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Seasonal Pattern of Acute Appendicitis in Central Anatolia

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ABSTRACT

Objective: The most common cause of acute abdomen requiring surgical intervention globally is acute appendicitis (AA). In this study, we aimed to investigate how AA diagnosis is affected by seasonal changes in Central Anatolia.

Materials and Methods: In this study, patients who underwent appendectomy with the diagnosis of (AA) between January 1, 2015 and January 1,2019 were evaluated retrospectively. We divided the patients into three groups based on their histopathological results: Group 1 Acute Appendicitis (AA), Group 2 Appendix vermiformis (AV) and Group 3 Perforated appendicitis (PA). Patients were evaluated concerning age, sex and season of operation.

Results: Seven hundred ninety-five patients participated in our study. They were separated into the following groups: Group 1 (n=614), Group 2 (n=125), and Group 3 (n=56). Concerning the sex variable, no statistically significant differences were found between the groups (p=0.061). The mean age of the patients in the perforated appendicitis group was higher when compared to the other groups (p=0.001). When evaluated by season, it was seen that during winter, the patients in Group 1 were significantly higher than the patients in the other groups (p=0.009). In our study, acute appendicitis was most frequently diagnosed during winter (28.7%); appendix vermiformis was most frequently diagnosed during spring (32%) and perforated appendicitis was most frequently diagnosed during summer (41%).

Conclusion: Although the diagnosis of acute appendicitis varies seasonally, age and seasonal changes may be effective in the frequency of acute appendicitis. In Central Anatolia, the incidence of acute appendicitis increased during winter, while the rate of perforated appendicitis increased in summer and the rate of negative appendectomy increased in spring.

Keywords: Appendicitis, sex, seasonal distribution, age

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INTRODUCTION

The most common cause of acute abdomen requiring surgical intervention worldwide is acute appendicitis (AA). The lifetime risk for AA is defined as 7% (1). Surgical diagnosis and early treatment are important for the prevention of complications. The first appendectomy was performed by Sir Claudius Amy in 1736. AA can be defined simply as inflammation of the appendix vermiformis. The obstruction of the lumen is the most common cause of AA. Bacterial infection, fecaliths, nutrient residues, lymphoid growth and intestinal parasites may cause an obstruction of the lumen. It is usually seen in adolescents and young adults. AA incidence varies according to country, geographical region, race, sex, age, food culture and seasons (2).

Although AA is one of the common diseases requiring urgent surgery, its etiology has not been thoroughly explained yet. Various factors, such as genetic predisposition, various infections, vascular diseases, stress, and smoking, may induce AA. It has been observed in many studies that the incidence of AA is affected by age, sex and seasonal changes (3). However, the cause of these differences is not yet fully known. In the studies on etiology and risk factors, the annual seasonal pattern of appendicitis is interesting. Climatic factors may affect the incidence and prevalence of infections, and short-term air temperature affects inflammation markers in potentially susceptible individuals (3–5).

Many studies have reported that the incidence of AA is higher in the summer than in winter, throughout the world. The reason is that why AA cases are present more in the summer than in other seasons is not clear yet. In recent years, there has been research conducted on the relationship between climate factors and the incidence of acute appendicitis worldwide. As the presence of acute appendicitis is more likely to be seen in the summer months, direct relationships with factors, such as dietary changes, relative humidity, and travel, are suspected (6).

Although some authors have suggested that there may be a link with seasonal viral, bacterial and parasitic infections, the causes of this phenomenon are still uncertain. In a study conducted in two cities with different altitudes and climatic characteristics in Turkey, AA was more commonly seen in the summer season in the city with a lower

Table 1. Seasonal variation of the acute appendicitis

Measurements	Acute appendicitis (n=614)		Appendix vermiformis (n=125)		Perforated appendicitis (n=56)		p
	n	%	n	%	n	%	
Age, Mean±SD (Min.–Max.)	34.8±14.8 (18–87)		32.7±13.7 (18–85)		42.46±18.3 (19–85)		**0.001**
Sex							
Male	355	57.8	58	46.4	30	53.6	0.061
Female	259	42.2	67	53.6	26	46.4	
Season							
Winter	176	28.7	27	21.6	15	26.8	**0.009**
Spring	149	24.3	40	32.0	14	25.0	
Summer	145	23.6	33	26.4	23	41.1	
Autumn	144	23.5	25	20.0	4	7.1	
Age groups							
Between 18–39	431	70.2	90	72.0	29	51.8	**0.008**
Between 40–60	136	22.1	30	24.0	17	30.4	
61 and above	47	7.7	5	4.0	10	17.9	

Chi-square test was used to compare categorical variables. One-way ANOVA analysis of more than two variables was used to compare continues measurements by controlling distributions between groups. SD: Standard deviation; Min.: Minimum; Max.: Maximum

altitude and more commonly seen in the winter season in the city with a higher altitude (7).

