Vascular

Experiences Using an Angiography System with a 17 × 17 Inch FPD - CT-Like Imaging of the Neck and Abdomen -

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1. Introduction

The evolution of angiography systems away from analog images using image intensifiers From (I.I.) to digital images using flat-panel detectors (FPD) has enhanced the image quality and reduced the X-ray exposure dose. In addition, rotational angiography using digital technologies can produce axial images (CT-like images) that are similar to computed tomography (CT) images.

During an upgrade of equipment at this hospital, we replaced our Shimadzu I.I. system with a new Shimadzu BRANSIST safire direct-conversion FPD system **(Fig. 1)**. The selection criterion was that, although the target areas were all regions apart from the head and heart, the system should be effective for angiography of the abdominal region and lower extremities, particularly for TACE of the liver and for intraabdominal bleeding. As a result, the Shimadzu system was introduced due to its large 17 × 17 inch FPD and higher DSA image quality than other manufacturers.

This paper reports on our experiences using this system and on its clinical utility for CT-like images in particular. We include comparisons with the previous system.

Fig. 1 BRANSIST safire with Large-Viewfield 17 × 17 Inch Direct-Conversion FPD and Custom-Order Protective Patient Stand

2. Operability and Image Quality

The flat image receiving surface (detector) of the newly introduced BRANSIST safire is much thinner than an I.I. and achieves a simple external appearance, despite its 17 × 17 inch size. The extremely smooth C-arm movements ensure rapid and pleasant positioning.

When using a conventional I.I. system to perform radiography of regions containing differences of X-ray absorption, such as the liver, a compensation filter had to be inserted at the boundary between the liver and lung fields to prevent halation.

Attempting to suppress such halation without a compensation filter results in reduced radiography conditions that produce noisy images with somewhat lower diagnostic performance. Consequently, in order to fully exploit the system performance and permit imaging with low contrast staining at this hospital, when observing tumor staining for TACE of the liver, for example, we used the continuous DSA mode with a compensation filter inserted, and increased the X-ray parameter values to a level where halation would appear if the compensation filter were not inserted at the optimal location.

However, the new BRANSIST safire produces no halation even without a compensation filter and, despite using pulsed DSA with a low X-ray dose, produces images equivalent to those obtained by the previous system using continuous DSA. The ability to perform angiography without a compensation filter eliminates tedious operations and reduces lost time. This is particularly helpful for angiography of the neck, where the shape of the compensation filter is more complex than for angiography of the liver. Subsequent image processing by mouse operations similar to using a personal computer makes the system extremely user friendly. In addition, the IVR NEO installed as a dedicated image controller in the radiography room and the IVR shuttle in the control room offer virtually the same method of operation as before, but the additional mouse operations make it even more convenient. (In addition to the conventional remasking method, it is possible to add multiple images to create the mask image and obtain images with improved S/N ratio.)

2.1 DSA Images

Shimadzu direct-conversion flat-panel detectors (FPDs) offer high sharpness in the high-frequency region. The result is clearer clinical images of peripheral blood vessels than the previous system. **(Fig. 2)**

Fig. 2 Comparison of Celiac DSA by Old and New Systems
(a) FPD Image **(b)** I.I. Image

2.2. RSM-DSA Images

Shimadzu's unique RSM-DSA images also exploit the properties of the direct-conversion FPD described above to produce extremely low-noise, high-contrast images with blur correction and background glare suppression similar to DSA images obtained by temporal subtraction. **(Fig. 3)**

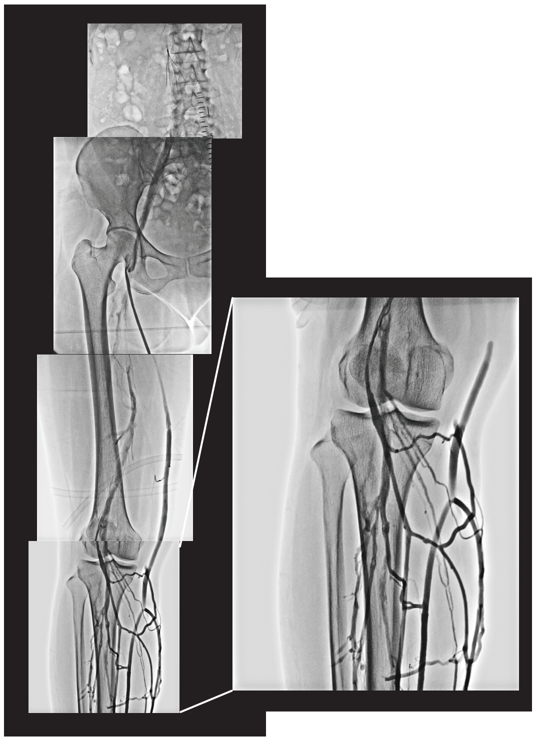

Fig. 3 RSM-DSA Images of lower extremities

2.3. X-Ray Exposure Dose

The exposure dose for liver tumor imaging and the tumor stain visibility were compared under the radiography conditions for **Fig. 2**.

