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Small animal image-guided radiotherapy

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This *BJR* special feature focuses on recent developments in the novel research field of image-guided precision irradiation for preclinical studies. It is a follow-up to the first *BJR* special feature on this theme that was published in January 2017. Translational research, from lab to clinic, has recently seen rapid expansion due to (1) availability of realistic models for tumours and normal tissues, and (2) the development of sophisticated image-guided precision irradiation research platforms, for photon and proton beams. The unprecedented capabilities of these platforms, with beam modulation and accurate targeting of structures, combined with various forms of high resolution imaging, offer research opportunities far beyond the conventional radiation cabinet sources that have been used for many decades.

Workers in this young research field recently gathered in Lisbon, Portugal for what was already the 4th in a series of conferences on small animal precision image-guided radiotherapy. The conference ran from 12-14 March 2018, organised by Pedro Vaz and Ana Belchior from the Centro de Ciências e Tecnologias Nucleares –Instituto Superior Técnico / Universidade de Lisboa – C2TN/IST, Portugal, and Frank Verhaegen from Maastro Clinic in the Netherlands. This turned out to be a great meeting place to exchange ideas between the multidisciplinary mix that is needed to make this field a success: researchers and vendors in radiobiology, radiotherapy, radiation physics, translational research, imaging, dose calculation, and even data science. After three earlier editions of the conference, the field is now reaching maturity, with a big influx of young scientists. Alongside the papers published in this feature, there were in total nearly 50 presentations at the conference, of which three were awarded Best Young Speaker awards.

This special feature opens with 3 review papers on various topics including spatially fractionated proton minibeams (Meyer, BJR-D-18-00466), the role of magnetic resonance image guided radiation therapy in neuro-oncological research (Vanhove, BJR-D-18-00713) and an overview of preclinical models of radiation induced lung damage (Butterworth, BJR-D-18-00473). Significant attention went on the first reports of preclinical image-guided preclinical proton irradiations and alongside the review paper (Meyer, BJR-D-18-00466) this feature discusses the use of a compact clinical proton beam with a special aperture system for delivering very small beams preclinically (Almeida, BJR-D-18-00446). Dedicated proton research beams are expensive to justify, therefore the use of existing clinical beams could be beneficial. One would still need a platform to dock to the clinical proton beam, which would also hold the image-guidance equipment, at a cost which is a fraction of the beam facility itself.

Several speakers introduced new advanced tumor models, which is essential for the success of this field: e.g. lung cancer (Buetof BJR-D-18-00539, Sosa Iglesias BJR-D-18-00476). Issues investigated included how to determine the treatment margin in small animals, which can have relatively large breathing motions compared to humans (Vaniqui, BJR-D-18-00445). This study was done with a 4D mathematical phantom that modelled realistic breathing motion. Modern research platforms offer many more degrees of freedom compared to the equipment used in earlier decades. One paper explores the differences in treatment plans when arcs, couch rotations, etc. are used in an orthotopic glioblastoma model (Rutherford, BJR-D-18-00469). The platforms are also ideal for investigating combinations of radiation and other therapeutic agents; a paper investigates mild hyperthermia as a radiosensitiser in prostate cancer (Cohen, BJR-D-18-00759). Accurate dose calculations are an important component of this new field, knowledge of animal tissue composition is therefore essential (Schyns, BJR-D-18-00454).

Technological advances in this field are much needed to optimally benefit from the combination of imaging and radiation technology. Topics covered in this feature are: automatic multi-atlas based organ at risk segmentation (van der Heyden, BJR-D-18-00364), quantifying setup uncertainty (Walb, BJR-D-18-00487), the effect of different image reconstruction techniques on dual-energy CT (Vaniqui, BJR-D-18-00447), the impact on x-ray filter design on dosimetry and radiation quality (Poirier BJR-D-18-00537). An advanced dose painting technique by synchronising the motion of the gantry and the couch, is also introduced (van

Hoof, BJR-D-18-00744). The all-important clinical big-data management systems are also making an introduction in the preclinical world (Persoon, BJR-D-18-00455).

The number of small animal image-guided precision photon irradiators has grown from a handful ten years ago to more than a hundred now, and several institutes have added small proton beams to the research arsenal recently. Small animal imaging techniques are still rapidly evolving, and many realistic models for tumours and normal tissue diseases are becoming available. This, combined with the unbridled enthusiasm of workers, exemplified by those who attended the Lisbon conference, holds great promise for facilitating important clinical discoveries.