Our aim with this study was to investigate how the incidence of AA in Anatolia is affected by seasonal changes.

MATERIALS and METHODS

After the study protocol was approved by the Ethics Committee of Erciyes University Faculty of Medicine dated 08.05.2019 and numbered 2019/299, 850 patients who were operated with the preliminary diagnosis of acute appendicitis in Erciyes University General Surgery Clinic between 1 January 2015 and 1 January 2019 were included in this study. Acute appendicitis was diagnosed by clinical history and imaging methods. Patients who underwent incidental appendectomy, patients under 18 years of age, patients with malignancy in their pathology, and patients whose records were not accessible were excluded from this study. A total of 795 patients were included in this study. A common database was created by examining patient files and hospital information system records. Patient data were evaluated retrospectively using this database.

We divided the patients into three groups based on their histopathological results: Group 1- Acute appendicitis (AA), Group 2 - Appendix vermiformis (AV), and Group 3 - Perforated appendicitis (PA). Similar to the description used in other studies in the literature, cases with neutrophil leukocyte infiltration in the lumen and wall of the appendix were evaluated as AA, and the cases with perforation were also separately noted. The cases without inflammation were evaluated as AV. We divided the patients into three groups based on their age: 18–40, 40–60, and over 60. The age and sex of the patients were examined in the seasonal groups, in which the operation was performed. In addition, sex distribution and age distribution in climates were examined in separate groups.

Kayseri, which is the city where our study takes place, is located in the Middle Kızılırmak section, where the southern part of Central Anatolia and the Toros Mountains approach each other. Kayseri is located between 37 degrees 45 minutes, and 38 degrees 18 minutes north latitudes, and 34 degrees 56 minutes, and 36 degrees 58 minutes east longitudes. The altitude of the city center is 1054 meters. There are many steppe climate characteristics in Kayseri. Summers are hot and dry; winters are cold and snowy. The weather data of the cities were obtained from the Turkish Government Meteorological Service (http://www.mgm.gov.tr/veridegerlendirme/il-ve-ilceler-ista-tistik.aspx). The seasons are defined according to the Northern Hemisphere, as; winter (December-February), spring (March-May), summer (June-August) and autumn (September-November).

We used IBM SPSS Statistics for Windows, version 24 (IBM Corp., Armonk, N.Y., USA) package program for the statistical analysis of the data. Categorical measurements were summarized as numbers and percentages, and continuous data as means and standard deviations (median and minimum-maximum where necessary). The chi-square test was used to compare categorical variables. We used the Shapiro-Wilk test normal distribution assumption for continuous variable. One-way ANOVA analysis of more than two variables was used to compare continuous measurements by controlling distributions between groups. The statistical significance level was taken as 0.05 in all tests.

RESULTS

795 patients participated in our study. They were separated into the following groups: Group 1 - Acute Appendicitis (AA) (n=614,

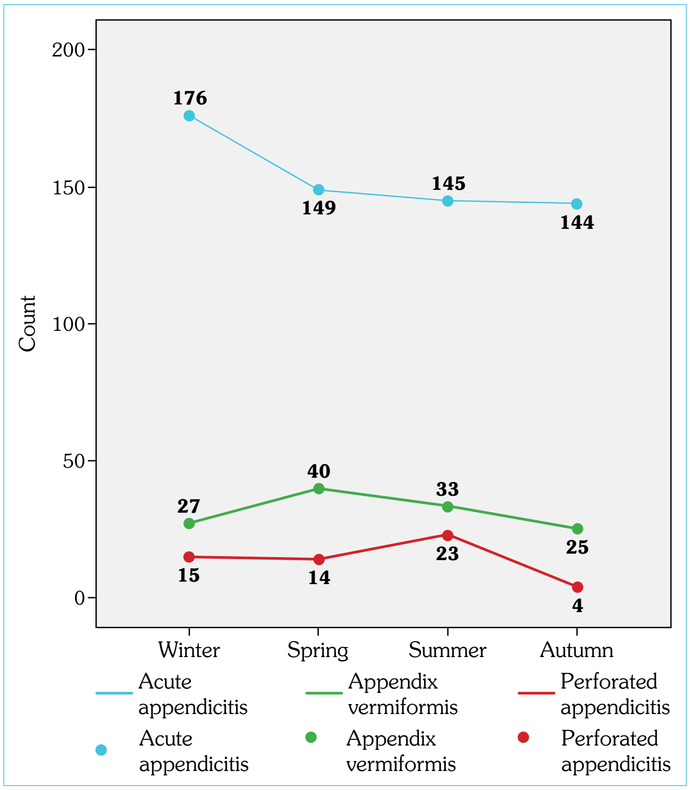

Figure 1. Distribution of appendectomy operation according to seasons

77.2%), Group 2 - Appendix Vermiformis (AV) (n=125, 15.7%) and Group 3 - Perforated appendicitis (PA) (n=56, 7.1%).

