Neck Dissection Planning Based on Postchemoradiation Computed Tomography in Patients With Head and Neck Cancer

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Objectives: To determine what findings on postchemoradiation neck computed tomography (CT) may predict removal of the internal jugular vein (IJV) or sternocleidomastoid muscle (SCM) and to examine whether pretreatment CT had any bearing on the ultimate posttreatment neck dissection with regard to the IJV and SCM.

Design: Retrospective review of CT, intraoperative, and pathologic findings.

Setting: Tertiary care academic medical center.

Patients: Thirty-four patients who underwent 43 planned post-CRT hemi-neck dissections for pretreatment N2 or greater disease.

Results: Of the 43 neck dissections, 39 (91%) were selective neck dissections, 2 (5%) were modified radical dissections, and 2 (5%) were radical neck dissections. The IJV was removed in 6 of the 39 selective neck dissections (15%), in 1 of the 2 modified radical dissections, and in both of the 2 radical neck dissections. The SCM was removed in the 2 modified radical dissections and 2 radical neck dissections. The IJV was removed in 7 of the 9 dissections (78%) in which the IJV was abnormal on preoperative CT (filling defect or thrombosed) vs 2 of the 34 dissections (6%) with a normal IJV on CT (P<.001; positive predictive value, 78%; negative predictive value, 94%). The SCM was removed in 4 of the 11 dissections (36%) in which the tissue plane between the carotid sheath and the SCM was indistinct on CT vs 0 of the 32 dissections with a radiographically normal SCM tissue plane (P=.003; positive predictive value, 36%; negative predictive value, 100%). In 27 patients with pre-CRT CTs for comparison, the IJV normalized in 3 of the 8 patients (38%) with an abnormal IJV on pre-CRT CT, and the tissue plane around the SCM normalized in 15 of the 24 patients (63%) with an indistinct tissue plane on pre-CRT CT.

Conclusions: Filling defects or thrombosis of the IJV is highly predictive of need for removal intraoperatively, which may affect planning especially in bilateral neck dissections in which an effort may be made to preserve at least 1 vein. Presence of a clear tissue plane between the SCM and carotid sheath predicts the ability to preserve this muscle. Changes in the status of the IJV and SCM seen on CT that occur as a result of CRT may make preservation of these structures more feasible, even in patients with advanced neck disease.

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POSTCHEMORADIATION (POST-CRT) neck dissection is a common practice in many institutions for advanced pretreatment neck disease and persistent posttreatment pathologic lymphadenopathy. In most instances, these neck dissections can still be carried out within the boundaries of the aponeuroses of the neck as described in the original publication on the “conservative neck dissection” by Bocca,1 though they are often challenged by indistinct or obliterated tissue planes.

For some patients, tumor involvement of major landmarks in the neck, specifically the internal jugular vein (IJV) and sternocleidomastoid muscle (SCM), necessitate the removal of these structures. Removal of these structures carries additional potential complications and disabilities; it would be helpful to be able to preoperatively predict whether IJV or SCM can be preserved or will likely be removed.

Computed tomography (CT) has been a standard staging and screening tool at our institution for many years, used both before and after CRT as well as for operative planning. Although positron-emission tomography and magnetic resonance imaging (MRI) each have their advantages for the evaluation of neck disease and anatomy, these modalities were not routinely used at the time the patients in this study were treated (1995-2002) and are currently only used by us for select circumstances. Therefore, in the present study we focused on CT for availability of data and also because it is a more

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commonly used and less expensive modality than either positron-emission tomography or MRI. Our goal was to determine what findings on post-CRT neck CT may predict removal of the IJV or SCM. In addition, we examined whether the pretreatment CT had any bearing on the ultimate posttreatment neck dissection with regard to the IJV and SCM.

METHODS

Retrospective review of patients who underwent CRT for head and neck cancer from November 1998 to August 2002 at the University of Chicago, Chicago, Illinois, as part of a prospective, multi-institution clinical trial of induction chemotherapy followed by concurrent CRT. Because of availability of data, the present study only included those patients treated at our institution. The results of this trial (including all participating centers) are described in detail elsewhere. Briefly, the 3-part protocol (A, B, and C) consisted of induction carboplatin-paclitaxel followed by 5 cycles of concomitant hydroxyurea-fluorouracil-paclitaxel and radiation in a total dose ranging from 72 to 75 Gy. The radiation dose was reduced sequentially for groups A, B, and C, and the induction chemotherapy schedule was altered for group C during this trial.

