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Original Article / Özgün Makale

Effectiveness of intraoperative bimanual palpation in metastatic tumors of lung

Akciğerin metastatik tümörlerinde intraoperatif bimanuel palpasyonun etkinliği

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ABSTRACT

Background: In this study, we aimed to compare effectiveness of thoracic computed tomography versus intraoperative bimanual palpation in the detection of number of nodules in patients undergoing thoracotomy.

Methods: Between January 2011 and January 2019, a total of 157 patients (63 males, 94 females; mean age: 46.6±11.2 years; range, 13 to 77 years) who underwent pulmonary metastasectomy in our institution were retrospectively analyzed. Metastatic nodules evaluated using thoracic computed tomography were compared with nodules detected by intraoperative palpation.

Results: A total of 226 muscle-sparing thoracotomy was performed in 157 patients. The time between the preoperative thoracic computed tomography and operation ranged from 3 to 24 days. Metastasectomy with muscle-sparing thoracotomy was performed in 41 (26%) patients two times, in eight (5%) patients three times, and in four (2.5%) patients four times due to bilateral lung metastasis or re-metastasectomy. The thoracic computed tomography could detect 476 metastatic nodules, while 1,218 nodules were palpated and resected intraoperatively. Of these nodules, 920 were pathologically evaluated as metastatic.

Conclusion: Our study results showed that the number of nodules reported as pathologically malignant after resection was 1.9 times higher than those reported by thoracic computed tomography. This finding indicates that intraoperative bimanual examination significantly increases the possibility of complete resection. This situation raises the need for more caution for the thoracoscopic metastasectomy procedure in which there is no possibility of intraoperative bimanual palpation.

Keywords: Computed tomography, intraoperative bimanual palpation, metastasis, thoracic surgery.

ÖZ

Amaç: Bu çalışmada torakotomi yapılan hastalarda nodül sayısının tespit edilmesinde toraks bilgisayarlı tomografi ile intraoperatif bimanuel palpasyonun etkinliği karşılaştırıldı.

Çalışma planı: Ocak 2011 - Ocak 2019 tarihleri arasında hastamizde akciğer metastazektomisi uygulanan toplam 157 hasta (63 erkek, 94 kadın; ort. yaş: 46.6±11.2 yıl; dağılım, 13-77 yıl) retrospektif olarak incelendi. Toraks bilgisayarlı tomografi ile değerlendirilen metastatik nodüller, intraoperatif palpasyon ile tespit edilen nodüller ile karşılaştırıldı.

Bulgular: Toplam 157 hastaya 226 kas koruyucu torakotomi yapıldı. Ameliyat öncesi toraks bilgisayarlı tomografi ve ameliyat arasında geçen zaman 3 ila 24 gün idi. Bilateral akciğer metastazı veya yeniden metastazektomi nedeniyle 41 hastaya (%26) iki kez, sekiz hastaya (%5) üç kez ve dört hastaya (%2.5) dört kez kas koruyucu torakotomi ile metastazektomi uygulandı. Toraks bilgisayarlı tomografi ile 476 metastatik nodül tespit edilirken, intraoperatif olarak 1218 nodül palpe edilip rezeke edildi. Bu nodüllerin 920'si patolojik açıdan malign olarak değerlendirildi.

Sonuç: Çalışma sonuçlarımız rezeksiyon sonrasında patolojik açıdan malign olarak bildirilen nodül sayısının, toraks bilgisayarlı tomografiye kıyasla, 1.9 kat daha fazla olduğunu gösterdi. Bu bulgu, intraoperatif bimanuel muayenenin, tam rezeksiyon olasılığını anlamlı düzeyde artırmakta olduğunu göstermektedir. Bu durum, intraoperatif bimanuel palpasyon olasılığının olmadığı torakoskopik metastazektomi ameliyatında daha dikkatli olunması gerekliliğini ortaya koymaktadır.

Anahtar sözcükler: Bilgisayarlı tomografi, intraoperatif bimanuel palpasyon, metastaz, göğüs cerrahisi.