The mean age of the patients in the perforated appendicitis group was found to be higher than the mean age of the patients in acute appendicitis and appendix vermiformis groups, these differences were found to be statistically significant (p=0.001) (Table 1).

No statistically significant differences were found between the groups concerning the sex variable (p=0.061) (Table 1).

In the season group, it was found that there were more presentations in the winter months when compared to the spring, summer and autumn months (Table 1) (Fig.1).

In this context, it was determined that during winter, patients in the acute appendicitis group were significantly higher than the patients in the appendix vermiformis and the perforated appendicitis groups (p=0.009) (Table 1).

It was observed that patients aged between 18 and 39 years were diagnosed at a higher rate than the patients in other age groups. In the examination done in this context, patients between the ages of 18 and 39 years in the perforated appendicitis group were found to be significantly lower than those in the appendix vermiformis group and the acute appendicitis group (p=0.008) (Table 1).

When the sex variables of the patients in this study and the seasonal groups were compared, no statistically significant differences were found between the sex variable in the winter (p=0.364), spring (p=0.425), summer (p=0.581) and autumn (p=0.399) seasons (p>0.05) (Table 2).

When the season variable was compared with the mean age of the patients in the disease groups, participants in the winter season had a lower arithmetic mean age than those diagnosed in spring, summer and autumn seasons, and the differences found between them were statistically significant (p=0.001) (Table 2).

When the comparison of age groups and seasons with the disease groups were examined, no statistically significant differences were found between the age groups in the spring (p=0.691), summer (p=0.170) and autumn (p=0.326) seasons (Table 2). On the other hand, when significant differences concerning disease groups in the winter months were examined, patients between 18 and 39 years of age were diagnosed at a higher rate than other age groups and there were statistically significant differences between them (p=0.005) (Table 2).

DISCUSSION

The incidence of acute appendicitis shows significant changes based on age, sex, geographical region, country, race, socioeconomic status, hygiene, dietary habits, and seasons (8, 9). In our series, the highest incidence in all three groups was between the ages of 18–39. The sex distribution of our appendicitis cases was consistent with the results of previous studies, showing a significant male dominance (7). In our series, no statistically significant differences were found in the three groups between seasons, concerning sex distribution.

The general incidence of perforation is between 4-12% (10, 11). In our series, the rate of perforated appendicitis was 7.2%. The mean age in the perforated appendicitis group was found to be higher when compared to the other groups in all of the seasons. The incidence in males was higher in all three groups. We think that the increased incidence of perforation at an advanced age may be due to various factors, such as non-specific symptoms and laboratory findings, misdiagnosis or delayed diagnosis, delay in hospitalization, communication problems and socioeconomic factors. Delay in the diagnosis or delay in operation after diagnosis of appendicitis, especially in elderly patients, is typically associated with appendix rupture and peritonitis, which may lead to perforation within 48 hours if not treated (7, 12).

In our series, it was determined that the clinically given appendicitis preliminary diagnosis or diagnosis was confirmed histopathologically with a ratio of 84.7%. The rate of appendicitis vermiformis was 15.3%. The rate of negative appendectomy has been reported in the literature as between 4–15% (13, 14). The cause of high negative appendectomy rates is the fear of perforation and they have an inverse correlation (15). Worldwide, AV is reported as 9% in male patients and 19–47% in female patients (10, 15). Negative appendectomy rate is higher in female patients because of gynecologic causes, such as hemorrhagic corpus luteum, ovarian cyst, ovarian torsion, ruptured ectopic pregnancy mimic the clinical presentation of acute appendicitis. In our series, the negative appendectomy rate was found to be higher in female patients in accordance with the literature. In our series, the rate of a negative appendectomy was highest in spring, and we attributed this to lymphoid hyperplasia that arises from an allergic reaction due to pollen release.

