

# Combined use of modified Alvarado score and USG in decreasing negative appendectomy rate

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## Abstract

**Introduction** Appendicitis is notorious in its ability to simulate other conditions and in the frequency it can be mimicked by other pathologies. Despite extraordinary advances in modern radiography imaging and diagnostic laboratory investigations the accurate diagnosis of acute appendicitis remains an enigmatic challenge. Of the various commonly used diagnostic aids for appendicitis, no single test can reduce the rate of negative appendectomy to zero.

**Materials and methods** Fifty admitted cases of suspected appendicitis were subjected to ultrasonography (USG). All the patients were scored out of 9 according to modified Alvarado score. A treatment plan was devised according to which patients with modified Alvarado score  $\geq 7$  underwent immediate appendectomy even if USG was negative for appendicitis and patients with score  $< 7$  underwent appendectomy if USG was positive for appendicitis.

**Result** 84.3% of males and 44.4% of females admitted as case of suspected appendicitis had confirmed appendicitis. Due to high sensitivity (97.14%) and accuracy (92%) of our diagnostic approach, 85.71% cases of appendicitis were diagnosed in early stage, with only 8.57% perforation and abscess rate, leading to post appendectomy complication rate of only 5.14% in our study (one wound infection and

one urinary retention). We could achieve low negative appendectomy rate of 7.14% in males and 11.11% in females and overall 8.11% in our study.

**Conclusion** Combined use of modified Alvarado score and high frequency USG not only reduces negative appendectomy rate but also reduces morbidity and postoperative complications.

**Keywords** Ultrasonography · Acute appendicitis · Alvarado scores

## Introduction

It has been over 100 years since Fitz presented his classic paper describing the clinical features of appendicitis and recommended early surgical removal of the inflamed appendix [1]. Appendicitis is notorious in its ability to simulate other conditions and in the frequency it can be mimicked by other pathologies.

Despite extraordinary advances in modern radiography imaging and diagnostic laboratory investigations the accurate preoperative diagnosis of acute appendicitis remains an enigmatic challenge. Overall, a negative appendectomy rate of approximately 20% is commonly reported [2–9]. Nowadays commonly used diagnostic aids for appendicitis are CECT abdomen, laparoscopy, diagnostic scores, USG. By using diagnostic aids for acute appendicitis, prolonged observation, negative appendectomy and incidence of perforation can be reduced dramatically resulting in decreased financial cost of the systems employed. But no test can reduce the rate of negative appendectomy to zero, hence some authors have recommended a combination of two or more investigations to increase accuracy even more.

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**Aim of study**

To evaluate combined use of modified Alvarado score and USG in decreasing negative appendicectomy rate.

**Materials and methods**

This study was carried out in Motilal Nehru Medical College and associated hospitals, during January 2003 to April 2004, on admitted patients of right lower quadrant pain suspected of appendicitis. Evaluation of patient was done by comprehensive history, clinicopathological examination, investigations and modified Alvarado score.

**Alvarado score (Table 1)**

This scoring system as described by Alvarado is based on three symptoms, three signs, two laboratory findings [10].

In this study we used slightly modified version of the Alvarado score by excluding one laboratory finding; shift to left of neutrophil maturation as this was not available from our laboratory on emergency basis, therefore, our patients were scored out of 9 rather 10 points.

The laboratory finding of leucocytosis is defined as Total Leucocyte count (TLC) to excess of  $10 \times 10^9$  per litre (used in our study to asses Alvarado score).

*Temperature* Oral temperature  $>37.3^\circ$  was considered positive.

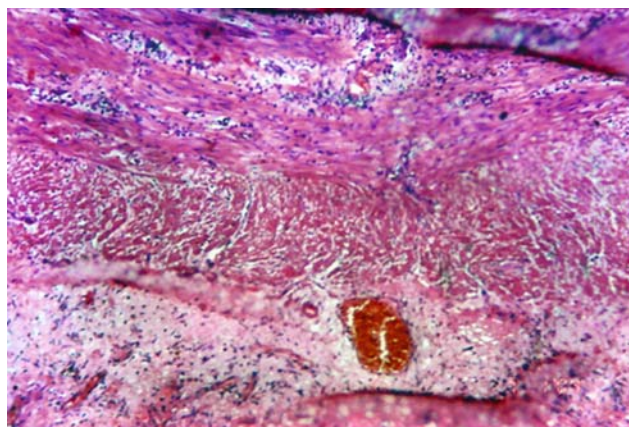
**Table 1** Alvarado score

		Score
Symptoms	Migratory Right Lower Quadrant (RLQ) pain	1
	Anorexia	1
	Nausea/vomiting	1
Signs	Tenderness RLQ	2
	Rebound tenderness	1
	Elevated temperature	1
Laboratory	Leucocytosis	2
	Shift to left	1
Total score		10

