendix results in SSI than mildly inflamed appendix and this association is found statistically significant.

IV. Discussion

Appendicitis present as a spectrum ranging from uncomplicated mild inflammation to severe life-threatening condition of gangrenous or perforated appendicitis. The diagnosis of acute appendicitis continues to be a dilemma as there is no pathognomonic sign or symptom or a diagnostic test. Why accurate diagnosis of acute appendicitis is important? It is mainly because of a variety of management pattern which varies according to patient and severity of appendicitis. When an uncomplicated catarrhal appendicitis can be safely managed by antibiotics and supportive care, complicated appendicitis with perforation or gangrene should be promptly managed by emergency appendectomy.^{6,7,8}

Imaging studies have an upper hand in diagnostic accuracy of acute appendicitis especially when it comes to complicated cases and special situations like in pediatric age group, pregnant women, history of renal calculi etc. Most commonly used, readily available, non-invasive and cheapest of them is conventional grey scale ultrasonography. Graded compression by USG have increased accuracy to diagnose acute appendicitis as described by Puylaert JB.⁹ As time progressed, advanced modalities of imaging like CT scan, MRI scan etc. came into existence but none gained popularity or acceptance as ultrasound for diagnosis of acute appendicitis. CT scan may not be readily available and the cost might be a big set-back for poor patients and at the same time have the risk of radiation hazard especially in children and pregnant women. Set back of MRI is mostly cost and non availability in all places.^{10,11}

Inorder to improve the specificity of conventional ultrasound, various modalities were incorporated to ultrasound like colourDoppler, power Doppler, contrast enhanced power Doppler etc. This study was mainly aimed to determine the diagnostic accuracy of colourDoppler in acute appendicitis and its advantage over conventional grey scale ultrasound.

In this study on the role of colourDoppler in acute appendicitis, incidence of acute appendicitis is high among 41-50 year age group followed by 21-30 year age group, with mean age of 36 years. Pain was the commonest presenting symptom and has been observed in all the cases (100%) of this study series, but only 72(70.6%) of the study population gave history of shifting pain and Murphy’s triad was present only in 15 patients (14.7%).

For confirming the diagnosis, grey scale ultrasound was done and was able to diagnose 94 cases out of 102 cases accurately as acute appendicitis. Sensitivity of ultrasound in our study was found to be 96.9% and specificity is 60%. It was found similar to Puylaert JBCM¹².et al research. As reported by Chan L¹³, Using a threshold measurement of 6 mm for the outer dimensions of a noncompressible appendix results in a sensitivity of 100% for appendicitis but a specificity of only 68%.

On application of colour Doppler to detect hyperemia of appendix, 3 patterns of signal were noticed in our study as described by Xu Y³. Punctate or curvilinear colour Doppler flow is noticed when appendix is inflamed moderately and highly respectively. Absent colour Doppler flow was noticed when appendix is normal or gangrenous/perforated depending on diameter of appendix.

In our study, punctate pattern is observed in 29 cases (28.4%) of which 20 cases were acute appendicitis and 7 cases were acute appendicitis with peri appendicitis in HPE. Curvilinear pattern is noted in 58 cases (56.8%) of which 9 cases were acute appendicitis, 2 cases were necrotizing appendicitis and remaining 47 cases were acute appendicitis with peri appendicitis in HPE. This conclusion is similar to Quilin SP¹⁴ research on colour Doppler of appendix.

Sensitivity of colour Doppler in our study is 98.9% while overall specificity is 60%. Accuracy of colour Doppler was found to be higher than conventional grey scale ultrasound, 97.08% and 95.09% respectively. In our study even though the overall specificity of ultrasound and colour Doppler remains same, specificity of curvilinear pattern in colour Doppler is highly specific for acute appendicitis (100%) without any false positive cases. Reduced overall specificity (60%) is due to low specificity of punctate pattern (40%) and absent flow pattern (40%). Sensitivity of curvilinear pattern is 85% and specificity is 100%. This is similar to the studies of Kumar DN¹⁵ where specificity of curvilinear pattern was found to be 94.9%. This study points towards better accuracy for acute appendicitis if Doppler is showing curvilinear flow of >3mm in long or short axis.

