

DOUBLE CONTRAST PERCUTANEOUS TRANSHEPATIC CHOLANGIOGRAPHIC CT IN PATIENTS WITH OBSTRUCTIVE JAUNDICE: AN INITIAL EXPERIENCE OF SEVEN CASES

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Purpose: To explore the technical feasibility of double contrast percutaneous transhepatic cholangiographic CT (DC-PCT-CT) in patients with bile duct obstruction.

Methods: Seven patients with bile duct obstructive diseases were studied, including 5 males and 3 females, ranging in age from 24 yrs to 74 yrs (average: 47.7 yrs). There were 5 cases of hilar cholangiocarcinoma, 1 case of sclerosing cholangitis, and 1 case of malignant transformation of adenoma at the distal end of the common bile duct. PTC was carried out initially, involving injection of 30ml 4.5-6.0mg/ml iohexol. After the bile duct system was filled, CT scan was performed, and further followed by enhanced CT with intravenous injection of 300mg/ml contrast agent. Arterial phase, venous phase, and parenchymal phase acquisitions were obtained. Raw CT images were viewed and multiplanar reconstruction (MPR), maximum intensity projection (MIP), and volume rendering (VR) image post-processing were performed.

Results: DC-PCT-CT was performed successfully and bile duct drainage was carried out. Mild lesion enhancement was demonstrated in three cases in arterial phase, while all seven cases demonstrated enhancement of various degrees in venous phase. The lesions lead to track-like, asymmetrical or irregular bile duct obstructive narrowing, and in one case intra-luminal filling defect. Reliable diagnosis was suggested in all cases. MPR, MIP and VR images were useful in demonstrating precise lesion location and for surgical planning.

Conclusion: In patients with bile duct obstruction, DC-PTC-CT is a feasible technique offering both important diagnostic value and drainage application.

Key-words: Bile ducts, stenosis or obstruction – Jaundice.

Jaundice caused by bile duct obstruction is common clinically. Its diagnosis and further surgical planning depends on imaging investigation. A number of noninvasive or invasive modalities are available for imaging of the biliary tract. Ultrasound is commonly used for assessing biliary duct diseases (1-3). It is, however, user-dependent and the captured images are not easily understood by clinicians. Endoscopic retrograde cholangiopancreatography (ERCP) is often regarded as the gold standard for visualizing biliary duct diseases. However this modality is invasive, user-dependent and may induce pancreatitis. It should therefore not be performed in patients where intervention is not certain (4, 5). Used widely prior to 1980s, percutaneous transhepatic cholangiographic (PTC) was an established technique for diagnosis of bile duct obstructive diseases (6, 7). With the introduction of advanced CT and MRI technologies, particularly with the application of MR cholangiography (MRC), ERCP and PTC are used

less frequently for diagnostic purpose. MRC does not require any contrast agent to visualise the bile ducts, and dilatation and gallstones in the common bile duct are easily detected, the images are appreciated by the surgeons for surgical planning (8-11). Unfortunately, MRC cannot be performed in all patients and hospitals due to limited availability of MRI or due to contraindications. MRC is also often inconclusive in patients with air in the biliary system, e.g. after papillotomy or liver surgery with entero-hepatic anastomoses. Surgical clips after cholecystectomy may also give artefacts.

3D imaging is useful for assessing the complex structure of the biliary tree. The normal-sized biliary tract can be adequately depicted during 3D spiral CT cholangiography, facilitating the detection of biliary variations that might increase the risk of duct injury during cholecystectomy, particularly laparoscopic cholecystectomy (12). The use of a cholangiographic contrast agent increases the contrast between bile ducts and

surrounding structures and between bile and most hypodense stones (12). CT cholangiography has not been commonly used due to the low resolution of single detector CT in the past and reports of adverse events after injection of biliary contrast agent (13, 14). The introduction of helical CT and multi-detector CT has renewed the interest for CT cholangiography because of the ability to obtain thin slices without misregistration and high-resolution reconstructions of the biliary tree (15). The number of adverse reactions with biliary contrast media has been reduced by drip infusing the contrast media instead of injecting. Drip infusion with an infusion rate of the biliary contrast agent adjusted according to the serum bilirubin value has been reported to be safe in patients with and without impaired biliary excretion (16). It was concluded that drip infusion CT cholangiography is a fast and widely available alternative technique to visualise hepatobiliary disease in patients with an inconclusive ultrasound and when MRI cannot be performed (16-19). It is less expensive and quicker than MRC. Nowadays, with the advances in CT technology such as thin-section, single-breath-hold helical CT and three-dimensional and multiplanar reformation reconstruction techniques, the resolution of CT cholangiography tends to exceed that of MR. It has been

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reported that the main advantage of CT cholangiography to MRI and MRC was the superior mapping of the biliary tree (20), in other respects the two modalities were considered equivalent for the therapeutic planning (21).

