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ORIGINAL ARTICLE

Clinical characteristics of appendiceal diverticular disease

Ekrem Çakar[1] · Savaş Bayrak[1] · Şükrü Çolak[1] · Fatih Dal[1,2] · Bünyamin Gürbulak[1] · Hasan Bektaş[1] · Enver Yarıkkaya[3] · Ayşe Gül Ferlengez[4]

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Abstract

Background Appendiceal diverticular disease (ADD) is a rare pathology which is associated with an increased mortality risk due to rapid perforation and high rates of neoplasm. In our study, we aimed to evaluate the clinical and histopathological characteristics of ADD with differences from acute appendicitis (AA) diagnosis and to determine the association with neoformative processes.

Methods The 4279 patients who underwent appendectomy were evaluated retrospectively. ADD patients histopathologically classified into four groups. Patients' demographic characteristics, imaging and preoperative laboratory findings, additionally postoperative histopathology results were compared between groups.

Results The prevalence of ADD was 2.29% (n = 98). In addition, the male/female ratio was 2.37 in ADD patients who were found to be significantly older than those with AA patients. Type III was the most frequently (62.2%) identified sub-group of ADD. The incidence of neoplasms, plastrone, and Littre's hernia was found statistically higher in ADD group than AA group. Mucinous adenomas (10.2%) was the most common neoplasm while the carcinoid tumor (1%) and precancerous serrated adenomas (4.1%) were also reported.

Conclusions As a result, high neoplasm in ADD patients can be shown with incidence of perforation and plastron, and in order to avoid possible neoplasm or major complications, it is necessary to carry out new studies for the right diagnosis of ADD whether the diagnosis is done preoperatively or ıntraoperatively. We recommend surgical resection of the ADD, which may even be incidentally detected during any surgical procedure, due to its high risk of neoplasm and rapid perforation.

Keywords : Appendiceal diverticular disease · Acute appendicitis · Neoplasm · Appendiceal neoplasm · Appendectomy

✉ Fatih Dal
fatihdal07@gmail.com

Ekrem Çakar
ekremcakar@hotmail.com

Savaş Bayrak
savasbayrak74@gmail.com

Şükrü Çolak
sukrucolak2@gmail.com

Bünyamin Gürbulak
bgurbulak@gmail.com

Hasan Bektaş
hasanbektas3417@hotmail.com

Enver Yarıkkaya
enveryerlikkaya@gmail.com

Ayşe Gül Ferlengez
aysegulsoylemez@yahoo.com

[1] Department of General Surgery, Health Sciences University Turkish Ministry of Health İstanbul Research and Training Hospital, İstanbul, Turkey

[2] Istanbul, Turkey

[3] Department of Pathology, Health Sciences University Turkish Ministry of Health İstanbul Research and Training Hospital, İstanbul, Turkey

[4] Department of Anaesthesiology, Health Sciences University Turkish Ministry of Health İstanbul Research and Training Hospital, İstanbul, Turkey

Introduction

Appendiceal diverticular disease (ADD) is an extremely rare pathology which represents about 0.004–2.1% of all appendectomies, and 0.2–0.66% of autopsy specimens [1, 2]. ADD is frequently acquired pseudodiverticula, resulting from mucosal herniation of weak muscularis propria with unknown etiology [2, 3]. Increased intraluminal pressure most commonly due to obstruction (benignant or malignant) or inflammation may predispose to the ADD formation in weak areas of the appendiceal vascular walls [2, 4].

Similar clinical presentation of AA with typical or atypical (normal fever or normal laboratory) symptoms and absence of pathognomonic findings usually causes an incidental diagnose of ADD after surgery [5]. However, some researchers have highlighted that diverticular disease can be distinguish from AA by higher rate of complications particularly rapid perforation, increased prevalence in older age and male gender, and late diagnosis due to insidious processes [6].

Recently, ADD has been associated with higher risk of various neoformative processes in particularly; intestinal carcinoid tumors (neuroendocrine tumors) and mucinous adenomas [2, 7]. An accurate diagnosis and effective management of operative approach is vital because of the complications that increase mortality, such as rapid progression to perforation and higher risk of appendicial neoplasm in patients with ADD [8]. Therefore, we aimed to evaluate the clinical and histopathological characteristics of ADD with differences from AA diagnosis and to determine the possible associations with neoformative processes.

