Observational Study

Medicine

OPEN

Solitary lung cavities on CT imaging

Differentiating malignant and nonmalignant diseases

Zeliha Cosgun, MD[a,*]

Abstract

This study aims to investigate the contribution of radiological findings in differentiating benign from malignant diseases in patients with solitary cavitary lesions detected on computed tomography (CT). In this study, lesion size, cavity wall thickness, and the presence of additional parenchymal findings were retrospectively evaluated to distinguish between benign and malignant diseases and examine the etiology of solitary pulmonary cavities. CT scans were reviewed by a radiologist specialized in thoracic radiology. The study was conducted using a 64-multidetector CT system, and measurements of lesion size and cavity wall thickness were recorded on axial images. The presence of consolidation and centrilobular nodules was also assessed. Receiver operating characteristic curves were generated to determine optimal cutoff points for distinguishing benign from malignant lesions based on cavity wall thickness. Benign lesions accounted for 47.9% of the cases, with active pulmonary tuberculosis being the most common diagnosis. In the malignant group, primary lung cancer predominated, with squamous cell carcinoma being the most frequent subtype. There were significant differences between benign and malignant cases regarding the mean maximum wall thickness and lesion diameter. Additionally, the presence of consolidation and centrilobular nodules was assessed. Maximum wall thickness thresholds of 7.2 mm and 23 mm were found to be the most accurate indicators of benign and malignant etiologies, respectively. In conclusion, CT findings revealed significant differences between malignant and benign solitary pulmonary cavities; benign lesions generally presented with smaller and thinner cavity walls, and perilesional parenchymal findings were observed in benign lesions of infectious origin but not in malignant lesions.

Abbreviation: CT = computed tomography.

Keywords: benign and malign disease, cavitary lesion, lung

1. Introduction

A lung cavity is defined as a gas-containing lesion within the lung, enclosed by a wall of variable thickness. An excavation refers to the appearance of a cavity, which may be located within an opacity such as consolidation, a mass, or a nodule. Various mechanisms can lead to the formation of cavities, with tissue loss due to necrosis within a mass or nodule being the most common cause. This necrosis can be neoplastic, infectious, or ischemic in nature.[1]

Cavitated lung lesions are frequently observed on imaging studies, with malignancies and infections representing the predominant origins. These lesions arise from diverse causes, leading to a range of etiologies and diagnostic challenges due to overlapping imaging features. The spectrum of potential causes for cavitary lung lesions is extensive, encompassing infectious diseases such as tuberculosis, fungal infections, and parasitic infections, as well as noninfectious conditions, including malignant and rheumatic lesions.[2–4]

Conventional chest radiography and computed tomography (CT) are the primary imaging modalities used for pulmonary disease assessment, with CT emerging as the most reliable and sensitive technique for evaluating cavitary lung lesions. In cases of solitary cavity lesions, multiple CT findings – such as cavity diameter, wall thickness, and surrounding parenchymal involvement – can aid in diagnosis. Guo, Juntang, et al found that a cavity wall thickness of <7 mm is highly specific for benign diseases, while a thickness >24 mm is highly specific for malignant diseases.[5] Additionally, the absence of perilesional parenchymal findings often supports malignancy, while their presence typically suggests benignity.[3]

Acute symptom onset may sometimes help distinguish between malignant and nonmalignant diseases. For example, a benign infection may cause hemoptysis if it affects a nearby vessel. Benign diseases can also result in fatigue and weight loss similar to those seen in malignancies. However, the acute onset of fever generally helps differentiate benign disorders from malignancies, although lung cancer can present with secondary superinfection.[6]

Solitary lung cavities also pose significant diagnostic and management challenges. While existing studies emphasize the

The authors have no funding and conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

[a] Department of Radiology, Bolu Abant Izzet Baysal University Hospital, Bolu, Turkey.

[*] Correspondence: Zeliha Cosgun, Department of Radiology, Bolu Abant Izzet Baysal University, Izzet Baysal Training and Research Hospital, Bolu, Turkey (e-mail: zeliha44@gmail.com).

