Case reports

Three-Dimensional Cholangiography Applying C-arm Computed Tomography in Bile Duct Carcinoma: A New Radiological Technique

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Running title: 3D-Cholangiography by C-arm CT

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Abbreviations: 3-dimension (3D), C-arm equipped with a flat detector CT (C-arm CT), multi-detector computed tomography (MDCT), magnetic resonance image cholangiography (MRC), percutaneous transhepatic cholangiography (PTC), endoscopic retrograde cholangiography (ERC), interventional radiology (IR), volume rendering (VR), images or mean intensity projection (MIP)

Abstract

Background/Aims: A C-arm equipped with a flat detector CT (C-arm CT) has been developed, which provides images with high spatial resolution that could facilitate effective 3D information during interventional procedures. The cone beam reconstructive method was applied for reconstruction of images. Time of reconstruction of 3D images was approximately one minute after the scan. The axial thin-slice images, the real-time volume rendering, maximum intensity projection, shaded surface display and multi-planner reconstruction images could be obtained from any direction in a single scan.

Methodology: We experienced 7 cases and present two informative cases with biliary obstruction by the tumor undergoing C-arm CT.

Cases: First case shows gall bladder carcinoma invading the hilum. The C-arm CT provided precise images of the stenotic bile ducts that could be viewed in any direction. Multiple expandable metallic stent could be accurately placed in 3 stenotic bile ducts. The second case shows a hilar bile duct carcinoma. By using various pressure infusion of the contrast medium, severely stenotic hepatic duct was confirmed before surgery.

Conclusions: C-arm CT provided useful information regarding the precise 3D status of the bile duct and the extent of tumor invasion.

INTRODUCTION

Imaging diagnosis contributes to accurate and early detection of tumor location in biliary carcinomas. Helical and multi-detector computed tomography (MDCT) or magnetic resonance image cholangiography (MRC) have been applied for the diagnosis of biliary carcinomas (1, 2). These imaging modalities provide useful information on biliary carcinoma. However, direct cholangiography by percutaneous transhepatic cholangiography (PTC) and endoscopic retrograde cholangiography (ERC) is still a useful diagnostic tool for detecting precise changes in tumor infiltration, and its diagnostic accuracy is probably superior to that of MDCT and MRC at present (3). The conventional direct cholangiography has, however, certain disadvantages such as high exposure to radiation due to the need to take several views from various directions, the amount of contrast media and the long time required for examination. Three-dimensional (3D) imaging has been applied in the field of interventional radiology (IR) (4). However, the volume of data of 3D imaging could not be used simultaneously at the time of IVR treatment. Recently, a C-arm equipped with a flat detector CT (C-arm CT) has been developed, which provides images with high spatial resolution (5, 6). This system provides the advantage of an immediate CT-like volume data set without patient transfer and, therefore, the C-arm CT can be a practical clinical tool that could facilitate effective 3D information during interventional procedures. The C-arm CT has been recently applied in various diseases (7-9). With respect to cholangiography, this system may provide accurate 3D images such as volume rendering (VR) images or mean intensity projection (MIP) images by the single C-arm scan, in addition to a short period of examination. Furthermore, in case of interventional biliary stenting, real-time 3D images can be obtained at each step of the procedure, making this system a more powerful supporting system relative to the conventional 2D cholangiographic images. To our knowledge, application of C-arm CT in biliary diseases has not been reported yet. We have experienced 7 patients with resectable and non-resectable bile duct carcinomas. We present two patients who underwent this new radiological technique.

