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Are Appendix Weight and Length Related to Inflammatory Parameters and Alvarado Score in Acute Appendicitis?

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ABSTRACT

We aimed to investigate if appendix weight and length affects clinical presentation.
This study prospectively enrolled 50 patients who were operated with the diagnosis of acute appendicitis. The appendix material was weighed in milligram. Then, the diameter of the appendix was measured in millimeter from its widest point using a surgical ruler. The length of the appendix was measured in millimeter using the same ruler. As appendix length may have influenced its weight, weight in milligram per millimeter was used for standardization. The obtained value was expressed as the unit weight (mg/mm).
In order to make a comparison by the obtained unit weight, the patients were divided into two groups.
Among 50 patients enrolled in the present study, 24 (48%) were men and 26 (52%) were women. The mean CRP level of the study population was 29.4 (3-160). The mean appendix diameter measured with ultrasonography at the preoperative period was 8.49 mm (range 6-13 mm), and the mean appendix diameter measured with a ruler at the postoperative period was 10.3 mm (range 8-20 mm). There was approximately a 2 mm difference between these measurements which were made from the widest points.
In conclusion, it was found that the unit weight of the appendix increased proportionally to the CRP level. The appendix would be more edematous, have a greater diameter and weight, and be more likely to perforate in patients with a higher unit weight.

Keywords: Appendicitis, Weight, Length

Introduction

Acute appendicitis (AA) is primarily diagnosed by clinical assessment. In patients with AA diffuse right lower abdominal pain, vomiting, nausea, and loss of appetite are seen. However, these typical symptoms are absent in 40% of patients (1). AA affects 1.5-1.9 person per 100.000 population, and is 1.4 time more commonly seen in men. The lifetime risk of having AA is 7%, and the perforation rate ranges between 17% and 20% (2). Some laboratory parameters (WBC, CRP), radiological studies, and scoring systems are used for an accurate and early diagnosis of AA. Radiological evaluation is most commonly made by ultrasonography (USG) while Alvarado score is the most widely used scoring system (3). Ultrasonographically, the appendix is identified as a dead-end intestinal appendage originating from the cecum, which is free of peristaltic waves. Appendix diameter can be measured at maximum compression applied with a transducer. A diameter of 5 mm or less excludes the diagnosis of appendicitis (4). No study in the literature has yet investigated the effect of appendix weight and length on clinical presentation. We aimed to investigate if appendix weight and length affects clinical presentation.

Materials and Methods

This study prospectively enrolled 50 patients who were operated at Van Yüzüncü Yıl University, Faculty of Medicine, Department of General Surgery with the diagnosis of acute appendicitis between July 2019 and December 2019. It involved patients with a clinical presentation compatible with acute appendicitis, who were operated laparoscopically after having been detected to have an appendix diameter of at least 6 mm on urgent abdominal ultrasonography. Patients with perforated, gangrenous, or necrotic appendicitis; those who were operated with open laparotomy or whose operation was switched to open laparotomy; and pregnant patients with acute appendicitis were excluded. Pathology report was considered the gold standard for the diagnosis of acute appendicitis.

The mesoappendix of the specimen removed from the abdomen after appendectomy was dissected with

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Table 1. Alvarado Scoring System For Acute Appendicitis

Diagnosis	Score
Symptoms	
Pain migration to right iliac fossa	1
Anorexia	1
Nausea & vomiting	1
Signs	
Right iliac fossa tenderness	2
Rebound tenderness	1
Fever 1	
Laboratory	
Leukocytosis	2
Shift of the white blood cell count to the left	1
Total	10

Score: <4 unlikely probability, 4-7 suspected probability, >7 definite probability

sharp dissection and removed. Sutures or clips on it were also removed. The appendix material, now in a tubular form, was weighed in milligram using a Neck I-2000 model precision kitchen scale. (Figure 1a, 1b) Then, the diameter of the appendix was measured in millimeter from its widest point using a surgical ruler. The length of the tubular appendix was measured in millimeter using the same ruler.(Figure 1c)

The volume of a cylinder is calculated as πr^2x h. In the present study the number pi was approximated to 3; r:radius was measured in cm; h:height, i.e. appendix length, was measured in cm. A comparison of the calculated volume with the measured weight showed that 1 cm3 was equal to approximately 1 gr.

