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# Clinical Characteristics and Coexistence of Malignancy in Patients with Respiratory Bronchiolitis-Associated Interstitial Lung Disease

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**Abstract**

**Introduction:** Respiratory bronchiolitis-associated interstitial lung disease (RB-ILD) is an extremely rare condition classified as smoking-related interstitial pneumonia. The purpose of this study was to investigate the demographic, radiological, and pulmonary function characteristics of patients diagnosed with RB-ILD based on radiological findings. In this study, we aimed to investigate the co-occurrence of lung cancer and non-lung cancers in patients with RB-ILD.

**Materials and methods:** Radiological images consistent with RB-ILD presentation (centrilobular opacity, ground glass areas, and air trapping) who attended the our center, were included in the study. Included patients were age 18 years and older, had a history of smoking (active or ex-smoker), and presented radiological evidence of RB-ILD. Demographic data, such as age, sex, cigarette packs smoked and history (pack-years), occupation, comorbidities, cancer frequency, and pulmonary function parameters were assessed.

**Results:** The study included 60 patients of which 91.7% were male. The mean age was 60.9±12.5 years, and the mean cigarette pack-year history was 33.7±12.0. Pulmonary function tests indicated small airway obstruction. Malignancy was present in 51.7% of patients with RB-ILD, with the most common types being small-cell lung cancer, colon cancer, gastric cancer, and prostate cancer. Patients were assigned into groups based on the presence of malignancy, with no significant differences found in gender, age, cigarette pack-years, and pulmonary function test values.

**Conclusion:** This study is the first nationwide investigation reporting the coexistence of RB-ILD and malignancy in a selected population of smokers. Besides smoking cessation, close monitoring for lung and extrapulmonary cancer development is advised for patients with RB-ILD.

**Key words:** Respiratory bronchiolitis; lung diseases, interstitial; respiratory function tests; iung neoplasms

## Introduction

Smoking is a major global driver of preventable mortality, with its strongest associations seen in lung cancer and chronic obstructive pulmonary disease. Moreover, tobacco exposure increases vulnerability to pulmonary infections and contributes to the progression of lung fibrosis. Beyond its established role in malignant diseases, smoking is also associated with a range of non-neoplastic pulmonary conditions, such as respiratory bronchiolitis (RB), Langerhans cell histiocytosis (LCH), desquamative interstitial pneumonia, and respiratory bronchiolitis–associated interstitial lung disease (RB-ILD). Respiratory bronchiolitis (RB) is a condition frequently observed in smokers and is usually not associated with marked respiratory symptoms. Histopathologically, RB is characterized by the presence of pigment-laden macrophages within the bronchioles, along with patchy submucosal and peribronchiolar infiltration of lymphocytes and histiocytes, and fibrotic changes surrounding the bronchioles that may extend to the adjacent alveolar walls. Respiratory bronchiolitis–interstitial lung disease (RB-ILD) refers to a subgroup within the RB spectrum characterized by a more advanced and severe disease course. The histopathological findings in the lungs of smokers were first described in 1974 (1). In 2002, RB-ILD was reclassified within the spectrum of interstitial lung diseases following a joint consensus by the American Thoracic Society (ATS), the American College of Chest Physicians (ACCP), and the European Respiratory Society (ERS) (2). There is no established causal relationship between RB and the development of malignancy. Both conditions share cigarette smoking as a common etiological factor, reflecting the widespread tissue damage induced by tobacco exposure. Smoking leads to small airway injury and contributes to carcinogenesis through mechanisms such as

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epithelial damage, DNA adduct formation, chronic inflammation, and oxidative stress (3).RB is not considered an independent risk factor for cancer; rather, it is more appropriately regarded as a marker of smoking-related lung injury. Although RB is frequently detected in smokers, there is no evidence to suggest that it undergoes malignant transformation (4). Therefore, the coexistence of RB (or RB-ILD) and malignancy in clinical settings is most likely attributable to shared tobacco exposure rather than a direct biological link. This study aimed to explore the demographic, radiological, and pulmonary function test (PFT) characteristics of patients with a radiological diagnosis of RB-ILD, and to describe the coexistence of malignancy in this population.