Materials and Methods

This study was performed in Istanbul Training and Research Hospital, Department of Surgery between January 2006 and December 2017. Total number of 4279 patients who underwent appendectomy were evaluated retrospectively in this study. Patients' demographic characteristics, imaging, and preoperative laboratory findings, in addition postoperative (laparoscopic or open appendectomy) histopathology results were evaluated and compared between ADD and AA groups.

Patients presented with appetite loss, nausea, and vomiting. The clinical findings which included right lower abdominal pain and rebound tenderness and localized and diffused rigidity of the abdominal wall were evaluated. The final diagnosis was based on the histopathologic assessment. ADD patients histopathologically classified into four groups according to the definition of Lipton S. et al. In addition, Type I, II, and III subtypes were re-grouped as being with or without perforation [9].

Type I. Acute diverticulitis with a normal appendix,
Type II. Acute diverticulitis with acute appendicitis,
Type III. Non-inflamed diverticulum with appendicitis, and
Type IV. Non-inflamed diverticulum with a normal appendix.

Statistical analysis

All the data were analyzed with SPSS (Statistical Package for the Social Sciences) software for Windows (v21.0; IBM, Armonk, NY, USA). Individual and aggregate data were summarized using descriptive statistics including mean, standard deviations, medians (min-max), frequency distributions, and percentages. Normality of data distribution was verified by Kolmogorov-Smirnov test. Comparison of the variables with normal distribution was made with Student's *t* test. The variables which were not normally distributed, the Mann Whitney and Kruskal Wallis tests, were conducted to compare between groups. Evaluation of categorical variables was performed by chi-squared test. *P* values of < 0.05 were considered statistically significant.

Results

The 4279 patients included in this study were 2533 (59.2%) male and 1746 (40.8%) female and the mean age of all patients was 34.65 ± 12.89 (ranged = 11–95) years. The overall prevalence of ADD was 2.29% ($n = 98$) in our study sample. The patients diagnosed with ADD ($n = 98$) in this study were 69 (70.4%) male and 29 (29.6%) female (male/female ratio = 2.37) and the mean age of ADD patients was 39.97 ± 14.62 years. Thus, ADD patients were found to be significantly older age than patients with AA ($p = 0.014$) (Table 1).

The average duration of preoperative symptoms was 44.43 ± 17.98 h (mean = 1.85 days) (ranged = 18–90 h) in ADD group. In histopathological analysis, type III was the most frequent subtype of ADD with the rate of 62.2% and followed by type II (22.4%), type I (12.2%), and type IV (3.1%), respectively. Moreover, the mean duration of symptoms was significantly shorter in type III sub-group than other subtypes of ADD ($p = 0.000$) (Figs. 1 and 2) (Table 2).

In our study, according to the evaluation of laboratory outcomes, the mean white blood cells (WBC) and neutrophil count was $13.78 \times 10^3/\mu L$ and $10.48 \times 10^3/\mu L$ in the AA group respectively, whereas in ADD group was $12.35 \times 103/\mu L$ and $9.42 \times 103/\mu L$. Thus, the mean WBC and neutrophil count measured in the AA group was statistically higher than

Table 1 Distribution of AA and ADD patients according to the age and gender

		n (%)	Age (mean ± SD)	*p* value	*p* value
AA	Female	1714 (41.0)	35.43 ± 13.71	0.054	0.014*
	Male	2467 (59.0)	33.97 ± 12.19		
	Total	4181 (97.71)	34.57 ± 12.85		
AD	Female	29 (29.6)	41.72 ± 16.23	0.607	
	Male	69 (70.4)	39.23 ± 13.95		
	Total	98 (2.29)	39.97 ± 14.62		
Total sample	Female	2533 (59.2)	34.06 ± 12.22	0.061	
	Male	1746 (40.8)	35.50 ± 13.76		
	Total	4279	34.65 ± 12.89		

p value = results of the Mann-Whitney *U* analysis between the total mean ages of the AA and AD groups; *$p < 0.05$ statistically significant

the ADD group (*p* values = 0.008 and 0.040 respectively) (Table 3).

Upon examining preoperative radiology (ultrasonography, computed tomography) and intraoperative surgery reports, it was determined that neither surgeons nor radiologists could clearly make an ADD (*n* = 98) diagnosis.

The incidence of perforated appendicitis was found as 5.1% (*n* = 218) in patients with AA; perforation rate increased to 7.1% (*n* = 6) with the presence of diverticulum (*p* = 0.459) (1.458 OR^2 , 0.579–3.670%95 CI) (Table 4). Additionally mean duration of symptoms was found statistically longer in ADD patients with perforation (70.00 ± 11.66 h) than not perforated ADD paients (41.79 ± 16.41 h) (*p* = 0.001).

