Comparison between the validity of the 'Modified Alvarado' and 'Raja Isteri Pengiran Anak Saleha' scores for the diagnosis of acute appendicitis

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Background

Clinical scores were designed to improve the diagnostic accuracy (DA) of acute appendicitis. However, their results vary when applied in different populations. This study aimed to compare the validity of the Modified Alvarado Score (MAS) with the Raja Isteri Pengiran Anak Saleha (RIPASA) score for diagnosing acute appendicitis in adult Saudi population.

Materials and methods

This study followed a prospective study design. It was carried out in Aseer Central Hospital, Abha, Saudi Arabia, during the period from November 2014 to May 2015. The study included 60 (aged >13 years) patients who were admitted in the Emergency Department and were clinically diagnosed as having acute appendicitis. Both the MAS and the RIPASA score were applied. A cutoff value for positive MAS was more than or equal to 7, and it was of at least 7.5 for positive RIPASA score. Surgical team members were blinded to the results of both scores. Operative findings describing the appendix, postoperative complications, hospital stay, and final diagnosis by histopathology were recorded.

Results

The study included 60 patients. There were 17 (28.3%) male and 43 (71.7%) female patients, with a mean age of 23.3±9.7 years. Negative appendectomy rate was 13.3%. The mean duration of hospital stay was 2.39±1.67 days. The MAS showed poor sensitivity (59.6%), poor DA (63.3%), and good specificity (87.5%). Compared with the MAS, the RIPASA score showed better sensitivity (96.2%) and DA (85.0%) when applied to our patients.

Conclusion

Neither the RIPASA score nor the MAS seems ideal for the accurate diagnosis of acute appendicitis when applied to patients in the southern region of Saudi Arabia.

Keywords:

acute appendicitis, appendectomy, diagnostic techniques, Modified Alvarado Score, Raja Isteri Pengiran Anak Saleha

Introduction

Acute appendicitis is the most common cause of acute abdomen in young adults. Appendicitis is sufficiently common and appendectomy is the most frequently performed abdominal operation [1]. The incidence of appendicitis is 1.5–1.9/1000, and it is ∼1.4 times greater in men than in women [2]. Accurate identification of patients who require immediate surgery as opposed to those who will benefit from active observation is not always easy [3].

The definitive diagnosis of acute appendicitis is only possible with histopathology results after appendectomy. However, the decision to perform surgery is based solely on clinical evaluation supported by laboratory data. Therefore, diagnostic errors are common, resulting in a median incidence of perforation of 20% and a negative laparotomy rate ranging from 2 to 30% [4].

Ultrasonography and computed tomography (CT) scan are used nowadays to decrease the incidence of negative laparotomies. Nevertheless, ultrasonography cannot replace clinical evaluation, as false-negative rates of up to 24% have been reported [5]. In addition, nonavailability of ultrasonography or CT scan in many medical institutes constitutes a main obstacle that forces many surgeons to depend on clinical evaluation even in difficult cases.

In order to reduce the negative appendectomy rates, various scoring systems have been developed for supporting the diagnosis of acute appendicitis [6].

The Alvarado scoring system is one of them and is purely based on history, clinical examination, and laboratory tests [7]. The classic Alvarado score included left shift of neutrophil maturation yielding a total score of 10. However, in 1994, Kalan *et al.* [8] omitted this parameter and produced a modified score. The Modified Alvarado Score (MAS) has comparable sensitivity and specificity to the classic Alvarado score and is easier to apply [9]. Differences in sensitivities and specificities were observed if the scores were applied to various populations and clinical settings, usually with worse yield when applied outside the population in which they were originally created [3].

In 2010, a group in Raja Isteri Pengiran Anak Saleha (RIPASA) Hospital, in Brunei, developed a new scoring system called the RIPASA score [10] and claimed that it was more suitable for Asian and Middle Eastern populations compared with the classic Alvarado and the MAS system that were created for European population.

