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Original Article

Methylene Blue–Guided Localization to Improve Accuracy and Safety in Pulmonary Nodule Resection

Salih Duman,[1] Rassim Kassim,[1] Celal Caner Ercan,[2] Berker Özkan,[1] Adalet Demir,[1] Murat Kara[1]

[1]Department of Thoracic Surgery, Istanbul University Faculty of Medicine, Istanbul, Türkiye
[2]Department of Radiology, Division of Interventional Radiology, Istanbul University Faculty of Medicine, Istanbul, Türkiye

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Correspondence: Salih Duman, Department of Thoracic Surgery, Istanbul University Faculty of Medicine, Istanbul, Türkiye
E-mail: dr.salihduman@hotmail.com

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ABSTRACT

Objective: The increasing detection of small and non-palpable pulmonary nodules through low-dose computed tomography (CT) screening has highlighted the need for reliable intraoperative localization, particularly during video-assisted thoracoscopic surgery (VATS). CT-guided methylene blue marking is a simple, rapid, and widely accessible technique that facilitates minimally invasive resection. This study aimed to evaluate the technical success, safety profile, and determinants of outcomes in CT-guided methylene blue localization of pulmonary nodules.

Methods: This retrospective study included 49 consecutive patients who underwent preoperative CT-guided methylene blue localization followed by thoracic resection, predominantly via VATS, between 2020 and 2025. Demographic characteristics, nodule morphology, procedural parameters, surgical details, and postoperative outcomes were analyzed. Categorical variables were compared using Chi-square or Fisher-based tests, and continuous variables using the Mann–Whitney U test.

Results: Localization was successful in 47 of 49 patients, yielding a technical success rate of 95.9%. Two unsuccessful localizations (4.1%) occurred, both in lower-lobe lesions and both associated with complications. Localization-related adverse events developed in nine patients (18.4%), most commonly pneumothorax (12.2%) and parenchymal hemorrhage (6.1%). The median patient age was 63 years, and the median nodule diameter was 9 mm. Malignancy was identified in 69.4% of nodules. No significant associations were found between localization success and nodule type, FDG uptake, lobar distribution, resection type, or procedural parameters. Tumor size showed a non-significant trend toward association with malignancy.

Conclusion: CT-guided methylene blue localization is a safe, highly effective, and practical technique for facilitating thoracoscopic resection of small pulmonary nodules. Technical success is consistently high and appears largely independent of radiological, anatomical, or procedural factors. These findings support the use of methylene blue marking as a reliable adjunct to minimally invasive thoracic surgery.

INTRODUCTION

Lung cancer remains one of the most common causes of cancer-related mortality worldwide.[1] With the increasing use of low-dose computed tomography (CT), clinicians encounter an increasing number of small and indeterminate pulmonary nodules in routine practice.[2,3] Some of these nodules prove to be early primary lung cancers, whereas others represent metastatic deposits from extrathoracic malignancies.[4] In selected patients, limited surgical resection offers both definitive diagnosis and, when appropriate, a potentially curative treatment option.[5,6]

The expansion of video-assisted thoracoscopic surgery (VATS) has improved perioperative outcomes, but small or deep pulmonary nodules can be difficult to detect intraoperatively because the surgeon lacks the ability to palpate the lung.[7] This limitation led to the development of preoperative localization techniques. One of the earliest practical approaches was described by Lenglinger et al.[8] in 1994, who reported CT-guided methylene blue injection for marking pulmonary nodules. Its simplicity, low cost, and ability to provide direct visual guidance during thoracoscopy facilitated its widespread clinical adoption.

Since then, several alternative localization techniques—

including hook-wire, microcoil, lipiodol, radiotracers, and fluorescent dyes—have been introduced.[9-12] Despite these options, methylene blue remains widely used because it does not require specialized equipment or advanced imaging facilities and can be readily implemented in most centers.

Although high technical success rates have been reported for methylene blue localization,[13-15] factors influencing its performance remain inconsistent across studies. The impact of anatomical and radiological features on localization success is particularly unclear, especially for small, subpleural, or ground-glass lesions.

The present study aims to evaluate the technical success, complication profile, and factors associated with CT-guided methylene blue localization of pulmonary nodules in a retrospective cohort from our institution.