## Materials and Methods

Given the rarity of RB-ILD, this study was planned retrospectively. Patients with radiological findings consistent with RB-ILD (centrilobular opacity, ground-glass areas, and air trapping) identified by a radiologist were included in the study. The images were retrospectively evaluated by screening patients (both oncologic and non-oncologic) who were followed up at our center. These patients presented to the Department of Pulmonary Diseases at Tokat Gaziosmanpaşa University Faculty of Medicine between January 2022 and August 2024. Patients age 18 years and older, who had a history of smoking (active or ex-smoker), and had radiological findings consistent with RB-ILD were included in the study. The study included patients in which RB nodules (micronodules with relatively symmetrical, ill-defined borders and a centrilobular distribution in the upper lobes) could be clearly identified. The decision that patients had RB or RB-ILD was made based on the consensus of radiologists and pulmonologist, supported by radiological, clinical and laboratory data. The condition was distinguished from non-fibrotic hypersensitivity pneumonitis, which produces a similar radiological appearance, by the absence of a history of smoking, the identification of exposure to an organic antigen, and the demonstration of elevated lymphocyte counts in bronchoalveolar lavage. Cases of desquamative interstitial pneumonia (alveolar-macrophage pneumonia)—another smoking-related interstitial lung disease—characterised by a radiological pattern of lower-lobe dominance and ground-glass opacities were excluded from the study. The radiology images of the patients were evaluated by a radiologist specializing in lung diseases. Patient imaging was performed via a 64-slice CT scanner (GE Optima CT660) utilizing a helical scanning bone algorithm at a 0.625 mm slice thickness and a rotation speed of 0.5 seconds. The technical settings were configured to 120 kVp and 350 mAs, with a 1 mm collimation and an average exposure duration of 3.13 seconds. While the field of view was tailored to each individual, the 'Large Body' preset was selected prior to scanning. For a 32 cm phantom, the dose length product (DLP) was established at 386.74 mGy.cm. Finally, scans were captured in the supine position during deep inspiration, covering the area from the thyroid gland down to the lower costophrenic sinuses. Expiratory CT images were not obtained. The images were assessed by a radiologist with 11 years of experience in cardiothoracic radiology. Image assessment was performed using a 21.3-inch, 3-megapixel IPS medical-grade monitor integrated with the Sectra IDS 7 picture archiving and communication system (PACS). The demographic data, smoking history (pack-years), and pulmonary function parameters (FEV1, FVC, FEV1/FVC, and MEF 25–75) of the patients were accessed from the automation system. The study planned to assess the patients' demographic data, including age, sex, smoking history (pack-years), occupation, comorbidities, and cancer prevalence, and their pulmonary function parameters. We compared age, sex, smoking history, and pulmonary function parameters between patients with and without cancer.

**Ethical approval:** Approval was obtained from the Clinical Research Ethics Committee of the Tokat Gaziosmanpaşa University Faculty of Medicine (protocol No. 24-KAEK-074; decision No. 83116987-198).

**Statistical analysis:** All statistical evaluations were carried out using SPSS version 20.0 (SPSS Inc., Chicago, IL, USA). The distribution characteristics of the variables were examined with the Kolmogorov–Smirnov test. Categorical variables were expressed as proportions and analyzed using the chi-square test. Student's t-test was applied to compare normally distributed continuous variables across categorical groups. For analyses involving more than two groups, one-way analysis of variance (ANOVA) was employed. Continuous variables were summarized as mean ± standard deviation, and statistical significance was defined as a p value $<0.05$.

## Results

60 patients presenting with radiological findings consistent with RB-ILD were included in the study. 91.7% were male (n=55), with an average age of 60.9±12.5 years. The mean smoking history