Overall prevalence of plastrone appendicitis was 0.1 % (*n* = 5) in our study. Of these, 3 (0.1%) were in the AA group and 2 (2.9%) were reported in patients with diverticulum (Table 4). Thus, the prevalence of plastrone appendicitis detected in the ADD group was statistically higher than AA group (*p* = 0.004) (16.275 OR^2 , 1.672–158.455%95 CI). Besides, elective resection was recommended for patients with plastrone appendicitis after 3 months of medication, and 1 patient was evaluated as mucinous neoplasia postoperatively.

In this study, Littre's hernia was observed in 6 patients (0.2%). Of these, 5 (0.2%) were reported in AA group and 1 (1.4%) were in the ADD group. Therefore, prevalence of Littre's hernia observed in the ADD group was statistically higher than AA group (*p* = 0.013) (9.759 OR^2 , 1.125–84.655%95 CI). Furthermore, 1 ADD patient with Littre's hernia was diagnosed with mucinous neoplasm after appendectomy.

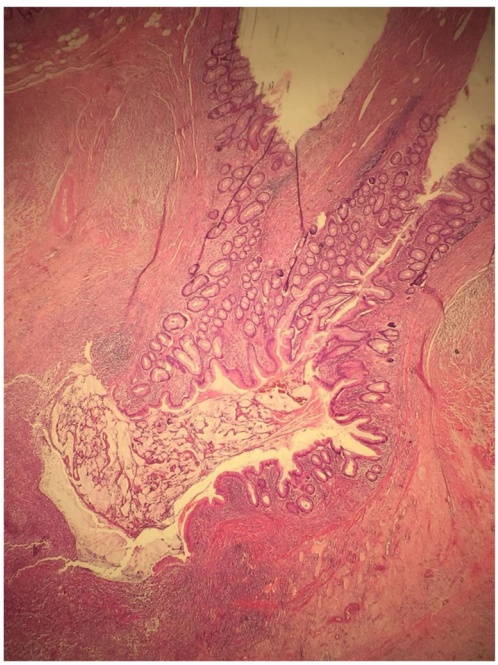

Fig. 1 Histological section of appendiceal diverticulum at the tip of the appendix (H&E stain, magnification × 40)

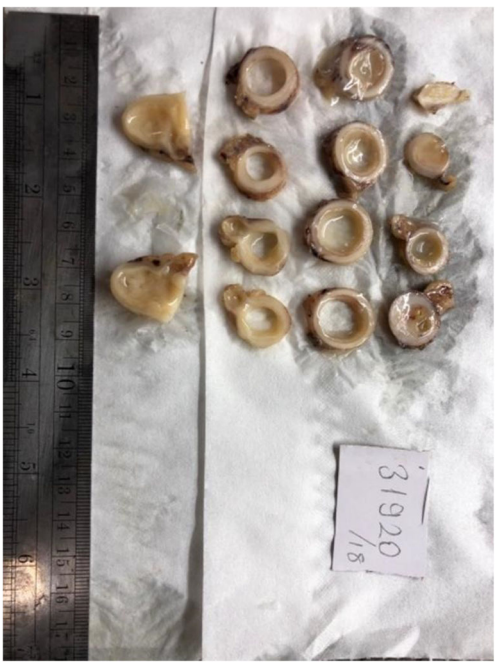

Fig. 2 Macroscopic view of appendiceal diverticulum and low-grade mucinous neoplasm

Table 2 Histopathological classification of ADD patients

Histopathogical group	*n*	%	Symptom duration (h) mean ± SD	*p* value
Type I	12	12.2	68.89 ± 13.78	0.000*
Type II	22	22.4	62.00 ± 8.71	
Type III	61	62.2	36.70 ± 13.60	
Type IV	3	3.1	42.50 ± 7.77	

