

Factors associated with postoperative complications following appendectomy in elderly patients

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SUMMARY

OBJECTIVE: Appendicitis in elderly patients is more challenging due to delayed presentation and higher comorbidities, which are associated with increased postoperative morbidity. The aim of this study was to evaluate factors that predict 30-day complications in elderly patients undergoing appendectomy.

METHODS: The records of elderly patients who underwent appendectomy were reviewed. The primary outcome was 30-day postoperative complications. Independent variables examined included demographic data, comorbidities, preoperative laboratory values, pathological findings, and surgical features. Both univariate and multivariate regression analyses were performed to identify factors associated with postoperative complications.

RESULTS: Evaluation was performed on 80 patients, comprising 63.8% females with a mean age of 71.3 years. Notably, 19 (23.8%) patients had one or more complications within 30 days after surgery. No significant difference was found between patients with and without complications in respect of age, gender, or laboratory features. The rates of American Society of Anesthesiologists scores 3–4 ($p=0.006$), hypertension ($p=0.016$), cardiovascular disease ($p=0.049$), and obesity ($p=0.040$) were significantly higher for patients with complications than for those without. On multivariate analysis, obesity (OR 9.41), chronic obstructive pulmonary disease (OR 9.72), and open appendectomy (OR 14.87) were independently associated with 30-day postoperative complications.

CONCLUSIONS: Older patients undergoing appendectomy tend to have poorer outcomes than younger patients. Therefore, it is critical to identify factors that could reduce the possibility of adverse outcomes in this frail population. The results of this study suggest that obesity, chronic obstructive pulmonary disease, and an open approach are independent factors for complications in elderly patients undergoing appendectomy.

KEYWORDS: Appendicitis. Appendectomy. Elderly. Postoperative complications.

INTRODUCTION

Acute appendicitis is a common surgical emergency worldwide, which has a lifetime risk of approximately 7%¹. Although more frequently diagnosed in younger patients, 5–10% of cases occur over the age of 60 years². An aging population driven by a global increase in life expectancy is likely to result in an increased incidence of acute appendicitis in elderly individuals over time^{3,4}. Older patients undergoing appendectomy tend to have poorer outcomes than their younger counterparts³. The rates of perioperative morbidity and mortality are higher

in elderly patients who are more likely to have concomitant comorbidities and often have delayed presentation and atypical symptoms, leading to an increased risk of complicated appendicitis, appendiceal perforation, intra-abdominal abscess, and even mortality^{5,6}. Reported complication rates following appendectomy in the elderly range from 10–40%, with mortality rates as high as 3%^{2,5,7–10}. Therefore, understanding and identifying risk factors that predict postoperative outcomes for elderly patients undergoing appendectomy are important steps in managing these patients. The aim of this study was to

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evaluate factors that might be predictive of 30-day complications following appendectomy in elderly patients.

METHODS

Study design and patients

The medical records were retrospectively reviewed of elderly patients (aged ≥ 65 years) who underwent appendectomy for acute appendicitis at a tertiary level hospital in Turkey between January 2017 and December 2020. Patients who underwent an appendectomy as part of another major operation or those with appendiceal malignancy were excluded from the study. This study was approved by the Ethics Committee of Gulhane Training and Research Hospital (2021-51) and was registered at Clinicaltrials.gov (NCT04791657).

Data collection

Data collected included age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) classification, comorbidities, preoperative laboratory values, diagnostic studies, surgical techniques and surgical procedures, intensive care unit (ICU) stay, length of hospital stay, in-hospital mortality, and 30-day outcomes. The diagnosis of appendicitis was confirmed with histological evaluation. Complicated appendicitis is defined as cases with peri-appendicular abscess, gangrenous appendicitis, and/or perforation of the appendix noted on radiological imaging studies, operative notes, or pathological results.

Outcome variables

The primary clinical outcome of interest was 30-day postoperative complications. The Clavien–Dindo classification was used to grade postoperative outcomes and complications¹¹. Secondary outcomes were the rate of complicated appendicitis, in-hospital mortality, and 30-day readmission, which was defined as an unplanned readmission to hospital within 30 days of discharge.

