Vascular

CT-Like Imaging Using an Angiography System with 9-Inch Flat Panel Detector (FPD)

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1. Introduction

At this hospital, we employ CT-like imaging using an angiography system with 9-inch flat panel detector (FPD) for abdominal angiography. While technical advances in flat panel detectors have led to startling increases in their size, our Department of Radiology adopted a 9-inch FPD for cardiac and abdominal examinations in the angiography room.

You might be concerned whether a 9-inch FPD would permit examinations across the abdominal region but our radiologists have determined that the FPD can sufficiently support these examinations. This paper describes how we determine the contrast injection protocol for 3D applications and introduce the utility of CT-like imaging in actual cases.

2. Angiography Room

Nihon Koukan Hospital was established in 1937 as the first general hospital in Kawasaki City near an industrial area in the east of the city. The hospital offers 395 beds and the adjacent clinic handles an average of 1,300 outpatients per day. All imaging equipment in the Department of Radiology became fully digital in July 2009. The department uses a total of ten flat panel detectors, with both direct-conversion and indirect-conversion types. An angiography system with a 9-inch FPD was introduced in March 2007. The 3D applications added in March 2009 permit 3D-angiography (3D-DA) and CT-like imaging. Although the 3D applications have been in use for only a few months, we perform CT-like imaging on virtually all cases of abdominal interventional radiology (IVR).

The equipment we use is a Shimadzu BRANSIST safire with a 9-inch flat panel detector and a ceiling-mounted C-arm.

After the 3D applications were first introduced, the number of monitors in the examination room increased from four to six, but we have now taken measures to operate with four monitors. Because the 3D applications are not applied to cardiac catheterization, the two upper monitors can be switched to display polygraph and 3D workstation screens (Fig. 1). The 3D workstation uses only a single screen, so that the remaining screen can be used to display PACS images sent over the internet. It is extremely popular with doctors performing procedures, due to its ability to display a variety of images. Abdominal angiography accounts for 41 % of all the procedures performed in the angiography room over the past year. Of these, approximately 60 % are angiography performed for transcatheter arterial chemoembolization (TACE) for hepatocellular carcinoma (HCC). Cardiac catheterization accounts for 43 % of the total procedures, which is about the same proportion as abdominal examinations.

Non-vascular examinations represent 12 %, with the remainder being upper extremity shunt angiography and associated PTA or other treatments, and lower extremity arteriography. Details of abdominal IVR, the most common use of the 3D applications in our angiography room, are

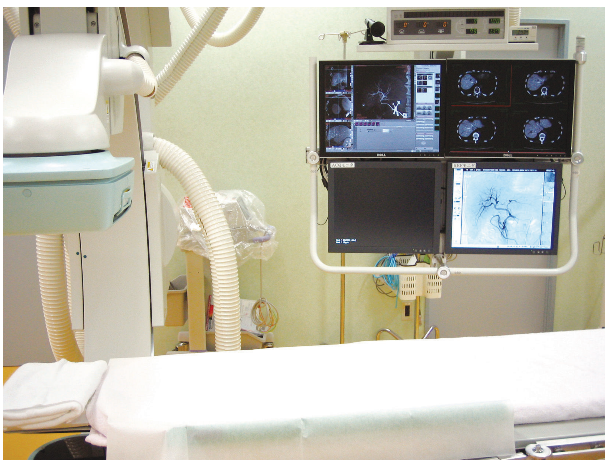


Fig. 1

introduced below. The 3D applications we introduced are 3D-DA and CT-like imaging. 3D-DA is used to track blood vessels and CT-like imaging is used to confirm tumor staining and feeding vessels of the organ.

3. Radiography Sequences

Table 1 shows the radiography sequences for the 3D applications. The approach time is the time from the start of C-arm rotation until the start of X-ray exposure; it is the time for the C-arm to reach rotational speed and take images. The contrast medium is used as a stock solution for 3D-DA and used diluted two times for CT-like imaging.

