Chron Precis Med Res 2023; 4(2): 119-125
DOI: 10.5281/zenodo.8063721

ORIGINAL ARTICLE
ORİJİNAL ARAŞTIRMA

The investigation of appendiceal size and volume in pediatric appendectomy specimens in terms of histopathological diagnosis, seasonal variability, age, and gender

Pediatrik apendektomi örneklerinde histopatolojik tanı, mevsimsel değişkenlik, yaş ve cinsiyet açısından apendiks boyutu ve hacminin incelenmesi

Sevinç Şahin[1], Sema Avcı[2], Esra Çobankent Aytekin[3]

[1]Department of Pathology, Alanya Alaaddin Keykubat University, Faculty of Medicine, Antalya, Turkey
[2]Department of Histology and Embryology, Alanya Alaaddin Keykubat University, Faculty of Medicine, Antalya, Turkey
[3]Department of Pathology, Konya Numune Hospital, Konya, Turkey

ABSTRACT

Aim: Acute appendicitis is a common condition mostly in children with unclear etiology that is treated with an emergency appendectomy. However, some unexpected diagnoses called as "negative appendectomy" that do not require treatment may be detected histopathologically. In this study, it was aimed to investigate the histopathologic diagnoses of pediatric appendectomy specimens, considering the macroscopic dimensions and volume of the specimens for the first time in the literature and comparing them with age and gender groups, and seasons of the operations to achieve additional data in preventing negative appendectomy.

Material and Method: A total of 122 cases were included in this study. The length, longest diameter, and shortest diameter, as well as the volume of each specimen, were measured during the macroscopic examination. The specimens were evaluated for histopathologic diagnosis according to age, gender, and the season in which the operation was performed.

Results: The male-to-female ratio was 1.2. Histopathologically, there were 81 (74.6%) inflammatory diseases [mainly acute appendicitis (65.5%)], and 31 (25.4%) non-inflammatory diseases [mainly lymphoid hyperplasia (21.3%)] that were considered negative appendectomy. Inflammatory diseases were operated mostly in winter (p=0.0099), while non-inflammatory diseases were operated mainly in autumn (p=0.0099). The length, longest diameter, and appendiceal volume were significantly greater in inflammatory than in non-inflammatory ones (p=0.0006, p=0.0126, and p=0.0016, respectively). Length and volume were more significant in acute appendicitis than in lymphoid hyperplasia (p=0.0124 and p=0.0358, respectively). In patients ≤12 years, lymphoid hyperplasia was more common in females than in males (p<0.001). In patients >12 years, acute appendicitis was more common in females than males (p<0.034).

Conclusion: In this study, histopathological diagnoses observed in appendectomy specimens were evaluated for the first time in the literature according to macroscopic appendix size and volume, as well as age, gender, and seasonal variations. The obtained data have the potential to provide additional information to the literature regarding epidemiological, appropriate preoperative, and pathological approaches.

Keywords: Appendectomy, appendicitis, carcinoid, fibrous obliteration, Enterobius vermicularis, pediatric specimens

ÖZ

Amaç: Akut apandisit, çoğunlukla çocuklarda görülen, etiyolojisi belirsiz yaygın bir durumdur ve acil apendektomi ile tedavi edilmektedir. Bununla birlikte, tedavi gerektirmeyen bazı beklenmedik tanılar, histopatolojik olarak tespit edilebilmektedir ve bunlar "negatif apendektomi" olarak adlandırılmaktadır. Bu çalışmada negatif apendektomi vakalarının önlenmesinde literatüre katkı sağlayabilecek ek verilere ulaşmak amacı ile pediatrik apendektomi örneklerinde saptanan histopatolojik tanılar literatürde ilk kez makroskopik apendektomi boyutları ve hacimleri göz önünde bulundurularak, yaş ve cinsiyet grupları ve operasyonların yapıldığı mevsimlerle karşılaştırılarak incelenmiştir.

Gereç ve Yöntem: Bu çalışmaya toplam 122 olgu dahil edilmiştir. Her bir örneğin uzunluğu, en uzun çapı, en kısa çapı ve hacmi makroskobik inceleme sırasında ölçülmüştür. Örnekler, yaş, cinsiyet ve operasyonun gerçekleştirildiği mevsime göre histopatolojik teşhis açısından değerlendirilmiştir.