How to cite this article: Cosgun Z. Solitary lung cavities on CT imaging: Differentiating malignant and nonmalignant diseases. Medicine 2024;103:52(e41022).

Received: 20 August 2024 / Received in final form: 24 November 2024 / Accepted: 2 December 2024

http://dx.doi.org/10.1097/MD.0000000000041022

importance of various radiological features in differentiating benign from malignant causes, no single feature is diagnostic, and overlapping radiological findings are common. Although a preliminary radiological diagnosis can be valuable for early diagnosis and guiding patient management, radiological studies in this area remain limited. Therefore, the aim of this study is to discuss diagnostic CT findings in benign and malignant cavitary lung lesions, presenting them in light of existing literature.

2. Materials and methods

This retrospective study included 73 patients with solitary cavitary lesions, diagnosed through clinical, laboratory, pathological findings, or follow-up imaging, who underwent thoracic CT examinations between January 2015 and May 2021. Approval for the study was obtained from the hospital's ethics committee (Abant Izzet Baysal University Ethics Committee, date: June 8, 2021, approval no: 2021/233). The images of the patients were reevaluated for cavitary lesion characteristics by a radiologist with 9 years of experience in thoracic radiology and a total of 17 years of radiological experience, using the Picture Archiving and Communication System.

Examinations were conducted using 64-multidetector CT systems (General Electric Revolution EVO, 64 slices). CT scans were performed without electrocardiography gating, with the following scan parameters: 0.6 mm collimation, 1.5 mm slice thickness, 1.4 mm increment, 100 kV, 135 mAs, a pitch of 0.9, and a gantry rotation time of 0.33 seconds. Intravenous administration of 100 cc nonionic contrast material was done using an automatic injector at a flow rate of 4 mL/s via a vein in the arm.

Each examination involved recording the lesion's size (maximum diameter) and the maximum wall thickness of the cavity, both measured on axial images, along with any associated findings, regardless of their location or extent. Images were volumetrically acquired and assessed using high-resolution and soft kernels on pulmonary and mediastinal windows, respectively. Measurements were specifically conducted in the axial plane on the pulmonary window to enhance result reproducibility and employ a readily applicable technique.

Consolidation was defined as a uniform increase in lung attenuation that obscured the margins of adjacent vessels and airway walls. Centrilobular nodules were identified as nodular opacities situated at the center of a normal secondary pulmonary lobule, following the guidelines set forth by the Nomenclature Committee of the Fleischner Society.

The Statistical Package for the Social Sciences software (version 15, SPSS Inc., Chicago, IL) for Windows was used for statistical analysis. Patients were categorized into 2 groups based on their final diagnosis: malignant and nonmalignant etiologies of solitary pulmonary cavities. Group variables were assessed using independent-sample student's *t* tests for numerical data with a normal distribution, and chi-square tests for categorical

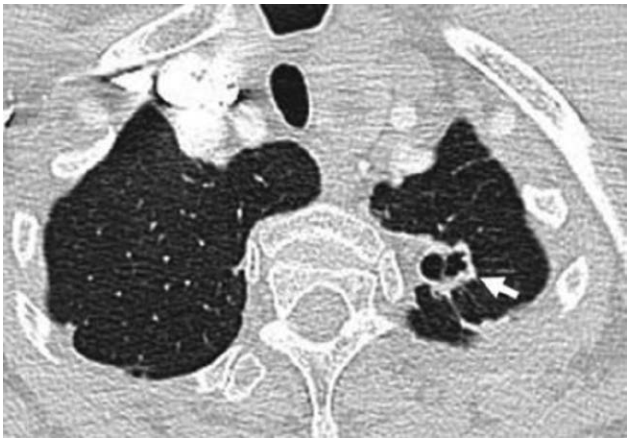

Figure 1. In a patient with a history of previous tuberculosis, a cavitary lesion (white arrow) with a stable thin wall in the apicoposterior segment of the left lung was interpreted as consistent with a sequel tuberculosis cavity.