	Rotational Speed	Approach Time	Imaging Time	Processing Time
3D-DA	60°/sec	1.7sec	3.3sec	45sec
CT-like	20°/sec	2.0sec	10.75sec	60sec

Table 1 Radiography Sequences for 3D Applications

4. Determining the Contrast Injection Protocol for 3D Applications

The method used to determine the contrast injection protocol for the 3D applications at this hospital is described below. **Fig. 2** shows the procedure to determine the contrast radiography protocol. The delay time is the optimal time from the start of contrast medium injection to the start of imaging. It is set by selecting the images in which the target blood vessels are most full of contrast medium amongst the DSA images taken before 3D imaging, and dividing the number of frames by the frame rate determined by the DSA radiography sequence. The injection time is calculated by adding this delay time to the appropriate 3D-DA or CT-like imaging time in **Table 1**.

The important point when displaying the target blood vessels or region as 3D data is that the target blood vessels must be full of contrast medium when imaging starts and remain full during imaging. This applies to both 3D-DA and CT-like imaging. The injection rate must be the same as during DSA. Next, the total injection volume of contrast medium is determined. As stated above, the contrast medium must be injected during the imaging process. Therefore the total injection volume of contrast medium is calculated by multiplying the injection time by the injection rate (mL/sec).

In terms of the BRANSIST safire, the delay time is the time until the C-arm rotation starts, called the ACQ-delay. Consequently, it includes the approach time. Therefore, the values input into the system are the delay time minus the corresponding 3D-DA or CT-like approach time shown in **Table 1**, 1.7 sec and 2.0 sec, respectively.

- Delay time =
  optimal number of DSA frames ÷ frame rate (fps)

Imaging time

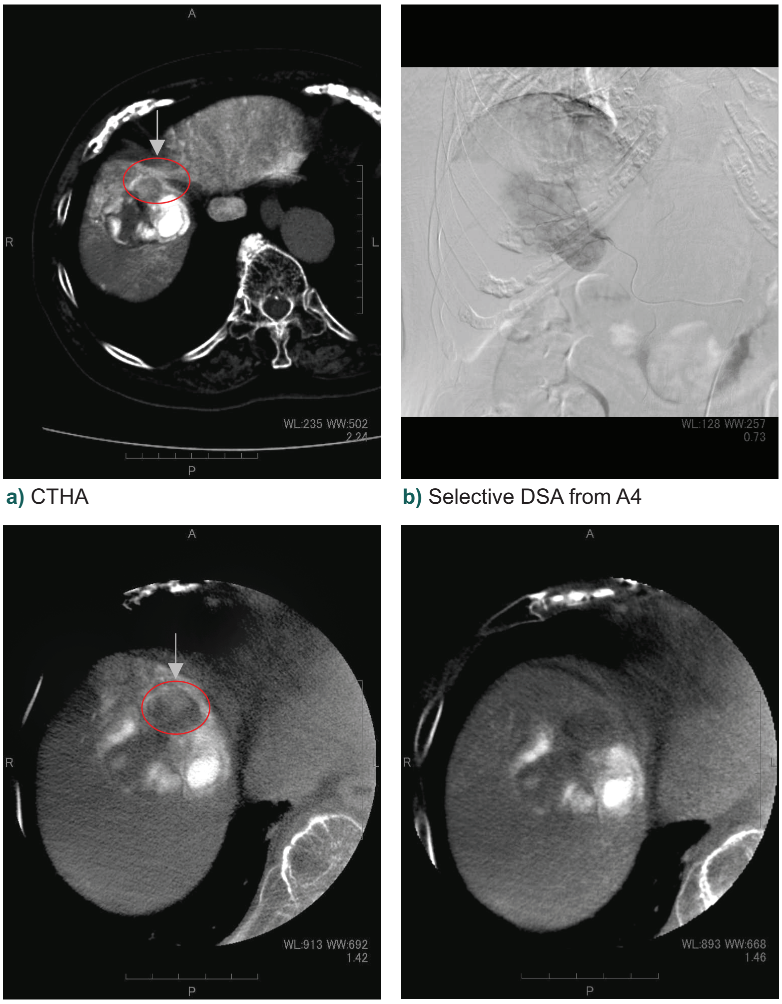
- 3D-DA injection time = delay time + 3.3 sec
- CT-like injection time = delay time + 10.75 sec

