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Correlations between findings at computed tomography (CT) and at thoracoscopy/thoracotomy/autopsy in pleural mesothelioma

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ABSTRACT: Thirty five computed tomography (CT) scans of the thorax and upper abdomen of thirty three patients with malignant pleural mesothelioma were correlated with the findings at thoracotomy (28 patients), thoracoscopy (2 patients) or autopsy (5 patients). Pleural thickening with contrast medium enhancement was detected on the CT scans of all patients. This finding was a valuable diagnostic tool, especially in cases of large amounts of pleural effusion and/or only thin layers of tumour barely or not at all visible on plain film chest X-rays. Difficulties in defining the exact extent of the diseases for clinical staging and/or evaluation of treatment response arose at the following sites: diaphragmatic pleura, chest wall, pericardium, mediastinum and mediastinal lymph nodes. Extension into the lung was difficult to identify following chemo- and/or radiotherapy.

Our results show that CT is essential in the clinical management of mesothelioma. We recommend that CT scans of the chest and upper abdomen, using contrast medium enhancement, should be required in routine practice and in particular in clinical trials involving pleural mesothelioma.

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In previous studies [1–5] computed tomography (CT) has been found to be superior to plain chest radiography in establishing the stage of pleural mesothelioma. By demonstrating lesions not detectable on conventional imaging studies, CT may alter staging and therapy in many patients with pleural mesothelioma [3]. CT has distinct limitations, but is probably the most accurate method for follow-up of patients with mesothelioma [6].

A reliable imaging method is needed for the establishment of the clinical stage of mesothelioma, as well as for the evaluation of treatment response. In order to further define the value of CT in the detection and staging of pleural mesothelioma we have compared the findings of 35 CT scans to those at thoracoscopy, thoracotomy or autopsy in a series of 33 patients.

Patients and methods

From 1982–1988 histologically confirmed malignant pleural mesothelioma was diagnosed in 93 patients at the Helsinki University Central Hospital. All of these patients participated in therapeutic trials of multimodality therapy. In 33 patients it was possible to correlate the CT scan findings either to those of thoracotomy (28 scans), autopsy (5 scans) or thoracoscopy (2 scans). Two patients were scanned both before thoracotomy and before autopsy. All interventions were performed less than one month after the reference CT scan. The 28 males and 5 females had a mean age of 57 yrs (range 39–73 yrs). Therapies consisted of debulking surgery, chemotherapy and hemithorax irradiation.

The CT scans were performed with one of three scanners (Siemens Somatom 2, DR2 or DRH, West Germany) (125 kV, mAs 230, slice thickness 8 mm, exposure time 4.5–3 s) using contrast medium (Angiografin® 305 mgI·ml^{-1} 450 mgI·kg^{-1} or Omnipague® 350 mgI·ml^{-1} 450 mgI·kg^{-1}). The entire thorax and upper abdomen down to the level of the second or third lumbar vertebra was scanned in each patient. The first bolus of contrast medium was injected at the level of the diaphragm to show possible tumour growth into the liver or blood-borne liver metastasis; the second bolus of contrast medium was given prior to examination of the chest. To assess contrast enhancement of the pleural masses a plain scan was first performed, and thereafter the scan was repeated after injection of contrast medium.

The CT scans were read retrospectively by the same radiologist, who paid special attention to pleural surfaces, pleural fluid, pericardium, pericardial fluid, chest wall, peritoneum, peritoneal fluid, visceral organs, bone, lymph nodes and subcutaneous tissue. Mediastinal lymph nodes larger than 1.5 cm in diameter were considered abnormal. Radiological findings were correlated, also retrospectively, with findings at operation or in autopsy reports. Apart from the reference CT scans, performed less than one month prior to the intervention, further follow-up CT scans were available as follows: 1, 2, 3, 6, 12 months and yearly following the intervention. Follow-up CT scans served as controls for the nonoperated side of the chest and for documenting the clinical course of the disease.