METHODOLOGY

Image systems

The applied apparatus of C-arm CT and workstation system were the AXIOM Artis dBA and the syngo X-Workplace (Siemens, Germany). This system is a Cone beam CT by the flat detector (FD). Scanning by rotation at an approximate angle of 200 degree of C-arm with FD was carried out at the working table and CT-like reconstructed images were automatically constructed by the workstation. Since various image corrected algorithms were included, less artifact and high-resolution images of contrasted vessels and surrounding soft tissues (10 mm/10 HU; 16 cm CATPHAN phantom) could be obtained. The maximum field of view ranged from 25 cm x 20 cm. The pixel size was 154 μm and maximum projection data of 1024 x 1024 matrixes were collected. Scanning time could be selected at 5, 10 or 20 seconds. The cone beam reconstructive method was applied for reconstruction of images. Time of reconstruction of 3D images (in-space 3D) was approximately one minute after the scan. The output images were the axial thin-slice images, the real-time volume rendering, maximum intensity projection (MIP), shaded surface display (SSD), and multi-planner reconstruction (MPR) images. The obtained 3D images could be observed from any direction in a single scan by manual operation. The moving image was stored as a digital file and watched using Windows Media Player (Microsoft Co., Seattle, WA).

RESULTS

All 7 patients with biliary diseases underwent surgical treatment under C-arm CT at the Division of Surgical Oncology, Department of Translational Medical Sciences, Nagasaki University Graduate School of Biomedical Sciences. Patients included 5 males and two females and their age ranged from 53 to 74 years. The biliary diseases included hilar bile duct carcinoma in 2 patients, intrahepatic cholangiocarcinoma in 4 and gall bladder carcinoma in 1. Two patients underwent surgical resection and 5 underwent biliary stenting. 3D cholangiography could be obtained by a single scan as well as images of conventional cholangiography.

REPRESENTATIVE CASE PRESENTATION

Case 1

Clear images of biliary obstruction were obtained in all patients. We firstly present a 66-year-old female with gall bladder carcinoma invading the hilum. Peritoneal dissemination was observed intraoperatively, and accordingly we planned biliary stenting after surgery. The C-arm CT provided precise images of the stenotic bile ducts that could be viewed in any direction by simply moving the VR image after a single scan (**Fig. 1a-c**). After this scan, three expandable metallic stents were placed in the left hepatic duct to the common hepatic duct, right hepatic duct and in a small hepatic duct in segment 5, as confirmed at each procedure by using the MIP image of 3D cholangiography (**Fig. 2a**). Comparison with 2D cholangiography indicated a more precise imaging (**Fig. 2b**). These findings indicate that the C-arm CT provides useful information to establish the exact site of stenosis and the position of the stent during IVR procedure, especially when multiple biliary stenting is carried out.

Case 2

The second case was a 68-year-old female with a hilar bile duct carcinoma located mainly in the left hepatic duct. MDCT and 2D cholangiography showed dilatation of the anterior hepatic duct and hepatic duct in segment 6 by tumor involvement (**Fig. 3**). However, the branch in

segment 7 could not be observed by these modalities. Accordingly, we decided to use the C-arm CT. The use of a low-pressure infusion of the contrast medium resulted in similar VR images (**Fig. 4a**). However, the use of a higher pressure allowed identification of tumor involvement in segment 7 (**Fig. 4b**). Involvement of this hepatic duct was confirmed at the cut plane of parenchymal transection during hepatectomy and this branch was ligated because segment 7 was already atrophic. Thus, continuous infusion of contrast media under high pressure during C-arm CT scan allowed detection of a small abnormality of the bile duct on the 3D images.

DISCUSSION

MDCT, drip infusion CT and MRCP also provide excellent 3D cholangiographic images. However, only static images can be obtained by these tools and biliary findings peripheral to tumor stenosis is not often observed. The C-arm CT provides various navigation data during IR, including various 3D imaging and CT-like image including the surrounding tissue image (10, 11). The spatial resolution power of 3D C-arm CT images is higher than that of 2D cholangiography. Referral and processing of image data was easy at the time of IVR treatments. A previous report showed that C-arm CT has been applied in liver diseases and small tumor lesions could be observed by this modality (8, 12, 13). Furthermore, the transfer of patient is not necessary; and C-arm CT also reduces artifact imaging caused by patient's movement. On the other hand, the density contrast between soft tissues seems insufficient compared to MDCT. Furthermore, the operation of the C-arm CT system is more complicated and the cost of the system is still expensive. Therefore, the spread of use of this system is likely to take some time before these issues are resolved.