As appendix length may have influenced its weight, weight in milligram per millimeter was used for standardization. The obtained value was expressed as the unit weight (mg/mm). (Figure 1d) The mean unit weight of the whole patient population was 78 mg/mm. In order to make a comparison by the obtained unit weight, the patients were divided into two groups: Group 1 had a unit weight of ≥78 mg/mm (19 patients; 38%); Group 2 had a unit weight of <78 mg/mm (31 patients; 62%).

Both groups were compared with respect to age, sex, Alvarado score (5) (Table 1), WBC (white blood cell), neutrophil, CRP (C-reactive protein), and BMI (body mass index).

Statistical Analysis: The descriptive statistics included median, mean, standard deviation, minimum, maximum for continuous variables and number and percentage for the categorical variables. Comparison of the groups 'means with respect to continuous variables was performed using Independent samples T test. Correlation between study variables was tested with Pearson Correlation coefficient. Statistical significance level was set at 5%. All statistical analyses were performed using SPSS (ver.24) statistical software.

Results

Among 50 patients enrolled in the present study, 24 (48%) were men and 26 (52%) were women. The mean age of the study population was 31.6 (range 18-60) years. The mean age was 36.4 (range 21-60) years for Group 1 and 28.6 (range 18-60) years for Group 2.

A sex-based analysis showed that women had a mean unit weight of 79 mg/mm and men 77 mg/mm. Although women had a higher mean unit weight, the difference between the two sexes did not reach statistical significance (p=0.906).

The mean Body Mass Index of the study population was 24.2 kg/m2. The groups were compared for BMI. The mean BMI was 25.0 kg/m2 among 19 patients in Group 1 with a unit weight of ≥78 mg/mm while 31 patients in Group 2 with a unit weight of <78 mg/mm had a mean BMI of 23.7 kg/m2. The difference between the two BMI values was not statistically significant (p=0.350).

The mean WBC count of the study population was 13.0 x10³/uL (7.2-21.3 x10³/uL). Group 1 had a mean WBC count of 11.2 x10³/uL while Group 2 had a mean WBC count of 14.1 x10³/uL. Although the difference between the two groups was statistically significant (p:0.009), the patients with a low unit weight had a higher white blood cell count and those

Table 2. Descriptive Statistics

	Count	Median	Mean	Standard Deviation	Minimum	Maximum
Age	50	27.00	31.62	11.96	18.00	60.00
Weight (kg)	50	70.00	70.92	10.97	53.00	103.00
Lenght (cm)	50	169.50	169.96	7.72	150.00	186.00
BMI	50	23.98	24.21	4.68	6.21	36.49
Preop Appendix diamater (mm)	50	8.50	8.49	1.56	4.00	13.00
WBC	50	12.59	13.08	3.90	7.24	21.31
Neutrophil	50	8.85	9.70	3.80	3.78	18.93
CRP	50	13.75	29.47	36.69	3.00	160.00
ALVORADO	50	8.00	8.12	.75	6.00	9.00
Postop.Appendix weight (mg)	50	4895.00	5513.40	2956.93	1770.00	17400.00
Postop. Appendix lenght (mm)	50	65.00	72.22	23.16	31.00	135.00
Postop appendix diamater (mm)	50	10.00	10.31	2.35	6.00	20.00
Unit weight (mg/mm)	50	68.20	78.36	39.73	32.20	268.70

with a high unit weight had a lower WBC count. (Table 2)

The mean neutrophil count of the study population was 9.7 x10³/uL (3.7-18.9 x10³/uL). Group 1 had a mean Neutrophil count of 8.2 x10³/uL while Group 2 had a mean Neutrophil count of 10.5 x10³/uL. Although the difference was statistically significant (p:0.038), neutrophil count was higher in those with a low unit weight and lower in those with a high unit weight.

The mean CRP level of the study population was 29.4 (3-160). The mean CRP levels of Group 1 and Group 2 were 48.7 mg/dl and 17.6, respectively. The difference between the two was statistically significant (p:0.003). CRP was lower in patients with a low unit weight and higher in those with a high unit weight.

