Efficiency of a minicourse in radiation reducing techniques: a pilot initiative to encourage less irradiating cardiological interventional techniques (ELICIT)

E Kuon, K Empen, D M Robinson, A Pfahlberg, O Gefeller, J B Dahm


The reported mean dose–area product (DAP) received by patients from coronary angiography and percutaneous coronary intervention (PCI) is high and typically varies too greatly in invasive cardiology—that is, within 16–106 Gy cm² and 34–109 Gy cm², respectively. Skin erythema, chronic radiodermatitis, and musculocutaneous deep injury in conjunction with complex coronary interventions may result.1 2

The International Commission on Radiological Protection points out that, unfortunately, “Many interventionists are not aware of the potential for injury from procedures, their occurrence, or the simple methods for decreasing their incidence utilising dose control strategies”.2 Recently in clinical routine and with no negative diagnostic implications, effective dose reduction techniques enabled mean patient DAPs of 4.2 (1.6) and 6.7 (5.2) Gy cm² for elective coronary angiography and one vessel PCI, respectively.1 3

In realisation of the European Directive 97/43 that “Member States shall ensure that practitioners ... have adequate theoretical and practical training for the purpose of radiological practices”,2 new European guidelines in that field have been established.3 We describe the contents of a training minicourse in less irradiating cardiac interventional techniques and its validation in clinical routine.

METHODS
Before and after the minicourse we analysed the following mean radiation parameters of 10 coronary angiographies, performed by each of the seven participating interventionists at the cardiac centre of Greifswald University, Germany: total DAP, radiographic (DAPR) and fluoroscopic (DAPF) fractions of DAP, the number of radiographic frames and runs, and fluoroscopy time. Bypass graft controls, significant valve disease, emergency catheterisations, and PCI were excluded, since they are inhomogeneous.

We based our oral in-house PowerPoint minicourse in radiation reducing techniques, 90 minutes in length, on the following recommendations1 4:

- Restriction to essential radiographic frames
- Consistent systematic use of the low level fluoroscopy mode
- Training of fluoroscopy saving blind positioning to the region of interest
- Restriction to the ostial region of interest during intubation of coronary arteries
- Preference for projections that rotate out the spine
- Adequate, instead of a best possible, image quality
- Full inspiration during radiography if necessary
- Adequately experienced and well rested interventionists.

Images were obtained with a digital, single arm flat panel system (AXIOM Artis dFC; Siemens AG, Erlangen, Germany). With a focus image detector distance of 1.2 m, a 25 mm thick aluminium absorber, and a 20 cm flat panel detector field format, detector entrance dose rates amounted to 0.029 μGy/pulse (15 pulses/s) for fluoroscopy and to 0.170 μGy/frame for radiographic documentation (15 frames/s). DAP was measured by a light transparent ionisation chamber (K1-S Axiom; PTW, Freiburg, Germany).

We based statistical comparison of radiation dose parameters before and after the minicourse on analysis of variance and covariance models (checked by the Shapiro-Wilks test), which adjusted any mean values for the effect of the interventionist, as well as age, sex, and body mass index of the study patients.

RESULTS
Patients’ mean (SD) overall DAP of all seven interventionists decreased from 30.8 (9.8) to 19.2 (6.8) Gy cm² (p < 0.001) due to a reduction in radiographic DAPR from 21.0 (6.6) to 11.7 (3.2) Gy cm² (p < 0.001). This was a result of slightly shorter radiographic runs but mainly of the efficient application of radiation reducing tube angulations and a significantly better collimation to the region of interest. DAPF/frame decreased from 29.2 (6.9) to 18.4 (4.5) mGy cm² (p < 0.001) and DAPF/s decreased from 42.5 (11.7) to 26.4 (8.3) mGy cm² (p < 0.001). However, the latter attempts took time: fluoroscopy time increased slightly from 245 (82) seconds to 266 (101) seconds, so that the reduction of DAPF missed significance.

For individual interventionists, the reduction of mean total DAPR and DAPR was apparently less influenced by the number of radiographic frames and the fluoroscopy time than by the DAPR/frame and the DAPF/s. Total DAP seems not to depend on the operator’s interventional experience (fig 1).

DISCUSSION
The presented minicourse in radiation reducing techniques, the first validated course to date, promises considerably less patient radiation exposure and consequently occupational operator dose due to coronary angiography in clinical routine. That dose reduction predominantly resulted from consistent collimation to the region of interest during both radiography and fluoroscopy.

In this pilot study, mean DAP before and after the minicourse did not correlate with fluoroscopy time, which increased slightly. Moreover, the fact that DAPF significantly exceeded DAPR raises questions about the widely accepted predominant significance of fluoroscopy time for total patient DAP and the operator’s efforts in reducing radiation.1 2

If DAPF and DAPR are recorded separately, the ratios of DAPR/frame to DAPF/s depends on the flat panel detector.
dose value, which—according to recommended “as low as reasonably achievable” principles—should be reduced to an adequate, instead of best possible, image quality. For constant detector entrance doses, these parameters vary according to the special requirements of tube angulation. That is, as recommended in our course programme, interventionists should avoid the typical caudal left anterior oblique spider view for documentation of the left main stem, in favour of the cranial posteroanterior view for its proximal region and caudal posteroanterior view for its distal bifurcation. Similarly, the posteroanterior cranial 0°/30° view should be preferred over the cranial left anterior oblique 60°/20° view for the bifurcation into the left anterior descending artery and diagonal artery: clinical and experimental measurements documented dose reductions of 33–69% for the patient and in consequence of 60–94% for the operator. For identical projections, moreover, the time adjusted DAP fractions indicate the quality of collimation to the region of interest.

In conclusion, the present study definitively confirms that efforts to reduce patient radiation exposure in clinical routine favour both consistent collimation to the region of interest and less irradiating tube angulations. Regular documentation of DAP$^3$ and DAP$^3K$ and of the number of radiographic frames in addition to fluoroscopy time and total DAP would be well suited to monitor, by self surveillance or by supervisory authorities, each operator’s individual long term efforts towards decreasing radiation exposure.

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