Table 2. Case distribution of the age groups and sex in seasons

Measurements	Acute appendicitis (n=614)		Appendix vermiformis (n=125)		Perforated appendicitis (n=56)		p
	n	%	n	%	n	%	
Winter							
Male	113	64.2	14	51.9	8	53.3	0.364
Female	63	35.8	13	48.1	7	46.7	
Spring							
Male	87	58.4	19	47.5	7	50.0	0.425
Female	62	41.6	21	52.5	7	50.0	
Summer							
Male	71	49.0	14	42.4	13	56.5	0.581
Female	74	51.0	19	57.6	10	43.5	
Autumn							
Male	84	58.3	11	44.0	2	50.0	0.399
Female	60	41.7	14	56.0	2	50.0	
Season & Age							
Winter	33.1±13.7 (18–80)		31.3±11.7 (18–51)		46.7±20.5 (20–80)		**0.001**
Spring	35.5±14.5 (18–82)		36.4±17.7 (18–85)		41.9±16.9 (19–74)		
Summer	36.7±16.8 (18–87)		33.2±11.1 (20–56)		40.5±19.5 (19–85)		
Autumn	34.4±14.0 (18–77)		27.6±10.0 (18–53)		39.2±6.1 (33–45)		
Winter							
18–39	134	76.1	19	70.4	8	53.3	**0.005**
40–60	33	18.8	8	29.6	3	20.0	
61 and above	9	5.1	0	0.0	4	26.7	
Spring							
18–39	98	65.8	26	65.0	7	50.0	0.691
40–60	39	26.2	9	22.5	5	35.7	
61 and above	12	8.1	5	12.5	2	14.3	
Summer							
18–39	97	66.9	24	72.7	12	52.2	0.170
40–60	32	22.1	9	27.3	7	30.4	
61 and above	16	11.0	0	0.0	4	17.4	
Autumn							
18–39	102	70.8	21	84.0	2	50.0	0.326
40–60	32	22.2	4	16.0	2	50.0	
61 and above	10	6.9	0	0.0	0	0.0	

Chi-square test was used to compare categorical variables. One-way ANOVA analysis of more than two variables was used to compare continues measurements by controlling distributions between groups.

The frequency of high humidity and an association with a high rate of fecaliths is among the hypotheses that show seasonal variations in acute appendicitis. It is predicted that dehydration would increase due to increased humidity in summer and this would increase fecal stasis. Brummer et al. (16) found that there was a statistical relationship between the number of presentations of acute appendicitis and environmental humidity, but they did not find a relationship between temperature and acute appendicitis in the same study. Although fecal stasis plays an important part in the development of acute appendicitis, the city of our study had low humidity. We did not correlate the seasonal difference in our series with the humidity rate.

Ashley et al. (17) found in their study in Swansea (United Kingdom) that the incidence of acute appendicitis cases is high in the spring months of February-May, and found that this seasonal density may be due to some seasonal environmental factors, such as a non-specific virus infection, or an allergic reaction to pollen release.

A study of the Arabian Peninsula suggested that the increase in the incidence of acute appendicitis in the spring could be related to the onset of the sandstorm season in the Arabian Peninsula. Sandstorms are characterized by strong winds blowing dust in the desert. Inflammation in the mucosa-associated lymphoid tissue arises from allergens, bacteria and viruses occurring in the sandstorm season could be causally related to acute appendicitis and would explain the seasonal change (18).

In the past, research in some hot countries, such as the United States, Canada, Pakistan, Iran and South Africa, showed the highest incidence of AA in hot periods. The increase in the incidence of appendicitis in the summer months is said to be affected by the increased risk of gastrointestinal infections, intestinal parasite outbreaks, air pollution exposure, excessive alcohol consumption, and high carbohydrate and low fiber diet. In addition, the effects of touristic migration in the summer are particularly effective in touristic areas (8, 9, 19–21). When we looked at the perforated appendicitis group in our series, the incidence was higher in the summer (41%). We have attributed this increase in incidence to increased carbohydrate consumption in the summer months of our region's cuisine and the increase in the frequency of gastrointestinal infections.

It has been suggested in publications that reported that acute appendicitis is more common in the winter months, that air temperature, humidity rates and altitude may be effective in this. A study conducted in Kars, with an altitude of 1750 meters, indicated that appendicitis was more common in winter (7). In the study conducted in Kirman, Iran with an altitude of 1749 meters, it was determined that was appendicitis was seen more in winter (22). Also, in these two studies, the rate of perforated acute appendicitis was higher in the summer. The altitude of the region where the study was performed was 1054 meters, while the incidence of acute appendicitis was higher in the winter. The incidence of perforated appendicitis was higher during the summer months. The incidence of acute appendicitis was found to be higher during the summer months in three centers with an altitude of fewer than 100 meters (8, 19, 23). In other words, the increase in altitude resulted in an increase in the cases of appendicitis in the winter. The cause of this trend is unknown.

