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ORIGINAL ARTICLE

Medicine Science International Medical Journal

Medicine Science 2026;15(1):135-40

Incidence of malignancy in appendiceal surgical specimens: A retrospective single-center study

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Received 29 June 2025; Accepted 23 July 2025
Available online 20 February 2026 with doi: 10.5455/medscience.2025.06.176

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Abstract

Appendiceal neoplasms are rare entities often discovered incidentally in patients undergoing surgery for acute appendicitis. Accurate identification is critical due to differing prognoses and management strategies. This retrospective single-center study analyzed 2802 adult patients who underwent appendectomy for suspected acute appendicitis between January 2015 and May 2025. Demographics, surgical approach, histopathological findings, and tumor characteristics were evaluated. Of the 2802 patients, 0.7% were diagnosed with neuroendocrine tumors (NETs), 0.4% with low-grade appendiceal mucinous neoplasms (LAMNs), and 0.1% with adenocarcinomas. Patients with LAMNs and adenocarcinomas were older (mean age >50 years), whereas NETs were more common in younger patients (mean age 33.5 years). Most NETs were well-differentiated, Grade 1, with Ki-67 index <3%. LAMNs showed no invasive features, though acellular mucin was present in deeper layers. Adenocarcinoma cases demonstrated high-risk features including deep invasion, positive margins, and lymphovascular involvement. Appendiceal neoplasms, though uncommon, display significant variation in age distribution, histological features, and malignant potential. Routine histopathological examination of appendectomy specimens remains essential. Our study shows that careful pathological examination of appendectomy specimens is important to detect rare but invasive tumors.

Keywords: Acute appendicitis, appendiceal carcinomas, incidental lesions, retrospective study

Introduction

Acute appendicitis is the leading cause of abdominal pain in the emergency setting and appendectomy is the most commonly performed emergency surgical procedure [1–3]. Appendectomy is widely accepted as the first-line treatment for acute appendicitis in the absence of abscess formation or generalized peritonitis. Appendiceal tumors are rare and are most often diagnosed incidentally during histopathological examination of resected appendectomy specimens. They are seldom suspected prior to or even during surgery [1,3–5].

Although rare, the presence of appendiceal tumors highlights the critical role of routine histopathological examination of all surgical specimens and are found in approximately 1% of appendectomy specimens [6]. Globally, the incidence of appendiceal neoplasms ranges from 0.2% to 2.5%, while in Türkiye it has been reported to be approximately 0.78% [3,6].

Low-grade appendiceal mucinous neoplasms (LAMNs) account for about 0.5–1.7% of all appendectomy specimens—most estimates place their incidence around 0.5%, with large series reporting rates from 0.13% up to 0.7%—and they carry a risk of pseudomyxoma peritonei if mucin escapes into the peritoneal cavity [7].

Neuroendocrine tumors (NETs) are the most common type of appendix neoplasms, and according to recent data, appendiceal NETs occur in 0.3–0.9% of appendectomy specimens and account for 0.16–2.3% of all appendectomies for acute appendicitis [8]. In a 30-year retrospective series, the incidence rate was another 0.47%, with a median patient age of 21.5 years [9].

CITATION
Agirman E, Bingol F, Peksoz R, et al. Incidence of malignancy in appendiceal surgical specimens: A retrospective single-center study. Med Science. 2026;15(1):135-40.

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DOI: 10.5455/medscience.2025.06.176

Material and Methods

Approval for this study in accordance with Declaration of Helsinki was obtained from the Ethics Committee of Erzurum Atatürk University Faculty of Medicine. This study was designed as a retrospective single-center study. Data from 2802 patients who underwent open or laparoscopic appendectomy between January 2015 and May 2025 in the Department of General Surgery, Atatürk University. Inclusion criteria were: Being ≥18 years old, histopathological diagnosis after appendectomy data availability prior to surgery. Age, gender, operation type and postoperative pathological reports were recorded. After evaluation of pathological reports, results were classified as benign, low grade appendiceal mucinous neoplasm (LAMN) and malignant diseases.

Descriptive statistics were used to analyze patient age. The results are presented as mean and standard deviation, as the age variable showed a normal distribution. To illustrate demographic patterns across tumor subtypes, box-and-swarm plots were created to display age distribution by gender and pathology group (NET, LAMN etc.). Data visualization was performed using Python (Seaborn/Matplotlib libraries).

