

# Role of Doppler in Predicting the Complicated and Impending to Complicate Cases of Acute Appendicitis

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## ABSTRACT

**Introduction:** Acute appendicitis is one of the most common emergency surgical problems which could result due to obstructive or non-obstructive causes. The obstructive type progresses fast and could result in complications like gangrene formation and perforation frequently than the non-obstructive type. Uncomplicated cases of appendicitis can be managed conservatively, however complicated and impending to complicate cases need emergency surgical intervention to reduce the morbidity and mortality rates. Though, with pre-operative sonography, which is the principle imaging modality used for the differentiation between the complicated or uncomplicated type of appendicitis is possible, it is still challenging to find the cases that are impending to complicate.

**Aim:** To assess the role of Doppler study in differentiating the uncomplicated, complicated and impending to complicate cases among acute appendicitis patients.

**Materials and Methods:** Total 70 patients were included in the study who showed features of acute appendicitis on ultrasonography gray scale imaging and both color and power Doppler imaging was done in all these patients. Out of these 70 patients, 48 patients who had post-operative confirmative histopathological report were divided into Group-I - Uncomplicated appendicitis with non-obstructive cause (n- 13); Group-II - Impending to complicate cases with obstructive or non-obstructive cause (n-28); and Group-III -Complicated appendicitis (n-7) like perforated

appendix, appendicular abscess/mass. In all three groups histo-pathological findings correlation with imaging findings of both color and power Doppler was done. Vascularity was considered circumferential when the flow was evenly distributed around the walls of the inflamed appendix, while it was considered patchy in few uneven specks of flow.

**Results:** The flow was detectable in all the 48 patients on power Doppler study, however only (n-43) patients were showing flow on color Doppler study. Patchy and circumferential pattern of flow seen in 15.4% and 76.9% of cases on color Doppler and 23.1% and 76.9% of cases on power Doppler respectively in Group-I (n- 13). In 82.1% and 7.1% of cases on color Doppler and 92.9% and 7.1% of cases on power Doppler respectively in Group-II - (n-28). In 57.1% and 28.6% on color Doppler and 71.4% and 28.6% on power Doppler respectively in Group-III (n-7). For color Doppler results the p-value was <0.0001 and for power Doppler results the p-value was <0.0001.

**Conclusion:** We found that the presence and pattern of flow on Doppler study has an add-on value in diagnosing acute appendicitis along with gray scale USG. The pattern of flow in appendicular wall on both color and power Doppler imaging can be applied to find the acute appendicitis cases that are impending to complicate. Power Doppler will be of help in patients in whom color Doppler study shows negative results.

**Keywords:** Appendicular mass, Color Doppler, Non-obstructive, Obstructive, Power Doppler

## INTRODUCTION

Acute appendicitis is one of the most common emergency surgical problem [1]. Acute appendicitis could result due to obstructive or non-obstructive causes [2]. The obstructive causes being appendicolith, neoplasms like adenoma or adenocarcinoma [3]. Non-obstructive type has slow progression. Whereas, obstructive type progresses fast and could result in complications like gangrene formation and

perforation frequently than the non-obstructive type [4-6].

The principal imaging technique utilized for diagnosing acute appendicitis at many institutions is sonography. Sonographic features of the acute appendicitis are well established. The inflamed appendix will appear as non-compressible, blind ending and tubular structure. On transverse sonogram inflamed appendicular wall shows an external thick hypoechoic ring, an inner hyperechoic ring and a hypoechoic

center within representing the target sign [6]. On Doppler examination the presence of visible hyperemia in the mucosal layer of the appendix may be a marker of appendicitis [7–9].

Though it is possible to differentiate between the complicated or uncomplicated type of appendicitis with pre-operative sonography, to find the acute appendicitis cases that are impending to complicate is still challenging. Uncomplicated cases of appendicitis can be managed conservatively. However, complicated and impending to complicate cases need emergency surgical intervention. Early diagnosis and management of patients who have complicated appendicitis and appendicitis that are impending to complicate will prevent the undue complications and the resulting morbidity and mortality rates.