- Previous Shimadzu I.I. system
  80 kV 100 mA................................. 1000 mAs
  (10 s continuous DSA conditions)
- BRANSIST safire (FPD)
  80 kV 300 mA 13 ms 5 f/s .... 200 mAs
  (10 s pulsed DSA conditions)

With the previous system, a single imaging operation over a 10 s interval in the continuous DSA mode results in an exposure dose of 1000 mAs. The newly introduced BRANSIST safire FPD system reduces this to about one-fifth (200 mAs). The actual measurement of the exposure dose is also reduced from 50 mGy/10 s to 7 mGy/10 s (one-seventh the previous value). This is a revolutionary technical advance that obtains equivalent image quality with just one-seventh the exposure dose. (However, slight differences may occur between the measured and calculated values due to differences in the effective energy.)
Some caution is required with the exposure dose and image quality. In addition to the pulsed DSA described above, the BRANSIST safire offers serial DSA. As serial DSA has a longer pulse width and higher exposure dose than normal pulsed DSA, it improves the S/N ratio and produces

smoother images. However, it did not achieve good results for tumor stain visibility.

One possible reason is that the pulse width is too long, resulting in blurring due to movements, which in turn causes small tumor stains and fine blood vessels to be buried and difficult to see. This radiography method should probably be used for regions with extremely small movements, including pulsation of blood vessels, only when the advantages of good graininess and high contrast outweigh the disadvantage of high exposure dose.

3. Evaluation of CT-Like Images (Safire 3D-C)

The new system offers rotational radiography as an additional function. Rotational radiography creates tomographic images similar to computed tomography (CT). Shimadzu calls such images "CT-like images" (Safire 3D-C).

Previously, we have experienced several situations where both IVR and CT were required for treatment and diagnosis. This involved transporting the patient to the CT room and great care was required to avoid pulling out catheters in nonsterile conditions. This could be very difficult in the case of seriously ill patients and for some catheter positions.

However, the new system produces CT-like images by rotating the C-arm, which allows confirmation of the target position and blood vessels. The result is more accurate IVR and less invasion of the patient.

3.1 CT-Like Images for TACE of the Liver

During treatment for hepatoma, DSA is used to search for tumor stains. If the position matches that determined by dynamic CT or MR prior to the procedure, the diagnosis is confirmed and treatment performed. However, in some cases it is difficult to confirm tumor stains in DSA. In particular, it can be difficult to capture tumor stain images of tumors with low vascularity, and nonuniform liver staining can result in multiple apparent stained nodules, making it difficult to confirm tumor stains. CT-like imaging is extremely effective in such cases, as it can produce axial images and achieves superior low-contrast resolution to DSA images. Some striking cases of the utility of CT-like images are described below.

3.1.1 Case 1: TACE at Segment 7

In this case, the tumor stain contrast is low and the tumor difficult to distinguish due to nonuniform staining of the hepatic parenchyma. As the region was thought to be segment 7 in the CT image, we performed DSA from the posterior branch of the right hepatic artery. This resulted in failure to identify the tumor, however, so we performed CT-like imaging instead. **(Fig. 4)**

The CT-like images revealed tumor staining at the same position as the CT image.

In this case, observation of the various tomographic images permitted accurate evaluation of the tumor position by DSA

