

## Original Article

# Preoperative Appendix Diameter Obtained by Computerized Tomography Scanning Predicts Conversion from Laparoscopic to Open Appendectomy

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### ABSTRACT

**Background:** Open appendectomy (OA) has been the gold standard for a long time. Laparoscopic appendectomy (LA) has gained wide acceptance and popularity, outdoing open approach. Yet, conversion may be required when laparoscopic approach fails. **Aims:** To predict conversion from laparoscopic appendectomy to open appendectomy using Oreo-ratio radiological appendices diameter. **Materials and Methods:** This is a retrospective cohort study conducted on 320 (included) patients who underwent appendectomy between January 2018 and August 2018 in the General Surgery department of Haseki Training and Research Hospital, Istanbul, Turkey. Appendiceal diameter obtained during preoperative radiological screening was evaluated about its relationship to conversion from LA to OA. Age, sex, inflammatory serum parameters and pathology reports were also investigated. **Results:** A total of 269 (84%) cases were started LA and 17 (6,3%) laparoscopic cases were converted to open. The appendix diameter, the grade of inflammation (perforated or gangrenous), age, and c-reactive protein (CRP) were found to have significant importance in conversion,  $P = 0.003$ ,  $P = 0.000$ ,  $P = 0.042$ , and  $P = 0.018$ , respectively. When a cutoff of 50 years was chosen for age, the odds ratio (OR) was 3. For the appendiceal diameter of 14 mm, the OR was 3.0286. **Conclusion:** Preoperative evaluation of appendix diameter is a quick and useful method for a surgeon to distinguish cases with risk of conversion in the emergency department. The other risk factors associated with conversion of LA to OA are grade of inflammation, age and CRP levels.

**KEYWORDS:** *Appendectomy, conversion, predictivity*

## INTRODUCTION

The most common emergency surgical condition of the abdomen is acute appendicitis (AA).<sup>[1]</sup> The lifetime prevalence of AA is approximately 7-8%.<sup>[2]</sup> Open appendectomy (OA) has been the gold standard treatment of AA.<sup>[3]</sup> However, laparoscopic appendectomy (LA) has gained global popularity after having been performed by Kurt Karl Stephan Semm.<sup>[4]</sup> One main advantage of LA is less abdominal wall trauma; however, this advantage may not be so significant in OA, because it is usually performed through a small abdominal incision.<sup>[5]</sup> LA has been associated with less postoperative pain, a shorter hospital stay, earlier return to work, and fewer surgical site infections; conversely, LA has been associated with slightly higher intra-abdominal abscess and

intraoperative bleeding.<sup>[6]</sup> There are also other reports about longer operative times and higher costs associated with LA.<sup>[7,8]</sup>

The laparoscopic approach has the advantage of a wider vision and better diagnostic potential than the traditional McBurney incision. Conversion remains a therapeutic option when the laparoscopic approach fails and superior precision with hands is required. However, conversion is unwanted since it increases the operative time and number of incisions, as well as costs.

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This study aimed to evaluate and identify the parameters that are associated with conversion to open procedure in appendectomy that started with laparoscopic intervention. The authors hypothesized that increased appendiceal diameter obtained during preoperative radiological screening may help to predict conversion from LA to OA (converted appendectomy [CA]). The following factors were also analyzed to identify which ones were associated with conversion age, sex, serum inflammatory parameters, the degree of inflammation as stated in the pathology reports.

## MATERIALS AND METHODS

### Study population and data collection

The medical records of patients who underwent appendectomy for AA in the General Surgery department of Haseki Training and Research Hospital, Istanbul, Turkey between January 2018 and August 2018 were reviewed in this retrospective cohort study. Study approval from the local ethics committee was granted (approval number: 29.11.2018/269), and this study complied with the Helsinki Declaration of 1975, as revised in 2000. Written consent from all patients was obtained before the operation. The patients who underwent appendectomy for purposes other than appendicitis (normal appendix, parasitic appendicitis, appendiceal mucocele) and patients without preoperative radiological screening were excluded.