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Approximately 30% of patients with malignant solid tumors develop pulmonary metastasis (PM). Complete resection of PM contributes to survival in solid malignant tumors, when the primary is under control.[1,2]

The most important prognostic factor in PM surgery is complete resection feasibility.[3] In today's practice, the decision of complete resection is made by determining the number and localization of PMs on thoracic computed tomography (CT).[4] Although the standard surgical approach method in PM is by thoracotomy, some authors recommend video-assisted thoracoscopic surgery (VATS) or robot-assisted thoracic surgery in PM surgery thanks to significant improvements in minimally invasive approaches in the last few decades.[3-5] However, in 20 to 87% of the cases undergoing PM surgery with thoracotomy, more pulmonary nodules, the majority of which are PM, were detected compared to the number of nodules detected in the preoperative thoracic CT.[3-5] These findings are associated with the ability to perform a bimanual examination in open surgery. Therefore, careful and extensive manual palpation of the lungs is recommended as a standard intraoperative approach to provide complete resection in metastasectomy surgery of PMs which cannot be detected on preoperative thoracic CT.[5] Although minimally invasive surgeries are more comfortable for patients, the basis of cancer surgery is complete resection and this is unlikely to be abandoned.[1-5]

In this study, with the aim of finding the optimal surgical approach and answering the question of whether to use thoracotomy or VATS in PM surgery, we compared the effectiveness of preoperative thoracic CT with intraoperative bimanual examination in detection of number of nodules in patients undergoing thoracotomy.

PATIENTS AND METHODS

A total of 164 patients underwent metastasectomy at Ankara University, Faculty of Medicine, Department of Thoracic Surgery between January 2011 and January 2019. Preoperatively, all patients were evaluated for their medical history, physical examinations, complete blood counts, routine blood biochemistry tests, pulmonary function tests, electrocardiographs, posteroanterior and lateral chest radiographs, and thoracic CT scans. The patients undergoing surgical resection after 2014 were also evaluated using the positron emission tomography (PET). The patients were evaluated using the magnetic resonance imaging (MRI), if indicated (Figures 1a-c). Seven patients who underwent thoracic CT at an external center or with a period of more than four weeks between CT scan and operation time were excluded from the study. Finally, a total of 157 patients (63 males, 94 females; mean age 46.6±11.2 years; range, 13 to 77 years) were included in this retrospective study.

