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AGE-RELATED DIFFERENCES IN SEVERITY, MANAGEMENT, AND OUTCOMES OF ACUTE APPENDICITIES: A BALKAN SINGLE-CENTER RETROSPECTIVE COHORT STUDY

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Abstract

Aim: To assess differences in disease severity, operative management, and short-term outcomes of patients undergoing appendectomy for acute appendicitis by age.

Methods: This was a single-center, retrospective cohort study, including patients undergoing appendectomy in a tertiary surgical center in North Macedonia from January 2024 to December 2025. Patients were divided into two groups: < 60 years and ≥ 60 years. The primary outcome was the rate of complicated appendicitis, defined as gangrenous, perforated, abscess-forming, or peritonitis-associated disease. Secondary outcomes included operative approach, postoperative morbidity, and length of stay, readmission, and 30-day mortality.

Results: Of 261 patients, 221 were aged <60 years and 40 were aged ≥60 years. Older patients had a higher prevalence of comorbidity than younger patients (30.0% vs 5.4%; p<0.001), underwent CT more frequently (42.5% vs 17.2%; p=0.001), and were less often treated laparoscopically (50.0% vs 76.0%; p=0.003). Complicated appendicitis was more common in patients ≥60 years of age (75.0% vs 32.6%; p<0.001). Postoperative morbidity was significantly higher in older adults (17.5% vs 5.4%, p=0.018), and hospital length of stay was longer (median, 4.5 vs 3 days, p<0.001). In multivariable analysis, age ≥60 years was the strongest independent predictor of complicated appendicitis (OR, 6.01; 95% CI, 2.81–12.88; p<0.001), followed by comorbidity presence (OR, 2.34; 95% CI, 1.01–5.42; p=0.047).

Conclusion: Patients aged ≥60 years undergoing appendectomy more frequently presented with complicated appendicitis, experienced higher postoperative morbidity, and had longer in-hospital stays than younger patients. These findings support earlier diagnostic escalation and careful perioperative risk assessment in older adults with suspected appendicitis.

Keywords: acute appendicitis, appendectomy, complicated appendicitis, computed tomography, elderly, laparoscopy.

Introduction:

Acute appendicitis remains one of the most common surgical emergencies worldwide, yet its presentation and clinical course vary substantially across age groups. In older adults, diagnosis is often more challenging because symptoms may be atypical, inflammatory markers are less reliable, and the differential diagnosis is considerably broader. As a result, elderly patients are more likely to present with complicated disease and to experience worse postoperative outcomes than younger individuals (1,2).

Recent population-based and multicenter studies have documented that older adults with appendicitis undergo computed tomography more frequently, have higher rates of perforation or abscess formation, are more often treated with open surgery, and have longer hospital stays and greater postoperative morbidity (2,3). Although laparoscopic appendectomy has demonstrated favorable outcomes in older patients, including reduced complications and shorter length of stay, its use may be limited in the setting of severe inflammation or delayed presentation (4,5).

With the aging of the global population, appendicitis in older adults is becoming increasingly relevant in everyday surgical practice. However, data from Southeastern Europe and resource-limited healthcare systems remain limited. Therefore, this study aimed to compare outcomes between younger and older patients undergoing appendectomy at a tertiary surgical center in North Macedonia, using a clinically relevant age threshold of 60 years, with emphasis on the presence of complicated appendicitis, operative management, and short-term postoperative outcomes.

Materials and Methods

Study Design and Setting

This retrospective cohort study was conducted at a tertiary surgical center in North Macedonia. Consecutive patients undergoing appendectomy between January 1, 2024, and December 31, 2025, were included. The study aimed to evaluate age-related differences in preoperative characteristics, operative management, and outcomes of acute appendicitis.

Study Population

All patients who underwent appendectomy during the study period were screened for eligibility. Patients were excluded if key clinical data were incomplete or operative findings were missing. A total of 261 patients met the inclusion criteria and were included in the final analysis.

Patients were stratified into <60 years and ≥60 years age groups. Age-related differences in the management and outcomes of appendicitis were examined using an age cutoff of 60 years.

