Diffusion Imaging in Head & Neck Cancer (Pre & Post-therapeutic)

Robert Hermans, MD, PhD, Department of Radiology, University Hospitals Leuven, Belgium

CT and MRI are well established methods in the initial diagnostic evaluation of head and neck malignancy, and are also widely used for treatment monitoring and follow-up. MRI is the preferred method for imaging certain tumour sites, such as the nasopharynx, skull base and sinonasal cavities. As in other areas of the body, the results obtained with these anatomy-based imaging methods are not always optimal, because of difficulties to identify early disease or small volume lesions, as well as to differentiate tumour from inflammation and/or scar tissue. Also, the characterisation of neck lymph nodes remains a difficult issue with anatomy-based imaging methods.

Although diffusion-weighted MRI (DWI) is already a long time in use for evaluation of brain diseases, its potential utility for evaluating extracranial neoplastic disease is only recently recognized. For staging neck lymph nodes in squamous cell cancer, with DWI, sensitivities and specificities around 90% were reported, better than what is obtainable by CT or conventional MRI [1]. These improved results are possible because of a better identification of very small nodal metastases [2, 3]; a sensitivity of 76% for the detection of subcentimetric neoplastic lymph nodes was reported for DWI, while this was only 7% using conventional MRI sequences [2]. False negative results are possible with DWI in necrotic adenopathies, as these will show a high ADC [2]. Therefore, DWI should not be used as a stand-alone technique, but as a complementary method to standard imaging methods.

In the surgical setting, this additional information provided by DWI may help to determine the required extent of neck dissection, by detecting or excluding contralateral nodal metastases and ipsilateral skip metastases [2]. In the radiotherapeutic setting, this improved nodal characterization may result in a closer conformity of the radiation target volume to the anatomical tumour extent [4], possibly improving tumour control and reducing treatment side effects.

Using DWI, nodal lymphoma can be differentiated from nodal involvement by squamous cell cancer with high accuracy, as the ADC in both diseases is different [5]. Also, undifferentiated nasopharyngeal carcinoma can be distinguished from nasopharyngeal lymphoma by DWI [6].

In recent years, chemoradiotherapy evolved to the primary treatment modality for advanced head and neck cancer. The diagnostic and therapeutic management of the head and neck after radiotherapy is a challenging issue. CT has a relatively high accuracy for detecting recurrent squamous cell cancer after radiotherapy, allowing earlier identification of treatment failure than clinical examination alone [7]. However, false positive and false negative results do occur because of radiation-induced tissue distortions. This problem has not been resolved by conventional MRI-techniques. Eighteen-fluoro-deoxy-glucose Positron Emission Tomography (FDG-PET) can provide complementary information to anatomical imaging modalities, allowing earlier diagnosis of recurrent squamous cell cancer. However, inflammatory changes and the low spatial resolution of this technique limit its diagnostic accuracy in the post-radiotherapy setting [8].

Radiotherapy-induced non-tumoral tissue changes such as edema, inflammation, fibrosis, and necrosis are expected to show low cellularity on histological examination, in contrast with recurrent or persistent tumour. This completely different microstructure will be reflected by a different signal intensity and ADC-value on DWI. Based on ADC-values, DWI allows differentiation of tumoral tissue from post-radiotherapy alterations and tissue necrosis with high accuracy, and this both in early and late tumour recurrences. Sensitivities in the range of 84-93% and specificities in the range of 90-96% were reported [9, 10].

The management of patients with persistent enlarged lymph nodes after radiotherapy is controversial. Neck dissection may reduce the regional failure rate and improve survival. However, many of these neck resection specimens do not contain tumour, exposing the patient to the inherent risks of surgery, with no benefit. While CT has a very high negative predictive value in this setting, the positive predictive value of this technique is low. DWI may help to select patients for a planned neck dissection, by better identifying residual tumoral tissue in lymph nodes after irradiation [9, 11].
Also, studies investigating the role of DWI as a prognostic tool during, and very early after treatment, are ongoing. Preliminary results are encouraging [12] and if confirmed, tailoring treatment according to the very early individual response, as seen on DWI, may become feasible.

FDG-PET is, in general, not recommended for the routine diagnostic work-up of a head and neck neoplasm. However, FDG-PET should be performed in case of a clinically unknown cancer, if CT or MRI fail to reveal the primary tumour. Also, in case of evidence of extranodal tumour spread, or if adenopathies are present low in the neck (both factors increase the risk of metastasis), FDG-PET can be used to search for distant disease. Possibly, DWI may replace FDG-PET as whole-body imaging method for some indications in the future. As for the other applications of DWI, further technical developments and clinical validation are awaited.

References