In the present series, 3D images provided useful information to confirm the placement of multiple biliary stents immediately after the procedure, and to confirm the bile ducts that involved the tumor by various infusion pressures. Using conventional cholangiograph, more time and more contrast media infusion are usually necessary. Therefore, the total time for the procedure may be reduced by using this new radiological technology. In the present study, we showed representative cases indicating the superiority of 3D cholangiography in comparison with conventional images. In case 1, we compared images obtained by 2D and 3D cholangiography after stenting, and the resolution of images in the 3D cholangiography was clearer than in 2D cholangiography. In case 2, the bile duct in segment 7 could not be clearly confirmed by conventional images. As this duct is in the remnant liver and anastomosis with the intestine is necessary after left hepatectomy, confirmation of this duct is quite important. 3D-CT using the C-arm CT provided a clearer cholangiographic image by controlling the infusion

pressure of contrast media. If 2D cholangiography had been performed, more procedures would have been required.

Drip infusion cholangiography-CT (DIC-CT) also provides a useful 3D cholangiographic image (14). We did not compare both cholangiographic images between the DIC-CT and the C-arm CT. Tube placement is not necessary and precise images can be obtained using DIC-CT and, therefore, this modality is less invasive. In cases without remarkable obstructive jaundice, we also chose DIC-CT. However, in cases with biliary obstruction, DIC-CT cannot be applied until the jaundice recovers. On the other hand, 3D cholangiography by C-arm CT can be obtained during the drainage procedure. Therefore, each modality must be selected based on the status of the biliary obstruction, and comparison of both 3D images is necessary in the next step.

CONCLUSIONS

C-arm cholangiographic CT is a new tool that can provide useful information regarding the 3D status of the bile duct and the extent of tumor invasion. Furthermore, the time of examination and the amount of radiation exposure are markedly reduced in C-arm CT compared to conventional CT. Therefore, this imaging modality can be potentially used on a large scale to provide supporting data in patients with various biliary diseases.

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FIGURE LEGENDS

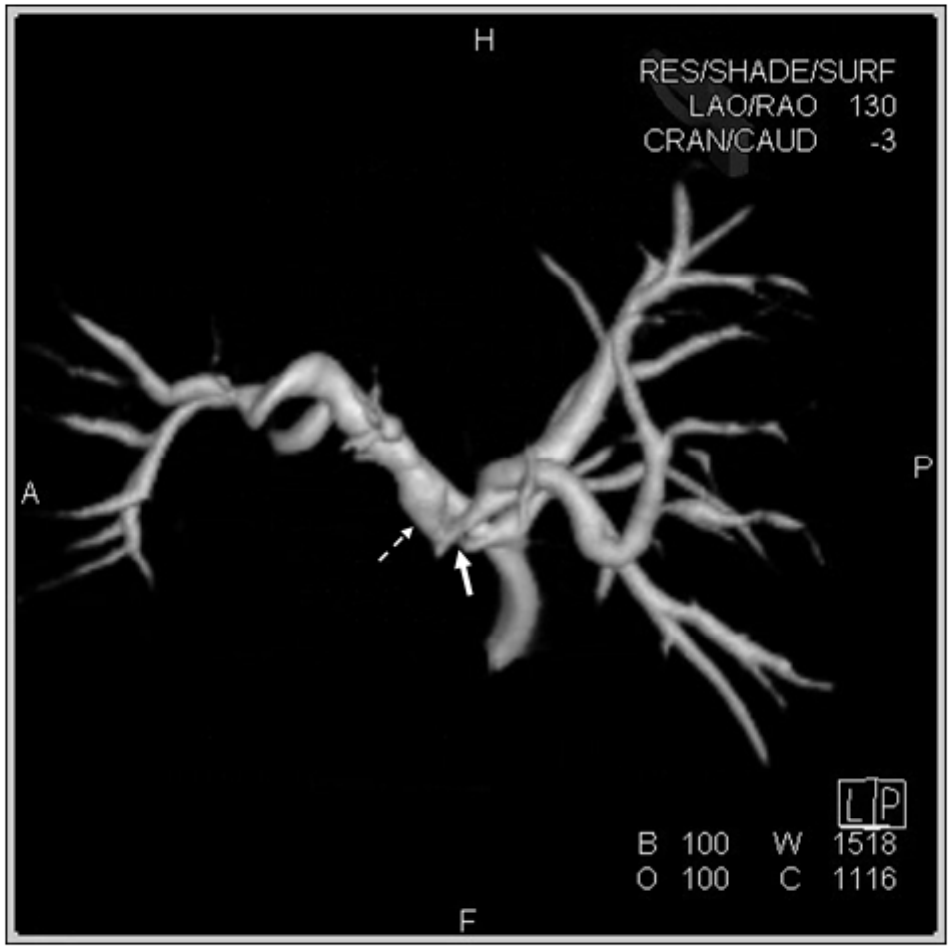
Fig. 1. VR image of C-arm CT cholangiography showing stenosis of hilar bile duct by tumor infiltration. a; Posterior view. Arrow: stenotic right hepatic duct, dotted arrow: stenotic left hepatic duct. b; Lateral view from the caudate side. c; Oblique view. Double arrow: separated hepatic duct in segment 5.