Bulgular: Erkek-kadın oranı 1.2 olarak saptanmıştır. Histopatolojik olarak, 81 (%74.6) inflamatuar hastalık [çoğunlukla akut apandisit (%65.5)] ve negatif apendektomi olarak değerlendirilen 31 (%25.4) non-inflamatuar hastalık [çoğunlukla lenfoid hiperplazi (%21.3)] tespit edilmiştir. İnflamatuar hastalıkların genellikle kış mevsiminde (p=0.0099), non-inflamatuar hastalıkların ise genellikle sonbaharda (p=0.0099) opere edildiği saptanmıştır. Uzunluk, en uzun çap ve apendiks hacminin, inflamatuar hastalıklarda non-inflamatuar hastalıklara göre önemli ölçüde daha fazla olduğu gözlenmiştir (sırasıyla p=0.0006, p=0.0126 ve p=0.0016). Uzunluk ve hacmin, akut apandisitte lenfoid hiperplaziden daha fazla olduğu saptanmıştır (sırasıyla p=0.0124 ve p=0.0358). 12 yaşından küçük hastalarda, lenfoid hiperplazinin erkeklerde kızlara göre daha yaygın olduğu izlenmiştir (p<0.001). 12 yaşından büyük hastalarda ise akut apandisitin, kızlarda erkeklere göre daha yaygın görüldüğü tespit edilmiştir (p<0.034).

Sonuç: Bu çalışmada, apendektomi materyallerinde izlenen histopatolojik tanılar literatürde ilk kez makroskopik appendiks boyutunun ve hacminin yanı sıra yaş, cinsiyet, ve mevsimsel değişkenliklere göre değerlendirilmiştir. Elde edilen veriler, epidemiyolojik, uygun preoperatif ve patolojik yaklaşım konusunda literatüre ek veriler sağlayabilecek niteliktedir.

Anahtar Kelimeler: Apendektomi, apandisit, karsinoid, fibröz obliterasyon, Enterobius vermicularis, pediatrik spesmenler

Corresponding Author: Sevinç Şahin
Address: Alanya Alaaddin Keykubat University/School of Medicine, Department of Pathology, Alanya, Antalya, Turkey
E-mail: sevinc.sahin@alanya.edu.tr

Başvuru Tarihi/Received: 04.06.2023
Kabul Tarihi/Accepted: 12.06.2023

INTRODUCTION

Appendectomy is one of the most common urgent operations in the surgical routine, mainly performed for acute appendicitis (1). Acute appendicitis is seen in all age groups. However, it occurs more frequently in children and adolescents (2,3). Overall lifetime risk is 8.6% for males and 6.7% for females (4).

The etiology of acute appendicitis has not been fully clarified and considered multifactorial (3,5,6). Nutrition, hygiene, and genetic predisposition are claimed to be the primary factors in the development of acute appendicitis (3,7). In addition, some environmental factors, such as regional and seasonal variation have been noted to be responsible for the development of acute appendicitis, in some studies in the literature, from different geographic locations, and only a few from Turkey (3,5).

Lumen obstruction is the most common cause of acute appendicitis (1). Obstruction often develops due to fecaliths and lymphoid hyperplasia (1). However, there are some rare causes of obstruction detected incidentally in the appendectomy specimens such as neoplasms and parasites that require additional treatment (1). Obstruction causes lumen dilation, thickening of the appendix wall, and even perforation due to luminal bacterial overgrowth, inflammation, and ischemia (8,9). Therefore, imaging methods such as ultrasonography (USG) and abdominopelvic computer tomography (CT) are often used to determine the changes in the appendiceal dimensions to confirm acute appendicitis and rule out negative cases along with the clinical scoring methods and laboratory findings (10). Similarly, an increase in the appendix diameter and dilatation in the lumen can be easily detected during the macroscopic examination of appendectomy specimens with acute appendicitis that are submitted to the pathology laboratory. On the contrary, approximately 8.9% (range 1-40%) of the pediatric appendectomy specimens with a preoperative diagnosis of appendicitis show neither macroscopical nor microscopical features of appendicitis, called negative appendectomy (11). Therefore, it is of great importance to know both the macroscopical and histopathological findings of acute appendicitis and normal appendix in children, to exclude false positive cases and prevent negative appendectomies.

In the current study, we aimed to examine the pediatric appendectomy specimens performed for preliminary diagnosis of acute appendicitis to explore the spectrum of the histopathological diagnoses, particularly the unexpected ones, correlate with the age and gender of the patients, the seasons when the operation performed, and the dimensions and volume of the appendix measured during a macroscopical examination to serve additional data to the literature about epidemiology and a proper preoperative and pathological approach.

MATERIAL AND METHOD

After obtaining ethical approval from the Ethics Committee of Akdeniz University for this retrospective study (26.04.2023/number 354), electronic archive records, pathology reports, and histological sections of 122 patients who underwent appendectomy diagnosed with acute appendicitis between January 2012 and December 2018 at the Department of Pathology of Bozok University Faculty of Medicine were reviewed. The age, gender, macroscopical findings, histopathological diagnosis of the cases, and the seasons of the operation were obtained from the pathology reports.

