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Dose Optimisation in Cardiac X-ray Imaging

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Introduction

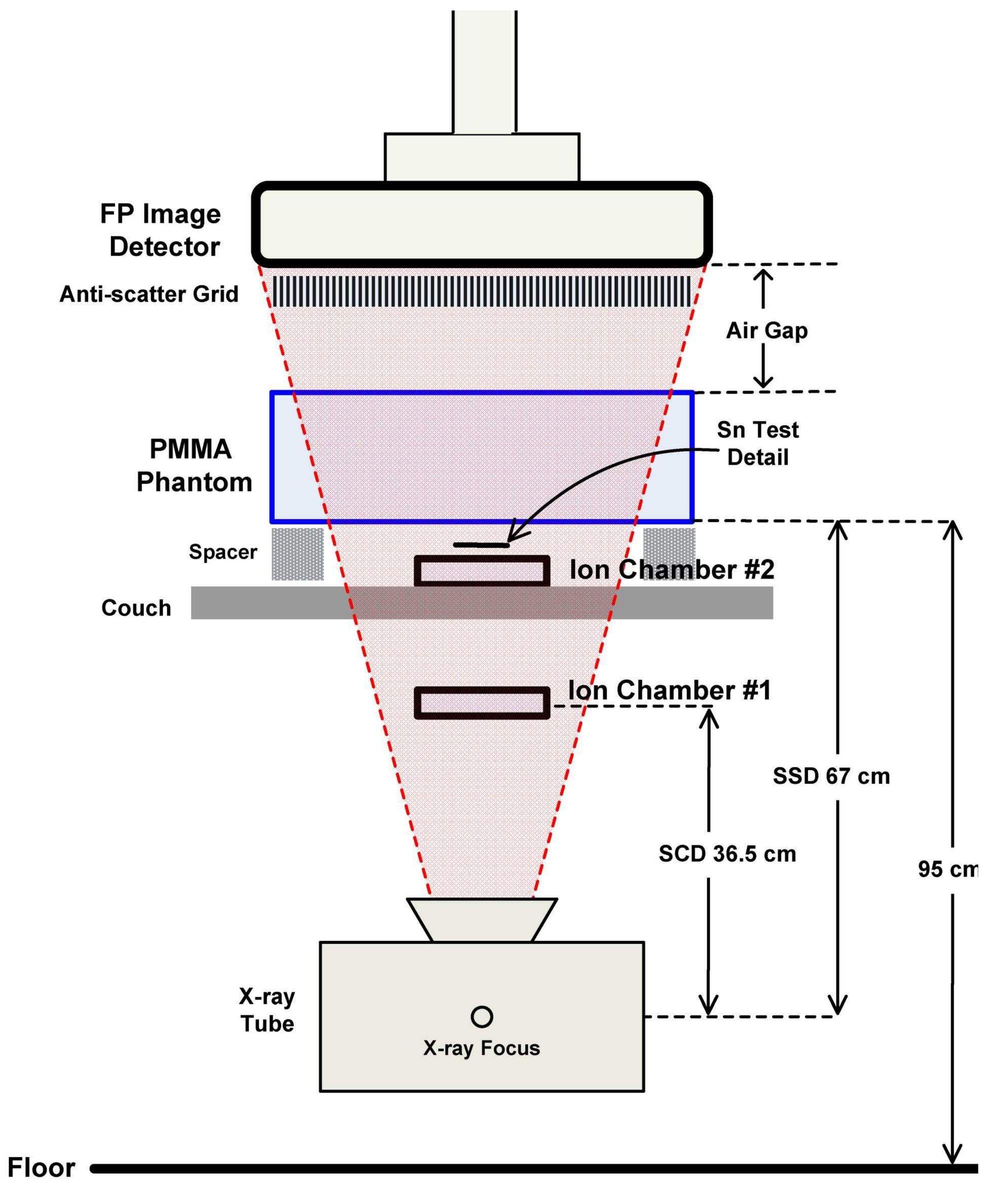
Interventional X-ray systems used for cardiac catheterisation procedures are operated by pre-programmed automatic dose rate control (ADRC)[1]. Radiographic factors are selected based on imaging geometry and estimated patient thickness.

The research aim was to determine optimal X-ray beam energy for cardiac digital image ('cine') acquisition in a system-independent manner (bypassing ADRC), for a range of patient sizes.

Methods

Patients and iodine based contrast medium were simulated using PMMA and tin with PMMA thickness 8.5, 12, 16, 20, and 30 cm representing a range of patient chest thickness in the posterior-anterior (PA) projection [2,3]. X-ray tube voltage (kVp) and Cu X-ray beam filtration were independently varied and raw images were captured on a flat panel detector based cardiac X-ray system.

