How low can we go? A first study to assess the impact of very low X-Ray dose levels on imaging quality in EP procedures

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Introduction: Fluoroscopy is the basic imaging modality in the EP catheterization laboratory. Since fluoroscopic systems are technically optimized for high-resolution angiography, there may be room for additional dose reduction when these devices are used for EP interventions not requiring detailed resolution. Aim of this study was to determine the minimum X-Ray dose necessary to achieve adequate imaging quality in EP procedures.

Material & Methods: A phantom experiment was carried out involving an Artis zee biplane angiography system (Siemens AG, Forchheim, Germany). The realistic thoracic phantom (Fig.1) was prepared on the patient table, the imaging plane in PA-view penetrated 34 cm water equivalent matter, representing a patient with a BMI of 35. The second imaging plane in the lateral view penetrated 27 cm water equivalent matter, representing a patient with a BMI of 23. Standard EP catheters (decapolar mapping catheter, RF-ablation-catheter, cryo-balloon-catheter) were placed inside the phantom heart. To study the image quality at different dose levels, the detector entrance dose was varied from 6 nGy/pulse to 41 nGy/pulse. For each selected detector entrance dose, the tube voltage was changed from 70 kV to 125 kV. The acquired fluoroscopic images were stored for later multi-observer analysis. Eight EP specialists evaluated the quality of stored images. It was rated as insufficient, if the electrodes of the circular mapping catheter were no longer identifiable, rated as sufficient, if all ten electrodes were visible and rated as good, if the electrodes were readily identifiable. In addition a software algorithm using Gaussian noise was derived from phantom data evaluation in order to simulate very low dose settings on clinical fluoroscopy images. These simulated low dose clinical data were evaluated as well.