Therefore, the aim of our study was to compare the validity of the MAS with the RIPASA score for diagnosing acute appendicitis in adult Saudi population in Aseer region (southwestern part of Saudi Arabia) in terms of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy (DA).

Patients and methods

This study followed a prospective study design that was carried out in Aseer Central Hospital, a tertiary care hospital in Abha, Saudi Arabia, during the period from November 2014 to May 2015. The study included patients above 13 years of age admitted in the Emergency Department with complains of acute abdomen who were clinically diagnosed as having acute appendicitis. Patients below 13 years of age were treated by the pediatrics' team according to the policy of our hospital and were excluded from the study.

The sample size was calculated according to Dahiru *et al.* [11] to be 60 patients (with $Z_\alpha = 1.96$, expected prevalence of correctly diagnosed cases of appendicitis is 85%, and accepted error of 0.09).

Diagnosis and decision to operate were made by general surgical team members who were not involved in this research and their decision was based totally on clinical judgment supported by investigations. The research team met the patients and recorded the data required once clinical diagnosis of appendicitis was made. If a patient was placed under observation, the scores were recorded on admission and every 6 h, and only cases that eventually underwent appendectomy were included in the study and their last recorded data were used.

Preoperative workup

All patients included in the study were subjected to history taking and clinical examination. Investigations were reported. Informed consent for the operation and for participation in the research was obtained from all patients. Both the MAS and RIPASA scores were applied by the research team (Tables 1 and 2). A cutoff value for positive MAS was at least 7 [9], whereas the cutoff for positive RIPASA score was at least 7.5 [10]. The surgical team members were blinded to both scores to avoid influencing their clinical decision.

Table 1 Modified Alvarado Score

Items	Score
Symptoms	
Migration of pain to the right lower quadrant	1
Anorexia	1
Nausea/vomiting	1
Signs	
Tenderness in the right iliac fossa	2
Rebound tenderness in the right iliac fossa	1
Elevated temperature (>37.3°C)	1
Investigations (leukocytosis) (>10 000/ml)	2

Table 2 Raja Isteri Pengiran Anak Saleha scores

Items	Score
Demographic data	
Male	1.0
Female	0.5
Age <39.9 years	1.0
Age ≥40 years	0.5
Symptoms	
RIF pain	0.5
Migration of RQP	0.5
Anorexia	1.0
Nausea/vomiting	1.0
Duration of symptoms <48 h	1.0
Duration of symptoms >48 h	0.5
Signs	
RIF tenderness	1.0
RIF guarding	2.0
Rebound tenderness	1.0
Rovsing's sign	2.0
Fever >37–<39	1.0
Investigations	
Raised WBCs	1.0
Negative urinalysis	1.0
Additional scores	
Foreign ID	1.0

RQP, right quadrant pain; RIF, right iliac fossa; WBCs, white blood cells.

Operative workup

The operative findings describing the appendix were recorded (normal, inflamed, or perforated).

Postoperative workup

Postoperative complications (if any) in addition to hospital stay and final diagnosis by histopathology were recorded by the researchers.

Outcomes

Primary endpoint

The primary endpoint was the comparison between the validity (sensitivity, specificity, PPV, NPV, and DA) of the MAS and the RIPASA score in accurately diagnosing acute appendicitis.

Secondary endpoint

The secondary endpoint was determination of the effect of patients' age and sex on the validity parameters for the MAS and the RIPASA score in accurately diagnosing acute appendicitis.

The statistical analysis of the data was performed to determine the validity of both the MAS and the RIPASA score using the statistical package for the social sciences (SPSS, version 22). To test significance of differences, the independent sample t-test was applied for quantitative data, whereas the χ^2-test was applied for qualitative data (the Fisher exact test was used when appropriate). A statistically significant P-value was considered at P less than 0.05.

Number of trial registry ACTRN12614001043628 (http://www.ANZCTR.org.au/ACTRN1261400104 3628.aspx).