Results

Mesothelioma occured in the left hemithorax in 15 patients, in the right hemithorax in 17 patients and on both sides in one case. In all but one patient the pleural thickening showed marked contrast medium enhancement. The visceral and parietal pleura could not be distinguished unless pleural fluid was present. Pleural fluid was present on the CT scan of 21 patients (one patient had effusions on both sides). In one patient the pleural effusion seen on the CT scan could not be confirmed at autopsy. The pleural tumoral lesions varied from tiny nodules to enormous masses of thickened pleura occupying almost the whole hemithorax. When the mediastinal, anterior, posterior, lateral, diaphragmatic and interlobar pleurae were evaluated separately and correlated to findings at thoracotomy there were no false positive findings but sensitivity was lowest in the region of the diaphragmatic pleura (table 1). In the one patient where interlobar involvement was missed by CT, there was poor aeration of lung tissue on the affected side.

Thoracic extrapleural lesions were less accurately diagnosed by CT scans as compared to pleural findings (table 2). Tumour growth through the chest wall was detected by CT in 6 out of 6 of cases, whereas tumour growth within the chest wall was missed on one third of the CT scans. Pericardial involvement was detected in 6 out of 9 patients. Tumour infiltration of the mediastinum or of mediastinal lymph nodes was detected correctly in 15 out of 18 patients, false negative findings being more common than false positive ones. Pulmonary parenchymal metastases found in three patients at autopsy were not identified by CT scanning. In none of the preoperative reference CTs was there loss of volume of the affected hemithorax.

Table 1. – The accuracy of computed tomography (CT) diagnosis of different pleural lesions of mesothelioma when correlated to the findings at thoracotomy/thoracoscopy/autopsy

Localization of pleural lesion	True positive	False negative	False positive
Mediastinal	32/33	1/33	
Anterior	28/30	2/30	
Posterior	38/39	1/39	
Lateral	30/33	3/33	
Diaphragmatic	30/34	4/34	
Interlobar	14/15	1/15	

The results of the radiological evaluation of abdominal tumour growth by extension through the diaphragm are given in table 3. Peritoneal and liver involvement was diagnosed in all cases; a splenic metastasis was missed on the CT scan, and one splenic metastasis was falsely diagnosed. Ascites was never seen in this series. Bone involvement was detected in 3 out of 3 patients. At autopsy additional lesions outside the scanned areas were identified in the adrenal glands (one patient, liver not scanned) and in the thyroid gland (one patient).

Table 2. – The accuracy of computed tomography (CT) diagnosis of thoracic extrapleural lesions of mesothelioma when correlated to the findings at thoracotomy/thoracoscopy/autopsy

Localization of mesothelioma	True positive	False negative	False positive
Chest wall in	10/14	4/14	
through	6/6		
Pericardium	6/9	2/9	1/9
Mediastinal infiltrate nodes	15/18	2/18	1/18
Pulmonary parenchyma	0/3	3/3	

Table 3. – The accuracy of computed tomography (CT) diagnosis of abdominal extension and other extrathoracic sites of pleural mesothelioma

Localizaton of mesothelioma	True positive	False negative	False positive
Peritoneum	4/4		
Liver	2/2		
Spleen		1/2	1/2
Lymph nodes	3/3		
Subcutis	3/4	1/4	
Bone	3/3		

Discussion

Before CT became available, plain chest radiography was the most important radiological tool in the detection and staging of pleural mesothelioma. Bulky, lobulated tumours were easily detected on plain radiographs. By contrast, thin tumour layers, nodular studding, diaphragmatic, mediastinal, pericardial and interlobar affisions were almost impossible to detect by this

method. Frequent large collections of pleural fluid additionally diminished the diagnostic potential of plain chest radiographs. CT, with its transverse images, allows better spatial and density resolution by comparison with conventional chest radiographs, although transverse sections may, by partial volume effect, miss some information from transverse or oblique surfaces such as the diaphragm [7].

