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Research

# ROLE OF ULTRASOUND IN DIAGNOSIS OF ACUTE APPENDICITIS: SHOULD YOU 'SOUND' BEFORE YOU 'SCOPE'?

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## Abstract

**Background:** In this study we aimed to analyse the role of Ultrasound in accurate diagnosis of Acute Appendicitis with an aim to bring down the Negative Appendectomy Rate. **Materials and Methods:** 126 patients were included in the study. All the patients were segregated into two groups namely "High risk" and "Low risk" on the basis of whether they had a score of 7 and above or 6 and below in the Alvarado scoring system, respectively. All patients then underwent Ultrasound evaluation and were further segregated into following four groups: High Risk with or without sonological evidence of Appendicitis and Low risk with or without sonological evidence of Appendicitis. All high-risk patients (irrespective of USG diagnosis) and all low-risk patients noted to be "Positive for Appendicitis" underwent Diagnostic Laparoscopy. **Result:** Mean age of patients was 31.50 (±13.60) years with a minimum of 9 and maximum of 67 years. Fifty-Four (42.85 %) patients were females and 72 (57.14 %) were males. 49 out of 81 (60.49%) from Low-Risk group and 37 out 45 (82.22%) from High-Risk group were found to be "Positive for Appendicitis" on Ultrasound examination. 32 out of 81 (39.51%) from Low-Risk Group and 8 out of 45 (17.77%) from High-Risk group were found to be "Negative for Appendicitis". 94 patients out of the 99 patients who were operated were confirmed to have Appendicitis on Histopathological examination. Two were noted to have appendicolith blocking the appendicular lumen. Both appendicoliths were reported in patients in Low-Risk group and "Negative for Appendicitis" but were operated because they continued to be symptomatic with lower quadrant pain despite being on conservative management. Three appendices out of 99 (NAR of 3.03%) were reported to be "normal" with no signs of inflammation within. We found a False Positive rate of 3.48% and False Negative arte of 11.11% on Ultrasound for Acute Appendicitis. Amongst the clinical symptoms and signs, Anorexia (89/94; 94.68%) and Rebound tenderness (87/94; 92.55%) respectively had the highest positive correlation with Histopathological diagnosis of Acute Appendicitis in all appendectomies performed. **Conclusion:** Use of Ultrasound as a diagnostic tool in suspected Acute Appendicitis patients having low Alvarado score, helps in bringing down the Negative Appendectomy Rate.

## INTRODUCTION

Accurate diagnosis of Acute Appendicitis (AA) and prevention of negative appendectomies has been a constant endeavour of surgeons. The negative appendicectomy rate (NAR) is a quality metric in the management of appendicitis.[1] Delayed diagnosis may lead to necrosis and perforation of inflamed appendix causing an increased mortality and morbidity. Although with significant improvements in quality and availability of imaging techniques, accurate diagnosis of acute appendicitis has increased in recent years but negative appendectomy still remains a concern, with a rate of 3.7–13.5 % in children and about 12 % in adults, imposing additional risks and costs both to patients and health system.[2] During the past two decades, appendiceal computed tomography and graded


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compression ultrasonography have gained widespread use.[3]

Alvarado score (AS) for clinical assessment of Acute Appendictis is simple, effective and can be easily applied. It is a reasonably consistent triage tool for ruling out appendicitis and identifying those at higher risk. However, diagnostic accuracy of clinical scoring systems like Alvarado scoring system remains modest with sensitivity ranging from 56.8% to 93.5%.[4,5] However in combination with Ultrasound the sensitivity of Alvarado scoring system has been known to increase to 68.4% and diagnostic accuracy to 71.9%.[4] Combination of imaging methods with clinical scoring system is hence gaining wider acceptance especially for patients presenting with diagnostic dilemma or low Alvarado score. Atypical cases present a diagnostic dilemma. Therefore, clinical diagnosis should be complemented with other diagnostic modalities such as ultrasound, computed tomography (CT), laparoscopy, and C-reactive protein levels to bring down NAR in equivocal cases.[5] In order to reduce NAR, routine CT scanning was advocated by some studies. However, routine CT scanning in patients with suspected appendicitis is not feasible or cost-effective in the resource-limited communities. Moreover, the risks of exposure to ionizing radiation may limit the wide application of CT scanning.[4]