Gaining access to the biliary tract by minimal invasive image-guided techniques is one of the most used procedures for interventional radiologists to manage biliary bile duct obstructive diseases. For patients with obstructive jaundice requiring bile duct decompression and drainage, we explored the diagnostic value of double contrast CT with percutaneous transhepatic cholangiography together with intravenous contrast agent injection. We termed this technique double contrast percutaneous transhepatic cholangiographic CT (DC-PTC-CT). Our initial clinical experience with DC-PTC-CT is reported in this paper.

Materials and methods

DC-PTC-CT was carried out in seven cases, composed of five males and two females, aged 24-74 yrs (mean: 47.7). These seven cases included 5 cases of hilar cholangiocarcinoma, one case of sclerosing cholangitis, and one case of malign-

ant transformation of adenoma at the distal end of the bile duct. The patients had highly elevated serum bilirubin. The detailed information of these 7 cases is listed in table I.

Before procedures, prothrombin time and platelet count were checked to be in competent range. All patients received broad-spectrum antibiotics. PTC was performed with the guidance of an X-ray DSA unit. The puncture site was right mid-axillary 8th-9th rib space. Under local anaesthesia, a small cut was made to the skin. Then the puncture needle was introduced horizontally toward vertebrae 11 and 12, and stopped when the needle tip reached a distance of 2 cm to the right border of vertebrae. Diluted contrast material was gently infiltrated while retracting the needle until a bile duct was opacified. A micro-guidewire was introduced via the puncture needle to one of the major intra-hepatic biliary duct or the common biliary duct, and a catheter was introduced for contrast agent injection and the micro-guidewire was removed. When the bile duct system was filled with contrast agent satisfactorily under DSA fluoroscopy, the catheter position was fixed, and the patient underwent CT examinations. The contrast agent for PTC was iohexol

["Ominpaque 300", GE] diluted with normal saline to 4.5-6.0 mg/ml (density: 200 Hu) in six cases. In one initial case (case 1), a higher concentration (30 mg/ml) was used resulting in beam hardening CT artefact.

After the filling of contrast agent in the bile duct system, CT was performed before and after intravenous contrast agent administration. For intravenously contrast enhanced CT, Iohexol (300 mg/ml) of 1.5 ml/kg body weight was used. The total contrast volume was 70-120 ml, injected at the rate of 3-5 ml/sec. The completion of contrast agent injection was followed by a flush with 30-50 ml normal saline at the same rate. Bolus tracking technique was used for arterial phase acquisition, a region-of-interest (ROI) was placed on the aorta just above the diaphragm. Acquisition was started 6 sec later than the threshold reached 120 Hu. Venous phase was performed 15 sec after the arterial phase. Delayed phase acquisition was obtained 3-5 min later. CT was performed with a Toshiba Aquilion 16 slices scanner, using a standard abdominal protocol with FOV of 40 cm*40 cm, collimation of 1-mm, and a pitch of 0.9.

CT image post-processing was performed with Vitrea 2 Imaging Software (Vital Images, Minneapolis,

Table I. — General information of the seven patients who underwent double contrast percutaneous transhepatic cholangiographic CT.

