MR Imaging to Detect Chest Wall and Pleural Involvement in Patients with Lymphoma: Effect on Radiation Therapy Planning

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OBJECTIVE. The purpose of this study was to determine the influence that accurate MR detection of chest wall and pleural disease has on the type and extent of radiation therapy subsequently performed in patients with thoracic lymphoma.

MATERIALS AND METHODS. MR images and CT scans of the chests of 57 patients who had biopsy-proved lymphoma were retrospectively examined for evidence of involvement of the chest wall and pleura. For patients with thoracic lymphoma, we compared radiation portals and dosage designed by using information from MR images with portals and dosage designed by using information from chest radiographs and CT scans.

RESULTS. Chest wall or pleural disease was detected in 22 of the 57 patients examined. Chest wall disease was identified on MR images in 20 patients (29 sites) and pleural disease in 14 patients (16 sites). Chest wall and pleural disease were identified on CT scans in seven and five patients, respectively. Of the 15 patients who received radiation therapy, three (20%) had treatment planning altered, either by increasing the area exposed to radiation or by increasing the radiation dose, because of findings noted only on MR images.

CONCLUSION. Chest wall and pleural sites of disease that may be detected only on MR images can be important in designing appropriate radiation portals and dosage for patients who have chest lymphoma.

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Accurate anatomic staging in patients who have malignant lymphoma is important to determine the appropriate treatment regimen and to indicate the patient's prognosis. Tumor extension into the chest wall may significantly affect the management of patients. In patients treated with radiation alone, radiation portals may be altered, bolus radiation may be used, or local boost radiotherapy may be added to treat chest wall or pleural disease. Detection of significant extension of chest wall or pleural disease outside the usual mantle radiation portals can also influence the decision to use a combination of various types of therapy rather than radiation alone. Furthermore, even when chemotherapy is the first step in treatment, the radiation oncologist may choose to alter standard radiation fields that were based on the initial extent of disease, especially if soft-tissue involvement is extensive [1]. Conversely, unrecognized disease outside radiation portals exposes patients to an increased risk of relapse.

CT is currently the primary imaging technique for determining the extent of lymphoma in the chest [2, 3]. Recently, we have shown that MR imaging is more sensitive than CT for detecting the extent of chest wall involvement by lymphoma [4]. The objective of this study was to determine whether the additional sites of disease detected on MR images altered radiation therapy planning in patients who had malignant chest lymphoma.
Materials and Methods

Subjects

Patients who had MR images and CT scans of the chest obtained within 1 month of each other were included in this study (57 patients, 60 studies). Patients had MR imaging in addition to CT scans at the discretion of their referring physicians. Radiation therapists and oncologists were more likely to refer patients for MR imaging of the chest if the patients had bulky mediastinal disease or had signs or symptoms of chest wall involvement. The patients were from 13 to 64 years old; 31 were female, 26 were male. Forty-nine had Hodgkin's disease and eight had non-Hodgkin's lymphoma. Forty-three patients evaluated had newly diagnosed disease, and 14 patients had recurrent lymphoma. Twenty-seven subjects were included from a previous study [4]. All patients included in this study had biopsy-proved lymphoma with involvement of the mediastinum.

Twenty-two of the 57 patients examined had evidence of chest wall disease on either MR images, CT scans, or both. The presence of chest wall or pleural disease on MR images was confirmed histologically by fine-needle aspiration in two of the 22 patients. In 14 patients, the presence of disease was confirmed by resolution on follow-up MR images of abnormalities seen on earlier MR images; of these 14, six also had palpable chest wall masses that disappeared after treatment. Four patients with chest wall abnormalities had progression of disease and subsequently died; all of these were patients with stage IV disease who were treated with chemotherapy only. Two patients were lost to follow-up.