The mean Alvarado score of the study population was 8.1 (6-9). The mean Alvarado score of Group 1 was 8.3 while it was 8.0 in Group 2. The difference was not statistically significant. (p:0.148)

The mean appendix diameter measured with ultrasonography at the preoperative period was 8.49 mm (range 6-13 mm), and the mean appendix diameter measured with a ruler at the postoperative period was 10.3 mm (range 8-20 mm). There was approximately a 2 mm difference between these measurements which were made from the widest points. (Table 3)

Discussion

Acute appendicitis constitute approximately 2% of all emergency department admissions with abdominal pain (3). As the diagnosis of AA is based on a patient's signs and symptoms, it is considerably difficult to make in obese people, women, and the young (5). Moreover, making a decision to simply observe or operate a patient is a serious problem for a surgeon. A decision to proceed with early surgery may lead to removal of a normal appendix tissue as well as increased mortality and morbidity due to an unnecessary surgical procedure. On the other hand, diagnostic delay may also increase mortality and morbidity (6). Early diagnosis is not necessarily a simple task (7). Therefore, surgeons need to use a simple, easy-to-use, and reliable test to confirm acute appendicitis. (such as uit weight mg/mm).

Routine laboratory markers like CRP and WBC are not 100% specific and sensitive (8). Patients with normal WBC and CRP have a low likelihood of needing appendectomy and are either managed conservatively or undergo additional imaging studies to exclude appendicitis (9). This in turn may be used for unit weight calculation. Ultrasonography (USG) and Computerized Tomography (CT) are widely used to diagnose acute appendicitis. These imaging modalities are currently available at almost all hospitals.

There is no literature study on the measurement of the appendix. However, Tames et al. measured the diameter, length of the appendix, and the angle it