Statistical analysis

Examinations of normal distribution assumptions for continuous variables were visually assessed with quantile–quantile plots and histograms and confirmed with the Shapiro–Wilk test. Categorical data were presented as number (n) and percentage (%), and continuous data as mean \pm standard deviation or median with range values, depending on the distribution assumptions. Associations between variables were evaluated using the Student's *t*-test or the Mann–Whitney U test (for continuous variables) and the Pearson's χ^2 or Fisher's exact test (for categorical variables), where appropriate. Factors identified at

$p < 0.20$ in univariate analysis were selected for inclusion in a multivariate logistic regression model to assess the independent effect of these variables in the presence or absence of 30-day postoperative complications. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated. All tests were two-sided, and a $p < 0.05$ was considered statistically significant. All statistical analyses were performed in RStudio statistical software, version 1.3.1093 (RStudio, Inc., Boston, MA, USA). A forest plot was created according to the result of the multivariate logistic analysis, using GraphPad Prism version 8.0.1 for Windows (GraphPad Software Inc., CA, USA).

RESULTS

The study population consisted of 80 patients, and 51 (63.8%) patients were female with a mean age of 71.3 ± 5.9 years. Overall, 28.8% of patients had no comorbidity, and 71.2% had at least one comorbid disease.

Preoperative ultrasonography was performed in all patients and computed tomography was performed in 53 (66.3%) patients. In respect of surgical technique, an open approach was applied to 58 (72.5%) cases and the laparoscopic technique to 22 (27.5%). A total of 31 (38.8%) patients had complicated appendicitis, and 49 (61.3%) patients were uncomplicated. ICU admission after the surgical treatment of appendicitis was required by 28.8% of all the patients. The mean ICU stay was 0.7 days, and the average hospital stay was 6 days. The in-hospital mortality rate was 1.3% ($n=1$), and 30-day readmission and 30-day rehospitalization rates were 12.5 and 2.5%, respectively. The demographic characteristics and perioperative data of the patients are presented in Table 1.

Overall, 19 (23.8%) patients had one or more complications after surgery. Of these patients, 8 (42.1%) developed wound infection. Other complications included wound dehiscence in two patients, wound seroma or hematoma in two patients, prolonged ileus in three patients, bowel obstruction in one patient, atelectasis in one patient, and respiratory infection in one patient. One death was due to sepsis secondary to intestinal obstruction and evisceration.

The comparative analysis of patients with 30-day complications and those without complications is summarized in Table 2. No statistically significant difference was found between patients with and without complications in respect of age, gender, or laboratory features including leukocyte and C-reactive protein values. Patients with complications had a significantly higher prevalence of ASA score 3 or 4 (52.6 *versus* 18.0%, $p=0.006$), obesity (BMI ≥ 30 kg/m²) (47.4 *versus* 23.0%, $p=0.040$), hypertension (78.9 *versus* 47.5%, $p=0.016$), and cardiovascular disease (CVD) (42.1 *versus* 19.7%, $p=0.049$) than those without

Table 1. Demographic characteristics, preoperative evaluation, clinicopathological features, and postoperative outcomes of the study population (n=80).

Demographic characteristics	
Age (years)	71.3±5.9 (range, 65–87)
Female gender, n (%)	51 (63.8)
Body mass index (kg/m ²)	28.1±5.9 (range, 15.7–47.8)
Comorbidities	
ASA classification, n (%)	
1–2	59 (73.8)
3–4	21 (26.3)
Hypertension, n (%)	44 (55.0)
Diabetes mellitus, n (%)	23 (28.8)
Cardiovascular disease, n (%)	20 (25.0)
COPD, n (%)	8 (10.0)
Kidney disease, n (%)	5 (6.3)
Preoperative evaluation	
Leukocyte (×10 ⁹ /L)	14.2±5.0 (range, 6.0–28.1)
Neutrophil (×10 ⁹ /L)	11.4±4.9 (range, 1.5–24.5)
Lymphocyte (×10 ⁹ /L)	1.6±0.7 (range, 0.5–3.7)
C-reactive protein (mg/L)	147.7±109.3 (range, 1.5–457)
Diagnostic study, n (%)	
Only USG	27 (33.8)
USG and CT	53 (66.3)
Surgical and pathological features	
Surgical technique, n (%)	
Open	58 (72.5)
Laparoscopic	22 (27.5)
Pathological findings, n (%)	
Uncomplicated appendicitis	49 (61.3)
Complicated appendicitis	31 (38.8)
Postoperative outcomes	
ICU stay, n (%)	23 (28.8)
Length of ICU stay (days)	0.7±1.9 (0–14)
Length of hospital stay (days)	6.0±4.7 (range, 1–24)
In-hospital mortality, n (%)	1 (1.3)
30-Day complication, n (%)	19 (23.8)
30-Day readmission, n (%)	10 (12.5)
30-Day rehospitalization, n (%)	2 (2.5)