Data Collection and Definitions

Data were extracted from electronic medical records, discharge summaries, laboratory reports, and operative notes using a standardized data extraction form. Collected variables included demographics, comorbidity status, inflammatory markers, preoperative imaging, operative approach, intraoperative findings, postoperative complications, length of stay, 30-day readmission, and 30-day mortality.

Gangrenous, perforated, abscess-forming, or peritonitis-associated appendicitis was defined as complicated appendicitis. The rest was classified as uncomplicated appendicitis.

Outcomes

The primary outcome was the incidence of complicated appendicitis at operation. Secondary outcomes included operative approach, postoperative morbidity, hospital length of stay, 30-day readmission, and all-cause 30-day mortality.

Statistical Analysis

Statistical analyses were performed using R version 4.5.1 (R Foundation for Statistical Computing, Vienna, Austria). Categorical variables are presented as frequencies and percentages, and continuous variables as mean ± standard deviation or median (interquartile range), as appropriate. Group comparisons were performed using the chi-square or Fisher exact test for categorical variables and the Student t test or Mann–Whitney U test for continuous variables. Multivariable logistic regression was used to identify independent predictors of complicated appendicitis. Results are expressed as odds ratios (ORs) with 95% confidence intervals (CIs). All tests were two-sided, and $p < 0.05$ was considered statistically significant.

Ethical Considerations

All data were anonymized before analysis. The study was conducted in accordance with the principles of the Declaration of Helsinki and local institutional standards. Ethical approval was obtained from the relevant institutional review body before data analysis.

Results

A total of 261 patients underwent appendectomy during the study period. Of these, 221 patients (84.7%) were aged <60 years, and 40 (15.3%) were aged ≥60 years.

Baseline demographic, diagnostic, and preoperative characteristics did not differ in gender distribution between groups. Patients aged ≥60 years had a substantially higher prevalence of comorbidity than younger patients (30.0% vs 5.4%, p<0.001). Diagnostic imaging also varied by age: ultrasonography was more frequently used in younger patients, whereas computed tomography was more commonly obtained in the older cohort. Elevated C-reactive protein levels were more frequent among older adults (95.0% vs 81.0%, p=0.036), while leukocytosis showed a no significant trend in the same direction (Table 1).

Variable	<60 years (n=221)	≥60 years (n=40)	p-value
Male, n (%)	120 (54.3)	23 (57.5)	0.840
Female, n (%)	101 (45.7)	17 (42.5)	
Presence of comorbidity, n (%)	12 (5.4)	12 (30.0)	**<0.001**
Ultrasound performed, n (%)	149 (67.4)	18 (45.0)	**0.009**
CT performed, n (%)	38 (17.2)	17 (42.5)	**0.001**
Both ultrasound and CT performed, n (%)	21 (9.5)	4 (10.0)	0.924
No imaging performed, n (%)	13 (5.9)	1 (2.5)	0.694
Elevated white blood cell count, n (%)	130 (58.8)	30 (75.0)	0.079
Elevated C-reactive protein, n (%)	179 (81.0)	38 (95.0)	**0.036**

Note: Values are presented as n (%).

Table 1. Baseline demographic, diagnostic, and preoperative characteristics stratified by age group

Laparoscopic appendectomy was performed less often in patients aged ≥60 years (50.0% vs 76.0%), with a corresponding increase in open or converted-to-open procedures (50.0% vs 24.0%, p=0.001). Marked differences were observed in disease severity. Uncomplicated appendicitis predominated in younger patients, whereas complicated appendicitis was present in three-quarters of older adults (75.0% vs 32.6%, p<0.001). Perforated and abscess- or peritonitis-associated forms were notably more common in the elderly cohort (Table 2). These patterns are illustrated in Figure 1.