**Table 1:** Demographic characteristics, comorbidities and PFT findings of RB-ILD patients

| Parameters | Findings |
|---|---|
| Gender | n(%) |
| Male | 55 (91.7) |
| Female | 5 (8.3) |
| Age (Mean±SD) | 60.9 ± 12.5 |
| Smoking pacs-years (Mean ±SD) | 33.7 ± 12.0 |
| Occupation | n(%) |
| Officer(civil servant) | 8 (13.3) |
| Labor | 12 (20) |
| Tradesman | 5 (8.3) |
| Retired | 7 (11.7) |
| Farmer | 10 (16.7) |
| Housewife | 5 (8.3) |
| Student | 1 (1.7) |
| Others | 12 (20) |
| Comorbidity | n(%) |
| Hypertension | 6 (10) |
| Ischemic Heart Disease | 8 (13.4) |
| Diabetes Mellitus | 3 (5) |
| COPD | 7 (11.7) |
| Asthma | 2 (3.4) |
| Obstructive Sleep Apnea | 1 (1.7) |
| Cerebrovascular Disease | 2 (3.4) |
| Neurologic Dis. (M. Gravis) | 1 (1.7) |
| Gastritis | 2 (3.4) |
| Hepatitis | 1 (1.7) |
| Psychiatric Disease | 4 (6.8) |
| Chronic Kidney Failure | 2 (3.4) |
| Malignancy | 31 (51.7) |
| Rheumatological disease | 1 (1.7) |
| Pulmonary Function Test | (Mean ±SD) |
| FEV1/FVC Ratio | 71.9 ± 11.6 |
| FEV1 (lt) | 2.86 ± 1.26 |
| FEV1 (%) | 79.7 ± 19.9 |
| FVC (lt) | 3.45 ± 1.08 |
| FVC (%) | 88.4 ± 16.6 |
| PEF (lt) | 5.06 ± 1.93 |
| PEF (%) | 64.8 ± 22.3 |
| MEF (25%) | 54.6 ± 28.6 |
| MEF (50%) | 60.3 ± 34.2 |
| MEF (75%) | 66.8 ± 32.3 |

**Abbreviations:** AA: Arithmetic Average, SD: Standard Deviation, FEV1: Forced Expiratory Flow in 1 Second, FVC: Forced Vital Capacity, PEF: Peak Flow, MEF: Maximum expiratory flow

was 33.7±12.0 pack-years. The most common occupations were laborer (20.0%), farmer (16.6%), and civil servant (13.4%). The most common comorbidities were malignancies (51.7%), ischemic heart disease (13.4%), chronic obstructive pulmonary disease (11,7%) and hypertension (10.0%). Pulmonary function tests showed that the FEV1/FVC ratio was on the borderline of obstruction, with findings consistent with small airway obstruction (FEV1/FVC 71.9±11.6%; PEF 64.8±22.3%; MEF [25%] 54.6±28.6%; MEF [50%] 60.3±34.2%; MEF [75%] 66.8±32.%; table 1). Due to the presence of malignancy in 51.7% of patients with RB-ILD, the cancer subtypes were analyzed. The most common associated malignancies were non-small-cell lung cancer (NSCLC, 11.7%), colon cancer (10.0%), gastric cancer (6.7%), and prostate cancer (5.0%;

table 2). Patients were categorized into two groups based on malignancy status, and no statistically significant differences were observed between the groups with respect to sex, age, or pulmonary function test results (table 3).

**Table 2:** Distribution of malignancy types in patients with RB-ILD and malignancy coexistence (n=31)

| Cancer type | Frequency |
|---|---|
| Lung cancer (n=9) | n(%) |
| Non-small cell cancer | 7 (11.7) |
| Small cell cancer | 2 (3.4) |
| Colon cancer | 6 (10) |
| Gastric cancer | 4 (6.7) |
| Prostate cancer | 3 ( 5) |
| Renal cell cancer | 1 (1.7) |
| Larynx cancer | 1 (1.7) |
| Bladder cancer | 1 (1.7) |
| Pancreas cancer | 1 (1.7) |
| Hematological malignancy (n=3) | |
| CLL | 1 (1.7) |
| NHL | 1 (1.7) |
| Multiple Myeloma | 1 (1.7) |
| Lung and colon cancer co-existence | 1 (1.7) |
| Colon and prostate cancer co-existence | 1 (1.7) |

