

# Optimized Fluoroscopy Setting and Appropriate Project Position Can Reduce X-ray Radiation Doses Rates during Electrophysiology Procedures

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## Abstract

**Background:** Nonfluoroscopic three-dimensional electroanatomical system is widely used nowadays, but X-ray remains indispensable for complex electrophysiology procedures. This study aimed to evaluate the value of optimized parameter setting and different projection position to reduce X-ray radiation dose rates.

**Methods:** From June 2013 to October 2013, 105 consecutive patients who underwent complex ablation were enrolled in the study. After the ablation, the radiation dose rates were measured by two different settings (default setting and optimized setting) with three projection positions (posteroanterior [PA] projection; left anterior oblique [LAO] 30° projection; and LAO 45° projection). The parameter of preset voltage, pulse width, critical voltage, peak voltage, noise reduction, edge enhancement, pulse rate, and dose per frame was modified in the optimized setting.

**Results:** The optimized setting reduced radiation dose rates by 87.5% (1.7 Gy/min vs. 13.6 Gy/min,  $P < 0.001$ ) in PA, 87.3% (2.5 Gy/min vs. 19.7 Gy/min,  $P < 0.001$ ) in LAO 30°, 85.9% (3.1 Gy/min vs. 22.1 Gy/min,  $P < 0.001$ ) in LAO 45°. Increase the angle of projection position will increase the radiation dose rate.

**Conclusions:** We can reduce X-ray radiation dose rates by adjusting the parameter setting of X-ray system. Avoiding oblique projection of large angle is another way to reduce X-ray radiation dose rates.

**Key words:** Ablation; Fluoroscopy; Projection Position; Radiation Dose

## INTRODUCTION

Radiation damage to patients and operators has been paid more and more attention with the development of interventional electrophysiology (EP).<sup>[1-4]</sup> Radiation exposure can only be reduced but cannot be avoided although the use of three-dimensional electroanatomical (EAM) mapping systems.<sup>[5,6]</sup> It is a challenge for the operator to reduce the radiation dose as far as possible.

Reduction in total fluoroscopy time is an effective way to minimize radiation exposure. But the fluoroscopy time depends on the proficiency of the operator and the complexity of the disease. The use of maximal collimation can also reduce the radiation exposure significantly.<sup>[7]</sup> In addition to these, the use of low fluoroscopy pulse rates, short fluoroscopy pulse durations, and soft radiation filtration has been demonstrated to reduce radiation exposure and which in

modern fluoroscopy systems are frequently preprogrammed to low setting for EP procedures.<sup>[8-10]</sup> Even the default low setting provide images more clearly than we need. We can adjust the “default setting” to “optimized setting” and further reduce the radiation exposure. In this study, we aimed to evaluate the value of different parameter setting and projection position to reduce the X-ray radiation dose rates.

## METHODS

### Patients

Patients who underwent “complex” ablation (ablation of atrial fibrillation, atypical atrial flutter, and ventricular tachycardia) from June 2013 to October 2013 were enrolled in the study. The study protocol was presented in detail to the Institutional Review Board (IRB) and was approved by the IRB and Ethics Committee. Informed consent was obtained from participants or surrogates.

The laboratory is equipped with a fluoroscopy system (AXIOM-Artis, Siemens Medical Systems, Erlangen,

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Germany) which uses automatic brightness control to select tube current, kilovoltage, and copper beam filtration. The fluoroscopy time and dose area product (DAP), air kerma (AK) can be displayed directly by the system. The radiation exposure rate (Gy/min) also can be displayed during the fluoroscopy. Default X-ray setting and “optimized” setting are shown in Table 1.

All EP procedures were completed by an experienced electrophysiologist using the optimized setting. After the procedures, fluoroscopy time and DAP, AK were recorded. Then the radiation exposure rates (Gy/min) of both optimized and default setting were recorded in the fluoroscopy system when the patients were projected in three positions (posteroanterior [PA] projection; left anterior oblique [LAO] 30° projection; LAO 45° projection) for about 3–5 s each position.

### Statistical analysis

Continuous data were tested for normality. Continuous data that were normally distributed are reported with a mean ± standard deviation. The significance of differences between two data sets was assessed using paired Student’s *t*-tests. One-way analysis of variance (ANOVA) followed by *post-hoc* testing using Student–Newman–Keuls test was used to analyze the relationship of radiation dose rate with projection position.  $P < 0.05$  was considered statistically significant.

## RESULTS

### Patient characteristics

One hundred and five patients who underwent complex ablations between June 2013 and October 2013 were enrolled in this study. Baseline characteristics are summarized in Table 2. Mean patients age was  $54.7 \pm 11.1$  years and 81% were male. Most of them were suffered from atrial fibrillation (81.9%).

### Radiation data

In the EP procedure, the median fluoroscopy time was 17.4 min, the median DAP was  $219 \mu\text{Gym}^2$ , the median AK was 39 mGy. Compared with some other studies, our studies seems to provide a lower dose of radiation exposure in DAP and AK.<sup>[5,7,8]</sup>

The result for radiation dose rate is shown in Table 3. The optimized setting reduced radiation dose rates by 87.5% (1.7 Gy/min vs. 13.6 Gy/min,  $P < 0.001$ ) in PA projection, 87.3% (2.5 Gy/min vs. 19.7 Gy/min,  $P < 0.001$ ) in LAO 30° projection, 85.9% (3.1 Gy/min vs. 22.1 Gy/min,  $P < 0.001$ ) in LAO 45° projection.