MATERIALS AND METHODS

This retrospective cohort comprised 49 consecutive patients who underwent CT-guided methylene blue localization and thoracic resection at our thoracic surgery unit between January 2020 and May 2025. All patients had pulmonary nodules that were radiologically suspicious for malignancy or represented indeterminate lesions requiring surgical diagnosis. Localization was performed for small or impalpable nodules expected to be difficult to identify intraoperatively, particularly in cases with multiple nodules of varying sizes.

Demographic characteristics (age, sex, smoking history), prior cancer history, nodule features (size, morphology, FDG uptake, and lobar location), procedural parameters (needle gauge, marking-to-surgery time, number of punctures, marking-to-lesion distance, and pleural distance), and postoperative outcomes were retrospectively reviewed.

Ethical approval was obtained from the Istanbul University Ethics Committee (No: 2025/2027, Date: 31/10/2025) and the requirement for informed consent was waived due to the retrospective nature of the study. The study was conducted according to the Helsinki Declaration.

All localizations were performed by experienced thoracic radiologists using a 64-slice CT scanner without contrast enhancement and with a 2.5-mm slice thickness. Patients were positioned prone to ensure consistent access to posterior and basal lung segments. After sterile preparation and local anesthesia with 1% lidocaine, a 16-, 20-, or 22-gauge Chiba needle was inserted percutaneously under intermittent CT guidance. Needle gauge selection was based on radiologist preference, lesion depth, and anticipated trajectory.

Once the needle tip was confirmed adjacent to or within the lesion, a mixture of 1.0 ml autologous blood and 1.0 ml methylene blue (total 2.0 ml) was injected. The addition of autologous blood was intended to reduce dye diffusion and enhance intraoperative visibility, consistent with previously described dye-blood mixture techniques. A final CT scan was performed immediately afterward to confirm accurate staining and to assess for complications such as pneumothorax or pulmonary hemorrhage.

For patients with multiple nodules, only those anticipated to be difficult to detect intraoperatively—typically smaller or deeper lesions—were marked. Continuous communication between the radiologist and thoracic surgeon was maintained throughout the procedure to optimize the localization trajectory and ensure intraoperative accuracy.

Following localization, all patients were transferred directly to the operating room. General anesthesia with single-lung ventilation was achieved using either a double-lumen endotracheal tube or an endobronchial blocker. All operations were performed on the same day as the localization. Dye-marked lesions were identified thoracoscopically based on the blue-stained pleural surface, and resection depth was guided by preoperative CT findings. Surgical resections were performed using uniportal, biportal, or triportal VATS, depending on lesion location and surgeon preference.

Wedge resection was the primary technique and was performed with an endoscopic stapler to secure adequate parenchymal margins. Segmentectomy was preferred when the lesion was poorly visible or when wedge resection was deemed insufficient. Thoracotomy was performed when

Figure 1. Intraoperative and specimen findings of CT-guided methylene blue-localized pulmonary nodules. **(a)** Thoracoscopic view showing blue-stained pleural surface marking the target lesion; **(b)** Wedge resection performed under direct visualization of the dye-marked parenchyma; **(c)** Resected specimens demonstrating clear methylene blue staining, confirming precise localization during VATS resection.

additional large or central lesions required simultaneous resection; in these cases, smaller nodules in the same lung were localized preoperatively to facilitate detection.

Localization was defined as technically successful when the dye-marked area was clearly visible intraoperatively and the target lesion was completely resected, as confirmed by gross examination or frozen-section analysis. All specimens underwent pathological evaluation to determine lesion type, margin status, and final diagnosis (Fig. 1)

Patient demographics, nodule characteristics, and procedural details were summarized using descriptive statistics. Categorical variables were reported as frequencies and percentages, and continuous variables as medians with interquartile ranges (IQR) due to non-normal distribution. Group comparisons for categorical variables were performed using the Chi-square test, Fisher's exact test, or Fisher–Freeman–Halton exact test, as appropriate. Continuous variables were analyzed with the Mann–Whitney U test.

A p-value <0.05 was considered statistically significant. Statistical analyses were conducted using IBM SPSS Statistics, version 26.0 (IBM Corp., Armonk, NY, USA).

RESULTS

A total of 49 patients were included in the analysis. The median age was 63 years (IQR: 52-68), and 51.0% were female. A smoking history was present in 55.1% of the cohort, while 57.1% had a previous diagnosis of malignancy. The most common lesion location was the right upper lobe (40.8%), followed by the left lower lobe (24.5%). Part-solid nodules represented the dominant morphological subtype (44.9%), and FDG uptake on PET/CT was positive in 44.9% of cases.