Variable	<60 years (n=221)	≥60 years (n=40)	p-value
Surgical approach, n (%)			**0.003**
Laparoscopic appendectomy	168 (76.0)	20 (50.0)	
Open appendectomy	50 (22.6)	19 (47.5)	
Conversion to open	3 (1.4)	1 (2.5)	
Pathologic subtype, n (%)			**<0.001**
Simple appendicitis	134 (60.6)	10 (25.0)	
Phlegmonous/empyematous appendicitis	15 (6.8)	0 (0.0)	
Gangrenous appendicitis	32 (14.5)	8 (20.0)	
Perforated appendicitis	24 (10.9)	9 (22.5)	
Abscess/peritonitis-associated forms	16 (7.2)	13 (32.5)	
Grouped severity, n (%)			**<0.001**
Uncomplicated appendicitis	149 (67.4)	10 (25.0)	
Complicated appendicitis	72 (32.6)	30 (75.0)	

Table 2. Operative characteristics and intraoperative findings stratified by age group

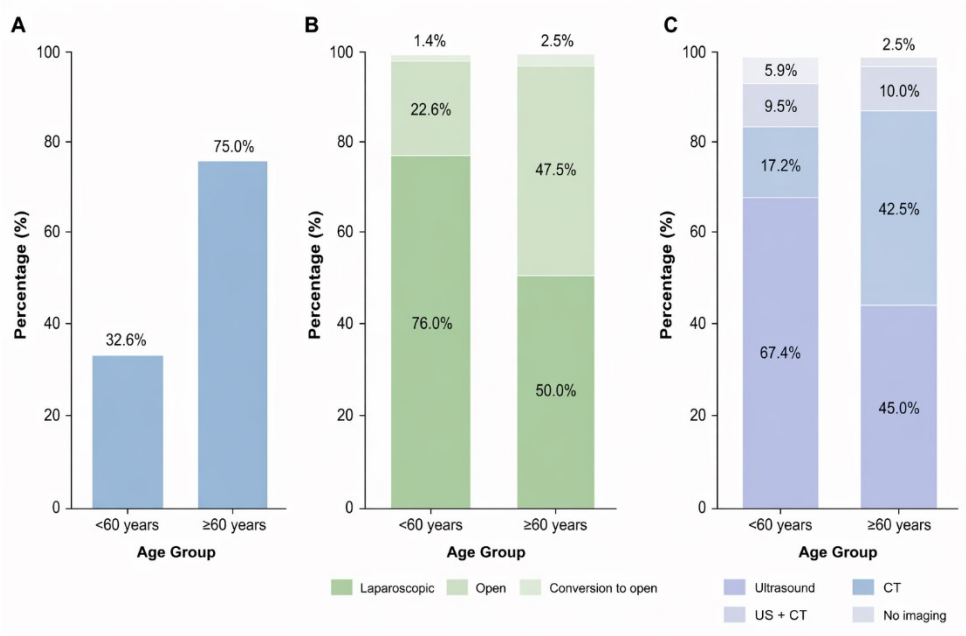

Figure 1. Comparative perioperative characteristics according to age group. (A) Proportion of complicated appendicitis. (B) Surgical approach distribution. (C) Preoperative imaging modality.

Postoperative outcomes showed higher overall morbidity among patients aged ≥60 years (17.5% vs 5.4%, p=0.018). Hospital stay was longer in older adults (median, 4.5 vs 3 days; p<0.001). One death occurred in the ≥60-year group (Table 3).

Variable	<60 years (n=221)	≥60 years (n=40)	p-value
Specific postoperative complications, n (%)			**0.031**
Wound infection	3 (1.4)	1 (2.5)	
Intra-abdominal abscess	1 (0.5)	1 (2.5)	
Postoperative ileus	2 (0.9)	2 (5.0)	
Bleeding / hematoma	1 (0.5)	1 (2.5)	
Cardiopulmonary/medical complications	2 (0.9)	2 (5.0)	
Mixed/multiple complications	3 (1.4)	0 (0.0)	
Overall outcomes, n (%)			
Any postoperative complication	12 (5.4)	7 (17.5)	**0.018**
Readmission within 30 days	3 (1.4)	1 (2.5)	0.488
All-cause 30-day mortality	0 (0.0)	1 (2.5)	0.153
Hospital length of stay, days, median (IQR)	3 (2–4)	4.5 (4–7)	**<0.001**

Table 3. Postoperative outcomes and specific complications stratified by age group

Logistic regression analysis identified age ≥60 years as the strongest predictor of complicated appendicitis (OR, 6.01; 95% CI, 2.81–12.88; p<0.001). Presence of comorbidity was also independently associated with complicated disease (OR, 2.34; 95% CI, 1.01–5.42; p=0.047). Gender was not associated with disease severity. Computed tomography use showed a borderline association with complicated appendicitis (Table 4).