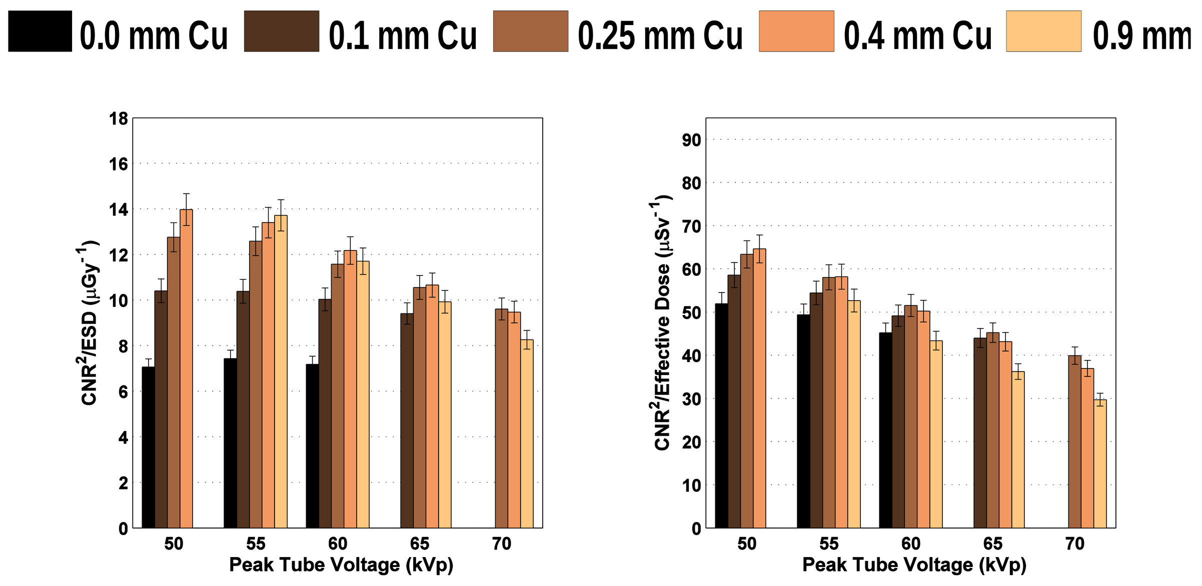
Tin detail contrast was calculated and flat field image noise was measured to determine the contrast to noise ratio (CNR). Entrance surface dose (ESD) and effective dose measurements were obtained to calculate CNR^2 / dose, which determined dose efficiency.



