Enlarged Lymph Nodes of the Neck: Evaluation with Parallel Extended Field-of-View Sonographic Sequences

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A standardized extended field-of-view sonographic examination technique of the neck is evaluated. In a prospective study we screened 50 patients suspected of having carcinoma or lymphoma for enlarged cervical lymph nodes. After conventional CT of the neck, extended field-of-view sonography was performed using defined axial parallel scanning sequences. The results were interpreted separately by two radiologists. Of 245 lymph nodes (diameter 1 cm or greater) diagnosed with conventional CT, 218 were correctly identified by extended field-of-view ultrasonography. With respect to the entire neck, the sensitivity of extended field-of-view sonography was 92%, and the correlation coefficient between the methods was $r = 0.98$ ($P < 0.001$). Fifteen of 17 false-negative lymph nodes were located in the mandibular angle region. False-positive results ($N = 10$) were caused by misinterpretation of primary tumors, blood vessels, lobulated salivary glands, and double imaged lymph nodes. Our results indicate that extended field-of-view sonography in parallel scanning sequences represents a reliable method for the detection of cervical lymphadenopathy. KEY WORDS: Ultrasonography, comparative studies; Computed tomography; Lymphatic system; Neck; Lymph nodes, cervical.

Assessment of lymph nodes of the head and neck has a major impact on diagnosis and treatment of a variety of diseases.¹ Lymph nodes in these sites are involved in local and general disorders as well as inflammatory processes and neoplasms.² Many diseases are associated with visible lymphadenopathy. Currently available imaging procedures play an important role in the evaluation of diseases accompanied with lymph node enlargement. Ultrasonography, CT, and MR imaging are far more accurate than inspection and palpation.³

Conventional ultrasonography has gained acceptance as a technique for routine examination in the detection and delineation of enlarged lymph nodes of the neck. Among the drawbacks of this imaging method, however, are the limited field of view without topographic orientation, and, therefore, the inability to compare sonographic images to those of other cross-sectional modalities. Until now CT and MR were the only potential alternatives to improve neck examination by demonstrating topographic anatomy. Another disadvantage of ultrasonography might be that sonographic examinations are not standardized, and therefore, the findings often depend on the experience of the user.
EFOV-US is an imaging process that was developed in an attempt to overcome some of the drawbacks of conventional gray scale ultrasonography. EFOV-US uses a specialized computer processing technique to produce a large field-of-view image with conventional freehand real-time transducers. No position sensor or articulated arm is required to improve perspective in ultrasonograms when EFOV-US is used. In particular, the method described here appears to offer advantages for the scanning of extended and tubular structures as well as large and enlarged organs and abnormally large volumes.

We describe a standardized EFOV-US examination technique of the neck using parallel scanning sequences. The present prospective study investigated whether this EFOV-US examination method is able to identify enlarged cervical lymph nodes. The findings were correlated with CT scans as the accepted method of choice for accurate assessment of lymph nodes of the head and neck.

PATIENTS AND METHODS

A total of 50 consecutive patients with pathologic lymph nodes diagnosed previously by CT were included in this study. All lymph nodes exceeding 1 cm in diameter were considered as “pathologic.” The patient population included 33 men and 17 women (age range, 27 to 82 years; mean, 59.1 years). The underlying diseases were lymphomas (n = 24), oropharyngeal cancer (n = 23), melanoma (n = 2), and medullary thymoma (n = 1). Five patients had undergone earlier surgical treatment.

After conventional CT, the EFOV-US examination was done on the same day by different examiners. To allow statistical comparison between conventional CT and EFOV-US of the neck, all patients were examined according to standardized CT and sonographic examination protocols.

All CT scans were performed with a Siemens Somatom Plus VD 30 (Siemens, Erlangen, Germany). Contiguous 5 mm thick sections at 120 kVp with 210 mA were conducted from the lower orbital wall to the thoracic inlet (scan time, 2 × 1 s; reconstruction algorithm “high”). We generally adopted a biphasic modality of contrast medium injection (Ultravist, Schering AG, Berlin, Germany), divided into a first bolus of 25 ml at 1 ml/s and a subsequent infusion of 75 ml at 0.3 ml/s flow rate. All scans were obtained in craniocaudal direction with a constant gantry angle (between –9 and –15 degrees) parallel to the maxilla.

All ultrasonographic examinations were performed with EFOV-US technology (SieScape), which is integrated with the sonography device Sonoline Elegra (Siemens Medical Systems, Issaquah, WA), using a 7.5L40 or 5.0HDPL40 transducer. The insonating frequencies were between 7.2 MHz and 9.0 MHz (gain, 63%; depth, 3 to 5 cm; dynamic range, 70; persistence, 2).