AA is a common abdominal emergency with a lifetime prevalence of about 7 %.[6] With such a vast majority of population likely to be affected during its lifetime, use of an imaging modality which is cheap, dependable and harmless for screening large subsets of population is desirable. Most surgeons pride themselves on their ability to diagnose appendicitis without resorting to scoring systems but NARs using 'clinical judgement' alone have been as high as 17–36%.[1] Study by Denizbasi et al,[7] suggested that patients with an AS of ≤4 can be discharged without hospitalization, for those with an AS of 5–7, radiological methods can be used, and those with an AS of >7 should be operated. Similarly, Mckay and Shepherd,[8] concluded that imaging methods should be used in patients with an AS of 5–7 for diagnosis and patients with an AS of ≥7 should directly undergo operation without any more workup.

## MATERIALS AND METHODS

### Study design and Setting

This prospective single-center study was conducted between October 2017 and December 2019 at a tertiary-care teaching hospital of the Armed Forces. Patients reporting to the OPD as well those reporting to emergency department were included in this study. Consent for participating in the study was obtained from all patients. If the patient happened to be a minor, informed written consent was obtained from the parents or legal guardians.

### Participants

Patients at any age whose primary diagnosis according to history and physical examination (conducted by a Senior Surgeon) was Acute Appendicitis were included in the study.

Pregnant women and those who had presented with clinically palpable appendicular lump were excluded from this study.

### Intervention

Initial screening was done by third year post-graduate General Surgery residents. Those patients who had initial history and clinical examination suggestive of Acute Appendicitis were then re-examined by a senior surgeon. Only those who fitted into the clinical diagnosis of Acute Appendicitis were then recruited into this study.

Included patients then underwent further blood tests and ultrasound studies performed by an experienced Radiologist in this tertiary care centre. High-resolution 7.5 MHz linear-array probe was used for radiological diagnosis of Acute Appendicitis. 3MHz curvilinear probe was used for assessment of pelvis to rule out other possible causes mimicking pain of Acute Appendicitis.

Those diagnosed with definite pelvic/ ovarian pathologies, urinary pathologies (renal stones) etc. which could explain the Right Lower Quadrant pain were excluded from this study.

Patients who were taken up for Surgery in form of Laparoscopic Appendectomy had their Laparoscopic Findings recorded. Those patients who were noted to have an inflamed appendix underwent Laparoscopic Appendectomy. Those whose appendix was noted to be normal underwent diligent laparoscopic search for other pelvic and abdominal pathologies to explain the symptoms. In those whose appendix was apparently normal and were not found to be having any other gross pathology, appendectomy was done. In those who were noted to have a normal appendix but had a gross disease on laparoscopy which could possibly explain the patients symptoms were treated accordingly. The final pathology report was considered as gold standard of diagnosis.

### Ultrasound Protocol

Result was considered sonologically "Positive for Appendicitis" if any of the following were present:

- Non-compressible aperistaltic blind-ending tubular structure in right lower quadrant with antero-posterior outer wall to outer wall measuring 6 mm or more of abdomen in longitudinal axis.
- Appendicolith of any size (bright echogenic foci with distal acoustic shadow) found within appendix lumen
- "Target sign" in axial section associated with 'Probe tenderness'
- Peri-appendicular fluid collection


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- Increased echogenicity of the peri-appendicular fat
- Distinct appendicular wall layers (laminated walls)

Result was considered sonologically "Negative for Appendicitis" if appendix was not visualized or/and even one of the above criteria was not met.

**Data Analysis**

Descriptive data are reported as mean (±standard deviation), maximum and minimum. Categorical data are presented with percentages and 95 % confidence intervals. Sensitivity, specificity, positive and negative predictive values, positive and negative likelihood ratios are calculated.

## RESULTS

Over a 26 month period, One hundred and thirty four successive patients were assessed for eligibility to participate in the study. Three patients had palpable appendicular lump noted during the physical examination and were excluded. Two patients were found to be pregnant and were excluded. Three patients refused to give consent and were not included. One hundred and Twenty-Six (n=126) patients were enrolled in study.

