Case Reports in Oncology

Case Rep Oncol 2025;18:508–514
DOI: 10.1159/000545435
Received: November 10, 2024
Accepted: March 13, 2025
Published online: March 25, 2025

Case Report

Precise Localization of the Subsolid Lesion by Colour Marking under CT-Guided Control before Video-Assisted Surgery Resection: A Case Report

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Keywords
Blue dye marking · Lung cancer · Subsolid nodule · Video-assisted surgery

Abstract
Introduction: Lung cancer is one of the leading causes of death worldwide. Lung lesions, often discovered incidentally on chest CT, pose a diagnostic challenge due to their diverse etiology, including both benign and malignant nature. A key step in the assessment of these lesions is the evaluation of their morphological features in the CT image, size, and behavior over time. Nodules are divided into solid and subsolid according to their density. When surgical resection is necessary, solid lesions are palpable peroperatively, whereas subsolid lesions may be unidentifiable by palpation, and their precise localization is difficult. To spare patients from extensive surgery such as thoracotomy, it is advantageous to use one of the methods of preoperative marking of these lesions. Best practices include marking with mixtures containing patent blue and contrast agents, applied under CT guidance. This method allows accurate visualization of the localization of the lesion, which facilitates their resection by minimally invasive video-assisted surgery (VATS). ***Case Presentation:*** A 51-year-old female patient was found to have a subsolid lesion in the right lung during a routine follow-up CT scan of the lung

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for a history of malignant melanoma. The lesion was followed for 4 years and showed slow size progression and change from a pure ground glass nodule to a subsolid nodule. Due to the persistence of the nodule, change in morphology, and size progression, the patient was indicated for surgical resection. Using preoperative labeling with a mixture of blue dye and contrast agent, the nodule was successfully located and sublobary VATS resected. ***Conclusion:*** The color marking allowed accurate identification of the subpleurally located lesion, which would otherwise have been unvisualized and intangible, thus minimizing the need for more extensive surgery. This case highlights the key role of color marking in increasing resection success and surgical safety, particularly in small and subsolid nodules.

Introduction

Lung cancer is one of the leading causes of death worldwide. According to the World Health Organization (WHO) in 2020, it is the second leading cause of death globally and the leading cause of death before the age of 70 years [1]. In the Czech Republic, lung cancer was the fourth most common diagnosis in 2021, with men affected more often than women by a ratio of 1.6:1. More than 65% of newly diagnosed cases were detected at an advanced stage, leading to a 5-year survival in only 21.5% of cases [2].

Pulmonary nodules, often detected incidentally on chest CT scans, pose a diagnostic challenge due to their diverse etiology. They may be a manifestation of infections, inflammatory processes, granulomatous diseases, or primary or secondary tumors [3]. Early and accurate diagnosis of these lesions is essential for effective treatment and prognosis of patients. Incorrect assessment can lead to either overmonitoring, invasive interventions (overtreatment), or, on the contrary, delayed diagnosis and treatment with negative consequences for the patient.

A key factor in the diagnosis of pulmonary nodules is the estimation of the probability of their malignancy based on CT images. The most important parameters are the size of the lesion, its density, and growth potential [4, 5]. Other features observed include the presence of calcifications, fatty component, or spiculation. According to the density, nodules are divided into solid and subsolid lesions. Subsolid nodules are further classified as pure ground glass nodules (pure ground glass) and part-solid nodules (part-solid) [4, 5]. Pure ground glass nodules may represent preinvasive forms of lung adenocarcinoma, such as atypical adenomatous hyperplasia and adenocarcinoma in situ (AIS), whereas part-solid nodules may indicate the presence of minimally invasive adenocarcinoma or adenocarcinomas with lepidic growth [6].

Management of these lesions is complicated by their potential for progression to malignant forms and slow growth [7]. Subsolid nodules require close monitoring, and surgical intervention should be considered in the case of persistence or size progression. However, precise localization of these nodules during surgery is often difficult, especially in small and subpleurally located lesions, which are invisible on video-assisted thoracoscopy (VATS) and may be non-palpable [8].

This case report is unique for several reasons. We present the case of a 51-year-old female patient with a subsolid pulmonary lesion who was incidentally detected as having a subsolid pulmonary lesion during a routine follow-up during a dispensary check-up for malignant melanoma. The lesion was followed up for 4 years and subsequently resected videothoracoscopically after preoperative labeling with a mixture of blue dye and contrast agent.

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This procedure allowed precise localization and minimally invasive resection of the lesion. Marking of the lesion was crucial as it was a slow-growing malignant tumor that would have been difficult to detect by palpation without this method. This case also highlights the importance of the minimally invasive approach and preoperative marking in situations where accurate tumor location may be problematic but is essential for resection.

