Low-Dose Solution -
The Ultimate Low-Dose Imaging Technology

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Following graduation from Saitama Medical University in 1986, Dr. Takahashi joined the Second Department of Internal Medicine, Tokyo Medical and Dental University. From 1996, he undertook two years of additional study at the University of Bordeaux in France, and attained his current position in 2003. Dr. Takahashi was the first physician in Japan to begin Catheter ablation for the treatment of atrial fibrillation. Yokosuka Kyosai Hospital is one of the leading medical institutions for catheter ablation, performing more than 1000 procedures a year.

Reducing Exposure Levels During Treatment of Arrhythmia and Peripheral Vascular Intervention

- Experience in the Use of Spot Fluoroscopy -

Although tremendous progress has recently been achieved in catheterization and treatment using radiation in the field of cardiovascular care, the issue of reducing the exposure dose for patients and healthcare personnel has yet to be resolved. Since atrial fibrillation ablation and lower limb intervention require prolonged surgery times, exposure to patients and operators during fluoroscopy can present a problem. We need to maintain a level of image quality acceptable for treatment while also reducing exposure levels. This case study provides a report about my experience in using a fluoroscopy system developed by Toshiba Medical Systems Corp. while focusing on functions for reducing exposure levels.

Reduction of Fluoroscopy Exposure Levels

The following provides an introduction to two approaches used to reduce exposure levels attributable to fluoroscopy. The first involves reducing the exposure dose during fluoroscopy, and this approach is employed by pulsed fluoroscopy, which is already used widely in the clinical setting, and "SNRF" (Super Noise Reduction Filter) low-dose-setting fluoroscopy developed by Toshiba. The second approach involves reducing the dose area product (irradiated area) by exposing regions of interest (ROI). "Spot Fluoroscopy", which is a function for reducing the exposure area in order to accomplish low doses, has been jointly developed by Yokosuka Kyosai Hospital with Toshiba.

Reduction of Exposure Dose During Fluoroscopy

– Pulsed Fluoroscopy and SNRF

Pulsed fluoroscopy is used as a method for reducing X-rays output from an X-ray tube. Although pulsed fluoroscopy attempts to reduce the exposure dose by using as few pulses as possible, it can only be considered effective to the extent that the procedure will not be affected by residual images or dropped frames. In addition, although exposure can be further reduced by reducing the exposure dose per pulse, increases in noise levels caused by this must not impede adequate visual confirmation of the device. Therefore, SNRF was developed by Toshiba as an image processing concept to solve these problems.

Although the exposure dose can be reduced by increasing tube voltage to enhance X-ray penetration, this results in decreased contrast. The standard setting conventionally used by Toshiba for fluoroscopy consists of a tube voltage of 70 kV and pulse rate of 15 pps. However, SNRF image processing allows the acquisition of fluoroscopic images that do not hinder the procedure even at the ultra-low-dose setting of 80 kV and 5 pps, making it possible to reduce the exposure dose by 78% in comparison with the standard setting. The Toshiba angiography system permits fine setting of the pulse rate to 30, 20, 15, 10, 7.5, 5, 3, 2 or 1 pps, and allows the acquisition of fluoroscopic images that are essentially free of residual images even if the pulse rate is lowered.

In looking at the correlation between fluoroscopy time and incident dose during catheter ablation, the dose can be reduced considerably by combining a reduction in the

pulse rate with SNRF (Fig. 1). Fluoroscopic images with SNRF are far superior to those without SNRF, as they are sharper and there are no afterimages (Fig. 2). Quality is comparable to that of radiographic images.

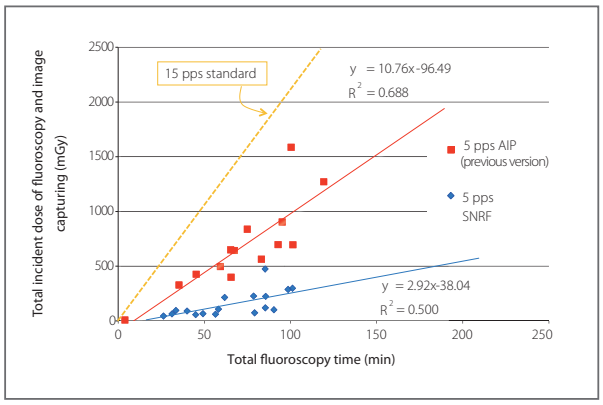

Fig. 1 Effect of Low-Dose Fluoroscopy Mode (Results for Ablation)

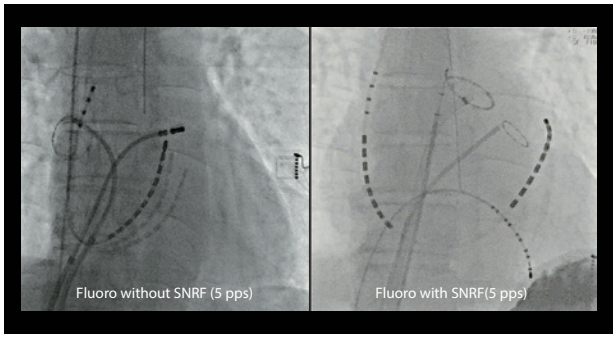

Fig. 2 Comparison of Image Quality for Non-SNRF and SNRF Fluoroscopy

Adequate visual confirmation of the device is possible even when the low-dose fluoroscopy mode offered with SNRF is compared with fluoroscopy without SNRF.

