Vascular

Improvement of Functions Supporting Neuro-IVR

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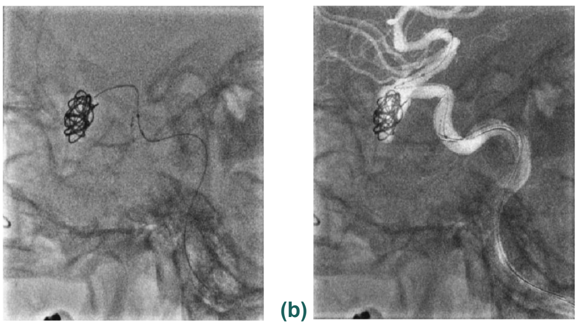
1. Introduction

The use of techniques in which intravascular treatment is performed with the aid of angiography systems (i.e., interventional radiology, hereafter referred to as "IVR") has spread widely, and the relevant technology is advancing at an ever-increasing rate. At the same time, functions that can support the advanced techniques used in treatments are required of angiography systems. We have developed a function for supporting the precise device operations used in IVR procedures performed in the neuroendovascular treatment. Here, I will describe the purpose and operating principle of this function, and present some examples of its use.

2. Current State of Functions Supporting Neuro-IVR

For some time, angiography systems have incorporated a MAP mode as a function for supporting IVR. By superimposing fluoroscopic images and angiographic images obtained by performing radiography after the injection of a contrast medium that absorbs X-rays, this function indicates the positional relationship between blood vessels and devices being manipulated **(Fig. 1)**.



(a) (b)

Fig. 1 Examples of Fluoroscopic Image and MAP Image
(a) Fluoroscopic Image, (b) MAP Image

This function makes it possible for the operator to more accurately grasp the position and state of the devices being manipulated and is an effective support function for procedures.
A function that provides a 3-dimensional sense of the shape of blood vessels using angiography systems has also been developed. This function obtains information from X-ray images taken of the subject from various directions by rotating the C-arm and performs 3D reconstruction to produce a steric display of blood vessel images. Our BRANSIST safire angiography system is equipped with this function. The observation of 3D images facilitates simulations for investigating the direction from which the region of interest should be observed in order to obtain images that are effective for treatment. This function has become indispensable for treatment.

3. Problems with Standard MAP Function

As described in the previous section, the MAP function is an extremely effective tool for intravascular treatments, and there is no doubt that it supports the operator. One problem with this function, however, is that it does not work if the fluoroscopy position and the position used to obtain the mask image (i.e., the other component of the MAP image) do not coincide. This means that MAP mode can be used only if the position of the C-arm acquiring the X-ray image is not changed and images are not enlarged. In the manipulation of devices, it is normal to try to identify locations and image sizes that give greater visibility, and refraining from changing the size or position is out of the question. Normally, DSA is performed frequently in response to a change in size or position in order to create mask images **(Fig. 2)**. This gives rise to the two secondary problems: increased X-ray exposure to the patient and contrast medium consumption and the necessity of interrupting device manipulation.

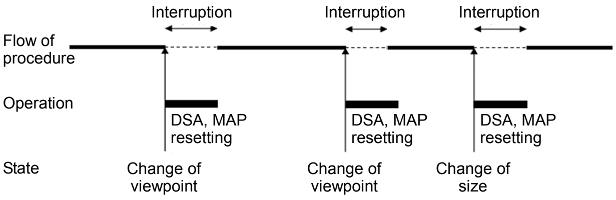


Fig. 2 Example of Flow of IVR Procedure Highlighting Creation of Mask Images

4. Concept of 3D-MAP Function

The 3D-MAP function is based on the idea of solving the problem faced with the standard MAP function by using a 3D image as the mask image. (Hereafter, in order to compare it with the 3D-MAP function, I will refer to the standard MAP function as the "2D-MAP" function.) With a 3D image, changing the viewpoint from which reconstructed images are observed allows the observation of blood vessel images from various angles. Therefore, using a 3D image expressed in accordance with the position and size of the desired fluoroscopic image makes it possible for a single set of image data to replace the multiple mask images that would have been created for each new state in the past.