Mean age of patients was 31.50 (±13.60) years with a minimum of 9 and maximum of 67 years. Eighteen (14.2 %) patients were <18 years old. Seven (5.5 %) patients were >60 years old. Fifty-Four (42.85 %) of patients were females, and 72 (57.15 %) were males. Most patients (65.87 %) were aged between 20 and 40 years old. Other baseline data are summarized in [Table 1].

All the patients clinically diagnosed as Acute Appendicitis were subjected to Blood investigations to look for Rise in TLC and Shift to Left, if any (in addition to other blood tests, depending on the age profile, to ascertain fitness for surgery and ruling out other co-morbidities). On the basis of symptoms, clinical signs and blood investigations, patients were grouped into low and high risk based on the Alvarado scoring system [Table 2]. Those having an Alvarado/ MANTRELS score of 6 or less were labelled as "Low Risk" and those having a score of 7 and above were labelled as "High Risk". 81 (64.28%) were found to be "low risk" by the Alvarado scoring system and 45 (35.71%) were found to be high risk. Those pts whose MANTRELS score was less than 4 were discharged and were not included in the study.

**Table 1: Baseline history and physical examination derived data**

| Variable | Frequency |
|---|---|
| Frequency of complaints, NO (%) | |
| Abdominal pain | 121 (96.03%) |
| Migratory Pain | 42 (33.33%)) |
| Vomiting | 16 (16.49) |
| Anorexia | 94 (74.60%) |
| Nausea | 77 (61.11%) |
| Gynecologic / Pelvic symptoms | 12 (9.52%) |
| Physical exam findings, NO (%) | |
| Tenderness | 112 (88.88%) |
| Rebound Tenderness | 91 (72.22%) |
| Guarding | 4 (3.17%) |
| Fever | 9 (7.14%) |
| Tachycardia | 27 (21.42%) |
| Past medical history, NO (%) | |
| Diabetes mellitus | 9 (7.14%) |
| Hypertension | 11 (8.73%) |
| Ischemic heart disease | 4 (3.17%) |
| History of renal stones | 14 (11.11%) |
| History of cholelithiasis | 11 (8.73%) |
| History of previous abdominal surgery | 24 (19.04%) |
| No remarkable past medical history | 53 (42.06%) |
| Blood Reports, NO (%) | |
| Raised TLC | 57 (45.23%) |
| Polymorphonuclear Leucocytosis (with normal TLC) | 41 (32.53%) |
| Ultrasound findings, NO (%) | |
| Positive for Appendicitis | 89 (70.63%) |
| Negative for Appendictis | 37 (29.36%) |

**Table 2: The Alvarado scoring system for acute appendicitis.**

| Empty Cell | Empty Cell | Alvarado score |
|---|---|---|
| Symptoms | Migratory RIF pain | 1 |
| | Nausea/vomiting | 1 |
| | Anorexia | 1 |
| Signs | Right iliac fossa tenderness | 2 |
| | Elevation of temperature | 1 |
| | Rebound tenderness RIF | 1 |


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| | | |
|---|---|---|
| Laboratory findings | Leukocytosis | 2 |
| | Neutrophilic shift to the left (>75%) | 1 |
| | | Total score = 10 |

All 126 were subsequently subjected to Ultrasound examination following the protocol mentioned above. 49 out of 81 (60.49%) from Low Risk group and 37 out 45 (82.22%) from High Risk group were found to be "Positive for Appendicitis". 32 out of 81 (39.51%) from Low-Risk Group and 8 out of 45 (17.77%) from High-Risk group were found to be "Negative for Appendicitis". [Table 3]

**Table 3: The Cohort**

| N=126 | Low-risk(81) | High-risk(45) |
|---|---|---|
| Positive for Appendicitis (n=86) | 49 | 37 |
| Negative for Appendicitis (n=40) | 32 | 8 |

