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The diagnostic accuracy of three scoring systems in the diagnosis of acute appendicitis in the Egyptian population

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Abstract
Background: Acute appendicitis is a common but elusive surgical condition and remains a diagnostic dilemma. It may simulate other conditions and diagnosis is usually made on clinical grounds, leading to the evolution of scoring systems for more accurate diagnosis. The Alvarado, RIPASA, and Lintula scoring systems are three important scoring systems, for diagnosis of acute appendicitis.
Patients and Methods: A prospective study on 320 patients presented with right lower abdominal pain. The diagnostic accuracy of Alvarado, RIPASA, and Lintula scores in diagnosing acute appendicitis was compared. A score of 7 is the optimal cut off threshold for Alvarado, 7.5 for RIPASA, and 21 for Lintula scoring system. Sensitivity, specificity, accuracy, positive predictive and negative values were done.
Results: The sensitivity, specificity, and accuracy of Alvarado score were 90.3%, 47%, and 83.4%, respectively. The sensitivity, specificity, and accuracy of RIPASA score were 95.9%, 33.3%, and 85.9%, respectively. The sensitivity, specificity, and accuracy of Lintula score were 97.8%, 84.3%, and 95.6%, respectively. The positive predictive value for Alvarado was 90% and negative predictive value was 48%. The positive predictive value of RIPASA was 88.4% and negative predictive value 39.3%. The positive predictive value for Lintula was 97% and negative predictive value was 87.8%. Lintula score correctly classified 95.6% of all patients confirmed with histological acute appendicitis to the high probability group (Lintula score greater than 21), compared with 85.9% with RIPASA score (RIPASA score greater than 7.5), and with 83.4% with Alvarado score (Alvarado score greater than 7.0; p-value is 0.001).
Conclusion: Lintula scoring system is the most convenient, accurate and specific scoring system for Egyptian population suffering from acute appendicitis followed by RIPASA scoring system and lastly Alvarado scoring system.

Keywords: Acute Appendicitis, Lintula, RIPASA, Alvarado

1. Introduction

Acute Appendicitis is considered to be one of the most common surgical diseases worldwide with life time incidence of approximately 15% [1]. The diagnosis is mainly clinical, and as regard to investigations only contrast enhanced CT (computed tomography) has the highest sensitivity and specificity for the proper diagnosis [2]. High cost and limited availability are major factors that hinder its routine use especially in the developing countries. There has been a need of suitable scoring system that can overcome these obstacles with acceptable sensitivity, specificity and negative appendectomy rate.

Typical symptoms, signs, and suggestive laboratory data are not present in 20- 30% of acute right lower abdominal pain patients in whom acute appendicitis is the primary diagnosis [3]. Delayed diagnosis may lead to perforation, periappendicular abscess, wound infection, and intra-abdominal adhesions. It has been believed that the most effective method to avoid these complications was to widen surgical indications at the expense of an increased cases of negative appendectomy (up to 40%) [4]. The drawbacks of this approach are increased hospital bed utilization, loss of productivity, and higher treatment costs. The Alvarado (Table 1), RIPASA (Table 2), and Lintula (Table 3) scoring tools were developed in an attempt to assist surgeons in distinguishing acute appendicitis in the differential diagnosis of acute abdominal pain, with the aim of decreasing negative appendectomies [5].

Acute abdominal pain cases with a total score of ≤3 on the Alvarado, ≤5 on the RIPASA, and ≤15 on the Lintula scales have a lower likelihood of acute appendicitis and thus needs no hospitalization. Patients with scores of ≥7, ≥7.5, and ≥21, respectively, have a higher likelihood of acute appendicitis requiring urgent appendectomy. Patients with Alvarado scores between 4 and 6, RIPASA scores between 6-7, and Lintula scores between 16 and 20 are suspected cases for acute appendicitis; close inpatient follow-up is recommended for this group [6].

The use of the leucocytic count in the diagnosis of acute appendicitis is subject to several limitations. First, patients with abdominal pain often first ask care from primary care provider or clinic where laboratory resources may not available. From the patient perspective, venipuncture for blood picture causes pain, distress, as well as anxiety [7]. In addition, the time required for completion of total and differential leucocytic count may increase time to diagnosis and early surgical interference. Also, these routine tests may lead to increased health care costs. Finally, the overall reported sensitivities and specificities of the total and differential leucocytic count range from 60 to 100 % and 20–50 % respectively [8]. Given the previous mentioned limitations of the total and differential leucocytic count for the diagnosis of

appendicitis, scores depending exclusively on clinical manifestations may be more beneficial.