ASA: American Society of Anesthesiologists; COPD: chronic obstructive pulmonary disease; CT: computed tomography; ICU: intensive care unit; USG: ultrasonography.

complications. The rate of complicated appendicitis did not differ between patients with and without 30-day complications (31.6 *versus* 41.0%, $p=0.462$). The length of ICU stay, hospital stay, and the 30-day readmission rate were higher in patients with complications ($p=0.018$, $p<0.001$, and $p=0.001$; respectively), and the 30-day rehospitalization rate was similar in both groups ($p=0.421$).

Univariate and multivariate logistic regression analyses were performed to determine the factors that predicted 30-day complications. Univariate regression analysis showed that age, male gender, obesity, ASA scores 3–4, hypertension, CVD, COPD, and open approach were associated with an increased risk of developing postoperative complications. In the multivariate analysis, only obesity (OR 9.41, 95%CI 1.79–14.31), COPD (OR 9.72, 95%CI 1.21–77.78), and open appendectomy (OR 14.87, 95%CI 1.55–142.33) were found to be independently associated with increased 30-day postoperative complications (Figure 1).

DISCUSSION

Despite a significant decrease in morbidity and mortality rates after the surgical treatment of acute appendicitis in elderly patients over the past five decades, nearly one-third of older patients undergoing appendectomy still have postoperative complications^{2,7,8,10,12}. When considering the increase in life expectancy and aging population in the coming years, the number of elderly patients with appendicitis appears to be increasing^{1–3}. This will most likely lead to more patients with complications and comorbid conditions, potentially leading to increased resource utilization and increased economic cost for health care systems^{8,13,14}. However, a limited number of studies have been conducted to evaluate the predictors of postoperative outcomes in elderly individuals undergoing emergency appendectomy^{2,8,9,12}. Therefore, this study aimed to identify the risk factors that predict postoperative complications in elderly patients undergoing appendectomy.

In the analysis of 80 elderly patients with a mean age of 71.3 years in this study, nearly three quarters had at least one comorbid condition, and 30-day postoperative complications developed in 23.8% of the patients, which was similar to the findings of the previous studies that have reported rates ranging from 10% to 40%. The most common complications were superficial wound infection, prolonged ileus, deep wound infection, wound dehiscence, and wound seroma/hematoma. Patients with complications within postoperative 30 days had a significantly higher prevalence of ASA score 3 or 4, obesity, hypertension, and CVD than those without complications. The length of ICU stay, hospital stay, and the 30-day readmission rate were the other

Table 2. Comparison of the patients with postoperative complications and those without complications