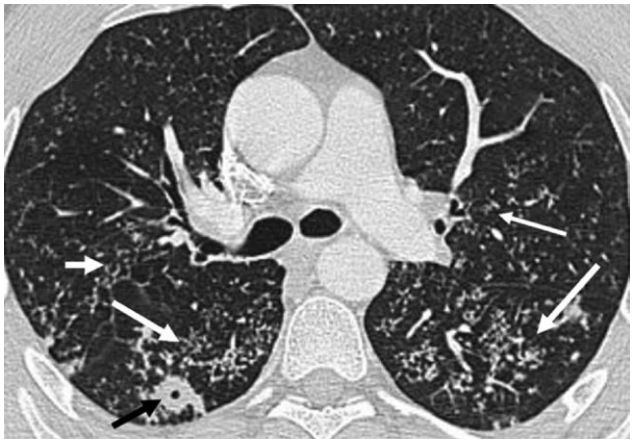

Figure 2. In a patient diagnosed with active tuberculosis, a cavitary lesion in the superior segment of the right lower lobe (black arrow) of the lung and widespread tree-in-bud opacities in the bilateral lung parenchyma (white arrows), consistent with endobronchial spread, were observed.

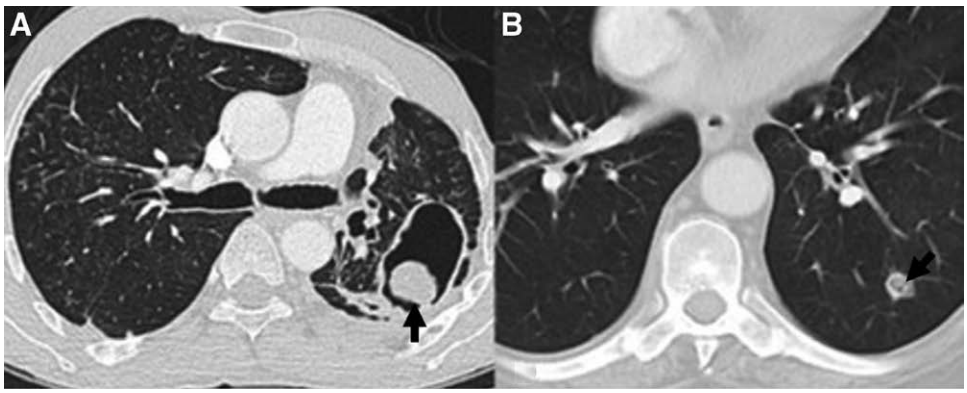

Figure 3. Fungal infections, in a patient diagnosed with Aspergillus fumigatus, a fungus ball (black arrow) within the cavity was observed in the left lung following left upper lobectomy (A). In a patient diagnosed with *Candida albicans*, a cavitary lesion containing a solid component (black arrow) was observed in the left lower lobe of the lung (B).

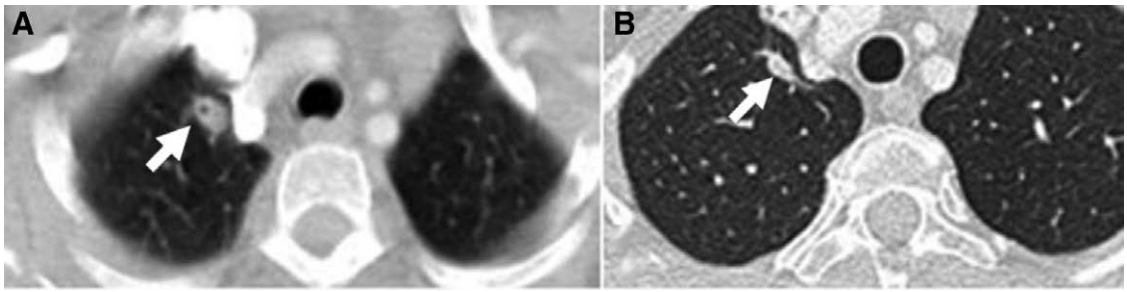

Figure 4. A cavitary lesion (white arrow) observed in the right lung apex (A), patient followed up with a diagnosis of hydatid cyst, demonstrates regression (B) (white arrow) after hydatid cyst treatment.