The EFOV-US examination technique of the neck was standardized by defined axial parallel scanning sequences (“slice packages”). The anatomic region was defined by the jugular fossa and the mandible (craniocaudal direction) and the dorsolateral margin of the left and right sternocleidomastoid muscle (transverse direction). The first scan started from the dorsolateral margin of the left sternocleidomastoid muscle along the upper clavicular edge to the margin of the right sternocleidomastoid muscle. The second scan started again at the left neck side in a scanning line on the cranial margin given by the traces from the first scan in the sonographic gel. This proceeding guaranteed parallel contiguous or overstepped sonograms. The aim was to obtain parallel axial EFOV-US scanning sequences not only at distances less than 1 cm but also at a constant transducer scanning angle. For anatomic reasons the latter was possible only up to the lower margin of the submandibular gland. At this region the EFOV-US scan was split; each side of the neck required two or three submandibular scans and two submental scans delimited by the left and right submandibular gland with different transducer angles (Fig. 1).

Figure 1  The principle of EFOV-US scanning technique of the neck. The sonographic examination technique was standardized by defined axial parallel scanning sequences.
CT examinations and EFOV-US slice packages of defined anatomic regions were reviewed in random sequence by two observers (M.J., T.W.), who were blinded to the results of the other imaging study. CT was considered the standard method in the detection of enlarged cervical lymph nodes. The size of the lymph nodes was determined by measuring the largest diameters on the scan. Lymph nodes were classified as enlarged if the diameter was 1 cm or greater. The carotid bifurcation was considered an anatomic landmark in the evaluation of the findings.

From the CT examinations we retained the total number of CT scans of each entire neck examination and, in particular, the scans obtained from anatomic regions correlating with the EFOV-US slice packages. Moreover, neck length, total number, and localization of pathologic cervical lymph nodes were determined. Additional lymph nodes located nuchally and above the mandible were documented as well.

From EFOV-US examinations we retained the complete number of scans, including the submandibular and submental scans. In each case a split submandibular or submental scan of the left or right side was considered a complete scan. Both the total number and the location of pathologic cervical lymph nodes were assessed.

The results obtained by reviewing the EFOV-US slice packages were correlated with the findings from conventional CT. Statistical analyses included determination of the sensitivity of the method; moreover, the correlation coefficient (EFOV-US versus CT) was determined according to Pearson’s method.

RESULTS

The average number of EFOV-US scans for the examination of the defined scan area at the neck was 13, including the submandibular and submental scans. The minimum number of scans required was 9, and the maximum was 23. In contrast to EFOV-US, complete CT examination of the entire neck needed a mean of 24 scans, 18 of which were compared with EFOV-US according to the definition of the scan area. The mean lengths of the entire neck analyzed by CT and EFOV-US were 11.70 cm and 8.78 cm, respectively. Depending on the number of scans, the average scan distances were 0.49 cm for CT and 0.68 cm for EFOV-US.

Table 1 presents the detection rate of enlarged cervical lymph nodes for each modality. In 34 of 50 (68%) patients the detection rate for both methods was identical. The other 16 patients included 4 patients with false-positive results, 9 patients with false-negative lymph nodes, and 3 patients with both false-positive and false-negative lymph nodes. The number and location of falsely diagnosed nodes in parallel-scanned EFOV-US sequences are listed in Table 2. The majority of false-negative nodes were located cranial to the carotid bifurcation. Reasons for false-positive diagnoses (N = 10) were misinterpretation of primary tumors (mouth floor carcinoma (N = 2; Fig. 2) or tonsil lymphoma (N = 2; Fig. 3) and several single cases with misinterpretation due to muscle tissue, a blood vessel, a lobulated parotid gland, a double imaged lymph node, and a tonsil affected with Hodgkin disease.

Reasons for false-negative results (N = 17) were single cases with misinterpretations due to muscle, blood vessels, and a postoperative seroma. In two cases lymph nodes were smaller than 1 cm on EFOV-US imaging, and in two additional cases they were localized cranial to the mandibular angle. In the remaining 10 cases the lymph nodes were simply not depicted on the scanned EFOV-US sequences.

With respect to sensitivity of EFOV-US, for the entire neck it was 92%, cranial to the carotid bifurcation it was 91%, and caudal to the carotid bifurcation it was 97%. The results show that the falsely diagnosed nodes were located mainly cranial to the carotid bifurcation. However, the sensitivity for the entire neck was still excellent (Fig. 4). Pearson’s correlation coefficient was \( r = 0.98 \) \((P < 0.001)\) for the entire neck in 49 patients (Fig. 5). For the determination of

<table>
<thead>
<tr>
<th>CT</th>
<th>EFOV-US</th>
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<tr>
<td>Caudal to carotid bifurcation</td>
<td>79</td>
</tr>
<tr>
<td>Cranial to carotid bifurcation</td>
<td>166</td>
</tr>
<tr>
<td>Total</td>
<td>245</td>
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</table>

Data represent numbers of lymph nodes.

