DIAGNOSTIC VALUE OF PREOPERATIVE LABORATORY AND IMAGING PARAMETERS IN STRATIFYING APPENDICITIS SEVERITY

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ABSTRACT: Background: Acute appendicitis is the most common intra-abdominal surgical emergency. Accurate differentiation between uncomplicated and complicated appendicitis is essential for determining optimal treatment and minimizing postoperative morbidity. While laparoscopic appendectomy remains the gold standard, conservative management is increasingly considered a viable option for uncomplicated cases. **The aim** of our study was to highlight the importance of preoperative laboratory and imaging diagnostics in differentiating the severity of intraoperative findings in acute appendicitis and optimizing therapeutic strategy. **Methods:** This retrospective study analyzed 231 patients diagnosed with acute appendicitis at the Clinical Hospital Center Zemun between December 2021 and September 2023. Patients were stratified into uncomplicated and complicated appendicitis groups based on clinical, intraoperative, and histopathological findings. Demographic, clinical, laboratory and ultrasonographic data were compared between groups. Statistical analyses were performed using SPSS version 21. **Results:** Complicated appendicitis was present in 63 patients (27.27%), who were significantly older and had longer symptom duration ($p < 0.01$). Febrile episodes, leukocytosis, and elevated CRP levels were more prevalent in the complicated group. The mean CRP concentration was significantly higher in the complicated group (109 mg/L) compared to the uncomplicated group (24.55 mg/L, $p < 0.01$). Ultrasonography showed limited ability to differentiate between disease severities. No significant association was found between diabetes mellitus and disease complexity. **Conclusion:** Our study confirms that older age, fever, prolonged symptom duration, and elevated CRP levels are key factors associated with complicated acute appendicitis. CRP stood out as the most reliable preoperative biomarker for assessing disease severity. These results emphasize the need to integrate clinical evaluation with selected laboratory markers, especially CRP to improve preoperative diagnosis and guide timely treatment.

Keywords: acute appendicitis, CRP, complicated appendicitis, diagnosis, laboratory markers

INTRODUCTION

Acute appendicitis is the most common intra-abdominal surgical emergency [1]. In Serbia, the morbidity of acute appendicitis is similar to global trends, and the overall lifetime risk is approximately 8.6% in men and 6.7% in women [2]. The diagnosis and management of acute appendicitis can be complex, as they require the exclusion of various differential diagnoses and prioritization of surgical intervention according to disease severity. Timely and accurate treatment remains essential for reducing appendicitis-related morbidity.

Distinguishing between uncomplicated and complicated appendicitis is crucial for determining the appropriate therapeutic approach [3]. Inadequate or delayed diagnosis and treatment of complicated appendicitis are associated with serious complications and postoperative morbidity, further emphasizing the importance of identifying parameters that reflect disease severity [4].

Accurate differentiation between these two forms aims to support the selection of the most appropriate therapy, while simultaneously reducing the number of unnecessary surgical interventions and the risk of associated complications. In addition to laparoscopic appendectomy, which remains the gold standard for the treatment of complicated appendicitis, a conservative approach is increasingly being used in the management of uncomplicated cases [5–7].

The diagnosis of appendicitis is primarily based on the clinical presentation, although inflammatory markers, ultrasound, and computed tomography can contribute to diagnostic accuracy [8]. In our institution, ultrasound examination is routinely used together with the assessment of C-reactive

protein (CRP) levels and white blood cell (WBC) count to facilitate diagnosis and evaluate disease severity. CT is used rarely, and only in cases where the clinical presentation and laboratory findings are not sufficiently clear. C-reactive protein (CRP) is an inflammatory marker that has been identified in several studies as an independent predictor of complicated appendicitis [9,10].

The main objective of this study is to determine whether CRP can be used to distinguish between complicated (gangrenous or perforated) and uncomplicated appendicitis.

MATERIALS AND METHODS

This study presents a retrospective analysis of 231 patients with clinical signs of acute appendicitis who were hospitalized at the Department of General Surgery of the Clinical Hospital Center (KBC) Zemun between December 2021 and September 2023. All data used in the study were obtained from medical records. The patients underwent surgical treatment, either open or laparoscopic appendectomy, and the diagnosis of acute appendicitis was confirmed by postoperative histopathological examination of the removed appendix.

Based on clinical, intraoperative, and histopathological findings, the patients were divided into two groups: those with uncomplicated appendicitis and those with complicated appendicitis. Uncomplicated appendicitis was defined as catarrhal or phlegmonous inflammation of the appendix, whereas complicated appendicitis referred to gangrenous inflammation, with or without perforation.

In addition to analyzing and comparing C-reactive protein levels, white blood cell counts, and ultrasound findings, the study also assessed various clinical and demographic parameters. These included symptom duration, the presence or absence of febrile episodes, and the existence of comorbidities. Basic demographic characteristics such as patient sex and age were also included to evaluate their potential impact on clinical presentation and disease course. A body temperature higher than 37.4°C was considered significant.