All 45(100%) from the High-risk group (irrespective of Ultrasound findings) and 49 out of 81 (60.49%%) from Low-Risk group whose Ultrasound was "Positive for Appendicitis" were offered upfront Surgery in form of Laparoscopic Appendectomy (Total- 94/126; 74.60%). Remaining 32 out of 126 (25.40%) were offered conservative management in form of observation with only Nil by Mouth (NBM), Intravenous (IV) hydration and Proton Pump Inhibitors (without any parenteral antibiotics) for next 48 hours. 7 out of 32 (21.87%) had either persistent symptoms or worsening of symptoms and aggravation of Alvarado score during their period of observation and were taken up for Laparoscopic appendectomy without subjecting to repeat Ultrasound imaging. Remaining 25 out of 32 (78.12%) had complete resolution of symptoms during the period of observation with disappearance of pain, absence of tenderness and return of appetite. They were discharged on normal diet within 12 hours of resolution of symptoms.

**Laparoscopy findings**

80 out of the 86 (96.38%) who were found to "Positive for Appendicitis" during work-up were found to have frank signs of inflamed appendix, inflamed meso-appendix and/or periappendiceal fluid collection on Laparoscopy. Two out of 80 (2.5%) had to be converted to open surgery because of early lump formation which was neither picked up during clinical examination nor during Ultrasound. 2 out of 86 (2.32%) had subtle signs, with inflammation limited to the tip. 4 out of 86 (4.65%) had normal looking appendix. One was found to have a sealed Duodenal Ulcer (DU) Perforation with Greater Omentum adherent to the Perforation site and presence of purulent fluid in Morrison's pouch and pelvis. Thorough peritoneal lavage and re-inforcement of Omentum by modified Graham's Patch repair was done. Appendix was not excised. Remaining three out of four underwent appendectomy after thorough search of abdominal and pelvic cavity failed to find out other possible causes of Right lower quadrant pain.

Eight patients from High-risk group (n= 45) were found to be "Negative for Appendicitis" but were still subjected for up-front Laparoscopic Appendectomy (after discussing with the patient about risk vs benefits and obtaining informed written consent). Seven patients were found to have inflamed appendix (15.55% false Negative on Ultrasound) as per the criteria described above. Laparoscopic Appendectomy was also completed for one out the 8 patients who had an apparently "normal" looking appendix after a thorough diagnostic lap failed to yield any other possible cause of Appendicitis.

Seven pts who belonged to the Low-risk group (n=81) and were found to "Negative for Appendicitis" (False Negative of 8.64%) on USG examination either developed aggravation of symptoms and worsening of ALVARADO scoring (from Low Risk to High-Risk group) or showed no improvement during their period of observation and were taken up for Diagnostic Laparoscopy without subjecting to them to repeat Ultrasound. Six out of 7 had frank signs of Appendiceal inflammation and one had inflamed Appendicis Epiloicae. Lap Appendectomy was done for 6 of them and Laparoscopic excision of inflamed appendage was done for one.

Hence, in all a total of 99 patients out of the initial 126 (78.57%) who had a clinical suspicion of Acute Appendicitis based on history and clinical examination underwent Appendectomy. 97 out of these 99 (97.97%) under Lap appendectomy and remaining two had to be converted (2.02%) into Open appendectomy.

**USG correlation**

Eight out of the 45 patients belonging to high risk group who were labelled as "Negative for Appendicitis" but were subjected to Diagnostic Laparoscopy were found to have frank signs of inflammation in 3 cases, subtle signs of inflammation in 2 and an apparently normal looking appendix in 3 cases. One of the pts who was noted to be having a DU Perforation but normal appendix, was reported to having a pelvic and peri-appendiceal collection and was hence marked "Positive for Appendicitis". (False Negative of 5 out of 45;11.11%)

Seven out of the 32 patients of the Low-risk group and labelled "Negative for Appendicitis" subsequently developed worsening of symptoms and had to be subjected to Diagnostic Laparoscopy. Six


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out of these 7 were noted to have inflamed Appendix and one was noted to have inflamed Appendicis epiploicae. In all these 6 patients, appendix was found to be retrocaecal in position. (False negative of 6 out of 32; 18.75%)

Eighty two out of 86 patients (95.34%) who were reported to be "Positive for Appendicitis" were confirmed to have signs of inflammation on Diagnostic laparoscopy too. One patient who was labelled as "Positive for Appendicitis" was found to have a sealed DU Perforation and was noted to be periappendiceal fluid collection in addition to pelvic collection. Remaining 3 out of 86 (False positive of 3.48%) despite being labelled as "Positive for Appendicitis" were found to be having a normal looking appendix.