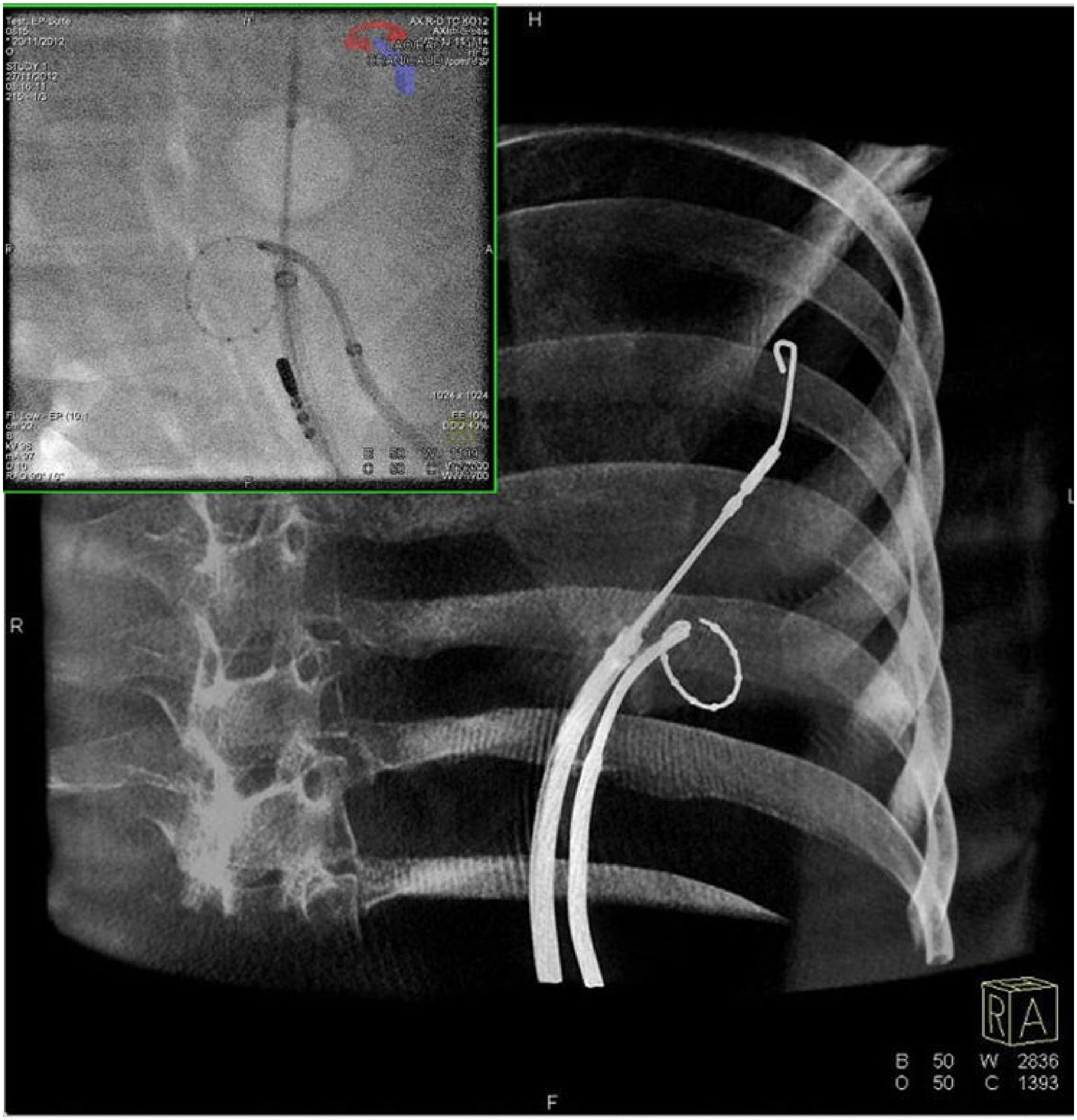

Fig. 1: C-Arm CT of thoracic phantom, RAO view on 3D reconstruction. Decapolar mapping catheter and cryo balloon positioned. The green box shows the lateral fluoroscopic view on the phantom using acquisition settings with 57% lower dose than the currently available lowest clinical imaging protocol.

Results: Fig.2 shows the mean low dose acceptance rate (sufficient or good quality) of different low dose settings. Beyond insights regarding potential X-ray dose savings, our experiment yielded a relationship between detector entrance dose and maximum tube voltage for just-acceptable image quality (Fig.3). Settings below the curve resulted in acceptable image quality. Areas above the curve indicate settings that yielded insufficient image quality. Very low dose settings were simulated on fluoroscopic images of n=20 right-atrial and n=20 PVI procedures. Image quality was still sufficient in right-atrial procedures after X-Ray dose reduction of 74%, resp. 65% in PVI procedures, as compared to the currently available clinical EP low dose protocol.