Predictor	Odds Ratio	95% CI	p-value
Age ≥60 years	6.01	2.81–12.88	**<0.001**
Male sex	1.10	0.67–1.82	0.701
Presence of comorbidity	2.34	1.01–5.42	**0.047**
CT imaging performed	1.89	0.99–3.61	0.054

Table 4. Logistic regression analysis for predictors of complicated appendicitis

Discussion

This study found that patients aged ≥60 years had a substantially higher-risk clinical profile than younger adults. Older patients had more comorbidities, underwent CT imaging more frequently, were less often treated laparoscopically, and showed markedly higher rates of complicated appendicitis, postoperative morbidity, and prolonged hospitalization. These findings support the growing evidence that appendicitis in older adults represents a clinically distinct surgical entity rather than merely the same disease occurring later in life (2,3).

The most striking finding in our cohort was the significantly higher burden of complicated appendicitis among patients aged ≥60 years. Three-quarters of older adults had gangrenous, perforated, abscess-forming, or peritonitis-associated appendicitis, and age ≥60 years was the strongest independent predictor of complicated disease. Similar age-related trends have been consistently reported. Cimino et al. (2) found complicated appendicitis in 46.7% of elderly patients versus 20.7% of younger adults, while Gal et al. (3) reported significantly higher complicated appendicitis rates in patients older than 60 years in a nationwide cohort. Earlier elderly-focused studies also documented high perforation and morbidity rates, including a 40% perforation rate reported by Calis (1). Collectively, these data indicate that delayed or advanced presentation in older adults is not an isolated local finding, but a consistent pattern observed across diverse healthcare settings.

One likely explanation is delayed recognition. Older adults often present later, describe symptoms less specifically, or have competing medical conditions that obscure diagnosis. Cimino et al. (2) reported substantially longer symptom duration before admission in elderly patients, while Calis (1) emphasized that delayed presentation was strongly associated with perforation. Although symptom duration was unavailable in our dataset, the high rates of perforation, abscess, and peritonitis in our older cohort strongly suggest a similar mechanism. In practical terms, clinicians should maintain a lower threshold for further diagnostic evaluation and early surgical consultation when assessing abdominal pain in older adults.

The diagnostic approach in our cohort also differed significantly by age. CT was used much more frequently in patients aged ≥60 years, whereas ultrasonography predominated in younger adults. This mirrors previous evidence. Kirshtein et al. (6), using the same ≥60-year threshold, reported greater CT use in elderly patients and concluded that CT substantially improves diagnostic accuracy in this population. Likewise, Cimino et al. (2) demonstrated CT utilization in 86.1% of elderly patients compared with 54.0% of younger adults. This likely reflects the broader differential diagnosis in older patients, where diverticulitis, malignancy, bowel obstruction, ischemia, or other intra-abdominal pathology may mimic appendicitis.

Evidence from Southeastern Europe regarding appendicitis outcomes in older adults remains scarce. Our findings provide contemporary data from a tertiary surgical center in North Macedonia and highlight the importance of age-sensitive diagnostic pathways in healthcare settings where ultrasonography frequently serves as the first imaging investigation for patients presenting with acute abdominal pain.

Inflammatory markers in our study provide an additional clinically relevant signal. CRP elevation was significantly more common in older adults, whereas leukocytosis showed only a nonsignificant trend. This aligns with previous literature suggesting that WBC alone may be less informative in elderly appendicitis. Armağan et al. (7) reported that CRP may be more useful than WBC in identifying perforated appendicitis, while Dowgiałło-Wnukiewicz et al. (8) found higher CRP levels in older patients and associations between elevated CRP, gangrenous appendicitis, and longer hospitalization. Our findings therefore support CRP as a potentially more robust marker of advanced inflammatory burden in older patients.