Three dimensions [length (x), longest diameter (y), and shortest diameter (z)] (**Figure 1**) of each appendectomy specimen were recorded according to the macroscopic examination data, and the appendix volume was calculated by multiplying these dimensions with each other. Cases with neutrophil leukocyte infiltration in the appendix wall were considered inflammatory diseases. Those without neutrophil leukocyte infiltration in the appendix wall were considered non-inflammatory diseases that indicated negative appendectomy.

According to age and gender, the patients were divided into four groups: Group 1 (≤12 years old, female), Group 2 (≤12 years old, male), Group 3 (>12 years old, female), and Group 4 (>12 years old, male).

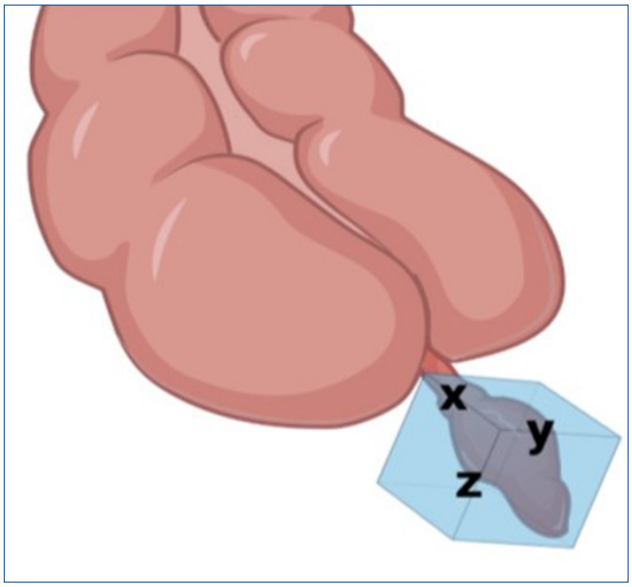

Figure 1. The illustration of the length (x), longest diameter (y), and shortest diameter (z) of appendix vermiformis.

Statistical Analysis

After evaluating the normality in the groups, One-way ANOVA and multiple comparison tests (Dunn's/Tukey's) were used. The student's t-test was preferred for pairwise percentage comparisons. A difference of $p<0.05$ between the groups was considered significant. The groups with a difference between them were indicated in the columns by writing the letter symbol given for each group over the p-value. The drawings were made with the BioRender (U.S.) program.

RESULTS

Of the 122 patients, 67 (54.9%) were male, and 55 (45.1%) were female. The male-to-female ratio was 1.2. The ages of the patients ranged from 1 to 18 years (mean: 12). Lumen dilatation (n=106, 86.8%), luminal fecalith (n=103, 84.4%), periappendiceal fibrin (n=89, 72.9%), and perforation (n=2, 1.6%) were determined in macroscopical records (**Table 1**). Histopathologically, there were six different inflammatory diseases in descending order of frequency: acute appendicitis (n=80, 65.5%), perforated appendicitis (n=8, 6.5%), phlegmonous appendicitis (n=3, 2.4%), necrotizing appendicitis (n=2, 1.6%), vasculitis (n=1, 0.8%), and granulomatous appendicitis (n=1, 0.8%). Four different microscopical diagnoses of non-inflammatory diseases were detected: lymphoid hyperplasia (n=26, 21.3%), enterobiasis (n=2, 1.6%), neuroendocrine tumor (n=1, 0.8%), and fibrous obliteration (n=1, 0.8%), in decreasing order of frequency. And, one case was reported as normal appendix vermiformis (n=1, 0.8%). The detailed macroscopical and microscopical findings are given in **Table 1** according to the groups based on age and gender.

There was no statistically significant difference between inflammatory and non-inflammatory diseases according to the age and gender groups ($p>0.05$). However, lymphoid hyperplasia was more common in Group 1 than Group 2 while acute appendicitis was more common in Group 3 than Group 4 ($p<0.001$, $p<0.034$, retrospectively) (**Table 1**).