A prospective study was constructed to determine how charges would have changed if the Alvarado, RIPASA, and Lintula appendicitis scoring systems had been used in patients presented with manifestations suggestive appendicitis. A secondary objective of the study was to determine the diagnostic accuracy of the Alvarado, RIPASA, and Lintula scoring systems.

Patients and Methods

Study population included 320 patients presented with manifestations suggesting appendicitis in the period from December 2013 to December 2016. Patients were diagnosed as having acute appendicitis depending on clinical findings by senior single surgeon and operated upon. Strict guidelines of management were applied to all patients. Patients below fourteen years and those above sixty years were not included in the study. Pregnancy, history of urolithiasis, pelvic inflammatory disease, and mass in the right iliac fossa were also exclusion criteria. Also, patients who underwent elective, interval, or incidental appendectomy were excluded.

Demographic data from every patient were collected and evaluated, and total and diff. leukocytic count done for all cases. Abdomino-pelvic ultrasound performed for selected patients. The standard operating technique for appendectomy with McBurney's incision and primary closure was followed. All appendectomy specimens were evaluated by experienced histopathologist. All the 320 patients were scored as per Alvarado, RIPASA, and Lintula scoring systems. Alvarado score contained 8 parameters, RIPASA score contained 18 parameters, whereas Lintula score contained 9 parameters. The score for the parameters ranged from 1 to 2 for Alvarado, 0.5 to 2 for RIPASA, and 2-7 for Lintula as shown in (Table 1).

Scoring charts were fulfilled by the surgeon after admission. A score of 7, 7.5, and 21 for Alvarado, RIPASA, and Lintula scoring systems respectively was considered as high probability of acute appendicitis. Decision of surgery was based on clinical judgment plus findings of laboratory and radiological investigation. Alvarado, RIPASA, and Lintula scores were only done for the study purpose. All patients were monitored after admission, surgery and till hospital discharge. Follow up included monitoring of vital parameters two times per day, and systemic and local examination once per day till discharge. Histopathology of the operated cases was correlated with every score. From the 320 patients operated upon, 269 patients (84.1%) were positive for appendicitis in histopathological report and 51 patients (15.9%) were negative. The histological reports were collected and evaluated from all the study patients.

Different scores were compared by Chi-square test (SPSS windows version 20 was used). Comparison of data was done with Pearson chi-square and of interval data with t-test. P-value was considered statistical significance at < 0.05. Cut-off points determined sensitivity, specificity and accuracy. Positive, negative, and other predictive values were also detected.

Results

Of the total of 320 patients, 260 (81.25%) were <40 years of age and 60 (18.75%) were ≥40 years; the mean age was 25.44 years ranging from 14 to 60 years. Two hundred and eight patients (65%) were males and 112 (35%) were females. Right iliac fossa pain was present in 320 (100%) patients in the study group. Pain migration was present in 240 (75%). Anorexia was present in 288 patients (90%). Nausea and vomiting was present in 256 patients (80%). Fever was present in 194 patients (60.6%) and patients presenting with duration of symptoms <48 h were 224 (70 %).

Tenderness was present in 294 patients (91.9%) in the study group. Rebound tenderness was present in 179 patients (55.9%). Guarding was present 134 patients (41.9%) and Rovsing's sign was present in 102 patients (31.9%). Total leucocytic count was raised in 170 patients (53.1%) with shift to the left in 132 patients (41.3%). Urine analysis was normal in 298 patients (93.1%). Of all the symptoms right iliac fossa pain, anorexia, nausea and vomiting and duration of symptoms came out to be statistically significant with *p* value 0,001, 0.03, 0.01 and 0.03, respectively. Of all the signs only right iliac fossa tenderness came out to be highly statistically significant with *p* value 0.001.

The distribution of patients with individual scoring systems RIPASA, ALVARADO, and Lintula were shown in (Table 2). Of the total 320 patients, 269 (84.1%) were histopathologically positive and 51 (15.9%) were negative for appendicitis. Chi-square analysis of gender distribution between the groups was significant ($p=0.01$) with more male patients 25 (12%) in negative appendectomy group compared to 183 (88%) in the positive group in contrast to female patients 26 (23.2%) in negative appendectomy group compared to 86 (76.8%) in the positive group. Other statistically significant findings between the groups using t-test were higher values for the true appendectomy group regarding pre-operative symptom duration (hours) 26.2 ± 4.6 ($p < 0.01$), admission body temperature 37.8°C ($p=0.01$) and Lintula score 21.2 ± 3 ($p < 0.01$).

