PhD Thesis title: 'Quantification and tumour delineation in PET'

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ABSTRACT:

Positron emission tomography (PET) is a non-invasive functional imaging modality that can provide information about metabolic, physiological and molecular processes in (tumour) tissue. There is an increasing interest in using multimodality imaging devices (e.g. PET/CT) to delineate the gross tumour volume (GTV) for advanced radiotherapy techniques (i.e. intensity-modulated radiation therapy) or to assess metabolic volume for response assessment.

For radiotherapy purposes, accurate tumour delineation is vital in order to generate a highly conformal radiation dose distribution within the target area, thereby sparing surrounding normal tissue and allowing a higher radiation dose to the most active part of the tumour. Various techniques to determine GTV boundaries using PET have been proposed, ranging from manual delineation to (semi-)automatic methods. To reduce the large inter-observer variation associated with manual delineation, (semi-)automatic delineation methods have been proposed. Apart from delineating tumour volume, quantitative measures of the metabolic tumour volume are also important when analysing clinical PET studies. Many methods are used ranging from simplified methods to full kinetic analysis, which is the most quantitative measure of the metabolic rate of glucose (chapter 2). However, full kinetic analysis requires both a dynamic PET scan and an arterial plasma input function, which can be measured directly using an automatic online blood sampling device and/or manual blood samples. A commonly used simplified method is the standardized uptake value (SUV). This method requires only a static PET scan and no plasma input function is needed. Arterial cannulation is less convenient for patients and not always possible in patients undergoing multiple courses of chemotherapy. There are, however, several limitations related to the use of SUV, such as dependency on patient preparation, image reconstruction and image analysis procedures.

In this thesis the validity of metabolic tumour volumes derived using various types of (semi-) automatic tumour delineation methods was investigated. This validation included (1) simulations (chapter 3) and clinical test-retest studies (chapter 4) to assess performance for varying image related parameters, (2) a comparison of the maximum diameters obtained from metabolic tumour volumes with those obtained from pathology (chapter 5), and (3) a comparison of metabolic volumes derived from SUV analysis with those derived from full tracer kinetic analysis (chapter 6).

This thesis showed that performance of several (semi-)automatic tumour delineation methods depends on various imaging characteristics associated with different image reconstruction settings and filtering, contrast/noise levels and spatial resolutions and

tumour characteristics. Fortunately, (semi-)automatic tumour delineation methods that take local signal to background ratio into account provided good results for defining the (metabolically) active part of lung tumours. In addition, these methods showed good agreement with pathology (gold standard), and provided the most consistent results between SUV and Patlak images. Taken together, these results indicate that careful optimization of imaging parameters and delineation methods are needed when using metabolic volume as a response assessment parameter.

References to author publications that relate specifically to the dissertation:

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