4.1. Acquisition of Mask Images

It is possible to acquire 3D-MAP mask images using the 3D-Angio function that, for some time, has been provided as an option for BRANSIST safire. In IVR procedures where 3D-MAP is used, 3D-Angio imaging is nearly always performed in order to ascertain the form of the blood vessels. For this reason, there are probably only a very small number of cases in which additional imaging is performed for 3D-MAP **(Fig. 3)**.

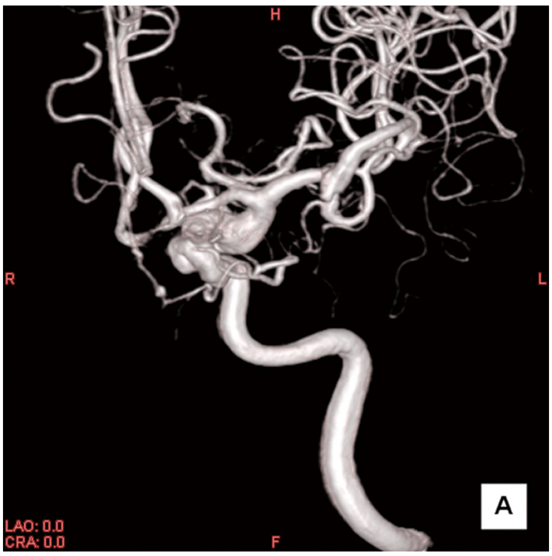


Fig. 3 Example of 3D-Angio Image

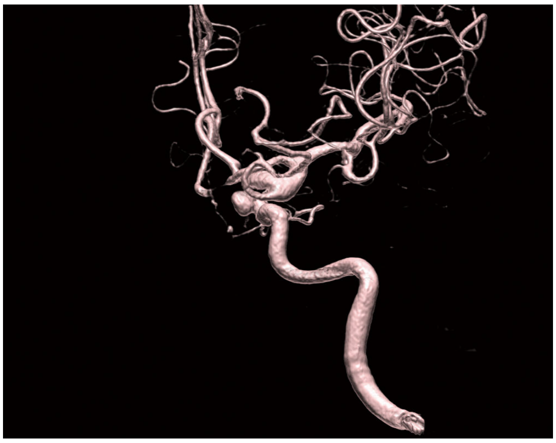


Fig. 4 Example of Mask Image Display on 3D-MAP

4.2. Display of 3D-MAP Images

First, the 3D image data acquired with 3D-Angio is transferred to the 3D-MAP Work Station (hereafter referred to as "WS"), and on the 3D-MAP WS, the 3D image to be used for 3D-MAP is specified and the transfer operation is performed using the menus. Approximately 10 sec after transfer starts, a reconstructed image of the blood vessels is displayed on the 3D-MAP screen **(Fig. 4)**. On comparison with **Fig. 3**, it can be observed that the front-back relationship is reversed. This is due to consideration of the fact that, whereas the blood vessels are visualized from the frontal perspective in the 3D-Angio image, the fluoroscopic image used for 3D-MAP is a projected image originating from the X-ray source, which is situated on the opposite side from the flat panel detector on which it is formed, and so the front-back size relationship is reversed.

4.3. Tracking Capability and Effect of 3D-MAP Images

Real-time information on the positions and sizes of images is provided to the rendering engine for the 3D images used for mask images, and mask images that track the movement of the C-arm are displayed **(Fig. 5)**. This eliminates the need for the DSA images that were obtained whenever the C-arm was moved in order to create mask images, and allows procedures to be performed without interruptions **(Fig. 6)**. A clinical example is shown in **Fig. 7**.

