ROLE OF ULTRASOUND IN ACUTE APPENDICITIS

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Background: Misdiagnosis of acute appendicitis is a common and crucial problem in general surgery. Graded compression ultrasonography is one of the new diagnostic technique that is reported to have improve the diagnostic accuracy and clinical outcome. The aim of current study is to assess the role of this diagnostic modality in the management of acute appendicitis. **Methods:** This is a cohort observational study comparing the adverse outcome in two different groups of patients admitted with suspected acute appendicitis at two different hospitals in two different countries. The first group of 200 patients at Ayub Teaching Hospital Abbottabad, Pakistan, was managed without preoperative ultrasonography. In the second group of 200 patients admitted at Najran General Hospital Najran Saudi Arabia, graded compression abdominal ultrasonography was routinely performed preoperatively. Diagnostic accuracy of the protocol in each group was measured statistically and rates of negative appendicectomy and perforation were determined. **Results:** Addition of routine ultrasonography in clinical assessment for acute appendicitis decreases the sensitivity but significantly increases the specificity of the protocol thereby reducing the false positive rate translating into decreased negative appendicectomy rate. Rate of negative appendicectomy was 22.5% in group one and 4.7% in group two.Perforation rate was 15.6% in group 1 and 15% in group two. **Conclusion:** Proper clinical assessment is the mainstay of diagnosis in acute appendicitis and addition of routine ultrasound by graded compression technique can improve the diagnostic accuracy and adverse outcome.

Key Words : Acute Appendicitis, Ultrasonography, Diagnosis,

INTRODUCTION

Acute appendicitis is the most common surgical abdominal emergency with a life time prevalence of one in seven[1]. The diagnosis is mainly clinical but because of myriad presentation and is correct in up to 80% of the patients.[2] As the consequences of missed diagnosis are dire, the common surgical practice has been to operate on doubtful cases rather than to wait and see till the diagnosis is certain. This resulted in negative appendicectomy rate of 20 to 30% and has been considered acceptable.[3] This concept is being challenged at present day of quality assurance. The removal of normal appendix is not a benign procedure and negative appendicectomy carries a definitive morbidity[4] Today's aware patient is also concerned about removal of his normal appendix. In order to improve the diagnostic accuracy different aids were introduced like computer aided programs, different scoring systems, GIT contrast studies, CT.scan, Ultrasonograhy, MRI and laproscopy[5]. Among these modalities, Ultrsonography is simple, easily available, noninvasive, convenient and cost effective.[6]

The ultrasound in the diagnosis of acute appendicitis was first popularized by Puylaert in 1986, one hundred years after the publication of first paper on acute appendicitis by Fitz.[7,8] In graded compression technique, where a uniform pressure is applied in RIF by a hand held US transducer. Normal and gas filled loops of intestine are either displaced from the field of vision or compressed between anterior and posterior abdominal walls. Inflamed appendix being incompressible is thus optimally seen the inflamed appendix is seen as a blind ended tubular structure with laminated wall arising from the base of caecum.It is aperistaltic, noncompressible and its diameter should be more than 6mm.Appendicoliths appear as bright echogenic foci with distal acoustic shadowing, and their visualization is another contributory finding. Similarly there may be increased echogenicity of the periappendiceal fat. Puylaert reported the sensitivity of 89% and specificity of 100% of his technique in the diagnosis of acute appendicitis. Ultrasonic probe tenderness can be elicited and patient himself can localize the most tender point and hence the site of inflamed appendix[9]. Lim HK and Quillin SP had described the usefulness of color doppler in detecting inflamed appendix. The inflamed thick walled, noncompressible appendix fixed in position by compressing transducer will show circumferential color in contrast to the normal gut which is thin walled and compliant with frequent peristalsis transmitting no or minimum signals. .Doppler signals disappear when gangrene or perforation occur[10, 11].

Objective of this study is to evaluate the role of graded compression ultrasonography used a s a diagnostic tool preoperatively comparing it a protocol where only clinical assessment was used as diagnostic protocols.