	Patients without complications (n=61)	Patients with complications (n=19)	p-value
Age (years)*	69 (65–87)	74 (65–84)	0.088
Male gender, n (%)	19 (31.1)	10 (52.6)	0.089
Body mass index (kg/m ²), n (%)			0.040
<30	47 (77.0)	10 (52.6)	
≥30	14 (23.0)	9 (47.4)	
ASA classification, n (%)			0.006
1–2	50 (82.0)	9 (47.4)	
3–4	11 (18.0)	10 (52.6)	
Hypertension, n (%)	29 (47.5)	15 (78.9)	0.016
Diabetes mellitus, n (%)	17 (27.9)	6 (31.6)	0.755
Cardiovascular disease, n (%)	12 (19.7)	8 (42.1)	0.049
COPD, n (%)	4 (6.6)	4 (21.1)	0.086
Kidney disease, n (%)	4 (6.6)	1 (5.3)	1.000
Leukocyte (×10 ⁹ /L)†	14.1±5.0	14.3±5.0	0.879
C-reactive protein (mg/L)*	120 (1.5–409)	142 (34–457)	0.263
Surgical technique, n (%)			0.058
Open	41 (65.6)	17 (89.5)	
Laparoscopic	20 (32.8)	2 (10.5)	
Complicated appendicitis, n (%)	25 (41.0)	6 (31.6)	0.462
ICU stay, n (%)	14 (23.0)	9 (47.4)	0.040
Length of ICU stay (days)*	0 (0–6)	0 (0–14)	0.018
Length of hospital stay (days)*	4 (1–14)	5 (1–24)	<0.001
In-hospital mortality, n (%)	0	1 (5.3)	0.237
30-Day readmission, n (%)	3 (4.9)	7 (36.8)	0.001
30-Day rehospitalization, n (%)	1 (1.6)	1 (5.3)	0.421

ASA: American Society of Anesthesiologists; COPD: chronic obstructive pulmonary disease; ICU: intensive care unit stay. *Values are represented as median (range). †Data are expressed as mean±standard deviation. Statistically significant results (p<0.05) were written in bold format

statistically significant factors that were higher in patients with complications. However, these factors were not included in the regression model, because they reflect an association rather than a cause-and-effect relationship; it might be possible that early postoperative complications cause longer ICU and hospital stay. The results of the multivariate logistic regression analysis showed that the independent predictors of postoperative complications were obesity, COPD, and open appendectomy.

Margenthaler et al.⁸ identified the predictors of postoperative morbidity and mortality in patients undergoing surgical intervention for appendicitis based on the ACS NSQIP database. Predictors of morbidity included advanced age, ASA class ≥3, “partially dependent” status, history of COPD, weight loss of >10% within 6 months, and preoperative blood

urea nitrogen, bilirubin, albumin, and leukocyte count as well as an infected or contaminated wound and longer operative duration. A retrospective study by Renteria et al.⁹ comparing appendectomies in 195 young patients and 62 elderly patients investigated the predictors of complications. Surgery with an open approach, as shown in this study, and a positive cardiac history were reported to independently predict complications, regardless of age. These results are consistent with the findings by Masoomi et al.⁶, which compared laparoscopic and open appendectomy in the elderly, and found that compared with the laparoscopic approach, open appendectomy was associated with an increased likelihood of postoperative complications.

In the present study, patients with postoperative complications had a higher prevalence of obesity, hypertension, and