CT Scans

For most CT scans obtained at our institution, a GE 9800 scanner was used; a few were obtained with a GE 6800 CT scanner. Axial contiguous 1-cm sections from the lung apex to the adrenal glands were scanned. Technically comparable scans obtained at other institutions were included in our study. IV contrast material was administered for initial staging and was used for follow-up scans when needed to define vascular structures. Scans were viewed at both mediastinal (window, 450; level, 40) and lung (window, 1000; level –600 to –800) settings.

MR Images

MR images were obtained with a 1.5-T GE Signa superconducting magnet (53 images) or a 0.38-T Resonex resistive magnet (seven images). MR sequences included coronal and axial T1-weighted (300–800/15–25 [TR/TE]), and axial T2-weighted (1800–2800/20–30, 70–80), and short-T1 inversion recovery (STIR, 1500/30/100–150 [TR/TE/TI]) sequences.

Image Evaluation

Both MR images and CT scans were retrospectively evaluated for pleural and extrapleural disease by consensus by two radiologists who did not know the patients' clinical status. CT criteria for chest wall and pleural disease were based on contour abnormalities of soft tissues. MR criteria for chest wall disease included evidence of increased signal intensity on T2-weighted or STIR images, suggesting infiltration of the extrapleural soft tissues or bones. Abnormal supraclavicular and axillary lymph nodes were not included as chest wall disease. MR criteria for pleural disease included isolated increased signal intensity of the pleura except for dependent signal suggesting pleural fluid.

Treatment Planning

Determination of treatment with chemotherapy, radiation, or combined radiation and chemotherapy was made without knowledge of the MR findings but was based on stage, tumor type, and whether the disease was recurrent. Of those patients who had evidence of chest wall or pleural disease on MR imaging studies, only those treated with the combined technique or radiation therapy were further evaluated. In all but one patient, radiation therapy portals were initially designed by using radiographic and CT information. The radiation portals were then retrospectively redesigned by a radiation oncologist, who used the chest radiographs in addition to data obtained from MR imaging. These redesigned portals were then compared with those initially formulated from the chest radiographic and CT information. If chest wall or pleural disease identified on MR images was not included in the treatment field designed initially by using CT data and, therefore, required modification of treatment (i.e., altered portal, bolus, local boost), we concluded that the MR imaging influenced clinical management. In one patient, as the utility of chest MR imaging was being recognized, the radiation portals were changed prospectively on the basis of the MR imaging data. In this patient, the portals were designed using the additional information obtained from the MR images.

Results

Chest wall or pleural abnormalities were detected in a total of 22 patients, 19 who had Hodgkin's disease and three who had non-Hodgkin's lymphoma. Chest wall disease was seen on MR images in 20 patients (29 sites), pleural disease in 14 patients (16 sites), and both in 12 patients. Chest wall disease that was not detected on CT scans was identified on MR images in 13 patients (19 sites) and pleural disease in nine patients (11 sites). Disease that most commonly altered radiation therapy was sub- and interpectoral lymphadenopathy and anterior chest wall invasion that extended lateral to the standard chest mantle.

Seven of the 22 patients were treated with chemotherapy alone. Of these, three had non-Hodgkin's lymphoma, two had recurrent disease after previous mantle radiation, one had stage IV disease, and one had an incomplete response to chemotherapy and received a bone marrow transplant. The remaining 15 patients received radiation therapy. Of these, seven were treated with radiation therapy alone, and eight were treated with a combination of techniques. In five of the seven patients treated with radiation alone, chest wall disease detected on MR images was within the radiation mantle fields designed by using radiographic and CT information and, therefore, required no modification. In one patient, radiation portals were modified on the basis of chest wall involvement that was evident on both CT scans and MR images. Chest wall disease that was detected only on MR images caused radiation therapy to be modified in one patient from this group. In this patient, two areas of chest wall lymphoma were detected only on MR images, and one area was underestimated on the basis of CT findings, resulting in three portal modifications. The left interpectoral nodes and the medial extent of the right subpectoral nodes were not evident on CT scans and required trimming of the upper lung blocks (Figs. 1A and 1B). In addition, high-intensity signal extended along the left anterior pleural surface, for which the left lung block was trimmed medially (Figs. 1C–1E). The third portal modification in this patient was made because disease had extended from the mediastinal mass deep into the anterior parasternal soft tissues, noted as abnormally increased signal on MR images. Because of the parasternal chest wall extension, increased radiation was applied to this area by
Fig. 1.—A, CT scan shows bilateral axillary and right subpectoral lymphadenopathy. Medial extent of right subpectoral nodes was underestimated on basis of CT findings.