MATERIALS AND METHODS

This cohort observational study was conducted longitudinally in two hospitals in two different countries. The first half of the study is retrospective and conducted at 'Surgical B unit of Ayub Hospital Complex, Abbottabad, Pakistan.200 patients above age twelve with suspected acute appendicitis were admitted, managed and followed up for one year from 1st.January 2004 to 30th June 2005. The patients with appendicular mass, signs of generalized peritonitis and problem cases in which ultrasound or CT abdomen was performed preoperatively were excluded from the study. Avarado scoring alone was used for decision to operate in this group. All the patients with Alvarado score 7 or above were immediately operated upon. The patients with Alvarado score 4 or below were discharged on short follow up appointments. . Patients with Alvarado score 5-6 were retained and reassessed at 4 hourly bases. Decision to operate or discharge was made within 24 hours depending on progress in their clinical course with score 6 as cut off point. All non-operated patients were followed for one year and eight of them returned with recurrent appendicitis and operated upon.

The second group of 200 cases with same criteria were admitted and managed at Najran General Hospital Najran, Kingdom of Saudi Arabia. from 1st.August 2004 to 31st.July 2005. Were included in the study The patients with abdominal mass, generalized peritonitis and those in whom CT scan abdomen was used preoperatively were excluded from the study. Abdominal ultrasonography by graded compression technique was performed routinely in all these 200 patients within 4 hours of admission. The ultrasound machine was SIEMENS using linear transducer of 7 M, H. frequency.

The sonographic findings were recorded as positive and negative for acute appendicitis. The criteria for positivity included visualization of non-compressible tubular and blind-ended aperistaltic structure with diameter of 6 mm. or more in right iliac fosse. The demonstration of appendicolith, probe tenderness, increased echogenecity of the periappendiceal fat, free intraperitoneal fluid particularly in RIF or pelvis and circumferential color on Doppler ultrasound were additional criteria of positvity. The criteria of negativity were nonvisualization of appendix or visualization of normal appendix with or without alternative diagnosis. The patients with Alvarado score 5 and above with positive ultrasonography were operated immediately. Patients with negative ultrasound but Alvarado score 8 or above were also operated upon. Patients with Alvarado score 4 or below with negative ultrasound were discharged immediately with short follow up appointment. Patients with Alvarado score4 or below with positive ultrasound were retained for 48 hours under observation and decision to operate was made then based on repeat scoring and sonographic scanning. All the patients were followed for one year.

Operative findings in both groups were classified as negative, positive and perforated. Negative appendicectomy was defined as normal looking appendix on operation and absence of acute inflammation on histopathology. Positive cases included appendices showing acute or subacute inflammatory changes on histopathology. Perforation was described to occur when it was clearly visible on operation, gangrenous changes discerned on histopathology or peritoneal swab yielded growth of any bowel organism. Two by two table was used for statistical analysis to compare the accuracy of two diagnostic protocols in terms of their sensitivity, specificity, false negative and positive values and their predictive values. The 8 patients in group-1 and 12 in group-2, operated during follow-up were also included in 2x2 statistical tables.

Rates of negative appendicectomy and perforations were calculated in both groups. Negative appendicectomy rate (NAR) was defined as the percentage of operated cases with normal appendix during their first admission. Alternative diagnoses incidentally found during operation were dealt accordingly but the procedure was called negative appendicectomy. Such diagnoses were not considered for calculation of results, as this was not the aim of study. Perforation rate (PR) was defined as the percentage of operated patients with perforated appendix also during their first admission.

RESULTS

There were 108 females and 92 males all the patients in group one. In second group there were 133 females and 67 males. Figure -1 shows the overall profile of group one.

In the second group ten patients with positive ultrasound were not operated upon because of clinical improvement... and 12 among the non-operated patients returned with recurrent acute appendicitis and were operated upon.

The eight patients in group-1 and 12 in group-2 admitted subsequently during follow up were not considered for calculating these rates. Alternative diagnoses incidentally found during operations were dealt with accordingly.