It is been noticed from this study that when diameter of appendix is less than 7mm, and there is no Doppler signals, it can be taken as normal appendix while any diameter more than 8mm with absent Doppler signals, gangrenous or perforated appendix should be suspected and immediate intervention should be sought as they are more prone for complications. 3 cases with ultrasound diameter of 8mm in this study with absent Doppler pattern was found to have perforation intra operatively and acute appendicitis with peri appendicitis in HPE. Appendix was showing only mild inflammation in 5 cases which turned out to be normal/sub acute appendicitis (4.9%). Appendix was gangrenous in 3 patients (2.9%) and perforated in 5 cases (4.9%). In rest of the patients appendix was moderate to highly inflamed. In the literature, complicated appendicitis reported rates range from 27% to 51%.¹⁶ In most reports, gangrenous appendicitis is grouped with perforated appendicitis and considered complicated.

The rate of negative appendectomy in our study is 5% which is comparatively lower than other studies. This may be due to the selection of patients which included only if ultrasound could visualise appendix and addition of colour Doppler facility in confirming the ultrasound diagnosis thus increasing the accuracy of diagnosis.

Interestingly, visualization of appendicoliths on imaging studies increases the probability of appendiceal perforation, possibly because appendicoliths accelerate the rate at which perforation occurs. Same is noted in our study also. 5 cases of perforated appendicitis diagnosed intra operatively had faecolith also. Thus, the presence of one or more appendicoliths in association with periappendiceal inflammation is virtually diagnostic of perforation.¹⁷

Appendectomy is a relatively safe procedure with a mortality rate for non-perforated appendicitis of 0.8 per 1000 and after perforation is 5.1 per 1000. The mortality and morbidity are related to the stage of disease and increase in cases of perforation.¹⁸ In our study, mortality was nil.

Surgical site infection was the most common complication and the reported incidence from the literature ranges between 1.2 and 12%. From the study of Anderson BR¹⁹, rates of wound infection vary from < 5% in simple appendicitis to 20% in cases with perforation and gangrene. The use of perioperative antibiotics has been shown to decrease the rates of postoperative wound infections. In our study a positive correlation was noticed between colour Doppler pattern and incidence of wound sepsis.

Surgical site infection is more common in patients who had curvilinear pattern in Doppler which corresponds to highly inflamed/ complicated appendicitis with p value <0.05.

Significant association is demonstrated between incidence of SSI and presence of appendicolith in this study. Presence of appendicolith is suggestive of rapid progression of appendicitis with high chance of perforation, abscess and post op complications like pyrexia, SSI.

Various studies revealed that antibiotic treatment of patients with uncomplicated acute appendicitis was not shown to be inferior to appendectomy for uncomplicated appendicitis within the first year of observation following initial presentation of appendicitis and majority (73 %) of patients with uncomplicated acute appendicitis were successfully treated with antibiotics.^{20,21} These data put forward the possibility of avoiding emergency appendectomy for uncomplicated appendicitis. It is possible to differentiate between uncomplicated appendicitis and complicated appendicitis based on ultrasonographic findings and assessment of hyperemia of appendix by colour Doppler.^{5,22,23}

Meanwhile patients with complicated appendicitis like presence of appendicular abscess, perforation of appendix in ultrasound or gangrenous appendicitis on addition of colour Doppler requires more aggressive

management as they tend to develop complications more and mortality rate is high. Thus addition of colour Doppler provides a useful adjunct in triaging patients with acute appendicitis and deciding the treatment modality. Our study had certain limitations. Firstly, this study was prone to selection bias as effect of Doppler could only be studied if appendix was visualized in conventional ultrasound. Secondly, we did not perform analysis on healthy individuals; however, our intention was to evaluate the diagnostic role of colour Doppler in acute appendicitis. Thirdly, ultrasound and colour Doppler are operator dependent and artifacts can occur during Doppler study which can be confused with Doppler patterns described before. Use of advanced ultrasound machines and trained personals will be helpful for a better outcome.

V. Conclusion

Colour Doppler is more accurate and the curvilinear pattern is highly specific (100%) for acute appendicitis than grey scale ultrasound. Overall sensitivity and specificity of colour Doppler is 98.9% and 60% respectively while accuracy is 97.05%

The addition of colour Doppler to the conventional grey scale ultrasound helps to distinguish between complicated and uncomplicated appendicitis, based on the Doppler pattern. Punctate pattern is seen mostly with moderately inflamed appendix while curvilinear pattern is associated significantly with perforated or gangrenous appendicitis.

To conclude, from this study it is evident that accuracy of colour Doppler is higher than that of conventional grey scale imaging and its combination with ultrasound gives an added advantage of distinguishing between complicated and uncomplicated appendicitis thus helpful in triaging patients with acute appendicitis and deciding best treatment plan.

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