The mean value of x, y, and z dimensions, and the total appendiceal volume in inflammatory diseases were 6.5±1.4 cm (range, 3-11.4 cm), 1.8±0.6 cm (range, 0.5-5 cm), 1.1±0.3 cm (range, 0.5-2 cm), and 13.1±0.7 cm^3 (range, 3-30 cm^3), respectively. The mean value x, y, and z dimensions, and the total appendix volume in non-inflammatory diseases were as 5.8±2.1 cm (range, 2.1-9.6 cm), 1.2±0.6 cm (range, 0.6-3.7 cm), 0.7±0.3 cm (range, 0.4-1.9 cm), and 7.6±1.8 cm^3 (range, 1.5-19.4 cm^3), respectively. X and y dimensions and the total appendix volume of the inflammatory diseases were more significant than the non-inflammatory ones ($p=0.0006$, $p=0.0126$, and $p=0.0016$, respectively). The mean value of x, y, and z dimensions and the total appendix volume in lymphoid hyperplasia, the most common non-inflammatory disease in the study, were 5.3±0.3 cm (range, 2.9-8.7 cm), 1.2±0.13 cm (range, 0.6-3.7 cm), 0.8±0.07 cm (range, 0.5-1.9 cm), and 8.7±2.2 cm^3 (range, 1.5-58.3 cm^3), respectively. When acute appendicitis and lymphoid hyperplasia were compared in terms of these measurements, only the x dimension and the total volume were statistically significantly greater in acute appendicitis than in lymphoid hyperplasia ($p=0.0124$ and $p=0.0358$, respectively). There was no statistically significant difference between the x, y, and z dimensions or the total appendix volume of the inflammatory and non-inflammatory diseases according to the age and gender groups ($p>0.05$).

Table 1: Macroscopical and microscopical findings of all cases according to the groups based on age and gender.

		Group 1[a]	%	Group 2[b]	%	Group 3[c]	%	Group 4[d]	%	P value
	Total (n)	**34**	**27,87**	**28**	**22,95**	**21**	**17,21**	**39**	**31,97**	
Macroscopical Findings										
Lumen dilatation	106 (86.8%)	31	25.41	23	18.85	17	13.93	35	28.69	<.001[c,d]
Luminal fecalith	103 (84.4%)	29	23.77	23	18.85	17	13.93	34	27.87	<.001[c,d]
Periappendiceal fibrin	89 (72.9%)	22	18.03	25	20.49	13	10.66	29	23.77	<.013[c,d]
Perforation	2 (1.6%)	0	0	0	0	1	0.82	1	0.82	>.05
Microscopical Findings										
Acute appendicitis	80 (65.5%)	18	14.75	26	21.31	10	8.20	26	21.31	<.034[c,d]
Perforated appendicitis	8 (6.5%)	2	1.64	0	0	4	3.28	2	1.64	<.049[c,b]
Phlegmenous appendicitis	3 (2.4%)	1	0.82	0	0	1	0.82	1	0.82	>.05
Necrotizing appendicitis	2 (1.6%)	2	1.64	0	0	0	0	0	0	>.05
Vasculitis	1 (0.8%)	1	0.82	0	0	0	0	0	0	>.05
Granulomatous appendicitis	1 (0.8%)	0	0	0	0	0	0	1	0.82	>.05
Lymphoid hyperplasia	26 (21.3%)	10	8.20	2	1.64	6	4.92	8	6.56	<.001[a,b]
Enterobiasis	2 (1.6%)	0	0.00	1	0.82	0	0	1	0.82	>.05
Fibrous obliteration	1 (0.8%)	1	0.82	0	0	0	0	0	0	>.05
Carcinoid tumor	1 (0.8%)	0	0	1	0.82	0	0	0	0	>.05
Normal appendix vermiformis	1 (0.8%)	0	0	0	0	0	0	1	0.82	>.05

The most common season that appendectomy operations performed was winter (n=43, 35.2%), followed by autumn (n=42, 34.5%), summer (n=23, 18.8%), and spring (n=14, 11.5%), respectively (**Table 2**). In parallel with those findings, surgery for inflammatory diseases was performed mainly in the winter and least in the spring (p=0.0099). However, surgery for non-inflammatory diseases was performed chiefly in the autumn and least in the spring (p=0.0099). There was no statistically significant difference between the seasons of the operation for inflammatory or non-inflammatory diseases according to the age and gender groups (p>0.05). Detailed information about the cases regarding the seasonal distribution is given in **Table 2** and **Table 3**.

DISCUSSION

Appendectomy specimens are frequently examined in the daily pathology routine, and are primarily diagnosed as acute appendicitis, as in our study (12). The annual incidence rate of 0-4 years-old children is 1-6/10.000, while it increases to 19-28/10.000 in children <14 years old (13). It is most commonly seen between the ages of 10 and 19 (14). The rate of acute appendicitis varies among countries (13,14). Males are more commonly affected than females (13), similar to our study (male/female=1.2). However, in patients >12 years considered as adolescents, acute appendicitis was found to be more common in females than males, in the current study.

