Vascular

Lower Radiation Doses in IVR Procedures with Trinias
—Benefits of the Latest Image Processing Engine in Arrhythmia Ablation—

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1. Introducing the Hospital

The University of Tokyo Hospital **(Fig. 1)**, located in the Bunkyo Ward of Tokyo, has 1,226 beds (including 48 psychiatric care beds), 7 medical divisions with 38 medical departments, and treats all types of diseases. Every year, the hospital provides medical care to 580,000 outpatients (2,374 per day on average) and 320,000 inpatients (880 per day on average). The hospital also performs around 10,000 surgical procedures each year, the most of any national university hospital in Japan[1].

Fig.1 The University of Tokyo Hospital

The hospital is a designated "advanced treatment hospital," "core hospital for cancer genomic medicine," and "core hospital for clinical research," as well as a "Tokyo disaster base hospital," and provides regional medical care as a "base hospital for coordination of regional cancer care." The University of Tokyo Hospital is also a designated "emergency medical care center," receiving 10,000 emergency patients each year and providing care for acutely ill patients in all fields of medicine.

The angiography section of the Department of Radiology has 6 systems (including a hybrid angiography system in the operating room) and performs around 3,200 cases for diagnostic catheterizations and IVR procedures each year.
In total, the hospital has around 4,000 employees, and all medical staff including physicians, nurses, and radiological technologists coordinate across medical disciplines and are dedicated to providing advanced medical care on a routine basis.
The unchecked spread of COVID-19 from the beginning of 2020 had a major impact on normal medical practice at the hospital, resulting in a significant drop in cases across the board compared to previous years.
A feature of cardiology care at this hospital is that, as a heart transplant facility, the hospital performs more investigations and procedures specifically related to heart failure than other facilities. The hospital also performs diagnostic and IVR procedures for ischemic heart disease, arrhythmia, valvular disease, pulmonary hypertension, and other cardiac disorders.

2. Background to System Acquisition and System Features

In April 2007, the hospital acquired Shimadzu's BRANSIST safire VB9 bi-plane system, which was used for coronary angiography by the Department of Cardiovascular Medicine and for diagnostic and IVR procedures in the head region by the Department of Neurosurgery. The first FPD system acquired by the angiography section of the Department of Radiology was a direct conversion FPD system. This system was used for 12 years and was updated into a Trinias system, which is currently used, in January 2019. This update included the installation of a large format monitor with the capacity for simultaneous signal input/output on up to 27 channels, allowing

Fig.2 Photograph of Main System Unit and Large Format Monitor

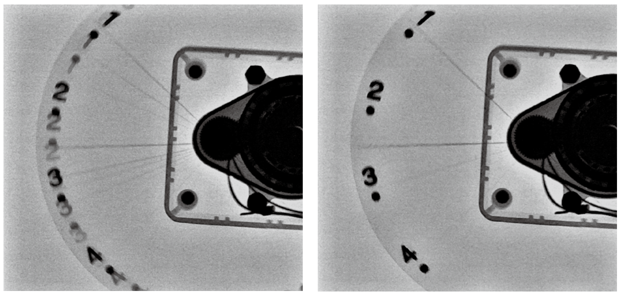
Fig.3 Comparison of RCA Images (Left: Old, Right: New)

each clinical group at the hospital to use a different screen layout on the monitor. Touch panel consoles in the examination room and control room can be used to select and display electronic patient records, PACS images, results from workstation analysis, and other information as required, which aids diagnostic and IVR procedures **(Fig. 2)**.

Another major benefit of updating to the latest Trinias system has been a simultaneous reduction in X-ray doses to patients and improvement in image quality **(Fig. 3)**.

3. Impact of New SCORE PRO Advance X-Ray Image Processing Technology

IVR is now being performed on increasingly difficult cases and operators are employing ever more demanding techniques. Because of this trend, physicians now demand both higher levels of expertise for radiological technologists and improved image quality and lower X-ray doses for the equipment itself. The hospital's Trinias system is equipped with SCORE PRO Advance X-ray image processing technology with state-of-the-art motion tracking noise reduction technology that reduces noise without afterimages due to object movement, an extremely useful feature for IVR procedures **(Fig. 4)**.



(a) Recursive Filter Processing **(b)** SCORE PRO Advance Processing

Fig.4 Example Noise Reduction Processing in Fluoroscopic Image of Rotating Phantom
(Excerpt from Kazuhiro Mori, MEDICAL NOW, No. 76 2014)

4. Hospital Experience with Shimadzu's Angiography System

Our Shimadzu angiography system is 70 % used to perform ablation (ABL) for arrhythmia and 30 % to perform coronary angiography, percutaneous coronary intervention (PCI), and other procedures for ischemic heart disease. More arrhythmia procedures, including cardiac pacemaker implantation procedures, are being performed every year, with around 320 ABL procedures annually and a four-fold increase over the past 10 years. The most common ABL procedure performed at the hospital is pulmonary vein isolation for atrial fibrillation, a procedure that aims to block signal conduction between the pulmonary vein and the left atrium. This procedure can be performed by two main methods: by applying radiofrequency energy with a catheter, or by balloon ablation with a cryoballoon, radiofrequency hot balloon, or laser balloon. ABL procedures are safely performed using intracardiac echography and 3D mapping systems such as CARTO, EnSite, and Rhythmia to construct a 3D view of the cardiac chamber and display sources of arrhythmia, reentry circuits, and the ablation catheter **(Fig. 5)**.