	Age	Gender	Weight (kg)	Lenght (cm)	Bmi	Appendix diameter measured with preop usg (cm)	Wbc	Neutrophil	Crp	Alvarodo Score	Postop. appendix weight(gram)	Postop. appendix length (cm)	Postop. appendix diameter (cm)	Unit weight (mg/mm)
1	45	M	83	170	28.7	0.9	13.7	8.5	3	8	3.03	5.5	1.0	55.0
2	24	M	87	176	28.0	0.95	15.8	12.9	3	9	3.24	4.7	1.1	68.9
3	31	M	82	173	27.3	1.0	14.7	12.1	93	8	5.24	6.5	1.0	80.6
4	27	F	59	167	21.2	0.9	8.1	4.7	3	6	4.83	7.0	1.2	69.0
5	55	F	103	168	36.4	0.8	10.0	7.1	10.3	9	4.05	7.0	1.4	57.8
6	60	M	95	183	28.3	1.0	7.2	3.7	10.4	7	6.08	9.0	1.2	67.5
7	56	F	80	164	29.7	0.84	9.4	7.4	160	9	5.61	6.1	0.9	91.9
8	27	F	64	169	22.4	0.75	16.8	13.0	13.5	8	2.25	4.2	0.8	53.5
9	24	F	57	167	20.4	0.8	21.3	18.9	3.02	8	3.92	6.1	1.0	64.2
10	22	F	60	163	22.5	0.75	16.3	12.5	39.1	8	3.0	7.5	0.8	40.0
11	32	M	70	173	23.3	1.3	10.0	8.2	3	9	6.44	6.0	1.1	107.3
12	20	M	61	167	21.8	0.9	19.5	14.1	3	7	4.82	6.3	1.0	76.50
13	32	F	58	170	20.1	0.83	12.7	10.7	26.5	9	5.62	5.5	1.1	102.1
14	19	F	64	168	22.7	0.73	11.2	6.7	18.9	7	5.07	6.5	0.9	78.0
15	38	M	80	170	27.7	0.83	9.9	5.2	44.6	8	2.21	5.2	0.9	42.5
16	24	M	75	172	25.3	1.0	10.7	7.9	7.3	8	5.39	7.6	1.3	70.9
17	20	F	59	155	24.5	0.7	18.4	7.2	3.0	7	3.43	4.7	0.8	72.9
18	25	M	67	175	21.8	0.9	16.1	12.7	14	8	2.27	4.5	1.0	50.4
19	31	F	66	166	23.95	1.1	12.4	9.8	15.6	9	3.15	6.0	1.0	52.5
20	27	M	62	171	21.2	0.9	20.0	15.9	3.02	8	4.42	8.0	1.0	55.2
21	25	M	73	174	21.1	0.8	14.8	11.0	3.02	9	17.40	10.0	2.0	174.0
22	24	F	68	163	25.5	0.8	10.3	6.8	68	8	14.78	5.5	1.1	268.7
23	28	F	71	160	27.7	1.1	11.2	9.8	7	8	1.77	3.1	1.0	57.0
24	18	M	70	172	23.6	0.9	17.5	13.8	48.9	8	6.1	11.0	0.8	55.4
25	20	M	70	183	20.9	0.76	20.9	18.2	3	9	4.37	7.0	0.9	62.4
26	24	M	84	186	24.2	0.85	13.4	10.0	15	8	6.44	11.0	0.8	58.5
27	31	M	72	180	22.2	0.85	14.3	10.5	77	9	6.55	13.5	1.0	48.5
28	23	F	53	165	19.5	1.0	16.5	14.0	3.02	8	4.68	8.7	1.1	53.7
29	22	M	82	180	25.3	0.85	10.3	6.3	17.9	7	4.47	8.0	0.8	55.8
30	21	F	55	157	22.3	0.83	12.0	7.7	3.02	8	3.19	6.3	0.8	50.6
31	24	F	63	162	24	0.8	14.4	12.1	9.46	9	4.68	12.0	0.8	39.0
32	24	F	73	168	25.8	0.5	13.9	8.9	5.45	8	2.47	7.0	0.6	35.2
33	21	M	77	181	23.5	0.95	11.4	8.2	24.6	7	3.87	12.0	1.1	32.2
34	21	F	59	167	21.1	0.4	8.4	4.0	3	7	8.67	9.0	0.8	96.3
35	27	F	64	163	24.0	0.85	8.7	5.9	28	8	4.38	9.0	1.0	48.6
36	31	F	62	185	18.1	0.78	7.4	4.1	10.1	7	6.0	6.0	1.0	100
37	52	F	78	167	27.9	0.92	7.9	6.2	88.8	8	6.21	11.0	0.9	56.4
38	60	F	66	150	29.3	1.2	11.3	8.0	102	8	9.43	10.0	0.9	94.3
39	39	M	75	174	24.7	0.73	19.4	16.7	10.6	8	3.9	6.0	1.4	65.0
40	21	M	57	180	17.5	0.86	13.5	11.1	14.2	9	2.43	3.5	0.9	69.4
41	29	F	85	165	31.2	0.9	16.9	14.4	3	9	4.96	9.0	1.5	55.1
42	45	F	83	172	28.0	0.73	11.1	8.7	11.5	8	7.0	7.0	1.5	100
43	38	M	74	168	26.2	0.86	8.2	5.6	63.5	9	6.0	6.0	1.2	100
44	36	F	67	164	29.9	0.6	9.5	6.8	68.3	8	4.37	5.3	0.8	82.4
45	34	M	83	173	27.7	0.74	8.1	6.2	123	9	8.8	8.0	1.0	110
46	59	F	84	160	32.8	0.82	9.41	4.21	33.5	8	8.0	5.5	1.1	145.4
47	47	M	74	179	23.0	1.0	18.8	14.0	8.01	9	8.52	8.0	1.2	106.5
48	46	F	73	165	26.8	0.9	13.5	10.9	98	9	5.37	6.0	1.0	89.5
49	24	M	60	175	19.5	0.72	10.2	8.4	28.3	8	10.6	9.0	1.0	117.7
50	28	E	59	173	19.7	0.85	15.1	11.8	17.2	8	6.19	5.4	0.9	114.6