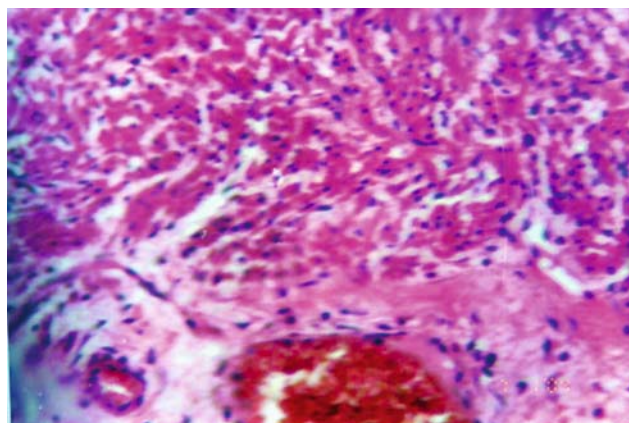
**Table 2** Plan of treatment

Modified Alvarado score	USG	Treatment plan
<7	Negative	Conservative
<7	Positive	Appendicectomy
$\geq 7$	Negative	Appendicectomy
$\geq 7$	Positive	Appendicectomy

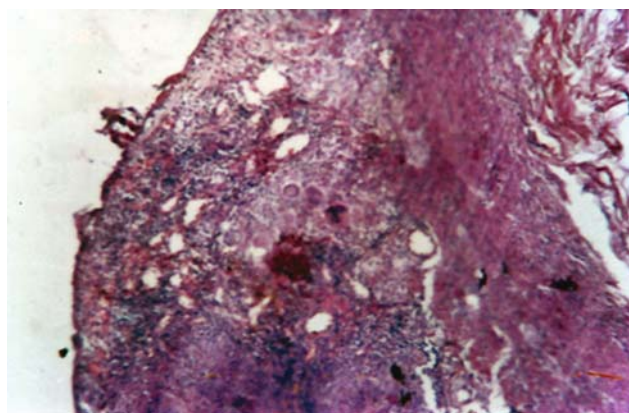
*Ultrasonography (USG):* USG of every patient was performed with 5 MHz or 7.5 MHz linear array transducer to diagnose appendicitis and with 3.5 MHz convex transducer to rule out any other abdominal pathology. USG



**Fig. 1** Histological section of acute appendicitis showing congestion and inflammation in muscularis propria Hematoxylin and Eosin stain (HE) ( $\times 100$ )



**Fig. 2** High power view of the above section showing neutrophilic infiltration in muscularis propria HE ( $\times 400$ )



**Fig. 3** One of our patient had tubercular appendicitis Histological section showing Langhans giant cells in lamina propria H.E ( $\times 100$ )

criteria for diagnosis of acute appendicitis was maximum diameter  $\geq 6$ mm, or wall thickness  $\geq 3$ mm, or increased periappendicular echogenicity (Fig. 5).

### Plan of treatment (Table 2)

Confirmation of diagnosis of acute appendicitis was done by histopathological examination of appendix in all operated cases ( Fig. 1,2,3,4).

### Discussion

Patients undergoing appendectomy on clinical judgement had a diagnostic accuracy of only 70–75%, negative appendectomy rate of 25% and 35–45% in males and females, respectively has been found in studies conducted by Jess et al. [6], Dunn et al. [7], Lewis et al. [5], Chang et al. [4], diagnostic accuracy much less than our study (92%), and negative appendectomy rate much more than our study, males 7.14% and in females 11.11% (Tables 3, 4a, 4b, 12).

**Table 3** Age-wise and male/female distribution of other pathologies presenting as acute appendicitis

Diagnosis	0–10		11–20		21–30		31–40		41–50		51–60		Total	
	M	F	M	F	M	F	M	F	M	F	M	F	No.	%
Acute mesenteric lymphadenitis			2		1	1							4	8
Abdominal tuberculosis	1			3									4	8
Ovarian cyst				1				1					2	4
Terminal ileitis			1			1							2	4
Tuboovarian mass (cause TB)				1									1	2
Meckel's diverticulitis							1						1	2
Acute cholecystitis						1							1	2
Total	1		3	5	1	3	1	1					15†	

†15 (15 out of total 50 patients admitted with suspected appendicitis)

**Table 4a** Result of our treatment plan

Sex	Modified Alvarado score $\geq 7$	USG Positive		Treatment plan		Confirmed appendicitis	
		No.	(%)	Conservative	Appendectomy	No.	(%)
Men	10	7	(70)	1†	9	9‡	(90)
Women	3	2	(66.67)	–	3	3	(100)
Children	2	2	(100)	–	2	2	(100)
Total	15	11	(73.3)				