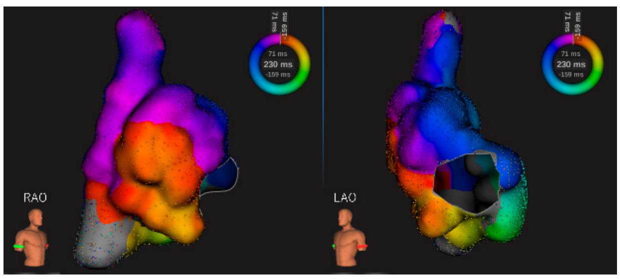


Fig.5 3D Mapping of a Common Type Atrial Flutter

In general, magnetic fields created by these 3D mapping systems cause stripe-shaped noise in fluoroscopy and radiography images, and imaging programs of angiographic system must be modified to reduce this noise, which is unique to each 3D mapping system (CARTO, EnSite, and Rhythmia). However, Trinias is protected physically by magnetic shielding on the sensor sides that reduces image noise to a level acceptable for clinical use. This ability to reduce image noise without special image processing or modifications to the imaging program is a great benefit of Trinias.

Trinias also allows us to download cardiac CT data to the 3D workstation and display roadmap fluoroscopy images on the 3D workstation during procedures, which helps procedures (optional feature).

5. Our Efforts in Reducing X-Ray Doses

Upon acquiring Trinias, imaging protocols were changed through consultation with physicians to match the resulting improvements in image quality. For ABL, the fluoroscopy pulse rate was changed from 3.75 pulse/sec to 3 pulse/sec and the radiography acquisition frame rate was changed from 15 frame/sec to 5 frame/sec.

Fig. 6 shows where our use of Trinias places among fluoroscopic dose rates for pulmonary vein isolation as reported in "Multicenter Survey on Radiation Dose of Cardiac Intervention," published in the Japanese Journal of Radiological Technology (Vol. 76, No. 7, 2020)[2]. The graph shows this hospital uses relatively low fluoroscopic dose rates for pulmonary vein isolation compared to the 98 facilities surveyed throughout Japan.

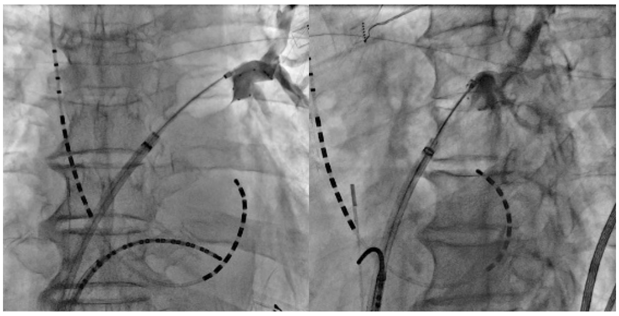


Fig.7 Pulmonary Venogram of Cryoballoon Pulmonary Vein Isolation

The fluoroscopic dose per minute was lowered by around 65 % at the patient entrance reference point (PERP) and the radiography dose was reduced by around 62 %. **Fig. 7** shows a pulmonary venogram acquired with Trinias during pulmonary vein isolation by cryoballoon ablation.

The image is a contrast-enhanced image obtained by manually injecting contrast medium and shows the cryoballoon placed in the upper left pulmonary vein. The contrast of the image is good and contrast medium injected from the catheter lumen has pooled in the pulmonary vein, indicating complete succesful occlusion of the pulmonary vein by the balloon.

Fig. 8 compares fluoroscopic time and air kerma (Ka,r) clinical data from ABL procedures for arrhythmia performed before and after the Trinias update in January 2019. Although fluoroscopic times increased significantly after the update, air kerma (Ka,r) values displayed by the system reduced significantly. The increase in fluoroscopic times may be explained by a change in physicians soon after the update and because the younger physicians were less experienced with the procedure.