Every clinical suspicion of appendicitis was further confirmed by mandatory laboratory analyses and ultrasound examination to increase diagnostic accuracy and guide further management. A positive ultrasound finding was established based on the identification of one or more of the following criteria: presence of free intraperitoneal fluid, regional lymphadenopathy, and/or an increased appendiceal diameter with thickening of the appendiceal wall.

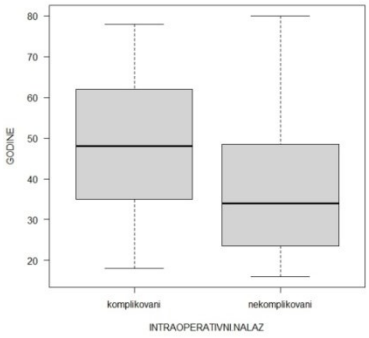
Statistical analysis was performed using SPSS software, version 21. Variables between the two patient groups were compared using the Mann–Whitney U test for numerical data and the chi-square test for categorical data. Statistical significance was defined as a p-value of less than 0.05..

RESULTS

The sample of 231 patients diagnosed with appendicitis during the study period was divided into two groups. The first group consisted of 168 patients (72.73%) with uncomplicated appendicitis, while the second group included 63 patients (27.27%) with complicated appendicitis. The overall patient population comprised 110 men (47.62%) and 121 women (52.38%). Among patients with complicated appendicitis, 34 (54%) were men and 29 (46%) were women, whereas in the group with uncomplicated appendicitis, 76 (45.2%) were men and 92 (54.8%) were women. No statistically significant difference in sex distribution was observed between the two groups ($p = 0.242$).

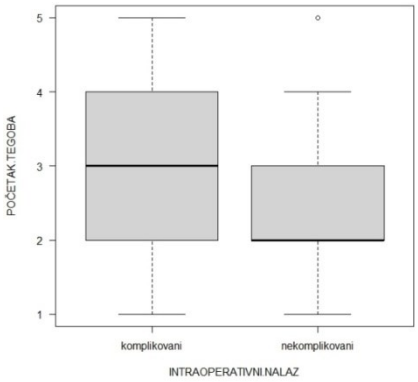
The mean age of our patients was 40.31 ± 17.06 years, with the youngest patient being 16 and the oldest 80 years old. In the subgroup of patients with complicated appendicitis, the median age was 47 years. In contrast, patients with uncomplicated appendicitis were significantly younger, with a median age of 34 years, representing a statistically significant difference ($p < 0.01$).

Figure 1. The box-plot diagram illustrates the relationship between patient age and intraoperative findings in complicated and uncomplicated appendicitis. The diagram indicates a statistically significant difference in the severity of intraoperative findings between younger and older patients. The central line within each box represents the median age, while the edges of the box denote the first and third quartiles.



In most patients with complicated inflammation, symptoms appeared within 24 to 48 hours prior to establishing the preoperative diagnosis. In contrast, patients with uncomplicated inflammation most commonly experienced symptoms for less than 24 hours before arriving at the hospital. This difference in symptom duration between the two groups was statistically significant ($p < 0.01$), indicating an association between longer symptom duration and the development of complicated disease. These findings highlight the importance of early clinical assessment and intervention to reduce the risk of complications..

Figure 2. The box-plot diagram illustrates the relationship between symptom duration and intraoperative findings in complicated and uncomplicated appendicitis. The diagram shows that longer symptom duration is associated with a higher incidence of complicated intraoperative findings. The central line within each box represents the median duration, while the edges of the box denote the first and third quartiles..



A total of 63 patients (27.27%) experienced episodes of elevated body temperature during the course of their symptoms, of whom 26 had complicated and 37 had uncomplicated appendicitis. Considering the difference in group size, the difference in the presence of fever between the groups was statistically significant ($p < 0.01$).

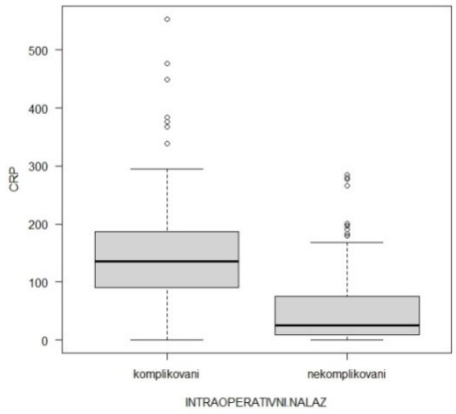
Regarding comorbidities, a total of 7 patients (3.02%) were diagnosed with diabetes mellitus. Of these, 5 patients were in the uncomplicated appendicitis group, while 2 patients were in the complicated appendicitis group. Statistical analysis did not show a significant difference in the prevalence of diabetes between the groups, suggesting that in this sample, the presence of DM did not significantly influence the likelihood of developing complicated appendicitis.

Ultrasound examination demonstrated findings indicative of acute appendicitis in 134 patients (58.01%), while 97 patients (41.99%) had no ultrasonographic evidence of the disease. Among patients with positive ultrasound findings, the prevalence of complicated versus uncomplicated appendicitis was assessed. Although a higher percentage of patients with positive findings had complicated appendicitis, the difference between the groups was not statistically significant ($p = 0.134$).