Of these patients from the University of Chicago, those who underwent neck dissection following CRT were selected, and the radiology records of these patients were reviewed for completeness. Those patients with available images from at least 1 post-CRT, pre–neck dissection, head and neck contrast-enhanced CT were identified for further study. These CT scans were reviewed independently by 2 radiologists (S.K. and A.A.) blinded to the surgical procedure and clinical history on a standard PACS (picture archiving and communication system) workstation using soft-tissue and bone windows. Specific attention was paid to the status of the IJV and SCM and the surrounding tissue planes. Emphasis was placed on obvious CT findings that could be easily interpreted by nonradiologists. Differences were adjudicated between themselves, and a final interpretation was created.

The status of the carotid artery was not addressed in this study because no patients required carotid removal. In addition, we chose not to address the radiologic status of post-CRT lymph nodes with regard to the ultimate finding of tumor in the neck dissection on pathologic evaluation. This topic involves the decision of whether to perform neck dissection at all, rather than the present study’s focus on dissection planning once the decision to perform a neck dissection has been made. The former topic will be addressed in future publications.

Intraoperative findings were reviewed from dictated operative reports. As standard practice at our institution, the IJV, SCM, and other structures are spared unless these structures are unable to be separated from the tumor specimen or surrounding structures owing to fibrosis. The type of neck dissection performed and which, if any, structures were removed were recorded.

Associations between radiologic characteristics and surgical outcomes were examined using the Fisher exact test. A 2-sided P value < .05 was considered statistically significant. Statistical analyses were performed using Stata version 9 software (StataCorp, College Station, Texas). The institutional review board of the University of Chicago approved this retrospective study as an adjunct to the preexisting prospective CRT study protocol.

RESULTS

Fifty-two patients in this protocol underwent planned neck dissections at our institution following CRT, 34 of whom had a preoperative CT scan available in our PACS system for review. Although all 52 patients had CT scans at the time of treatment, as evidenced by dictated reports, the original images were not available for 18 patients. These scans were not available either because they were performed at an outside institution and were not stored on our system after the images were used by our team for treatment planning or because they were performed at our institution but were unable to be obtained from our archives owing to difficulties with an older magnetic tape archiving system that has since been replaced. The 34 patients with images available underwent 43 hemi-neck dissections. See Table 1 for demographics and tumor characteristics of these patients.

Of these 43 neck dissections, 39 (91%) were selective neck dissections (SNDs), 2 (5%) were modified radical (MRNDs), and 2 (5%) were radical neck dissections (RNDs). The IJV was removed in 6 of the 39 SNDs (15%), in 1 of the 2 MRNDs, and in both of the 2 RNDs. The SCM was removed in the 2 MRNDs and 2 RNDs (Figure 1).

The IJV was removed in 7 of the 9 dissections (78%) in which the IJV was abnormal on preoperative CT (filling defect or thrombosed) vs 2 of the 34 dissections (6%) with a normal IJV on CT (P < .001; positive predictive value [PPV], 78%; negative predictive value [NPV], 94%). The SCM was removed in 4 of the 11 dissections (36%) in which the tissue plane between the tumor mass and the SCM was indistinguishable on CT vs 0 of the 32 dissections with a radiographically normal SCM tissue plane (P = .003; PPV, 36%; NPV, 100%). See Table 2 for complete data.

