Pulmonary metastases: can accurate radiological evaluation avoid thoracotomic approach?∗

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Abstract

Objectives: To evaluate the effectiveness of radiological assessment (high-resolution CT (HRCT), helical CT (HCT) scan) of lung metastases and to verify if a complete manual exploration by thoracotomy is necessary. Materials and methods: From 1/96 to 1/00, 166 consecutive patients presenting with lung metastases were treated. Preoperative CT scan (HRCT in 78 patients, group A; HCT in 88 patients, group B) to assess the number, size and location of the lesions (slice thickness 5 mm; reconstruction interval 3–5 mm) was always performed. All patients underwent axillary thoracotomy (staged when lesions were bilateral); accurate palpation of the lung parenchyma was always performed to identify any undetected lesion. Non-metastatic lesions were excluded. Results: We performed 356 wedge resections in 161 patients (113 monolateral, 70.2%; 48 bilateral, 29.8%) and five lobectomies. In group A, primary neoplasm was epithelial in 44 patients, sarcoma in 26 and germ cell in eight, and in group B, epithelial in 61 patients, sarcoma in 20 and germ cell in seven. Three hundred and sixty-one histologically proven metastases were resected (188 in group A and 173 in group B). HRCT correctly identified 142/188 lesions (sensitivity 75%); HCT revealed 142/173 metastases (sensitivity 82.1%). Sensitivity for lesions less than 6 mm in maximum diameter was 48% (30/58 false negative) in group A and 61.5% (20/52 false negative) in group B. Conclusions: The sensitivity of HCT exceeds that of HRCT. However, complete manual exploration by thoracotomy remains the procedure of choice for patients undergoing pulmonary metastasectomy, because of limitation in preoperative radiological assessment of lung lesions smaller than 6 mm. © 2002 Elsevier Science B.V. All rights reserved.

Keywords: Pulmonary metastases; Surgical treatment; CT scan

1. Introduction

Surgical resection remains the most important treatment for pulmonary metastases from a variety of solid tumors. If the primary tumor is controlled, metastasectomy is a safe and potentially curative procedure [1]. When video-assisted thoracic surgery (VATS) was introduced, it was quickly adapted to metastasectomy [2]; nevertheless, retrospective [3] and prospective [4] studies concluded that VATS was an inadequate procedure: identification of all metastatic pulmonary nodules might not be possible without a complete manual palpation of the entire collapsed lung because the missed lesion rate on preoperative conventional CT scan was too high.

Some authors [5–7] have recently remarked that the helical CT (HCT) scan has been shown to be superior to the conventional CT scan in detecting pulmonary metastases; therefore, the VATS approach to pulmonary metastases has been re-proposed as a less invasive and curative technique, especially in selected patients.

In this retrospective study, we evaluated the effectiveness of radiological preoperative assessment (conventional and high-resolution CT (HRCT) scan vs. HCT scan) of lung metastases. The end points were the sensitivity of both techniques and the number of failures to evaluate if VATS is a suitable procedure or if manual palpation of the lung during thoracotomy still remains the most accurate method to detect any lung metastases.


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2. Materials and methods

From January 1996 to January 2000, 166 consecutive patients with a history of malignancies underwent lung metastasectomy in our institution. This study group included 114 males and 52 females with a mean age of 43 years (range 11–78 years). Lung metastases were monolateral in 118 cases (71%) and bilateral in 48 (29%).

Patients were randomly submitted preoperatively to HRCT scan or HCT scan to assess the number, size and location of the secondary lesions. HRCT scan was performed in 78 patients (51 males and 27 females) included in group A. In the remaining 88 patients (63 males and 25 females) radiological assessment was completed by means of HCT scan (group B). All CT scans were performed with a current generation scanner. In both groups, no IV contrast medium was administered. Images were reconstructed at intervals of 3 mm (HRCT) and 3–5 mm (HCT).