Reduction of Dose Area Product (Irradiated Area) by Limiting Irradiation Range

– Spot Fluoroscopy

X-ray beam collimators have conventionally been used to limit the irradiation range. However, the use of an X-ray beam collimator has various disadvantages, including the area covered by the collimator becoming completely black, which can be disconcerting for the operators; the decrease in X-ray beam size, resulting in an increase in dose due to the system sensing a low level of X-rays; and the need to position the region of interest in the center since the collimator only enables targeting in the left and right and upward and downward directions symmetrically.

Newly developed Spot Fluoroscopy makes it possible to perform fluoroscopy in which only the region of interest is exposed to X-rays, while a static display for the most recent image obtained by fluoroscopy is provided for the area blocked by the collimator (Fig. 3). Switching between full field fluoroscopy and Spot Fluoroscopy is available to the operator at any time (Fig. 4). A region of interest can be simply set by moving the region displayed on the fluoroscopy monitor and adjusting its size using the mouse. Fig. 5 shows an example of a case in which restenosis was observed within a stent during SFA angio-graphy. Since only the area containing the stent needs to be visualized, the use of Spot Fluoroscopy makes it possible to acquire a fluoroscopic image by exposing only the area within the white frame while displaying a static image in the surrounding area. Since the area surrounding a region of interest does not move in the case of, for example, percutaneous transluminal angioplasty (PTA), displaying a static image in the surrounding area does not present a problem, and this is considered to be one of the better applications of Spot Fluoroscopy.

The dose area product and scattered dose were measured during fluoroscopy performed on a piece of acrylic plastic having a thickness of 20 cm in order to confirm the dose reduction effects of Spot Fluoroscopy. Spot Fluoroscopy was confirmed at four exposure field sizes consisting of full, large, medium, and small, and the area ratios were made to be 0.25, 0.11 and 0.0625 for the large, medium, and small sizes, respectively, based on a value of 1 for the full field size. Based on a value of 100% for the dose area product of

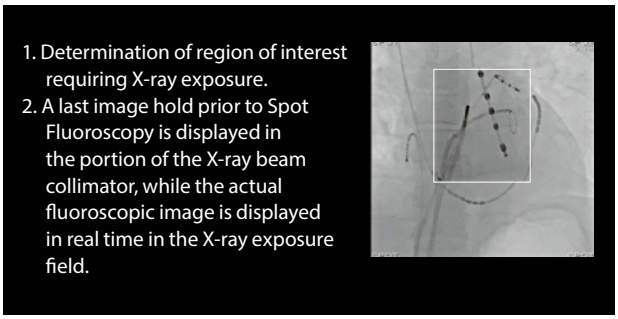

Fig. 3 Procedure of Spot Fluoroscopy

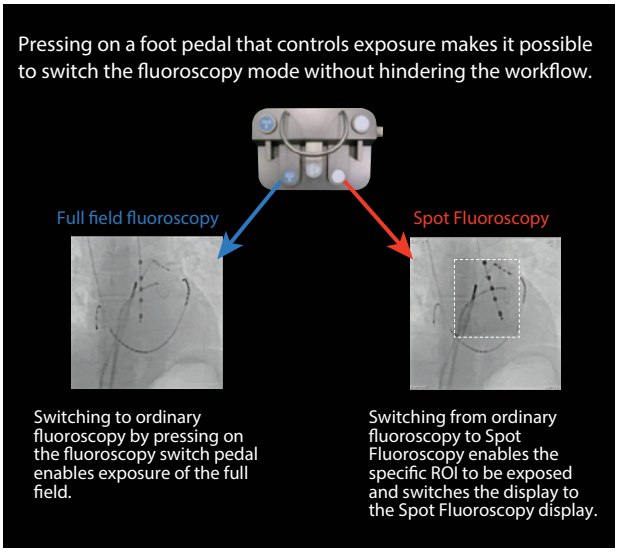

Fig. 4 Overview of Spot Fluoroscopy Procedure

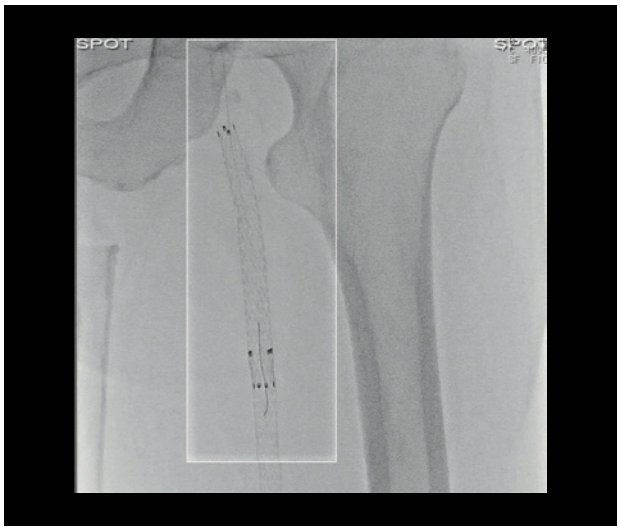

Fig. 5 Spot Fluoroscopy (using 5 pps low-dose mode)

full field, it was possible to reduce the dose area products of the other field sizes to 27%, 15%, and 11%, respectively. Moreover, it was possible to reduce scattered dose, which results in exposure to the operators, to 52%, 34%, and 28%, respectively (as measured at a distance of 50 cm from the X-ray tube and at a height of 150 cm from the floor).