Table 3. Results

formed with the caecum, using CT. They found a mean appendix length of 6.6 cm and a mean appendix diameter of 0.6 cm (10). In our study the mean postoperative appendix length was 7.2 cm. We also found a mean postoperative appendix diameter of 10.3 mm and a mean preoperative appendix diameter of 8.4 mm measured with USG. Routine radiological imaging is performed for cases presumed to be appendicitis. The length and the maximal diameter of the appendix can be measured using USG or CT. The volume of this cylindrical organ can be calculated and its unit weight can be determined. In a study by Ekici et al. the length and diameter ratio of the appendix were measured using the pathology reports of the appendectomy materials. According to that study, the rate of perforation significantly increased when the ratio of appendix length/diameter ratio was less than 10 (11). Similarly, another study measured the mean outer diameter of the appendix, which was found 10.2 for the phlegmonous group, 12.4 mm for the gangrenous group, and 12.4 mm for the perforated group. Accordingly, it can be suggested that the risk of perforation rises as the appendix diameter is increased (12).

Tanrıkulu et al. found a higher rate of perforation for long appendices and appendices with a wider stem diameter (13). Our study used the unit weight to standardize the appendix diameter and length.

Unit weight can be used to support the diagnosis of suspected cases and to pick up cases manageable by medical therapy. Additionally, it may be used to determine cases that are likely to perforate. As cases with a unit weight above 78 mg/mm may be likely to perforate, medical therapy should not be considered for such cases.

S. Mohammadi et al. from Iran measured the length, diameter, and weight of the appendix in 693 cadavers. They reported a mean appendix length of 8.5 cm, a mean appendix diameter of 1.2 cm, and a mean appendix weight of 6.4 gr (14). Those figures are higher than the mean values of our cases in the present study.

The diameter and length of the appendix can be measured in a convoluted appendix albeit it is difficult to do so. As the appendix is a tubular organ, the volume of a cylinder can be used to calculate appendix volume, in other words its weight (πr^2x h). Volume calculation for appendix showed that 1 cm3 volume was equal to 1 gr weight.

Özozan et al reported that a high CRP (C-reactive protein) level may be additively used to diagnose perforated appendicitis (15). Our study showed that unit weight and CRP were proportional to each other. As a result, patients with a unit weight of more than 78 mg/mm can be considered more likely to have perforated appendicitis. The same study also found that WBC was more sensitive in patients with a time from symptom onset of less than 24 hours whereas CRP had a greater sensitivity in patients with a time from symptom onset of greater than 24 hours (16). Unit weight being inversely proportional to WBC, neutrophil and proportional to CRP suggests that no substantial diameter and weight increase occur within the first 24 hours in acute appendicitis.

A study by Ahmed N, showed that a CRP level above 48 mg/dL considerably increased the perforation risk (17). Likewise, another study reported a sensitivity of 71.0% and a specificity of 100% for a cut-off value of 40.1 mg/dL of CRP to identify perforated appendicitis (18). In our study, the mean CRP level was 48.7 mg/dL in Group 1 with a unit weight greater than 78 mg/mm and 17.6 mg/dL in Group 2.