- Total injection volume (mL) =
  injection time (sec) × injection rate (mL/sec)

Fig. 2 Procedure to Determine Contrast Injection Protocol for 3D Applications

5. Case 1

Angiography for TACE in a patient with HCC recurrence. The position of recurrence was the right lobe of the liver (S8/4). Residual lipiodol from the previous TACE is visible adjacent to the position of recurrence in the CTHA image (**arrow in Fig. 3-a**) taken with the 16-slice MDCT in the adjacent CT room. Consequently, tumor staining superimposed on lipiodol is subtracted in DSA. In addition, as the lesion is positioned under the diaphragm, the effects of motion artifacts due to the heart pulse and breathing make visualization of tumor staining difficult using normal DSA. Contrast radiography was attempted from A4 using a microcatheter but the tumor staining in S8/4 could not be confirmed (**Fig. 3-b**). CT-like imaging using the same catheter position in A4 as for DSA clearly reveals the tumor staining at the position of the recurrence in the axial image (**arrow in Fig. 3-c**). Comparison with the CT-like axial image (**Fig. 3-d**) from the right hepatic arteriography conducted previously reveals that the position of recurrence in the CTHA image (**Fig. 3-a**) shows staining only when contrast medium is injected from A4. In this case, TACE was completed from A4. Lipiodol CT after one week confirmed satisfactory accumulation. This CT-like imaging was performed with a delay time of 6 seconds, injection rate of 0.8 mL/sec for the right hepatic artery and 0.4 mL/sec for A4 of 300 mgI/mL iodine content contrast medium diluted two times.