Table 1. Demographics and Tumor Information for the 34 Patients

<table>
<thead>
<tr>
<th>Location</th>
<th>No. (%)</th>
</tr>
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<tbody>
<tr>
<td>Pharynx</td>
<td>16 (47)</td>
</tr>
<tr>
<td>Larynx</td>
<td>5 (15)</td>
</tr>
<tr>
<td>Nasopharynx</td>
<td>4 (12)</td>
</tr>
<tr>
<td>Hypopharynx</td>
<td>3 (9)</td>
</tr>
<tr>
<td>N category</td>
<td></td>
</tr>
<tr>
<td>N2a</td>
<td>4 (12)</td>
</tr>
<tr>
<td>N2b</td>
<td>13 (38)</td>
</tr>
<tr>
<td>N2c</td>
<td>8 (24)</td>
</tr>
<tr>
<td>N3</td>
<td>9 (26)</td>
</tr>
</tbody>
</table>

*Staging is based on the 2002 American Joint Committee on Cancer staging criteria.*

Table 2. Demographics and Tumor Characteristics

<table>
<thead>
<tr>
<th>Stage</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV</td>
<td>32 (94)</td>
</tr>
<tr>
<td>III</td>
<td>2 (6)</td>
</tr>
</tbody>
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For 27 of the 43 neck dissections, pretreatment CT images were also available for comparison. The IJV was abnormal in 8 (30%) of the pre-CRT scans. Its status changed significantly in 4 patients from pre-CRT to post-CRT, with 3 IJVs recanalizing (Figure 2) and conversely 1 thrombosing. The IJV was ultimately removed in 5 of the 8 necks (63%) without pre-CRT abnormalities.

The tissue plane surrounding the SCM was abnormal in 24 (89%) of the pre-CRT scans. This improved with CRT in 15 of the 24 (63%) (Figure 3). Although for post-CRT CT we were able to correlate tissue plane abnormalities and SCM removal, our analysis using pre-CRT CT was limited due to the almost uniform presence of abnormal tissue planes compared with the small number of ultimately removed SCMs.

There was no statistically significant difference between the treatment groups (A, B, or C) with regard to removal rate of the IJV (P = .40) or SCM (P = .64). Similarly, there was no difference in the removal rate of the IJV or SCM based on level of pathologic nodes (P values ranged from .55 to >.99 for levels I-V).

Pathologic analysis of the neck dissection specimens revealed 5 necks with viable tumors. None of these specimens had tumors extending to the margins of the dissection. Furthermore, with a mean of 27 months of follow-up, no patients developed neck recurrences, suggesting that intraoperative decisions to spare the IJV and/or SCM did not result in leaving behind residual tumor.

**COMMENT**

The present study examined radiologic predictors of the ability to spare the IJV and SCM during a post-CRT neck dissection. Bocca1 noted that postirradiation conservative (selective) neck dissection was feasible and in fact offered the benefit of increased carotid coverage and protection, and we4 and subsequently others5,6 have demonstrated the

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**Table 2. Computed Tomographic (CT) Findings and Intraoperative Removal**

<table>
<thead>
<tr>
<th></th>
<th>Removed</th>
<th>Preserved</th>
<th>P Value</th>
<th>PPV, %</th>
<th>NPV, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>IJV Abnormal on CT (n=9)</td>
<td>7 (78)</td>
<td>2 (22)</td>
<td>&lt;.001</td>
<td>78</td>
<td>94</td>
</tr>
<tr>
<td>Normal on CT (n=34)</td>
<td>2 (6)</td>
<td>32 (94)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCM Abnormal on CT (n=11)</td>
<td>4 (36)</td>
<td>7 (64)</td>
<td>.003</td>
<td>36</td>
<td>100</td>
</tr>
<tr>
<td>Normal on CT (n=32)</td>
<td>0</td>
<td>32 (100)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: IJV, internal jugular vein; NPV, negative predictive value; PPV, positive predictive value; SCM, sternocleidomastoid muscle.

*Computed tomographic findings of a filling defect or thrombosis of the IJV predicted removal, and absence of these finding predicted the ability to preserve the IJV. For the SCM, a normal tissue plane surrounding this muscle predicted preservation.

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**Figure 1.** Axial contrast-enhanced computed tomography (CT) of the neck for 2 patients following chemoradiation (CRT). Patient A retained an indistinct tissue plane around the sternocleidomastoid muscle (SCM; arrow) and an absent internal jugular vein (IJV) following CRT. Both required intraoperative removal. Patient B had bilateral indistinct tissue planes surrounding the SCM (arrowheads) and an absent IJV on the right. These were removed, but the normally filling IJV on the left (asterisk) was able to be preserved.
feasibility of selective neck dissection after CRT. However, in the post-CRT neck, it can be difficult to determine preoperatively, and even intraoperatively, whether tumor involvement of the IJV or SCM has occurred and whether these structures require removal.