Seasonal differences in the presence of appendicitis are thought to be influenced more by different climatic characteristics, such as humidity, precipitation, or increased bacterial or virus infections, rather than temperature. In countries with a tropical climate, such as Nigeria, the rainy season, humidity, the prevalence of known bacterial and viral infections and the high prevalence of intestinal parasites in developing countries may explain some cases of acute appendicitis. It has been found that inflammation in appendicitis can be initiated by and associated with parasites. Commonly associated parasites are Schistosoma mansoni, Haematobium, Enterobius vermicularis, Ascaris, and Entamoeba histolytica. In the literature, it shows a higher prevalence in the periods where bowel parasites are more common (24, 25).

In a study conducted in India, the incidence of acute appendicitis increased in two periods. The first increase was due to the very large differences in the temperature and allergic reaction to pollens at the beginning of the pre-monsoon season. The second increase occurred in monsoon season and was associated with increased humidity, and increased frequency of bacterial and viral infections, and parasites (26). The region where our study was conducted was not influenced by the monsoon climate.

Wolkomir et al. (27) concluded in their 56-year and 12,686 case series that seasons had no effect on the incidence of acute appendicitis. They suggested that many variables could affect the frequency of acute appendicitis at different degrees throughout the year.

The presence of seasonal variation indicates the possibility of heterogeneous external factors, such as humidity, allergens, solar radiation and viral and bacterial infections in the etiology of acute appendicitis. While many believe that the etiology of acute appendicitis is multifactorial, none has been able to demonstrate its precise etiology. The role of sex, ethnic origin and genetic factors has been demonstrated with evidence. Dietary factors, hygiene, climate and infection agents were blamed (28).

In their study, Fukuda et al. hypothesized that a change in atmospheric pressure affects the immune system through the autonomic nervous system. Thus, a change in atmospheric pressure affects the incidence of acute appendicitis, regardless of the variables of sex or age. Granulocytosis is increased under high pressure due to sympathetic activity, and lymphocytosis is increased under low pressure due to parasympathetic activity. This seems to mean that granulocytosis arises from an increase in sympathetic activity may be closely related to the onset of gangrenous appendicitis. Even in cases of gangrenous appendicitis, when it was examined by electron microscopy, bacteria were not found around the granulocytes in the appendix or in the cytoplasm of granulocytes. These results may be extremely useful in investigating the etiology of suppurative diseases that do not cause significant bacterial infections (29, 30). Increased incidence of acute appendicitis in winter may be due to the increased high atmospheric pressure in winter.

A Japanese study in the literature showed a statistically significant increase in atmospheric pressure in the two weeks before the diagnosis of female patients aged 20 to 29. High atmospheric pressure leads to clear air and patients are more likely to leave their homes and spend time outside when the weather is nice and clear. Therefore, the effects of high atmospheric pressure may result in higher medical consultations and diagnostic rates (6).

CONCLUSION

Similar to the previous studies, we demonstrated the effects of age and sex on the development of acute appendicitis. However, we have found that seasonal changes may affect the incidence of appendicitis. The incidence of acute appendicitis in Anatolia, represented by our study, increases in winter, the incidence of perforated appendicitis increases in summer, and negative appendectomy rate increases in spring. This seasonal variability is associated with various reasons. Increased incidence of bacterial and viral infections (causing lymphoid hyperplasia leading to blockage of the appendix lumen) may be held responsible for the increased incidence in regions with similar climatic characteristics during the winter months. However, the exact cause is unknown. As a result of this study, for patients with an initial diagnosis of acute appendicitis in spring, with suspicious clinical findings that are not supported with radiology or laboratory examinations, instead of referring them for an operation, the clinician could change their emergency surgery decision to follow-up, and likewise, in the summer, patients diagnosed with acute appendicitis could be taken into surgery before any complications develop and avoid wasting time.

Ethics Committee Approval: The Erciyes University Clinical Research Ethics Committee granted approval for this study (date: 08.05.2019, number: 2019/299).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – UT, MG, ABÖ, DGİ; Design – MA, FD; Supervision – KD, ES, MA; Materials – DGİ, UT, MG, ABÖ, MA; Data Collection and/or Processing – DGİ, UT; Analysis and/or Interpretation – MG, ABÖ, MA, KD; Literature Search – MG, ABÖ, UT, ES, KD; Writing – UT, MG, MA ABÖ; Critical Reviews – ES, KD, MA.

Conflict of Interest: The authors have no conflict of interest to declare.

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