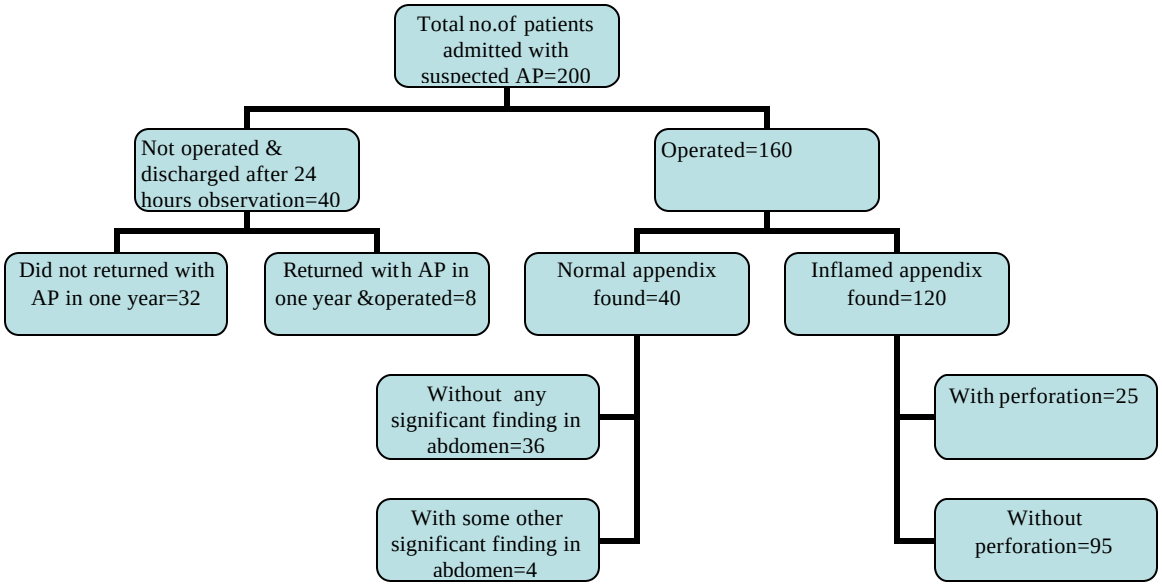

Figure 1. Profile of Group-1 (AP =Appendicitis)

