CRUK Cambridge Centre MRes rotation project

Rotation Project Title	**Real time habitat tracking in renal cancer**
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Programme	Imaging
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Laboratory Location	Dept of Radiology

Project Outline	**Aims and objectives** Multi-parametric magnetic resonance imaging (mpMRI), including 13C hyperpolarized imaging, can identify habitats representing metabolically and physiologically distinct tumour clusters within the renal carcinoma tumour mass. As part of window-of-opportunity trials in renal cancer (i.e. AZ/CRUK funded WIRE study) we seek to integrate mpMRI with ultrasound (US) to allow real time, precision biopsy of different metabolic and physiologic areas (habitats) within kidney tumours, which has not previously been possible with standard image guided percutaneous biopsy of a kidney mass. **Significance** Developing this technology will provide completely new insights into differential drug effects in different tumour microenvironments and facilitate spatially co-registered longitudinal tracking of these effects in the window of opportunity and neo-adjuvant studies.
Experimental plan	**Patients and Image acquisition** Research imaging will be undertaken prior to biopsy (t1) and pre-nephrectomy (t2) in 20 patients with renal cell carcinoma enrolled into the WIRE study. The MRI examinations will be performed on a 3T whole body MRI system (GE medical systems) using a multi-channel array coil and will include volumetric MRI sequences followed by physiological sequences such as advanced DWI (e.g. IVIM and DKI) and DCE-MRI. **Image Analysis** Regions of interest (ROIs) will be placed on the renal tumour (the entire tumour will be outlined) on volumetric anatomical images by an experienced MRI genitourinary radiologist. Imaging habitats will be identified using k-means clustering of the mpMRI derived f, D and Ktrans voxels. Clustering will be performed independently for each imaging time point. **Habitat-guided image fusion and precision biopsy** Habitat images will be fused with the T2w MRI images. New methods will be developed in order to fuse the resulting composite images in real time with US. This will be done in the US department where CT and MRI fusion capabilities are available. Habitat/cluster guided core biopsies will be performed by an interventional radiologist at baseline. Several strategies will be explored for longitudinal cluster/habitat tracking, including (i) cluster matching using mean parameter distances between t1 and t2; (ii) cluster matching using relative cluster ranking within each time point; and (iii) spatial adaptation using deformable co-registration.

Main Techniques	• Computational medical imaging • Image segmentation and registration • Radiomics/habitat extraction and analysis • Computer vision • Machine learning
Key References	1. Gerlinger M, Rowan AJ, Horswell S, et al. Intratumor Heterogeneity and Branched Evolution Revealed by Multiregion Sequencing. N Engl J Med. Massachusetts Medical Society ; 2012;366(10):883–892. 2. Turajlic S, Xu H, Litchfield K, et al. Tracking Cancer Evolution Reveals Constrained Routes to Metastases: TRACERx Renal. Cell. Elsevier Inc.; 2018;(173):1–14. 3. Sala E, Mema E, Himoto Y, Veeraraghavan H, Brenton JD, Snyder A, Weigelt B, Vargas HA. Unraveling tumor heterogeneity using next generation imaging: radiomics, radiogenomics and habitat imaging. Clin Radiol 2016; 72 (1): 3-10. 4. Carano RA, Ross AL, Ross J et al. Quantification of tumor tissue populations by multispectral analysis. Magn Reson Med 2004;51(3):542-551.