Twenty five of 32 Low risk patients who were labelled as "Negative for Appendicitis" improved with conservative management and were discharged soon after resolution of symptoms (Presumed to be True Positive- 78.12%). In all 14 out of the total cohort of 126 (False Negative rate of 11.11%) labelled as "Negative for Appendicitis" were later found to have Acute Appendicitis on Diagnostic Laparoscopy.

**Histo-Pathological Correlation**

A total of 99 Appendices were sent for Histo-Pathological Examination (HPE) in this study. Out of the 99 samples, 94 were reported as Acute Appendicitis with "mononuclear cell infiltration" being the most commonly observed phenomenon. Two were noted to have appendicolith blocking the appendicular lumen. Both appendicoliths were reported in patients in Low-Risk group and "Negative for Appendicitis" but who continued to be symptomatic with lower quadrant pain despite being on conservative management. Three appendices out of 99 (NAR of 3.03%) were reported to be absolutely normal with no signs of inflammation within. All negative appendectomies were reported in patients belonging to High-risk group and labelled as "Negative for Appendicitis" on USG examination. All three apparently "normal looking appendix" on Diagnostic Laparoscopy from High-risk group were found to have signs of inflammation on Histo-Pathological Examination.

**Correlation of Initial Presentation with Final HPE Report**

Pain (94/94; 100%) and Anorexia (89/94; 94.68%) were the most consistent symptom in all those patients confirmed to be having Acute Appendicitis on HPE. History of Migratory pain could be elicited only in 42 out of 94 patients (44.68%) although 100% of the patients who had migratory pain were found to be having Acute Appendicitis on HPE.

Though tenderness in the right lower quadrant was the commonest sign present on initial medical examination, 18 patients were subsequently found not to have any Appendicitis.

Amongst the clinical signs, rebound tenderness had the highest positive predictive value with 87 out of 94 (92.55%) patients exhibiting it. One patient each had a sealed DU Perf oration and an inflamed Appendicis Epiploicae in whom rebound tenderness was also elicited. Four patients remained in Low-risk group and were labelled as "Negative for Appendicitis" despite noted to be having rebound tenderness. They improved with conservative management. One turned out to have a normal appendix on HPE.

## DISCUSSION

Appendicitis is defined as the presence of inflammatory cells (polymorphonuclear leucocytes, lymphocytes or plasma cells) in the appendix.[1] Accurate definitive diagnosis of acute appendicitis, the most common abdominal emergency surgery, has been always challenging because of its non-specific symptoms, signs and laboratory findings which can mimic several other pathologies (from a viral gastroenteritis to a complicated ovarian pathology), especially in young women, children and elder patients.[2] Accurate diagnosis using clinical methods alone is known to be associated with high NAR.[1]

Diagnostic accuracy of Alvarado scoring system, the most prevalently used clinical scoring system, has its sensitivity ranging from 56.8%,[4] to 93.5% in different studies.[5] But in combination with Ultrasound the sensitivity of Alvarado scoring system has been known to increase to 68.4% and diagnostic accuracy to 71.9%.[4] Appropriateness criteria prepared by American College of Radiology recommended Graded Compression Sonography as a screening test for most patients with suspected appendicitis. These criteria also recommend that CT scan be used only in patients who are obese, have rigid non-compressible abdomen and are thought to have appendicitis complicated by an abscess.[3]

In our study, use of Alvarado scoring system alone would have probably led to more appendectomies or posed a potential risk of perforation in a sizeable number of patients. Use of Ultrasound for diagnosis in Low-risk cases prevented 25 appendectomies, who improved only with IV hydration and Proton-pump inhibitors bringing down out NAR from possibly 25.39% to just 3.03%. Even the three Negative Appendectomies that were reported in our study, were reported in patients who were labelled as "Negative for Appendicitis" but were taken up for Laparoscopic Appendectomy since they fell in the high-risk group by Alvarado scoring system.