The clinical, demographic, surgical, and pathological data of these patients were included in a retrospective database. The following factors were analyzed to identify which ones were associated with conversion from LA to OA (CA): age, sex, c-reactive protein (CRP), white blood cell (WBC) count, aspartate transaminase (AST) and alanine transaminase (ALT) levels, operative findings such as the degree of inflammation and the appendiceal diameter obtained during preoperative radiological screening.

During our study period, LAs were performed by different residents and accompanying surgeons. The decision to convert the operation to an open procedure was made by the individual attending surgeon on a case-by-case basis.

### Statistical analysis

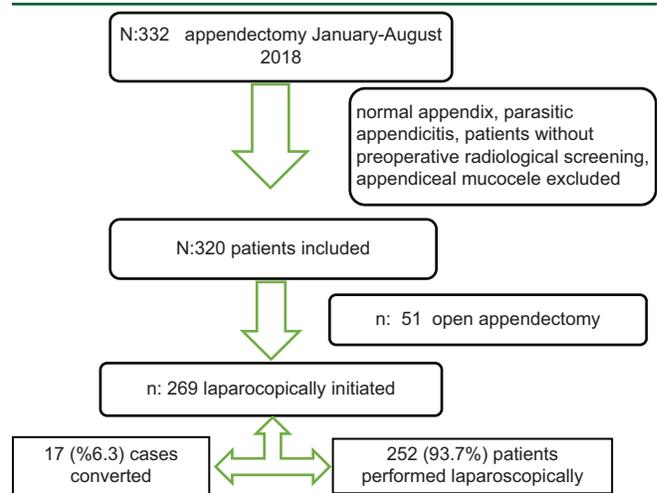
The data were tested for normality using the Shapiro–Wilk test, normality plots, kurtosis, and skewness. Continuous variables with a normal distribution are reported as a mean and standard deviation. Non-normal variables were reported as a frequency and interquartile range (IQR). The analysis was conducted using the Student *t*-test and Mann–Whitney U test when necessary. A binary logistic regression analysis

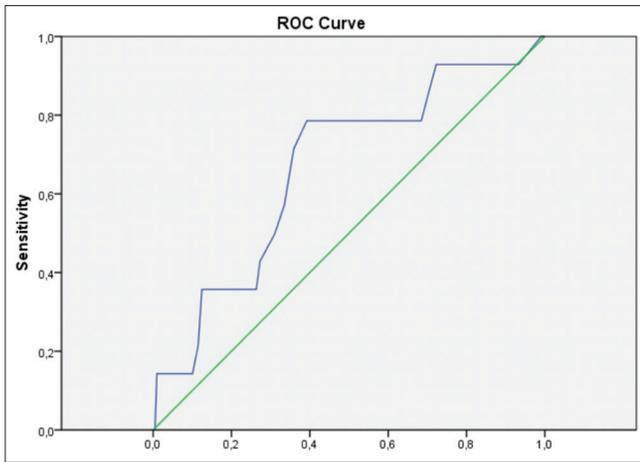
was performed to identify the parameters related to conversion. The receiver operating characteristic (ROC) curve analysis was performed to test the diagnostic ability of the significant countable parameters, i.e. the appendiceal diameter, age, and CRP level, and to define a discrimination threshold if possible. All statistical tests were performed with Statistical Package for the Social Sciences version 22 (IBM Corp., Armonk, NY). A *P* value <0.05 was considered significant. To determine the sample size, we used PS: Power and Sample Size Calculations, version 3.0 software (Dupondt/Plummer, Vanderbilt University). It was estimated that 180 subjects would be needed ( $\alpha$  level *P* = 0.05, power 80%) to detect a statistically significant difference in the appendiceal diameter (if it exists) between LA and CA cases. All patients underwent preoperative routine hematological and biochemical analyses and a preoperative radiological examination as part of the diagnostic procedure. The study group included all patients who underwent appendectomy during the study period. Since it was a retrospective cohort study, selection bias may inevitably occur. The OA and LA groups were compared to determine if they significantly differed in the tested parameters to reduce this selection bias, when needed. All records were available, and no bias due to loss to follow-up occurred.