Result

A total of 2802 patients underwent appendectomy were included to the study (Figure 1). Demographic features and operation types according to disease pathologies are shown in Table 1. There were 1586 (56.7%) female and 1216 (43.3%) male, with a mean age of 35.3±15.0 years. Of the 2802 patients included in the study, 2338 (83.4%) underwent open appendectomy and 464 (16.6%) underwent laparoscopic appendectomy. Histopathological examination revealed that 2770 cases (98.8%) were benign, 9 (0.4%) were LAMN, and 23 (0.8%) were malignant (Table 1).

A total of 9 patients (0.4%) were diagnosed with LAMN. The mean age in this group was higher than the overall cohort (54.0±14.9 years). Most tumors were localized to the distal appendix, and tumor sizes ranged from 5 mm to 25 mm. In several cases, acellular mucin was identified within the muscularis propria, subserosa, or mesoappendix; however, serosal involvement or extra-appendiceal mucin spread was uncommon. All surgical margins were negative, and no lymphovascular or perineural invasion was observed. Nine patients were operated on; 5 underwent open procedures and 4 underwent laparoscopic procedures. Histopathology results indicated that right hemicolectomy was planned for 3 patients (Table1,2).

As presented in Table 3, 20 patients (0.7%) were diagnosed with appendiceal neuroendocrine tumors (NET), with a mean age of 33.5 years (range: 18–60). All NET cases underwent appendectomy, with 18 patients (90%) treated by open surgery and 2 (10%) by laparoscopy. According to histopathology findings, right hemicolectomy was planned for 3 patients. The tumors were predominantly well-differentiated (n=16, 80%) and classified as Grade 1 (n=17, 85%), with the remaining being Grade 2 or unspecified. The tumors were mostly located in the distal appendix (n=10, 50%) or subserosa, with sizes ranging from 2 mm to 45 mm. Depth of invasion extended to the subserosa in 11 patients (55%) and to the muscularis propria in 3 patients (15%), while serosal involvement was observed in 1 patient. Surgical margins were negative in 19 cases (95%). Lymphovascular invasion was reported in 3 patients (15%), and perineural invasion in 4 patients (20%). The Ki-67 index was <3% in the majority of cases, consistent with low proliferative activity.

Based on the findings summarized in Table 4, 3 patients (0.1%) were diagnosed with appendiceal adenocarcinoma. The mean age in this group was 56 years (range: 44–66). Histopathological subtypes included two mucinous adenocarcinomas and one well-differentiated (non-mucinous) adenocarcinoma. Lymphovascular invasion was observed in two patients, and perineural invasion was noted in one. Additionally, one case demonstrated macroscopic tumor perforation. According to histopathology findings, right hemicolectomy was planned for 3 patients.