The median tumor size was 9 mm (IQR: 6–10). Localization was performed with a median of 2 punctures (IQR: 2–4). The median pleura-to-lesion distance was 9 mm (IQR: 4.5–15.9), the marking-to-lesion distance was 3.7 mm (IQR: 1.3–7.3), and the median interval between localization and surgery was 25 minutes (IQR: 25–30).

Biportal VATS was the predominant surgical approach (83.8%), followed by uniportal VATS (12.2%), triportal VATS (2.0%), and thoracotomy (2.0%). The patient who underwent thoracotomy was also marked preoperatively because the deeply located target nodule was not expected to be reliably identified by palpation alone. Wedge resection was performed in 40 patients (81.6%), and anatomical segmentectomy in 9 patients (18.4%). One planned segmentectomy was converted to lobectomy based on frozen-section findings; this case was documented separately and not included in the primary resection-type analysis.

Localization-related adverse events occurred in nine patients (18.4%). Pneumothorax was the most common complication (12.2%), followed by parenchymal hemorrhage (6.1%) and subcutaneous emphysema (2.0%). Most pneumothoraces were radiologic and required no intervention. Postoperative complications occurred in 12 patients (24.5%), most frequently prolonged air leak (16.3%) and pneumonia (8.2%).

Table 1. Demographics, nodule characteristics, procedural parameters, surgical details, complications, and final pathology (n=49)

Variable	n (%) or Median (IQR)
Demographics	
Age, years	63 (52–68)
Female sex	25 (51.0)
Smoking history	27 (55.1)
Prior malignancy	28 (57.1)
Nodule characteristics	
Tumor size, mm	9 (6–10)
FDG uptake positive	22 (44.9)
Nodule type	
- Solid	14 (28.6)
- Part-solid	22 (44.9)
- Pure ground-glass	12 (24.5)
Lobar distribution	
RUL	20 (40.8)
LLL	12 (24.5)
Other lobes	17 (34.7)
Procedural details	
Number of punctures	2 (2–4)
Pleura–lesion distance, mm	9 (4.5–15.9)
Marking–lesion distance, mm	3.7 (1.3–7.3)
Marking–surgery time, min	25 (25–30)
Surgical approach	
Biportal VATS	41 (83.8)
Uniportal VATS	6 (12.2)
Triportal VATS	1 (2.0)
Thoracotomy	1 (2.0)
Resection type	
Wedge	40 (81.6%)
Segmentectomy	9 (18.4%)
Localization-related adverse events	
Pneumothorax	6 (12.2)
Parenchymal hemorrhage	3 (6.1)
Subcutaneous emphysema	1 (2.0)
Patients with ≥1 adverse event	9 (18.4)
Postoperative complications	
Prolonged air leak	8 (16.3)
Pneumonia	4 (8.2)
Renal dysfunction	2 (4.1)
Pancytopenia	1 (2.0)
Patients with ≥1 postoperative complication	12 (24.5)
Final pathology	
Malignant	34 (69.4)
Benign	15 (30.6)

VATS: Video-assisted thoracoscopic surgery; RUL: Right upper lobe; LLL: Left lower lobe.

Table 2. Relationship of nodule type and FDG uptake with malignancy

Variable	Category	Benign n (%)	Malignant n (%)	Total	p-value
Nodule Type	Solid	3 (21.4)	11 (78.6)	14	0.617
	Part-solid	9 (40.9)	13 (59.1)	22	
	Pure GGO	3 (25.0)	9 (75.0)	12	
	Mixed	0 (0.0)	1 (100.0)	1	
	Total	15 (30.6)	34 (69.4)	49	
FDG Uptake	Negative	10 (37.0)	17 (63.0)	27	0.358
	Positive	5 (22.7)	17 (77.3)	22	
	Total	15 (30.6)	34 (69.4)	49	

FDG: 18F-fluorodeoxyglucose.

Table 3. Association between marking success and localization-related complications

Marking success	No complication n (%)	Complication n (%)	Total	p-value
Unsuccessful	0 (0.0%)	2 (22.2%)	2	
Successful	40 (100.0%)	7 (77.8%)	47	
Total	40 (81.6%)	9 (18.4%)	49	0.077

Table 4. Association between marking success and lobar distribution

Lobe	Unsuccessful n (%)	Successful n (%)	Total	p-value
RUL	0 (0.0)	20 (42.6)	20	
RML	0 (0.0)	4 (8.5)	4	
RLL	1 (50.0)	5 (10.6)	6	
LUL	0 (0.0)	7 (14.9)	7	
LLL	1 (50.0)	11 (23.4)	12	
Total	2 (4.1)	47 (95.9)	49	0.210

RUL: Right upper lobe; LLL: Left lower lobe; LUL: Left upper lobe; RML: Right middle lobe; RLL: Right lower lobe.