Table 2: False-Positive and False-Negative Lymph Nodes in Parallel Scanned EFOV-US Sequences

<table>
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<tr>
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<th>False-Positive Nodes</th>
<th>False-Negative Nodes</th>
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</thead>
<tbody>
<tr>
<td>Caudal to carotid bifurcation</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Cranial to carotid bifurcation</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>17</td>
</tr>
</tbody>
</table>

Data represent numbers of lymph nodes.
Figure 2 Squamous cell cancer of the left anterior floor of the mouth in a 49 year old man. A, Misinterpreted false-positive lymph node in a submental EFOV-US scan (arrow). B, Corresponding CT scan revealed primary tumor (arrow).

Figure 3 Bilateral tonsil carcinoma in a 55 year old woman. A, False-positive lymph nodes in EFOV-US scan. B, Corresponding CT scan revealed the tonsil carcinoma (arrow).
the correlation coefficient one patient with malignant lymphoma and multiple nodes was excluded to prevent invalidation of the results (Fig. 6). The correlation coefficient for regions cranial to the carotid bifurcation was \( r = 0.95 \) \((P < 0.001)\) and for regions caudal to the carotid bifurcation \( r = 0.997 \) \((P < 0.001)\).

**DISCUSSION**

In general, our results indicate that parallel scanning EFOV-US sequences (i.e., slice packages) are highly effective and equivalent to CT with respect to the evaluation of lymph node enlargement in patients with head and neck disorders.

For assessment of lymph nodes, sonographic scanning has the advantage that it allows free rotation of the scanning plane; however, it suffers from the limited field-of-view, rendering a direct comparison with other cross-sectional imaging procedures impossible.\(^9\) EFOV-US reconstructs a panoramic image that offers the advantage of topographic orientation.\(^4\)–\(^6\) Hence, parallel scanned sequences of the neck with EFOV-US allow for a manner of documentation similar to that of CT.

Our results indicate that the detection rate of enlarged lymph nodes of the neck by the standardized examination technique of EFOV-US is virtually the same as that obtained by CT. However, in contrast to CT, this method does not reliably recognize lymph nodes that are located in the nuchal region. This limitation is acceptable, since lymph node enlargement limited to this region is extremely rare. Moreover, the use of ultrasonographic technique has the benefits of not using ionizing radiation, being of low cost, and not being very time consuming. The time to complete a sonographic examination in our study was 10 to 15 min. For the examiner, the main difference in comparison to a conventional sonographic examination is the need to concentrate on the neck of the patient and not on the sonographic image. The examination could be improved by the use of a lined gel pad to achieve constant scan distances of parallel sequences.

The data show that the method proves to be significantly more accurate caudal to the carotid bifurcation than cranial to this landmark. Analysis of the misinterpreted lymph nodes revealed that the region of mandibular angle constitutes a pitfall in the detection of enlarged lymph nodes. It is technically very difficult and often impossible to obtain parallel scans of the mandibular angle region with a constant probe angle. Thus, in deep regions the slice distances may exceed 1 cm and lymph nodes might be missed. EFOV-US technology might be improved by obtaining imaging data not only by longitudinal scans but also by the transverse approach. This multi-slice

**Figure 4** Non-Hodgkin lymphoma in a 54 year old man. **A,** Two enlarged submental lymph nodes in an EFOV-US scan. **B,** Corresponding CT scan.

**Figure 5** Correlation of lymph node detection of the entire neck \((x\text{ axis})\) and EFOV-US \((y\text{ axis})\). Significant correlation was found.
technique should incorporate multidirectional scanning options for ultrasonography. Thus, structures in regions that cannot be scanned with a constant probe angle could be analyzed better. Precise assessment of the size of cervical lymph nodes in both longitudinal and transverse directions would be possible.10–14

The results of the EFOV-US slice packages also were influenced by the individual neck anatomy. “Slight” necks are more difficult to scan because of the steplike surface, in contrast to “bulky” necks, in which the transducer can be directed more easily in one and the same movement. So-called adipose tissue “buffers” decrease bone artifacts, and soft tissue structures can be differentiated better. The different EFOV-US artifacts seen in our study (intralaryngeal air, blood vessel pulsation, lateral shadowing) were the same as known from conventional ultrasonography and did not correlate with misinterpreted lymph nodes. In general, the sonographic echotexture is more suitable for demonstrating hypoechoic lymph nodes in a higher image quality than the density-dependent images obtained by CT. In addition, in our and other studies small recurrent nodes of 5 to 10 mm in diameter are difficult to detect on CT scans, but these may be visualized by ultrasonography.10,14

These findings demonstrate that a standardized ultrasonographic examination by parallel scanned sequences of EFOV-US allows for a direct comparison with other cross-sectional modalities used in clinical practice, such as CT and MR imaging. In the future, this method may be widely employed for restaging or monitoring the treatment of patients with head and neck disorders.

REFERENCES