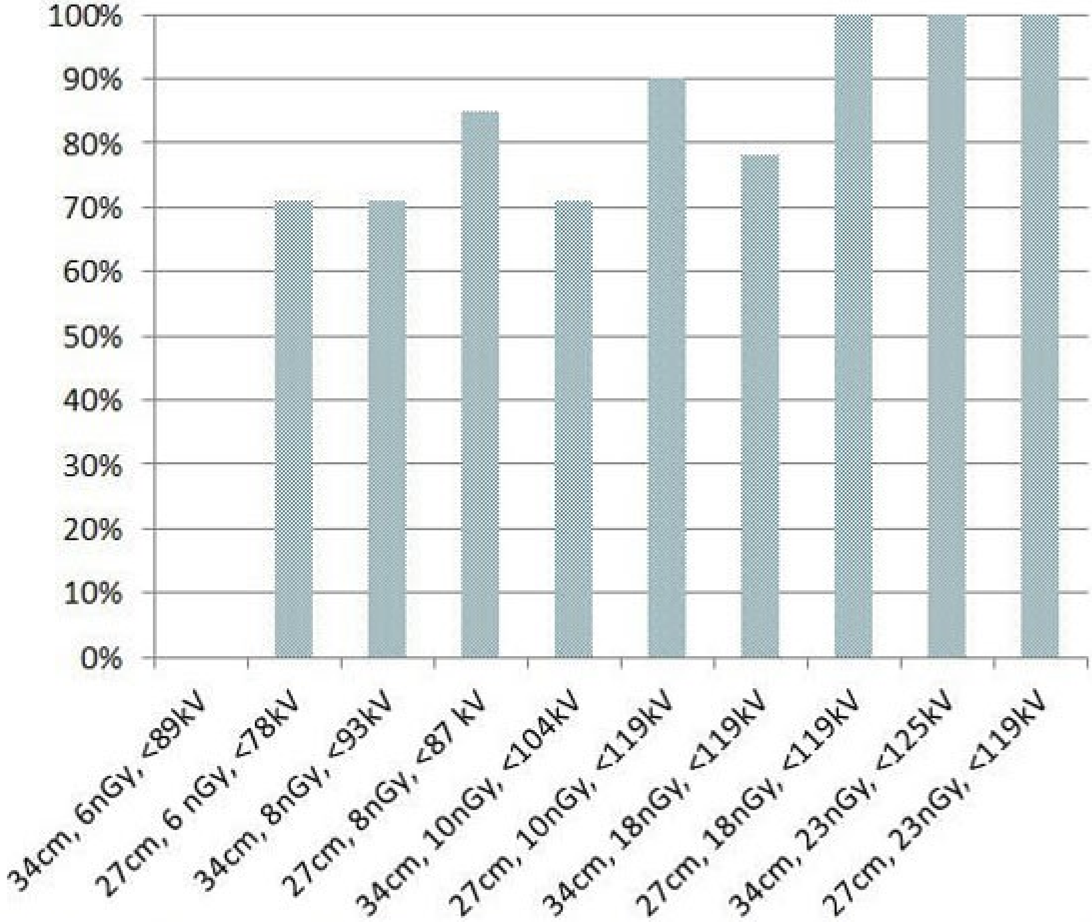

Fig. 2: Acceptance rates of different low dose protocols for obese (34cm) and normal-weight (27cm) patients.

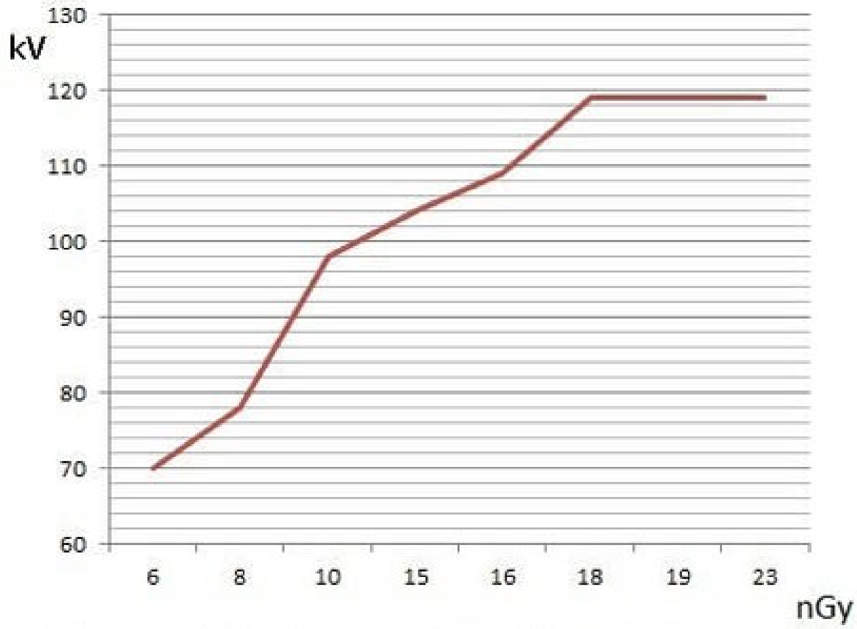

Fig.3: nGy dose and necessary tube voltage for adequate imaging quality in normal-weight patients using special low dose acquisition settings. Areas below the curve are considered acceptable, settings above the curve yielded insufficient image quality.

Conclusions: The lowest available clinical acquisition settings for fluoroscopic EP procedures are operated at 23 nGy/pulse. Our findings suggest that a just-adequate image quality for normal-weight patients can be obtained at dose levels that are up to 74% lower than the current lowest settings. For obese patients, one may be able to save up to 57% of X-ray dose. In general a dose reduction of 74% seems possible for right-atrial procedures (6 nGy/pulse). Optimized EP X-ray acquisition protocols can help to reduce X-Ray dose to the patient and personnel.