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COMMENTARY

Radiation protection training for cardiologists in the era of multiple imaging techniques and complex interventions

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ABSTRACT

Cardiologists are among the heaviest medical users of ionising radiation. This usage is growing in proportion to the expanding range of cardiac diagnostic tests and interventional treatments. The primary focus of cardiologists is achieving clear diagnoses as well as technically and clinically successful treatments. That has to be set alongside strong awareness of the properties of ionising radiation and associated safety issues. This article illustrates some of the interplay between contemporary cardiology, radiological techniques, cardiology training and ionising radiation regulations and aims to set context for training and accreditation of cardiologists who use ionising radiation.

COMMENTARY

Cardiologists rely heavily on ionising radiation imaging as a guide to diagnosis, prognosis and treatment. There is growing use of a range of both non-radiation- and radiation-based imaging techniques.¹ In the UK, the Health Protection Agency carries out assessments of population dose from all sources of radiation,² and of the dose and frequency from medical and dental exposures using X-rays.³ Using data from 2005, the Health Protection Agency found that cardiology contributed 9% to the collective dose from X-ray exposure in the UK,³ 0.04 mSv per head. Nuclear medicine as a whole averaged 0.03 mSv per head, with cardiac studies comprising 34% of the dose (0.01 mSv) (period 2003–4).⁴ The situation in the rest of Europe is less clearly illustrated with data, but international comparisons illustrate widely varied effective dose and often poor compliance with best practice in nuclear cardiology.⁵ Thankfully, of the 900 diagnostic radiology notifications published by the Care Quality Commission in its latest report,⁶ only 6 notifications related to cardiology examinations, although lack of awareness and under-reporting are possible. Despite this, it is highly likely that the number of imperfect examinations, where patients have received more than the required exposure for the desired benefit, hugely exceeds the number of reported cases. Although doctors have historically been found to be less aware of radiation doses than they should be,⁷ there is growing awareness among the cardiology community, particularly those who work in catheterisation laboratories, of ionising radiation issues, perhaps enhanced

by some evidence of increased occupational risk of exposure-related cancer in practising cardiologists.⁸ This awareness is highlighted in a very recent editorial comment in the online version of the *Journal of the American College of Cardiology*⁹ and in a welcome position document on “The appropriate and justified use of medical radiation in cardiovascular imaging” from the European Society of Cardiology.¹⁰ On a more general level, careful estimates of the number of cancer cases attributable to diagnostic radiation have been made, one source suggesting that 0.59% of UK cancers in 2010 were caused by diagnostic radiation.¹¹ That awareness does need to translate into a robust culture within the speciality to optimize ionising radiation dose, to limit exposures to occasions when it is absolutely necessary and to ensure protection of patients and staff from associated risks.

It is sometimes difficult to judge from the outside as to when radiation dose is acceptable and when it is excessive. For example, percutaneous coronary intervention for chronically occluded arteries often involves high X-ray doses. To clinicians who believe strongly that chronic occlusion percutaneous coronary intervention is a highly beneficial treatment, it is easier to justify high doses. However, those who question the value of such treatments or doubt the appropriateness of a proportion of them will have a lower tolerance for the X-ray doses used. The final judgment on each case probably has to rest with the cardiologist who carries out the procedure and who presumably believes it strongly justified. It is therefore crucial

that the “as low as reasonably practicable” principle occupies a prominent position in their mindset. There is evidence of that beginning¹² and hopefully it will lead to widespread emphasis on both X-ray and contrast dose minimization techniques in chronic coronary occlusion treatment.

Changes in ways of working need to be taken into account for safe and effective use of ionising radiation. For example, the growing number of cardiac structural interventions such as transcatheter aortic valve intervention, mitral valve procedures and procedures to close the left atrial appendage can be lengthy and require different imaging protocols to those we are used to for pacemaker therapy and coronary intervention. In addition, these procedures often involve a greater number of staff, often including an echocardiographer, cardiac surgeon, surgical assistant, multiple interventional operators and an anaesthetist, as well as the usual presence of radiographer, nurse and cardiac physiologists. Some of these staff may not be used to catheterisation laboratory environments and may be less radiation aware than is ideal. There is therefore a duty to ensure these personnel are adequately informed and protected.

When clinicians use diagnostic imaging, they can be tempted to look at each method in isolation from other investigations a patient may have had or may be scheduled to have. There are many situations where a more rounded understanding of imaging methods can be beneficial. A common example is the patient presenting with acute chest pain who undergoes negative CT pulmonary angiography. Before proceeding to cardiac imaging in such cases, it can be appropriate to review the existing CT images and if necessary seek radiologist expertise to focus particularly on non-pulmonary aspects of the images, such as the extent of coronary calcification, anomalies of coronary origins, obvious problems with proximal parts of each coronary artery, coexistence of a hiatus hernia, the presence of lymph nodes or other tumours and so on. This can help the cardiologist make better judgments about further management and also meets the need to consider cumulative radiation dose to patients over the course of many hospital admissions.

Knowing how to get the most out of a combination of imaging methods requires working knowledge of them all. It has long been standard to teach cardiologists that a patient must not leave the catheterisation laboratory without a complete and detailed angiographic depiction of all aspects of the coronary anatomy. When pursued to its logical conclusion, this approach can result in excessive X-ray dose and contrast agent volume. This leads to an inelegant and “challenging” procedure with high radiation dose at no extra clinical value. Contrast that situation with one where the operator quickly learns that imaging perfection is not going to be

achieved without risks and therefore resorts to other imaging or functional tricks such as intravascular ultrasound, pressure wire testing and review of previous cross-sectional imaging to get to the desired outcome. On other occasions, good knowledge of newer functions of particular imaging systems can reduce unnecessary use of other techniques. For example, an understanding of when to use image settings designed to enhance the deployment profile of a coronary stent can reduce the need to use intravascular ultrasound or intracoronary optical coherence imaging. These things can be addressed only if those who train cardiologists have a subtle understanding of such techniques and issues.