**Abbreviations: CLL:** Chronic lymphoid leukemia, **NHL:** Non-Hodgkin Lymphoma

**Table 3:** Comparison of data of RB-ILD patients according to the presence or absence of malignancy

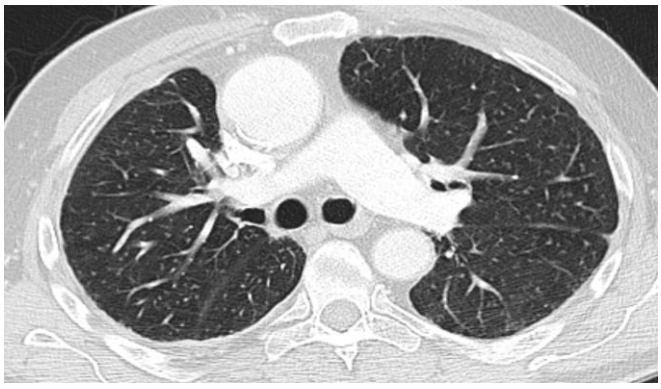
| Parameters | With Malignancy (n=31) | Without malignancy (n=29) | p value |
|---|---|---|---|
| Gender | n(%) | n(%) | |
| Male | 29 (52,7) | 26 (47.3) | 0.66 |
| Female | 2 (40) | 3 (60) | |
| | (Mean ±SD) | (Mean ±SD) | |
| Age(year) | 63 ± 8.3 | 58.7 ± 15.6 | 0.18 |
| Smoking pacs-years | 33 ± 9.3 | 34.5 ± 14.6 | 0.65 |
| FEV1/FVC | 64.9 ± 13.1 | 74.5 ± 10.5 | 0.17 |
| FEV1 (%) | 64.7 ± 17.4 | 85.1 ± 18.5 | 0.07 |
| FVC (%) | 78.3 ± 13.3 | 92.1 ± 16.7 | 0.16 |
| PEF (%) | 56 ± 18.7 | 68 ± 23.3 | 0.37 |
| MEF (25%) | 34.2 ± 16.3 | 62.1 ± 28.9 | 0.09 |
| MEF (50%) | 42.5 ± 31.1 | 66.8 ± 34.3 | 0.23 |
| MEF (75%) | 43.4 ± 21.9 | 75.4 ± 31.9 | 0.09 |

**Abbreviations:** AA: Arithmetic Average, SD: Standard Deviation, FEV1: Forced Expiratory Flow in 1 Second, FVC: Forced Vital Capacity, PEF: Peak Flow, MEF: Maximum expiratory flow

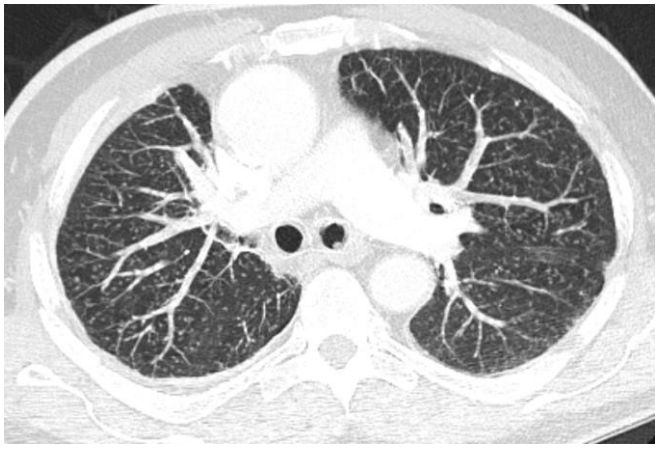
## Discussion

To our knowledge, this is the first nationwide study describing the coexistence of respiratory bronchiolitis–associated interstitial lung disease (RB-ILD) and malignancy in a smoking-exposed population. The most commonly associated malignancies were non-small cell lung cancer, followed by colon, gastric, and prostate cancers. When patients were stratified according to malignancy status, no statistically significant differences were observed in terms of sex, age, cumulative smoking exposure (pack-years), or pulmonary function test parameters. Given that both RB-ILD and malignancies share cigarette smoking as a common etiological factor, the