All 33 patients in our series showed pleural pathology on CT. Every pleural lesion except one showed contrast medium enhancement. The real nature of the one lesion without contrast medium enhancement remained obscure; it was situated on the contralateral side, was not thoracoscopied and did not grow during the follow-up period. Contrast medium enhancement may be present in any pleural malignancy as well as an active benign process such as infection [8]. The lesion without contrast medium enhancement could represent contralateral pleural thickening unrelated to mesothelioma, as has been reported [3].

Theoretically, the false negative CT findings in our study could be due to any of three factors: 1) at the time of the study the metastasis was too small (*i.e.* less than 2–3 mm) to be detected by the scanner; 2) the metastasis developed between the time of the CT scan and the operation/autopsy; or 3) the metastasis escaped the detection of the radiologist.

False positive results were found in cases of suspected pericardial infiltration (1 out of 9), suspected malignant mediastinal lymph nodes (1 out of 18) and suspected lienal metastasis (1 out of 2). It is likely that extensive mediastinal pleural involvement was falsely interpreted as pericardial thickening in one case. The fact that CT cannot differentiate between malignant lymph nodes and nonmalignant enlarged nodes is probably the reason for the false positive finding for mediastinal lymph nodes. The misinterpretation in the case of the suspected lienal metastasis was possibly due to a technical artefact.

In the staging of pleural mesothelioma, the most difficult CT findings to interprete have previously been chest wall involvement, mediastinal lymph nodes involvement, transdiaphragmatic extension of the tumour, peritoneal studding and solid organ metastases less than 2 mm in size [6]. Our results largely confirm this, although all of our apparent peritoneal metastases (two patients) could be verified by CT. None of the three metastases within the pulmonary parenchyma found at autopsy was detected by CT. As lung tissue is often poorly aerated due to pleural tumour mass or fluid, and may have been injured by chemo- and/or radiotherapy, detection of pulmonary metastases is difficult on CT. The same may apply to the interlobar pleura in advanced disease.

Our results show that CT of the chest and upper abdomen with contrast medium enhancement, is a reliable and accurate imaging method for early detection of pleural mesothelioma. CT should be included in the diagnostic work-up of patients with or without asbestos exposure, who present with unclear chest pain or a non-diagnostic collection of pleural fluid.

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Corrélations entre les observatons en tomographie computée et la thorascopie/thoracotomie/autopsie, dans les mésothléliomes pleuraux. P. Maasilta, T. Vehmas, L. Kivisaari, L. Tammilehto, K. Mattson.

RÉSUMÉ: Trente-cinq tomographies computées du thorax et de l'abdomen supérieur ont été mises en corrélation chez trente-trois patients atteints de mésothéliome pleural malin, avec des observations faites lors de la thoracotomie (28 patients), de la thoracoscopie (2 patients) ou de l'autopsie (5 patients). L'épaississement pleural avec renforcement par milieu de contraste a été décelé à la tomographie computée chez tous les patients. Cette observation constitue un outil valable de diagnostic, particulièrement dans les cas ou l'épanchement pleural est abondant et/ou lorsque de fines couches de tumeur ne sont qu'à peine ou pas du tout visibles sur le cliché thoracique standard. Des difficultés pour la définition de l'étendue exacte de la maladie, pour la stadification clinique et/ou l'évaluation de la réponse au traitement, existent aux sites suivants: la plèvre diaphragmatique, la paroi thoracique, le péricarde, le médiastin et les ganglions lymphatiques médiastinaux. L'extension à l'intérieur du poumon est difficile à identifier après chimio- et/ou radiothérapie.

Nos résultats montrent que la tomographie computée est essentielle pour la prise en charge clinique du mésothéliome. Nous recommandons que des C.T. scans du thorax et de l'abdomen supérieur, avec renforcement par milieu de contraste, soient exigés en pratique de routine, et en particulier dans les essais cliniques concernant les mésothéliomes pleuraux.

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