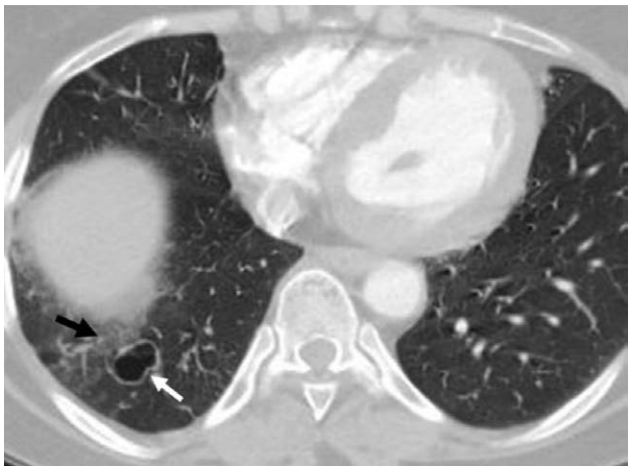

Figure 5. In a patient diagnosed with *Streptococcus pneumoniae*, a cavitary lesion (white arrow) in the posterior basal segment of the right lower lobe of the lung accompanied by perilesional ground-glass opacities (black arrow).

data or proportions. All tests were 2-tailed, with significance set at $P < .05$. Following initial analysis, receiver operating characteristic curves were generated to identify optimal cutoff points for distinguishing between malignant and nonmalignant lesions based on maximum wall thickness of the cavities.

3. Results

Upon reviewing CT images and medical records, 73 patients with solitary pulmonary cavities (35 benign, 38 malignant) were identified. The average age for benign lesions was 58 ± 14 years, whereas for malignant lesions it was 64 ± 9 years. Among the total of 73 patients, 15 (13.7%) were female. Of those with benign lesions, 10 were female and 25 were male, while among those with malignant lesions, 5 were female and 33 were male.

Nonmalignant lesions accounted for 35 cases (47.9%), while 38 cases (52.1%) were malignant. Among the nonmalignant diagnoses, mycobacterial infection sequelae comprised 5 cases (14.3%) (Fig. 1), active pulmonary tuberculosis 11 cases (31.4%) (Fig. 2), fungal infections 4 cases (11.4%) (Fig. 3A and B), infectious causes other than fungal infections 12 cases (34.3%) (Figs. 4–7) and rheumatoid nodules 3 cases (8.6%) (Fig. 8).

Of the 12 patients with non-fungal infections, 2 were under follow-up with a diagnosis of hydatid cyst (Fig. 4A and B), 1 had Streptococcus pneumoniae (Fig. 5) as the pathogen, 2 had Nocardia (Fig. 6), and 1 had a bacterium other than the Mycobacterium tuberculosis complex (Fig. 7). In 6 patients, regression of the lesion on follow-up imaging led to the consideration of an infectious etiology for the lesion. Among the 4 patients diagnosed with fungal infections, Aspergillus fumigatus was detected in 2 cases (Fig. 3A), and Candida albicans in 2 cases (Fig. 3B).

In the malignant group, primary lung cancer was diagnosed in 32 patients, while 6 patients (15.8%) had metastases (Fig. 9A). Among primary lung cancers, there were 9 cases of adenocarcinoma (23.7%) (Fig. 9B), 23 cases of squamous cell carcinoma (60.5%) (Fig. 9C). All malignant cases were histologically confirmed, whereas nonmalignant cases were confirmed by clinical/radiological and laboratory findings, as well as follow-up imaging.

Benign lesions were most commonly observed in the apical segment of the right upper lobe (12 patients, 34.3%), while malignant lesions were most frequently detected in the anterior-posterior segment of the same lobe (8 patients, 21.1%).

In 11 out of 35 patients with benign lesions, accompanying perilesional consolidation areas and centrilobular nodules were observed. While perilesional parenchymal findings were not detected in malignant lesions, accompanying satellite nodules were observed in 6 patients ($P < .01$).

The maximum lesion diameter averages differed significantly between malignant and nonmalignant groups. In the malignant group, the longest dimension was 47.7 mm (25–70), while in the benign group it was 30.9 mm (16–42) ($P < .01$). The maximum wall thickness at the thickest point of the cavity was 20.6 mm (8.8–35) in malignant cases, whereas it was 6.8 mm (3.8–7) in benign cases ($P < .01$).

