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ORIGINAL ARTICLE

The Alvarado Score is accurate in pregnancy: a retrospective case–control study

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Abstract

Background Acute appendicitis is the most frequent abdominal condition that requires non-obstetric surgical intervention during pregnancy. This study aims to scan pregnant patients operated on for acute appendicitis to evaluate the efficiency of using the Alvarado Score (AS) for diagnosis.

Methods Our study included 48 pregnant patients who were pre-diagnosed with acute appendicitis and operated on at our department of general surgery from January 2010 to July 2016 and whose files were accessed. Fifty-three non-pregnant female patients of reproductive age who were operated on for appendicitis during the same period were included in the study as the control group. The patients in both groups were divided into two groups based on their AS total score being 7 and ≥ 7.

Results The mean age of the 48 pregnant patients was 28 (19–42) years, while the mean age of the 53 control patients was 31 (18–45) years. Among pregnant and non-pregnant women, about a third of patients had an AS < 7 (16 of 48 versus 18 of 53). There was no significant difference when the AS scores of both groups were compared ($p = 0.947$). Using pathology results as reference test, the sensitivity and specificity of the AS in pregnant women was 79 and 80%.

Conclusions As a result, when the data collected by our study are evaluated, we see that pregnancy does not have a negative effect on the efficacy of AS. Therefore, the AS system can be an easy, non-invasive auxiliary diagnostic tool with high diagnosis accuracy rates that can be used in pregnant patients suspected of having acute appendicitis.

Keywords Pregnancy · Alvarado score · Acute appendicitis

Introduction

Acute appendicitis is the most common reason for acute abdominal surgery seen in the 15–40 age group in all communities and sexes; if it occurs during pregnancy, non-obstetrical surgery is required [1, 2]. It is easier to diagnose patients with a history of typical acute appendicitis. Furthermore, 20–33% of patients have atypical clinical and laboratory findings [3]. The clinical findings of acute appendicitis seen during pregnancy are generally atypical, and pregnancy makes it more difficult to make a diagnosis. The anatomical and physiological changes that occur during pregnancy change both the clinical symptoms and the physical examination findings of the clinical table that requires surgical intervention. These problems experienced in the diagnosis and treatment phase can lead to an increase in both maternal and fetal morbidity and mortality [4].

The patient's history, physical examination findings, laboratory results, imaging, and various scoring methods can be used to diagnose acute appendicitis [5]. The Alvarado Score (AS) system is one of the most common scoring methods used for the diagnosis of acute appendicitis. This scoring system evaluates the patient's anamnesis, examination findings, and lab results to come up with a total score (Table 1)

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Table 1 Components of Alvarado Score

Alvarado Score	Score
Migration of pain	1
Anorexia	1
Nausea	1
Tenderness in right lower quadrant	2
Rebound pain	1
Elevated temperature (> 37.3 °C)	1
Leukocytosis (> 10.000/mm^3)	2
Neutrophilia > 75%	1

[6]. While patients with an AS score from 7 to 10 are recommended to undergo an appendectomy, patients that score 5–6 are recommended to be evaluated using an additional method [7]. However, in previous studies, pregnant patients operated on for acute appendicitis were not assessed with the AS system.

The aim of our study is to scan pregnant patients operated on for acute appendicitis and evaluate the diagnostic efficiency of the AS system with the post-operative pathology results.

Materials and methods

Study design and population

Our retrospective case–control study included 48 pregnant patients who were pre-diagnosed with acute appendicitis and operated on at our department of general surgery from January 2010 to July 2016 and whose files were accessed. Fifty-three non-pregnant female patients of reproductive age who were operated on for appendicitis during the same period were included in the study as the control group. Demographic data, clinical and laboratory findings, imaging methods, average hospitalization time, post-operative complications, mortality, and pathology results were collected from the files. The AS scores of the patients in the pregnant and control group were calculated and compared with the pathology results. The patients in both groups were divided into two groups based on their AS total score being < 7 and ≥ 7. The study design was in accordance with the guidelines of the Declaration of Helsinki (second revision, 2008) and was approved by the local ethics committee.