The pathogenesis of acute appendicitis includes obstruction of the appendiceal orifice that increases intraluminal pressure, resulting in small vessel occlusion and lymphatic stasis (15). Subsequent bacterial overgrowth causes neutrophil leukocyte infiltration to some or all layers of the appendiceal wall (15). As a result, the appendix wall thickens, it becomes swollen, and the diameter of the appendix increases. These data are used in imaging methods to pre-diagnose acute appendicitis correctly to make proper medical and timely surgical therapy. Also, during the routine macroscopical examination, the increase in the size of the surgically removed appendix is easily encountered. Unless it is operated on time, perforation may also be encountered in the serosal surface of the appendectomy due to ischemic necrosis that may cause fatal peritonitis and abscess, clinically. The diameter of the normal appendix is ≤6 mm (16,17). The appendix diameter over 6 mm has a sensitivity of 93%, and a specificity of 92% in acute appendicitis, radiologically (18). An appendix diameter over 10 mm is accepted as acute appendicitis (17-19). Similar to the literature, the appendix diameter was longer than 7 mm (mean=17.8±0.7 mm) in each case with acute appendicitis in our study. The length of the appendix ranges from 2 to 20 cm, and its average length is 8 to 9 cm (20). There are only a few studies in the literature investigating the relationship between appendix length and appendicitis (20). Pickhardt et al. evaluated the association between appendiceal length and the development of appendicitis according to the CT

Table 2. Distribution of appendectomy operations according to the seasons.

	WINTER			SPRING			SUMMER			AUTUMN			
Month	12	1	2	3	4	5	6	7	8	9	10	11	
Cases (n)	15	24	4	5	6	3	3	6	14	13	15	14	122
Total (n) (%)	43 (35.2%)			14 (11.5%)			23 (18.8%)			42 (34.5%)			122

Table 3. Distribution of surgical operations in terms of seasons according to inflammatory and non-inflammatory diseases, and groups based on age and gender.

	Group 1	W	SP	SM	AUT	Group 2	W	SP	SM	AUT	Group 3	W	SP	SM	AUT	Group 4	W	SP	SM	AUT
INFLAMMATORY DISEASES																				
Acute appendicitis	18	7	2	2	7	26	11	2	5	8	10	5	2	1	2	26	10	1	4	11
Perforated appendicitis	2			1	1	0					4	1		1	2	2	1	1		
Necrotizing appendicitis	2		2			0					0					0				
Phlegmenous appendicitis	1	1				0					1	1				1		1		
Vasculitis	1				1	0					0					0				
Non-necrotizing granuloma	0					0					0					1				
Total (n)	**24**	**8**	**4**	**4**	**9**	**26**	**14**	**2**	**5**	**8**	**15**	**9**	**2**	**3**	**4**	**32**	**16**	**3**	**4**	**11**
NON-INFLAMMATORY DISEASES																				
Lymphoid hyperplasia	10	2	2	1	5	2		1		1	6	2	1	3		8	1	1	3	3
Enterobiasis	0					1				1	0					1			1	
Fibrous obliteration	1				1	0					0					0				
Carcinoid tumor	0					1	1				0					0				
Total (n)	**11**	**2**	**2**	**1**	**6**	**4**	**1**	**1**	**0**	**2**	**6**	**2**	**1**	**3**	**0**	**8**	**1**	**1**	**4**	**3**

Abbreviations: AUT: autumn, SM: summer, SP: spring, W: winter, Group 1 (≤12 years old, female); Group 2 (≤12 years old, male); Group 3 (>12 years old, female), and Group 4 (>12 years old, male)

findings (20). They reported that the appendiceal length of the cases with acute appendicitis varied between 4-10 cm, in 90% of the patients (20), similar to our study (mean length=6.4±0.2 cm, range=1-11.4 cm). Dibekoğlu et al. investigated the relationship between appendiceal length and the possible risk of perforated appendicitis. However, they did not find a significant relationship between these two parameters (21). The perforation rate in pediatrics has been reported between 18-72% in the literature (22). In the present study, the perforation rate was 6.5%, strikingly low compared to the literature. It might be related to the earlier and proper clinical diagnosis, the etiology of the disease, or inadequate macroscopical sampling from the perforation area.

In the present study, we also evaluated the relationship between appendix volume and acute appendicitis for the first time in the literature and all three dimensions of the appendix, to the best of our knowledge. In addition to the length, and the longest diameter, the total appendiceal volume of the inflammatory diseases (acute appendicitis, perforated appendicitis, phlegmonous appendicitis, necrotizing appendicitis, vasculitis, granulomatous appendicitis) was demonstrated to be greater than the non-inflammatory ones (lymphoid hyperplasia, enterobiasis, fibrous obliteration, and carcinoid tumor). Moreover, in the current study, the length and total appendiceal volume of acute appendicitis were greater than lymphoid hyperplasia, a common cause of negative appendectomy that mimics acute appendicitis. Accordingly, lymphoid hyperplasia was found to be the most common cause of negative appendectomy in our study, with a rate of (21.3%).