Thresholds for maximum wall thickness associated with nonmalignant and malignant lesions were identified: 7.2 mm was 84% specific and 77% sensitive for benignity, while 23 mm achieved a specificity of 97% and a sensitivity of 45% for malignant lesions (Fig. 10, Table 1).

4. Discussion

The most significant finding of this study is that cavity wall thickness is significantly greater in malignant lesions compared to benign ones. This study identified cutoff values for maximum wall thickness in differentiating benign from malignant lesions: 7.2 mm for benignity and 23 mm for malignancy. Consistent with these results, previous studies have emphasized the importance of imaging findings of cavitary lesions in aiding diagnosis. Additionally, numerous studies in the literature report significant differences in cavity wall thickness between benign and malignant cavitary lesions, findings which align with the results of this study. According to Woodring et al, a wall thickness exceeding 15 mm indicated a likelihood of malignancy on X-ray scans,[7,8] while Nin et al set the cutoff at >24 mm for CT scans.[3]

This finding, consistent with existing literature, indicates that increased cavity wall thickness in pulmonary lesions is associated with malignancy; however, this represents a correlation rather than a causative relationship. While increased wall thickness may relate to the invasive behavior of tumor cells, tissue damage, and the inflammatory response due to necrosis, it also

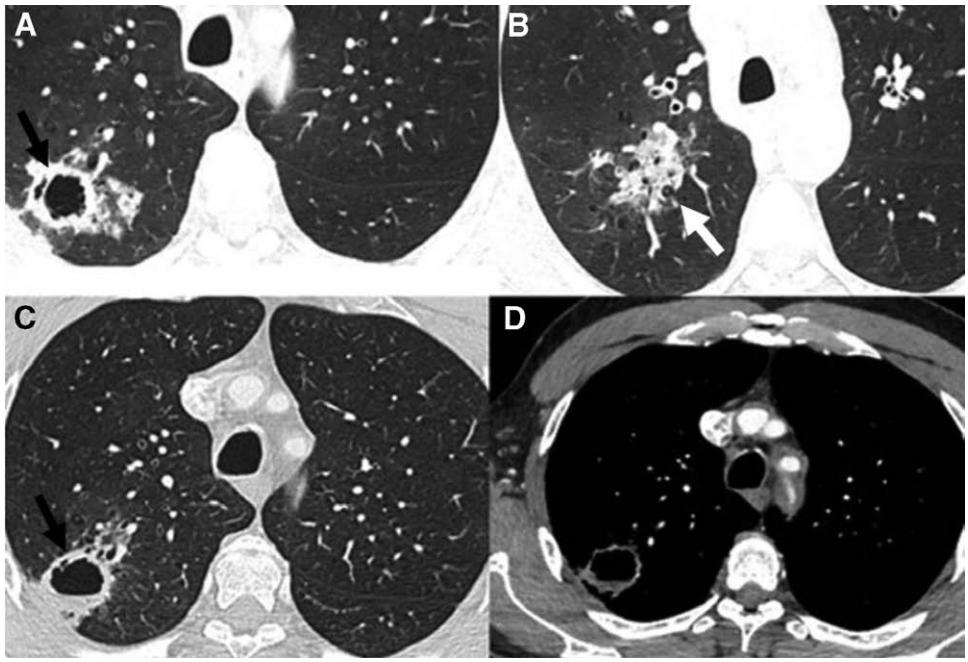

Figure 6. In a patient diagnosed with Nocardia, a cavitary lesion (black arrow) accompanied by perilesional consolidation (white arrow) was observed in the right lower lobe of the lung.