## MATERIALS AND METHODS

This prospective study was conducted in the Department of Radiology, Sri Manakula Vinayagar Medical College and Hospital, Puducherry, India, for a period of 18 months starting from November 2014. Institutional ethical committee clearance was obtained for conducting the study. Patient who showed evidence of acute appendicitis on ultrasound gray scale imaging within duration of one year were included in the study. Patients who had acute abdomen due to causes other than appendicitis were excluded from the study. The informed consent was obtained from all the patients and also from the parent if the patient is in pediatric age.

As per literature search there is no exact prevalence value found of acute appendicitis in India. Based on 2014 ultrasound records of referred patients with suspicion of acute appendicitis monthly entered in Department of Radiology, we have planned to study 70 patients.

Total 112 patients underwent ultrasonographic examination and out of these 112, 70 patients were considered for the study. In these 70 patients whoever underwent surgery and with histopathological data, we have analyzed our ultrasound imaging findings to correlate.

### Imaging Technique

All the patients were imaged on ultrasonography (USG) using both low frequency and high resolution, high frequency probes on Phillips HD 7XE Ultrasound Machine System (curvilinear array 3.5-7.0 MHz and linear array 7.5-7 MHz). Graded compression technique was applied at the anatomical location of the appendix in right iliac fossa or at the place where there is maximum tenderness. The bowel loops of the ileum and ileocecal junction point was traced for location of the appendix. Appendicitis was confirmed when the features of gray scale imaging of tubular non-compressible, aperistaltic, blind ending loop with dilated lumen more than 6 mm and target sign was seen [7,10–13]. After visualizing the appendix on gray scale imaging, the color Doppler and power Doppler imaging was done with the proper gain adjustments and frequency settings concentrating on the presence and pattern of flow in appendicular wall. Vascularity was considered circumferential

when the flow was evenly distributed around the wall of the inflamed appendix and patchy when only few uneven specks of flow were seen on both color and power Doppler.

Out of seventy patients examined on USG and Doppler, forty-eight patients were operated for the appendicitis and confirmed on Histopathological Examination (HPE). Based on the HPE reports, the cases were examined and categorized into three groups-

Group-I: Uncomplicated appendicitis with non-obstructive cause (n-13).

Group-II: Impending to complicate cases consist of uncomplicated appendicitis with obstructive or non-obstructive cause (n-28).

Group-III: Complicated appendicitis (n-7) included cases like perforated appendix, appendicular abscess/mass.

In all these three groups findings of preoperative USG gray scale imaging, presence and pattern of flow on both color and power Doppler imaging was done with pathological report data.

## STATISTICAL ANALYSIS

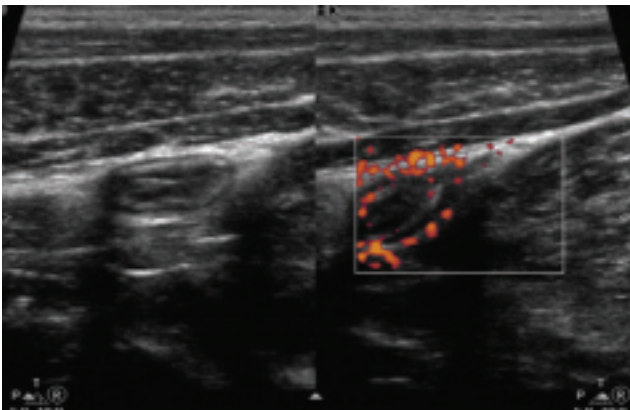
The data was analyzed with epi info software. The frequencies, percentages and associations are calculated using Chi-square test and p-values between groups of appendicitis and pattern of Doppler findings.

## RESULTS

**On gray scale imaging, color and power Doppler imaging:** In this study, all the cases of acute appendicitis who were operated showed probe tenderness at the McBurney's point on USG except two patients.

Group-I: Uncomplicated appendicitis with obstructive or non-obstructive cause (n- 13) who showed appendix with ulcerative mucosa, dense inflammatory infiltration of muscularis mucosa and lumen filled with exudates on HPE was found as a tubular, non-compressible, blind ending structure which was round in shape on gray scale imaging. The outer to outer diameter of the appendix was greater than 6 mm in all our cases of appendicitis ranging from 6.4 mm to 12.3 mm. Out of total 13 cases, on color Doppler two cases (15.4%) showed patchy flow and 10 cases (76.9%) showed circumferential flow. On power Doppler three cases (23.1%) showed patchy flow and 10 cases (76.9%) showed circumferential flow [Table/Fig-1].