Fig. 2. Cholangiography after biliary stenting. a; A conventional 2D cholangiography. b; MIP image by C-arm CT cholangiography. Arrow: stenotic right hepatic duct, dotted arrow: stenotic left hepatic duct, double arrow: hepatic duct in segment 5.

Fig. 3. Coronary section of MDCT. Bant: anterior branch of the right hepatic duct. B6: hepatic duct in segment 6.

Fig.4. VR image of C-arm CT cholangiography shows stenosis of hilar bile duct by tumor infiltration. Image shows the right hepatic duct in the anterior sector and segment 6. a; Cholangiography by low-pressure infusion of contrast medium. b; cholangiography by high-pressure infusion of contrast medium. Arrow: small hepatic duct of segment 7 with tumor infiltration.

Fig.1a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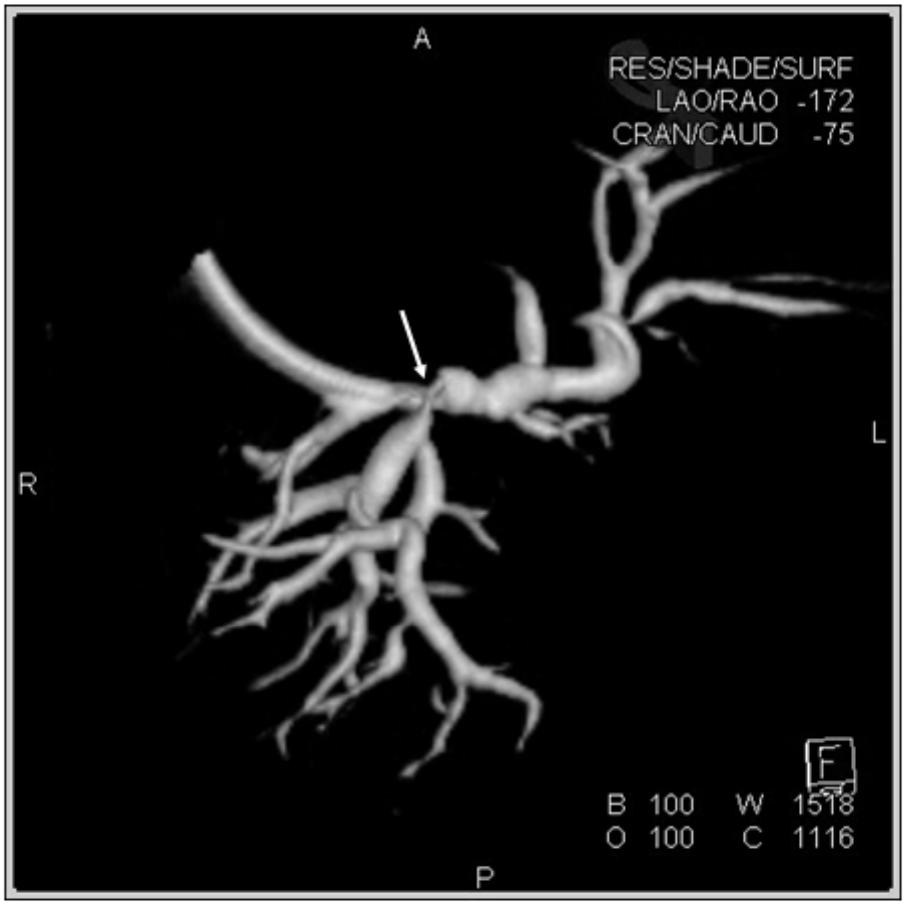
P
LP
B 100 W 1518
O 100 C 1116
F