presence of RB-related nodular findings may reflect a background of diffuse smoking-induced lung injury and should be interpreted within the context of smoking-related disease rather than as an indicator of malignancy. These findings indicate that RB-ILD is a condition that typically reflects heavy cigarette smoke exposure in clinical practice; it should be kept in mind that accompanying malignancies may also be observed in this patient group. RB-ILD is often detected in smokers undergoing lung biopsy for reasons unrelated to RB-ILD. Histopathological evidence of RB-ILD was reported in 89% of lung biopsies in smokers requiring surgical biopsy due to pneumothorax (5). Radiological evaluation reveals that approximately half of patients with RB demonstrate either emphysematous changes or findings consistent with desquamative interstitial pneumonia. Histopathological RB was detected in 12.8% of patients undergoing surgical resection due to lung nodules, 89% of whom were smokers (6). In a review of 168 lung biopsies, ten cases were RB-ILD (7). RB-ILD has been specifically identified in approximately 2–13% of idiopathic interstitial pneumonia cases (8, 9). These studies suggest that RB-ILD presentation is strongly associated with smoking. In our study, all patients had a smoking history. There are very few studies on the respiratory function parameters of patients with RB-ILD. The most common PFT finding in RB-ILD is a mixed obstructive-restrictive pattern (10). Obstructive physiology is understood to result from airway inflammation caused by heavy exposure to cigarette smoke, while the pathology leading to restrictive limitation is associated with interstitial disease related to RB-ILD. Of the ten patients diagnosed with RB-ILD, eight exhibited a moderate decrease in diffusing capacity for carbon monoxide (DLCO), with a mean value of approximately 57% of the predicted value. This was accompanied by abnormal spirometric findings or altered lung volumes. In two other patients, one had a normal PFT but reduced DLCO, while the other had completely normal PFT and DLCO (10). In our study, the PFT findings suggest mild obstruction. Chest X-rays are often taken of smokers presenting with symptoms such as breathlessness or coughing. In RB-ILD, radiographic findings may include diffuse, fine, reticular or nodular opacities, alongside relatively preserved lung volumes. However, approximately one-third of patients show no abnormalities on standard posteroanterior chest radiography. Bronchial wall thickening; peribronchovascular prominence; and small, regular, and irregular opacities are other common features of RB-ILD (11). The following non-specific imaging features may be seen on HRCT: centrilobular nodules, ground-glass opacities with a diffuse or patchy distribution, and air trapping. (12-15) (figure 1, The coexistence of neoplasms in the same patient is shown in figure 2). In another RB-ILD cohort, HRCT demonstrated central bronchial wall thickening in 90% of patients, peripheral bronchial wall involvement in 86%, centrilobular nodules in 71%, and ground-glass opacities in 67%. Additionally, a separate case series reported the presence of ill-defined centrilobular nodules with a predominance in the upper lobes in five RB-ILD patients (14). Another study found centrilobular emphysema in 57% of individuals with RB-ILD, predominantly affecting the upper lung zones, while prominent septal lines and a reticular pattern were observed in 33% of cases. (16,17). Previous reports suggest that imaging findings in RB-ILD most often include ground-glass opacities, poorly marginated centrilobular nodules, and thickening of the bronchial walls.(18–20). These findings predominantly involve the upper lung zones, while advanced fibrosis and honeycombing are uncommon.



1A



1B

**Figure 1:** A case with a 45 pack-year smoking history. A: Symmetric centrilobular micronodules with ground-glass density, consistent with respiratory bronchiolitis nodules, were observed in both lungs of an asymptomatic heavy smoker B: Nodules are demonstratively visualised using the MIP (maximum intensity projection) method.

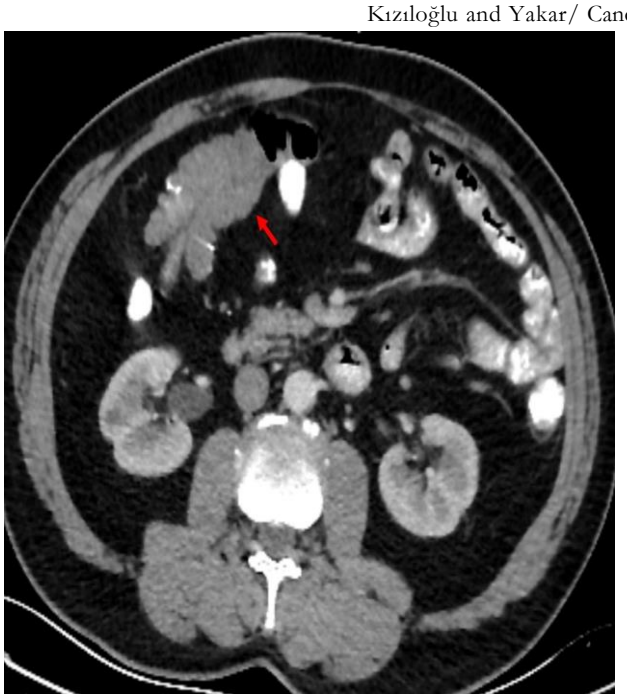


**Figure 2:** A soft tissue mass obliterating the lumen is observed in the distal transverse colon (red arrow). Pathological diagnosis: Colon adenocarcinoma