Radiation awareness and protection training for cardiologists has generally focused on specific ionising radiation imaging techniques and systems. We are now in an era of evolving complex interventional techniques and multiple imaging methods, some aimed at anatomical and others at functional imaging, many of which partially overlap in terms of the clinical information they can offer. Modern cardiologists therefore need an increasingly nuanced understanding of not only each imaging method, but also the interplay between them and the impact of each on the need for another. Such an understanding can be difficult to come and will rapidly become outdated with the march of technology.

The British Institute of Radiology, incorporating representation from the Royal College of Physicians Cardiology Specialist Advisory Committee, has formed a working party to provide an e-learning package for cardiologists. The result is a comprehensive syllabus reviewing the principles of ionising radiation and radiation protection, appropriate use of technologies to reduce unnecessary radiation dose, patient and staff safety, contrast agents and alternative imaging modalities. The curriculum is built on the foundations of previous Ionising Radiation (Medical Exposure) Regulations courses and is designed to meet the current needs of practising cardiologists. Although there is a focus on cardiac catheterisation laboratory aspects of ionising radiation, the syllabus has broader context and relevance to other aspects of cardiology. One can envisage a time when this or a similar course might form the basis for a Europe-wide training and accreditation programme for cardiologists, perhaps being interwoven with more general “user training” (as opposed to specialist accreditation) in the full range of cardiovascular imaging techniques as well as radiation protection training itself. In addition, a modified version of the new syllabus might be appropriate for non-medical staff who work in environments such as cardiac catheterisation laboratories. The immediate priority, although, is to develop appropriate awareness of ionising radiation use in cardiology in the UK, specifically based on existing Ionising Radiation (Medical Exposure) Regulations and best practice.

REFERENCES

1. Fonseca R, Otahal P, Wiggins N, Marwick TH. Growth and geographical variation in the use of cardiac imaging in Australia. *Intern Med J* 2015; 45: 1115–27. doi: <http://dx.doi.org/10.1111/imj.12867>
2. Watson SJ, Jones AL, Oatway WB, Hughes JS. Ionising Radiation exposure of the UK population. A 2005 Review. Health Protection Agency—Radiation Protection Division; May 2005. Report No: 001.
3. Hart D, Wall BF, Hillier MC, Shrimpton PC. Frequency and Collective Dose for Medical and Dental X-ray Examinations in the UK, 2008. Health Protection Agency—Centre for Radiation, Chemical

- and Environmental Hazards; December 2010. Report No: 12.
4. Hart D, Wall BF. A Survey of Nuclear Medicine in the UK in 2003/2004. Health Prot Agency—Radiat Prot Department; June 2005. Report No: 3.
 5. Einstein AJ, Pascual TN, Mercuri M, Karthikeyan G, Vitola JV, Mahmarian JJ, et al; INCAPS Investigators Group. Current worldwide nuclear cardiology practices and radiation exposure: results from the 65 country IAEA Nuclear Cardiology Protocols Cross-Sectional Study (INCAPS). *Eur Heart J* 2015; **36**: 1689–96. doi: <http://dx.doi.org/10.1093/eurheartj/ehv117>
 6. IR(ME)R Annual Report 2014. CQC's enforcement of the Ionising Radiations (Medical Exposure) Regulations 2000. Care Qual Comm; 2015.
 7. Correia MJ, Hellies A, Andreassi MG, Ghelarducci B, Picano E. Lack of radiological awareness among physicians working in a tertiary-care cardiological centre. *Int J Cardiol* 2005; **103**: 307–11. doi: <http://dx.doi.org/10.1016/j.ijcard.2004.08.070>
 8. Roguin A, Goldstein J, Bar O. Brain tumours among interventional cardiologists: a cause for alarm? Report of four new cases from two cities and a review of the literature. *Euro-Intervention* 2012; **7**: 1081–6. doi: <http://dx.doi.org/10.4244/EIJV7I9A172>
 9. Radiation Safety for the Interventional Cardiologist—A Practical Approach to Protecting Ourselves From the Dangers of Ionizing Radiation. cited 19 February 2016. Available from: http://www.acc.org/latest-in-cardiology/articles/2015/12/31/10/12/radiation-safety-for-the-interventional-cardiologist?w_nav=TI#sthash.VuDjTkHn.dpuf
 10. Picano E, Vañó E, Rehani MM, Cuocolo A, Mont L, Bodi V, et al. The appropriate and justified use of medical radiation in cardiovascular imaging: a position document of the ESC Associations of Cardiovascular Imaging, Percutaneous Cardiovascular Interventions and Electrophysiology. *Eur Heart J* 2014; **35**: 665–72. doi: <http://dx.doi.org/10.1093/eurheartj/ehv394>
 11. Parkin DM, Darby SC. 12. Cancers in 2010 attributable to ionising radiation exposure in the UK. *Br J Cancer* 2011; **105** (Suppl. 2): S57–65. doi: <http://dx.doi.org/10.1038/bjc.2011.485>
 12. Tran P, Phan H, Shah SR, Latif F, Nguyen T. Radiation safety during interventions of coronary chronic total occlusion. *Curr Cardiol Rev* 2015; **11**: 314–6. doi: <http://dx.doi.org/10.2174/1573403X11666150909112057>