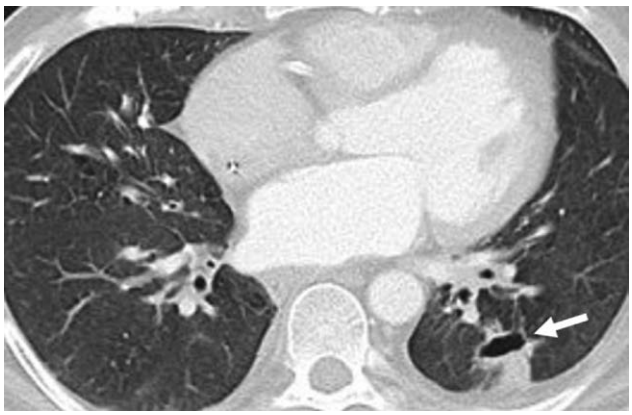

Figure 7. In a patient diagnosed with nontuberculous mycobacteria, a thin-walled cavitary lesion (white arrow) is observed in the left lower lobe of the lung.

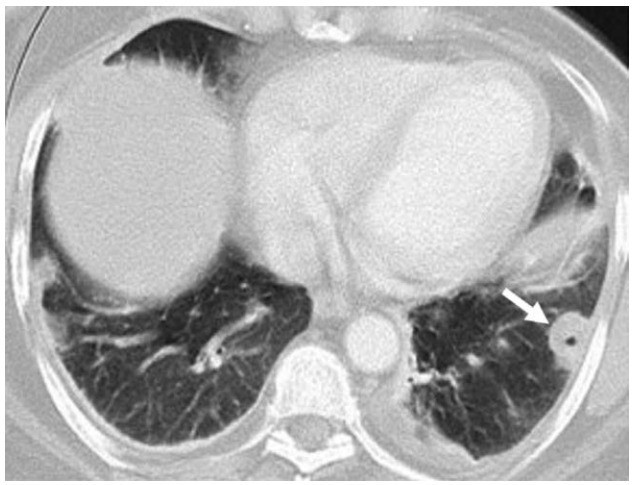

Figure 8. A cavitary lesion consistent with rheumatoid nodule, pathologically diagnosed in the left lower lobe of the lung.

results from the complex interplay between tumor biology and the host microenvironment. Increased cavity wall thickness may also be observed in infectious diseases, such as active tuberculosis. Thus, although increased cavity wall thickness does not definitively establish a diagnosis of malignancy, it can support preliminary diagnosis in cases where clinical and laboratory findings raise suspicion of malignancy, guiding further investigations and facilitating a quicker path to a definitive diagnosis.

Another significant finding of this study, consistent with the literature, is the presence of perilesional centrilobular nodules and consolidations accompanying benign lesions.[9–11] In this study, the observation that perilesional consolidation in cavitary lesions supports benignity emerged as an important finding. Consistent with the literature, perilesional consolidation is commonly associated with benign lesions, often attributed to infections, granulomatous diseases, and reactive changes. In this context, the presence of perilesional consolidation may decrease the likelihood of malignancy and support the benign nature of the lesion. However, it is crucial to note that perilesional consolidation alone is insufficient for diagnosis; clinical findings, imaging features, and histopathological examination, when necessary, should all be considered. This finding could serve as an additional criterion in the assessment of cavitary lesions in clinical practice, contributing to more accurate diagnoses during the diagnostic process.

The most significant limitation of this study is its retrospective design. Additionally, the relatively small sample size poses challenges in achieving statistical power, thereby limiting the generalizability of the findings and the potential for conducting more comprehensive analyses. Thoracic CT scans were exclusively performed as post-contrast images, and consequently, the contrast enhancement pattern of the cavity wall could not be evaluated. Additionally, some studies assess the ratio of length to diameter to describe the shape and degree of uneven thickness of the cavity wall; however, our study focused on findings that can be actively utilized in radiological practice, such as cavity wall thickness and parenchymal findings surrounding the cavity. These represent limitations of our study and could be