Ground-glass opacities are usually bilateral and show a patchy pattern, most frequently in the upper lobes (21). Owing to the presence of indistinct centrilobular nodules, RB is frequently misinterpreted as subacute hypersensitivity pneumonitis (17). In the differential diagnosis, factors such as a strong smoking history, the absence of organic antigen exposure, and nonspecific BAL findings are important, as lymphocytosis is characteristically seen in BAL samples from patients with hypersensitivity pneumonitis. So far, only one study has examined the link between RB-ILD and cancer. In the study conducted by Yamada et al., cancer prevalence among patients with RB was assessed in a cohort comprising 67 current smokers, 22 former smokers, and 35 never-smokers. Fibrosis-associated RB was identified in 13 of the 67 current smokers, whereas RB without fibrotic involvement was detected in 12 individuals. No cases of RB-ILD were reported among former or never-smokers. Among patients with fibrosis-associated RB, squamous cell carcinoma of the lung was observed in 11 of 13 cases, while lung adenocarcinoma was identified in 7 of the 12 patients with non-fibrotic RB (22). In the present study, the overall prevalence of malignancy was 51.7%, with lung cancer accounting for 15% of cases. In our cohort, no statistically significant differences were observed between patients with and without malignancy in terms of mean age, sex distribution, or smoking history. Given the study design and the absence of a control group, these findings are most appropriately interpreted as reflecting shared tobacco exposure rather than suggesting additional contributing factors and should be considered hypothesis-generating, warranting further investigation in controlled studies. The coexistence of RB and malignancy can be explained by exposure to tobacco smoke—a common aetiological factor—rather than by a direct causal relationship. Current findings indicate that in individuals with RB, extrapulmonary malignancies such as colon, stomach and prostate cancers may also be present, in addition to lung cancers. However, this suggests that RB should be regarded as a marker reflecting heavy and chronic tobacco exposure, rather than an independent carcinogenic process. From a radiological perspective, the RB nodules identified on CT scans should generally be regarded as a reflection of widespread lung damage associated with smoking. These findings may help to re-evaluate underlying tobacco exposure, particularly in cases where smoking history is incomplete or unreliable. Furthermore, the evaluation of such radiological findings within a clinical context can help to provide a more accurate interpretation of the patient's overall risk profile.

**Study limitations:** The primary limitation of this study was the absence of histopathological confirmation in the patient cohort. However, since RB-ILD is usually asymptomatic, histopathological diagnosis is rare. Additionally, due to advances in imaging techniques, it is now possible to diagnose this condition clinically and radiologically. Another important limitation was the retrospective nature of the study. However, because RB-ILD is a rare disease, a retrospective study was preferred to obtain data from a larger number of patients. The absence of inter-observer agreement during the detection of RB nodules is another limitation of the study. The insufficient number of patients in the subgroups negatively affects statistical significance. One of the key limitations of our study is the absence of a control group comprising individuals with a smoking history but no RB-ILD findings. Consequently, it has not been possible to determine whether RB-ILD is independently associated with malignancy. This limits the interpretability and generalisability of the results. The fact that a proportion of the study population consisted of patients undergoing oncological follow-up may have led to significant selection bias. This suggests that the radiological findings associated with RB may have been detected incidentally during imaging for malignancy, thereby limiting the interpretability of the findings.

## Conclusion

RB-related radiological findings should be interpreted as markers of smoking-related lung injury rather than indicators of malignancy. In this context, the coexistence of malignancy observed in patients with RB-ILD most likely reflects shared tobacco exposure rather than a direct biological relationship. Given the retrospective design, lack of a control group, and potential selection bias within our cohort, no conclusions can be drawn regarding an independent association or increased cancer risk. Therefore, our findings should be considered descriptive and hypothesis-generating. Future studies incorporating appropriately matched control groups and multivariable analyses are needed to better clarify this coexistence.

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**Conflict of interest:** The authors declare no conflicts of interest.
**Ethical approval:** Ethics committee approval was obtained from the Tokat Gaziosmanpaşa University Faculty of Medicine, Clinical Research Local Ethics Committee (protocol no: 24-KAEK-074; number: 83116987-198).
**Funding:** This research did not receive any funding from agencies in the public, commercial, or non-profit sectors.
**Data sharing:** We confirm that all relevant data are included in the article and its supplementary information files.
**Use of AI tools:** AI tools(large language models) were used to assist with the language editing.

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