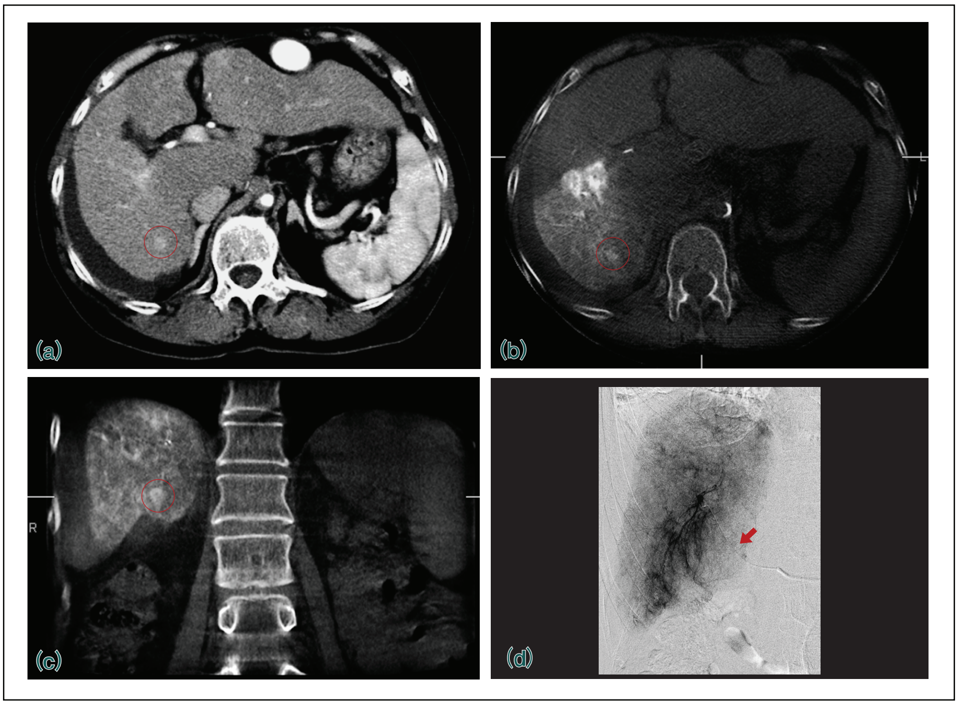

Fig. 4 TACE at Segment 7
(a) Liver dynamic CT image **(b)** CT-like (Axial) image **(c)** CT-like (Coronal) image **(d)** DSA image

3.1.2 Case 2: TACE at Segment 3

We have experienced many cases where a low-contrast tumor in the left lobe, which is easily affected by movements of the heart, can be difficult to visualize by DSA. In this case, a low-contrast tumor was confirmed in segment 3 in a dynamic CT image. DSA was performed for the left hepatic artery, A3, and A2, but no tumor staining was indicated. CT-like imaging from A3, on the other hand, clearly revealed the tumor stain and clearly identified the feeding vessels, and treatment was performed. **(Fig. 5)**

3.2 CT-Like Imaging of the Neck in Arterial Infusion Therapy

It is difficult to search for feeding vessels for tumors in the neck region due to their low vascularity and obstruction shadows from bones. The utility of CT is widely recognized but transferring a patient to the CT room can be dangerous with a catheter inserted in some positions. Therefore, when tumors were visible by the naked eye or through an endoscope, dye was injected at locations thought to be feeding vessels. The anticancer drug was injected after visual confirmation of tumor staining. This method was imperfect and often did not result in a definitive diagnosis. In such cases, the catheter was positioned significantly in front of the possible feeding vessels, and the anticancer drug was injected from a position thought to include the target site.

Since CT-like images became available, clear observations of the tumor and identification of the feeding vessels have been possible, whatever the location of the tumor or the state of the patient. In addition, for some areas included in the neck region, such as the brain and ophthalmic arteries, where no anticancer drug is permitted, CT-like images offer the major advantage of determining whether such areas have been avoided.

The CT-like image from the right ascending pharyngeal artery **(Fig. 6)** confirmed the blood vessels to be feeding vessels, and treatment was performed.

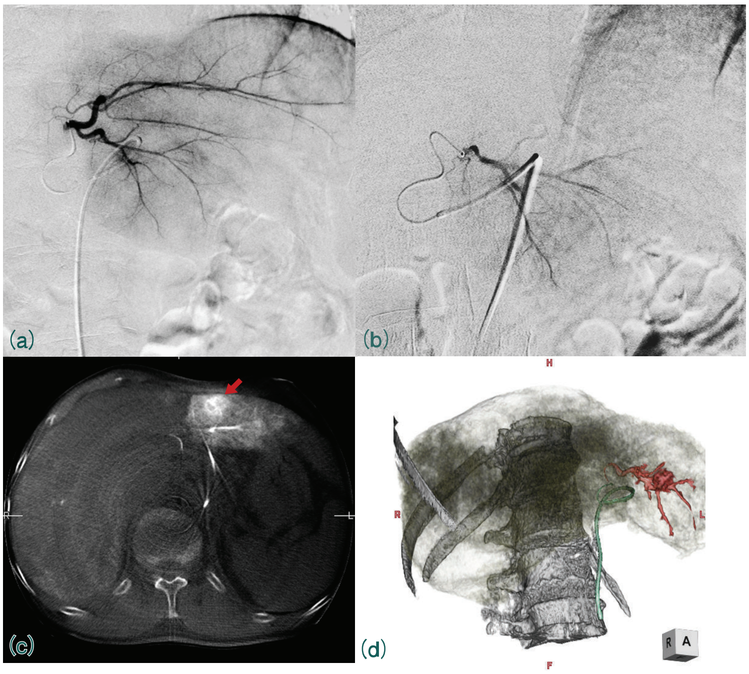

Fig. 5 TACE at Segment 3
(a) DSA image of LHA **(b)** DSA image of A3
(c) CT-like image of A3 **(d)** CT-like image 3D view