Results

The study included 60 [17 (28.3%) male and 43 (71.7%) female] patients who underwent appendectomy. The mean age of the patients was 23.3±9.7 (range: 14–62 years) years. Fifty-two (86.7%) patients were diagnosed immediately after clinical examination with or without radiological investigation. However, eight (13.3%) patients were placed under observation and the decision of operation was taken after a mean time of 17.43 h. Two of the eight patients who were placed under active observation were found by means of postoperative histopathology to have normal appendices. However, the MAS and the RIPASA score indicated false-positive results for both of them.

Postoperative histopathology was carried out for all 60 patients and revealed that 52 (86.7%) patients had acute appendicitis with variable degrees of inflammation, whereas eight (13.3%) patients did not have acute appendicitis. Details of histopathological findings are shown in Table 3.

The mean duration of hospital stay was 2.39±1.67 (range: 1–12 days) days. Four (6.7%) patients developed superficial wound infection in the form of erythema and serous discharge and were treated successfully with conservative measures. One (1.7%) patient developed localized pelvic collection and required ultrasound-guided drainage. One (1.7%) patient developed adhesive intestinal obstruction 5 months after surgery. Conservative measures were not successful to relieve his condition and laparoscopic adhesiolysis was performed.

Sensitivity, specificity, PPV, NPV, and DA were calculated [12] for the MAS and the RIPASA score for all patients (Table 4). Moreover, the same were calculated for young (≤30 years), old (>30 years), male, and female patients separately to determine the effect of age and sex on the accuracy of diagnosis of both scores (Table 4).

Analysis of the components of each score was performed to determine the possible positive or negative influences of each component on the corresponding score (Table 5).

Discussion

Although acute appendicitis is the most common emergency condition that requires surgical intervention [1], accurate diagnosis of acute appendicitis is a challenge all over the world. Accurate diagnosis of acute appendicitis is important to avoid missing cases of acute appendicitis resulting in further complications such as perforated appendix that may lead to an avoidable poor outcome. In addition, accurate diagnosis prevents operating negative cases, during which a patient is subjected unnecessarily to 10% risk for morbidity and mortality in addition to exhaustion of the resources of healthcare [13]. Until now, neither clinical nor laboratory investigations could provide 100% accuracy in

Table 3 Histopathology of excised appendices (n=60)

Findings	n (%)
Inflamed appendix	52 (86.7)
Acute uncomplicated appendicitis	31 (51.7)
Acute gangrenous appendicitis	16 (26.7)
Perforated appendix	5 (8.3)
Noninflamed	8 (13.3)
Carcinoid	1 (1.7)
Normal (ovarian cyst detected intraoperatively)	3 (5.0)
Normal	4 (6.7)

Table 4 Validity of the Modified Alvarado Score and the Raja Isteri Pengiran Anak Saleha score

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Diagnostic accuracy (%)
Modified Alvarado Score (all patients) (*n*=60)	59.6	87.5	96.9	25.0	63.3
RIPASA (all patients) (*n*=60)	96.2	12.5	87.7	33.3	85.0
Modified Alvarado Score					
Young (≤30 years) (*n*=52)	54.4	83.3	96.2	19.2	57.7
Old (>30 years) (*n*=8)	100.0	100.0	100.0	100.0	100.0
RIPASA					
Young (≤30 years) (*n*=52)	95.7	16.7	89.8	33.3	86.6
Old (>30 years) (*n*=8)	100.0	0.0	75.0	–	75
Modified Alvarado Score					
Male (*n*=17)	58.8	–	100	0	58.8
Female (*n*=43)	60.0	87.5	95.5	33.3	65.1
RIPASA					
Male (*n*=17)	100.0	–	100.0	–	100.0
Female (*n*=43)	94.3	12.5	82.5	33.3	79.1

RIPASA, Raja Isteri Pengiran Anak Saleha.