	sex	age	Symptoms	Serum total bilirubin*	Final diagnosis
Case 1	F	33	Cutaneous and sclera jaundice, yellow urine for two weeks	176.5 µmol/L	Hilar cholangiocarcinoma
Case 2	M	74	Cutaneous and sclera jaundice, yellow urine for 10 days	52.4 µmol/L	Hilar cholangiocarcinoma
Case 3	M	43	Recurrent upper abdominal discomfort with sclera jaundice and yellow urine for 1 month	21.2 µmol/L	sclerosing cholangitis
Case 4	F	48	Recurrent upper abdominal pain for 1 month Progressive jaundice 9 days.	52.4 µmol/L	Hilar cholangiocarcinoma
Case 5	M	51	Progressive jaundice for > one month	315.7 µmol/L	Hilar cholangiocarcinoma
Case 6	M	61	Recurrent fever, with progressive sclera jaundice and yellow urine for > one month	100.9 µmol/L	Malignant transformation of adenoma at the distal end of the common bile duct
Case 7	M	24	Two years post colon cancer surgery. Progressive jaundice for two weeks	18.2 µmol/L	Hilar cholangiocarcinoma

* reference value in authors' institution < 9 µmol/L.

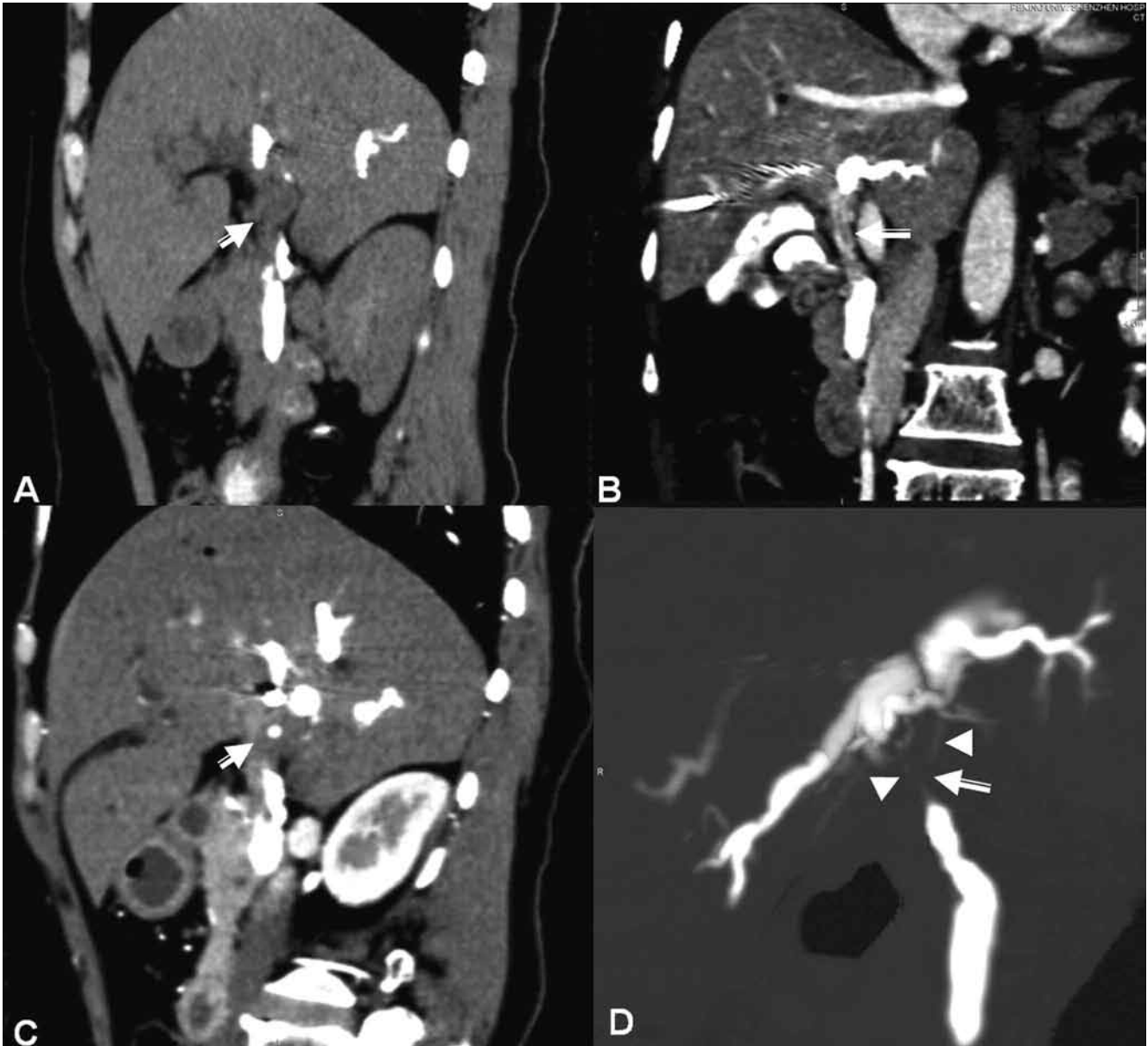


Fig. 1. — Case 4. 48-year-old female. Hilar cholangiocarcinoma involving left and right hepatic duct. (A). Percutaneous transhepatic cholangiographic CT demonstrates blockage of hilar hepatic duct. (B). Contrast CT arterial phase demonstrates mild enhancement of thickened hilar common hepatic duct wall. (C). Venous phase demonstrate marked enhancement of thickened hilar common hepatic duct wall and irregular lumen narrowing. (D). Volume rendering image demonstrates the hilar common bile duct blockage (arrow) and involvement of right and left hepatic ducts (arrow heads).

MN, USA). The reconstructed images had a slice thickness of 1 mm. Maximum intensity projection (MIP), multi-planar reconstruction (MPR), and volume rendering (VR) images were reviewed in addition to source images.

All the seven cases had percutaneous transhepatic cholangiographic drainage treatment. For this, a standard guidewire was introduced through the cholangiographic catheter. The cholangiographic catheter was removed and a biliary drainage catheter drainage catheter

was introduced through the guidewire. The guidewire was removed. The drainage catheter was fixed for external drainage.

In our series, in one case with severe jaundice, DC-PTC-CT was performed three days after the initial drainage, and surgery was performed one week later.

Results

In the first case of our series, as PTC catheter was introduced too deeply to superior segment of right

posterior hepatic duct, and too high concentration of contrast agent was used, the cholangiographic results were not optimal. However, the lesion location and lesion diagnosis were still being able to be made. The remaining six cases had satisfactory double contrast PTC-CT.

PTC-CT demonstrated dilated intra-hepatic bile duct for all seven cases, the lesion cannot be clearly shown (Fig. 1A, 2A). With DC-PTC-CT, the lesion locations can be demonstrated precisely i.e. 5 cases in the bile duct at hepatic hilum level,