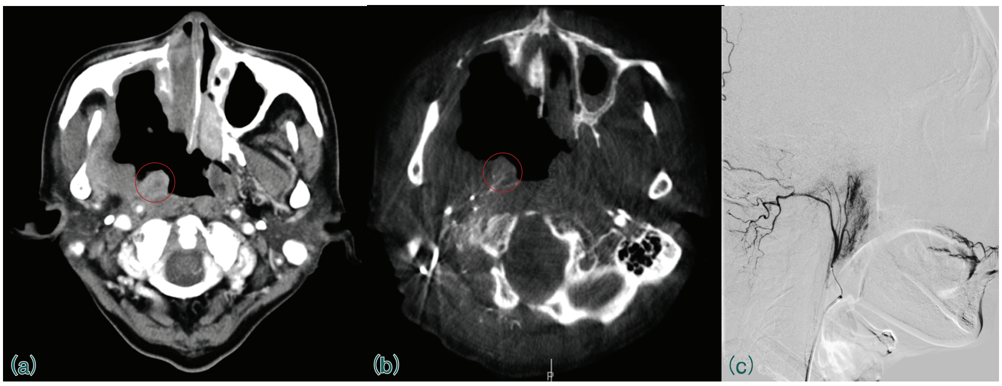

Fig. 6 CT-Like Imaging of the Neck in Arterial Infusion Therapy
(a) CT image **(b)** CT-like image **(c)** DSA image

3.3 CT-Like Imaging of TAE on Bone Tumor on the Fifth Lumbar Vertebra

In this case, the feeding vessels were embolized to suppress bleeding during excision of the tumor. CT-like imaging was performed on all embolized blood vessels. CT-like imaging from the left iliolumbar artery confirmed fine arteries entering the spinal cord **(Fig. 7)**. This blood vessel was therefore not embolized. The extremely high spatial resolution allowed observation of these fine blood vessels.

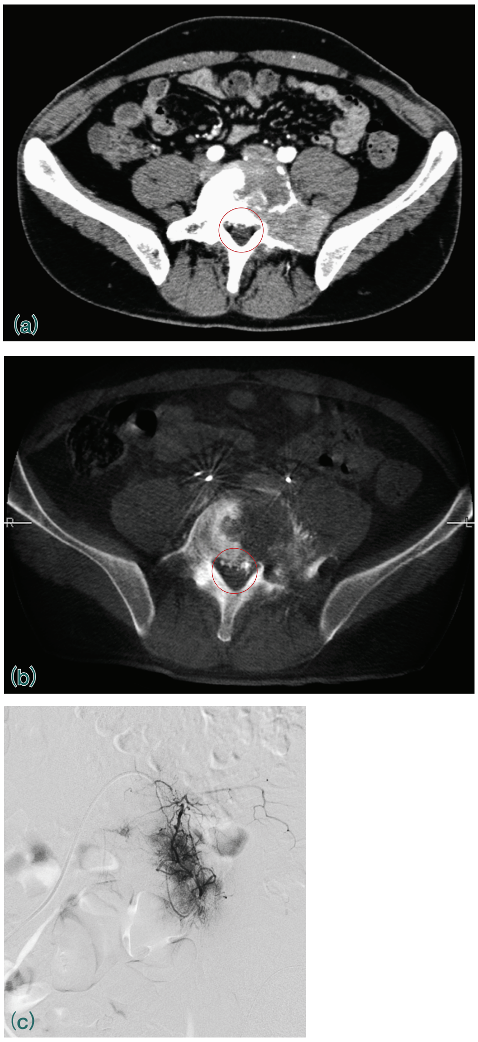

Fig. 7 CT-Like Imaging of TAE on Bone Tumor on the Fifth Lumbar Vertebra
(a) CT image
(b) CT-like image
(c) DSA image

4. Conclusions

BRANSIST safire meets all our demands for ease of use and DSA imaging. The major feature of the system is CT-like imaging. CT-like images are effective in cases where CT images are effective, liver tumors, BRTO, intraabdominal bleeding, and splenic embolization.

Due to the mechanics of the system, CT-like images and CT images are not identical. However, from the clinical viewpoint, CT-like images can substitute for CT images in IVR. The low exposure dose, freedom of the operator workflow, and the easy and rapid imaging make CT-like imaging superior to CT. In particular, when CT must be performed several times for IVR, CT-like imaging offers immeasurable advantages by eliminating frequent trips to the CT room and the associated effort and wasted time. Further suppression of scattered X-ray artifacts and ring artifacts would lead to enhanced quality of images and dramatically increase their clinical significance, making this system indispensable in facilities performing IVR.

Finally, I would like to thank the professors and chief technologist in the radiology department for their assistance with the introduction of this system.