Definition

The control group comprised female patients of reproductive age (15–49) [2]. The laboratory results were considered positive if the white blood cell count (WBC) value was > 10,000/mm^3, the neutrophilia percentage was > 75%, and the body temperature was > 37.3 °C [6]. The pregnancy week was calculated according to the date of the last menstruation. The patients were divided into three groups according to their week of pregnancy: first trimester (0–14 weeks), second trimester (15–28 weeks), and third trimester (29 weeks and after). Wound infection was diagnosed by the surgeon who had performed the operation. Erythema, induration and purulent effluent in the wound were considered positive for wound infection. All patients with suspected appendicitis in our clinic were performed ultrasonography (US). If diagnosis remained uncertain even after US, pregnant women received magnetic resonance imaging (MRI) and non-pregnant women underwent computed tomography (CT).

Statistical analysis

The statistical analysis was performed using SPSS 16.0 software (SPSS for Windows, Chicago, IL, USA). All data was presented in the form of mean and standard deviations. The Kolmogorov–Smirnov test was applied to analyze the distribution of the data. In the data determined to have normal distribution, the independent samples *t* test was used to analyze the differences between the quantitative parameters. Values with "p" lower than 0.05 were accepted as statistically significant.

Results

Preoperative factors

The mean age of the 48 pregnant patients is 28 (19–42) years, while the mean age of the 53 control patients was 31 (18–45) years. The mean weeks of pregnancy during the operation is 18.9 (4–33). There were 17 patients in their first trimester, 23 in their second trimester, and 8 in their third trimester. The most frequent parameter in the pregnant and control group was the location of the pain changed and leukocytosis. No statistical difference was observed in the mean WBC values of both groups ($p = 0.524$). The change of location of the pain, nausea/vomiting, and observation of rebound in the physical examination of the pregnant group was found to be significant compared to the control group ($p = 0.002$, $p < 0.001$, and $p = 0.039$, respectively). However, tenderness in the right lower quadrant was significantly less frequent ($p = 0.020$) among pregnant women (Table 2).

Among pregnant and non-pregnant women, about a third of patients had an AS < 7 (16 of 48 versus 18 of 53) (Table 3). The mean AS in pregnant patients was 6.9 (4–10), while the control group's was 6.6 (3–9). There was no significant difference when the AS scores of both groups were compared ($p = 0.947$). Using pathology results as reference

Table 2 Comparison of the clinical characteristics between the pregnant and control groups

Characteristics	Patients		
	Pregnant group ($n = 48$)	Control group ($n = 53$)	p value
Age	28.3 (19–42)	30.7 (18–45)	0.084
Gestational age	18.9 (4–33)		
Alvarado Score	6.9 (4–10)	6.6 (3–9)	0.947
Preoperative WBC (mm^3)	13.5 ± 1.8 ($n = 41$)	13.9 ± 1.9 ($n = 44$)	0.524
Migration of pain*	47 (97.9%)	41 (77.3%)	0.002
Anorexia	18 (37.5%)	26 (49.0%)	0.242
Nausea/vomiting	37 (77.1%)	22 (41.5%)	< 0.001
Tenderness in right lower quadrant	30 (62.5%)	44 (83.0%)	0.020
Rebound pain	39 (81.3%)	32 (60.3%)	0.039
Fever	12 (25.0%)	20 (37.7%)	0.169
Neutrophilia	78.9 (60–93)	75.2 (41–95)	0.054
Acute appendicitis	38 (79.1%)	45 (84.9%)	
Negative appendectomy	10 (20.8%)	8 (15.1%)	0.452
Perforated appendicitis	5 (10.4%)	2 (3.7%)	0.189
Wound infection	4 (8.3%)	3 (5.6%)	0.597

*Periumbilical to right inferior fossa

Table 3 Post-operation appendix histopathology examination results in pregnant and non-pregnant groups with Alvarado Score (< 7, ≥ 7)

Alvarado Score	Histopathology results		
	Acute appendicitis	Normal	Total
< 7	8	8	16
Pregnant			
Non-pregnant	12	6	18
Total	20	14	34
≥ 7	30	2	32
Pregnant			
Non-pregnant	33	2	35
Total	63	4	67

test, the sensitivity and specificity of the AS in pregnant women were 79 and 80%.

All of the patients included in the study were evaluated with US. MRI was utilized in 4 (8.3%) of the pregnant group because US did not clarified the diagnosis. CT was utilized in 11 (20.7%) patients in the control group.