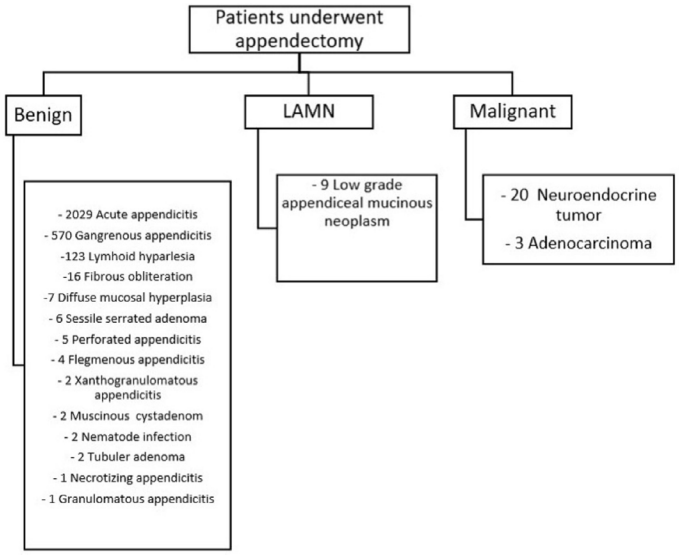

Figure 1. Distribution of histopathological findings

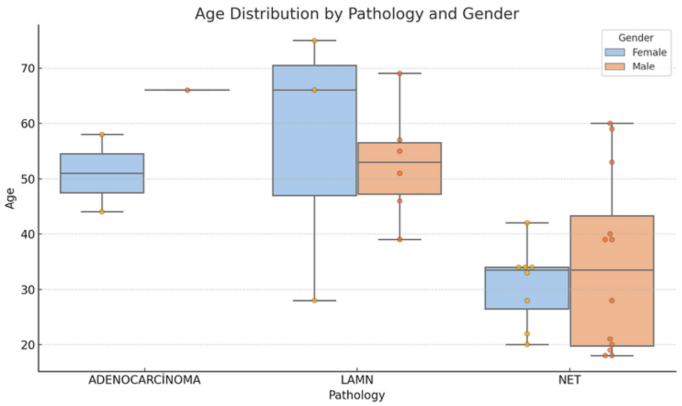

Figure 2. Age distribution by pathology and gender

DOI: 10.5455/medscience.2025.06.176

Table 1. Demographic and pathological distribution of the patients

Histopathological Groups	Benign (%) n=2770 (98.8)	LAMN (%) n= 9 (0.4)	NET and Adenocancer (%) n=23 (0.8)
Gender (F/M), n (%)	1573 (56.7)/1197(43.3)	6 (66.6)/3(33.4)	13 (56.5)/10 (43.5)
Age, mean±SD	35.2±15.0	54.0±14.9	36.0±14.9
Operation type			
Open appendectomy	2313 (83.5)	5 (55.55)	21 (91.3)
Laparoscopic appendectomy	457 (16.5)	4 (44.45)	2 (8.7)

Low-grade appendiceal mucinous neoplasms, NET: Neuroendocrine tumors

Table 2. The histopathological results of the patients with low grade appendiceal mucinous neoplasm

Patients	Age	Operation Type	Histopathological findings
1	28	Open appendectomy	Tumor localization: Distal appendix Tumor size: 25 mm Microscopic Tumor Involvement: The tumor is confined to the appendix. Acellular mucin is observed dissecting through the muscularis mucosa and submucosa. There is no evidence of penetration into the muscularis propria, subserosa, or serosa. Surgical margins: Negative for tumor Lymphovascular invasion: Absent Perineural invasion: Absent
2	39	Laparoscopic appendectomy	Tumor localization: Distal appendix Tumor size: 5 mm Microscopic Tumor Involvement: Acellular mucin pools were observed in the subserosa/mesoappendix. No mucin extravasation to the serosal surface or beyond the appendix was identified. Surgical margins: Negative for tumor Lymphovascular invasion: Absent Perineural invasion: Absent
3	46	Laparoscopic appendectomy	Tumor localization: Distal appendix Tumor size: 23 mm Microscopic Tumor Involvement: Acellular mucin is present with invasion into the subserosa/mesoappendix and the visceral peritoneum (serosa), consistent with extra-appendiceal extension. Surgical margins: Negative for tumor Lymphovascular invasion: Absent Perineural invasion: Absent
4	51	Laparoscopic appendectomy	Microscopic Tumor Involvement: Acellular mucin is invading the muscularis propria. Surgical margins: Negative for tumor
5	55	Laparoscopic appendectomy	Tumor localization: Distal appendix Tumor size: 5 mm Microscopic Tumor Involvement: Acellular mucin pools are present in the subserosa/mesoappendix. No mucin extravasation to the serosal surface or outside the appendix is observed. Surgical margins: Negative for tumor Lymphovascular invasion: Absent Perineural invasion: Absent
6	57	Laparoscopic appendectomy	The tumor itself is non-invasive, the presence of acellular mucin on the visceral peritoneum.
7	66	Open appendectomy	The tumor itself is non-invasive, the presence of acellular mucin on the visceral peritoneum.
8	69	Open appendectomy	Surgical margins: Negative for tumor
9	75	Open appendectomy	Microscopic Tumor Involvement: Acellular mucin is present in the muscularis propria. No acellular mucin or mucinous epithelium is observed in the subserosa or serosa. Surgical margins: Negative for tumor Lymphovascular invasion: Absent Perineural invasion: Absent

Table 3. The histopathological results of the patients with appendiceal neuroendocrine tumors