The profile of second group of patients is shown in Figure-2a and b

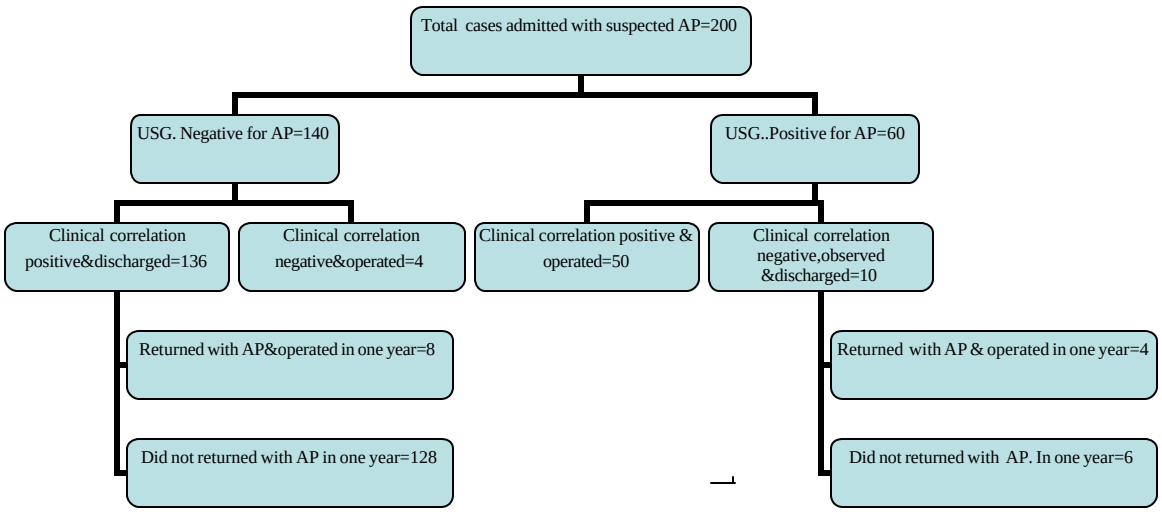

Figure 2(a). Profile of Group 2

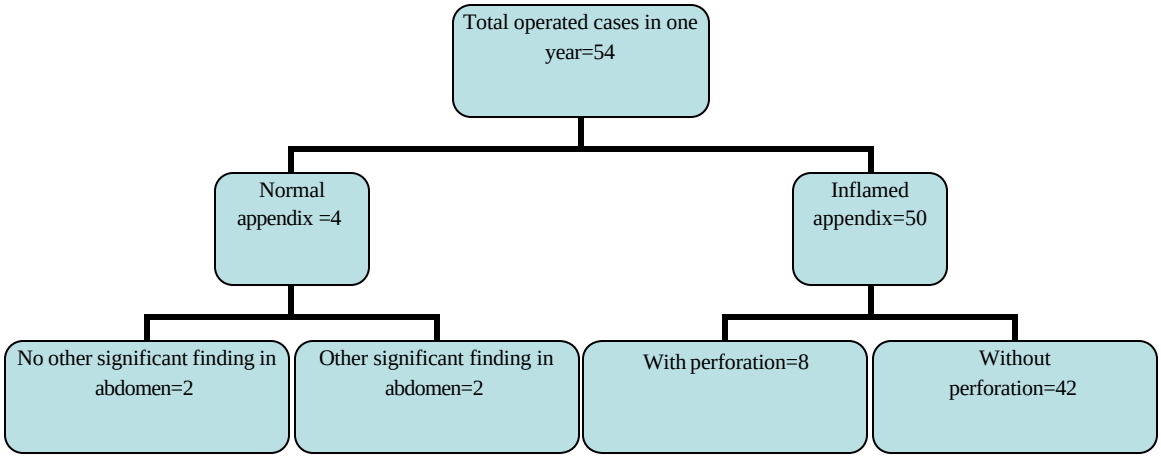

Figure 2 (b). Operative findings of group 2.

Figures 3 show the ultrasonographic scans in some of these patients

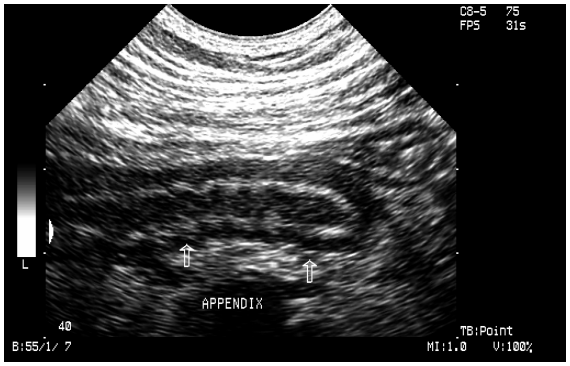

Figure-2.Longitudinal scans of the inflamed appendix (arrows) with thickened wall and hyperechoic periappendiceal fat.

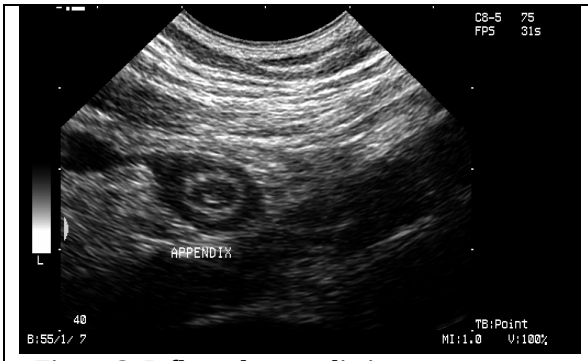

Figure-3. Inflamed appendix in transverse scan

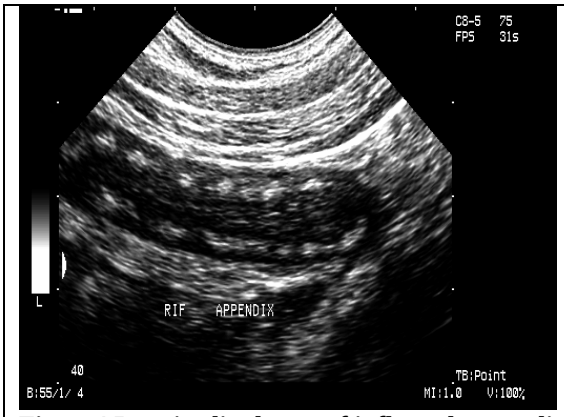

Figure4.Longitudinal scan of inflamed appendix with marked peri appendiceal fat echogenicity

