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Klinik Çalışma

Epidemiological and demographic features of appendicitis and influences of several environmental factors

Apandisitin epidemiolojik, demografik özellikleri ve oluşumunda çevresel faktörlerin etkisi

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BACKGROUND
In this study, we present the demographic features of appendicitis and investigate the influence of several factors (season, temperature, humidity, altitude) on the development of the condition.

METHODS
A total of 1871 patients operated between 2004 and 2007 were included and divided into two subgroups as perforated and non-perforated appendicitis. The demographic features and environmental factors were investigated. We compared the effects of environmental conditions with those observed in other countries.

RESULTS
Appendicitis was most frequent among males between 10 to 19 years of age. Perforated appendicitis was mostly seen between 0-9 years and after 50 years of age. The frequency of appendicitis was the highest during winter, but the rate of perforation was at its minimum during this season. During the coldest three months of the year, non-perforated appendicitis was mostly seen at temperatures of -8.8°C; however, perforated appendicitis was mostly seen at -11.2°C ($p<0.01$).

CONCLUSION
Our findings show that the frequency of appendicitis and perforation rate are influenced by sex and age. Environmental factors like season, temperature and altitude may also influence the frequency of appendicitis.

Key Words: Altitude; appendicitis; humidity; temperature.

AMAÇ
Bu çalışmada, akut apandisit tanısıyla ameliyat edilen hastaların demografik özellikleriyle hastalığın oluşumundaki mevsim, hava sıcaklığı, nem ve rakım gibi faktörlerin etkileri araştırıldı.

GEREÇ VE YÖNTEM
2004 ile 2007 yılları arası, ameliyat edilen 1871 hasta perfore ve non-perfore apandisitli olmak üzere iki gruba ayrıldı. Demografik özellikler ile mevsim, hava sıcaklığı, nem, rakım gibi çevresel faktörlerin etkisi araştırıldı. Bulgularımız, farklı ülkelerin, çevresel koşullarının etkileriyle karşılaştırıldı.

BULGULAR
Apandisit en sık erkeklerde ve 10 ile 19 yaşları arasında görüldü. Perfore apandisit ise en sık 0-9 ve 50 yaş üstü grupları arasında görülmekteydi. Kış mevsiminde apandisit en sık fakat perforasyon en az görülüyordu. Yılın en soğuk üç ayında non-perfore apandisit -8.8°'de en sık görülürken, perfore apandisit en sık -11.2°'de görülmekte idi ($p<0,01$).

SONUÇ
Bulgularımız, apandisitin ve perforasyonun oluşumunda yaş ve cinsiyetin etkili olduğunu göstermiştir. Mevsim, hava sıcaklığı ve rakım gibi çevresel faktörler apandisitin sıklığında etkili olabilmektedir.

Anahtar Sözcükler: Rakım; apandisit; nem; hava sıcaklığı.

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Appendicitis is among the most common abdominal conditions requiring admission to emergency surgery departments. Untreated appendicitis may be complicated with development of gangrene or perforation, resulting in high morbidity and mortality rates in almost all age groups. Claudius Amyand performed the first appendicitis operation at London St. George's Hospital in 1735.[1] Since then, the decreasing and increasing prevalence rates of the disease over time have directed researchers to undertake epidemiological and demographic studies.

Similar to many diseases,[2-4] the frequency of appendicitis may show variation by population, age, sex, socioeconomic status, and race.[5] Although eating habits and hygienic practices have been suggested to also have a role, such a relation is not widely accepted at present.[6] Recently, several researchers have found some relation between the development of appendicitis and some environmental factors such as season,[5] humidity,[7] and viruses.[7] However, the data are relatively scarce and the issue is still controversial, necessitating further studies.

This study was conducted in Kars, a city located in the easternmost part of Turkey, with the aim to present the demographic features of patients operated for appendicitis. We studied the effects of environmental factors such as temperature and humidity, which may have a role in the development of appendicitis. In addition, the effect of altitude as well as of seasonal variations was examined.

MATERIALS AND METHODS

Following the approval of the study protocol by the ethics committee of Kafkas University Faculty of Medicine, we retrospectively collected the data accumulated between 2004 and 2007 (January 2004 to December 2007) from two healthcare institutions of Kars: Kafkas University Faculty of Medicine and Kars State Hospital. The following sources were used to obtain data: records for patient histories and operations, registries of institutions (surgical clinics, in particular), and the ICD-10 (K35, K35.0) registries. Elective appendectomies and false-positive appendicitis cases were excluded. A total of 1871 acute appendicitis cases were diagnosed based on pathological features and were allocated to either the perforated or non-perforated appendicitis groups. For the purpose of analysis, patients were divided into six age groups as: 0-9 years (y), 10-19 y, 20-29 y, 30-39 y, 40-49 y, and ≥50 y.