Fig.1b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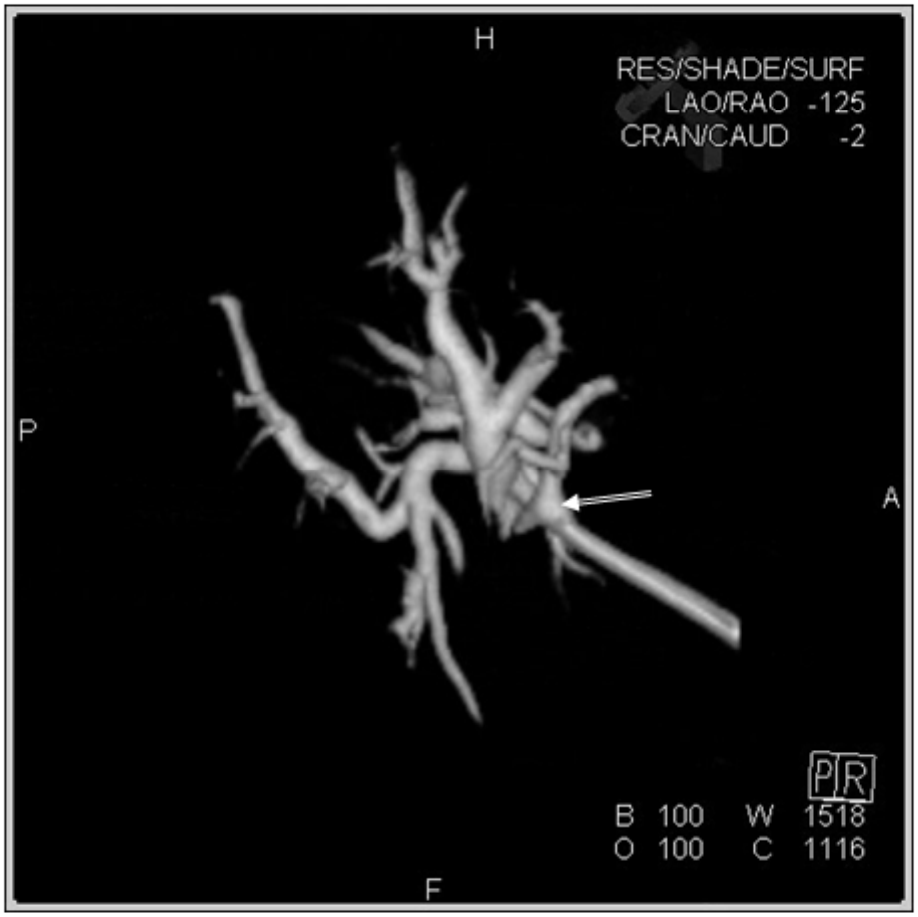
P

