Optimisation of radiation dose and image quality in interventional cardiology

Section 1 – Project Details:

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Rationale:
Interventional cardiology is a growing clinical specialty providing minimally invasive treatments such as stenting for atherosclerosis, ablations for heart arrhythmias and TAVI’s for replacement heart valves, all of which obviate the need for cardiac surgery and lengthen expected life expectancy. The procedures are guided by x-ray imaging and so issues arise with providing enough image quality for a successful outcome with the radiation dose to the patient and staff. Therefore there is a need to investigate methods to optimise this dose/image quality balance and this PhD would address some of those needs. This is a PhD with three distinct aspects to solving the above optimisation problem. These aspects provide a framework of research endeavour within which the student may chart their own research path and explore their own ideas. This allows both a feasible PhD project but also allows the student freedom to flourish as a researcher.

The first aspect is to reduce staff doses [cardiologists are some of the most exposed individuals to occupational radiation exposure and forthcoming legal dose limit reductions will make reducing their doses critical].

The second aspect will be to collect a large dataset on staff and patient radiation doses, using existing dosemeters, along with information on how the procedure was conducted to allow insight into where during a specific procedure type staff and patients receive most of the damaging radiation dose. This level of sub-procedural analysis has never been published before.

The final aspect will be to develop methodologies for and implement observer studies in interventional cardiology to better understand the relationship between equipment configuration and perceived image quality, thus allowing the x-ray imaging equipment to be configured for least dose to achieve maximum therapeutic efficacy.

Aims & Methodology:
Aim 1:
Investigate the benefit of real-time electronic dosemeters in raising staff awareness and thus reducing staff dose

Methodology 1:
NUH has agreed to evaluate electronic radiation dosemeters linked to a database that provide real-time dose information about specific users. This information will be used two-fold; firstly to feedback to cardiologists on a regular basis to assess impact on their longer-term cumulative dose, and secondly, to investigate the possibility of using these dosemeters to replace existing passive dosemeters for legally required monitoring of dose. This will require sound measurements of device sensitivity and drift in a field environment along with robust correlation to the passive dosemeter results to prove to legislators that the system is as good as the current passive dosemeters.

Aim 2:
Investigate the relationship between staff and patient dose with x-ray equipment configuration at the sub-procedure [i.e. at every instance of individual exposures] level.
Methodology 2: Utilising interventional x-ray equipment dose output files, electronic real-time staff dosemeter outputs and Cardiology Information Systems [containing contextual clinical procedural data], it is possible to analyse staff and patient dose irradiation at the single ‘radiation-event’ level. This data will show at which parts of procedures staff and patients receive the majority of radiation dose, thus enabling the effort to optimise to be prioritised and gain the largest effect.

Aim 3: Develop methodologies for and utilise observer studies to compare the clinically perceived image quality between control and intervention arm of any changes made to x-ray configuration.

Methodology 3: Studies of this type are not common and we utilise our existing relationship with the University of Leeds who have developed software to achieve this. When a potential improvement is identified to x-ray equipment configuration, the student will design a clinical trial to ascertain the impact on clinically perceived image quality.

Benefits & Suitability as a PhD Project:

The suitability as a PhD project is as follows:
- The aims are deliverable within a three-year time frame
- There is suitable academic content in the device characterisation, statistical analysis of large datasets and the development of observer study methodology to allow a successful outcome
- The partner supervisor has extensive knowledge in this field and has already supervised two UoN PhD students
- We have the full support of the host clinical department
- We have the support of the x-ray equipment manufacturer to access configurations and work collaboratively to change set-ups
- The doesmeters and clinical procedures are currently in use; no additional equipment or modification of clinical procedures are required
- We have clinical trial experience, especially within a radiation setting
- There are multiple cardiac cath labs meaning we can run a trial across more than 1 installation, aiding the control arm of any clinical trial

The benefits from funding this PhD project are:
- Fostering translational research between the UoN and NUH
- Widening imaging research in Nottingham to other complementary modalities other than those supported by the recent BRC and BEACON awards.
- Growing research capacity in a clinical specialty
- Producing peer-reviewed papers
- Potentially attracting increased inward investment with commercial collaborators
- Fostering links between the clinical and academic scientists within Nottingham
- Creating a PhD graduate who may either pursue a university-based academic or NHS-based clinical science career, able to apply for NIHR scholarships.
Key References:


Section 2 – Training Provision:

The training provided to the student will be as follows;
Medical Physics & Clinical Engineering [MPCE] will train in radiation & imaging science as required – this will be in the form of tutorials and directed reading. We have extensive experience of both national training schemes [we are an accredited training centre] and ‘on-the-job’ training for clinical scientists.

Part of MPCE Radiation Physics Section with access to our seminars, journal club programmes etc

The student will have access to facilities within Radiological Sciences with the the opportunity to network with other post graduate students and access to post-graduate training in statistical methods, research methodologies and thesis writing skills through the University of Nottingham.