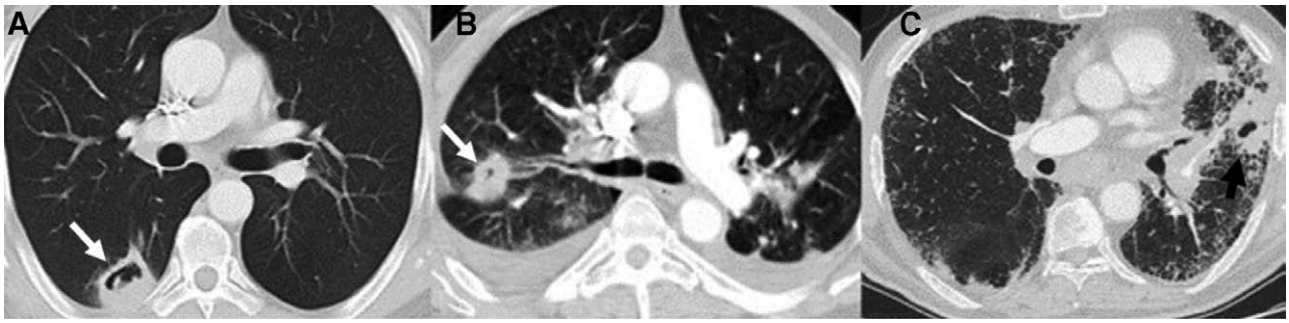

Figure 9. In a patient followed up with a diagnosis of bladder cancer, pathologically diagnosed with metastasis, a single cavitary lesion (white arrow) is observed in the superior segment of the right upper lobe of the lung (A). Primary lung adenocancer (white arrow) (B) and squamous cell carcinoma (black arrow) in the background of UIP pattern (C). UIP = usual interstitial pneumonia.

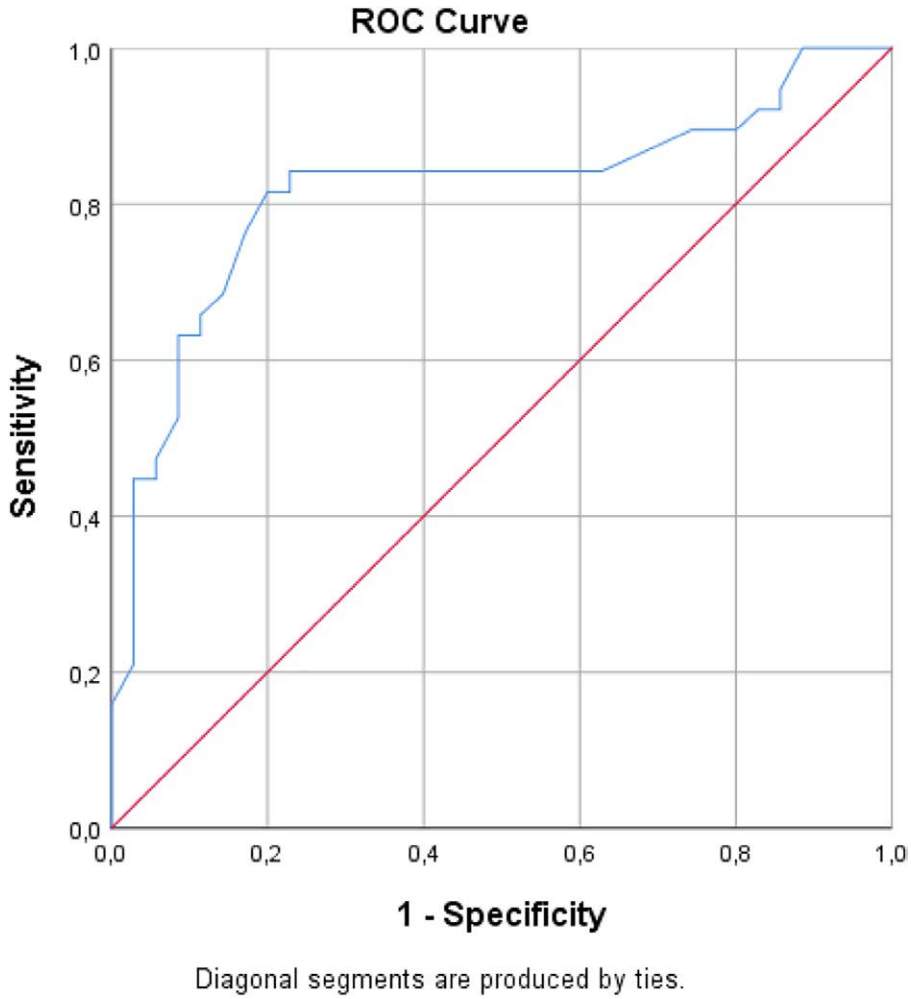

Figure 10. Receiver operating characteristic curves analysis in maximum wall thickness associated with malignant cavities lesions.

further examined in larger patient populations to evaluate their role in distinguishing between malignancy and benignity, as well as their diagnostic contribution.