## RESULTS

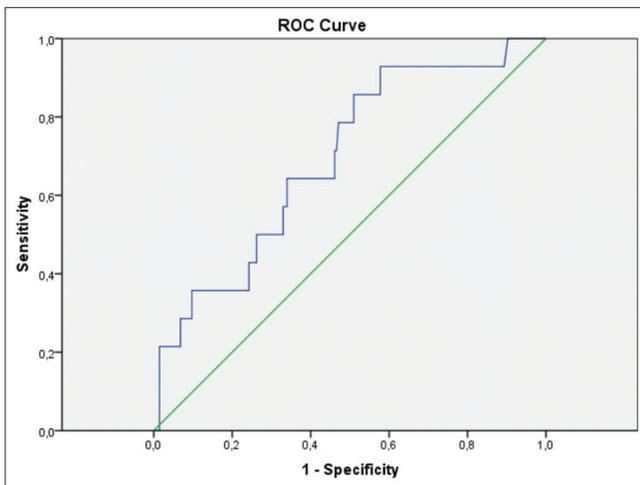
Two hundred and sixty nine (269) LA done between January 2018 and August 2018 were included in the study [Table 1]. However, in 17 (6.3%) cases of LA, conversion to OA was necessary. The collected data were tested for normality and found to be non-normally distributed, except for the WBC count. Patients’ median age was 29 (IQR 22-39) years. The median hospital stay was 2 (IQR 1-2) days. The mean WBC count

**Table 1: Flowchart**

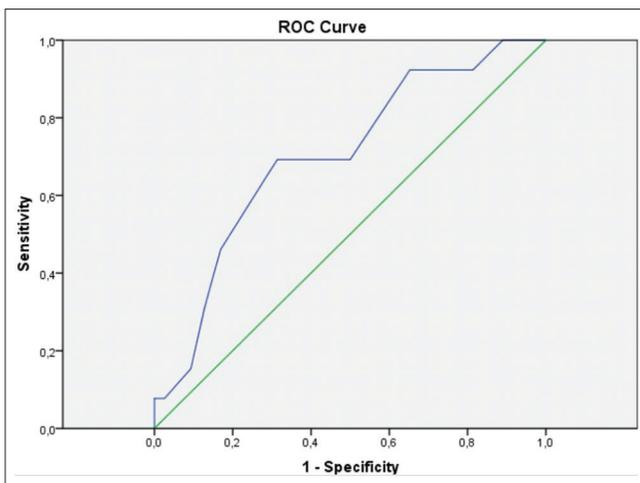




**Figure 1:** The area under the curve for age is 0.666 (confidence interval 0.518-0.813) and significant ( $P = 0.038$ )



**Figure 2:** The area under the curve for the C-reactive protein level is 0.693 and significant ( $P = 0.016$ )



**Figure 3:** The area under the curve for appendiceal diameter is 0.701 (confidence interval 0.556-0.847) and significant ( $P = 0.017$ )

was  $13.81 \pm 3.99 \times 10^3 \mu\text{L}$ , and the median CRP level was 19 (IQR 5.25-81.05) mg/L [Table 2]. The

**Table 2: Descriptive characteristics of the study group (original)**

	Laparoscopic approach	Conversion	P
Age (years)	29.00 (22.00-38.25)	35.50 (30.50-51.25)	0.032*
WBC count ( $10^3 \mu\text{L}$ )	13.80 (10.95-15.93)	12.89 (10.93-16.85)	0.899
RDW (%)	13.00 (12.60-13.60)	13.50 (12.70-14.95)	0.080
AST level (U/L)	20.00 (16.00-25.00)	18.00 (14.75-34.50)	0.692
ALT level (U/L)	17.00 (13.00-25.00)	15.00 (12.75-56.00)	0.810
CRP level (mg/L)	17.90 (4.400-73.50)	62.10 (19.18-195.1)	0.015*
Appendiceal diameter (mm)	10.25 (9.00-12.00)	12.00 (10.00-14.00)	0.017*