Table 1. Acute appendicitis in Kars according to gender, age and perforation status*

	All patients	Non-perforated	Perforated
No. (%)	1871 (100)	1679 (89.7)	192 (10.3)
Sex			
Females	870 (46.5)	800 (47.6)	70 (36.5)
Males	1001 (53.5)	879 (52.4)	122 (63.5)
Age (year)			
Mean (SD)	20.9 (13.9)	21.1 (13.7)	19.3 (15.5)
Median (IQ)	16 (11-27)	17 (11-27)	14 (10-22)

*2004-2007; SD: Standard deviation; IQ: interquartile range.

Data were analyzed for age, sex, length of stay in hospital, and perforation status. Daily temperature, humidity and altitude data and other seasonal information were obtained from the region's national weather stations (Turkish State Meteorological Service) and the internet (http://en.wikipedia.org).

Statistical Analysis

Data analysis was performed using SPSS for Windows, version 11.5. Normality of the continuous variables was tested using Shapiro Wilks test. Continuous data and qualitative data were presented as mean ± SD (minimum-maximum) and as percentages, respectively. The differences between perforated and non-perforated appendicitis groups in terms of humidity and temperature were analyzed using Mann-Whitney U test. Mean ages were compared using Student's t test. Chi-square test was used for the comparison of nominal data. A p value less than 0.05 was considered statistically significant.

RESULTS

Between the fiscal years 2004-2007, the average age and sex-adjusted annual incidence of acute appendicitis was 149.8 per 100,000 population. In our study, among 1871 patients operated for appendicitis, 1001 were males (53.5%) and 870 were females (46.5%), with a male to female ratio of 1.07:1.00 (154.7 per 100,000 males/year and 144.6 per 100,000 females/year). The mean age was 20.90±13.90 y (range: 1-80 y) (for males 20.87±14.11 y, for females 20.94±13.66 y). On the other hand, 1679 patients had non-perforated appendicitis (89.7%, male to female ratio: 1.02:1.00, incidences for males and females: 136 and 133 per 100,000/year, respectively) and 192 patients had perforated appendicitis (10.3%, male to female ratio: 1.62:1.00, incidences for males and females: 19 and 12 per 100,000/year, respectively). The mean age was 21.1±13.7 y and 19.3±15.5 y in patients with non-perforated and perforated appendicitis, respectively ($p>0.05$). Non-perforated appendicitis was more common in males than females (52.4% to 47.6%), and this preponderance increased further in perforated patients (63.5% to 36.5%) ($p<0.05$) (Table 1).

The mean length of hospital stay was 4.16±2.36 days (range: 1-17 days). Corresponding figures for patients with non-perforated and perforated appendicitis were 3.96±2.2 days and 5.70±2.8 days, respectively ($p<0.001$).

Appendicitis was mostly seen in the age group of

Table 2. The distribution of acute appendicitis according to gender and age

Sex	Non-perforated appendicitis	Perforated appendicitis	Total appendicitis
Male			
Age		Number of patients	
0-9	140	29	169
10-19	366	60	426
20-29	175	10	185
30-39	109	6	115
40-49	46	7	53
≥50	43	10	53
Total	879	122	1001
Female			
Age		Number of patients	
0-9	115	16	131
10-19	356	32	388
20-29	154	10	164
30-39	86	3	89
40-49	54	6	60
≥50	35	3	38
Total	800	70	870

10-19 (43.5%, n: 814, 1023 and 981 per 100,000/year, respectively), and its frequency was the lowest among patients ≥50 years old (4.9%, n: 91, 168 and 105 per 100,000/year, respectively) (Fig. 1). Perforation was mostly seen in the age groups of 0-9 y (15.0%, n: 45) and ≥50 y (14.3%, n: 13), ($p<0.001$) (Table 2).

When male and female subgroups were considered, perforated appendicitis was most frequent among males aged ≥50 y (18.9%, n: 10) and 0-9 y (17.2%, n: 29) ($p<0.05$). On the other hand, for females, it was more frequent between 0-9 y (12.2%, n: 16) and 40-49 y (10%, n: 6) ($p>0.05$). Perforation was present in 12.2% and 8.0% of male and female patients with appendicitis, respectively ($p<0.05$) (Table 2).

Amyand hernia (appendix in the vesicle of inguinal hernia) rate was 1.6 in 1000 appendicitis cases. It was present in three male patients at the ages of 3, 6, and 14, who were operated for inguinal hernia.