CT scan images of the first 75 patients studied until June 1998 were analyzed randomly by three different experienced radiologists. In the last 91 patients (39 group A, 52 group B) CT examinations were all interpreted by the same radiologist specializing in thoracic imaging.

Patients undergoing lung metastasectomy were selected according to the following criteria: (a) complete control of the primary tumor; (b) ability to resect all the preoperatively detected metastatic lesions; (c) ability of the patients to withstand the extent of pulmonary resection; (d) absence of extra-thoracic disease; (e) absence of better alternative treatment.

Respiratory function was evaluated in all patients by a spirometric test and hemo-gas-analysis. Perfusional pulmonary scintiscan was performed in patients in whom a major lung resection was likely to be required.

Patients underwent surgical resection 4–26 days (mean 14 days) after the radiological examination. CT scans older than 4 weeks were repeated. The surgical approach was always a muscle-sparing axillary thoracotomy at the fifth intercostals space, as described by Ginsberg in 1993 [8]. It was staged in case of bilateral lesions, according to our preference described elsewhere [9]. An interval of 3–4 weeks between the two staged procedures has generally been planned. In seven patients aged over 48 years who underwent staged thoracotomy for bilateral metastasectomies, controlateral lesions were not present on the CT scan at the time of the first side pulmonary resection. In these patients surgery on the opposite lung was performed after a minimum of 4 and a maximum of 15 months since the first thoracotomy.

In the case of synchronous bilateral metastases, the number of metastases in each side (the higher first) was the only selection criteria to decide which side to operate upon first. A double-lumen endotracheal tube was always used for ventilation, permitting isolated deflation of one lung. Accurate palpation of the lung parenchyma was always performed in order to identify any undetected lesion at preoperative radiological study. Every visible or palpable nodule was radically resected through ‘wedge’ resection or lobectomy. Resected non-metastatic lesions were not considered in this study.

2.1. Statistical analysis

We calculated the sensitivity of HRCT and HCT considering the intraoperative and histologic findings as the gold standard. We excluded resected benign nodules from this analysis, so that specificity could not be calculated. Differences in the numbers of nodules detected were analyzed using the $\chi^2$-test. Statistical significance was fixed at the 0.05 level ($P < 0.05$).

3. Results

Three hundred and sixty-one lung resections for metastatic lesions were performed in the 166 patients included in the present study (Table 1). Lung metastasectomy was a ‘wedge’ resection in 356 cases and a lobectomy in five cases. Pulmonary secondary lesions were monolateral in 118 patients (71%) and bilateral in 48 (29%).

Three hundred and sixty-one histologically proven metastasis were resected: 188 in group A and 173 in group B. In group A the size of the lesions was smaller than 6 mm in 58 cases, 6–10 mm in 47 cases and larger than 10 mm in 33 cases. In group B pulmonary nodules were smaller than 6 mm in 52 cases, 6–10 mm in 34 cases and larger than 10 mm in 87 cases.

Preoperative HRCT scan correctly identified 142 of 188 resected lesions in group A patients. Forty-six metastatic nodules, undetected by radiological procedures, were found and resected after palpatory exploration of the entire lung. HRCT sensitivity was 75%. In group B, HCT scan preoperatively detected 142 of 173 resected metastases. Surgical exploration revealed 31 false-negative findings. HCT sensitivity was 82%.

The sensitivity of CT visibly decreases according to the size of the metastases (Table 2). The sensitivity of HCT exceeded that of HRCT, but this difference did not achieve statistical significance ($P > 0.05$).

4. Discussion

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<th>Table 1 Patients and histologies</th>
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<td><strong>Group A (HRCT): 78 patients</strong> (188 lesions)</td>
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<td><strong>Group B (HCT): 88 patients</strong> (173 lesions)</td>
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Resection of pulmonary metastases is today the gold-st...
standard treatment for selected patients: in his review, Pastorino [1] strongly emphasized the role of surgery, reporting a survival rate ranging from 36% (5 years) to 26% (10 years).

