MINI REVIEW

Whole-neck imaging for the screening of metastatic nodes

Takashi Nakamura*, Misa Sumi, Yasuo Kimura, Tadateru Sumi

Department of Radiology and Cancer Biology, Nagasaki University School of Dentistry, 1-7-1 Sakamoto, 852-8588 Nagasaki, Japan

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1. Whole-neck imaging

Staging neck metastasis is a crucial step in managing patients with head and neck squamous cell carcinoma (HNSCC). The presence of lymph node metastasis in the neck in patients with HNSCC is an important prognostic determinant in staging cancers and in planning radiotherapy for the cancer patients.

High-resolution imaging techniques provide information about the changes in nodal architectures that are characteristic of metastatic nodes; for example, nodal necrosis (or focal defect) and obliteration of fat tissue in the hilum were effectively depicted by MR imaging and US [1—5]. However, these high-resolution imaging examinations may be cumbersome and ineffective due to limited examination time. Therefore, image acquisition time is a critical factor not only for high-resolution imaging, but also for a high through-put of the screening examination. Accordingly, a rapid imaging technique would be beneficial for the screening of metastatic nodes in the neck. Additional detailed imaging examinations using MR and ultrasonography could be more efficient after such a screening of the neck. It should also be noted that cost, sensitivity, and hazards of radiation are considered in selecting screening modalities.

2. MR imaging

2.1. Direct coronal fast spin-echo short inversion time inversion-recovery sequence

Fast spin-echo short inversion time inversion-recovery (STIR) is highly sensitive in detecting pathologic changes of lesions [6]. This is because most pathologic tissues are proton rich and have prolonged T1 relaxation and T2 decay times, resulting in high signal intensity on STIR images.

STIR imaging can be applied to whole-body MR imaging that allows imaging of the entire body in a reasonable time.

* Corresponding author. Tel.: +81 95 819 7707; fax: +81 95 819 7711. E-mail address: taku@nagasaki-u.ac.jp (T. Nakamura).
with HNSCC. A more recent study on patients with HNSCC demonstrated that STIR imaging along with the size criteria yielded compromised diagnostic ability with 100% sensitivity and 100% negative predictive value on a neck level basis [10]. However, normal and pathologic lymph nodes show similar high signal intensity. Therefore, the STIR technique cannot be used to differentiate between benign and malignant nodes when the obtained imaged data are interpreted only on the basis of the signal intensity of pathologic lesions. However, if the nodal sizes are also evaluated, the STIR technique could be applicable as a screening technique for metastatic nodes in the neck [10]. In addition, metastatic nodes in patients with HNSCC often exhibit nodal necrosis, which is depicted as very high signals in the nodes; this feature could be used as a pathognomonic indicator for metastatic nodes in patients with HNSCC [1—5].

A major shortcoming of the STIR technique is that background signals from blood vessels are not suppressed. Therefore, coronal STIR imaging with a long TE (for example, 80 ms) would be preferred, because this sequence well delineates the blood vessels in the neck and reduces the background signals, such as those from the muscles, more effectively than a sequence with a shorter TE [10] (Fig. 1A). The coronal STIR technique can detect metastatic nodes as effectively as the axial fat-suppressed T2-weighted imaging. However, the coronal STIR technique has a faster image acquisition time and relative refractoriness to susceptibility artifacts when compared with the fat-suppressed T2-weighted technique; these are advantages of the coronal STIR technique over the fat-suppressed T2-weighted technique as a screening tool for the detection of metastatic nodes in the neck.

2.2. Diffusion-weighted MR imaging with suppressed background signals

Diffusion-weighted imaging with the single-shot STIR-echo-planar technique could be useful as a whole-neck imaging. Takahara et al. have recently introduced STIR-based diffusion-weighted MR imaging with suppressed background signals (DWIBS), where the background body signals from the vessels, muscles, and fat were effectively suppressed by the diffusion-weighted and/or the STIR pulse [11]. Indeed, phase ghosting artifacts on direct coronal STIR images of the neck are frequently observed in the neck.

However, necrotic areas in metastatic nodes in patients with HNSCC often lack signals on DWIBS images (Fig. 1B); these necrotic regions could interfere with the effective detection of metastatic nodes in the neck [10]. The limitations of the DWIBS technique include (1) its susceptible to motion artifacts, particularly at higher magnetic field strengths, such as imaging at 3.0 T, resulting in stripe artifacts discernible on coronal and sagittal MIP images; (2) DWIBS images do not provide accurate anatomical locations of the lesions; and (3) tumor images on DWIBS may be less specific due to T1 and/or T2 shine-through effects [12]. Notwithstanding these shortcomings, the DWIBS technique could be a clinically feasible screening tool for tumor detection and lymph node imaging in the neck.