B, Short-T1 inversion recovery MR image delineates medial extent of right subpectoral nodes better than A does. Small left interpectoral node (arrow) is seen on MR image only. Apparent discrepancy between chest wall and mediastinal levels in this patient is due to differences in CT and MR gantry angles and arm positioning. Medial right subpectoral and left interpectoral nodes noted on MR images were not visible on corresponding CT scans.

C, CT scan shows asymmetry in parasternal tissues, which is suggestive of internal mammary lymphadenopathy.

D, MR image shows no internal mammary lymphadenopathy but does show abnormal signal (arrow) along anterior part of pleura on left side.

E, Radiation portals designed on basis of chest radiographic and CT information (dotted line) would have included longer and wider lung blocks covering some of right subpectoral and all of left interpectoral nodes in addition to diseased area of pleura. Radiation portals designed by using additional information obtained from MR images (solid line) required trimming of lung blocks superiorly and medially. These larger fields were treated with 15 Gy, after which redesigned blocks were applied to protect more lung parenchyma.

using a partial transmission lung block. Bilateral prominence of parasternal soft tissues noted on the CT scans in this patient suggested the possibility of internal mammary lymphadenopathy. The MR images of this region, however, showed no abnormal signal adjacent to the internal mammary vessels.

Of the eight patients treated with radiation in addition to chemotherapy, six had evidence of chest wall or pleural disease on MR images that either resolved after chemotherapy or was within the mantle designed on the basis of the chest radiographs and CT scans. In two patients, findings of chest wall and pleural disease detected only on MR images led to modification of radiation portals. In one of these patients, high-intensity signal on the MR image extended along the left anterior pleura, and the results of needle biopsy proved that the signal represented lymphoma (Fig. 2). The CT scan obtained at this level did not show pleural extension of disease. After chemotherapy, this area of increased signal intensity diminished, but because of its presence on the initial staging MR images, the left lung block was trimmed medially.

The second patient in whom the appearance on MR images caused alteration of portal design had increased signal intensity in the left parasternal soft tissues, suggesting tumor infiltration. Two treatment modifications were made as a result: the medial edge of the left lung block was modified to include this region in the treatment field and, in addition, a partial instead of full transmission lung block was used to treat potential microscopic lateral extension of disease.

Parasternal soft tissue was the most common site (n = 11) of lymphoma infiltration detected only on MR images (Fig. 3). Portal modifications were necessary for only one of these 11 patients. In the remaining 10, the parasternal disease was included within radiation portals designed for mediastinal disease, and therefore no additional modifications were needed.
Fig. 2.—A, CT scan shows extensive mediastinal lymphadenopathy but no pleural disease. B, MR image shows extension of disease (arrow) along anterior part of pleura on left side (biopsy proved). Also note small left-sided pleural effusion. C, Conventional mediastinal radiation portals (dotted line) would have covered left pleural disease. Modified portals based on MR findings (solid line) included medial trimming of lung blocks.

