Research Highlights

Highlights from the latest articles in imaging

Effect of window level on target volume delineation in treatment planning

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Evaluation of: Dalah EZ, Nisbet A, Bradley D: Effect of window level on target volume delineation in treatment planning. *Appl. Radiat. Isot.* (2009) (Epub ahead of print).

The efficiency of radiotherapy in medicine is highly related to the selection and delineation of the target volume to be treated. In fact, the radiotherapist tries to spare as much healthly tissue from radiation while including all the areas with potential micro-dissemination of the tumor. The integration of anatomical and functional information has a significant impact on improving selectivity and delineation of the target volume for certain types of cancer, such as head and neck, non-small-cell lung cancer, cervical and esophageal carcinoma.

In order to determine the volume on conventional 2D imaging, gray scale window and level adjustment are required and the accuracy of images obtained by techniques such as CT, MRI and PET may be influenced by the suitability of window gray scale selection.

This work, using a NEMA body phantom and ProSoma™ 3D simulation software, demonstrated that changes in window level significantly affects all CT, magnetic resonance and PET images. In particular, for CT imaging, the discrepancy is greater for spheres that range from 10 to 17 mm in diameter while a perfect match is obtained for spheres with diameters in the range of 17 to 37 mm. For MRI scans a discrepancy of up to 2 mm is noted for the largest spheres with diameters of 37 mm due to stretching of the luminance level function; conversely, PET images showed a consistent over-estimation, particularly for the larger spheres (28–37 mm), where a difference of up to 4.3 ± 0.05 mm was observed. It is worth noting that PET images were typically highly blurred at the edges, contributing as much as 2–3 mm to the diameter of all spheres larger than 13 mm as a result of the partial volume effect phenomenon.

In general, the manipulation of tool facilities produced discrepancies of up to 2 mm in all imaging modalities, causing considerable problems when they are used to assist in delineating a target for radiotherapy planning.

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New trends in the evaluation and treatment of cervix cancer: the role of FDG-PET

Evaluation of: Magné N, Chargari C, Vicenzi L *et al.*: New trends in the evaluation and treatment of cervix cancer: the role of FDG-PET. *Cancer Treat. Rev.* 34, 671–681 (2008).

Cervical cancer is a significant cause of death and one of the most frequent cancers in women worldwide. Accurate staging and assessment of prognostic factors are highly important both to predict the patient's prognosis and to determine the

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optimal treatment modality. This paper has investigated the place and role of ^{18}F-FDG PET scans in the management of patients with cervix carcinoma, through randomized clinical trials or historical reports on Medline and CancerLit. Recent guidelines and meta-analyses were taken into consideration. ^{18}F-FDG PET/CT, with a sensitivity of 97%, may be useful in the primary morphologic and metabolic evaluation of cervical tumors, but is limited for small lesions owing to its spatial resolution and its inability to detect parametrial disease. Regarding lymph node staging, a limited role was demonstrated in patients with early-stage disease (FIGO < IB1) and should not replace lymphadenectomy for pathological examination of lymph nodes. On the contrary, in patients with more advanced stage diseases (FIGO > IB2), PET/CT might be of interest because extrapelvic spread is frequent (15–30% of patients have involvement of para-aortic lymph nodes). Concerning the prognostic value, the maximal standardized uptake value (SUV_{max}) of FDG seems to reflect tumor aggressiveness and is negatively associated with survival. In particular, a SUV_{max} greater than 3.3 for a lymph node is predictive of poor outcome. PET/CT can also play an important role in customizing radiotherapy planning: it can change the therapeutic approach by modifying radiation fields. In patients with positive pelvic nodes and negative para-aortic lymph nodes, PET/CT might be used for biopsy guidance. For patients with negative pelvic and para-aortic lymph node involvement, PET may avoid unnecessary surgery. For cervical disease with extrapelvic spread, PET can indicate new areas that should be included in the field of treatment.

Ultimately, FDG-PET can provide significant information for the early evaluation of therapeutic response and long-term follow-up of patients with carcinoma of the cervix. In particular, it has been recently recommended that routine FDG-PET/CT should be performed 3 months post-therapy, every 6 months for 3 years, every year for two additional years and then as clinically indicated. However, further data from prospective clinical trials will be required to assess the clinical advantage of this approach.