VATS has been applied to the treatment of lung metastases since 1992: Landreneau et al. [2] remarked that metastasectomy with a VATS approach offered a less painful incision and a shorter hospital stay, but McCormack et al. [3] identified the potential problems of missing small metastatic lesions with a VATS approach. In their retrospective study, preoperative CT scan underestimated malignant lesions found at thoracotomies in 18 of 72 patients (25%).

In 1995, Liu et al. [10] reported the use of VATS to resect peripheral lung metastases in 47 patients. Digital lung palpation was employed in all cases and identified additional lesions missed at conventional CT in five patients (10.6%). The authors concluded that VATS was ideal to perform therapeutic metastasectomy, but only immediate postoperative results of this study were published.

The observations of McCormack were confirmed by the author herself who described results of the first 18 of 50 patients of a prospective study, which was stopped early because the estimated probability of missing metastases was too high if VATS alone was used (in ten of 18 patients (56%) additional malignant tumors were identified at thoracotomy) [4].

Our experience confirms that preoperative assessment by conventional CT scan is unsatisfactory, even when performed with a high-resolution technique. In our series, CT scan missed 46 of 188 lesions (24%), according to data of other authors. In the studies of Friedmann et al. [11], Chang et al. [12] and van der Veen et al. [13], preoperative conventional CT scan missed, respectively, 17/51 (30%), 45/92 (49%), and 22/78 (28%) metastases found at thoracotomy.

In our experience, additional high-resolution scans provide more accuracy. The sensitivity of the technique is 100% for lesions larger than 1 cm (no false-negatives on 83 metastases), but it visibly decreases according to the size of metastases (66% for lesions <10 mm but >6 mm and 48% for nodules smaller 6 mm). If only lesions >6 mm are considered, the sensitivity is 87% (16/130 false-negatives). These results suggest that preoperative conventional CT scan, even when performed with an additional high-resolution scan, is unsatisfactory.

We do not agree with Mutsaerts et al. [14] who considered video-thoracoscopic resection a viable treatment option for patients with a solitary peripheral pulmonary metastasis. In their study, the subsequent confirmatory thoracotomy found residual disease (one or more nodules) missed by preoperative conventional CT scan and by VATS in five of 17 patients (29%). Their policy seems to be inadequate, because the probability of thoracoscopic resection being complete is only 62%.

However, in recent years some authors have favored the use of VATS for resection of lung metastases. Watanabe et al. [7] in their study on 27 lesions found a sensitivity of 92% for a preoperative scan for patients with one or two lesions. In the review of Lin et al. [5] on 99 potentially curative resections of pulmonary metastases, the authors reported that the results appeared comparable with historical results by thoracotomy (mean survival: 37% at 3 years). To avoid underestimating lesions and compromising therapeutic intent, the authors performed a careful patient selection based on high-resolution HCT scan. Spiral CT scans have been shown [15] to improve the detection of lung nodules eliminating both the respiratory motion artifact and volume averaging. Remy-Jardin et al. [16] compared conventional and spiral CT scans in 39 patients: the mean number of nodules found with the spiral CT scan was significantly higher than the number found with the conventional CT scan (18 ± 4.5 vs. 12.6 ± 3.2).

In our HCT–surgical correlation, the sensitivity of HCT (82%) exceeds that of HRCT, but this difference did not achieve statistical significance (P > 0.05). HCT sensitivity also decreased according to the size of metastases: no false-negatives for lesions >10 mm, 11/34 (32%) for lesions <10 mm and >6 mm and 20/52 (38.5%) for lesions <6 mm were observed. The sensitivity of HCT for lesions >6 mm was 91% (11/121 false-negatives). In our experience, HCT has more sensitivity than conventional CT, but has the same limitation in detecting nodules smaller than 6 mm. Similar conclusions were proposed by Diederich et al. [17]: in their CT–surgical correlation on 43 histologically proven metastases, the sensitivity of HCT scan for lesions >6 mm was 95%, but decreased to 69% for lesions smaller than 6 mm.