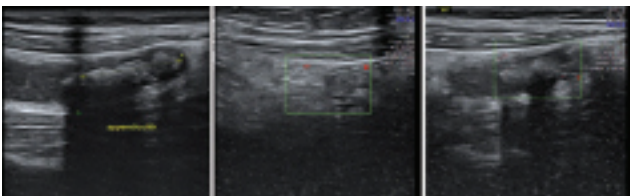
Group-II: Impending to complicate cases (n-28) of acute appendicitis with obstructive or non-obstructive cause were reported on HPE as inflamed appendix with evidence of dense transmural inflammation, necrotic exudates with debris formation. Few of them showed obstructed appendix with appendicolith. In these patients on USG apart from inflamed dilated appendix we found prominent and echogenic pericaecal and mesenteric fat with mild free fluid around it. Out of total 28 cases, on color Doppler 23 cases (82.1%) showed patchy flow and 2 cases (7.1%) showed circumferential flow. On power Doppler 26 cases (92.9%) showed patchy flow and



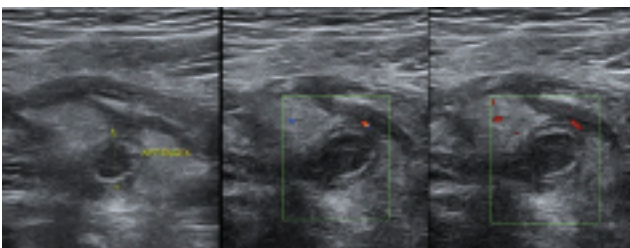
**[Table/Fig-1a,b]:** Patient with uncomplicated acute appendicitis showing evidence of inflamed and mildly dilated appendix with mild surrounding mesenteric fat inflammation on sagittal imaging on grey scale USG (a). Power Doppler study showing circumferential flow (b).

2 cases (7.1%) showed circumferential flow [Table/Fig-2,3].

Group-III: Complicated appendicitis (n-7) were reported on HPE as suppurative appendicitis with evidence of perforation and appendicitis with peri-appendicular abscess. On USG imaging out of the total ten cases, four cases showed perforated appendix with surrounding ill-defined appendicular mass formed by walled of collection, inflamed mesenteric fat and adhered adjacent bowel loops. Five cases showed loculated peri-appendicular abscess and one case showed appendicolith and appendicular mass with no significant collection. Out of total 7 cases, on color Doppler



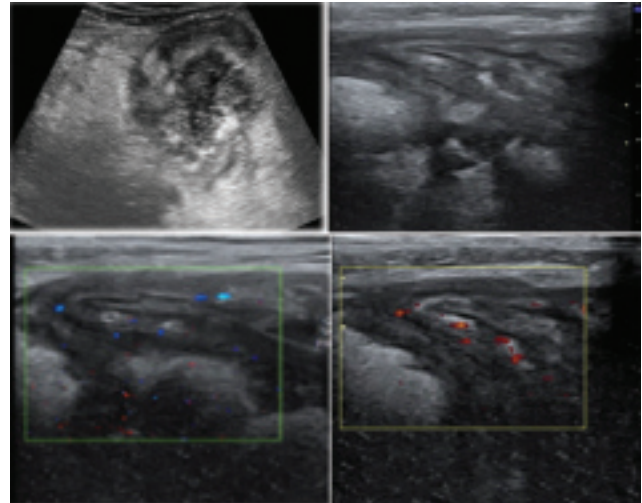
**[Table/Fig-2a-c]:** Acute appendicitis impending to complicate with obstructive cause (large appendicolith) showing large echogenic focus with posterior acoustic shadowing in appendicular lumen on gray scale imaging (a). colour and power Doppler images showing patchy specks of flow in appendicular wall (b and c).



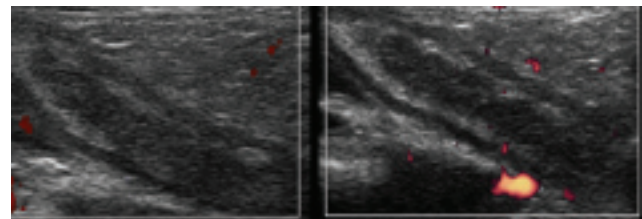
**[Table/Fig-3a-c]:** Acute appendicitis of non-obstructive cause impending to perforate- showing inflamed, dilated appendix with mild exudative collection in the lumen with surrounding inflamed mesenteric fat and minimal free fluid in transverse view in the gray scale image(a). colour and power Doppler images showing patchy specks of flow in appendicular wall (b and c).