At optimal cutoff threshold of ≥ 7.5, the sensitivity and specificity of the RIPASA scoring system were 95.9% and 33.3% respectively. At optimal cutoff threshold of ≥ 7 the sensitivity and specificity of the Alvarado scoring system were 90.3% and 47% respectively. Similarly, at optimal cutoff threshold of ≥ 21 the sensitivity and specificity of the Lintula scoring system were 97.8% and 84.3% respectively. The positive predictive value and negative predictive value of RIPASA score was 88.4% and 39.3% respectively. The positive predictive value and negative predictive value of Alvarado score is 90% and 48% respectively. The positive predictive value and negative predictive value of Lintula score is 97% and 87.8% respectively. The overall accuracy of RIPASA, Alvarado, and Lintula scoring systems was 85.9%, 83.4%, and 95.6% respectively. The detailed statistical values of the three scoring systems is summarized in Table 3.

Table 1: The RIPASA, Alvarado, and Lintula appendicitis scoring systems [5].

		RIPASA Score	ALVARADO Score	LINTULA Score
Patient's Demographic				
Gender	Female	0.5		
	Male	1.0		2
Age	Age < 39.9 yrs	1.0		
	Age > 40 yrs	0.5		
Symptoms				
RLQ pain		0.5		2
Pain migration to RLQ		0.5	1	4
Anorexia		1.0	1	
Nausea and Vomiting		1.0	1	2
Duration	< 48 hrs	1.0		
	> 48 hrs	0.5		
Signs				
Fever > 37 ºC <39 ºC		1.0	1	3
RIF Tenderness		1.0	2	4
Guarding		2.0		4
Rebound Tenderness		1.0	1	7
Rovsing's Sign		2.0		
Abnormal Bowel Sounds				4
Investigations				
Raised WBC		1.0	2	
Shift of WBC to left			1	
Negative urine analysis		1.0		
Additional Scores				
Foreign NRIC		1.0		
Total		14.5 - 16	10	32

RIF, Right iliac fossa; RLQ, Right Lower Quadrant; NRIC, National Registration Identity Card

Table 2: The distribution of patients with individual scoring systems RIPASA, ALVARADO, and Lintula

Ripasa		Alvarado		Lintula	
Score	**No. (%)**	**Score**	**No. (%)**	**Score**	**No. (%)**
< 5	8 (2.5%)	< 5	11 (3.4%)	< 15	6 (1.9%)
5 - < 7.5	20 (6.25%)	5 - < 7	39 (12.2%)	15 - < 21	43 (13.4%)
≥ 7.5	292 (91.25%)	≥ 7	270 (84.4%)	≥ 21	271 (84.7%)
Total	320 (100%)	Total	320 (100%)	Total	320 (100%)

Table 3: Statistical values of Alvarado, RIPASA, and Lintula scores.

	Alvarado	RIPASA	Lintula
Sensitivity	90.3%	95.%	97.8%
Specificity	47%	33.3%	84.3%
Accuracy	83.4%	85.9%	95.6%
Positive predictive value	90%	88.4%	97%
Negative predictive value	48%	39.3%	87.8%
False positive rate	52.9%	66.7%	18.7%
False negative rate	9.7%	4%	2.2%
False discovery rate	10%	11.6%	3%
False omission rate	52%	39.3%	12.2%
Prevalence	84.1%	84.1%	84.1%
Positive likelihood ratio	1.75	1.44	5.23
Negative likelihood ratio	0.21	0.12	0.03
Diagnostic odds ratio	8.33	12	174.33

Discussion

The diagnosis of acute appendicitis is predominantly depends on clinical grounds [9]. Few cases can be managed conservatively but most of them have to be operated upon. The risk of appendectomy in emergency is 12% and 23% in men and women, respectively [10]. Modern medical practice and surgical techniques reduced the overall risk but complications still high for certain subgroups e.g. extremes of age, diabetics, and immuno-compromised patients [11]. Unnecessary appendectomies are associated with increased morbidity and cost ineffective. Mortality complicating acute appendicitis has been brought down to <1% with modern surgical practice [12].

