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Computed tomographic scan of the chest underestimates the number of metastatic lesions in osteosarcoma

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Abstract

Purpose: Survival in osteosarcoma correlates with complete resection of primary and metastatic disease. The feasibility of complete pulmonary metastasectomy using thoracoscopy has been raised. Because palpation is not possible, minimally invasive techniques require preoperative radiological enumeration and localization of metastases not presenting at the lung surface. We hypothesized that computed tomographic (CT) scanning underestimated the number of pulmonary metastases in these patients.

Methods: Institutional review board approval was obtained. We determined the association between the number of lesions identified by CT scanning and the number of metastases found at thoracotomies for metastatic osteosarcoma from May 1996 to October 2004. Correlations between CT findings and pathology results were computed using the Kendall τ-b correlation coefficient. Depth, in millimeters, from the pleural surface was measured for those lesions seen on CT scan.

Results: We analyzed 54 consecutive thoracotomies performed in 28 patients for whom complete imaging was available. Computed tomographic scanning was performed a median of 20 days before thoracotomy (range, 1-85 days). Correlation between the number of lesions identified by CT and the number of metastases resected at surgery was poor, with a Kendall τ-b correlation coefficient of 0.45 ($P < .001$). In 19 (35%) of 54 thoracotomies, CT scanning underestimated the number of pathologically proven, viable and nonviable metastases found by the surgeon. Accounting for viable metastases only, correlation between the number of lesions identified by CT and the number of metastases resected at surgery was 0.50 ($P < .001$), and CT scanning underestimated the number of viable metastases present in 14 (26%) of 54 thoracotomies. Many lesions (32%) were pleural-based, but nearly half (47%) were 5 mm or deeper from the pleural surface of the lung.

Conclusions: Even in the era of modern CT scanning, only a very rough correlation exists between CT findings and the number of lesions identified at thoracotomy. In more than one third of thoracotomies in

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our series, metastases would have been missed by any tactic besides manual palpation of the lung during open thoracotomy. Minimal access procedures should not be the approach of choice if the goal is resection of all pulmonary metastases in osteosarcoma.

In 1970, all children and adolescents with osteosarcoma that relapsed in the lungs died within 5 years [1]. Today, even with multiagent chemotherapy, 75% to 85% of relapses still occur in the lungs [2,3], yet more than 25% of those undergoing thoracotomy will survive 5 years [4,5]. Resection of lung metastases has been credited in numerous series with improving outcomes for patients with osteosarcoma [6-15], and it has been shown, in a multivariate analysis of 202 patients, that the degree of completeness of surgical resection of all metastases has a significant impact on survival [16].

Concurrent with this progress in the treatment of osteosarcoma, great strides have been made in minimally invasive surgery. Thoracoscopic surgery has been said to be efficacious for patients with lung metastases from osteosarcoma [17]. However, the resection of metastases by thoracoscopy requires, as an absolute prerequisite, that the lesions are either visible on the surface of the lung or else have been fully and accurately localized by preoperative imaging.

We undertook this study to determine whether preoperative computed tomographic (CT) scanning accurately predicted the number of osteosarcoma metastases in the lungs of children. The study was performed in a retrospective fashion using data from every thoracotomy performed for osteosarcoma by the Pediatric Surgical Service at Memorial Sloan-Kettering Cancer Center over a period of 8.5 years. We report the number of tumor nodules identified on preoperative CT scanning, the number of nodules found and resected at open thoracotomy, and the histopathologic identity of the resected nodules. We hypothesized that CT scanning would fail to completely predict the number of lung metastases in patients with osteosarcoma and thus should be used with caution as the guidepost for planning minimally invasive operations.

1. Materials and methods

1.1. Inclusion criteria

An institutional review board waiver of authorization (WA0418-04) was granted for this retrospective study, in compliance with institutional and Health Insurance Portability and Accountability Act of 1996 (HIPAA) privacy standards. All thoracotomies performed upon patients with metastatic osteosarcoma by the pediatric surgical service at Memorial Sloan-Kettering Cancer Center from May 1996 to October 2004 were reviewed (n = 66). Thoracotomies were excluded if complete preoperative lung windows were not available (n = 3). Thoracotomies for miliary disease (>25 nodules by CT) were excluded (n = 3), even when metastasectomy was carried out in those cases, because confluency of nodules on CT confounded reproducible counts. Thoracotomies done for palliative intent (n = 2), chest wall biopsy (n = 1), after recent thoracoscopic wedge biopsy (n = 1), or those at which unresectable hilar disease or extraordinary miliary disease was discovered (n = 2) were eliminated because complete enumeration of lung nodules was precluded in those situations. By these criteria, 54 thoracotomies performed upon 28 patients were included for review.

1.2. Details of operative procedures

Our practice has been to perform staged bilateral thoracotomy when metastatic disease is suspected on the basis of preoperative imaging, proceeding to the contralateral side in those who are found to have metastases on the first side [18]. Operations in this series included vertical axillary thoracotomy (n = 6) and posterolateral thoracotomy (n = 48), usually performed in muscle-sparing fashion. No patient had sternotomy.

1.3. Methods of radiology

For scans performed at our institution, single or multidetector helical scanners were used, with scans performed at 5-mm intervals without intravenous contrast. Lung algorithms were used. Two pediatric radiologists, blinded to the outcome of each thoracotomy, retrospectively reviewed all scans and determined, by consensus, the number of nodules present.

Depth of each lesion from the nearest pleural surface was measured in millimeters using standard radiological software. These assessments were made by a single radiologist using available preoperative CT scans for 53 of the 54 thoracotomies studied.

1.4. Methods of evaluation of pathology

The number of lesions resected was determined by light microscopic examination of the original pathological material from each thoracotomy. Retrospective review was conducted by a single pathologist with experience in diagnosing osteosarcoma, who was blinded to the preoperative radiological findings. When metastatic osteosarcoma was found, it was further characterized as viable or nonviable. Other causes of nodularity leading to resection were characterized as well. Situations in which the same nodule was reresected because of close margins were counted as a single lesion.

1.5. Statistical methods

Scatterplots were constructed comparing the number of lesions found on CT scan with the numbers of overall and of