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EDITORIAL

Image-guided adaptive radiotherapy – integration of biology and technology to improve clinical outcome

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The present issue of Acta Oncologica contains publications from the 6th Acta Oncologica Symposium held in Aarhus, Denmark, on June 5–7, 2008. This symposium was dedicated to image-guided radiotherapy (IGRT). The purpose of the symposium was to evaluate the current knowledge in this field, which shows great promise with regard to improving clinical outcome of cancer treatment.

The concept of an Acta Oncological Symposium was developed nine years ago. The aim was to focus on an issue of emerging importance in oncology, preferably with a multidisciplinary approach. The topics of the five previous symposia have been sentinel lymph node biopsy in breast cancer, prostate cancer, stereotactic body radiotherapy, normal tissue morbidity and breast cancer [1–17].

Image-guided radiotherapy (IGRT) is often used as a term to cover the technological procedures related to on-line planar or volumetric imaging of the patient in treatment position. By hosting this symposium we aimed to extend the IGRT concept to also include biological and functional imaging to include the concept of a response adapted target, also known as image-guided adaptive radiotherapy (IGART) [18]. IGRT and IGART are tightly connected as they both rely on advanced imaging technology [19], and share the same demand for high quality imaging tools for image management, registration, segmentation and analysis [20–23]. In addition, both are prime examples of the individualisation of treatment which has been the main theme in the strive to improve radiotherapy in recent years. Key topics for the symposium, as well as the papers in this special issue, therefore included tumour delineation using CT / MRI / PET functional imaging, biological target volumes, dose painting, image-guided brachytherapy (IGBT), fiducial markers, cone-beam CT and other methods for on-line volumetric imaging, as well as adaptation of dose delivery based on anatomical changes. The organizers of the symposium invited a broad faculty consisting of distiguished international scientists within these research areas. Besides, many abstracts were submitted for the proffered paper sessions. The publications in the present issue of Acta Oncologica are therefore very much a reflection of the current international standard of the field.

The recent years development within radiotherapy in general and IGRT/IGART in particular fits the above Acta Oncologica Symposium criteria very well. Technical developments in radiotherapy with respect to methods for tumor delineation and treatment delivery have already showed promise to improve both tumor coverage and healthy tissue sparing. Regarding delivery, high precision conformal radiotherapy techniques like intensity-modulated radiotherapy (IMRT) as well as stereotactic radiotherapy have enabled target dose escalation with decreased volume of healthy tissue irradiated to high dose levels. However, the consequence of the increasingly conformal dose distributions is a higher sensitivity to changes in the patient between the planning and treatment situation. Setup errors and anatomical changes between and within delivery of each treatment fraction may cause deviations

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between planned and delivered dose distributions which can lead to underdosage of tumor volume and/or overdosage of normal tissue if not properly corrected for. While most setup errors can be avoided by conventional measures like rigid patient immobilisation and portal imaging protocols, the internal soft tissue motion and deformations occurring due to weight loss, tissue shrinkage, breathing motion or deformation of tumor/normal tissues require more sophisticated imaging and adaptive strategies. This may involve development of a new treatment plan on the basis of the new anatomic information. To this end, IGRT offers a possible solution and safety net. The recent advances in treatment-room image-guidance technologies [6,24] have facilitated convenient and frequent imaging of the patient anatomy throughout the treatment course, and thus form a basis for treatment plan adjustments to the shape and position of target and organs at risk on a regular/daily basis. The use of IGBT for locally advanced cervical cancer has already shown the therapeutic potential of using such a response adapted strategy [25]. In IGBT a very high dose is delievered according to repetitive imaging and target definition which take into account the tumour regression obtained by preceeding radiotherapy [25]. Emerging clinical data show a very promising therapeutic profile with very high rates of local control and very low rates of morbidity with this technique.

With integration of biological information – in particular functional imaging – into treatment planning and high precison radiotherapy delivery, IGART represents a groundbreaking merge of technology and biology with a potential to improve clinical outcome. Improvements in anatomical resolution and the biological specifity of various functional imaging techniques like MRI and PET are encouraging, and also the integration into the treatment planning process are rapidly emerging. However, biologically adapted radiotherapy has so far mostly been documented in technical reports and small clinical feasibility studies [26–32]. Obviously, the area is still in its early development and no proper clinical randomized trials exist to identify the indications for when and how to use image-guided adaptive radiotherapy. The present collection of articles describe to a large extent the current standings from which such clinical trials should take their starting point.

A large part of the symposium was devoted to clinical sessions covering tumour sites in the pelvis, thorax, head-and-neck and brain. In the pelvis, marker based (mostly 2-D) IGRT applications to account for geometrical uncertainties are well established for prostate treatment [33–37], while volumetric imaging is findingly its place in the treatment of bladder [38,39], rectal [40] and cervical [41] cancer. Breathing motion is the major challenge for tumour sites in the thorax, requiring imaging and treatment technologies to account for the resulting temporal variations in patient anatomy [42–46]. In the head and neck, the presentations at the meeting covered tumour and normal tissue deformations caused by variations in set-up, weight loss and tumour shrinkage/growth, calling for treatment plan adaptation based on volumetric imaging [47]. An interesting institutional review across tumour sites on the frequency and motivation for plan adapation based on findings from volumetric imaging was presented by the group in Portland, showing that 23% of patients treated according to a CBCT-based IGRT protocol were re-planned at least once during treatment [48]. This will obviously have a profound impact on departmental workload, but hopefully, it will also pay back in terms of improved treatment outcome.

It is our hope that by gathering the key persons in this field at the 6th Acta Oncologica Symposium and collecting the papers in the current issue, new fuel has been added toward creating evidence of the potential clinical benefit from image-guided adaptive radiotherapy.

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