Removal of a healthy appendix has been associated with greater risk of abdominal adhesions, as compared to acute appendicitis, and puts a healthy patient at risk for operative morbidity. Although hematological parameters such as leucocytic count and serum C-reactive protein can assist in more confident diagnosis, both are non-specific and can be raised in a variety of inflammatory and infective conditions. Radiological tools utilized to aid in acute appendicitis diagnosis including abdominal ultrasound, computed tomography (CT) and magnetic resonance imaging (MRI) have cost issues, require experienced personnel and are not available 24 hours a day in the majority of hospitals. Additionally, none of them is confirmatory [13]. Various scoring systems have been developed to aid in the accuracy of acute appendicitis diagnosis and decrease negative appendectomy rates. The Alvarado, RIPASA, and Lintula are the three most common used scoring systems in the Western populations [14].

Acute appendicitis is a common problem, it is difficult to diagnose particularly among the extremes of age and females of reproductive age where genitourinary and gynecological

conditions can represent itself with manifestations that are similar to those of acute appendicitis [15]. A delay in performing appendectomy to improve its diagnostic accuracy increases the rate of appendicitis complications (perforation and peritonitis), which in turn increases morbidity and mortality.

The opposite is also true, where with reduced diagnostic accuracy, the negative or unnecessary appendectomy rate is increased, and this is generally reported to be approximately 20-40% [16]. Several authors considered higher negative appendectomy rates acceptable in order to minimize the incidence of perforation [13, 17]. Diagnostic accuracy can be improved through the use of abdominal ultrasonography or computed tomography. However, such routine practice increase the cost of health care substantially. A recent study has suggested that such indiscriminate use of CT imaging may lead to diagnosis of early low-grade appendicitis with subsequent unnecessary appendectomies which would simply resolved spontaneously by antibiotics therapy [18]. Hence, scoring system were derived in order to increase accuracy of acute appendicitis diagnosis.

Alvarado scoring system is one of the most popular scores. It had a very good sensitivity, specificity, and accuracy when applied to western population [19, 20]. When this scoring system applied to oriental populations, it showed relatively less sensitivity, specificity, and accuracy to diagnose acute appendicitis [21, 22]. So, a new scoring system was developed (the RIPASA scoring system) which is more extensive yet simple consisting of 17 fixed parameters and an additional variable (National Registration Identity Card-NRIC) that is unique to Asian population. These scoring systems were evaluated on the Egyptian population and proved to be highly sensitive and specific [23-25].

The Lintula score was developed by Hannu Lintula and colleagues in Turku, Finland in 2009. It is a user friendly system and can be easily applied. It is used in the adult population with good precision and over-all accuracy. Using the Lintula cut-off point of ≤ 21, negative unnecessary admissions, appendectomies, and healthcare costs can be reduced [26]. Alvarado scoring system is widely used and accepted because of its high sensitivity and specificity in the western population [27]. RIPASA score developed by adding other variables (demographic, symptoms, signs and laboratory results) [28].

In Sinnet *et al.* [29] study, Alvarado scoring system recorded sensitivity and specificity of 65.17% and 90.0% for the diagnosis of acute appendicitis. In Ohle *et al.* [30], and Samad *et al.* [31] studies, Alvarado scoring system had a sensitivity and specificity of 53-88% and 75-80% respectively. In the present study, Alvarado scoring system had a sensitivity and specificity of 90.3% and 47% respectively.

Abdeldaim *et al.* [32], estimated positive and negative predictive values of Alvarado score to be 96 and 92% respectively. The positive predictive value of Alvarado score in the diagnosis of appendicitis was 96.67% and negative predictive value was 36.73% in Sinnet *et al.* study [29]. In the present study Alvarado scoring system had a positive and negative predictive values of 90% and 48% respectively. Overall, the diagnostic accuracy of Alvarado score in Sinnet *et al.* study was 69.73% [29]. In the present study Alvarado scoring system had a diagnostic accuracy of 83.4%.

RIPASA score in Sinnet *et al.* study had a sensitivity of 95.51% and a specificity of 65.0% [29]. The RIPASA score has been shown to achieve better sensitivity (88%) and specificity (67%) than Alvarado score which had a sensitivity of 59% and specificity of 23% in Asian populations [33].