†Patient managed conservatively due to appendicular lump and later on underwent interval appendectomy

‡One patient had Meckel's diverticulitis

**Table 4b** Results of our treatment plan

Sex	Modified Alvarado score $< 7$	USG positive		Treatment plan		Confirmed appendicitis	
		No.	(%)	Conservative	Appendectomy	No.	(%)
Men	19	16	(84.21)	2†	14‡	15+1#	(93.75)
Women	14	6	(42.86)	2†	4	5	(83.3)
Children	2	–	–	–	–	–	–
Total	35	22	(62.85)				

‡One negative appendectomy

#One appendicitis missed by USG with score  $< 7$ , explored due to rising pulse rate

†Interval appendectomy done later on

**Table 5** Sensitivity and specificity of our diagnostic approach in men

Diagnostic approach result	Diagnosis		Total
	Appendicitis	Not appendicitis	
Positive	(True positive) 24	(False positive) 2	26
Negative	(False negative) 1	(True negative) 2	3
Total	25	4	29

Sensitivity = 96%; Predictive value of positive test = 92.31%; Specificity = 50%; Predictive value of negative test = 66.67%; Accuracy = 89.66%

**Table 6** Sensitivity and specificity of our diagnostic approach in women

Diagnostic approach result	Diagnosis		Total
	Appendicitis	Not appendicitis	
Positive	(True positive) 8	(False positive) 1	9
Negative	(False negative) 0	(True negative) 8	8
Total	8	9	17

Sensitivity = 100%; Predictive value of positive test = 88.89%; Specificity = 88.89%; Predictive value of negative test = 100%; Accuracy = 94.12%  
Negative appendectomy rate = 11.11%

**Table 7.** Sensitivity and specificity of our diagnostic approach in children

Diagnostic Approach Result	Diagnosis		Total
	Appendicitis	Not Appendicitis	
Positive	(True positive) 2	(False positive) 0	2
Negative	(False negative) 0	(True negative) 2	2
Total	2	2	4

Sensitivity = 100%, Predictive value of positive test = 100%, Specificity = 100%,  
Predictive value of negative test = 100%, Accuracy = 100%  
But it is not significant as sample size is small (Only 4 children)

**Table 8** Overall sensitivity and specificity of our diagnostic approach

Diagnostic approach result	Diagnosis		Total
	Appendicitis	Not appendicitis	
Positive	(True positive) 34	(False positive) 3	37
Negative	(False negative) 1	(True negative) 12	13
Total	35	15	50

Sensitivity = 97.14%; Predictive value of positive test = 91.89%; Specificity = 80%; Predictive value of negative test = 92.31%; Accuracy = 92%

**Table 9** Sensitivity and specificity of USG

Diagnostic approach result	Diagnosis		Total
	Appendicitis	Not appendicitis	
USG positive	(True positive) 31	(False positive) 2	33
USG negative	(False negative) 4	(True negative) 13	17
Total	35	15	50

Negative appendectomy rate (false positive rate) = (2/33) 6.06%; False negative rate = (4/17) 23.53%; Sensitivity = 88.57%; Specificity = 86.67%;  
Predictive value of positive test = 93.94%; Predictive value of negative test = 76.47%; Accuracy = 88%

Clinical scoring systems devised by Teicher et al. [11], Alvarado [10], Lindberg and Fenyo [12], Ramirez and Dens [13], Galindo et al. [14] had sensitivity ranging from 48 to 77% while specificity of 73 to 87%, which is less than sensitivity of our diagnostic approach (97.14%) while specificity is nearly same (Tables 5, 6, 7, 8)

In 1992, Owen et al. [15] used Alvarado score prospectively and found negative appendectomy rate of 6% in men, 22% in women and 12% in children, with overall negative appendectomy rate of 12.6%. Kalan et al. [16] using modified version of Alvarado score found negative appendectomy of 14.6%, sensitivity of 93% in males and 67% in females. In a similar version of modified Alvarado score we had less negative appendectomy rate as well as less sensitivity, but our diagnostic approach has less negative appendectomy rate and more sensitivity (Tables 11, 12)

Studies conducted by using high frequency ultrasound in diagnosing appendicitis by Karstrup S et al. [17], Brooke et al. [18], Puylaert et al. [19], Yousef et al. [20], Schwerk et al. [21], David et al. [22], Wei-Ming kang et al. [23], Francois Vignault et al. [24], Riox [25], Crady et al. [26], John et al. [27] had sensitivity of 75–94%, specificity of 73–100%, predictive value of positive test 84–94.5%, predictive value of negative test 89–96.3% and accuracy of 76–95.7%. In all the above studies sensitivity is fairly less than our diagnostic approach (Table 8).