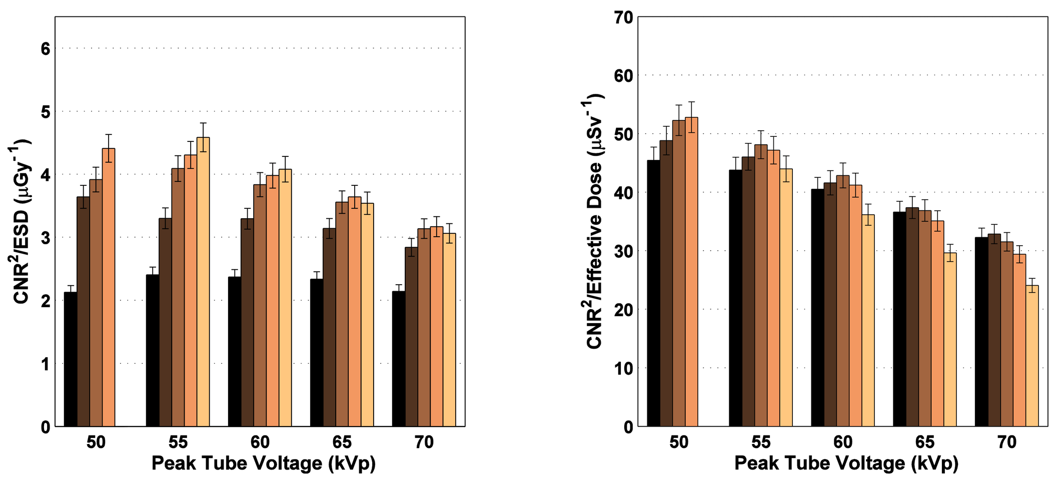
Experimental Set-up

Results

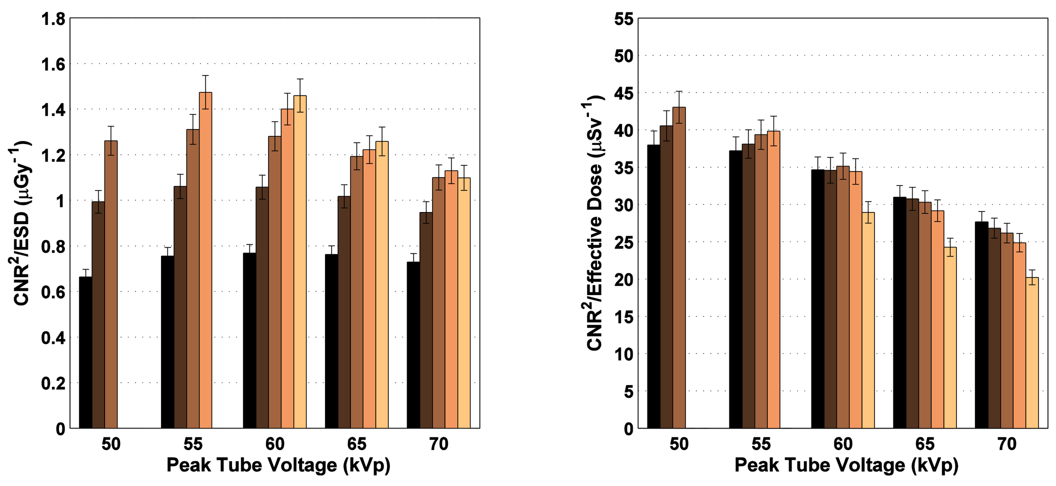
Results are shown below with 5% error; highest bars are most dose efficient. Lower peak tube voltage was favoured, more so for thinner PMMA and as Cu increased.



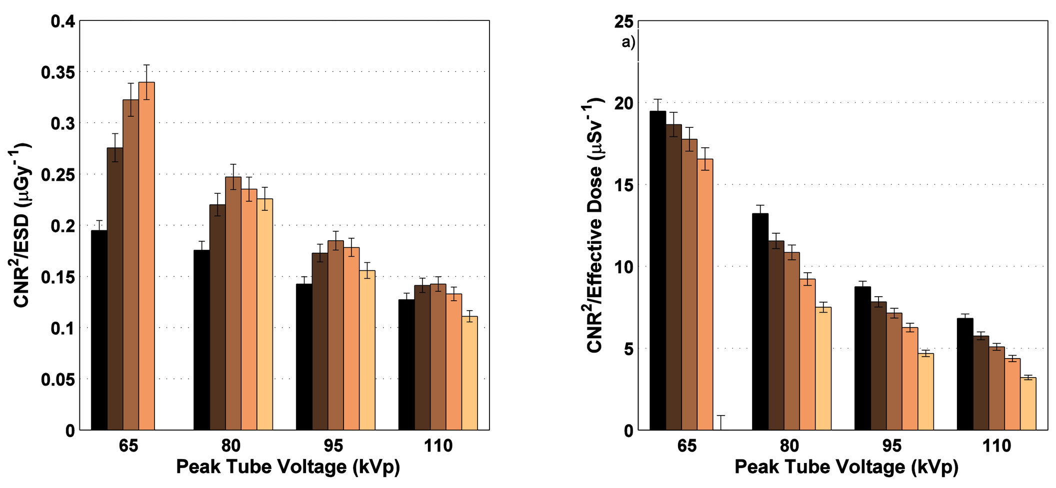
8.5 cm PMMA results, 50-70 kVp, entrance skin (left) and effective (right) dose



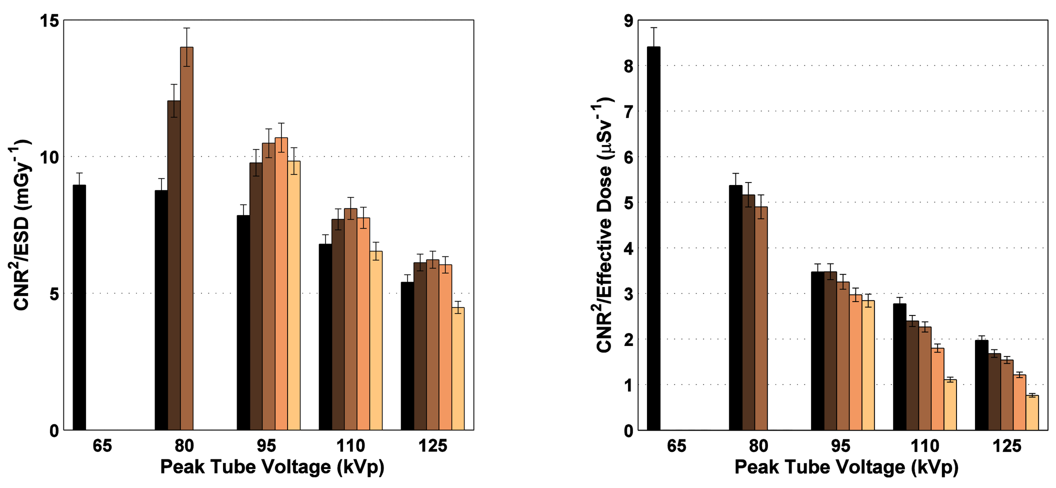
12 cm PMMA results, 50-70 kVp, entrance skin (left) and effective (right) dose