*$p < 0.05$ statistically significant

In the present study, the prevalence of neoplasm-associated lesions was 1.02% ($n = 45$) in AA group, and the incidence of neoplasms associated with ADD was 15.3% ($n = 15$) (Table 4). Thus, the incidence of neoplasms was found to be statistically higher in patients with ADD than in AA patients ($p = 0.000$) (9.760 OR^2 , 4.195–22.708%95 CI). Ten (10.2%) of these ADD-associated lesions were histopathologically identified as low-grade mucinous neoplasm and 1 (1%) as carcinoid tumor, and 4 (4.1%) patients were documented serrated adenoma (Table 5). Moreover type I has been significantly associated with higher incidence of neoplasms compared to the other subtypes of ADD ($p = 0{,}000$). In addition, the duration of symptoms in neoplasm-associated patients was found to be significantly longer (63.46 ± 13.18 h) than patients without neoplasm ($p = 0.000$). Furthermore, perforation was reported in 16.3% ($n = 7$) of the neoplasm-associated group and in 5% ($n = 167$) of the group without neoplasm in all patients of our study. Therefore, the presence of neoplasm was significantly associated with higher perforation risk ($p = 0.001$).

Discussion

The rare prevalence, insidious progression, asymptomatic or AA-like clinical presentation as well as rapid perforation, and more importantly, the harboring of the neoplastic processes of the appendiceal diverticulum, further complicate the management of the disease. Therefore, as a result of accurate management by clinical and histopathological evaluation, the appropriate treatment, which is guided by rapid and reliable diagnosis, is crucial in ADD [2, 10]. Thus, it would be more appropriate to focus on the distinction of AA in the initial clinical presentation of the patient. Although they have similar clinical presentation with AA, ADD has been associated with male gender and older age (> 30 years) in addition long-term recurrent moderate type abdominal pain [1]. Yamana I. et al. reported that ADD (TipI) patients (42.7 ± 15.4) were significantly older ($p = 0.009$) than patients with AA (29.1 ± 17.7) in their retrospective study conducted with 378 AA ve 12 ADD (TipI) patients [11]. Similarly, Lobo-Machín I. et al. documented significantly greater age (37.24 ± 19.98 vs. 54.81 ± 17.55 years, $p < 0.001$) and 2 times higher prevalence of male gender in ADD patients ($n = 27$) compared to the AA ($n = 54$) patients [6]. Supportively in our study, ADD patients were significantly older than AA patients, and the male/female ratio was 2.37 in patients with ADD.

The prevalence of ADD was reported to be between 0.2 and 2.1% in the published data, and also up to 2.6% in some surgical series [5, 12]. Chan DL. et al. reported ADD prevalence of 2.1% ($n = 57$) in a retrospective study with participation of 2711 patients between 2004 and 2007 years [13]. Martínez et al. documented an incidence of 2.49% ADD ($n = 38$) in a study performed with 2058 appendectomy series [1]. In accordance with these data, the overall prevalence of ADD was 2.29% in the present study.

In published data, type I has been documented as the most common subtype of ADD [14]. On the contrary, Marcacuzco et al. noted type I and type II as the most frequent ADD-subtypes with an equal rate of 33.3%, followed by type III (28.6%) in their study conducted with 7044 appendectomy series and 42 ADD-diagnosed patients between 2003 and 2013 years [8]. In another study consisted of 38 ADD-diagnosed patients, type II was the most common subtype

Table 3 Comparison of laboratory outcomes between AA and ADD groups

Laboratory results	AA mean ± SD	AD mean ± SD	Total mean ± SD	*p* value
WBC ($\times 10^9$/L)	13.78 ± 4.38	12.35 ± 3.60	13.75 ± 4.37	0.008*
Neutrophil ($\times 10^9$/L)	10.48 ± 4.25	9.42 ± 3.73	10.46 ± 4.25	0.040*
Lymphocyte ($\times 10^9$/L)	2.18 ± 1.56	2.10 ± 1.08	2.18 ± 1.55	0.504
PLN/LYM	7.00 ± 6.61	6.19 ± 5.76	6.98 ± 6.59	0.147
PLT ($\times 10^9$/L)	254.45 ± 72.30	245.22 ± 58.44	254.26 ± 72.05	0.292
MPV (fL)	8.30 ± 1.14	8.36 ± 1.25	8.30 ± 1.14	0.664

*$p < 0.05$ statistically significant

Table 4 Histopathologic characteristics of AA and ADD patients

Clinical variables	AA % (*n*)	AD % (*n*)	*p* value	OR[2]	%95 CI[3]
Perforation	5.1 (218)	7.1 (6)	0.459	1.458	0.579–3.670
Plastrone	0.1 (3)	2.9 (2)	*0.004**	16.275	1.672–158.455
Neoplasm	1.02 (45)	15.3 (15)	*0.000**	9.760	4.195–22.708