3. PET

PET is often used as a fusion imaging with CT (PET/CT) to improve the anatomical localization of neck lesions [13] (Fig. 2). PET is also a useful technique for the detection of metastatic nodes in the neck. The superiority of the PET/CT over MR imaging or ultrasonography (US) is still controversial [14—16]. For example, PET may demonstrate increased uptake in non-metastatic nodes of the neck due to reactive B-lymphocyte proliferation in germinal centers of the reactive nodes [17]. It was previously reported that PET provided high sensitivity and negative predictive values (100%), but its specificity and positive predictive value were low (16.7% and 37.5%, respectively) [15]. MR imaging and US were reported to yield much higher specificities and negative predictive values in detecting metastatic nodes of the neck, whereas their sensitivities and positive predictive values were lower than those of PET [5]. The high sensitivity and negative predictive values provided by PET are suitable for surveillance of the neck in patients with HNSCC. However, it should be
noted that extremely high sensitivities and negative predictive values reported by those studies were calculated on the node level basis, and not the node basis. In addition, the image resolution of PET is much lower than those of MR imaging and US. As in the cases of MR imaging and US, the detection of metastatic nodes is dependent on nodal size [18,19]; the incidence of false-positive results was higher for nodes with short-axis diameters less than 10 mm, and the cutoff values using standardized uptake value (SUV) positively correlated with the nodal size.

Management of clinically negative necks (N0) has been controversial issues in HNSCC, and the assessment of the N0 neck by different radiologic techniques has been extensively studied. Therefore, the next question is whether PET could effectively detect metastatic nodes in N0 necks. Schöder et al. demonstrated that true-positive and false-positive nodes exhibited similar SUVs, and that the sensitivity and specificity were 67% and 95%, respectively, on the basis of node level [20]. On the other hand, a follow-up study of 58 N0 patients with HNSCC demonstrated that a combination of CT and Doppler US yielded 87% sensitivity, 100% specificity, and 100% positive and 99% negative predictive values as assessed on the node basis [4]. Therefore, despite a reasonably high overall accuracy, the application of PET to N0 necks may be limited due to its low sensitivity for small metastatic nodes and a high number of false-positive results [21].

4. Multidetector CT

Multidetector CT (MDCT) enables high-resolution (submillimeter) image acquisition of the whole neck within 20 s, thereby allowing isotropic image reconstruction of the neck in arbitrarily chosen planes [22]. A hallmark of metastatic nodes in patients with HNSCC is the presence of nodal

Figure 2 62-Year-old man with cancer in buccal mucosa. (A) Coronal PET image shows high uptake area (SUV = 3.2) in the neck (arrow). (B) Coronal PET/CT fusion image shows metastatic node at level IIA.

Figure 3 82-Year-old man with oropharyngeal cancer. Contrast-enhanced coronal reformatted CT shows 3 metastatic nodes with necrotic foci (arrows) at level IIA.
necrosis [5]. Therefore, effective contrast enhancement is essential for the diagnosis of metastatic nodes in the neck (Fig. 3). A significant problem in the application of MDCT to the neck surveillance for metastatic nodes may be an increase in reconstruction and hundreds of images to review, which would diminish the productivity of a radiologist. To date, no comprehensive studies have yet been performed on whole-neck imaging by MDCT for the screening of metastatic nodes in patients with head and neck cancer. However, a recent study has shown that multiplanar evaluation and conventional 3-mm axial evaluation of head and neck MDCT both allows for accurate tumor staging with regard to tumor size and extent of tumor invasion into the surrounding structures and that no significant difference was found between the 2 methods [23].

A discussion of the imaging techniques for detailed assessment of individual metastatic and non-metastatic nodes is beyond the scope of this review. Instead, we would like to discuss the detection of sentinel lymph nodes (SLNs) in the neck. SLN mapping has become an important tool for neck staging and for minimally invasive surgery in patients with early-stage head and neck cancer [24]. Currently, SLN mapping and biopsy is performed intraoperatively by using splanchnography in combination with blue dye staining to facilitate localization of the SLN. However, this technique is cumbersome and has several limitations, primarily due to its low spatial resolution and the lack of detailed anatomy of the surrounding structures [25].

MDCT lymphography (MDCT-LG) has been applied to visualize the lymphatics in patients with lung or breast cancer [26,27]. This new technique enables the visualization of drainage lymphatic pathways on 3D MDCT-LG images and demonstrates the direct connection between an SLN(s) and peritumor sites of contrast medium injection. For example, the 3D MDCT-LG-guided SLN biopsy technique yielded 92% sensitivity, a 7% false negative rate, and 98% accuracy in patients with breast cancer [27]. Although the 3D MDCT-LG technique has not yet been applied in the detection of SLNs in the neck, it could be a promising technique for screening metastatic nodes in the neck when combined with other imaging techniques such as MR imaging.

5. Fusion imaging of MR and PET

Because of the high tissue contrast by MR imaging, the fusion of MR and PET images may provide better delineation of the lymph node than the fusion of CT and PET images. At present, the inline PET/MR system is still under development. However, a preliminary study showed that in 3 of 46 patients with HNSCC, the MR imaging alone and PET/MR fusion imaging yielded different results; 1 patient with a true-positive neck on MR imaging alone was diagnosed as negative by PET/MR fusion imaging and 2 patients with false-positive necks were diagnosed correctly by the fusion imaging [28]. Further technical innovations are required for establishing PET/MR fusion imaging as a surveillance tool in the necks of patients with HNSCC.

6. Conclusion

Several techniques are available for whole-neck imaging for screening metastatic nodes in patients with HNSCC. Recent advances in imaging techniques and post-imaging processing have enabled effective diagnosis of metastatic nodes in the neck. However, these techniques still have pros and cons. Clinicians should bear the characteristics of each imaging technique in mind and tailor such techniques to the specific needs of individual patients.

References