Dose Reduction Effects of Spot Fluoroscopy in Atrial Fibrillation Ablation

We examined the dose reduction effects of Spot Fluoroscopy in atrial fibrillation ablation. The subjects consisted of 41 patients presenting with atrial fibrillation (consisting of 26 cases of paroxysmal atrial fibrillation, 8 cases of persistent atrial fibrillation, and 7 cases of chronic atrial fibrillation). The subjects were divided into a Spot Fluoroscopy group consisting of 10 cases and a non-Spot Fluoroscopy group consisting of 31 cases, and comparisons were made between the two groups for fluoroscopy time and dose area product.

Atrial fibrillation ablation consists of cauterizing the areas surrounding the pulmonary veins in order to suppress extrasystole of the pulmonary veins, which triggers atrial fibrillation. In this study, fluoroscopy time and cumulative dose area product were measured after linearly cauterizing the left pulmonary vein, the right pulmonary vein, and the cavotricuspid isthmus.

As a result, there were no significant differences observed in ablation fluoroscopy times for the left pulmonary vein, right pulmonary vein, or cavotricuspid isthmus between the Spot Fluoroscopy and non-Spot Fluoroscopy groups (Fig. 6). On the other hand, dose area product significantly decreased to 181.4 cGy·cm^2 in the Spot Fluoroscopy group in contrast to 683.3 cGy·cm^2 in the non-Spot Fluoroscopy group during ablation of the left pulmonary vein (Fig. 7). Dose area product also decreased significantly, from 414.6 cGy·cm^2 to 92.15 cGy·cm^2 for the right pulmonary vein, and from 819.7 cGy·cm^2 to 211.2 cGy·cm^2 for the cavotricuspid isthmus. On the basis of these findings, Spot Fluoroscopy is considered to be extremely useful for reducing exposure with respect to atrial fibrillation ablation.

Conclusions

SNRF is a highly advanced fluoroscopy system that enables low-pulse fluoroscopy while also being capable of reducing the size of the X-ray exposure dose per pulse. In addition, newly developed Spot Fluoroscopy is considered to contribute to reducing the exposure area of patients during catheterization and to further reduce radiation exposure levels for healthcare personnel.

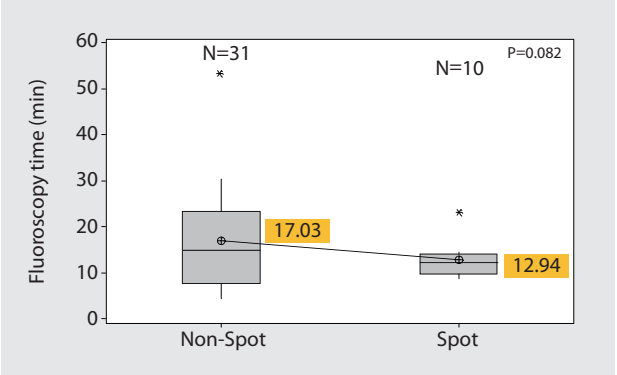

Fig. 6 Comparison of Fluoroscopy Times for Left Pulmonary Vein Ablation

There were no differences in fluoroscopy times between the Spot Fluoroscopy group and the non-Spot Fluoroscopy group.

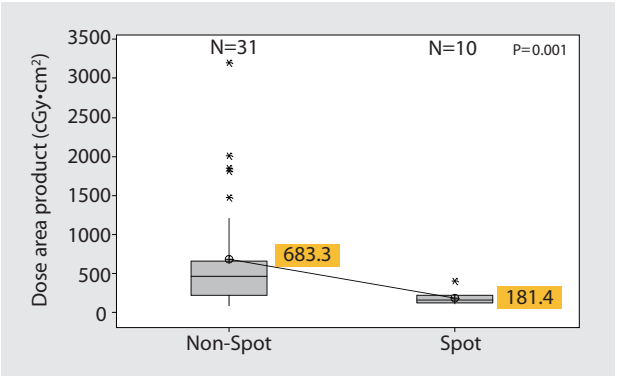

Fig. 7 Comparison of Dose Area Products for Left Pulmonary Vein Ablation

The dose area product was lower in the Spot Fluoroscopy group.

This article presents the highlights of a symposium lecture delivered by Atsushi Takahashi, M.D., at the 76th Annual Medical Meeting of the Japanese Circulation Society (JCS) in March 2012.

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