*$p < 0.05$ statistically significant

with a prevalence of 32.2%, followed by type I (28.9%) and type III (21.05%), respectively [1]. Thus, the published data particularly available on prevalence of ADD-subtypes appears to be conflicting. In present study type III was the most frequent subtype of ADD with the rate of 62.2%. To explain these differences in literature, it is necessary to do additional etiological research. Besides, Al-Brahim et al. reported a mean symptom duration of 3 days in a study consisted of 25 ADD patients, while Sohn et al. documented 3.6 ± 3.8 days with 38 ADD-diagnosed patients [4, 5]. In our study, mean duration of symptoms seems to be shorter (1.85 days) than published data, moreover significantly shorter mean duration of symptoms observed in type III ADD-patients. These findings supported the late clinical presentation of our patients.

Laboratory tests are widely available, simple, minimally invasive, and cost-effective markers that suggest potential benefits for preoperative differentiation of ADD. Although laboratory findings achieved clinically inadequate sensitivity and specificity, combination of the patient clinical characteristics and positive examination findings such as age and perforation state would improve diagnostic value in ADD. Yamana et al. found statistically lower leukocyte count in ADD-patients (n = 12) than patients with AA (n = 378) (11332 ± 4658 vs. 14236 ± 3861; p = 0.011). In addition, researchers reported a higher prevalence of perforation in AD patients [11]. Similarly, Al-Brahim et al. documented statistically lower leukocyte count and higher perforation rate in ADD patients than AA patients [4]. Supportively, Martínez JT. et al. reported a rate of 7.89% perforated diverticulum in 1526 appendectomies [1]. In addition, unlike acute appendicitis, higher incidence of plastrone documented in diverticular disease is also noteworthy. Supportively Lobo-Machín et al. observed statistically higher rates of plastrone appendicitis (p = 0.01, odds ratio 2.2) in ADD patients in a study consisted of 54 AA and 27 ADD patients [6]. In our study, consistent with these mentioned outcomes, the mean leukocyte and neutrophil count measured in the ADD group was statistically lower and plastrone appendicitis prevalence detected in the ADD group was statistically higher than the AA group. Additionally in the present study, although it was not statistically significant, numerically higher rate of perforation (7.1% vs. 5.1%) was observed in ADD group.

Table 5 Distribution of neoplasms in AA and ADD cases

Distribution of neoplasm	AD *n* (%)	AA *n* (%)
Low-grade mucinous neoplasm	*10 (10.2)*	15 (0.34)
Carcinoid tumor	*1 (1.0)*	18 (0.41)
Low-grade tubular adenoma	-	1 (0.02)
Musical	-	2. (0.04)
Sessile serrated adenoma	4 (4.1)	8 (0.18)
Colon carcinoma	-	1 (0.02)

There is a limited number of published data on association between appendiceal diverticulosis and neoformative processes. Chan et al. have highlighted that the risk of appendicular neoplasm increases more than 10 times in patients with ADD [13]. In a study of Dupre et al., appendiceal neoplasms were revealed in 47.8% of 23 ADD cases in 1361 appendectomies, while Kallenbach et al. significantly related appendiceal neoplasm with 43.6% of 39 ADD cases after 4413 appendectomy. Moreover, neoplasm association was reported as low as 2.1% and 1.2% respectively in non-ADD patients of these studies [7, 15]. Additionally, Marcacuzco et al. revealed neoplasm association in 7.1% of 42 ADD-diagnosed patients after 7044 appendectomies [8]. Similarly in our study, the incidence of neoplasms associated with ADD was 15.3% in 4279 appendectomies, and the neoplasms prevalence was found to be statistically higher in patients with ADD than in AA patients. It has been also demonstrated that the perforation rate was significantly increased with the presence of neoplasm. Furthermore for the first time, to our knowledge, type I has been significantly associated with higher incidence of neoplasms compared to the other subtypes of ADD.