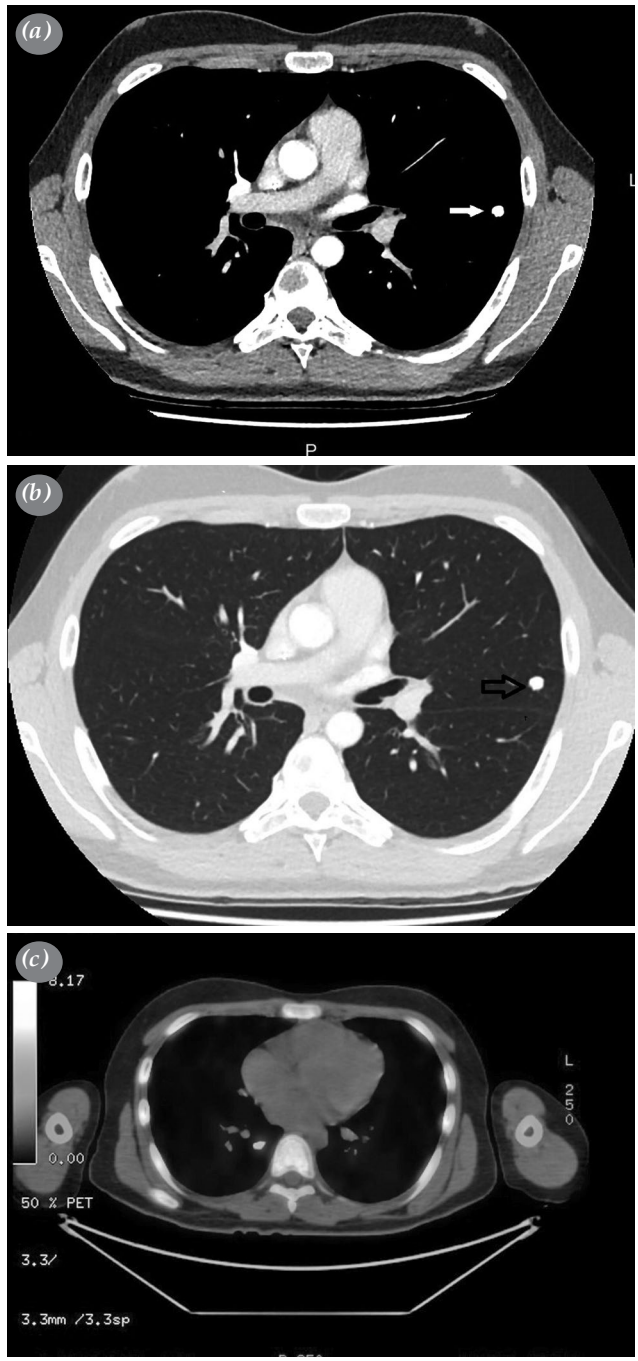

Figure 1. Computed tomography and PET images of a patient with an osteosarcoma. **(a)** Thorax CT mediastinal section. **(b)** Thorax CT parenchymal section. **(c)** PET CT display.
CT: Computed tomography; PET: Positron emission tomography.

Table 1. Nodule localizations in the lung

	Right	Left
	n	n
Mesenchymal tumors		
Upper lobe	64	53
Middle lobe	63	-
Lower lobe	180	146
Epithelial tumors		
Upper lobe	78	89
Middle lobe	17	-
Lower lobe	118	112

A written informed consent was obtained from each patient. The study protocol was approved by the Ankara University School of Medicine Ethics Committee. The study was conducted in accordance with the principles of the Declaration of Helsinki.

All thoracic CT assessments were performed using a 64-detector array (Toshiba Aquilion 64, Otawara, Japan) and a 16-detector array (Siemens Somatom Sensation 16, Forcheim, Germany) CT scanners. The collection parameters are 0.6-mm detector collimation, while 0.5-mm detector collimation, 120 kVp tube voltage, 0.5 sec portal rotation time, 1-mm reconstruction section thickness, and 0.8-mm reconstruction interval for detector collimation, 110 kVp tube voltage, 0.6 sec portal rotation time, 1.5-mm reconstruction section thickness, and 1-mm reconstruction range for 16 detector rows scanner. An automatic exposure control system in the range of 100 to 200 mA was used. All the patients were given an intravenous contrast agent for the CT scans.

For the patients undergoing pulmonary metastasectomy, the decision of operability was made by the Multidisciplinary Tumor Council considering the criteria of primary tumor control, resectability of all the metastatic lesions detected preoperatively, having adequate pulmonary reserve after resection, absence of extrathoracic metastasis, and absence of a more optimal alternative treatment method.

Muscle-sparing thoracotomy (MST) was used as an approach procedure for all the patients in our study. Wedge resection was performed for appropriate peripheral nodules, while segmentectomy and lobectomy procedure was performed for deep parenchymal lesions. For patients who were planned to have bilateral metastasectomy, priority was given to the side with a high probability of invasion into vital organs and to the side with a higher number of possible metastatic lesions.

RESULTS

A total of 226 MST was performed in 157 patients. The time between the preoperative thoracic CT and

Table 2. Primary diseases of metastatic lesions

Epithelial tumor (n=115)	n	Mesenchymal tumor (n=111)	n
Colorectal carcinoma	67	Osteosarkom	27
Renal cell carcinoma	9	Malign mesenchymal tumor	20
Papillary thyroid carcinoma	9	Uterine leiomyosarcoma	8
Breast carcinoma	6	Ewing's sarcoma	7
Bladder carcinoma	6	Chondrosarcoma	4
Endometrial carcinoma	4	Spindle cell sarcoma	3
Malign melanoma	3	Synovial sarcoma	2
Gastric cancer	2	Giant cell tumor of bone	2
Overian carcinoma	2	Rhabdomyosarcoma	2
Adenoid cystic carcinoma	2	Fibrosarcoma	1
Thymoma	2	Other sarcoma	35
Germ cell tumor	1		
Prostate carcinoma	1		
Hepatocellular carcinoma	1		