Patients	Age	Gender	Operation type	Differentiation	Grade	Tumor Localization	Tumor size (mm)	Mitotic activity	Depth of invasion	Surgical Margin	Lymphovasculer invasion	Perineural invasion	Ki67
1	18	F	Open appendectomy	Well	G1	Distal	8	Absent	Muscularis propria	Negative	Absent	Absent	<1
2	18	F	Open appendectomy	Well	G1	-	18	0-1/2 mm^2	Subserosa	Negative	Absent	Present	1-2%
3	19	F	Open appendectomy	-	G1	-	11	-	Serosa	Negative	Present	present	-
4	20	M	Open appendectomy	Well	G1	Proximal	11	1/10 HPF	Subserosa	Negative	Absent	Absent	1-2%
5	20	F	Open appendectomy	-	-	-	8		Subserosa	Negative	Absent	-	-
6	21	F	Open appendectomy	-	G2	Distal	14	3/10	Subserosa		Absent	Present	5%
7	22	M	Open appendectomy	Well	G1	Distal	2	Absent	Subserosa	Negative	Absent	Absent	<1%
8	28	F	Open appendectomy	Well	G2	Tip	16	0-1/10	Muscularis propria	Negative	Absent	Absent	5%
9	28	M	Open appendectomy				2			Negative	Absent		
10	33	M	Laparoscopic appendectomy	Well	G1	Tip	14	<2/2mm^2	Subserosa	Negative	Absent		
11	34	M	Open appendectomy		G1		4	Absent		Negative	Absent	Absent	<1%
12	34	M	Open appendectomy		G1		15	1/10 BBA		Positive	Present	Present	
13	34	M	Open appendectomy	Well	G1	Distal	6	0-1/10 BBA	Muscularis propria	Negative	Absent	Absent	1%
14	39	F	Open appendectomy	Well	G1	Distal	8	1/10 BBA	Subserosa	Negative	Absent	Absent	1-2%
15	39	F	Open appendectomy		G2	Distal	5	1/10 BBA	Subserosa	Negative	Absent	Absent	4%
16	40	F	Open appendectomy	Well	G1		8	Absent					1-2%
17	42	M	Open appendectomy	Well	G1	Distal	8	1/10 BBA	Subserosa	Negative			
18	53	F	Open appendectomy	Well	G1	Tip	8		Subserosa	Negative		Absent	<3%
19	59	F	Laparoscopic appendectomy	Well	G1		45	0-1/10 BBA	Subserosa	Negative	Absent	Absent	1%
20	60	F	Open appendectomy	Well	G1	Distal	9		Subserosa	Negative	Absent	Absent	1%

DOI: 10.5455/medscience.2025.06.176

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Table 4. The histopathological results of the patients with appendiceal adenocarcinoma

Patients	Age	Gender	Open	Histopathological Subtype	Tumor size (mm)	Depth of invasion	Surgical margins	Lymphovasculer invasion	Perineural invasion	Macroscopic tumor perforation	Planning surgery
Patient 1	44	M	Open appendectomy	Mucinous adenocarcinoma	90	Serosa	Positive	Present	Absent	Present	Right hemicolectomy
Patient 2	58	M	Open appendectomy	Well differentiated adenocarcinoma		Muscularis propria	Negative	Present	Present	Absent	Right hemicolectomy
Patient 3	66	F	Open appendectomy	Mucinous adenocarcinoma		Serosa	Positive				Right hemicolectomy

Discussion

In our study population, which included patients who underwent surgery for acute appendicitis, the incidence of appendiceal neoplasms were 0.7% for NETs, 0.4% for LAMNs, and 0.1% for adenocarcinomas. These findings are consistent with previously reported global data, where the incidence of appendiceal neoplasms in appendectomy specimens ranges between 0.2% and 2.5% [1,3–5].

As shown in Figure 2, patients with appendiceal adenocarcinoma and LAMNs were generally older, often over 50 years of age, whereas NETs predominantly occurred in younger individuals, frequently under 35. While adenocarcinoma and LAMN cases showed a slight male predominance or balanced gender distribution, NETs tended to affect both genders more equally. These findings align with previous population-based studies reporting younger age at diagnosis for appendiceal NETs and older age for mucinous and adenocarcinomatous neoplasms [1,4,5,9].

