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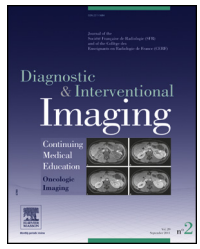

CONTINUING EDUCATION PROGRAM: FOCUS...

Perfusion in ENT imaging

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Abstract Perfusion MRI is an essential part of characterizing salivary gland tumors. The shape of the curves can provide a guide as to the type of lesion: benign (ascending plateau) or malignant (descending plateau), and can also occasionally strongly suggest a histological type such as a Warthin tumor (intense, rapid contrast enhancement with washout > 30%). Perfusion imaging (CT or MRI) for other head and neck tumors is currently being developed and is being assessed. It should be a tool to assist in choosing the most appropriate initial treatment (chemotherapy, radiotherapy or surgery) and should also allow poor responders to conservative treatment to be identified and recurrences to be detected in post-treatment damaged tissues. Aims: (a) to determine when to perform perfusion MRI; (b) to determine the type of perfusion to carry out: CT, T1-weighted MRI; (c) to determine how to position the region of interest to plot the perfusion curve; (d) to know how to interpret MRI curves for salivary gland tumors; (e) to know how to interpret the information obtained from perfusion CT or MRI for the upper aerodigestive tract.
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Perfusion imaging, with CT or MRI, can provide non-invasive access to the microcirculatory features of tissue lesions. The two methods which can be used in ENT imaging are CT perfusion and T1-weighted perfusion MRI.

Clinicians' requirements differ depending on the disease and the related problems in treating them which are raised. Perfusion methods seek to answer these practical patient care problems. They therefore have differing merits, depending on the type and site of the head and neck tumor.

The question faced by the surgeon for a salivary gland tumor is whether to operate or not. The answer to this depends on the type and site of the lesion. We will see that perfusion MRI provides what have become essential answers for the surgeon from the initial diagnostic and pre-treatment assessment.

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The questions which clinicians currently face with upper aerodigestive tract tumors (UADT) are related to the complex nature of the treatments which are available. These include chemotherapy and radiotherapy, and possibly both (conservative treatment) or surgery. Surgery may be carried out first line or as a salvage procedure after conservative treatment has failed. ENT surgery is often mutilating and raises two problems, one functional (voice and swallowing) and the other aesthetic. Organ preservation protocols are therefore becoming more popular and are becoming increasingly complex, in order to avoid initial mutilating surgery. It is essential, therefore, to be able to distinguish those patients who will benefit from conservative treatment from those who need surgery. The following problems arise:

- can we predict which patients will benefit from a conservative radiochemotherapy approach from the initial CT or MRI investigation before any treatment is offered? Also, it is possible to predict which patients who, on the other hand, will not respond and will benefit from surgery from the beginning? Salvage surgery is extremely difficult, particularly after radiotherapy, and carries a high risk of complications and local failure. It is therefore very important to identify, wherever possible from the start, which patients need surgery as, although it is mutilating, initial surgery carries less risk and offers a greater chance of local control of the disease when it is performed first line;
- is it possible to predict the response to conservative treatments (radiotherapy, chemotherapy or a combination of both), in order to determine the optimal treatment on an individual case basis? Do we have information to suggest that a patient will respond well, and what is the patient's likelihood of achieving a complete response after conservative treatment?
- can we objectively quantify and monitor the response to conservative treatments?
- can we detect poor responders to conservative treatment early? In particular, can we detect poor responders to radiotherapy and then stop the radiotherapy, to direct the patient to surgery more quickly?
- can we detect recurrences after treatment early, and distinguish these from inflammatory changes or radiation necrosis?
- can we obtain information which would allow us to optimally assess lymph nodes under a centimeter in size so that the lymph nodes are only removed if they are genuinely diseased?

We shall examine the following issues in succession in this article:

- routine perfusion MRI techniques which are essential for characterizing salivary tumors, in order: to establish when to perform a perfusion sequence, to decide what type of perfusion to perform, how to acquire and analyze the images, how to position the regions of interest and how to plot the perfusion curve in significant areas and be able to interpret the MRI curves to characterize salivary gland tumors;
- techniques which are currently being developed and assessed using CT and MRI for UADT carcinomas, in order: to establish when to carry out a perfusion sequence, to know which technique to use and to be able to interpret functional parameters from perfusion imaging.

Perfusion imaging for salivary gland tumors

General details

MRI has become an essential further investigation for any space-occupying lesion in a salivary gland. Salivary gland tumor pathology is complicated and includes a large variety of lesions.

In decreasing order of frequency, the salivary gland tumors include:

- benign tumors which, do however need to be excised surgically because of the risk of malignant degeneration: this is the case for pleomorphic adenomas;
- benign tumors which usually do not need any surgery: this is the case for Warthin tumors which are not treated surgically provided that formal evidence of the tumor is obtained by fine needle aspiration and MRI. They are then only treated surgically for aesthetic or comfort reasons;
- low-, intermediate- or high-grade malignant tumors which always require surgical excision: muco-epidermoid squamous cell carcinomas, cystic adenoid carcinomas, adenocarcinomas, squamous cell carcinomas, and undifferentiated carcinomas;
- malignant tumors which require systemic therapy: lymphomas;
- rare benign tumors which do not require surgery: branchial cysts, HIV lympho-epithelial cysts, oncocytomas, hemolymphangiomas and lipomas.

The first question the surgeon needs to answer is therefore whether or not he/she needs to operate. One of the merits of MRI and fine needle aspiration is that they have allowed us to avoid always resorting to surgery to establish the type of lesion. The second question the surgeon faces is the risk of malignancy. In parotid tumors, surgeons also want to assess the risk to the facial nerve. In this case, the aims of MRI are to determine the exact site of the lesion and to provide information in order to characterize it, to assist the surgeon in his/her decision of whether or not to operate and to help him to warn patients of the increased risk of temporary or permanent postoperative facial paralysis if malignant disease is assumed from MRI findings.

In this situation, perfusion MRI provides essential information for preoperative characterization of salivary gland lesions, provided that it is performed and interpreted rigorously.

Technique and image processing

The aim of MRI investigation of a salivary gland lesion is to determine the site, size, margins and T1- and T2-weighted signal characteristics of the lesion (without fat saturation). It has now been clearly established that diffusion imaging is essential and provides information about the cellularity of the lesion and its malignant potential [1—3]. However, the diagnostic accuracy of diffusion-weighted MRI either alone or combined with conventional T1- and T2-weighted sequences is inadequate [4]. This ''conventional''

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