Data are presented as a frequency and interquartile range in parentheses.  $P < 0.05$  is considered significant. \*denotes a significant value. AST: aspartate aminotransferase, ALT: alanine aminotransferase, WBC: white blood cell, CRP: C-reactive protein, RDW: red cell distribution width. Data are presented as a frequency and interquartile range in parentheses.  $P < 0.05$  is considered significant. \*denotes a significant value. AST: aspartate aminotransferase, ALT: alanine aminotransferase, WBC: white blood cell, CRP: C-reactive protein, RDW: red cell distribution width

reasons for conversion were periappendiceal abscess in five (29.5%) cases, a very wide appendiceal root in four cases (23.5%), necrosis and perforation of the appendix in four (23.5%) cases, dense adhesions in three (17.5%) cases, and intestinal injury in one (6%) case.

The grade of inflammation, appendiceal diameter, age, and CRP level were significantly important in conversion ( $P = 0.000$ ,  $P = 0.003$ ,  $P = 0.042$ , and  $P = 0.018$ , respectively). Sex, WBC count, red cell distribution width (RDW), and ALT and AST levels were insignificant ( $P = 0.338$ ,  $P = 0.992$ ,  $P = 0.901$ ,  $P = 0.936$ , and  $P = 0.536$ , respectively).

The ROC curve analysis is shown in Figures 1-3. The following area under the curves for age, CRP level, and appendiceal diameter were significant: 0.666 (95% confidence interval [CI] 0.518-0.813,  $P = 0.038$ ), 0.693 ( $P = 0.016$ ), 0.701 (95% CI 0.556-0.847,  $P = 0.017$ ), respectively.

To evaluate the importance of age as a predictive threshold, 65 years of age was used as the cutoff value to assess the difference between the groups ( $P = 0.064$ ). Fifty years of age was chosen as a cutoff value depending on the results of the ROC curve analysis, and for CA, the odds ratio (OR) was 3.91 (95% CI 1.2162-12.5720,  $P = 0.0221$ ). The threshold for appendiceal diameter was determined according to the ROC curve analysis, and for a threshold of 14 mm, the OR was 3.0286 (95% CI 0.8366-10.9642). When the ROC curve analysis was conducted for CRP, a threshold of 20 mg/L was

deduced, and the OR was 4.0254 (95% CI 1.0888 to 14.8815,  $P = 0.0368$ ).

## DISCUSSION

The grade of inflammation (a gangrenous or perforated appendix according to the final histopathological report), age, elevated serum CRP level, and appendiceal diameter were found to be predictive for conversion in laparoscopically initiated appendectomy. The rate of LA increased globally to 70.8% in 2008, and since 2005, LA has been the most commonly used treatment approach.<sup>[9]</sup> Conversion is a therapeutic option when the laparoscopic approach cannot be fulfilled and tactile intervention is required. Preoperative routine tests might predict the risk of conversion without the need for other interventions.

Advanced age has been found to increase conversion rates; for example, Liu *et al.*, reported a four times increased risk of conversion in those older than 65 years of age.<sup>[10]</sup> Elderly patients often have atrophic appendices with diminished lymphatic tissues; besides, the appendiceal diameter has been reduced and become stenotic because of fibrosis. Also, angiosclerosis leads to ischemia, and the mesenteric dysfunction may cause perforation at an early stage.<sup>[11]</sup> Aging may also impair immune system as well as neural responses that cause abnormal sensation and transfer of pain; thus, clinical manifestations of elderly patients are non-typical and ambiguous.<sup>[12]</sup> All these factors lead to complications or a delay in diagnosis.<sup>[13]</sup> In accordance, pathological findings of severe appendicitis were reported to be significantly more common in the elderly group.<sup>[14]</sup>

In a prospective study, Antonacci *et al.*, found that older patients had a higher risk for conversion than younger patients ( $46.0 \pm 19.3$  vs  $33.9 \pm 15.4$ ).<sup>[15]</sup> In agreement with this, the LA group was found to be significantly younger than the CA group in our study. However, when considering advanced age as a risk factor for conversion, middle age should be taken into consideration, especially if other factors are associated with this finding.