In this study, the mean white blood cell count in peripheral blood was $12.61 \times 10^9/L \pm 4.64 \times 10^9/L$, indicating that most patients presented with leukocytosis. In patients with uncomplicated appendicitis, leukocyte values ranged from $2.2 \times 10^9/L$ to $25.2 \times 10^9/L$, with a mean of $11.8 \times 10^9/L$. In the complicated appendicitis group, leukocyte counts ranged from $4.3 \times 10^9/L$ to $27.8 \times 10^9/L$, with a mean value of $14.4 \times 10^9/L$. Comparative analysis of this inflammatory marker between the two groups demonstrated a statistically significant difference ($p < 0.01$).

C-reactive protein (CRP) values among patients varied considerably, with a standard deviation slightly lower than the mean, amounting to 66.62 ± 65.60 mg/L. CRP concentrations ranged from 0.2 mg/L to 265.4 mg/L. The median CRP level in patients with uncomplicated appendicitis was 24.55 mg/L, which was significantly lower than the median of 109 mg/L observed in patients with complicated appendicitis..

Figure 3. The box-plot diagram illustrates the relationship between C-reactive protein (CRP) levels and intraoperative findings in appendicitis. Higher CRP levels are associated with more severe, complicated forms of appendicitis. The central line within each box represents the median CRP value, while the edges of the box denote the first and third quartiles..



DISCUSSION

Preoperative differentiation between complicated and uncomplicated acute appendicitis remains a major clinical challenge, particularly when clinical findings are unclear and laboratory tests lack sufficient specificity [11,12]. This diagnostic uncertainty contributes to a substantial rate of misdiagnosis, which, according to several studies, ranges between 12% and 30% [2,8,10]. Such errors may lead to unnecessary surgical intervention or delays in treatment, thereby worsening clinical outcomes. Therefore, improving diagnostic tools and criteria is essential for optimizing disease management and reducing negative appendectomies and complications.

Traditionally, early appendectomy has been recommended for uncomplicated appendicitis to prevent rupture [13]. However, recent randomized studies [13–15] and meta-analyses [16,17] show that nonoperative antibiotic treatment may be successful in carefully selected patients with uncomplicated appendicitis. According to the updated guidelines of the World Society of Emergency Surgery (WSES), established at the Jerusalem Consensus Conference in 2020, antibiotic therapy is recommended as a safe and effective alternative to surgery in patients with uncomplicated appendicitis without appendicolithiasis. It is important to note that unrecognized perforation may lead to severe complications such as abscess formation and purulent peritonitis [19]. The reported perforation rate in acute appendicitis ranges between 20% and 34% [20–22]. Among patients treated nonoperatively, it should be emphasized that there is an approximately 39% risk of recurrence within 5 years [14,18].

Laparoscopic appendectomy remains the gold standard for the management of suspected complicated appendicitis [23]. The need for a more invasive approach is justified by the serious complications that may arise, including infection, ileus, intra-abdominal abscess, and fistula formation [24–26]. Delaying surgery increases the risk of life-threatening conditions and rehospitalization [27].

Demographic characteristics, particularly age and sex, have been identified as significant factors in the development of complicated appendicitis. Birben et al. reported a higher incidence of complicated appendicitis in older and male patients [28]. Our study did not demonstrate a statistically significant sex difference, but patients with complicated appendicitis were significantly older. This may be explained by age-related declines in immune function and physiological reserves. Numerous studies report similar findings [2,3,6,29,30].

A long interval between symptom onset and diagnosis is directly associated with the development of complications. Our study confirms that longer symptom duration is a predictor of complicated disease, consistent with previous research [2,3,8,23,30,31].

Elevated temperature (≥37.4°C) has been shown to be a clinically useful indicator of complicated appendicitis [30,31,33]. Our findings, as well as the study by Akai et al. [34], confirm the significance of body temperature in assessing disease severity.

Although diabetes is associated with immune dysfunction and a more severe course of appendicitis, our study did not show a significant association, likely due to the small number of diabetic patients and better disease control in our institution [2,35].

Ultrasound is frequently the first diagnostic modality, but it is limited by subjective interpretation and patient-related factors [3,36,37]. Our results confirm that ultrasound alone is insufficient for distinguishing complicated from uncomplicated disease and should be used in combination with clinical evaluation and laboratory markers.

Leukocytosis is an important but nonspecific marker. Our results confirm its correlation with complicated appendicitis, although it lacks sufficient standalone predictive value [4,7,8,27,38].

CRP, as an acute-phase protein, exhibits proportional increases with the severity of inflammation [3,27,29,30,31,33,38,39]. Our study confirmed its markedly elevated levels in complicated cases (median 109 mg/L), further supporting its diagnostic utility..

CONCLUSION

Our study confirms that older age, elevated body temperature, longer symptom duration, and increased CRP levels are key factors associated with complicated acute appendicitis. CRP emerged as the most reliable preoperative biomarker for assessing disease severity. These findings emphasize the need to integrate clinical evaluation with selected laboratory parameters, particularly CRP, to ensure a more accurate preoperative diagnosis and the implementation of timely therapeutic strategies.

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