On comparing our diagnostic approach with our USG results (Table 10), our diagnostic approach is more sensitive (97.14%) and more accurate (92%). Though negative appendectomy rate of USG in our study is low i.e. 6.06%, but positive USG can not be a prerequisite for appendectomy as there is high false negative rate of 23.53% (Table 9). It can only complement clinical scores or

**Table 10** Results of modified Alvarado score

	Modified Alvarado score $\geq 7$	Confirmed appendicitis
Men	10 (FP, 10%)	9
Women	3	3
Children	2	2
Total	15	14
	Modified Alvarado score $< 7$	Confirmed appendicitis
Men	19	15 + 1† = 16
Women	14	5
Children	2	–
Total	50	35

†One case missed by even ultrasound (underwent exploratory laparotomy due to rising pulse rate)

**Table 11** Sensitivity and specificity of modified Alvarado score

Diagnostic test result	Diagnosis		Total
	Appendicitis	Not appendicitis	
Score $\geq 7$ positive	(True positive) 14	(False positive) 1	15
Score $< 7$ negative	(False negative) 21	(True negative) 14	35
Total	35	15	50

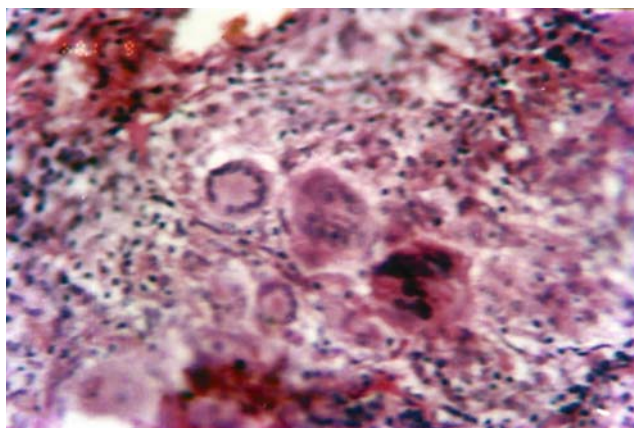
Negative appendectomy rate (false positive rate) = (1/15) 6.67%; Sensitivity = 40%; Specificity = 93.33%; Predictive value of positive test = 93.33%; Predictive value of negative test = 40%; Accuracy = 56%

**Table 12** Negative appendectomy rate of our diagnostic approach

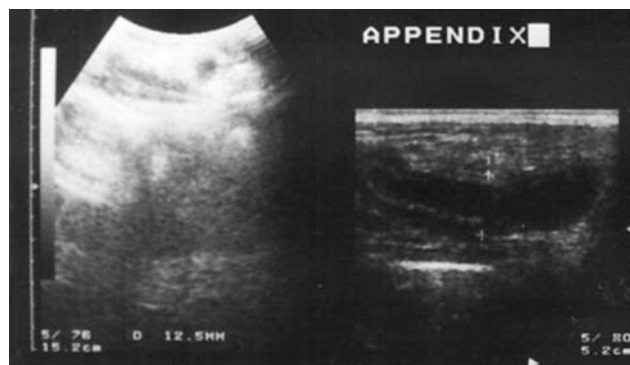
Appendectomy d/t our diagnostic approach	Appendicitis on H/P Examination		Negative Appendectomy	
	No.	%	No.	%
Male (28)	26	92.86	2	7.14
Female (9)	8	88.89	1	11.11
Total (37)	34	91.89	3	8.11

Overall negative appendectomy rate 8.11%





**Fig. 4** High power view of tubercular appendicitis showing Langhans giant cells in lamina propria HE ( $\times 400$ )



**Fig. 5** Ultrasound showing (left) dilated appendix with 3.5 MHz Probe, (right) dilated appendix of 12.5 mm diameter with 7.5 MHz probe

**Table 13** Pathological stages of acute appendicitis

Stage	Number	Percentage
Early acute appendicitis	30	85.71
Suppurative appendicitis	1	2.86
Gangrenous appendix	1	2.86
Perforated appendix	2	5.71
Abscess	1	2.86
Total	35	100

clinical judgement because in few cases inflamed appendix could not be visualised due to bowel gases or is missed due to inexperience of ultrasonologist, hence positive USG as pre-requisite for appendicectomy will increase perforation rate leading to increased morbidity and mortality.

## Conclusion

In spite of low negative appendicectomy rate, which prevented many negative laparotomies and its complications, combined use of modified Alvarado score and USG, in decision making for appendicectomy, has high sensitivity and accuracy, so that patients can be diagnosed in early acute appendicitis stage (Table 13), decreasing morbidity and postoperative complications.

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