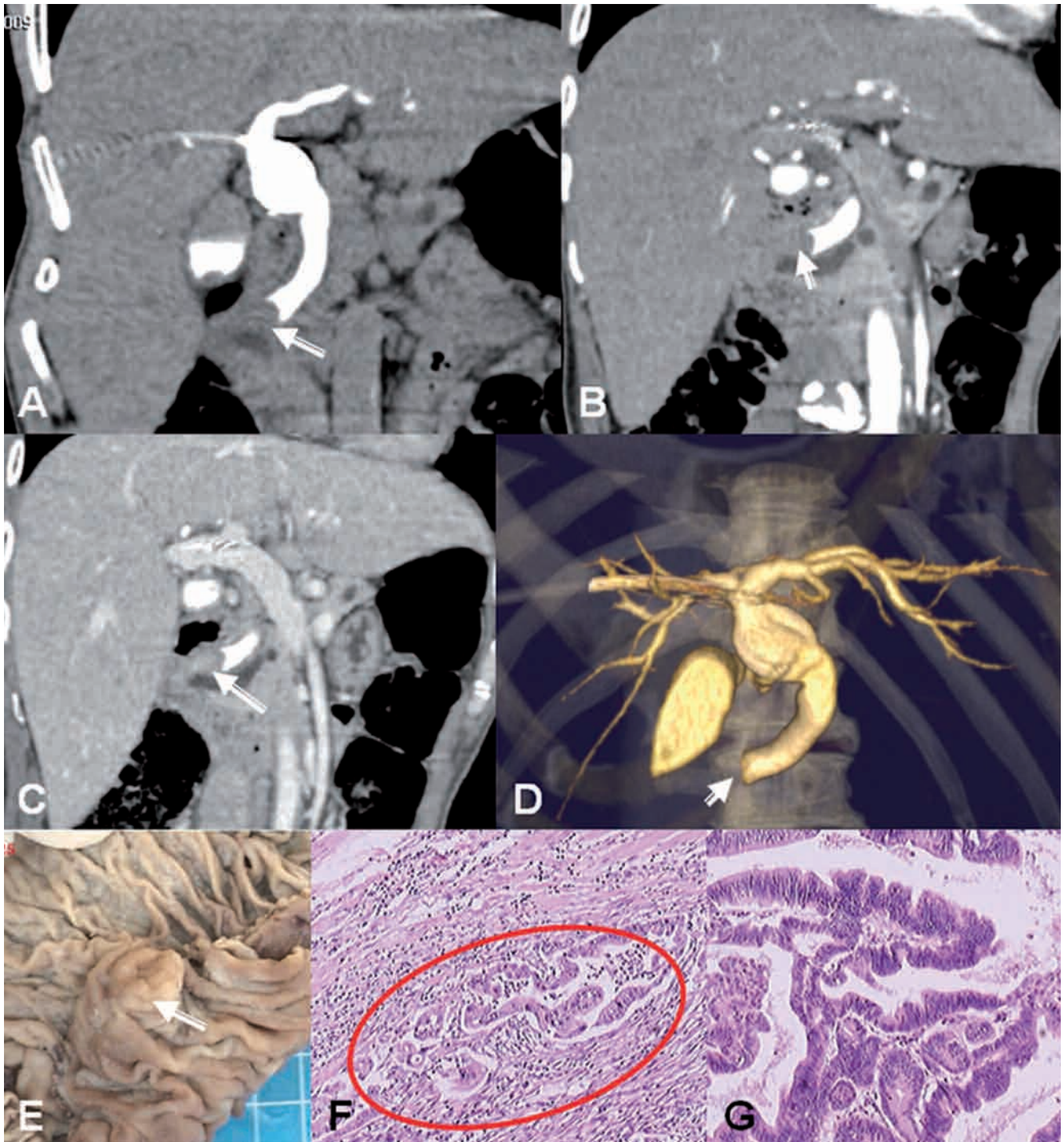


Fig. 2. — Case 6. 61-year-old female. Malignant transformation of adenoma at the distal end of the common bile duct. (A): Percutaneous transhepatic cholangiographic CT demonstrates distal common bile duct oval filling defect and dilatation of pancreas duct (arrow). (B): Double contrast CT arterial phase demonstrates mild enhancement of the lesion (arrow), with Hounsfield value increased by 15 Hu compared with pre-enhancement image. (C): Double contrast CT venous phase demonstrates marked enhancement of the lesion (arrow), with Hounsfield value increased by 28 Hu compared with pre-enhancement image. (D): Volume rendering image demonstrates blockage of the distal common bile duct (arrow) and upstream symmetrical dilation of the bile duct system. (E): Surgical specimen shows the small mass lesion (arrow). (F): Microscopic photograph of the resected specimen shows hyperplasia of mucous membrane in a villous adenoma shape, blockage of glandular tube, and infiltration of interstitial lymphocytes. (G): Zoomed-in image of G, Hyperplasia of local mucous membrane in a villous adenoma shape.

1 case involve both intra- and extra-hepatic bile duct (case 3), and 1 case at the distal end of the common bile duct (case 6).

In 3 cases, arterial phase contrast CT showed lesion mild enhancement (Fig. 1B, Fig. 2B). In the other 4 cases, there was no apparent

enhancement in arterial phase. Venous phase contrast CT demonstrated enhancement of lesion with various degrees for all the seven

cases (Fig. 1C, 2C). DC-PTC-CT, demonstrated track-like bile duct wall thickening with lumen narrowing in 3 cases (case 1, 5, 7), epicentral or irregular bile duct wall thickening with lumen narrowing in 2 cases (case 2, 4), symmetrical bile duct wall thickening with lumen narrowing in 1 case (case 3), and intraluminal filling defect in one case (case 6). There was no apparent enhancement for all the 7 cases in parenchymal phase. With three cases of hilar cholangiocarcinoma, tumour infiltration of the surrounding liver was observed.

In all cases, MPR and MIP images helped demonstrate the lesion and precise locations of these lesions. While VR was able to demonstrate the location of the lesion, it could not demonstrate the bile duct wall and extra-mural lesion, nor the lesion within the lumen. On the other hand, although the bile duct system and remnant anatomy could be easily deduced on the transverse source and MPR and MIP images, they were it depicted in its entirety most clearly on the VR images (Fig. 1D, 2D).