Our data are limited by its retrospective nature and the need to exclude patients for the lack of available images. However, in the 34 patients we were able to include, we found that the ability to trace the IJV from the thoracic inlet to the skull base on preoperative contrast-enhanced CT is a good predictor of IJV preservation (94% of those patients with a normal IJV on CT had it spared during dissection). Likewise, we found that the presence of a distinct tissue plane surrounding the SCM on CT is a good predictor of SCM preservation. However, this must be confirmed with larger studies.

We also found that following CRT, anatomy previously distorted by tumor became recognizable, tissue planes became distinct, and veins became visibly patent. Not only does this stress the importance of a post-CRT CT in neck dissection planning, but also suggests that CRT may make a selective neck dissection a viable option in patients whose bulky pre-CRT neck disease may have required a more radical neck dissection to extirpate.

Computed tomographic scanning has long been the modality of choice for evaluation of the neck at our institution based on lower cost compared with positron-emission tomography or MRI, rapidity and ease of scheduling, and in most cases, the provision of adequate information for treatment planning. Magnetic resonance imaging provides improved assessment of soft-tissue structures and tissue planes compared with CT, yet the results of this study suggest that CT is sufficient for evaluation of tissue planes and the status of the IJV.

One controversial issue we did not address in the present study but which also involves using information obtained from post-CRT CT, is the predictive value of a complete radiologic nodal response on the absence of viable tumor in the neck. We are in the process of examining this topic with our own data and note some recent publications on this issue. Our reservation with relying solely on radiologic nodal response as assessed by post-CRT CT lies with at least 2 patients at our institution (not in this series) who had “viable” tumor in their post-CRT neck dissection despite a complete response on CT. Physiologic imaging methods such as positron-emission tomography–CT or MRI may be useful in more accurately assessing tumor burden and response to treatment. These issues are also intimately tied with a still unclear definition of what constitutes “viable tumor” and is a topic greatly in need of careful research.

In conclusion, filling defects or thrombosis of the IJV is highly predictive of need for removal intraoperatively, which may effect planning especially in bilateral neck dissections where an effort may be made to pre-

**Figure 2.** Evaluation of internal jugular vein (IJV) abnormalities using axial contrast-enhanced computed tomographic (CT) scans of the neck of a patient prior to (A) and following (B) chemoradiation (CRT). The arrow in the pretreatment scan identifies absence of contrast in the IJV from either tumor compression or thrombosis. Following CRT, the IJV reappeared (arrow) and was preserved during the post-CRT neck dissection.
serve at least 1 vein. Presence of a clear tissue plane between the SCM and carotid sheath predicts the ability to preserve this muscle. Changes in the status of the IJV and SCM seen on CT that occur as a result of CRT may make preservation of these structures more feasible even in patients with advanced neck disease.

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Author Contributions: Dr Langerman had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Langerman, Vokes, and Stenson. Acquisition of data: Langerman, Comstock, Konda, Abramovitch, and Stenson. Analysis and interpretation of data: Langerman, Kasza, and Stenson. Drafting of the manuscript: Langerman, Comstock, Konda, Abramovitch, and Kasza. Critical revision of the manuscript for important intellectual content: Vokes and Stenson. Statistical analysis: Kasza. Obtained funding: Vokes. Administrative, technical, and material support: Stenson. Study supervision: Stenson.

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Figure 3. Evaluation of sternocleidomastoid muscle (SCM) abnormalities using axial contrast-enhanced computed tomographic (CT) scans of the neck of a patient prior to (A) and following chemoradiation (CRT). The arrow identifies absence of a clear tissue plane between the tumor and the SCM on pretreatment scanning. Following CRT, there has been a radiologic complete response of the tumor, and the tissue plane deep to the SCM has become distinct (arrow). The SCM was preserved during the post-CRT neck dissection.

REFERENCES