The pathophysiology of appendicitis is likely to be caused by obstruction of the appendiceal lumen. After having been obstructed, the appendix is filled with secretions and gets overloaded and distended.<sup>[16]</sup> Then, lymphatic and venous return deteriorate and then bacterial overgrowth occurs in the obstructed appendix.<sup>[17]</sup> We might infer that the increased diameter detected by computed tomography (CT) scans may point to a severe inflammation and elevated pressure on the root of the appendix, causing enlargement and, thus, putting the security of the operation at risk.

Male sex has been also associated with an increased risk of conversion.<sup>[18]</sup> However, there are also contradicting reports that do not associate male sex with conversion in appendectomies, in contrast to other laparoscopic procedures.<sup>[19]</sup> In our study, the male ratio in the LA group was 57% (153/269). However, in the OA group, most patients were men (83% [42/51]). This bias might be partly due to the diagnostic properties of laparoscopic intervention in female patients to rule out an ovarian pathology or a pelvic inflammatory disease. In our study, male sex was not associated with a higher conversion rate, unlike laparoscopic cholecystectomy procedure.<sup>[20,21]</sup>

Appendiceal diameter may be measured by both ultrasonography and CT with 1mm or 2 mm differences.<sup>[22]</sup> In the LA group, the appendiceal diameter was 10.25 mm (IQR 9.00-12.00). In contrast, the CA group of 17 (6.3%) patients had a median appendiceal diameter of 12 mm (IQR 10.00-14.00). In the non-parametric analysis, there was a significant difference between the CA and LA groups, considering the appendiceal diameter. A threshold was determined according to the ROC curve analysis, and for a threshold of 14 mm, the OR was 3.0286 (95% CI 0.8366-10.9642). One simple reason for conversion might be that converting to the classic McBurney incision is a fast and easy task to avoid an unsecured laparoscopic intervention.

Commonly utilized inflammatory parameters have been evaluated for prediction of conversion. CRP, which is a very commonly utilized parameter of inflammation, has been found to have a value in prediction. Abe *et al.* reported significantly elevated CRP levels in converted cases.<sup>[23]</sup> We also found a significant elevation of CRP in CA cases, suggesting that inflammation plays an important role in conversion. When we evaluate the operative notes, reasons that may directly be attributed to inflammation make up the majority of reasons for conversion (periappendiceal abscess, dense adhesions, necrosis, and perforation of the appendix making upto 70% [12/17]). Similar observations have been made in another study, Shimoda *et al.*<sup>[24]</sup> reported conversion was significantly related to elevated levels of CRP with an OR of 1.13. By a similar cutoff, the study by Abe *et al.* revealed the OR of 3.44. When we take a cutoff at 20 mg/L, we calculated the OR as 4.0254 (95% CI 1.0888 to 14.8815,  $P = 0.0368$ ).

The other significant reason for conversion was the grade of inflammation (gangrenous, perforated, or necrotizing), as confirmed by the pathology report. The advanced stage of inflammation has been associated with higher conversion rates in other studies, too.<sup>[25]</sup> For example, Antonacci *et al.* observed the presence of appendiceal

perforation, retrocecal appendix, appendicular abscess, and diffuse peritonitis as significant parameters in conversion in the final histopathological examination.<sup>[15]</sup>

The results were obtained over 8 months from a consecutive group of patients who were admitted to the emergency department, all of whom were included in this study. No patient data were lost because of missed follow-up since the follow-up examination was not part of the study. The tested parameters were part of a routine preoperative procedure and easy to obtain from the hospital database. The risk factors were easy to assess and integrate with the preoperative evaluation before the operation for suspected appendicitis was performed.

## CONCLUSIONS

Preoperative evaluation of appendix diameter is a prompt and helpful tool for a surgeon to discriminate patients with risk of conversion in the emergency department. The patients' age, histological grade of inflammation, and elevated serum inflammatory parameters are also significant in predicting conversion.

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## Conflicts of interest

There are no conflicts of interest.

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