Whether the default or optimized group, there was a significant difference in the radiation dose rates among the three projection positions (all  $P < 0.001$ ). The PA projection provided the least radiation dose rate, and the LAO 45° projection provides the most. The dose rate measured from LAO 30° projection is significantly higher than that from PA projection in default group (19.7 Gy/min vs. 13.6 Gy/min,  $P < 0.05$ ) and optimized group (2.5 Gy/min vs. 2.5 Gy/min,  $P < 0.05$ ). The dose rate measured from LAO 45° projection is also significantly

**Table 1: The X-ray parameter of the default and optimal setting**

Parameter item	Default setting	Optimal setting
Preset voltage (kV)	81	73
Pulse width (ms)	8.0	6.4
Critical voltage (kV)	90	102
Peak voltage (kV)	109	109
Noise reduction	Normal	Smooth
Edge enhancement (%)	10	20
Fluoro type	Pulsed	Pulsed
Pulse rate (P/s)	15	6
Minimum CU-filter (mm)	0.6	0.6
Maximum CU-filter (mm)	0.9	0.9
Dose (nGy/p)	29	6

**Table 2: The baseline characteristics of the patients**

Characteristics ( $n = 105$ )	Results
Age (years)	$54.7 \pm 11.1$
Males, $n$ (%)	85 (81.0)
Weight (kg)	$75.1 \pm 11.3$
Height (cm)	$171.0 \pm 8.1$
Body surface area (m <sup>2</sup> )	$1.85 \pm 0.18$
BMI (kg/m <sup>2</sup> )	$25.6 \pm 2.8$
Diagnosis, $n$ (%)	
PAF	54 (51.4)
PeAF	32 (30.5)
VT	7 (6.7)
AAFL	12 (11.4)

PAF: Paroxysmal atrial fibrillation; PeAF: Persistent Atrial Fibrillation; VT: Ventricular Tachycardia; AAFL: Atypical atrial flutter; BMI: Body mass index.

**Table 3: X-ray radiation dose rate in different projection position and setting**

Items	Default setting (Gy/min)	Optimized setting (Gy/min)	<i>P</i>
AP	$13.6 \pm 5.7$	$1.7 \pm 0.8$	$<0.001$
LAO 30°	$19.7 \pm 6.3$	$2.5 \pm 1.0$	$<0.001$
LAO 45°	$22.1 \pm 6.6$	$3.1 \pm 1.4$	$<0.001$
<i>F</i>	51.26	39.5	
<i>P</i>	$<0.001$	$<0.001$	

LAO: Left anterior oblique; AP: Anterior-posterior.

higher than that from LAO 30° projection in default group (22.7 Gy/min vs. 19.7 Gy/min,  $P < 0.05$ ) and optimized group (3.1 Gy/min vs. 2.5 Gy/min,  $P < 0.05$ ).

## DISCUSSION

Radiofrequency catheter ablation has become the first-line therapy for patients with arrhythmia in the past two decades. The use of fluoroscopy in EP procedures is still indispensable in spite of the development of three-dimensional EAM. The radiation dose of a complex procedure can cause patient potential radiation injury to patients and doctors.<sup>[11,12]</sup> A well-configured automatic exposure control of

the radiographic system is essential to keep the radiation dose as low as reasonably achievable. Modern digital systems are equipped with such control circuits to facilitate the acquisition of well-exposed radiographs.<sup>[13]</sup> In this study, we compare the difference in radiation dose rates of two settings in three projection positions.

Although image quality provided by fluoroscopic systems has steadily improved over time, the highest resolution and best available image quality may not be required for all types of procedure.<sup>[8]</sup> In fact, most of the EP procedures can be completed only by low image quality. There were several studies about the optimization of radiographic parameters in the EP procedures.<sup>[8,10,14,15]</sup> All of them succeed in reducing the radiation dose of procedures, but most of them do not refer or measure the radiation dose rates and merely using anthropomorphic torso phantom. We design a simple and feasible proposal to measure the radiation dose rates in the human body. Obviously the optimized mode which has been modified provides much lower radiation dose rates than the default mode in the same patients. Complex interventional EP procedures which need a long fluoroscopy time, lower radiation dose rates means lower radiation dose and lower damage.

Radiation dose rates vary considerably in different projection position.<sup>[16,17]</sup> The relationship of radiation dose rate with projection position was evaluated by anthropomorphic torso phantom in the past studies. We confirmed that radiation dose rate increase with increasing angle in the projection position, which reminds us that we should try to avoid the large tube angulations in the EP procedures. We did not record the radiation dose rate in right anterior oblique projection because too many extra projection positions may increase the radiation exposure burden on the patients.

### Study limitations

In this study, the X-ray radiation dose was measured by fluoroscopy system, not by dose box worn by the patients. The X-ray radiation dose in this study indirectly reflects the exposure dose of patients. Besides the fluoroscopy system setting and project position, the actual exposure dose of patients is associated with BMI, collimation, and shield. Therefore, the most accurate evidence should be acquired from the dose box worn by patients.

In conclusion, an X-ray system configuration with optimized parameter setting can dramatically reduce radiation dose rates relative to those of the default setting during interventional EP procedures. Decreasing the oblique projection is another way to reduce X-ray radiation dose rates. Under the premise of without increase fluoroscopy time, we should avoid the oblique projection of large angle.

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