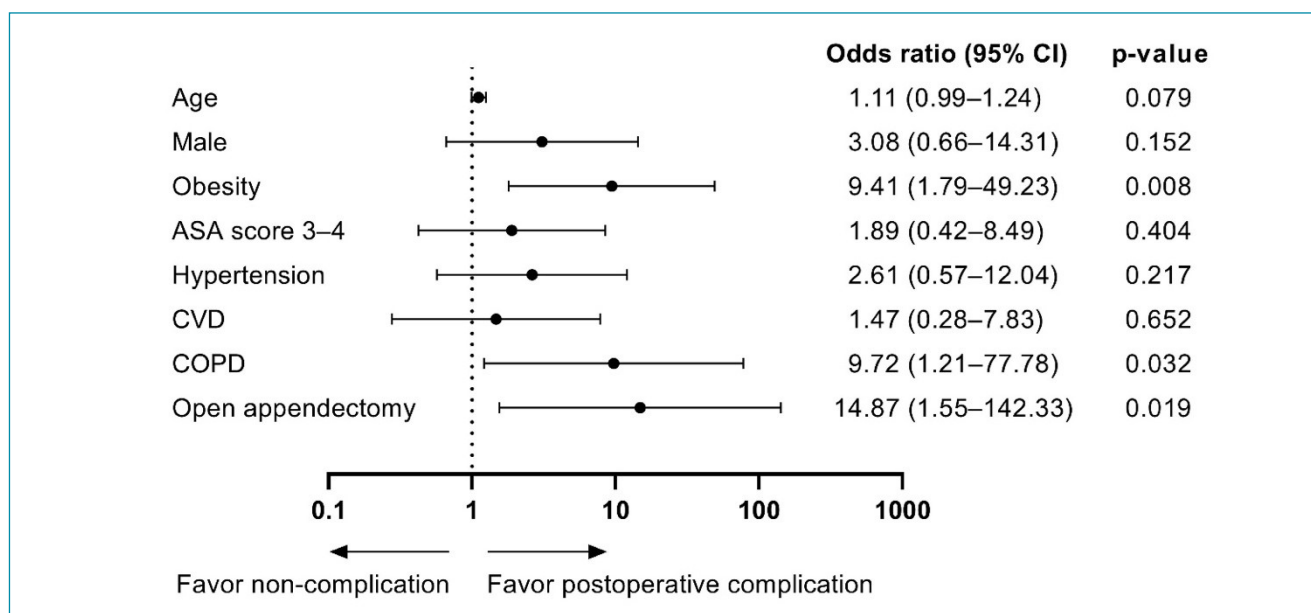


Figure 1. ASA: American Society of Anesthesiologists; COPD: chronic obstructive pulmonary disease; CVD: cardiovascular disease. Forest plot of significant factors in the multivariate analysis for 30-day postoperative complications in elderly patients undergoing appendectomy.

CVD in univariate analysis. However, these significant differences disappeared in the multivariate analysis when covariates were taken into consideration. Contrary to expectations, logistic regression analysis demonstrated that, compared with uncomplicated appendicitis, a complicated appendicitis did not predict increased 30-day complication rates. Other studies have identified several potential factors that may contribute to postoperative complications. Cohen-Arazi et al.² showed that a history of cardiac disease was the only predictor of perioperative morbidity. In another nationwide prospective cohort study¹² of 135 patients aged ≥ 65 years, only renal insufficiency was found to be a significant predictor, regardless of age, complicated or uncomplicated appendicitis, and other comorbid conditions.

In this study, only 27.5% of patients were treated with a laparoscopic approach. This rate appears to be low compared to the literature, which shows the increased use of laparoscopic surgery for the management of abdominal emergencies over the past two decades, with special regard to acute appendicitis.^{3,7,10,15} Relevant studies have confirmed that laparoscopic appendectomy is beneficial in terms of shorter recovery time and length of hospital stay and it reduced pain and incidence of wound complications compared to the open approach.^{6,10,16} In the present study, open appendectomy was identified as one of the independent predictors of 30-day postoperative complications. This may be interpreted as open appendectomy was more preferred in cases such as complicated appendicitis, peritonitis, or abdominal

adhesion. However, this study did not show a significant association between the preferred surgical technique and whether the patient had complicated or uncomplicated appendicitis. Therefore, this reflects the invasive and technically demanding nature of the open approach rather than a selection bias.

This study has several potential limitations. It was limited by the imperfections inherent in any retrospective analysis. The number of patients in this study was also relatively low, although the sample size was similar to other studies evaluating elderly patients with appendicitis, only 5–10% of cases occur in the elderly population. In addition, the present study included a cohort of patients from a single institution, which may lead to selection bias and limits the generalizability to other clinical settings. Finally, the inability to identify patients who were readmitted to a different hospital may have caused an underestimation of the readmission and complication rates. Despite these limitations, this study provides evidence for the understanding and identification of risk factors that predict postoperative outcomes for elderly patients.

CONCLUSIONS

It is critical to identify modifiable factors that can be addressed preoperatively to reduce the possibility of adverse outcomes and to ensure optimal health outcomes in this frail patient population, potentially leading to decreased resource utilization and economic

cost for the health care system. The study results showed that obesity, COPD, and open appendectomy were independent risk factors for 30-day postoperative complications after the surgical treatment of appendicitis. Hence, laparoscopic appendectomy should be considered an effective and safe procedure for elderly patients with acute appendicitis. Furthermore, elderly patients with comorbidities should be given prompt care to avoid complications.

AUTHORS' CONTRIBUTIONS

EL: Conceptualization, Data curation, Project administration, Writing – original draft, Writing – review & editing. **AD:** Conceptualization, Data curation, Project administration, Writing – original draft, Writing – review & editing. **SUC:** Conceptualization, Data curation, Project administration, Writing – original draft, Writing – review & editing

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