Table 5 Analysis of the components of both scores

Item	Negative component		Positive component		P value
	Nonappendicitis	Appendicitis	Nonappendicitis	Appendicitis	
MAS					
Migration of pain	7 (11.7)	15 (25.0)	1 (1.7)	37 (61.7)	0.001[*]
Anorexia	1 (1.7)	5 (8.3)	7 (11.7)	47 (78.3)	0.800
Nausea and vomiting	0 (0)	5 (8.3)	8 (13.3)	47 (78.3)	0.360
Tenderness RIF	0 (0)	0 (0)	8 (13.3)	52 (86.7)	–
Rebound tenderness RIF	1 (1.7)	2 (3.3)	7 (11.7)	50 (83.3)	0.296
Elevated temperature (>37.3°C)	5 (8.3)	7 (11.7)	3 (5.0)	45 (75.0)	0.006[*]
Leukocytosis	6 (10.0)	10 (16.7)	2 (3.3)	42 (70.0)	0.003[*]
RIPASA					
Sex					
Male	0	0	0	17	0.193
Female	1	2	7	33	
Age	18.0±0.0	22.0±0.0	24.7±6.4	23.3±10.4	0.928
Right IF pain	0 (0)	0 (0)	8 (13.3)	52 (86.7)	–
Migration of pain	7 (11.7)	15 (25.0)	1 (1.7)	37 (61.7)	0.001[*]
Anorexia	1 (1.7)	5 (8.3)	7 (11.7)	47 (78.3)	0.800
Nausea and vomiting	0 (0)	5 (8.3)	8 (13.3)	47 (78.3)	0.360
Duration of symptoms	0	26	8	26	0.008[*]
RIF tenderness	0 (0)	0 (0)	8 (13.3)	52 (86.7)	–
RIF guarding	6 (10.0)	33 (55.0)	2 (3.3)	19 (31.7)	0.524
Rebound tenderness	1 (1.7)	2 (3.3)	7 (11.7)	50 (83.3)	0.296
Rovsing's sign	5 (8.3)	30 (50.0)	3 (5.0)	22 (36.7)	0.797
Fever 37–39	4 (6.7)	5 (8.3)	3 (5.0)	47 (78.3)	0.008[*]
Leukocytosis	6 (10.0)	10 (16.7)	2 (3.3)	42 (70.0)	0.003[*]
Negative urinalysis	3 (5.0)	11 (18.3)	5 (8.3)	41 (68.3)	0.309
Foreign ID	7 (11.7)	49 (81.7)	1 (1.7)	3 (5.0)	0.477

Values are presented as mean±SD and *n* (%). IF, iliac fossa; MAS, Modified Alvarado Score; RIF, right iliac fossa; RIPASA, Raja Isteri Pengiran Anak Saleha. [*]Significant.

diagnosis. However, trials have been made to improve the DA in many centers of the world [6,7,10].

In our study, we had a negative appendectomy rate of 13.3%. Similar results were reported in the literature, with a negative appendectomy rate of 21% [14], 15.6% [15], and 15% [3]. It was proved in some studies that radiological modalities such as CT imaging further aid

in making a definite diagnosis and have been reported to have high sensitivity (94%) and specificity (95%) for diagnosing acute appendicitis [16]. However, such practice could not be standardized because of nonavailability of the CT facility in many medical institutes. It is also very costly and could not be implemented in poor countries. Furthermore, arrangement for CT scan may delay emergency

appendectomy. In addition, recent reports have suggested that the indiscriminate use of CT scan may lead to the detection of early low-grade appendicitis and these patients may then be subjected to unnecessary appendectomy, in a condition that would otherwise have resolved spontaneously with antibiotic therapy [17]. A population-based study in the USA indicated that there was essentially no change in the frequency of negative appendicectomy using CT scan for all patients with query appendicitis [18]. In our hospital, a selective approach is applied by requesting CT scan for doubtful cases only and not for all patients. The effect of CT scan in improving the DA is beyond the scope of our study.