We also compared fluoroscopic times and air kerma (Ka,r) values with data from 90 facilities throughout Japan that perform ABL **(Fig. 9)**. The graphs show

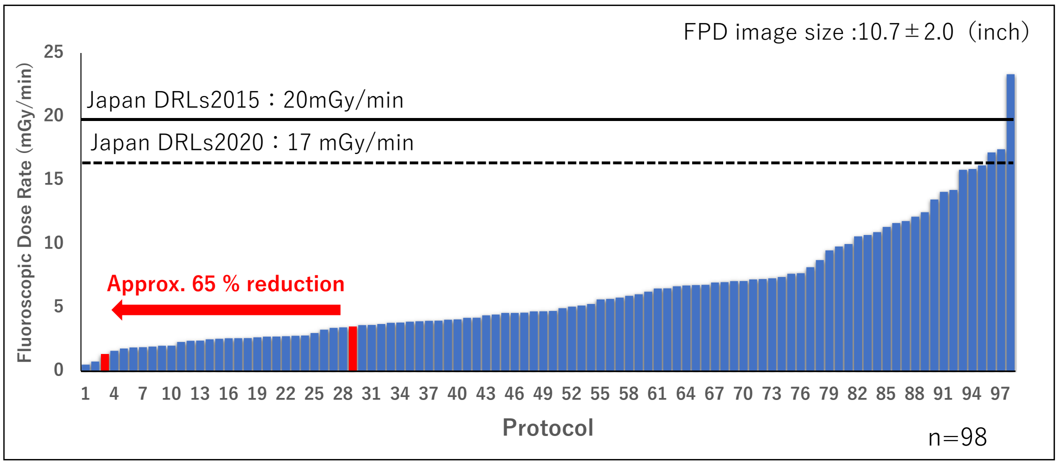


Fig.6 Fluoroscopic Dose Rate for Catheter Ablation

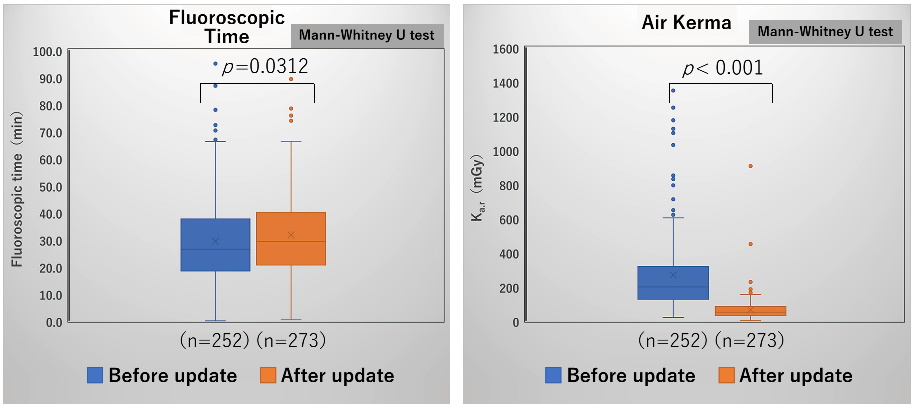


Fig.8 Fluoroscopic Time and Air Kerma (Ka,r) for ABL before and after Update

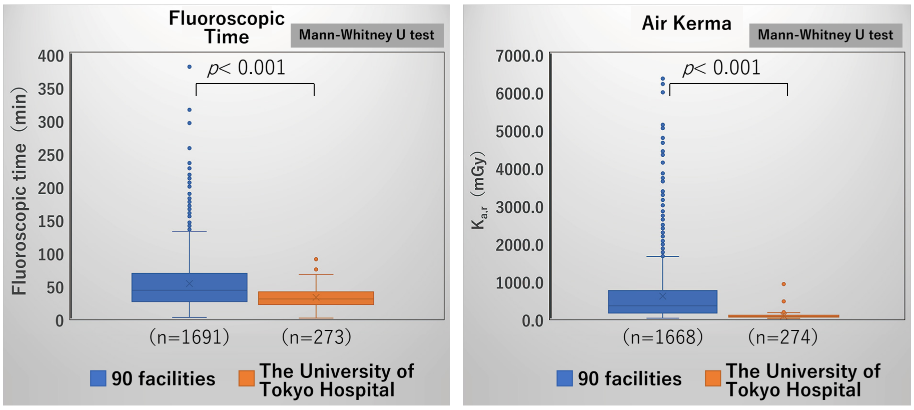


Fig.9 Comparison with 90 Facilities and the University of Tokyo Hospital

that fluoroscopic times and air kerma values displayed by the system are significantly lower at this hospital compared to the 90 facilities. These findings indicate the system update had a meaningful impact in reducing radiation doses for arrhythmia procedures.

6. Conclusion

This article presented our experiences with angiography systems procured by our hospital and used in arrhythmia procedures. In Japan, foreign equipment manufacturers have long dominated this area of medicine, but we believe this article shows the excellent results that can now be obtained with equipment from Japanese manufacturers. Clinical needs will continue to increase, and we look forward to further technological improvements and new developments from Shimadzu.

References

1) The University of Tokyo Hospital, Guidebook 2021–2022, 17-18

2) Hayashi T., Takeda K., Sato H., et al.: Multicenter Survey on Radiation Dose of Cardiac Intervention. Japanese Journal of Radiological Technology, 76(7), 715-724, 2020