Lymphoid hyperplasia is a common disease in children. The age and gender characteristics and the incidence differ between studies in the literature (23-25). In the current study, lymphoid hyperplasia was detected more frequently in females than males, regardless of age group. The difference between them was statistically significant under the age of ≤12. Lymphoid hyperplasia defines reactive lymphatic tissue enlargement in the appendix wall, particularly for viral gastroenteritis or mesenteric adenitis (23,25). The hyperplastic mucosal lymphoid tissue increases the maximal mural thickness and the diameter of the appendix to larger than 6 mm, which may lead to false-positive USG findings for appendicitis (26). Following the literature, the appendix diameter was ≥6 mm in each case with lymphoid hyperplasia in our study. Histopathologically, lymphoid hyperplasia describes a group of more than ten lymphoid nodules, each containing lymphoid follicles >2 mm. (25). The appendix wall usually does not include neutrophil leukocyte infiltration with lymphoid hyperplasia (26). Similar to the literature, in the present study, none of the cases of lymphoid hyperplasia accompanies acute appendicitis findings under a light microscope. Therefore, it is more plausible that lymphoid hyperplasia may be a reactive physiological response to inflammation rather than an exact cause of appendicitis. And it may regress without the need for surgery (25).

The relationship between the seasons and the incidence of appendicitis is still debated since the frequency of it varies from region to region in the world (6,13,27). In addition to the studies reporting that it is more common in summer (6,13), there are also publications reporting that it is more common in winter (7,27,28). There are scarce investigations about the seasonal distribution of acute appendicitis in Turkey (6,7,27). Summer is the most common season of appendectomy in Adıyaman and Niğde provinces, while the winter is the most common in Kars province, located in a high and cold region similar to Yozgat, the province of our study (6,7,27). It was reported that spring was the season with the least number of appendectomies in Adıyaman, similar to ours, regardless of whether the diseases were inflammatory or non-inflammatory (6). The seasonal diversity of the infectious agents and allergens, variations in diet (consumption of excessive alcohol, high-carbohydrate and low-fiber foods, etc.), smoking, and other environmental factors such as air pollution, humidity, temperature, and precipitation, may also contribute to the etiopathogenesis of acute appendicitis (6,7,27).

Rarely parasitic infections, benign tumors, or unexpected malignancies might be detected in appendectomy specimens incidentally (1,12). Thus, all appendectomies should be sent to pathology laboratories for histopathological diagnosis and macroscopic examination should be done carefully. Specimens that seem normal on macroscopic examination should also be examined microscopically. In particular, it is crucial to sample the distal part of the appendix, to dismiss the incidental carcinoid tumors, as it is often located in this area (29). The incidence of carcinoid tumors in children is reported to be 1–2/1000 appendectomies (29). Among children, it is generally seen between the ages of 10-12 and shows a preference for girls (30). The current study observed 1 (0.8%) incidental carcinoid tumor in an 11-year-old male patient.

Enterobius vermicularis is the most common parasite detected in the appendix and cecum lumen (31). It can be seen in all age groups but is more common in childhood, predominantly in females (31). Our study detected 2 (1.6%) male patients with Enterobius vermicularis. In the literature, the frequency of Enterobius vermicularis noticed in appendectomies varies between 0.2-41.8% by the current study (31). There were no acute appendicitis findings in the appendix wall accompanying Enterobius vermicularis in our study, similar to the literature (1).

Granulomatous appendicitis is a rare entity detected in appendectomy specimens with a frequency of 0.31-0.95% (12). Both infections (e.g., tuberculosis) and non-infectious processes, particularly Crohn's disease (appendiceal involvement rate of 21%), may cause granulomatous inflammation in the appendix (12,32). In our study, a non-necrotizing granulomatous reaction was observed in a 17-year-old male patient. Since no underlying disease was found after clinical investigations, it was considered "idiopathic granulomatous appendicitis" and followed up clinically.

Localized and systemic vasculitis may affect the appendix at a rate of 0.3-1.9% (33). In the present study, leukocytoclastic vasculitis was detected in an appendectomy of a six-year-old girl operated on for acute abdomen symptoms. The skin rash appeared soon after the operation, and consequently, the patient was diagnosed with Henoch-Schoenlein purpura (HSP). HSP is the most common systemic vasculitis in children (34). Intestinal involvement of HSP may cause colicky abdominal pain that mimics acute appendicitis and lead to an unnecessary appendectomy with a rate of 5-7% (19). The onset of abdominal pain before the rash is reported rarely in the literature (34), which increases the risk of misdiagnosis, similar to our case.

Fibrous obliteration is a benign entity that obstructs the appendix lumen, particularly the distal part, by spindle cells originating from neural tissue with a myxoid or collagenous background (35). It is seen in up to 30% of the cases operated with a preliminary diagnosis of acute appendicitis (36). Following the literature, fibrous obliteration was detected in 1 (0.8%) female patient of 10 years old in our study.