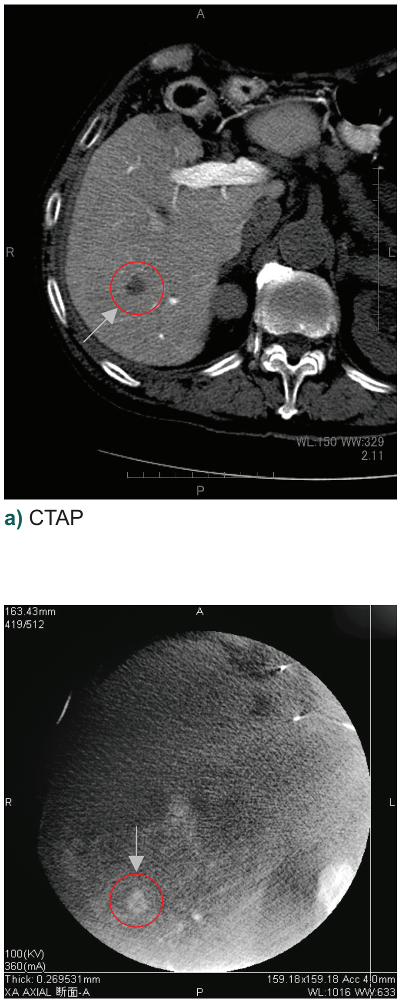
a) CTHA

b) Selective DSA from A4

c) CT-like imaging with contrast medium from A4

d) CT-like axial imaging from right hepatic arteriography

Fig. 3 Case of HCC Recurrence in S8/4. Angiography for TACE



a) CTAP

b) CT-like

Fig. 4 Case of HCC Recurrence in S6/7. Angiography for TACE

6. Case 2

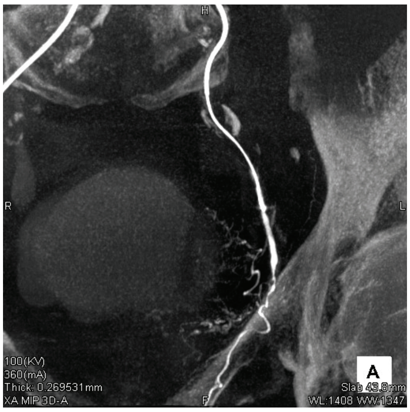
Angiography for TACE in a patient with HCC recurrence in S6/7. CTAP was performed by MDCT. A perfusion defect is clearly visible at the position of recurrence (**arrow in Fig. 4-a**). Next, the contrast radiography was performed selectively posterior to the right hepatic artery using a microcatheter. With DSA, the tumor staining was faint and not clear. Subsequent CT-like imaging (**arrow in Fig. 4-b**) with the catheter position the same as for DSA and axial reconstruction clearly shows the tumor staining at the same position as CTAP.

As a result, treatment was completed by performing TACE from A6 and A7 posterior to the right hepatic artery. Such tumor staining that cannot be clearly observed by DSA can be confirmed by CT-like imaging to allow treatment to be performed with confidence. Radiofrequency ablation (RFA) was performed after two weeks. The contrast injection protocol involved an injection rate of 1.3 mL/sec, a delay time of 8 seconds, and the same contrast medium concentration as Case 1.

7. Case 3

Angiography for intraarterial injection chemotherapy on a patient with bladder cancer on the left sidewall. Two-dimensional angiographs by DSA radiography in the AP (front view) of the pelvic region where many fine branches exist in the blood vessels do not clearly reveal superimposed branches or clearly capture the fine curves in blood vessels at this position. 3D applications are extremely useful in such situations. In this case, 3D-DA was initially performed from the left internal iliac artery to determine the paths of the blood vessels (**Fig. 5-a**).

a) 3D-DA



b) CT-like

Fig. 5 Angiography on Bladder Cancer on the Left Sidewall for Intraarterial Injection chemotherapy

The workstation image is aligned to an angle at which the branches of the vesical artery are visible (RAO45° in this case). This angle is transmitted to the C-arm, such that the C-arm can perform the examinations at the optimum angle to observe superimposed blood vessels. CT-like imaging was performed with a microcatheter inserted in the common trunk of the left superior vesical artery and left obturator artery. The images confirmed the contrast effect at the left sidewall of the bladder. Subsequently, intraarterial injection chemotherapy was performed at the same position to complete the treatment. MIP reconstruction for CT-like imaging provides a 3D view of the bladder cancer mass defect and feeding vessels, which are difficult to see with DSA (**Fig. 5-b**). CT-like imaging with MIP reconstruction is popular with radiologists, due to its approximately 5 to 6 cm slab width display that can be moved backwards and forwards.

8. Conclusions

CT-like imaging has already become an essential application for abdominal IVR in this angiography room. Despite the reputation of CT-like imaging using a 9-inch FPD for achieving significantly inferior density resolution to MDCT, it offers extremely good visualization of tumor staining and blood vessel pathways that are difficult to discern using DSA. However, we anticipate dramatic improvements, such as adjustable inclination of the C-arm with respect to the table, enhanced time resolution to reduce motion artifacts, and improved image quality. The radiologists judged that the field of view of the 9-inch flat panel detector presents no problems when used as it is used in our department, as shown in the cases above. Low magnification is adequate for cardiac examinations, as the panel can be moved close to the patient, resulting in clear images at low exposure dose. The FPD does not hinder treatments requiring the manipulation of a fine catheter, such as shunt PTA of the upper extremities, and ensures that operation proceeds smoothly. A future topic to be tackled is reducing the time until CT-like imaging can be performed. In particular, diluting the contrast medium delays the examinations. Realization of a practical version of the 2-head/2-motor injector displayed at last year's ITEM exhibition would lead to significantly smoother examinations.