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Clinical Investigation

Delineation of Supraclavicular Target Volumes in Breast Cancer Radiation Therapy

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Summary

Radiation of the supraclavicular fossa is commonly recommended for women with breast cancer who are at risk of harboring subclinical supraclavicular disease. Proper delineation of the supraclavicular clinical target volume is critical in such women. Herein, we map the location of known supraclavicular metastases in patients with breast cancer, to inform optimal supraclavicular clinical target volume segmentation.

Purpose: To map the location of gross supraclavicular metastases in patients with breast cancer, in order to determine areas at highest risk of harboring subclinical disease.

Methods and Materials: Patients with axial imaging of gross supraclavicular disease were identified from an institutional breast cancer registry. Locations of the metastatic lymph nodes were transferred onto representative axial computed tomography images of the supraclavicular region and compared with the Radiation Therapy Oncology Group (RTOG) breast cancer atlas for radiation therapy planning.

Results: Sixty-two patients with 161 supraclavicular nodal metastases were eligible for study inclusion. At the time of diagnosis, 117 nodal metastases were present in 44 patients. Forty-four nodal metastases in 18 patients were detected at disease recurrence, 4 of whom had received prior radiation to the supraclavicular fossa. Of the 161 nodal metastases, 95 (59%) were within the RTOG consensus volume, 4 nodal metastases (2%) in 3 patients were marginally within the volume, and 62 nodal metastases (39%) in 30 patients were outside the volume. Supraclavicular disease outside the RTOG consensus volume was located in 3 regions: at the level of the cricoid and thyroid cartilage (superior to the RTOG volume), in the posterolateral supraclavicular fossa (posterolateral to the RTOG volume), and in the lateral low supraclavicular fossa (lateral to the RTOG volume). Only women with multiple supraclavicular metastases had nodal disease that extended superiorly to the level of the thyroid cartilage.

Conclusions: For women with risk of harboring subclinical supraclavicular disease warranting the addition of supraclavicular radiation, coverage of the posterior triangle and the lateral low supraclavicular region should be considered. For women with known supraclavicular disease, extension of neck coverage superior to the cricoid cartilage may be warranted.

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Introduction

Breast cancer continues to be the most common non-cutaneous malignancy in women, with an estimated 235,030 women receiving a diagnosis of breast cancer and 40,430 breast cancer-related deaths in the United States in 2014 (1). For women with node-positive breast cancer treated with mastectomy, adjuvant radiation therapy to the chest wall and draining nodal regions (supraclavicular, axillary, and internal mammary) is associated with improvements in locoregional control (LRC) and overall survival (2-5). These data are often extrapolated to the breast conservation setting, to support regional nodal irradiation (RNI). It generally is accepted that patients with 4 or more involved lymph nodes are at sufficiently high risk of regional recurrence to warrant RNI (6). Randomized controlled trials and a meta-analysis have suggested that in women with 1 to 3 positive nodes, RNI results in improvements in LRC and breast cancer mortality after mastectomy (7) and in LRC and disease-free survival after breast-conserving surgery (8).

Studies evaluating patterns of treatment failure generally show that the supraclavicular fossa is the second most common site of locoregional failure, after the chest wall or breast (9, 10). Thus, determination of the optimal target volume for radiation delivery to this region is of great importance.

Increasingly, radiation oncologists are using 3-dimensional radiation therapy techniques in breast cancer treatment. Whereas fields previously were drawn on the basis of bony landmarks on radiographs, they are now routinely delineated on axial computed tomography (CT) on the basis of soft-tissue anatomy. Similarly, at many centers, treatments previously delivered with simple beam arrangements are now given with more sophisticated techniques, including intensity modulated radiation therapy (11) and proton therapy (12). Although these technologic advances allow for increased conformality and potential reductions in dose to normal tissues, care must be taken in delineating treatment volumes to avoid underdosing the tissues at highest risk for microscopic disease.

To reduce variability in delineation of breast target volumes and to inform guidelines for prospective clinical trials of breast radiation therapy, the Radiation Therapy Oncology Group (RTOG) has published an atlas of suggested target volumes for postoperative breast radiation therapy based on expert consensus (13). The aim of this study was to map the location of gross supraclavicular metastases in patients with breast cancer relative to these suggested volumes, in order to determine areas at highest risk for harboring subclinical disease and, in turn, to inform the supraclavicular clinical target volume (CTV) segmentation in our practice.

Methods and Materials

Following institutional review board approval of the study, we reviewed our breast cancer registry between January 1, 1990, and September 1, 2013, and identified patients with gross supraclavicular disease (SCD) at initial diagnosis of breast cancer or at first recurrence. Only patients with axial imaging available for review were included. Although the study period began on January 1, 1990, all patients meeting criteria received the diagnosis of SCD in 2003 or later, owing to the fact that axial imaging was more frequently performed in the later years of the study period. On the basis of the assumption that areas harboring gross disease are also the regions most likely to harbor microscopic disease (14-16), patients who presented with supraclavicular nodal metastases, as well as patients who had supraclavicular recurrence, were included. During the study period, patients with 1 or more nodal macrometastases were considered for radiation therapy to the supraclavicular region. Those cases in which disease recurred after prior supraclavicular radiation serve as potentially interesting case studies of field design. The location of SCD was determined on the basis of all available imaging modalities, including CT, positron emission tomography (PET), and magnetic resonance imaging. Consensus for the same was obtained on the basis of review by a radiation oncologist (L.C.B.) and a neuroradiologist specializing in the head and neck (F.E.D.). Lymph nodes that were fluorodeoxyglucose (FDG)-avid, had pathologic morphology, or exceeded 1 cm in greatest dimension were included.

Fifty-seven patients who presented with SCD at the time of diagnosis were identified. Eleven patients were initially excluded because their disease was confluent with axillary or mediastinal disease, precluding accurate determination of the epicenter of the nodal metastasis (n = 3); imaging was suboptimal (eg PET images only, without CT for anatomic correlation [n = 2]); disease was located in the infraclavicular fossa and not in the supraclavicular region (n = 3); disease was located in the mediastinum and not in the supraclavicular region (n = 1); or disease was not pathologic in appearance on axial imaging (n = 2). After review with a neuroradiologist specializing in the head and neck (F.E.D.), 2 other patients were excluded because the supraclavicular nodes seen on imaging were subcentimeter, non−FDG-avid, of normal morphologic characteristics, or a combination of these characteristics, and thus were not believed to be sufficiently abnormal-appearing to be presumed malignant. Thus, 44 patients who presented with SCD at initial diagnosis were analyzed.

Twenty-four patients had documented nodal recurrence in the supraclavicular fossa and axial imaging for review. There was no overlap between groups (ie no patient was included in both groups). Six patients were excluded because of SCD being contralateral to the initial primary (n = 1), confluence of disease precluding accurate determination of the epicenter (n = 1) infraclavicular location (n = 2), or because imaging was suboptimal (eg PET