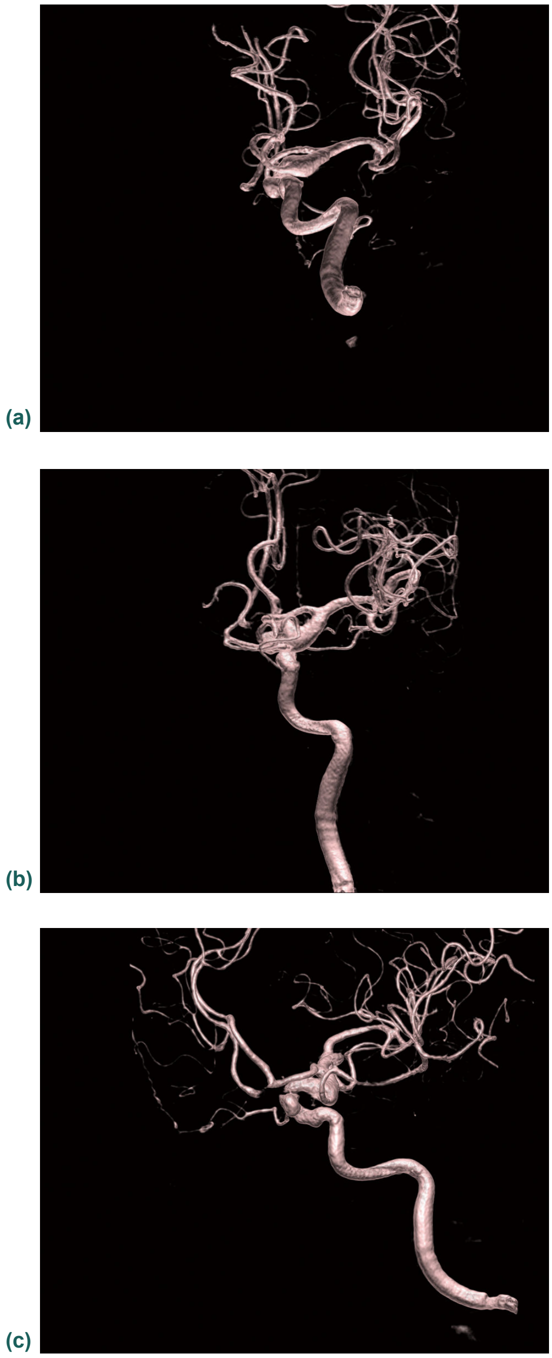


Fig. 5 3D-MAP Mask Images Tracking the C-arm Angle
(a) RAO20/CRA20, (b) RAO20/CAU20,
(c) LAO45/CRA0

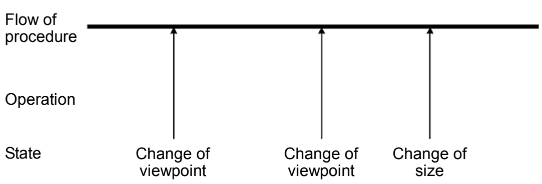


Fig. 6 Example of Flow of IVR Procedure Performed Using 3D-MAP (for Comparison with **Fig. 2**)

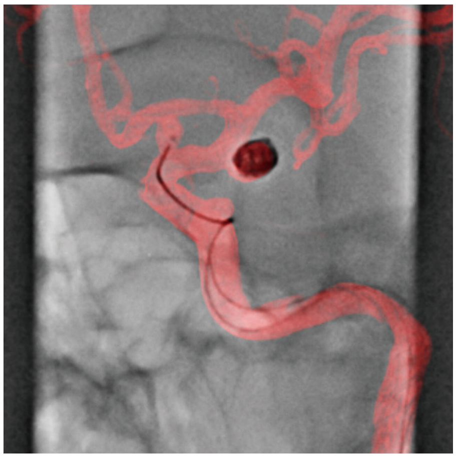


Fig. 7 Clinical Example of 3D-MAP

4.4. Free-Layout MAP Display

In order to provide a safer and more comfortable IVR environment, our roadmap function **(Fig. 8)** is equipped with the following features.