Diagnosis of acute appendicitis with nonclassic presentations represents a real challenge even for expert doctors. Junior doctors are the first ones to encounter patients of acute appendicitis in emergency departments; therefore, the idea of creating scoring systems to aid in the accurate diagnosis of acute appendicitis was good and theoretically helpful. The MAS system has been applied since 1994 to aid the clinical decision-making process in achieving an accurate diagnosis of acute appendicitis both efficiently and effectively [8]. However, the MAS was originally developed among western populations, and when applied in different communities, such as the Middle East and Asia, the sensitivity and specificity levels achieved were very low [15,19]. Accordingly, a new scoring system called the RIPASA score was developed and proved to be more extensive and avoided the theoretical mistakes of the MAS by considering demographic data such as age and sex in its components [19]. In a retrospective study, the RIPASA score has been shown to achieve better sensitivity (88%) and specificity (67%) compared with the Alvarado score (sensitivity 59% and specificity 23%) in an Asian population [10].

We agree with Horzić *et al.* [3] that any rigid scoring system that does not respect different significances of defined signs and symptoms within different subpopulations and geographical settings will not be as effective when applied to the entire population in the emergency department. In the literature, no studies were found to determine as to which of the most common scores, the MAS and the RIPASA score, will have a better DA when applied to our population in the southern region of Saudi Arabia. Therefore, in this study, we applied both scores to all patients who were subjected to appendectomy to determine their DA compared with the absolute evidence of accurate diagnosis, by histopathology. We followed a cutoff value for positive MAS to be

more than or equal to 7, whereas a cutoff for positive RIPASA score to be more than or equal to 7.5, as most of the studies showed better diagnostic parameters on these cutoff values [9,10,20]. When applied to our patients, the MAS showed poor sensitivity, poor DA, and good specificity (with a sensitivity of 59.6%, specificity of 87.5%, PPV of 96.9%, NPV of 25.0%, and DA of 63.3%). Similar poor results of the MAS were found in other studies that applied the score for non-European populations [10,15,19,21]. However, the RIPASA score showed better sensitivity and DA when applied to our patients compared with the MAS (with a sensitivity of 96.2%, specificity of 12.5%, PPV of 87.7%, NPV of 33.3%, and DA of 85.0%) but with evident very poor specificity. Both scores had good positive and bad NPV s. Our study showed female predominance, with 71.7% of female patients compared with 28.3% of male patients. A similar finding was reported by some authors in the middle east [22]. This is in disagreement with other studies in Africa that showed male predominance [23,24]. This may highlight the importance of considering the racial differences that affect presentation of different diseases. Both the MAS and the RIPASA score showed excellent PPV for diagnosing male patients compared with female patients. However, this may be influenced by the fact that all male patients included in the study showed positive histopathology results for appendicitis. The RIPASA score showed better DA compared with the MAS for both male and female patients, but with outstanding DA for male patients (100.0%). This may be attributed to the fact that female patients with right iliac fossa pain have a wide range of differential diagnosis, as a result of which acute appendicitis may be overdiagnosed. On analyzing the effect of age on both scores, the RIPASA score showed better sensitivity and DA for young people (≤30 years). However, the MAS showed 100% DA for older patients (>30 years) compared with 75% in the RIPASA score. From the previous results, we can find that the MAS is better for diagnosing patients older than 30 years, whereas the RIPASA score is better in diagnosing male patients.

Analysis of components of both scores showed that elevated temperature and leukocytosis have a significant positive influence. Ignoring demographic data of patients may have a negative influence on the MAS as described above. Surprisingly, migration of pain was found to have a significant negative influence in both scores. Moreover, duration of symptoms was found to have a significant negative influence on the

RIPASA score. This may be related to the patients' ability to describe their symptoms, which may necessitate the correlation of these negative results to the level of education of these patients.

Conclusion

We can conclude that neither the RIPASA score nor the MAS seems ideal for accurate diagnosis of acute appendicitis when applied to patients in the southern region of Saudi Arabia. If we consider that operating a negative appendicitis is less harmful compared with missing a positive one, the RIPASA score would be more suitable for our patients compared with the MAS. However, a future larger detailed study for all demographic and clinical data investigations, in addition to level of education may be required to determine factors that correlate significantly with the accurate diagnosis of our population.

Conflicts of interest
There are no conflicts of interest.

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