The current study had some limitations, such as the retrospective nature of the study, the relatively small number of cases, and the inaccessibility of radiological images and measurements of the cases due to the problems in the hospital automation system.

CONCLUSION

Detailed pathological evaluation and novel regional epidemiological data emphasizing seasonal variations in pediatric appendectomy specimens were presented in the current study. Winter was the most common season, and spring was a minor regular season in which appendectomy was performed, in both whole cases in the research and the patients with acute appendicitis. The most common cause of negative appendectomy was lymphoid hyperplasia which was operated mainly in the autumn and least in the spring. Incidental cases such as enterobiasis, carcinoid tumor, fibrous obliteration, non-necrotizing granuloma, and vasculitis were detected. To the best of our knowledge, the value of macroscopical measurements in appendectomy specimens was evaluated for the first time in our study in the literature. And statistically significant increases, particularly in length, longest diameter, and appendiceal volume, were detected in positive appendectomies compared to the negative ones. We suggest that those comparisons might aid in reducing negative appendectomies and conducting more comprehensive further studies.

ETHICAL DECLARATIONS

Ethics Committee Approval: This study was approved by the Akdeniz University Ethics Committee (Date: 26.04.2023, Decision No: 354).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

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

Financial Disclosure: The authors declared that this study has received no financial support.

Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

1. Yabanoglu H, Caliskan K, Ozgur Aytac H, Turk E, Karagulle E, Kayaselcuk F, et al. Unusual findings in appendectomy specimens of adults: retrospective analyses of 1466 patients and a review of literature. Iran Red Crescent Med J. 2014;16(2):e12931.
2. Flum DR, Koepsell T. The clinical and economic correlates of misdiagnosed appendicitis: nationwide analysis. Arch Surg. 2002;137(7):799-804; discussion
3. Ferris M, Quan S, Kaplan BS, Molodecky N, Ball CG, Chernoff GW, et al. The Global Incidence of Appendicitis: A Systematic Review of Population-based Studies. Ann Surg. 2017;266(2):237-41.
4. Addiss DG, Shaffer N, Fowler BS, Tauxe RV. The epidemiology of appendicitis and appendectomy in the United States. Am J Epidemiol. 1990;132(5):910-25.
5. Carr NJ. The pathology of acute appendicitis. Ann Diagn Pathol. 2000;4(1):46-58.
6. Öznur U, Sadık Ç, Ülkü S, Hatice K, Ruslan A. The Seasonal Distribution of Appendicitis. 105505/sakaryamedj201616056. 2016;6:120-3.
7. Alirıza E, Hacı B. Annual and Seasonal Distribution of Acute Appendicitis in Adults. Firat Medical Journal. 2021;26(4):218-23.
8. Bundy DG, Byerley JS, Liles EA, Perrin EM, Katznelson J, Rice HE. Does this child have appendicitis? JAMA. 2007;298(4):438-51.
9. Rabah R. Pathology of the appendix in children: an institutional experience and review of the literature. Pediatr Radiol. 2007;37(1):15-20.
10. Di Saverio S, Podda M, De Simone B, Ceresoli M, Augustin G, Gori A, et al. Diagnosis and treatment of acute appendicitis: 2020 update of the WSES Jerusalem guidelines. World J Emerg Surg. 2020;15(1):27.
11. Maloney C, Edelman MC, Bolognese AC, Lipskar AM, Rich BS. The Impact of Pathological Criteria on Pediatric Negative Appendectomy Rate. J Pediatr Surg. 2019;54(9):1794-9.
12. Akbulut S, Tas M, Sogutcu N, Arikanoglu Z, Basbug M, Ulku A, et al. Unusual histopathological findings in appendectomy specimens: a retrospective analysis and literature review. World J Gastroenterol. 2011;17(15):1961-70.