Surgical approach

Eleven (22.9%) of the patients in the pregnant group were administered general anesthesia, while 37 (77.1%) were given regional anesthesia. Ten of the patients in the (18.8%) control group were administered general anesthesia, while 43 (81.2%) were given regional anesthesia. Patients treated with open surgery in both groups underwent appendectomy through a McBurney incision. Appendix perforations were observed in five (10.4%) patients in the pregnant group and two (3.7%) patients in the control group. No significant difference was observed in the two groups in terms of perforation ($p = 0.189$). A birth by a simultaneous C-section operation during an appendectomy was performed due to a patient in the pregnant group going into labor. Despite the five perforated appendicitis, there was no fetal or maternal death.

Post-operative findings

The pathology reports that 38 (79.1%) of the 48 pregnant patients who pre-diagnosed with and operated on for acute appendicitis were acute appendicitis. Thirty of these patients were from the AS ≥ 7 group, while eight of them were from the AS < 7 group. Ten (20.8%) of the patients in the pregnant group had normal pathology results. Eight of them were from the AS < 7 group, while two of them were from the AS ≥ 7 group. All of the patients with perforated appendicitis were in the AS ≥ 7 group. The

pathology results of 45 (85%) of the 53 patients in the control group were reported to be acute appendicitis. 33 of these were in the AS ≥ 7 group, while 12 of them were in the AS < 7 group. Six of the eight (15.1%) patients that had normal pathology results in the control group were in the AS < 7 group, while two of them were in the AS ≥ 7 group (Table 3). The AS was calculated to have 80.0% diagnostic specificity, 78.9% sensitivity, a 93.7% positive predictive value, a 21.0% negative predictive value, and a 79.1% accuracy rate for pregnant women (Table 4).

When the patients in the pregnant group were evaluated based on their trimesters, there were 17 (35.4%) patients in the first, 23 (48.0%) in the second, and 8 (16.6%) in the third trimester. The pathology of the 15 cases in the first trimester was acute appendicitis (three perforated appendices) and 2 were normal. 14 of the cases with acute appendicitis as the pathology result were in group AS ≥ 7, while 1 of them was in group AS < 7. The pathology of 17 patients in their second trimester was acute appendicitis (1 perforated appendicitis), while 6 of them were normal. 11 of the cases with acute appendicitis as the pathology result were in group AS ≥ 7, while 6 of them were in group AS < 7. The numbers of acute appendicitis cases (1 perforated appendicitis) and normal appendix cases were even. Three of the cases reported as acute appendicitis were in group AS ≥ 7, while 1 of them was in group AS < 7; 1 of the normal cases was in group AS ≥ 7, while 3 of them were in group AS < 7. Specificity and sensitivity of the groups according to the trimesters are presented in Table 4.

In our study, wound infections occurred in four (8.3%) patients of the pregnant group and three (5.6%) patients in the control group. The mean follow-up time of these patients was 7.4 (4–12) days. There was no statistically significant difference in wound infection between the two groups ($p = 0.597$).

Table 4 Value of Alvarado Score in acute appendicitis with pregnant (total and each trimester) and non-pregnant

Statistical results	Pregnant (%)				Non-pregnant (%)
	Trimester			Total	
	1	2	3		
Sensitivity	93	65	75	79	73
Specificity	50	83	75	80	75
Positive predictive value	93	92	75	94	94
Negative predictive value	7	35	75	21	13
Diagnostic accuracy	88	70	75	79	74

Discussion

Acute appendicitis is the most frequent abdominal condition that requires non-obstetric surgical intervention during pregnancy [1, 2]. Although it occurs frequently, there is no marker that presents a definite diagnosis [8]. Therefore, negative appendectomy and complicated appendicitis rates increase. The literature cites negative appendectomy rates ranging from 17.4 to 23% and appendix perforation rates ranging from 12 to 14.9% [9, 10]. In our study, the negative appendectomy rate was 20.8% and the perforation rate was 10.4% in the pregnant group, while the negative appendectomy rate was 15% and the perforated appendicitis rate was 3.7% in the non-pregnant group. Both parameters in the pregnant group were higher; however, the difference was not statistically significant.

Acute appendicitis in pregnant women is seen in approximately 1 out of 1700 cases and most commonly during the second trimester [11]. 23 (48.0%) of the 48 patients in our study were in their second trimester. The most common radiological method used in diagnosing acute appendicitis in pregnant women is US [10]. A study carried out by Lim et al. in a population of 45 pregnant women suspected of having appendicitis showed that US is a sensitive diagnostic method [12]. The use of CT is limited due to radiation. Recent studies have shown that MRI has high specificity and sensitivity in the diagnosis of appendicitis in pregnant women [11]. When needed, other scoring methods such as AS and laparoscopy can also be used for diagnosing [10].