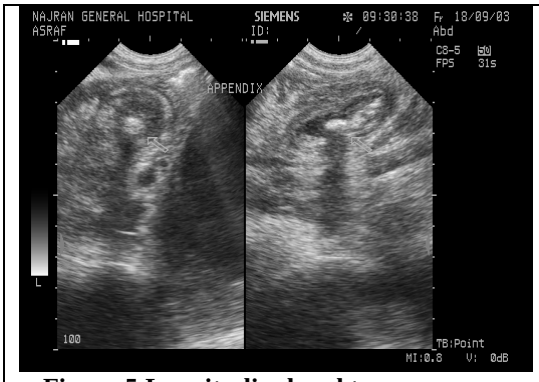

Figure-5.Longitudinal and transverse scan of inflamed appendix with appendicolith(arrow)

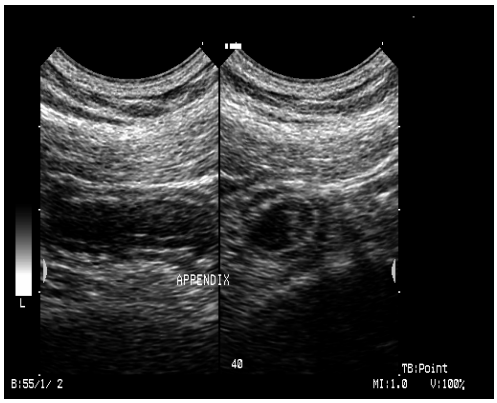

Figure-6.Longitudinal and transverse scans of inflamed appendix with small amount of fluid in periappendiceal region.

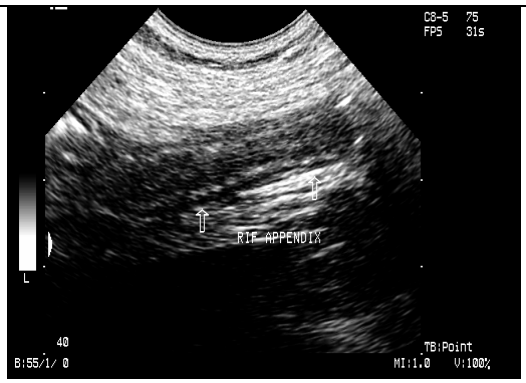

Figure-7, Longitudinal scan of inflamed appendix (arrows) arising from caecum

Diagnostic Performance assessment.

Table-1. Summery of results in group-1.

	Ac.Appendicitis+ (D+)	Ac.Appendicitis- (D-)	Totals
Clinical Diagnosis+ (T+)	120(TP) *	40(FP)**	160(All test positive
Clinical Diagnosis- (T-)	8(FN)***	32(TN)****	40(All test negative)
Totals.	128 (All diseased)	72(All disease free)	200 (G. total)

*-TP=True positive **-FP=False positive ***-FN=False negative ****-TN=True negative

Sensitivity = True positive rate (TPR) =Diseased with positive test/All diseased=120/128=0.93

Specificity =True negative rate (TNR) =Disease free with negative test/All disease free=32/72=0.444

False negative rate (FNR) =Diseased with negative test/All diseased=8/128=0.06

False positive rate (FPR) =Disease free with positive test/All disease free=40/72=0.555

Positive predictive value (PPV) =Diseased with positive test/All with positive test=120/160=0.75

Negative predictive value (NPV) =Disease free with negative test/All with negative test=32/40=0.8

Table 2. Summery of results in group-2

	Ac.Appendicitis+ (D+)	Ac.Appendicitis - (D-)	Totals
USG Diagnosis+ (T+)	54(TP)*	6(FP)**	60(All test positive)
USG Diagnosis - (T-)	12(FN)***	128(TN)****	140(All test negative)
Totals	60 (All diseased)	134(All disease free)	200 (Grand total)

*-TP=True positive **-FP=False positive ***-FN=False negative ****-TN=True negative

Sensitivity=True positive rate (TPR) =Diseased with positive test/All diseased=54/60=0.818

Specificity=True negative rate (TNR) =Disease free with negative test/All disease free=128/134=0.955