Case Report

The patient was born in 1970, without serious comorbidities, and underwent resection of malignant melanoma in April 2013. Subsequently, a suspicious lymph node (LU) in the left axilla was detected on ultrasound. Biopsy confirmed a metastasis of malignant melanoma. PET/CT was performed as part of staging, which showed a solitary finding in the left axilla. At the end of April 2013, dissection of the left axilla was performed, and only one of the 19 LNs extirpated was affected by metastasis. Molecular genetic testing revealed a BRAF mutation at codon 600, which led to the deployment of targeted therapy with BRAF inhibitors. Further follow-up was conducted at another institution and was assessed as a stable disease).

In November 2017, during a routine CT scan of the lungs, a new asymptomatic lesion was detected in segment S10 of the right lower lobe, measuring 7 mm in size, with a density consistent with a pure ground glass nodule. On a follow-up CT scan in June 2020, the lesion changed character to a subsolid lesion with the presence of a solid component. A PET/CT scan in July 2020 confirmed the persistence of the lesion without increased metabolic activity. A further follow-up in April 2021 confirmed persistence and additionally showed a slight size progression of the solid component of the lesion.

Due to the typical CT image of a subsolid lesion, which did not tend to regress, and the overall size of the lesion of 12 mm with a solid component of 7 mm, the patient was indicated by the multidisciplinary pulmonary committee for surgical resection in May 2021 (Fig. 1).

The lesion was located in the S10 segment of the lower lobe of the right lung, 13 mm from the pleural surface, and could not be visualized by videothoracoscopy. Due to its subsolid morphology and probably difficult palpability, it was marked preoperatively. Marking was performed in the patient who was positioned prone and by injecting 0.2 mL of a mixture of Omnipaque 350 mg I/mL iodine contrast agent and Patent Blue V, which was injected intrapulmonarily with a thin needle directly to the lesion under CT guidance. This procedure was without complications and allowed subsequent successful resection of the lesion by videothoracoscopic wedge resection supplemented by mediastinal LN sampling (Fig. 2). Histological examination of the resected tissue showed infiltration by primary lung adenocarcinoma, with predominantly acinar (85%) and less lepidic (15%) growth. The resection lines from the tumor margin to the resection margins were adequate, with the smallest measured dimension of 13 mm. No metastatic process was found in the examined mediastinal lymphatic nodes. The postoperative course was uneventful, and the patient was discharged to home care on the fourth day after surgery. She continues to be followed up regularly and remains free of signs of disease recurrence.

Discussion

Small pulmonary foci are generally difficult to reach by transthoracic and transbronchial biopsies. Similarly, percutaneous biopsies of subsolid foci can be false negative [9]. In the case of subsolid nodules, PET/CT examination is often unrewarding, especially in lesions with a

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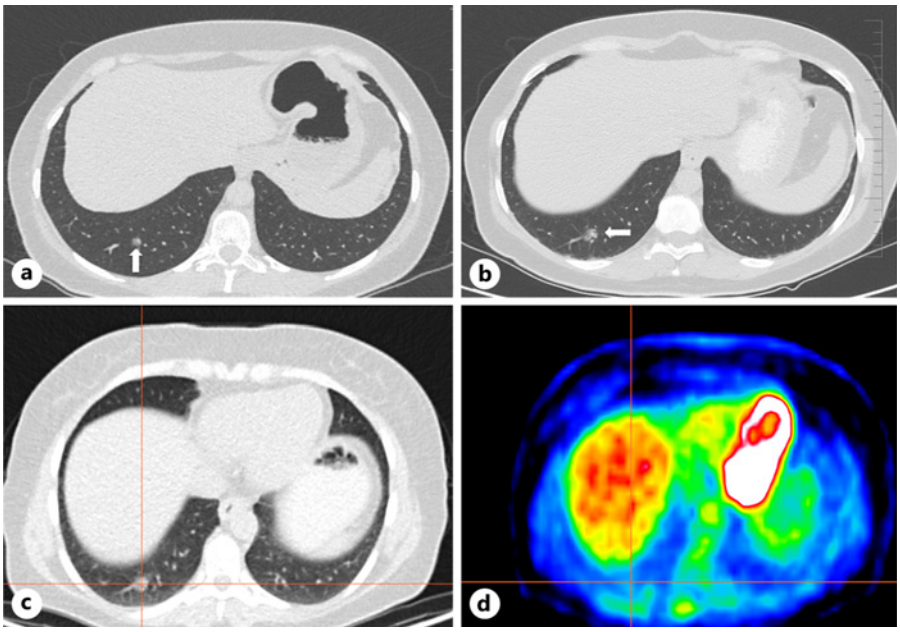

Fig. 1. a Axial CT scan from November 2017 with a small pure ground glass nodule. **b** The control axial CT scan from June 2020 shows a change in the nature of the lesion to a subsolid nodule with a solid component. **c**, **d** The PET/CT examination from July 2020 demonstrates the persistence of the deposit without its metabolic activity.