Particularly in the cases of ADD associated with neoformative processes, high rates of carcinoid tumor and mucinous adenoma are documented [16, 17]. Lamps et al. noted appendiceal diverticula in 8 of 19 low-grade mucinous neoplasms (42%) in 38 appendectomies and highlighted the significantly higher percentage ($p < 0.001$) of cases associated with appendiceal neoplasms [18]. Pasaoglu et al. reported that 60% of 20 low-grade mucinous neoplasms were accompanied by ADD diagnosis in 1922 appendectomies [19]. In another study, Dupre et al. evaluated appendiceal neoplasms including 5 well-differentiated neuroendocrine tumors (carcinoids), 3 mucinous adenomas, 2 adenocarcinomas, and 1 tubular adenoma in 47.8% of 23 ADD cases [7]. In addition, precancerous serrated adenomas have been documented in 5.12% of 39 ADD patients in the study of Kallenbach et al

[15]. In accordance with published data in present study, mucinous adenomas (10.2%) was the most common neoplasm in ADD-diagnosed patients followed by carcinoid tumor (1%) and precancerous serrated adenomas (4.1%), respectively. In other respects, an ADD-case with Littre's hernia who was diagnosed with mucinous neoplasia after appendectomy and another ADD-case with plastrone appendicitis diagnosed also with mucinous neoplasia after elective appendectomy is remarkable in terms of operative approach in patients with appendiceal diverticulosis.

The rarely seen preoperative ADD diagnosis is an important matter of debate in literature. Majeski J. [19] was not able to make a diagnosis despite of history, physical examination, imaging, endoscopy, barium enema, enteroclysis, and laboratory results and applied laparoscopic appendectomy to 6 patients complaining about chronic abdominal pain. After laparoscopic appendectomy, the abdominal pain was improved in all patients, and histopathologic examination revealed ADD (type IV) single diverticulum extending to the mesoappendix. Yamana I. et al. [11] diagnosed 4 of 12 patients with ADD (type I) preoperatively. When appendiceal diverticular disease (ADD type I), which has a high risk of perforation, is detected by ultrasound, they suggest appendectomy even if there is no severe abdominal pain. Lee KH et al. [20] reported contrast-enhanced abdominal computed tomography (CT) results of 20 patients diagnosed with appendiceal diverticular disease (ADD type I). The CT results showed that of the patients with diverticulitis, 80% showed a cystic sac with contrast enhancement. However, they reported false positive results in 50% of patients in this study. Odasa et al. [21] examined the multidetector computed abdominal tomography (MDCT) results of 7 pathologically diagnosed patients with appendiceal diverticular disease (ADD type I). Screenings showed diverticulitis in 6 out of 7 patients, with thick, enlarged walls, masses of fluid in the lumen, and enlarged solid protrusions from the joint. They detected normal diverticulitis in one patient. They reported that MDCT has diagnostic potential in the diagnosis of preoperative appendiceal diverticular disease. Ito D. et al. [22] examined the computed abdominal tomography (CT) of 25 patients with type IV ADD, whose pathological results were known and determined appendiceal diverticular disease in 6 patients (24%). As can be seen, the literature focuses on appendiceal diverticular disease (ADD type IV) in patients with known pathological diagnosis. There is insufficient information in terms of radiological evaluations before pathological diagnosis. A preoperative ADD diagnosis may reduce the risk for perforation, plastron, and neoplasia. In the present study, preoperative radiology and intraoperative surgical reports of all patients were evaluated as AA without histopathological results being known.

It was difficult for the surgeons to distinguish between preoperative AA and appendiceal neoplasms. Jia Lin Ng. et al. [2] reported that it is difficult to distinguish between primary adenocarcinoma of the appendix (PAA) and ADD and that, although rarely, surgeons and pathologists are not aware of the relationship between ADD and PAA. For the evaluation of regional appendiceal lymphatics, they recommended the excision of the entire mesoappendix. Some centers however say that the mesoappendix should be left behind [23, 24]. As seen in the literature, researchers agree on appendectomy. But the real question is, should the mesoappendix be excised or not excised during a surgical intervention? Due to the preoperative and intraoperative difficulties and risk of neoplasm in the diagnosis of AA and ADD, we recommend to excise the mesoappendix while performing appendectomy.

The most important limitation of this study is that it is based on retrospective histopathological data due to the rarity of ADD and difficulties in intraoperative and preoperative diagnosis.

In conclusion, high neoplasm in ADD patients can be shown with incidence of perforation and plastron, and in order to avoid possible neoplasm or major complications, it is necessary to carry out new studies for the right diagnosis of ADD whether the diagnosis is done preoperatively or ıntraoperatively. Particularly, characteristics and duration of the pain in patients with older age are unconfirmed AA diagnosis should increase the awareness for ADD. We recommend surgical resection of the ADD, which may even be incidentally detected during any surgical procedure, due to its high risk of neoplasm and rapid perforation. We also recommend an interval appendectomy for patients with plastrone appendicitis.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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