13. Anderson JE, Bickler SW, Chang DC, Talamini MA. Examining a common disease with unknown etiology: trends in epidemiology and surgical management of appendicitis in California, 1995-2009. World J Surg. 2012;36(12):2787-94.
14. Ohmann C, Franke C, Kraemer M, Yang Q. [Status report on epidemiology of acute appendicitis]. Chirurg. 2002;73(8):769-76.
15. Finkelstein P, Picado O, Muddasani K, Wodnicki H, Mesko T, Unger S, et al. A Retrospective Analysis of the Trends in Acute Appendicitis During the COVID-19 Pandemic. J Laparoendosc Adv Surg Tech A. 2021;31(3):243-6.
16. Baldisserotto M, Marchiori E. Accuracy of noncompressive sonography of children with appendicitis according to the potential positions of the appendix. AJR Am J Roentgenol. 2000;175(5):1387-92.
17. Benjaminov O, Atri M, Hamilton P, Rappaport D. Frequency of visualization and thickness of normal appendix at nonenhanced helical CT. Radiology. 2002;225(2):400-6.
18. Burak K, Ali A, Hamza C. The effect of appendix diameter on perforation in acute appendicitis cases. Cumhuriyet Medical Journal. 2019;41(2):392-7.
19. Webb EM, Wang ZJ, Coakley FV, Poder L, Westphalen AC, Yeh BM. The equivocal appendix at CT: prevalence in a control population. Emerg Radiol. 2010;17(1):57-61.
20. Pickhardt PJ, Suhonen J, Lawrence EM, Munoz del Rio A, Pooler BD. Appendiceal length as an independent risk factor for acute appendicitis. Eur Radiol. 2013;23(12):3311-7.
21. Dibekoglu C. Does the length matter in acute appendicitis for the perforation risk?: A retrospective cohort study. Medicine (Baltimore). 2022;101(48):e32001.
22. Monajemzadeh M, Hagghi-Ashtiani MT, Montaser-Kouhsari L, Ahmadi H, Zargoosh H, Kalantari M. Pathologic evaluation of appendectomy specimens in children: is routine histopatholgic examination indicated? Iran J Pediatr. 2011;21(4):485-90.
23. Mansueto P, Iacono G, Seidita A, D'Alcamo A, Sprini D, Carroccio A. Review article: intestinal lymphoid nodular hyperplasia in children--the relationship to food hypersensitivity. Aliment Pharmacol Ther. 2012;35(9):1000-9.
24. Buyukbese Sarsu S, Ucak R, Buyukbese MA, Karakus SC, Deniz H. Unusual Histopathological Findings in Childhood Appendectomy Specimens. Indian J Surg. 2015;77(Suppl 2):594-9.
25. Xu Y, Jeffrey RB, DiMaio MA, Olcott EW. Lymphoid Hyperplasia of the Appendix: A Potential Pitfall in the Sonographic Diagnosis of Appendicitis. AJR Am J Roentgenol. 2016;206(1):189-94.
26. Aydin S, Tek C, Ergun E, Kazci O, Kosar PN. Acute Appendicitis or Lymphoid Hyperplasia: How to Distinguish More Safely? Can Assoc Radiol J. 2019;70(4):354-60.
27. Sulu B, Gunerhan Y, Palanci Y, Isler B, Caglayan K. Epidemiological and demographic features of appendicitis and influences of several environmental factors. Ulus Travma Acil Cerrahi Derg. 2010;16(1):38-42.
28. Deng Y, Chang DC, Zhang Y, Webb J, Gabre-Kidan A, Abdullah F. Seasonal and day of the week variations of perforated appendicitis in US children. Pediatr Surg Int. 2010;26(7):691-6.
29. Yalcin B, Karnak I, Orhan D, Oguz B, Aydin B, Kurucu N, et al. Paediatric appendiceal neuroendocrine tumours: a review of 33 cases from a single center. ANZ J Surg. 2022;92(4):742-6.
30. Tchana-Sato V, Detry O, Polus M, Thiry A, Detroz B, Maweja S, et al. Carcinoid tumor of the appendix: a consecutive series from 1237 appendectomies. World J Gastroenterol. 2006;12(41):6699-701.
31. Ahmed MU, Bilal M, Anis K, Khan AM, Fatima K, Ahmed I, et al. The Frequency of Enterobius Vermicularis Infections in Patients Diagnosed With Acute Appendicitis in Pakistan. Glob J Health Sci. 2015;7(5):196-201.
32. Park NH, Oh HE, Park HJ, Park JY. Ultrasonography of normal and abnormal appendix in children. World J Radiol. 2011;3(4):85-91.
33. Misdraji J, Graeme-Cook FM. Miscellaneous conditions of the appendix. Semin Diagn Pathol. 2004;21(2):151-63.
34. Kim CJ, Chung HY, Kim SY, Kim YO, Ryu SY, Kim JC, et al. Acute appendicitis in Henoch-Schonlein purpura: a case report. J Korean Med Sci. 2005;20(5):899-900.
35. Sesia SB, Mayr J, Bruder E, Haecker FM. Neurogenic appendicopathy: clinical, macroscopic, and histopathological presentation in pediatric patients. Eur J Pediatr Surg. 2013;23(3):238-42.
36. Dincel O, Goksu M, Turk BA, Pehlivanoglu B, Isler S. Incidental Findings in Routine Histopathological Examination of Appendectomy Specimens; Retrospective Analysis of 1970 Patients. Indian J Surg. 2018;80(1):48-53.