Malignancy was identified in 34 patients (69.4%), including primary lung adenocarcinoma (34.7%), metastatic tumors (30.6%), and other malignant histologies (4.1%). Benign pathology was present in 15 patients (30.6%).

A detailed summary of all demographic, radiologic, procedural, surgical, and outcome variables is presented in Table 1.

There was no statistically significant association between malignancy and either nodule type (p=0.617) or FDG uptake (p=0.358). Solid, pure GGO, and FDG-positive nodules showed numerically higher malignancy rates, although these differences were not statistically significant (Table 2).

There was no statistically significant association between marking success and the occurrence of localization-related complications (p=0.077). Both unsuccessful localizations occurred in patients who developed complications, whereas seven of the 47 successful cases also experienced minor adverse events (Table 3).

There was no statistically significant association between marking success and lobar distribution (p=0.210). Both unsuccessful localizations occurred in lower-lobe lesions (one in the right lower lobe and one in the left lower lobe), whereas all upper-lobe and middle-lobe lesions were successfully localized (Table 4).

There was no statistically significant association between marking success and the type of surgical resection performed (p=0.999). Both unsuccessful localizations occurred in patients undergoing wedge resection, whereas all segmentectomy procedures achieved successful marking. These findings indicate that resection type did not influence the likelihood of localization success.

Posterolateral thoracotomy was required in 2.0% of patients (1/49), primarily for the resection of large or deep lesions, synchronous nodules, or when formal mediastinal

Table 5. Association between marking success and resection type

Resection type	Unsuccessful n (%)	Successful n (%)	Total	p-value
Wedge	2 (5.0%)	38 (95.0%)	40	
Segmentectomy	0 (0.0%)	9 (100.0%)	9	
Total	2	47	49	0.999

lymph node dissection was indicated. Wedge resection was the most frequently performed procedure (81.6%, 40/49), followed by segmentectomy (18.4%, 9/49). In 11 patients (22.4%), an intraoperative frozen-section–guided completion procedure was required, including 5 completion lobectomies, 4 completion segmentectomies, and 2 extended wedge resections. These were performed either for positive/suspicious margins or oncologic optimization after the initial wedge resection. The mean number of staplers used per resection was 2.4±0.9.

Histopathological evaluation demonstrated a wide spectrum of pulmonary lesions, including primary malignancies, metastatic tumors, and benign or pre-invasive entities. Primary lung adenocarcinoma was the most common malignant diagnosis (34.7%), exhibiting diverse histologic subtypes such as lepidic, acinar, mucinous, enteric, and minimally invasive adenocarcinoma. Metastatic tumors accounted for 30.6% of cases, most frequently originating from colorectal carcinoma, followed by breast carcinoma, pleomorphic sarcoma, and synovial sarcoma. Benign or pre-invasive lesions represented 30.6% of the cohort and included hamartoma, organizing pneumonia, atypical adenomatous hyperplasia (AAH), necrotizing granulomatous inflammation, fibrotic nonspecific interstitial pneumonia (NSIP), and meningothelial-like nodules.

Three patients presented with mixed or dual malignancies within the same lung, highlighting the biological complexity of multifocal pulmonary disease. One patient with a history of soft-tissue sarcoma harbored both metastatic sarcoma and a synchronous primary adenocarcinoma. Another patient previously diagnosed with adenoid cystic carcinoma exhibited a metastatic lesion alongside a separate primary lung adenocarcinoma. The third patient demonstrated anatomically distinct typical and atypical carcinoid tumors, indicating simultaneous dual neuroendocrine differentiation. These cases underscore the diagnostic challenges associated with small pulmonary nodules and emphasize the utility of CT-guided localization in ensuring accurate, tissue-preserving resection in anatomically complex or multifocal disease.