In Malik *et al.* study [13], RIPASA demonstrated a sensitivity that is comparable with Khalil and Chong *et al.* retrospective studies (both with a sensitivity 88%, specificity 67% and diagnostic accuracy of 81%) [34, 35], although not as accurate as Chong *et al.*'s prospective study (sensitivity 97.47% and specificity 81.82%) [36].

In Singala *et al.* study [37], RIPASA scoring system demonstrated sensitivity, specificity, accuracy, positive predictive, and negative predictive values of 95.6%, 80%, 81%, 97.7%, and 66.7% respectively. In the present study, RIPASA scoring system demonstrated sensitivity, specificity, accuracy, positive predictive, and negative predictive values of 95.9%, 33.3%, 85.9%, 88.4%, and 39.3% respectively.

Various studies have demonstrated sensitivity and specificity of the Lintula score as; 83.9% and 96.4% [38], 100% and 88% [5], 100% and 98% [6], 87.8% and 87.2% [39], 100%, and 88.4% [40] respectively. In the present study, these came out to be 97.8% and 84.3% respectively. Lintula *et al.* and Konan *et al.* stressed that the criterion used for true appendicitis should be ≥ 21 and to rule one out completely, it should be ≤ 15 [5, 39]. In the present study, these criteria were found to be the same i.e. 21 as the optimum criterion for diagnosis as true appendicitis.

The predictive values of the Lintula score (positive and negative) for the optimal cutoff point as determined by various researchers varied as 92.9% and 91.4% by Kirkil *et al.* [38], 83% and 100% by Lintula *et al.* [5], 98% and 86% by Lintula and Kokki *et al.* [6], 87.2% and 87.8% by Konan *et al.* [39], 97.3% and 100% by Rafiq *et al.* [40] respectively. In the present study, the positive and negative predictive values were 97% and 87.8% respectively.

The overall accuracy of the Lintula score as reported in the above mentioned studies were; 91.9% by Kirkil *et al.* [38], 92% by Lintula *et al.* [5], 92% by Lintula and Kokki *et al.* [6], 87.5% by Konan *et al.* [39], and 90.4% by Rafiq *et al.* [40] respectively. In the present study it was 95.6%. The present study was focused on using the Lintula for reducing negative appendectomies among patients with a diagnosis of acute appendicitis, which explains this higher value.

The present work compared sensitivity and specificity between Alvarado, RIPASA, and Lintula scoring systems. Sensitivity or true positive rate is the proportion of actual positives which is correctly identified that is the percentage of sick people who are correctly identified as having the condition. Specificity or true negative rate is the proportion of negatives which are correctly identified that is the percentage of healthy people who are correctly identified as not having the condition [41].

The Lintula score recorded the best results, while RIPASA score was considerably better than Alvarado score in correctly diagnosing acute appendicitis. The Lintula, RIPASA, and Alvarado scores correctly diagnosed 97.8%, 95.9%, and 90.3% of patients who actually had acute appendicitis respectively. The Lintula, RIPASA, and Alvarado scores correctly diagnosed 84.3%, 33.3%, and 47% of patients who actually have not acute appendicitis respectively. The Lintula, RIPASA, and Alvarado scores recorded accuracy rate of 95.6%, 85.9%, and 83.4% respectively.

The difference in diagnostic accuracy between Lintula, RIPASA, and Alvarado scores was statistically significant ($p<0.001$), indicating that Lintula score is a much better diagnostic score for the diagnosis of acute appendicitis. The difference in diagnostic accuracy between RIPASA, and Alvarado scores was statistically insignificant.

The Lintula score is a useful tool for diagnosis of acute appendicitis, as it contains simple parameters that include history and clinical examination. Thus, the operating surgeon can make a quick decision upon seeing patients with right iliac fossa pain, by Lintula scoring system with a score > 21 to be operated, while patients with a score < 15 can discharged, and patients with a score > 15 and <21 can either be observed in the unit's day ward or discharged with an early clinic review appointment. Unnecessary and expensive radiological investigations can be avoided by using Lintula score and thus reducing health care expenditure.

Conclusion

The Lintula score has high sensitivity, specificity, positive and negative predictive values and overall accuracy. Use of the Lintula score in the diagnosis of acute appendicitis in the adult population increases clinical accuracy and reduces the negative appendectomy rate. This results in a decrease in unnecessary admissions, the healthcare burden and cost and increases the overall efficiency of emergency surgical services.

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