The Ultrasound (as well as clinical examination) however failed to pick up early lump formation in two cases, though, both the high-risk cases were reported only as "Positive for Appendicitis" with no opinion about lump formation. After encountering difficulty in dissection and delineation of the base of appendix on Laparoscopy, both cases were


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converted and Open Appendectomy was performed. Ultrasound, in other studies has been found only to be moderately sensitive for diagnosing appendicitis but there is heterogeneity among the reported sensitivities and specificities.[3]

In our study, we found pain to be the commonest symptom (100%). History of Migratory pain could be elicited only in 42 out of 94 patients (sensitivity of 44.68%) although 100% of the patients who had migratory pain were found to be having Acute Appendicitis on HPE (Specificity of 100%). Zeki et al,[9] reported a specificity of 67.7% for migratory pain and a sensitivity of 69.6%. Similarly they noticed a sensitivity of 92.8 % and a specificity of 32.2% for rebound tenderness though in our study amongst all the clinical signs rebound tenderness had the highest positive predictive value with 87 out of 94 (92.55%) patients exhibiting it. Puttaraju et al,[11] noted a sensitivity of 41% and 77% for Migratory pain and rebound tenderness respectively. Tulin et al,[10] reported an NAR of 11.4%. Our study had an extremely low NAR (3.03%) possibly because all the low risk-cases who were marked as "Negative for Appendicitis" were placed under observation. Only those who had persistent symptoms or aggravation of symptoms were taken up for Diagnostic laparoscopy and Laparoscopic Appendectomy. Use of CT scan as a diagnostic modality has been recommended to keep the NAR to below 3%.[1] Lee et al,[12] reported a NAR of 2.6% following routine use of CT scan for evaluation of lower quadrant pain. A meta-analysis of studies that applied routine imaging showed excellent results with an overall pooled sensitivity and specificity of 83% and 93%, respectively for US 94% and for CT 94%.[13]

41 out of 81 patients in our study who were initially found to be low-risk for Acute Appendicitis by Alvarado score were found to be having Acute Appendicitis (50.61%). However most studies report such conversions from Low-score to Appendicitis ranging from 5.1% to 8%.[10,11] One of the reason for this could be 'no adminstration of antibiotics' to the patients who were placed under observation which otherwise could have masked the evolving signs of Acute Appendicitis in patients who had reported early.

Though in this study we did find that Ultrasound is an excellent diagnostic tool for picking up borderline cases of Acute Appendicitis, Terasawa and collagues opined that most studies tend to over-estimate the diagnostic performance of available imaging modalities due to inherent methodological weaknesses suggesting that True Sensitivity and Specificity of both USG as well as CT scan are lower than reported.[3] Flum & colleagues found that negative findings on appendectomy and rates of perforated appendicitis have remained unchanged despite use of diagnostic imaging.[14]

Lately, there have been numerous studies proposing Non-operative management of Acute Appendicitis. But with recurrence rates reported to be as high as 38% leading to repeated admissions,[15] prolonged hospital stay for parenteral antibiotic therapy and closer monitoring to rule out complicated Appendicitis and missing out on histology of a probable appendiceal tumour especially in elderly patients,[16] surgical management of Acute Appendicitis continues to be the Gold Standard.

## CONCLUSION

Acute appendicitis is the commonest cause of acute abdomen in young adults. Surgery continues to be the mainstay of treatment for Acute Appendicitis. A significant portion of Acute Appendicitis cases pose a diagnostic challenge. Excessive aggressiveness in surgical management creates an additional burden on the healthcare system and can increase the cost of treatment manifold. Delay in treatment increases the chances of perforation leading to an increase in morbidity for the patient apart from prolonging the hospital stay. Addition of one diagnostic tool in form of Ultrasound for screening of patients scoring low on clinical diagnostic tools, can help in reduction of morbidity as well as Negative Appendectomy rates.

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