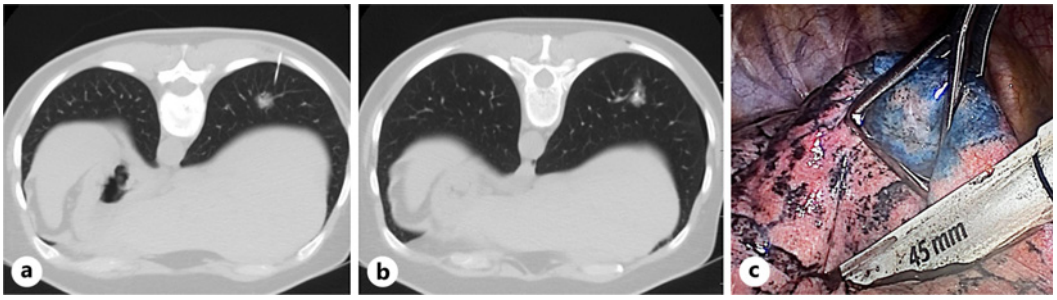

Fig. 2. a, **b** Axial CT scan of preoperative marking of the nodule. **a** Insertion of a fine needle under CT control to the bearing. **b** Scan after injecting a small amount of the marking mixture near the nodule. **c** Videothoracoscopic view of the marked part of the lung tissue before its resection.

minimal solid component [4, 5]. This phenomenon was confirmed in our case, where the lesion did not have increased metabolic activity.

Pulmonary metastases of malignant melanoma usually appear as solid lesions. Subsolid nodules are often of infectious etiology with a tendency to regress. However, if the lesion shows size progression, persistence, or transforms into a part-solid nodule, it should be considered potentially malignant. In the case of our patient, the lesion grew gradually over a period of 4 years, when the initially pure ground glass lesion turned into a subsolid nodule with the presence of a solid component.

The management of subsolid nodules depends mainly on their overall size, growth potential, and the size of the solid component. If the solid component exceeds 5 mm, invasive intervention should be considered [6]. Subsolid nodules are directly related to slow-growing

lung adenocarcinoma tumors such as adenocarcinoma in situ, minimally invasive adenocarcinoma, and invasive adenocarcinoma with lepidic growth [7]. In our patient's case, very slow growth was documented, with the lesion increasing in size by only 5 mm over a 4-year period.

Subpleurally located lesions are invisible to the surgeon during video-assisted thoracoscopy (VATS). The area in which the lesion is located is most accurately verified by the surgeon by palpation, which is often not technically possible with the mini-invasive short-incision approach. Subsolid nodules may be difficult to palpate. Pure ground glass nodules are non-palpable [10, 11].

Less aggressive surgical resection remains the cornerstone of treatment for GGO. Sublobar resections, including segmentectomy or wedge resection, have emerged as viable alternatives to lobectomy, and individual basilar subsegmental resections are technically complex and not commonly performed. Removal of the entire basilar segment is more commonly performer, so in this case we performed wedge resection [12].

In order to accurately localize the lesions and minimize the extent of surgery, various techniques have been developed to facilitate the identification of the lesion during surgery [13, 14]. In our department, we have successfully used the method of color marking with a mixture of Patent Blue and contrast agent [15].

Color marking is a simple, safe, and reliable method. This technique consists of applying a small amount of the marking mixture under CT control to the bearing or in close proximity to it. The blue-stained area containing the lesion is then easily visually undentified and resected [15].

The advantages of the color marking method are supported by several studies [15]. In our study, we achieved a labeling success rate of over 90%, which is consistent with the results of published studies [15–18]. A significant benefit of staining localization is described, especially in solitary or even multiple small subpleurally located pulmonary nodules or subsolid and pure ground glass foci that cannot be palpated [10]. Complications associated with these procedures are in general of a minor nature. The most common are pneumothorax and intrapulmonary hemorrhage. Generally, these procedures can be considered very safe. None of our complications required urgent intervention or prevented subsequent VATS resection [18–20].

Conclusion

The color marking allows precise identification of the lesions, reducing the need for more extensive surgical procedures such as thoracotomy and contributing to greater safety and patient friendliness. This technique is particularly useful for subsolid and ground glass nodules, which often have slow growth and a high potential for malignant transformation, as was demonstrated in our patient. The color marking method is reliable and has a minimum of complications.

Statement of Ethics

Written, informed consent was obtained from the patient for publication of the details of her medical case and any accompanying images. Ethical approval is not required for this study in accordance with local or national guidelines. The CARE Checklist has been completed by the authors for this case report, and is attached as online supplementary material (for all online suppl. material, see https://doi.org/10.1159/000545435).

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Funding Sources

There was no funding support for this study.

Author Contributions

Vladimír Červeňák and Zdeněk Chovanec contributed equally to this work as first authors. Jiří Vaníček and Viktor Weiss contributed to review and manuscript revision. Klára Novosádová contributed to provision of images. Jan Resler, Tomáš Hanslík, Alena Berková, and Ondřej Bílek contributed to provision of clinical data and manuscript revision. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

All data generated or analyzed during this study are included in this article and its online supplementary material files. Further inquiries can be directed to the corresponding author.

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