Fig.1c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F

Fig.2a

Fig.2b

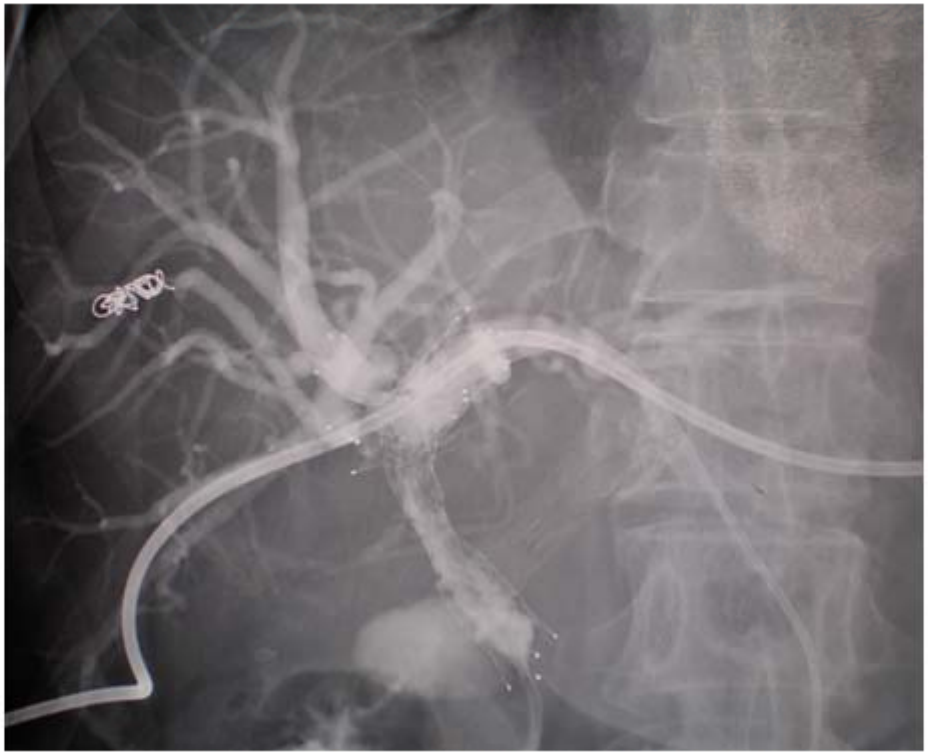

Fig.3

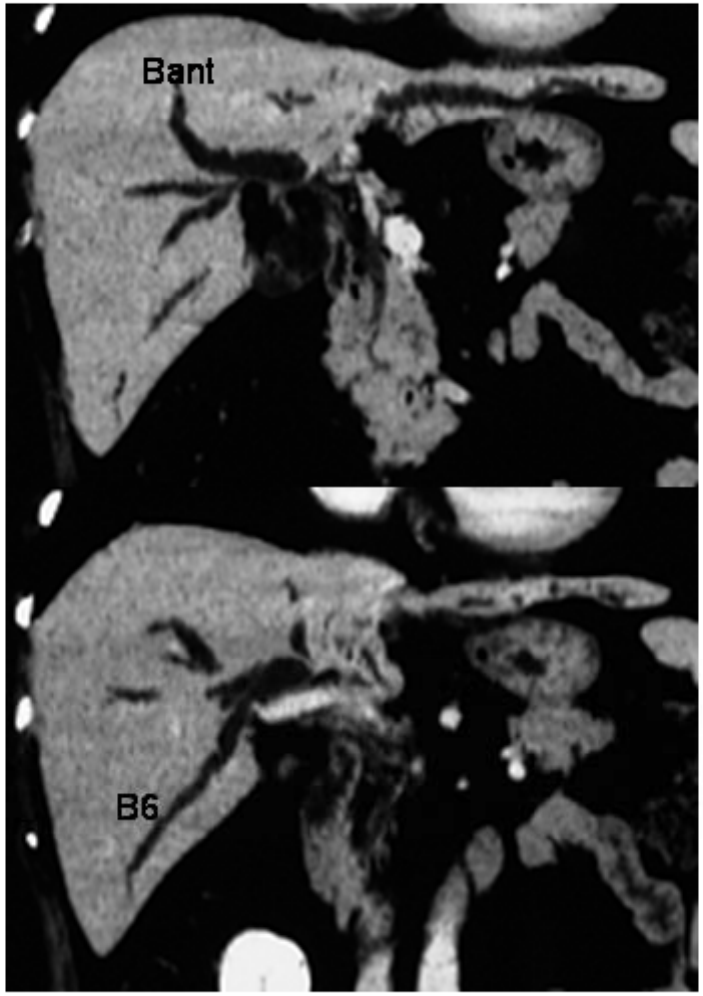

Fig.4a

Fig.4b


H
RES/SHADE/SURF
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CRAN/CAUD 0
R
L
A
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F