16 cm PMMA results, 50-70 kVp, entrance skin (left) and effective (right) dose



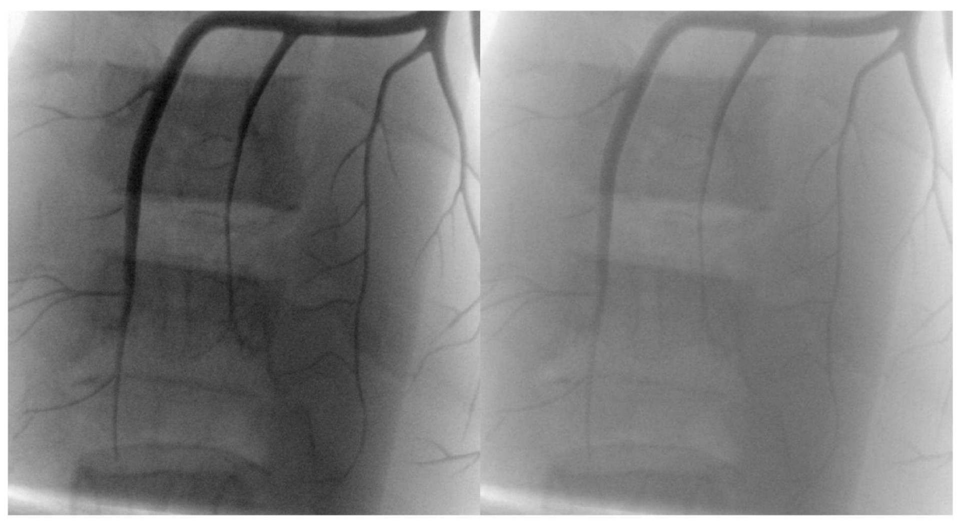
20 cm PMMA results, 65-110 kVp, entrance skin (left) and effective (right) dose



30 cm PMMA results, 65-125 kVp, entrance skin (left) and effective (right) dose

Anthropomorphic Phantom

As a first stage of assessing clinical implications of optimization results[4], two images of an anthropomorphic chest phantom with contrast-filled coronary arteries with the same ESD were compared, the left with 65 kVp, 0.4 mm Cu and right with 110 kVp, 0.9 mm Cu representing high and low adult dose efficiency respectively. Image quality is superior on the left hand side.



65 kVp, 0.4 mm Cu   110 kVp, 0.9 mm Cu

Conclusions

Optimal beam energy is patient thickness dependent; for thinner patients, lower tube voltage with thick Cu beam filtration is optimal whereas for thicker patients Cu filtration should be minimized. These settings can be used with x-ray tube current and/or pulse duration adapted for appropriate clinical image quality and X-ray tube loading limits, for a given task and patient size[5].

Acknowledgements

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References

[1] P.J.P. Lin, P. Rauch, S. Balter, A. Fukuda, A. Goode, G. Hartwell, T. LaFrance, E. Nickoloff, J. Shepard, K. Strauss, "Functionality and Operation of Fluoroscopic Automatic Brightness Control/Automatic Dose Rate Control Logic in Modern Cardiovascular and Interventional Angiography Systems: A Report of AAPM Task Group 125 Radiography/Fluoroscopy Subcommittee, Imaging Physics Committee, Science Council," AAPM REPORT NO. 125, AAPM (2012).
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[4] M. Bath, M. Hakansson, J. Hansson, L.G. Mansson, "A conceptual optimisation strategy for radiography in a digital environment," Rad Prot Dos 114, 230-235 (2005).
[5] A.J. Gislason, C. McMillan, A.G. Davies, A.R. Cowen, "Dose optimization in cardiac x-ray imaging," Med Phys. 2013 (in press).