Operative management also reflected these differences in disease severity. Laparoscopic appendectomy was significantly less frequent in the ≥60-year group, while open or converted procedures were twice as common. Similar trends have been reported repeatedly. Dowgiałło-Wnukiewicz et al. (8) found that patients older than 65 years were less likely to undergo laparoscopic appendectomy, and Cimino et al. (2) also observed reduced laparoscopic use among elderly patients.

Finnerty et al. (9) demonstrated that older age and complicated appendicitis, particularly abscess or peritonitis, were important predictors of conversion to open surgery. Thus, the lower laparoscopic rate in our older cohort likely reflects increased operative complexity rather than surgeon preference alone.

Importantly, the lower use of laparoscopy in our cohort should not be interpreted as evidence against minimally invasive surgery in older adults, as high-quality studies have demonstrated favorable outcomes with this approach. Moazzez et al. (10) reported lower morbidity and shorter hospital stay after laparoscopic appendectomy in elderly patients compared with open surgery. Ward et al. (5), analyzing more than 250,000 elderly patients, found shorter hospitalization, fewer patient safety events, and lower mortality with laparoscopy. A meta-analysis by Wang et al. (4) similarly demonstrated lower mortality, fewer postoperative complications, and shorter length of stay with laparoscopic appendectomy. Therefore, when technically feasible, minimally invasive surgery should remain the preferred strategy in older adults.

Postoperative outcomes in our cohort were meaningfully worse among older adults. Overall morbidity was more than three times higher, and hospital stay was significantly prolonged. These findings parallel those of Cimino et al. (2), who found higher complication rates and longer hospitalization in elderly patients, and Gal et al. (3), who reported increased infectious complications, mortality, and longer inpatient stay in patients older than 60 years. Even though mortality in our study was limited to a single event, its occurrence only in the older cohort is directionally consistent with broader literature.

Comorbidity likely plays a central role in explaining these outcomes. In our study, comorbidity was significantly more prevalent in older adults and independently associated with complicated appendicitis. Gal et al. (3) likewise found a greater burden of hypertension, diabetes, chronic kidney disease, heart failure, and other chronic illnesses among older appendicitis patients. Ashbrook et al. (11) extended this concept by showing that frailty strongly worsens outcomes in older adults with appendicitis, increasing complications, mortality, and resource use. Frailty was not formally measured in our study, but the higher comorbidity burden in our ≥60-year group likely reflects similar physiologic vulnerability.

Several limitations should be acknowledged. This was a retrospective single-center study, and the older cohort was relatively small, limiting precision for rare outcomes such as mortality. Variables such as symptom duration, frailty indices, ASA class, renal function, and functional dependence were not systematically available. These factors may be highly relevant in older emergency surgical patients, as emphasized by Ashbrook et al. (11) and Poillucci et al. (12). Nonetheless, the consistency of our results with large international studies strengthens the validity of our conclusions.

Taken together, these findings indicate that age substantially influences disease severity, diagnostic pathways, and postoperative recovery, supporting age-adapted emergency surgical strategies.

Conclusion

Patients aged ≥60 years undergoing appendectomy had a clearly higher-risk clinical profile than younger adults, including more comorbidities, more frequent CT use, lower laparoscopic treatment rates, higher rates of complicated appendicitis, greater postoperative morbidity, and longer hospitalization. Age ≥60 years was the strongest independent predictor of complicated disease, highlighting the need for early recognition and timely management in this population. Older adults with suspected appendicitis may benefit from earlier imaging, careful perioperative assessment, and prompt surgical decision-making. When feasible, laparoscopic appendectomy should remain the preferred approach.

Author Contributions

Conceptualization, methodology, analysis, and writing were performed by the authors. All authors approved the final manuscript.

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Informed Consent

Ethical approval was obtained from the relevant institutional review body before data analysis.

Conflicts of interest

The authors declare no conflicts of interest.

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