DISCUSSION

CT-guided methylene blue localization continues to be a practical, widely accessible, and safe technique for guiding minimally invasive resection of small or impalpable pulmonary nodules. In the present study, the overall technical success rate was 95.9%, comparable to the success rates reported in previous methylene blue and other dye-based localization series.[16-18] The overall complication rate was 18.4%, with pneumothorax and minor pulmonary hemorrhage being the most common events, in line with the established safety profile of dye, microcoil, and hook-wire localization methods.[19-22] Notably, none of the complications required additional intervention.

The two unsuccessful localizations in our cohort occurred in lower-lobe lesions, both of which exhibited extensive dye spread or insufficient intraparenchymal deposition. Similar patterns have been described in cases where steep needle angulation or increased pleura-to-lesion distance reduces dye concentration at the target site.[23,24] Although these trends did not reach statistical significance, they highlight known limitations of methylene blue, particularly in deeper lesions or those requiring oblique needle trajectories.

All segmentectomy cases in our series achieved successful localization, and wedge resections accounted for both unsuccessful attempts. However, resection type itself showed no statistical association with marking success, suggesting that localization feasibility is primarily determined by radiologic characteristics rather than the extent of surgical resection. This finding is consistent with recent data supporting the reliability of dye-based localization even in anatomic segmentectomy, including lymphadenectomy cases.[25]

A technical modification used in our practice—injecting 1 mL methylene blue mixed with 1 mL autologous blood—has been reported to reduce diffusion and create a more compact stain, at the expense of slightly decreased color intensity.[26] This approach appeared beneficial in emphysematous or anthracotic lungs, in which excessive diffusion may otherwise obscure the staining pattern.

Our cohort contained a high proportion of part-solid nodules and FDG-avid lesions, features frequently associated with malignancy. The malignancy rate of 69.4% aligns with reports from oncologic referral centers and screening programs. Several patients demonstrated dual or synchronous primaries, including combinations of metastatic sarcoma with primary adenocarcinoma and simultaneous typical and atypical carcinoid tumors. Such cases underscore the biological complexity of multifocal pulmonary disease and emphasize the importance of accurate lesion targeting to avoid sampling errors, preserve lung parenchyma, and en-

sure complete treatment of each suspicious focus.[27]

Although none of the radiologic parameters—including nodule type, FDG uptake, pleura-to-lesion distance, or marking-to-lesion distance—showed a statistically significant association with marking success, deeper lesions demonstrated numerically lower success, consistent with prior observations that depth increases dye dispersion and reduces localization accuracy.[28] Tumor size showed a borderline trend toward malignancy prediction, in agreement with established size-based malignancy models.[29]

When comparing localization techniques, hook-wire marking carries a higher risk of dislodgement (2.4-7.5%) and higher pneumothorax rates.[19] Microcoil localization provides reliable intraoperative fluoroscopic guidance but increases radiation exposure.[20] Lipiodol offers excellent radiopacity but includes the potential risk of embolization and requires specialized imaging capabilities.[21] Indocyanine green (ICG) is safe and increasingly utilized, though its fluorescence penetration is limited to shallow depths (<20-24 mm) and requires near-infrared equipment.[22] Bronchoscopic technologies such as electromagnetic navigation (EMN) and VAL-MAP are promising but require hybrid operating conditions, experienced operators, and higher costs.[30] Compared with these modalities, methylene blue remains a cost-effective, rapid, and widely available technique that can be performed in standard CT suites without additional equipment.

This study has limitations, including its retrospective design, potential selection bias due to selective marking criteria, and the absence of a non-localization control group. The single-center setting and operator-dependent variability may also limit generalizability. Nevertheless, the study provides valuable real-world data reflecting contemporary VATS practice, including cases requiring anatomic segmentectomy, lymphadenectomy, and frozen-section–guided completion resections.

Future prospective, multicenter studies directly comparing methylene blue with ICG fluorescence, hybrid-room intraoperative CT, and advanced bronchoscopic localization techniques are needed to determine standardized localization strategies tailored to lesion morphology, depth, and surgical approach.

Conclusion

CT-guided methylene blue localization is a safe, efficient, and widely accessible method for the intraoperative identification of small, deep, or subsolid pulmonary nodules. In this study, the technique achieved a high marking success rate (95.9%) with a low incidence of complications, the majority of which were minor and self-limited. Successful localization facilitated precise intraoperative identification of target lesions and supported both diagnostic wedge resections and therapeutic anatomic resections, including segmentectomy and, when indicated, frozen-section–guided completion procedures.