4 cases (57.1%) showed patchy flow and 2 cases (28.6%) showed circumferential flow. On power Doppler 5 cases (71.4%) showed patchy flow and 2 cases (28.6%) showed circumferential flow [Table/Fig-4-7].

The flow was detectable in all the 48 number of patients on power Doppler study, however only (n-43) out of total (n-48) patients were showing flow on color Doppler study. Out of this



**[Table/Fig-4a-d]:** Complicated-Perforated appendicitis with evidence of inflamed appendix, inflamed surrounding mesenteric fat and loculated collection in the sagittal and transverse view on grey scale image (a, b). colour and power Doppler images showing patchy specks of flow in appendicular wall (c and d).



**[Table/Fig-5a,b]:** Patient with impending to perforate acute appendicitis showing inflamed appendix with mildly dilated lumen filled with exudative collection, minimal surrounding free fluid and mild adjacent mesenteric fat inflammation. No flow demonstration on colour Doppler imaging(a). By applying power Doppler showing minimal flow in patchy pattern (b).

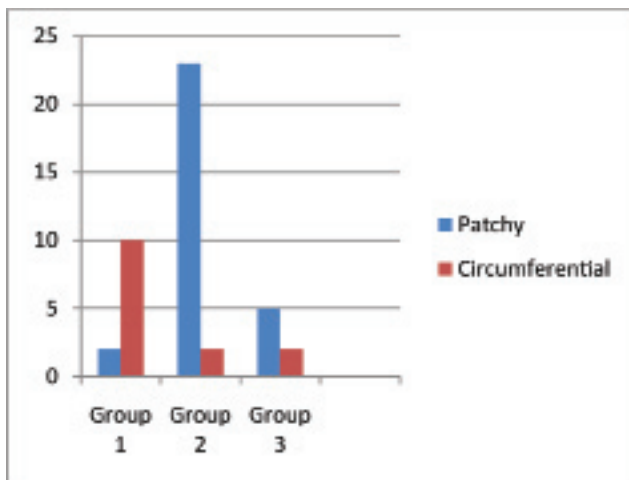
5 cases which did not showed flow on color Doppler imaging 1 case was in Group I, 3 cases were in Group II and 1 case in Group III [Table/Fig-8,9]. For color Doppler results the p-value was <0.001 and for power Doppler results the p-value was <0.001.

## DISCUSSION

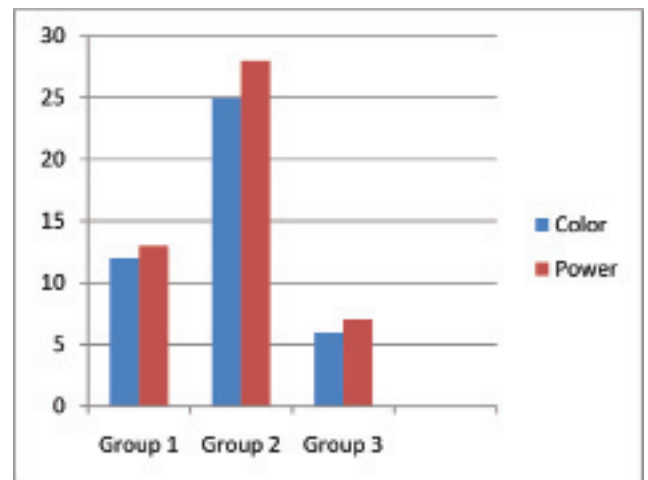
For diagnosing the acute appendicitis, the most commonly and widely used imaging modality is the USG. On USG, graded compression techniques was introduced for diagnosing appendicitis by Puyalert JB [14]. The anterior to posterior diameter of the appendix exceeding 6 mm was considered as sign of acute inflammation. However, at some instances