Discussion

Modifications in radiation therapy based on CT findings include alteration of the shape of lung blocks, the use of partial transmission blocks, and application of bolus radiation to treat superficial extension of disease. These modifications have resulted in more effective radiation treatment programs [2] and have reduced the risk of intrathoracic relapse in patients who have bulky mediastinal adenopathy from 35% to less than 10% [1, 5]. Recently, in a small number of patients, we showed MR imaging to be more sensitive than CT for detecting chest wall involvement by lymphoma [4]. In the current study, chest wall disease (13 patients, 19 sites) and pleural disease (9 patients, 11 sites) were again detected on MR images that were not visible on CT scans, but more importantly, we found that in some patients, these additional findings on MR images affected radiation therapy planning.

Of the 15 patients in this study treated with radiation therapy who had chest wall disease, three (20%) had their radiation therapy portals altered because of the MR findings. Changes made on the basis of additional information obtained from MR images included widening of treatment portals to encompass chest wall or pleural disease and the use of par-
tial transmission lung blocks to provide additional radiation to the chest wall. Evidence of chest wall disease detected on MR images that resulted in alterations in radiation treatment included abnormal intercostal and subpleural lymph nodes, tumor extending laterally along the pleural surface, and extension of disease into the parasternal soft tissues. In our series, infiltration of parasternal soft tissue detected only on MR images was common (11 of 57 patients). This avenue of disease extension is rarely detected on CT scans. Fortunately, however, this area is included often within radiation portals designed for mediastinal disease. Detection of tumor extending to within 1 cm of the skin surface is important because this condition requires tissue-equivalent bolus radiation to enhance the local radiation dose and thereby avoid undertreating superficial tumor. In addition, if tumor extends laterally beyond the bulk of the mediastinal mass, the lung block should be trimmed medially or a partial transmission lung block used to treat the full extent of tumor.

Clinically evident chest wall involvement by lymphoma, particularly in the parasternal soft tissues, has previously been described [6, 7]. This avenue of disease extension from the mediastinum into parasternal soft tissues and along pleural surfaces adjacent to the mediastinum is consistent with the well-known centrifugal spread characteristic of Hodgkin's disease. Goldman [6] and Fayos [7] considered disease in the parasternal soft tissues to spread from internal mammary nodes. Alternatively, disease in the mediastinum may spread directly into the parasternal soft tissues and along the pleural surfaces without involving the internal mammary nodes.

Although differentiation of tumor from edema is not always possible with MR imaging, our assumption that abnormal signal in the chest wall represents lymphomatous involvement was supported by biopsy proof of disease in two cases and by clinical and radiologic response to therapy in 14 others. Increased signal intensity in the chest wall adjacent to other types of malignant pulmonary lesions has previously been shown to represent malignant invasion of the chest wall [8]. Nonetheless, without biopsy proof, we cannot be certain that increased signal intensity in the chest wall represents disease extension. In treating patients who have lymphoma, however, less risk is involved to the patient in extending radiation portals to include signal that may represent edema than in undertreating areas of increased signal that may represent lymphoma.

One limitation of this retrospective review is that at a tertiary care institution such as ours, patients who have lymphoma are referred after initial diagnosis, and CT scans are often obtained before referral. MR images are thus usually obtained after CT scans, and therefore some progression of disease may occur in the interval. We attempted to minimize this problem by including only patients in whom the interval between CT scanning and MR imaging was no longer than 1 month. The average time between CT scanning and MR imaging in the 22 patients who had chest wall disease was 12 days.

Our results suggest that lymphoma extension into the chest wall and along pleural surfaces occurs more commonly than previously recognized. Although we suspect that patients who have bulky mediastinal disease are at greater risk, parasternal and pleural spread can occur in patients who have relatively moderate mediastinal tumor bulk. We therefore recommend careful attention to the parasternal area on both CT scans and MR images in all patients who have mediastinal lymphoma.

Because unrecognized chest disease increases the risk of treatment failure in patients who have lymphoma, we conclude that the additional information on chest wall and pleural lymphoma provided by MR images is important in planning radiation therapy. MR findings will most likely have the greatest impact on those patients treated with radiation alone but also may lead to alteration in radiation portals in patients treated with a combination of techniques.

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