False negative rate (FNR) =Diseased with negative test/All diseased=12/66=0.18

False positive rate (FPR) =Disease free with positive test/All disease free=6/34=0.044

Positive predictive value (PPV) =Diseased with positive test/All with positive test=54/60=0.9

Negative predictive value (NPV) =Disease free with negative test/All with negative test=128/140=0.914

Table 1&2 summarize results in group1&2 using 2x2 contigency table.Diagnosis of Acute Appendicitis was taken as positive when confirmed on operation, histopathology or both. Diagnosis was considered negative, when patient recovered completely without operation, did not return during follow-up or normal appendix removed on operation. Accuracy and predictive values for both diagnostic protocols are compared in table-3.

Table-3. Comparison of two diagnostic protocols in statistical terms.

Statistical values	Group-1	Group-2
Sensitivity	0.93	0.818
Specificity	0.444	0.955
FNR	0.06	0.18
FPR	0.555	0.044
PPV	0.75	0.9
NPV	0.8	0.914

Comparison of performance values of the two protocols show that diagnostic specificity in Group-2 is significantly higher and FPR is significantly lower than the corresponding values in Group-1.This means that very few cases of Acute Appendicitis will be missed.

Negative appendicectomy rate (NAR) was significantly higher in Group-1.Table-4 compares negative appendicectomy rate in two groups.

Table-4.Negative appendicectomy rate (NAR)

	Group-1	Group-2
Total no. of admitted cases	200	200
Total no. of operations	160	54
No. normal appendices	40	[3]
NAR	25%	7.4%

Perforation rate was also higher in group -1 but the difference was not marked.Table-5 illustrates this difference.

Table-5...Perforation rate in two groups

	Group-1	Group-2
Total no. of admitted cases	200	200
No. of operations	160	54
No. of patients with perforated appendix	25	8
PR.	15.6%	15%

Both negative appendicectomy and perforation are adverse clinical outcome. An overall adverse outcome in each protocol can be measured by adding both these indices. Table -5 analyses this difference.

Table-5. Over all adverse outcome in each group

	Group-1	Group-2
NAR	25%	7.4%
PR	15.6%	15%
Total adverse outcome	40.6%	22.4%

DISCUSSION

Diagnosis of Acute Appendicitis is not always straight forward. Sometimes presentation is so atypical that even the most experienced surgeon may remove normal appendix or sit on the perforated one.[2] Clinical decision to operate leads to removal of 20% of normal appendices to avoid the complications of missed or delayed diagnosis in equivocal cases.[12], This was said to be the optimum balance between negative appendicectomy and rate of perforation which were thought to be reciprocally related,[3]This traditional concept is however being questioned recently.[13] Incorporation of new diagnostic modalities in clinical decision making , low negative appendicectomy rate can be achieved without increasing the rate of perforation.[14] The most widely studied new diagnostic modalities are CT Scan, Ultrasonography and Laparoscopy.[15-17] We have selected the Ultrasound because of its wide availability, simplicity,low cost, and noninvasiveness.

Usefulness of US in the diagnosis of acute appendicitis is now established. When Puylart first introduced his graded compression method, he reported sensitivity of 89% and specificity of 100%.[8] Many other workers later on reproduced the same findings. [18-23]

In our first group of patients ultrasound was not used and decision was purely clinical...The sensitivity of diagnostic protocol in this group was 93% but dropped to 81% in second group when ultrasound was routinely incorporated in diagnostic process. .This explains the relatively higher FNR in group two.If ultrasound alone would have been the deciding factor ten more patients would have been unnecessarily operated upon. We believe therefore that ultrasound findings should not be allowed to override the clinical judgment. This observation is in consistent with many other observers.[24,25] The specificity on the other hand is significantly improved in group two, being 95% as compared to 44% in group 1.This is reflected in low FPR and consequently low NAR in group 2. Predictive values, both positive and negative were higher in group two patients. This observation again reflects the usefulness of ultrasonography in statistical language.