- Both 2D and 3D roadmap images can be produced.
- Standard fluoroscopic images and roadmap images can be arranged freely.
- During operation of the roadmap function, the optimal display layout is switched to automatically and so no special operations are required.

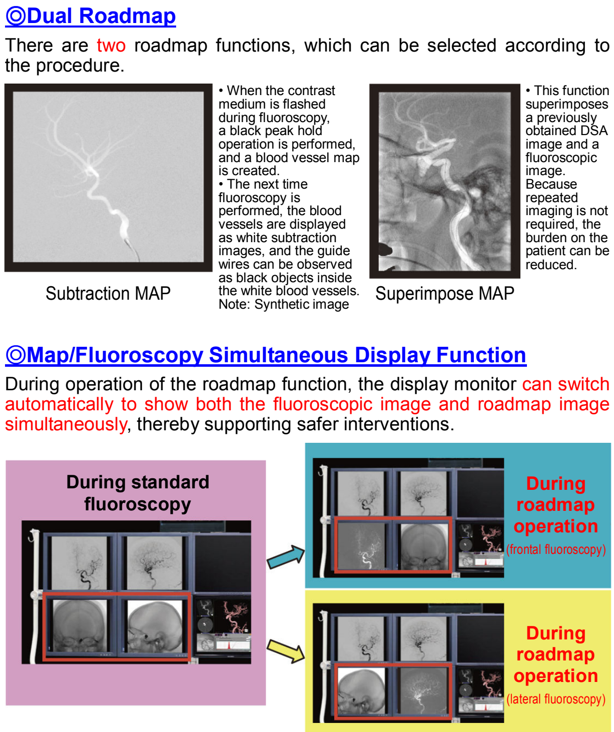


Fig. 8 Roadmap

It is also possible to view and interpret images while performing image acquisition processing for fluoroscopy or radiography. One example of an application that utilizes this ability is the dynamic reference function **(Fig. 9)**. With this function, a reference image with the same angle as the fluoroscopy/radiography angle and the current fluoroscopic image are displayed on the same monitor, alternating according to whether or not fluoroscopy is being executed. Previously, the operator had to switch his or her gaze between the fluoroscopy monitor and the reference monitor while performing catheter operations. The dynamic reference function eliminates this necessity and allows easy comparative operation of images.

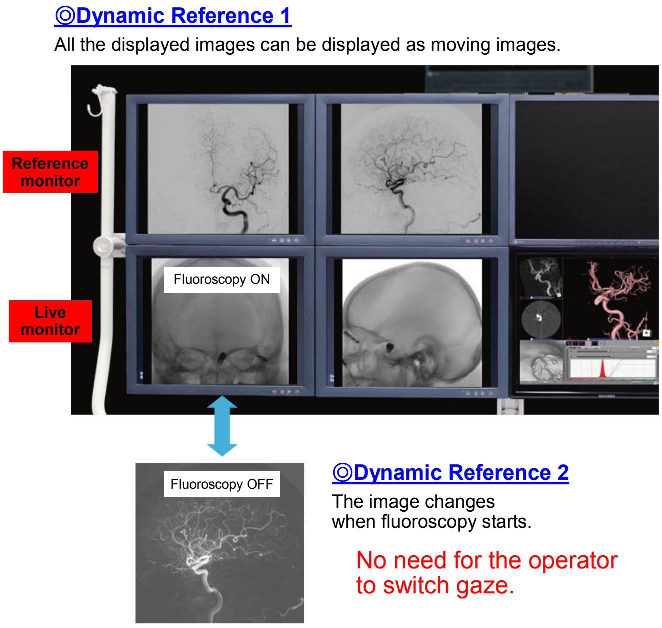


Fig. 9 Dynamic Reference Function

4.5. CT-Like Imaging Function

The CT-like imaging function is coming to be regarded as an indispensable tool for the IVR of various regions, and is already incorporated in the BRANSIST safire angiography system, which offers the largest field of view in the world with a 17 × 17-inch FPD. Details are given in issue number 64 of this magazine[1)]. We have developed this function in a way that is suitable for systems equipped with a 9 × 9-inch FPD. This has made it possible to use our CT-like imaging function with all fields of view, from small to large, and to apply it to the IVR of a wide range of regions. A clinical example is shown in **Fig. 10**.

