Dr Andrew Tootell, University of Salford

Radiation Dose Assessment: Measurement, Estimation and Interpretation

Thesis for the Degree of Doctor of Philosophy

PhD by Published Works

Abstract

New technologies or methods of image acquisition are driven by the need for increased anatomical information to improve diagnostic accuracy or surgical planning. These new technologies are often accompanied with additional radiation dose, yet this can be justified through the consideration of the benefit it brings. Examples include the use of CT colonography instead of double contrast barium enemas, CT urography replacing intravenous urography and, in nuclear medicine imaging the increased use of CT imaging as part of single photon emission tomography and positron emission tomography to correct emission data or localise or characterise identified lesions. Manufacturers are quick to promote their systems as “low-dose” but little independent evaluation of this claim existed. In the context of nuclear medicine, the additional imaging raised questions as to the use of the attenuation correction data specifically. The question of should the cross-sectional images be reviewed for pathology was has been the focus of debate. It was recognised that the quality of these images is poor due to the “low-dose” acquisition.

The research presented in this thesis and portfolio of published work aimed to establish an accurate method of assessing the radiation dose, initially from the CT attenuation correction acquisition, but later in other imaging modalities. In this thesis eight papers are used to illustrate the methods developed in this work, and how they were applied to other fields of medical imaging. Six of these papers were completed as the first author and the remainder as co-author. Initially, the concepts of radiation dose were critically evaluated. Following identification of sub-optimal techniques, steps were taken to improve the accuracy of dose measurement using thermoluminescent dosimeters, digital dosimeters and simulation through software. These techniques have been analysed critically and where appropriate improvements are recommended.

Radiation dose, in particular the associated risk, is a challenging concept to convey to patients and care givers and simply providing a figure of dose does not convey the required information needed to allow consent to be given. Methods by which radiation dose and risk can be interpreted is critiqued with reference to published literature. The thesis concludes with a description of the intellectual contribution illustrating the role played as first author and as a co-author in the works included in the portfolio and a review of impact considering citation metrics and downloads. It was also decided to include citations from within the Diagnostic Imaging Research Programme and PhD theses from The University of Salford to demonstrate how research activities within the portfolio of published works have influenced other methodologies and outputs.