


EDITORIAL

Lowering fluoroscopy pulse rates to reduce radiation dose during cardiac procedures

James Crowhurst, BSc (Hons),^{1,2}  & Mark Whitby, PhD³

¹Cardiology Department, The Prince Charles Hospital, Chermside, Queensland, Australia

²University of Queensland, School of Medicine, St Lucia, Queensland, Australia

³Biomedical Technology Services, The Prince Charles Hospital, Chermside, Queensland, Australia

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Radiation dose to patients undergoing cardiac imaging procedures in cardiac catheterisation laboratories (cath labs) can be relatively high, so implementing strategies to reduce dose should be a priority for radiation practitioners and catheter operators when working in this environment. Radiation dose to patients should be kept as low as reasonably achievable (ALARA principle) and during cardiac procedures utilising fluoroscopy, radiation dose parameters including fluoroscopy time, accumulated air kerma (at the reference point, $K_{a,r}$) and air kerma area product ($P_{k,a}$) should be monitored throughout the procedure and recorded in the patient records.¹ The air kerma area product or dose area product (DAP) is an important measure in estimating the radiation dose to the patient, as it is a measure of both the incident air kerma and the area of the patient exposed. In addition, the incident air kerma at a reference point from the radiation source is a useful measure in estimating the peak skin dose. Fluoroscopy time (FT) is less indicative of the radiation exposure as it does not capture information regarding the fluoroscopy pulse rate, the dose per pulse and the number of digital acquisitions although it may give an indication of the complexity of the procedure.

There are many ways in which patient dose can be reduced during cardiac procedures, even before optimising the exposure settings of the equipment. These include; using good beam geometry, maintaining a minimal patient to detector distance and keeping the patient as far away from the X-ray tube as possible. Collimating tightly to the area of interest and not overusing electronic magnification is also important. In addition, the inherent advantage of newer systems allows for far greater functionality to adapt default post processing parameters, helping to find the correct balance between image quality and radiation dose for an individual department/cath lab.

However, one of the easiest ways to reduce dose is to reduce the fluoroscopy pulse rate and/or the digital acquisition frame rate. The advantage of this strategy being that it can be easily adjusted mid-procedure, without interrupting workflow on most modern X-ray systems. Normally, fluoroscopy pulse rates of between 7.5 and 15 pulses per second (PPS) are used for coronary angiography and the choice of pulse rate is dependent on the operator's preference. The publication by Badawy et al.² in *Journal of Medical Radiation Sciences* explores the possibility of using a new image processing protocol and fluoroscopy pulse rates as low as 3 PPS. Their well written retrospective study investigates the impact of reducing the fluoroscopy pulse rate on the total dose area product (DAP) for the procedure. To our knowledge, this is the first study to report pulse rates as low as 3 PPS for coronary angiography. The study reported that a significant reduction in DAP (up to 58%) and $K_{a,r}$ could be achieved by operating as low as 3 PPS, with no significant increase in fluoroscopy time. The authors highlighted the inevitable image quality changes with this approach, such as a reduction in temporal and spatial resolution as well as a degradation of low contrast detectability. However, after a period of adjustment, with appropriate changes made to post processing parameters, such as noise reduction, edge enhancement and temporal filtering, acceptable image quality could be maintained. Though all procedures were successfully completed in the 3 PPS protocol without protocol deviation, only one operator utilised the 3PPS technique. This paper demonstrates that 3 PPS is feasible but future studies of this technique should investigate multiple operators and procedural complication data should be included. This would demonstrate that 3 PPS technique is safe when implemented more widely.

Other studies have also investigated reducing fluoroscopy pulse rates for coronary angiography; Abdelaal et al.³ investigated this in a randomised controlled trial in 2014. The study cohort was 363 patients undergoing coronary angiography, with or without ad-hoc percutaneous coronary intervention (PCI). In their trial, patients were randomised, at a ratio of 1:1 using sealed envelopes to indicate whether their procedure be undertaken at either 15 PPS or 7.5 PPS. All X-ray system parameters other than the pulse rate were the same. During diagnostic coronary angiograms, fluoroscopy time was non-significantly different between the groups but DAP was 26% lower in the 7.5 PPS group and interestingly, operator dose saw a 40% relative reduction in the 7.5 PPS group. These results indicate how lower pulse rates can significantly reduce radiation dose to patients and in addition, to the staff performing the procedure.³ A natural progression of this work is in the optimisation of the digital acquisition (DA) parameters, as DA is used to document the vascular anatomy and is of a higher dose than fluoroscopy. Adjusting DA parameters would potentially contribute to a large reduction in patient and operator dose.

Implications For Staff Radiation Dose

The study by Badawy et al² also has implications for the radiation dose to the staff present, particularly the primary operator, who stands closest to the patient during these procedures. Radiation exposure to staff working in cath labs can be significant. Staff who work in this environment have been reported to be at a higher risk of developing certain pathologies, such as skin lesions, cataracts, depression, orthopaedic problems and thyroid disease in comparison to staff who do not work in cath labs.⁴ Further to these findings, an increase in the risk of skin lesions, hypertension, hypercholesterolemia, cataract and cancer across years of working in cath labs was also reported.⁴ As such, it is important that every effort should be made to reduce radiation exposure during cardiac fluoroscopy procedures. This is especially relevant to those that may spend their entire career working in this environment.

Electrophysiology Procedures

Lowering fluoroscopy pulse rates are also a particularly important dose reduction tool during electrophysiology procedures as electrophysiology procedures perform few digital acquisitions so the majority of the radiation exposure comes from fluoroscopy. In a previous study, a modern X-ray system, with low fluoroscopy pulse rates

and a low dose per pulse was demonstrated to reduce DAP by over 90%, when compared to an older generation system.⁵ That study also tailored the image processing to this low pulse rate and low dose rate protocol. Using a pulse rate of 3 PPS for most electrophysiology procedures has been advocated by the European Heart Rhythm Association (EHRA).⁶

Radiation Safety Implications

The paper by Badawy et al² demonstrates the impact that proactive staff working in the cath lab can have on the radiation exposure of the patient. Using an X-ray system 'straight out of the box' without some form of customisation to the local environment is ill-advised. The team using the equipment, including the treating physician, radiographer, medical physicist and equipment manufacturer should optimise the equipment for procedures depending on usage, which may be different from other sites using the same model. Furthermore, ideally, the X-ray system should be optimised for individual operators, as each will have preferences in terms of image quality (e.g. can tolerate more noise, prefers more edge enhancement).

Fluoroscopy pulse rates, acquisition frame rates and the radiation dose for each pulse can be readily changed on most modern fluoroscopy systems. Further software changes that will enhance the image can also be optimised. In addition, it is important for the team to have multiple options for radiation protocols to suit the needs of the procedure. These protocols should be adjusted during the procedure as required and this should be performed in conjunction with the continuation of good radiation practice, such as optimal beam geometry and adjusting collimation and filtration as necessary. This paper is an excellent example of how exploring imaging options beyond those traditionally used can reduce radiation exposure to low levels, which is of benefit to the care of the patient and the staff working in this environment. Sensible, iterative changes, where minor progressive adjustments are made to the imaging protocol can lead to significant patient and staff radiation dose reductions.

Conflict of Interest

The authors declare no conflict of interest.

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Correspondence

James Crowhurst, Cardiac Investigations Unit, The Prince Charles Hospital, Chermerside, Queensland 4032, Australia.

Tel: +61 7 31395540; Fax: +61 7 31394819;

E-mail: jimcrowhurst@hotmail.com