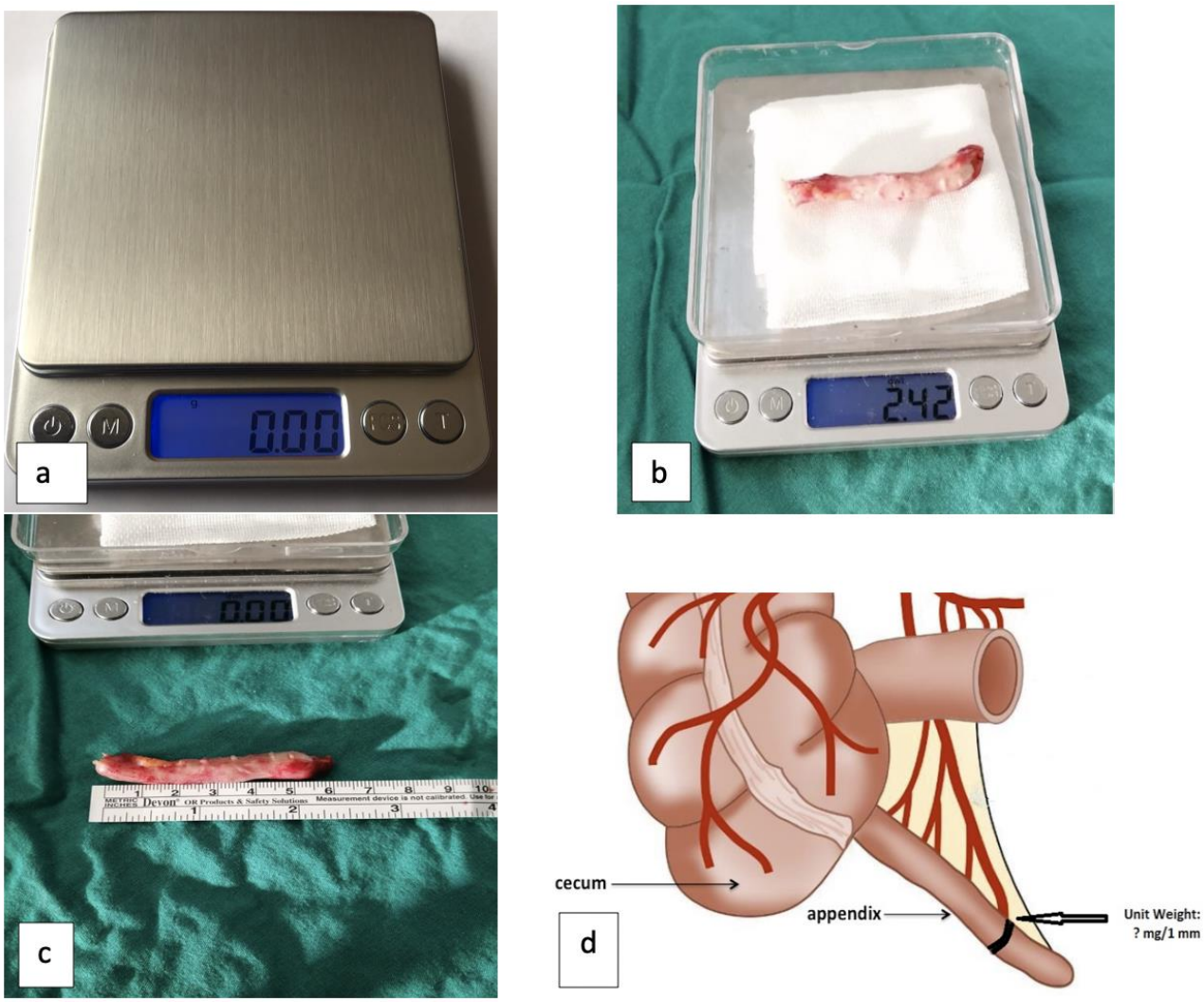
Gynecological conditions cause a high negative appendectomy rate difficulty in making the diagnosis of acute appendicitis in women (19). Our study revealed a mean unit weight of 79 mg/mm, and we believe that values above this cut-off value would lower the negative appendectomy rate.

Previous appendicitis operation has been linked to an increased risk of developing some diseases. It has been shown to increase the rate of developing chronic renal failure, diabetes progression, and the risk of lupus erythematosus in women (20). In another study appendectomy was listed among factors increasing the risk of developing inflammatory bowel diseases (21). It is beyond dispute that the appendix has an immunological role. Therefore, conservative treatment in acute appendicitis has become the main topic of debate.

Recent evidence has shown that cases with definite AA but without perforation can be treated conservatively (22). It is well known that antibiotic therapy alone is a safe first-line treatment strategy for uncomplicated acute appendicitis (15,23). The unit weight and cut-off values determined by this study can be used to identify such patients in the future. Medical therapy can be considered for patients with a low unit weight.

Furthermore, the appendix diameter measured ex-vivo at postoperative period was found 2 mm greater than that measured with ultrasonography at preoperative period.

In conclusion, it was found that the unit weight of the appendix increased proportionally to the CRP level. It is reasonable to conclude that the negative appendectomy rate would be lower and the appendix would be more edematous, have a greater diameter



a. Neck I-2000 model precision kitchen scale
b. Weight
c. Lenght
d. Unit weight

and weight, and be more likely to perforate in patients with a higher unit weight.

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