In all seven cases, clinical symptom improved with the drainage, and in all cases, correct diagnosis was suggested and later confirmed with later surgery or follow-up. No case had adverse reactions during the DC-PTC-CT procedure.

Discussion

Bile duct system is small in size with high tortuosity in its course. Although there are a number of techniques to demonstrate the bile duct, most are good at demonstrating the location of obstruction and the changes within the lumen while cannot demonstrate the bile duct wall itself well. Some techniques suffer from sub-optimal spatial resolution. Ultrasound can demonstrate dilatation of the bile duct system, but it is can be of limited value in lesion diagnosis and differential diagnosis, and often is inconclusive for hilar lesions. Of the 7 cases in this study, all underwent ultrasound test initially. However, none of the cases ultrasound was able to diagnose the nature of lesion. X-ray PTC and ERCP demonstrate the bile duct system proximal or distal to the obstruction and intra-luminal changes, however, they cannot demonstrate the changes in the wall and extra-mural changes. In some cases due to sub-optimal spatial resolution and respiration artifacts, MRI/MRC may not

demonstrate periductal-infiltrating lesions well.

With DC-PTC-CT, high resolution CT image can demonstrate the bile duct wall and extra-luminal changes including the changes in the surrounding liver parenchyma. Intravenously enhanced CT can demonstrate the blood supply status of the lesion. After filling of contrast agent in the bile duct, MPR and MIP can demonstrate symmetrical or asymmetrical track-like, tapering narrowing, or abrupt narrowing of the bile duct wall and lumen. When lesion infiltrate extra-murally or infiltrate surrounding liver parenchyma, extra-mural lesion enhancement can be observed.

DC-PTC-CT can be helpful in lesion differential diagnosis. There are many causes with bile duct obstruction, with the common ones being stone, cholangiocarcinoma, and cholangitis. When stones contain sufficient calcium, CT is also able to make the diagnosis. However, CT has difficulties in demonstrating negative biliary stone. Concentrated biliary fluid may also demonstrate stone-like appearance. With stones of mixed components and irregular shapes, particularly with surrounding secondary inflammation, it is difficult for MRC or CT to make correct diagnosis. Combined with 3D image post-processing techniques, DC-PTC-CT is able to provide information of lesion's blood supply, growth pattern and lesion extent, and is able to make a more accurate differential diagnosis. Lesion enhancement excludes bile duct stone. In case 6 in this series, PCT CT demonstrated filling defect within bile duct lumen, and diagnosis was not able to be made. Double contrast CT indicated there was lesion enhancement. A diagnosis of adenoma or adenocarcinoma was reached.

Through the experience of this series, we found that the success and quality of DC-PTC-CT depend on successful catheter induction, proper concentration of contrast agent, and skilled image reconstruction. The concentration of contrast agent for PTC is important for quality demonstration of bile duct system in CT. Too high concentration can lead to artefact, while too low concentration does not fulfil the purpose of contrast. The experience gained from this series is 4.5-6.0 mg/ml solution is suitable for CT contrast.

DC-PTC-CT also offers the drainage treatment for jaundice. Patients with obstructive jaundice

tend to have various degrees of liver function compromise. In addition to fulfill the purpose of diagnosis, particularly for the patients with selective surgery plan, drainage treatment for jaundice can help improve liver function, and lead to lower mobility or mortality (22, 23). In all our cases, clinical symptom improved with the drainage after DC-PTC-CT procedure.

There are a few limitations with DC-PTC-CT technique. PTC-CT is an invasive technique also involving radiation. In our institution, PTC under the guidance of DSA and CT scans were performed in the separate units of radiology department. To move the patient from DSA unit and CT unit is not convenient. This difficulty can be overcome with an interventional CT unit where a CT scanner and a radiofluoroscopic system are combined together.

In conclusion, the technical feasibility and clinical application of DC-PTC-CT in bile duct obstruction patients was explored in this study. DC-PTC-CT can provide mapping of the biliary tree and a reliable diagnosis. Particularly, DC-PTC-CT is suitable for patients with severe jaundice and bile duct drainage is part of the therapeutic plan. In terms of diagnostic performance, further head-to-head comparison with other techniques such as MRI/MRC remained to be carried out.

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