The improved performance parameters in group two were translated in better clinical outcome. Both NAR and PR were lower in this group although decrease in NAR was more significant statistically.NAR was 25% in group 1 but dropped to 7.4% in group 2.Perforation rate was 15.6% in group 1 and decreased to 15% in group 2. This difference is very small but it is in sharp contrast to many other studies where PR was observed to incline with the decline of NAR.[26]

Most of the workers have reported the same rates of negative appendicectomy and perforation when decision to operate was clinical[27]. Some workers have reported lower values of NAR and PR than our observation with Alvarado score., This might be due to their extended period of observation, more female patients in their study or cut off point of the score for decision to operate. Our cut off point for operation in group 1 was Alvarado score 6 similarly lower PR in some studies are also due to differences in definition of perforation. In one such study gangrenous appendix was not counted as perforated and separate rates of perforation and gangrene were reported as 7.8% and 10.9% respectively [28].

When ultrasound was incorporated in diagnostic work up in our second group of patients, NAR was dropped to 7.4% and PR dropped to 15%...This finding refutes the concept of reciprocal relationship between negative appendicectomy and perforation rates.Incarporation of ultrasound decreased the negative appendicectomy significantly without increasing the perforation rate. Contrarily perforation rate was also decreased. Our findings are in consistence with many other reports where preoperative ultrasound improved the clinical outcome favorably [23]. Stefan Pug et al in 2003 have reported 36.6% NAR without US and 13.2% after US. However their perforation rates were significantly more in US group testifying the hypothesis of inverse relation. Velanovich V and

Satava R (1992) in their study of 10,000 patients have also reported the same concept of inverse relationship.[27] Our low PR in group 2 might be due to low cut off point of Alvarado score in this cohort of patients. Our cut off point in group 1 was 6 but 5 in groups 2.

Both negative appendicectomy and perforation are adverse outcome. We can add both events and calculate the adverse outcome without any reference to their mutual relationship Adverse outcome dropped from 40.6% to 22.4%.This improved clinical outcome signifies the importance of ultrasonography in diagnostic workup of the patients admitted with suspected acute appendicitis.

After the pioneer article of Puylart in 1986, a number of workers have studied the role of ultrasound in management of suspected acute appendicitis. Most of these authors have reported increased diagnostic accuracy when ultrasound was added to the clinical work up of these patients.[6,18,29] Ultrasound has been reported more helpful in clinically equivocal cases Because of false positive and false negative results, ultrasound should not be allowed to override the clinical acumen in extremes of the wide clinical spectrum of acute appendicitis.[5] Although we have routinely used ultrasound in our second group of patients, we always considered the results in correlation with our clinical judgement.We operated upon those patients with Alvarado score 8 or above irrespective of ultrasound findings. At the other extreme in patients with Alvarado score 4 or below operation was not performed straight away on positive ultrasound findings alone. We therefore conclude indirectly that ultrasound findings in suspected acute appendicitis should always be correlated clinically and its main value is in borderline cases.

An important additional advantage of ultrasound in acute appendicitis is the diagnoses of alternative conditions in abdomen mimicking acute appendicitis [30].As some of these conditions do not need surgery, so operation can be avoided. We also noticed these extra appendiceal conditions in our study but we did not incorporate these findings in calculating inferences, as this was not the aim of study.

We did not stratified our patients in groups based on age and sex. All of our patients were adult and we measured the usefulness of ultrasound in acute appendicitis in general. There are however, sub groups of patients who benefit from ultrasound more than others as reported by most of the workers.[31]

There are certain draw backs in ultrasonography for acute appendicitis. The foremost important is the experience of the sonologist, as the procedure is highly operator dependant. The sinologist involved in this study has experience of 20 years with special interest in graded compression technique. This is the main reason of our better outcome. There are reports in the literature against the usefulness of ultrasound in diagnosis of acute appendicitis. Operator dependency of the technique may also be the reason for these reports with poor outcome[32,33]. In one such report from the similar setting Mufti TS et al[34] concluded that use of graded compression ultrasonography as preoperative diagnostic technique has a good sensitivity (84.3. % and 81.81 %) but poor specificity implying that value of ultrasonography may remain unclear in reducing the negative appendisectomies.

In conclusion ultrasound by graded compression technique is a useful adjuant to the clinical armamentarium of the present day surgeon. It can reduce the negative appendicectomy rate without adversely affecting the perforation rate particularly in equivocal cases. However US findings should be correlated carefully with clinical findings.

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