| Type      | Color Doppler |      |                 |      | Total           | Power Doppler |      |                 |      | Total          |
|-----------|---------------|------|-----------------|------|-----------------|---------------|------|-----------------|------|----------------|
|           | Patchy        |      | Circumferential |      |                 | Patchy        |      | Circumferential |      |                |
|           | n             | %    | n               | %    |                 | n             | %    | n               | %    |                |
| Group-I   | 2             | 15.4 | 10              | 76.9 | n-12<br>f=92.3% | 3             | 23.1 | 10              | 76.9 | n-13<br>f=100% |
| Group-II  | 23            | 82.1 | 2               | 7.1  | n-25<br>f=89.2% | 26            | 92.9 | 2               | 7.1  | n-28<br>f=100% |
| Group-III | 4             | 57.1 | 2               | 28.6 | n-6<br>f=85.7%  | 5             | 71.4 | 2               | 28.6 | n-7<br>f=100%  |

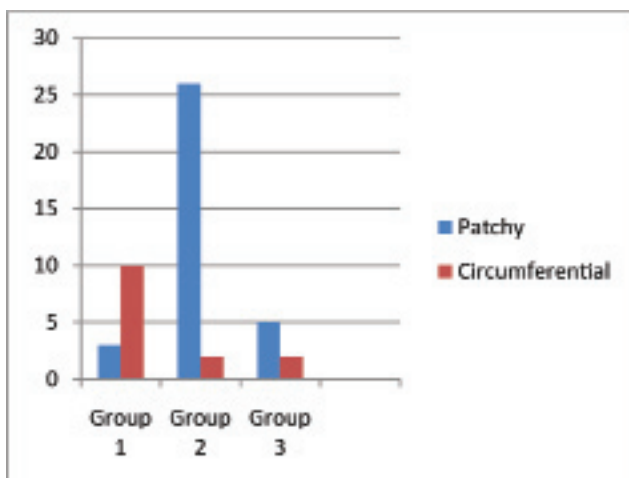
**[Table/Fig-6]:** Enumeration of presence and pattern of flow in all three groups of acute appendicitis patients on both colour and power Doppler imaging.



**[Table/Fig-7]:** Distribution of color Doppler vascularity pattern among various groups of acute appendicitis correlated with HPE reports.



**[Table/Fig-9]:** Comparison of vascularity pattern distribution among various groups of acute appendicitis correlated with HPE reports on both colour and power Doppler imaging.



**[Table/Fig-8]:** Distribution of power Doppler vascularity pattern among various groups of acute appendicitis correlated with HPE reports.

this criteria may be unreliable because of the presence of faecal material within the lumen of appendix, could cause the enlargement [15]. Hence, differentiation between a normal and

a pathologic appendix still remains a challenging diagnostic problem in some instances [16,17]. On color Doppler examination the presence of hyperemia in the mucosal layer of the appendix may be a marker of appendicitis [7].

Uncomplicated acute appendicitis (Group I) seen as a tubular, non-compressible, blind ending structure which was round in shape on gray scale imaging with outer- outer diameter ranging from 6.4 mm to 12.3 mm correlated with the study done by Rettenbacher T et al., [16].

The cases of acute appendicitis which were impending to complicate (Group II), on USG imaging showed dilated and inflamed appendix and also prominent and echogenic pericaecal and mesenteric fat with or without mild free fluid around it. These added findings could be indirect signs of perforations/ abscess. Present findings were consistent with the Fa EM et al., findings impending to perforation [18]. But these added findings were not consistent in Group II patients of this study, making it difficult to categorize the acute appendicitis cases in to impending to complicate cases only with gray scale USG imaging findings.

In complicated cases of appendicitis (Group-III) the USG imaging features like perforated appendix with surrounding

ill-defined appendicular mass formed by walled collection, inflamed mesenteric fat and adhered adjacent bowel loops and loculated peri-appendicular abscess will help us to discriminate the acute appendicitis patients with complication who need immediate surgical intervention.

In the study done by Carpenter JL et al., in differentiating perforated and non-perforated appendix they concluded that ultrasound is highly specific but lag in its sensitivity for detecting perforated appendicitis in pediatric population [19].

In forty-eight patients whom study for color and power Doppler was done, the results were compared with histopathological findings to correlate them. There was generalized hyperemia noted in all cases of appendicitis with predominant circumferential pattern of flow in uncomplicated cases and predominant patchy specks of flow in impending to complicate and complicated cases with statistically significant difference.