The present study also examined the seasonal variation of the appendicitis cases. Overall, acute appendicitis tended to occur in winter ($p>0.05$). On the other hand, while non- perforated appendicitis was mostly seen in winter (27.9%, n: 468), perforated appendicitis was seen in summer and autumn (for both, 27.6%, n: 53) (Table 3). A remarkable relation was the negative correlation between the number of appendectomies and rate of perforation. During the seasons with a low number of appendectomies, the rate of perforation was high. Appendicitis was most frequent during winter while perforation had the lowest frequency during that season (18.2%, n: 35) ($p<0.05$) (Fig. 2).

In our study, regression analysis did not reveal any significant relation between the frequency of appendicitis and humidity levels ($p>0.05$). Furthermore, the mean daily humidity levels were similar for non-perforated and perforated patients ($p>0.05$) (Table 4). However, in December, January and February (during the coldest three months of the year), we observed a statistically significant relation between temperature and perforation of appendicitis. In these months, non-perforated appendicitis was mostly seen at -8.8°C [-8.8±5.41 (-21.2 - 4.0)], while perforated appendicitis was mostly seen at -11.2°C [-11.2±5.36 (-21.2 - 4.0)] ($p<0.01$).

DISCUSSION

We examined demographic features of acute appendicitis patients using data from our region and investigated the seasonal variation of acute appendicitis and the relation of its frequency with temperature, humidity and altitude.

Demographic Features

Our findings regarding sex distribution of appendicitis cases were consistent with the results of previous studies,[6,8,9] with a marked male predominance. Addiss et al.[5] estimated the lifetime risk of appendicitis as 8.6% for males in the United States population, while the corresponding figure for females was 6.7%.

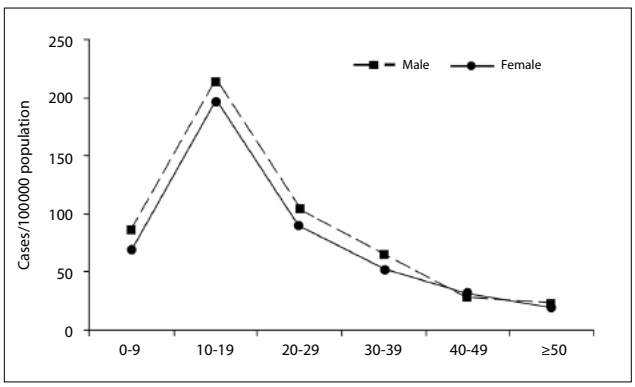

Fig. 1. The distribution of acute appendicitis according to age groups and sex.

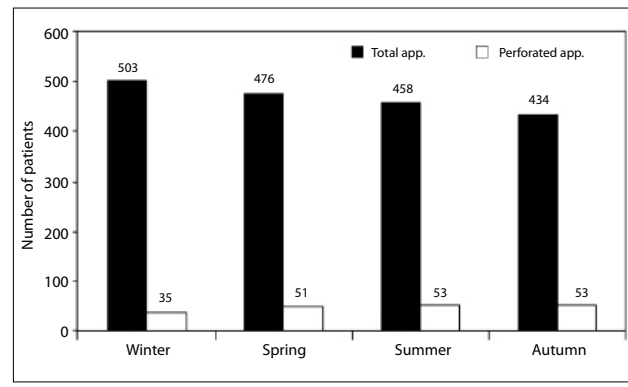

Fig. 2. The relation between appendicitis rates (with and without perforation) and seasons.

Table 3. The distrubution of acute appendicitis by season

	Acute appendicitis					
	Non-perforated		Perforated		Total	
	n	%	n	%	n	%
Season						
Winter	468	93.0	35	7.0	503	26.9
Spring	425	89.3	51	10.7	476	25.4
Summer	405	88.4	53	11.6	458	24.5
Autumn	381	87.8	53	12.2	434	23.2
Total	1679	89.7	192	10.3	1871	100.0

In the present study, acute appendicitis was mostly seen from 10 to 19 years of age, whereas it was least common at ages over 50 years. Perforation was seen at early ages or in the elderly. Our results were parallel to the previous studies.[10,11] Hardin Jr.[10] defined lymphoid hyperplasia as the most important cause of appendicitis in children and adolescents, resulting in an increased frequency of this condition at these ages. In another study, lymphoid hyperplasia was observed in 91% of the infected appendicitis cases, and it was described as the most common cause of acute appendicitis seen at early ages.[11] The non-specific nature of the symptoms and laboratory findings, misdiagnosis or delayed diagnosis, delayed admission to hospital, communication problems, and socioeconomic factors (ethnic issues and health insurance problems) have been cited for the high perforation rates at very early ages and in the elderly.[12-15] According to Eldar et al.,[16] these factors increase postoperative infection rates and duration of hospitalization. In the present study, surgical site infection rate was 22% and 8% for patients with and without perforation, respectively. Therefore, duration of hospital stay was two days longer among patients with perforation. The delayed admission to hospital, which may be due to the high rate of rural residences around Kars together with difficulties in communication and transportation, may explain the high rate of perforations. In addition, for the same reasons, patients might have been kept longer in the hospital, leading to the increased duration of hospitalization.