Impact of PET with ^{18}F-FDG in radiotherapy treatment planning and outcome prediction in patients with cervical carcinoma

Evaluation of: Dolezelová H, Slampa P, Ondrová B *et al.*: The role of PET in the diagnosis and prediction of the treatment response in patients with cervical carcinoma treated with radiotherapy – results of pilot study. *Klin. Onkol.* 21(2), 66–70 (2008).

Carcinoma of the cervix is one of the most frequent malignancies in women. The most important prognostic factors are tumor volume and involvement of lymph nodes. The control of disease in regional lymph nodes can increase overall survival, but CT has low accuracy in assessing nodal involvement. The role of PET in staging and restaging in suspected relapses of cervical malignancies is well known. On the contrary, few works have studied the impact of ^{18}F-FDG PET/CT in radiotherapy treatment planning in patients with locally advanced cervical cancer. The aim of this study was to assess the impact of PET in staging, radiotherapy planning and treatment prediction in 51 patients with cervix carcinoma not eligible for a surgical approach.

Radiotherapy was delivered using results from the CT and PET examination: if the disease involvement on PET was larger than on CT, the volume was increased to this area.

All the patients were treated with a combination of external-beam radiotherapy, delivered in the pelvic area, and intracavitary brachytherapy, with or without concomitant cisplatin chemotherapy. All patients underwent PET/CT and CT scans before and after treatment (3 and 9 months post-treatment). The results showed that in 14 cases (27.45%) the nodal involvement was more extensive according to PET and in five cases (9.8%) nodal involvement was more extensive according to CT. Using PET in treatment planning modified the radiation fields in nine patients (17.4%); one patient died on progression and the remaining are alive with no sign of carcinoma.

PET scans conducted 3 months post-treatment were negative in 35 cases (69%), showed stable disease in three cases (6%), partial regression in three cases (6%) and progression of disease in four cases (8%). There were no false-positive results caused by inflammatory reaction persisting 3 months after radiotherapy, as was confirmed by PET scans conducted 9 months post-treatment. This study showed that PET seems able to predict treatment response earlier than CT examination. The standardized uptake value was not prognostic of the treatment response. The predictive value of PET has not yet been validated.

Molecular PET/CT imaging-guided radiation therapy treatment planning

Evaluation of: Zaidi H, Vees H, Wissmeyer M: Molecular PET/CT imaging-guided radiation therapy treatment planning. *Acad. Radiol.* 16, 1108–1133 (2009).

Ionizing radiation was discovered more than 100 years ago and in the 1980s, the use of CT imaging as a guide to treatment planing enabled target definition to increase from 30 to 70% of patients. CT imaging has enabled treatment planning to progress from using radiographic bony landmarks to determine disease location to a more precise system of using soft tissue to define both the tumor target and the normal organs in 3D. This approach, achieved by using a greater number of incident beams, avoids toxicity to sensitive organs, such as the salivary glands, bowel, bladder and spinal cord.

In the last two decades, radiotherapy has gone through a series of revolutions offering the possibility to produce highly conformal radiation dose distributions by using techniques such as intensity-modulated radiation therapy.

Since metabolic changes generally precede anatomical ones, FDG-PET is a widely used tool in the diagnosis, staging and assessment of tumor response to treatment and radiation therapy planning. Molecular imaging is employed to guide radiation therapy, improving definition of tumor target volumes and relating the absorbed dose information to image-based patient representations. A summary of recent papers has assessed that one of the main consequences of using PET/CT on target volume definition is the reduction in the gross tumor volume in malignancies characterized by an hypermetabolic area noticeably smaller than the anatomic contour. This enables dose constraints for organs at risk, for example the spine, to be respected. Moreover, the presence of FDG-avid lymph nodes suggests that a booster dose is required to sterilize them. Another important finding is that PET/CT could modify the TNM staging, shifting treatment modality from curative to palliative. Besides FDG, many other PET tracers have been introduced during the last few years. The main targets of these compounds are hypoxia, amino acid, cell membrane and fatty acid metabolism and somatostatin receptors. Medical image segmentation remains an unsolved problem and several approaches have been proposed. Currently, manual delineation of target volumes, using different window level settings, is the most common and widely used technique in clinical practice. Unfortunately, this method is highly operator dependent and, in this regard, semi- or fully-automated delineation techniques may improve reproducibility. At present, other challenges are performance validation and respiratory motion.