How much image noise can be added in cardiac X-ray imaging without loss in perceived image quality?

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Rationale

X-ray imaging systems which provide images in real-time are essential for diagnosis and interventional treatment of coronary heart disease. Cardiologists use live, moving images of the coronary arteries called angiograms for diagnosis. X-ray exposure may cause damaging short term effects such as skin burns and long term genetic effects such as cancer. As interventional procedures become longer, more complicated, and more frequent, it is increasingly important to minimize X-ray dose whilst maintaining adequate image quality. Technical image quality measurements including noise are generally used to determine optimal dose levels, and they can be accurately measured using static phantom images, however it is not well understood how changes in these measurements are perceived by a clinician. For example, when treating a patient's heart, a clinician may not notice image degradation caused by reducing the X-ray dose. This study aims to determine how much noise can be added to a patient image without altering the perceived quality of the image. Noise is directly related to radiation dose, therefore results may demonstrate potential for a reduction in radiation dose used for cardiac interventional procedures; this would benefit patients and personnel.

Methods

Image noise was added to five percutaneous coronary interventional (PCI) patient angiograms, selected to represent the range of adult cardiac patient sizes and to include angular cardiac views commonly used in clinical practice. Incremental amounts of computer-generated quantum noise were added to the angiograms – frame by frame, pixel by pixel - to simulate corresponding levels of dose reduction. Ten cardiologists, radiologists and radiographers working in a cardiac catheter lab viewed image pairs, selecting the preferred image in a two alternative forced choice staircase (1 up / 3 down) psychophysics experiment; each pair had the original and a degraded image. After a training period the level of image degradation was varied based on the previous response, to determine the point of subjective equality. The software used was written in MATLAB specifically for this task.

Results

The median point of subjective equality was 33% ± 16% dose reduction for the five PCI patients.

Conclusions

Results demonstrated scope to increase noise of cardiac X-ray images by up to 33% before it is noticeable by clinical professionals, indicating a potential for 33% dose reduction.