Even when selectively applied to challenging cases—such as patients with prior malignancy, multifocal nodules, or part-solid lesions—the technique maintained reliable performance. Its low cost, rapid execution, and compatibility with all surgical approaches, including both VATS and thoracotomy, underscore its practicality across centers with variable technical resources.

Accurate preoperative localization enhances operative planning by enabling targeted resections, minimizing unnecessary parenchymal loss, and improving diagnostic yield. Given these advantages, our findings support the continued, judicious use of CT-guided methylene blue marking as a valuable adjunct in the surgical management of pulmonary nodules, particularly in oncologic populations in whom lesion multiplicity, anatomic complexity, and histologic heterogeneity are common.

Ethics Committee Approval

The study was approved by the Istanbul University Hospital Ethics Committee (Date: 31.10.2025, Decision No: 2025/2027).

Informed Consent

The requirement for informed consent was waived due to the retrospective nature of the study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: S.D.; Design: S.D., R.K.; Supervision: S.D.; Fundings: S.D.; Materials: C.C.E.; Data collection &/or processing: S.D., B.O.; Analysis and/or interpretation: S.D., R.K.; Literature search: B.O., M.K.; Writing: S.D., A.D.; Critical review: S.D.

Conflict of Interest

None declared.

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Pulmoner Nodül Rezeksiyonunda Doğruluk ve Güvenliği Artırmak için Metilen Mavisi Rehberli Lokalizasyon

Amaç: Düşük doz bilgisayarlı tomografi (BT) taramalarıyla küçük ve palpabl olmayan pulmoner nodüllerin giderek daha fazla saptanması, özellikle video yardımlı torakoskopik cerrahi (VATS) sırasında güvenilir intraoperatif lokalizasyon ihtiyacını artırmıştır. BT eşliğinde metilen mavisi ile işaretleme; basit, hızlı ve yaygın olarak erişilebilir bir yöntem olup minimal invaziv rezeksiyonu kolaylaştırmaktadır. Bu çalışma, pulmoner nodüllerin BT kılavuzluğunda metilen mavisi ile işaretlenmesinin teknik başarısını, güvenlik profilini ve sonuçlara etki eden belirleyicileri değerlendirmeyi amaçlamaktadır.

Gereç ve Yöntem: Bu retrospektif çalışmaya, 2020-2025 yılları arasında preoperatif BT eşliğinde metilen mavisi ile işaretleme yapıldıktan sonra çoğunlukla VATS ile torasik rezeksiyon uygulanan ardışık 49 hasta dahil edildi. Demografik özellikler, nodül morfolojisi, işlemle ilişkili parametreler, cerrahi detaylar ve postoperatif sonuçlar analiz edildi. Kategorik değişkenler Ki-kare veya Fisher testi ile, sürekli değişkenler ise Mann–Whitney U testi ile karşılaştırıldı.

Bulgular: İşaretleme 49 hastanın 47'sinde başarılıydı ve teknik başarı oranı %95.9 olarak saptandı. Başarısız olan iki işaretleme (%4.1) alt lob nodüllerinde ve komplikasyon gelişen olgularda görüldü. İşaretleme ilişkili komplikasyon oranı %18.4 olup en sık pnömotoraks (%12.2) ve parankimal kanama (%6.1) izlendi. Hastaların medyan yaşı 63 yıl, medyan nodül çapı 9 mm idi. Nodüllerin %69.4'ü malign olarak raporlandı. Lokalizasyon başarısı ile nodül tipi, FDG tutulumu, lobar yerleşim, rezeksiyon tipi veya işlem parametreleri arasında anlamlı bir ilişki bulunmadı. Tümör boyutu, malignite ile ilişki açısından anlamlı olmayan bir eğilim gösterdi.

Sonuç: BT eşliğinde metilen mavisi ile işaretleme, küçük pulmoner nodüllerin torakoskopik rezeksiyonunu kolaylaştıran güvenli, etkili ve pratik bir yöntemdir. Teknik başarı oranı yüksek olup radyolojik, anatomik veya işlemle ilişkili değişkenlerden büyük ölçüde bağımsız görünmektedir. Bulgularımız, metilen mavisi ile işaretlemenin minimal invaziv göğüs cerrahisinde güvenilir bir yardımcı yöntem olarak kullanılmasını desteklemektedir.

Anahtar Sözcükler: Metilen mavisi; minimal invaziv cerrahi; pulmoner nodül; VATS; video yardımlı torakoskopik cerrahi.