5. Conclusion

In conclusion, these findings regarding increased cavity wall thickness and the presence of perilesional consolidation in pulmonary lesions provide valuable insights into the diagnostic evaluation of these lesions. The association between increased cavity wall thickness and malignancy, along with the supportive role of perilesional consolidation in benignity, underscores the importance of thorough radiological assessment to guide clinical decision-making. Incorporating these imaging findings into the diagnostic algorithm can enhance the accuracy of diagnosing pulmonary lesions and facilitate appropriate patient management strategies.

Author contributions

Conceptualization: Zeliha Cosgun.
Data curation: Zeliha Cosgun.

Table 1

Receiver operating characteristic curves analysis in maximum wall thickness associated with malignant cavities lesions.

Risk factor	AUC (95%)	Cut off	*P*-value	Sensitivity (%)	Specificity (%)
Maximum wall thickness	0.818 (0.714–0.921)	23	<.001	44.7	97.1

Abbreviation: AUC = area under the curve.

Formal analysis: Zeliha Cosgun.
Funding acquisition: Zeliha Cosgun.
Investigation: Zeliha Cosgun.
Methodology: Zeliha Cosgun.
Project administration: Zeliha Cosgun.
Resources: Zeliha Cosgun.
Software: Zeliha Cosgun.
Supervision: Zeliha Cosgun.
Validation: Zeliha Cosgun.
Visualization: Zeliha Cosgun.
Writing – original draft: Zeliha Cosgun.
Writing – review & editing: Zeliha Cosgun.

References

[1] Ben Romdhane MHB, Brillet P-Y, Brauner M. Syndrome cavitaire. EMC: radiologie et imagerie médicale – cardiovasculaire – thoracique – cervicale. 2015;10:1–17. doi: 10.1016/S1879-8535(14)66445-X.
[2] Hansell DM, Bankier AA, McMahon H, McLoud TC, Müller NL, Remy J. Fleischner society glossary of terms for thoracic imaging. Radiology. 2008;246:697–722.
[3] Nin CS, De Souza VV, Alves GR, et al. Solitary lung cavities CT findings in malignant and non-malignant disease. Clin Radiol. 2016;71:1132–6.
[4] Parkar A, Kandiah P. Differential diagnosis of cavitary lung lesions. J Belg Soc Radiol. 2016;100:100.
[5] Guo J, Liang C, Sun Y, Zhou N, Liu Y, Chu X. Lung cancer presenting as thin-walled cysts: an analysis of 15 cases and review of literature. Asia Pac J Clin Oncol. 2016;12:105–12.
[6] Akinosoglou KS, Karkoulias K, Marangos M. Infectious complications in patients with lung cancer. Eur Rev Med Pharmacol Sci. 2013;17:8–18.
[7] Woodring JH, Fried AM, Chuang VP. Solitary cavities of the lung diagnostic implications of cavity wall thickness. AJR Am J Roentgenol. 1980;135:1269–71.
[8] Woodring JH, Fried AM. Significance of wall thickness in solitary cavities of the lung a follow-up study. AJR Am J Roentgenol. 1983;140:473–4.
[9] Burrill J, Williams CJ, Bain G, Conder G, Hine AL, Misra RR. Tuberculosis a radiological review. Radiographics. 2007;27:1255–73.
[10] Rossi SE, Franquet T, Volpacchio M, Giménez A, Aguilar G. Tree-in-bud pattern at thin-section CT of the lungs radiologic-pathologic overview. Radiographics. 2005;25:789–801.
[11] Collins J, Blankenbaker D, Stern EJ. CT patterns of bronchiolar disease what is "tree-in-bud?". AJR Am J Roentgenol. 1998;171:365–70.