The majority of patients with LAMN in our series underwent laparoscopic appendectomy with negative surgical margins. Although acellular mucin extended to the subserosa, mesoappendix, or even visceral peritoneum in some cases, no lymphovascular or perineural invasion was observed. These findings are consistent with the known behavior of LAMNs, which are characterized by pushing rather than infiltrative invasion, and often present with extra-appendiceal acellular mucin without true malignant features [10]. The extent of acellular mucin spread can influence management decisions: cases with mucin on the serosal surface -even without epithelium- may warrant closer follow-up or additional surgical intervention due to the risk of pseudomyxoma peritonei. However, current guidelines suggest that non-invasive LAMNs with negative margins and no epithelial spread beyond the appendix can be managed conservatively following appendectomy alone [10,11].

In our cohort of appendiceal NETs, most patients were under 40 years of age, consistent with the typical age profile reported in the literature. The Ki-67 index, a key marker in grading NETs, was generally low across the group, with most values falling below 3%, supporting a diagnosis of well-differentiated G1 tumors. No clear difference in Ki-67 distribution was observed between genders. These findings align with WHO classification criteria and previous studies showing that appendiceal NETs are commonly detected incidentally in young adults and typically exhibit indolent behavior with low proliferative activity [12]. Although Ki-67 >3% is uncommon in appendiceal NETs, close monitoring remains essential in cases approaching G2 thresholds due to the potential implications for prognosis and follow-up strategies [11,13,14].

The appendiceal adenocarcinoma cases in our series demonstrated several high-risk pathological features, including deep wall invasion (up to serosa), positive surgical margins, and lymphovascular invasion. One patient also presented with macroscopic tumor perforation, a known risk factor for peritoneal dissemination, especially in mucinous subtypes. These findings are consistent with previous studies reporting that appendiceal adenocarcinomas, particularly mucinous variants, tend to present at more advanced stages and carry a higher risk for peritoneal spread and recurrence [15,16]. Given these characteristics, aggressive surgical management such as right hemicolectomy and consideration of cytoreductive surgery with intraperitoneal chemotherapy may be warranted in select cases.

The optimal surgical approach for localized mucinous appendiceal neoplasms remains a subject of debate, as these tumors are frequently diagnosed either intraoperatively or after surgery. As a result, nonperforated low-grade (grade 1) tumors that are completely removed by appendectomy may be managed with surveillance. However, right hemicolectomy is recommended for grade 2 and grade 3 mucinous appendiceal neoplasms to allow proper staging and ensure oncologic control [11,12,17].

The surgical management of appendiceal NETs depends primarily on tumor size, location, invasion depth, and histopathological risk features. For tumors ≤2 cm confined to the appendix with negative margins, no mesoappendiceal invasion >3 mm, and absence of lymphovascular or perineural invasion, appendectomy alone is generally considered curative [13,17]. However, tumors >2 cm, those with mesoappendiceal invasion, positive margins, or high proliferative indices (e.g., Ki-67 >2%) may require right hemicolectomy due to increased risk of nodal metastasis and recurrence [18]. On the other hand, appendiceal adenocarcinomas are rare but aggressive tumors that often require more extensive surgical intervention than

DOI: 10.5455/medscience.2025.06.176

other appendiceal neoplasms. Right hemicolectomy is the standard surgical approach, especially in cases with invasion beyond the muscularis propria, positive or close margins, lymphovascular invasion, or high-grade histology [15–17].

Our study has some limitations. Its retrospective design and lack of long-term follow-up data limit the ability to assess oncological outcomes and recurrence risk. Therefore, prospective studies with standardized follow-up protocols are needed for better decision-making.

Conclusion

Appendiceal neoplasms are rare but clinically significant findings in patients undergoing surgery for suspected acute appendicitis. Their demographic, histopathological, and prognostic features vary widely by tumor type, with NETs typically affecting younger individuals and LAMNs or adenocarcinomas more common in older adults. Accurate pathological evaluation and risk-based surgical decision-making are essential to ensure appropriate management and follow-up.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
The study received ethical approval from the Ethics Committee of Erzurum Atatürk University Faculty of Medicine (Date:31.01.2025, Approval No:B.30.2.ATA.0.01.00l/302).

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