Waters et al. [18] obtained similar results in their radiological/pathological study performed on four dogs affected with osteosarcoma; the sensitivity of the HCT scan was 91% for lesions >5 mm but 44% for lesions ≤5 mm.

In the recent experience of Ambrogi et al. [19], manual palpation was able to identify 8/52 metastatic lesions missed at HCT scan (sensitivity 84%).

### 5. Conclusions

HCT scan remains the preferred imaging modality for pulmonary metastases. The technique has some limitations in the detection of pulmonary metastases, especially for nodules smaller than 5–6 mm. Therefore, the role of VATS in the excision of pulmonary metastases needs to be redefined. In other words, we feel that the statement of McCormack in 1993, that “the use of a probe, or single digit

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<th>Metastases</th>
<th>HRCT sensitivity</th>
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<tr>
<td>&gt;10 mm</td>
<td>100% (83/83)</td>
<td>100% (87/87)</td>
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<tr>
<td>&gt;6 mm &lt;10 mm</td>
<td>66% (31/47)</td>
<td>68% (23/34)</td>
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<tr>
<td>≤6 mm</td>
<td>48% (28/58)</td>
<td>61.5% (32/52)</td>
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Table 2
CT sensitivity and size of metastases
might not suffice as a substitute for the surgeon’s hand” still retains all its validity. Therefore, a muscle-sparing thoracotomy is mandatory in the surgical approach of pulmonary metastases.

References


Appendix A. Conference discussion

Dr P. Thomas (Marseille, France): Concerning the study design, did you collect your data prospectively?

Dr Margaritora: No. This was a retrospective study. The number of observed patients is similar in the two groups by chance only. In our hospital there are two CT scans for this kind of patient: one is helical and the other one is for high-resolution CT. The patients have been studied by one or the other only by chance.

Dr Thomas: How did you determine the number of metastases, in collaboration with radiologists?

Dr Margaritora: Yes, sure.

Dr Thomas: You reviewed all the films.

Dr Margaritora: We reviewed all the CT scan films with the radiologists.

In the high-resolution CT scan, the slice thickness was 3 mm whilst the helical scans have been realized during the time of one breath only.

Mr D. Waller (Leicester, UK): So your conclusion is that you can’t trust the CT scan. You need to palpate the lung?

Dr Margaritora: Yes, this is our conclusion.

Mr Waller: Then do you advocate routine bilateral exploration of the thoracic cavity?

Dr Margaritora: No. We just perform unilateral exploration when we have unilateral evidence of nodules by CT scan.

Mr Waller: So you believe the CT scan?

Dr Margaritora: This is a timely discussed question. We believe that if we have a unilateral lesion in the follow-up of these patients, we have more probability to have other nodules on the same side. Exploring the contralateral side seems an overtreatment. So when we have the evidence of a unilateral disease we think that it is reasonable to realize a limited vertical axillary thoracotomy, as described by Robert Ginsberg. This procedure allows us to perform a complete lung parenchyma palpation.

Dr J. Hasse (Freiburg, Germany): Please, can you comment on the location of those overlooked metastases? Were they subpleurally or were they in the depth of the parenchyma?

Dr Margaritora: In the false negatives cases, the vast majority of the nodules were located deeply into the lung parenchyma and their size was not bigger than 1 cm.

Dr D. Branscheid (Hamburg, Germany): I want to congratulate you because I waited for a paper like that for a long time, and I think a lot of questions have been asked already and they are fantastic and they are very good and they come to one thing. They come to the situation that we need to resec the metastasis radically. This means we have to give the patient a complete remission, a surgical remission. Only then he has a benefit from it. That means we have to perform a median sternotomy or a thoracotomy on the right or a thoracotomy on the left at the same site to give the patient a complete resection. I want to underline that, I want to provoke a little discussion about it, but I think this is mandatory.