Although various rates have been reported for Amyand hernia, ours is close to the rate reported by Ryan[1] (1.3 in 1000 cases). Our patients had been operated with suspicion of strangulation (severe abdominal pain, fever, leukocytosis).

Effects of Season, Altitude, Humidity, and Temperature on Acute Appendicitis

In the present study, appendicitis had a tendency to occur during winter. Several studies have investigated acute appendicitis and seasonal variations in rates of occurrence.[5,7,17-22] Most of those studies reported an increase during summer. Interestingly, regions with an increase in appendectomy rates during summer (Jersey City,[17] Ferrara,[20] Ontario,[21] and Shahr - e - Rey,[22]) also had a low altitude. In Kirman,[19] a region with an altitude similar to that of Kars, appendicitis was mostly seen during winter, whereas perforated appendicitis was mostly seen during summer and autumn. These findings are in line with that of the present study, all suggesting a role of altitude in the seasonal variation of the appendicitis rate (Table 5).

In the present study, no association was found between humidity and the frequency of appendicitis. Brummer[7] found a significant negative correlation

Table 4. The distribution of humidity in non-perforated and perforated appendicitis in four seasons (2004-2007)

Seasons	Non-perforated	Perforated	z	p
Humidity (%)				
Winter	76.7±7.95 (54.0-94.0)	76.7±8.01 (60.7-94.0)	-0.054	0.957
Spring	68.2±10.24 (30.0-93.3)	67.7±10.77 (40.0-89.3)	-0.047	0.963
Summer	63.9±8.75 (35.0-87.8)	64.7±10.33 (36.0-87.8)	-1.191	0.234
Autumn	71.9±9.60 (47.3-94.0)	71.7±9.91 (48.7-93.3)	-0.148	0.882
Total	70.4±10.32 (30.0-94.0)	69.6±10.75 (36.0-94.0)	-0.548	0.584

Table 5. The seasonal tendency of total and perforated appendicitis according to the altitude of different regions

	Altitude (meters)	Appendicitis	Perforated
Ferrara	9	Summer	
Jersey City	25	Summer	
Ontario	86	Summer	
Shahr-e-Rey	1050	Summer	
Kirman	1749	Winter	Summer-Autumn
Kars	1750	Winter	Summer-Autumn

between humidity and acute appendicitis. According to those investigators, the loss of body water caused by the decrease in humidity may result in fecal stasis/dehydration and inflammation, thereby increasing the risk of plugging in the appendix lumen. Choi et al.[23] found that humidity variations had a smaller influence on the rates of non-traumatic diseases than traumatic diseases. In the present study, there was no relation between humidity and appendicitis. During the summer, when the humidity was at a minimum, the incidence of appendicitis was also the lowest. Although fecal stasis has an important role in the development of acute appendicitis, we believe that the degree of humidity itself is not important for stasis; on the other hand, daily water consumption, nutritional habits and the amount of dietary fiber have a greater influence on peristalsis. The perforation rate among our patients was affected by the daily temperature. As the altitude increased, peak incidence of appendicitis moved from winter to summer months. However, with increasing altitude, frequency of perforation in winter months decreased.

Our findings also demonstrated that in the coldest three months of the year (December, January, February), non-perforated appendicitis was seen mostly at temperatures of -8.8° [-8.8±5.41 (-21.2 - 4.0)], while perforated appendicitis was seen mostly at -11.2° [-11.2±5.36 (-21.2 - 4.0)]. Some infectious agents with an etiological role in the development of appendicitis may be active at certain altitudes, and their virulence or frequency may increase when temperature falls below a certain degree, resulting in high perforation rates.

In conclusion, similar to previous studies, we also demonstrated the influence of age and sex on the development of acute appendicitis. However, we described additional factors that may influence the rate of appendicitis such as seasonal variations, temperature and altitude. These factors have not been discussed in detail previously. On the other hand, nutritional habits (low fiber content in diet), hygiene, ethnic and genetic tendency, socioeconomic status, and bacterial, viral and parasitic infections have already been defined as causes of appendicitis.[5,11] Seasonal variation observed in the present study may be related to the dominance of certain infectious agents during the winter. However, further large-scale studies are needed to support this conclusion.

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