Fig. 10 Clinical Example of CT-Like Imaging Performed with 9 × 9-Inch FPD

4.6. Intuitive, Stress-Free Operating Interface

In order to realize operation that is more intuitive and stress-free with the BRANSIST safire HB9/VB9 bi-plane systems, we have developed the following interfaces.

(1) X-Ray Control Console: System Display
We have developed a system display **(Fig. 11)** that, as an X-ray control console for the control room, enables the unified management of system information (e.g., X-ray conditions and mechanical information). It has an extremely simple operating system that can be operated with a touch-screen.

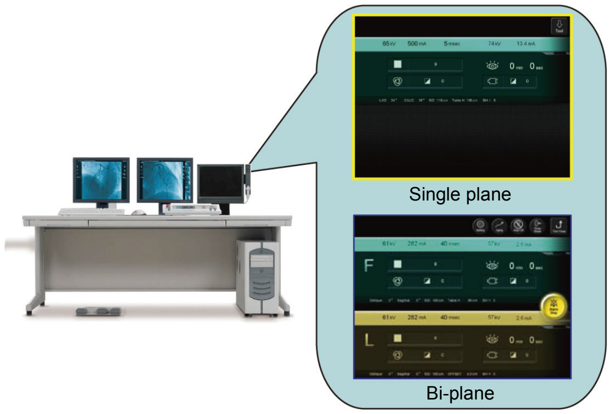


Fig. 11 X-Ray Control Console: System Display

(2) Examination Room Display: Information Display
We have developed an information display **(Fig. 12)** that shows, in an integrated way, information related to C-arms in the examination room. It efficiently organizes large amounts of information and makes it easy to acquire the necessary information instantly.

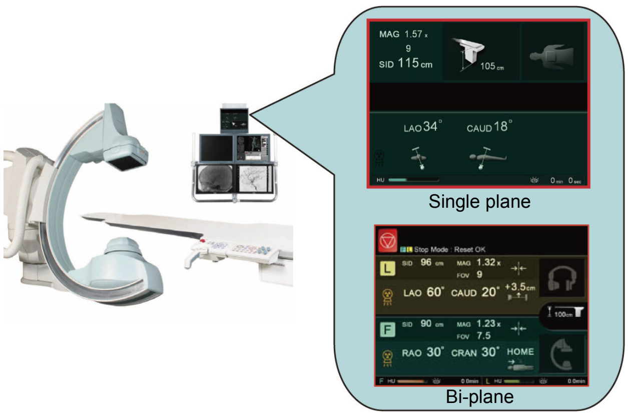


Fig. 12 Examination Room Display: Information Display

(3) Controller for Control Room: IVR Shuttle
We have developed the IVR shuttle **(Fig. 13)** as a controller for the control room. This makes it possible for anyone to perform the various operations required in clinical facilities, such as the display, frame-by-frame playback, and contrast adjustment of acquired images, with simple operations and without a manual.

Fig. 13 Controller for Control Room: IVR Shuttle

5. Summary

In pursuing the improvements to functions supporting neuro-IVR described here, we gave the highest priority to the opinions of users performing cutting-edge intravascular treatments in medical facilities and focused on ways of making the IVR performed in the treatment of blood vessels safer and more precise. In the future, we will continue to pursue functional improvements aimed at enhancing treatment, and focus on coordination with other modalities that affect the environment in which these functions are used as well as the development of new applications.

Reference

1) Kazuyoshi Nishino: Development of CT-like Imaging Function for BRANSIST safire Angiography System VC17, MEDICAL NOW, No. 64, p. 25-27, 2008