Though, there are many other studies done previously to evaluate the role of Doppler in imaging acute appendicitis, not many studies have focused on different pattern of the flow like circumferential/patchy in differentiating complicated and uncomplicated cases. As per our knowledge we could find one similar study in the literature done by Prince H Al et al., using color Doppler [20]. They have divided the cases of appendicitis depending on severity of appendicitis and pattern of flow in 50 cases which were operated. More number of cases showed patchy type of flow in the cases impending to perforation whereas, diffuse flow noted in the cases of non-obstructive and uncomplicated cases.

Our study also showed similar kind of color flow pattern distribution among cases of uncomplicated, impending to complicate and complicated appendicitis. The predominant circumferential pattern of flow noted in uncomplicated cases of appendicitis could be explained by the diffuse hyperemia secondary to inflammation resulting in generalized increase of vascularity of the appendicular wall. In cases impending to complicate and complicated cases of appendicitis predominant patchy pattern of flow was noted probably because of the decrease blood supply to appendix due to underlying ongoing necrosis in these cases.

In our study the primary focus was on to discriminate the acute appendicitis cases that are impending to complicate as it is difficult to identify these patients only with the findings on USG gray scale imaging. Early detection of impending to complicate cases is mandatory in order to provide the management without delay and to reduce the unfavorable outcomes.

We also had an added objective in our study to evaluate the role of power Doppler in the same number of cases and compared the results of both color and power Doppler study in different groups of acute appendicitis. In our study all the five cases of appendicitis in three different groups, color Doppler had not shown flow but power Doppler had showed flow with patchy pattern in all these cases. This explains the efficiency of power Doppler over the color Doppler in detecting up of

even minimal hyperemia due to its high sensitivity to flow. With our results the power Doppler seems to be more sensitive than the color Doppler in detecting the flow in all cases of appendicitis than the color Doppler. Hence, the power Doppler can be used in evaluating the patients with gray scale USG imaging features of appendicitis in whom the color Doppler is negative to support the diagnosis and also in differentiating the cases into uncomplicated, impending to complicate and complicated cases along with the gray scale findings.

The power Doppler superiority over color Doppler imaging was already explained by one of the previous study done by Pinto F et al., in which they compared color and power Doppler and found power Doppler to be superior than color Doppler in detecting the minimal hyperemia [21], predominantly due to its angle independent factor. Though, power Doppler sensitivity was proven in this study, the pattern of flow in differentiating uncomplicated and complicated cases of appendicitis was not included in this study. The present study results regarding power Doppler sensitivity over color Doppler in detecting acute appendicitis patients agree with this previous study and in addition provided us with the common pattern of flow associated with complicated and impending to complicate cases.

## LIMITATIONS

Though, USG is the common and widely used imaging modality to diagnose appendicitis it does have few pitfalls too. Localization of the appendix by ultrasound in all patients is not possible due to varying anatomical positions of appendix. The bowel gas artifact could also obscure the proper visualization of the appendix. Proper technique has to be followed while Doppler imaging to avoid false negative results and artifacts like aliasing by proper adjustment of gain and frequency settings. Operator dependence of ultrasound and Doppler imaging is also one of the major drawbacks.

## CONCLUSION

The presence and pattern of flow on both color and power Doppler study has an add-on value in diagnosing acute appendicitis when combined with typical imaging findings on gray scale USG evaluation. On both color and power Doppler imaging, the pattern of flow can be employed to differentiate the uncomplicated cases where the common pattern of flow is circumferential from the complicated and impending to complicate cases where the common pattern of flow is patchy. This will be especially useful in cases that are impending to complicate which are difficult to be discriminated only with USG gray scale imaging. Power Doppler will be of help in situations where color Doppler imaging is negative due to its high sensitivity to even minimal hyperemia, especially in impending to complicate and complicated cases where there is reduced flow. Thus, the usage of Doppler imaging in pre-operative prediction of acute appendicitis patients who are impending to complicate and patients with complication will help in reducing the delay in surgical management of these

patients and in turn will help in reducing the resultant morbidity and mortality.

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### FINANCIAL OR OTHER COMPETING INTERESTS:

None.

Date of Publishing: Apr 01, 2017