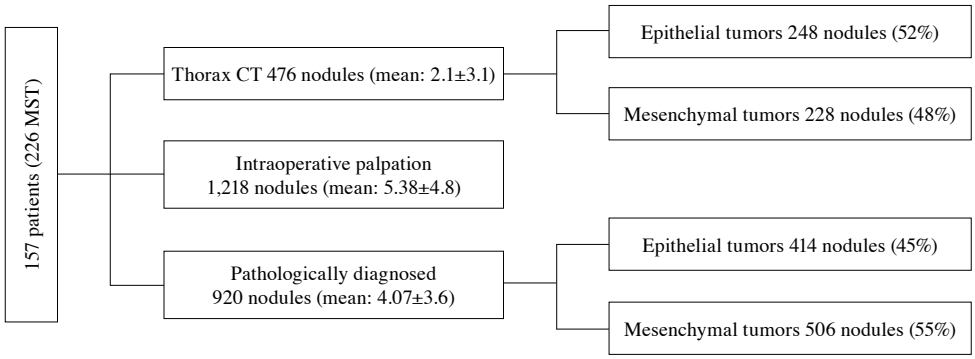

Figure 2. Primary diseases of metastatic lesions.
CT: Computed tomography; MST: Muscle-sparing thoracotomy.

operation ranged from 3 to 24 days. Due to bilateral lung metastasis or re-metastasectomy, MST was performed in 41 (26%) patients for two times, in eight (5%) patients for three times, and in four (2.5%) patients for four times.

A total of 476 nodules (mean: 2.1±3.1) detected by thoracic CT were evaluated as metastatic. The number of resected nodules was 1,218 (mean: 5.38±4.8). A total of 920 (mean: 4.07±3.6) of these nodules were histopathologically reported as metastatic. The number of nodules which were detected intraoperatively by bimanual palpation was 2.55 times higher than the number detected by thoracic CT. In addition, the number of nodules reported as pathologically malignant after resection was 1.9 times higher than those reported by thoracic CT.

Among 476 nodules which were determined radiologically, 52% (n=248) of the patients had a history of epithelial tumor and 48% (n=228) of them had a mesenchymal tumor history. Among 920 nodules which were diagnosed pathologically, 55% (n=506) of the nodules were reported as mesenchymal tumors and 45% (n=414) were reported as epithelial tumors (Table 1). The mesenchymal tumor nodules detected radiologically were resected after palpation and received a pathological diagnosis by 2.21 times more frequently. The nodules detected radiologically that were suspected as epithelial tumor nodules were resected after palpation and received a pathological diagnosis by 1.66 times more frequently.

The pathological results of 226 metastatic nodules removed with MST were examined, and 50.8% (n=115) were epithelial tumors and 49.1% (n=111) were mesenchymal tumors. Pathological diagnoses are indicated in Table 2.

DISCUSSION

Metastasectomy is accepted as a curative treatment option for patients with PMs who do not have extrathoracic disease and whose primary disease is under control.[6,7] In most patients with PM, systemic chemo/radiotherapy is applied due to extrathoracic metastases (75%).

The survival rates of metastasectomies performed in selected patients are higher than patients that cannot be operated or cannot have complete resection.[8-10] Long-term survival is achieved by complete resection of diseased tissues in metastasectomy surgery. There are many factors affecting prognosis. Among these factors, complete resection and disease-free survival rates are the most researched and most effective parameters.

Resection of metastatic nodules as a result of well-defined preoperative thoracic CT scan and/or palpation of the lungs intraoperatively affects both complete resection and disease-free survival rates. In 20 to 87% of patients with nodules which cannot be defined with thoracic CT, it has been shown that at least one metastatic lesion can be detected with palpation.[11-14] In our study, the number of nodules reported as pathologically malignant after resection (n=920, mean: 4.07±3.6) was 1.9 times higher than those reported by preoperative thoracic CT (n=476, mean: 2.1±3.1) were reported as metastatic. Resection of metastatic nodules more than the ones detected in thoracic CT once again showed the necessity of palpation for complete resection (Figures 2).

The study of Nakajima et al.[15] showed that 40% of the nodules removed surgically were benign. Similarly, in another study performed by Eckardt and Licht,[16] the benignity rate of the nodules was 50%.