Acute appendicitis is generally diagnosed clinically. The high number of gynecological pathologies that blend with acute appendicitis in female patients makes diagnosing difficult; when pregnancy is added (physiological and anatomical changes), this makes diagnosis even more difficult. This increases morbidity and mortality in pregnant women. Using more than one parameter in diagnosing acute appendicitis can further help in early and accurate diagnosing of the disease. AS, which makes an assessment based on symptoms, physical examination findings, and laboratory results, is commonly used to diagnose acute appendicitis in the literature [13, 14]. We also use this scoring system in addition to radiological examinations (US, MRI and CT) in our clinic.

When compared to non-pregnant patients with appendicitis, pregnant patients are known to have higher rates of appendix perforation. It is also claimed that there are higher maternal mortality and fetal morbidity rates in cases with appendix perforation [15, 16]. We are of the opinion that this could be caused by diagnostic difficulties due to the anatomical and physiological changes that occur during pregnancy. İn this study, appendix perforation was observed in five (10.4%) patients in the pregnant group and two (3.7%) patients in the control group ($p = 0.189$). Despite the five perforated appendices, there was no fetal or maternal death.

We believe that the absence of maternal–fetal mortality in our cases is associated with a small number of patients with perforated appendicitis.

A review of the literature shows that the negative appendectomy rate is significantly higher in pregnant than in non-pregnant women [16]. The negative appendectomy rate found in the present study (21%) compares favorably with the study by Ito et al., who noted a rate of 36% [16]. Still, there continues to be a need for more reliable diagnostic methods for this patient group [17]. The AS is frequently used to diagnose acute appendicitis in non-pregnant women. Many studies have reported AS sensitivity to be 54.0–96.2% and the specificity to be 54.0–74.3% [18, 19]. In our study, we evaluated the sensitivity and specificity of the AS in both groups as a result of the pathology of the patients who underwent surgery for appendicitis. We found that AS's sensitivity was 78.9% and specificity was 80.0% in pregnant patients and specificity was 75.0% and sensitivity was 73.3% in the control group. The average AS in pregnant patients was 6.9 (4–10) for pregnant patients and 6.6 (3–9) for the control group. There was no significant difference when the mean AS, sensitivity, and specificity of both groups were compared ($p = 0.947$).

The AS can be higher in pregnant women due to the WBC values being higher and the frequency of nausea and vomiting, especially during the first trimester. The pain localization in the right lower quadrant and the pain migration (periumbilical to right inferior fossa) might vary due to growth of the uterus, and therefore the AS can be lower in pregnant patients. Pain localization should be carried out with consideration of the change of location of the appendix, depending on the trimester. When we looked at the results of the second trimester in our study, we found that sensitivity of AS was less. We think that this could be caused by the anatomical and physiological changes that occur during pregnancy that develop after second trimester.

Our work has several limitations. These include a small sample size (especially third trimester), and the retrospective study design. Due to the retrospective design, we cannot rule out that clinical examination was performed or documented in better detail in pregnant as compared to non-pregnant women. Furthermore, only those women who underwent appendectomy were analyzed, who limit the generalizability of results. In a broader sample of females with right lower quadrant abdominal pain, the prevalence of appendicitis would be lower, which could lead to a lower positive predictive value and a higher negative predictive value of the AS. Another limitation is that the results are single-centered. Further studies, including multicenter studies, may be useful to determine the accuracy of Alvarado Score in pregnant woman with appendicitis.

As a result, when the data collected by our study are evaluated, we see that pregnancy does not have a negative effect on the efficacy of AS. However, the AS is an easy-to-apply, non-invasive auxiliary diagnostic tool with high diagnosis accuracy rates that can be used in pregnant patients suspected of having acute appendicitis.

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Compliance with ethical standards

Conflict of interest Faik Tatli, Yusuf Yucel, Orhan Gozeneli, Abuzer Dirican, Ali Uzunkoy, Hüseyin Cahit Yalçın, Abdullah Ozgonul, Osman Bardakci, Adnan İncebiyik declare that they have no conflict of interest. The authors have stated explicitly that there are no financial supports or relationships that may pose potential conflict of interest in this article. The authors received no financial support for this study.

Ethical approval We have the necessary ethical approval for this study by the local ethics committee.

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