Althagafi et al.[17] showed that 48% of the nodules that were palpated and resected were reported as malignant. Conversely, in our study, 298 (24%) of the 1,218 (mean: 5.38±4.8) nodules, which were removed from our patients with metastasectomy, were benign nodules.

The nodules palpated as a result of awareness during intraoperative complete resection also cause resection of parenchymal lymph nodes, nodules secondary to infection, granulomas, hamartomas, and fibrotic lesions. It should be kept in mind that such unnecessary resections increase morbidity. Parenchymal damage and prolonged air leaks as a result of unnecessary resections may prolong the hospitalization period.[15,16,18,19]

Although the number of nodules which could not be detected in the conventional thoracic CTs used in the past were corrected with spiral CTs used in today's technology, the number of nodules which are preoperatively overlooked is still underestimated.[20-22] Preoperative thoracic CT sensitivity varies depending on the underlying malignancy type, time period between the CT scan and metastasectomy, disease-free survival, and number and size of the existing lesions.[20] While 52% of the 476 nodules detected on thoracic CT had a primary disease as epithelial tumors, 55% of the 920 metastatic nodules were reported as mesenchymal tumor metastases. These rates seem to be depending on the biological features of mesenchymal tumors, as it is thought that the probability of being undetectable by preoperative thoracic CT compared to epithelial tumors is higher.[21] Considering these features of mesenchymal tumors, we believe that a particular care should be exercised while planning surgery of mesenchymal metastatic tumors with minimally invasive methods.

In PM surgery, low mortality rates (2%) can be provided by thoracotomy or sternotomy; however, it is still very appealing to consider minimally invasive methods.[22] Minimally invasive approaches have been described as alternative methods to thoracotomy in metastasis surgery even today. Although there are equivalent oncological results in terms of long-term survival and local recurrence, low morbidity and shorter hospital stays in metastasectomy cases with VATS, there are no head-to-head, prospective, randomized studies comparing these advantages with standard thoracotomy.[23-25]

The major debate in pulmonary metastasectomy is whether it is appropriate to apply VATS technique for curative purposes. The two issues against VATS are the difficulty of removing all diseased lesions with VATS for complete resection and poor ability to provide the required margin for the removed nodules.[26-28] In our study, thoracotomy was performed in all 157 patients.

In their study, McCormack et al.[27] showed that 56% more metastatic nodules were removed by confirmatory thoracotomy after VATS. There are also publications showing that this wide gap can be closed owing to recent technological advances in minimally invasive surgery.[29] It is well known that VATS has certain advantages in terms of the length of hospital stay, operative bleeding, and postoperative pain control.[29,30] In addition, having less adherence during reoperation and having a shorter preparation time for bilateral surgery are the main advantages for metastasectomy surgery.

Comparison of <3 metastatic nodules resected by thoracotomy versus VATS is more appropriate. In addition, due to the existing studies showing no contribution of <5-mm nodules which cannot be detected intraoperatively, metastasectomy using VATS is an acceptable technique. As a disadvantage of VATS, however, the possibility of complete resection, particularly for multi-metastatic and deep parenchymal nodules, is always questionable.

Furthermore, the fact that the safe surgical margin VATS is uncertain in VATS indicates the need for thoracotomy. The requisite of preoperative detection of sarcomatoid metastases has been previously described. The underlying malignancy type is also an important condition for manual palpation.[30-32]

Nonetheless, there are several limitations to this study. It has a retrospective design, and the ratio of nodules which cannot be detected by thoracic CT due to radiological technique is unknown. Unfortunately, we do not have data to compare the survival of patients with nodules that could not be detected by preoperative thoracic CT and the survival of patients matching the number of nodules detected on CT. We believe that its effect on prognosis may be a separate research subject using many parameters affecting survival in metastasis surgery.

In conclusion, bimanual palpation should be a standard method for complete metastasectomy in the presence of nodules which cannot be detected on preoperative thoracic computed tomography. In addition, standard thoracotomy may be a safer method with the presence of deep parenchymal nodules where palpation is not possible, with metastases originating from mesenchymal tumors, and when a concern of an achievable safe surgical margin is present.

Declaration of conflicting interests

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