Clinical Research Paper

Application of multislice spiral CT angiography on transcatheter arterial chemoembolization for hepatocellular carcinoma

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Key words: liver neoplasm, tomography, X-ray computed, postprocessing technology, angiography, chemoembolization

Background and Objective: Multislice spiral CT angiography (MSCTA) is very important in the diagnosis and treatment of liver diseases. Currently, most studies on three-dimensional MSCTA of the liver vascular system focus on the liver tumors, preoperative assessment of liver transplantation and the systematic anatomy of the liver vascular system. This study was to investigate the clinical application of MSCTA on transcatheter arterial chemoembolization (TACE) for hepatocellular carcinoma (HCC) by comparing images of MSCTA and digital subtraction angiography (DSA). Methods: MSCT dual-phase enhanced scanning was performed in 50 patients with advanced HCC. Both hepatic artery angiography and portal vein angiography were conducted using maximal intensity projection (MIP) and volume rendering technique (VRT). DSA of the celiac artery, superior mesenteric artery, renal artery and diaphragm artery, as well as TACE were performed in all patients. MSCTA and DSA images of the 50 patients were compared. Results: MSCTA and DSA showed equal detectability in revealing classification of the hepatic artery anatomy and tumor blood vessels, with a coincidence of 100% (p = 1.00). However, MSCTA was superior to DSA in displaying arterioportal shunt and portal vein tumor thrombus. Conclusions: As a noninvasive and easy to conduct technique, MSCTA can accurately provide information of the hepatic artery, portal vein and tumor supply vessels. Therefore MSCTA has a favorable value to guide TACE for HCC.

Multislice spiral CT angiography (MSCTA) has characteristics of fast scanning speed, large cover area, clear imaging of hepatic vessels, three-dimensional (3D) display from multiple angles and so on; thus, it is of great importance in the diagnosis and treatment of hepatic diseases. Currently, most studies on 3D MSCTA of the liver vascular system primarily focus on hepatic tumors, preoperative assessment of liver transplantation and anatomical analysis of the hepatic vascular system. There are only a few reports on the application of MSCTA on transcatheter arterial chemoembolization (TACE) for hepatic carcinoma.1-5 In this research, we compared MSCTA and digital subtraction angiography (DSA) images of patients with hepatocellular carcinoma (HCC), and investigated the clinical application of MSCTA on TACE for HCC.

Data and Methods

Clinical data. From June 2005 to March 2007, 50 patients with HCC were admitted in the Sun Yat-sen University Cancer Center. There were 39 cases of males and 11 cases of females, aged 24-77 years, with a medium age of 54.6 years. Twenty-seven patients were initially treated, 15 patients received TACE only once and eight patients received TACE twice or above. The morphological classification of HCC included 28 cases of massive type, 17 cases of nodular type and five cases of diffuse type. The diameters of tumor were around 3.5 cm to 13.5 cm, with an average of 6.5 cm. Thirty-seven cases had the hepatic lesion located in the right lobe, while 13 cases had the lesion located in the left lobe. Forty-four cases were diagnosed as HCC by typical presentations detected by CT or MRI, and six suspected cases were pathologically confirmed by biopsies.

Techniques and methods. CT scanning and reconstruction. The Philips BrillianceTM 16-slice spiral CT scanner was used. Before scanning, patients were required to drink 800 to 1,000 ml warm water to fully fill the stomach and duodenum. After regular scanning of the liver, MSCT dual-phase enhanced scanning was performed. Using an automatic high pressure injection apparatus, the contrast agent, 300 mg I/ml iopamidol injection (Bracco, Italy), was administered via the median cubital vein at a speed of 4 ml/s. The thickness of the scanned layer was 5 mm, the scanning voltage was 120 kV and the current was set at 300 mAs. At 25 s to 30 s after injection, patients were requested to hold their breath during the scanning of the entire liver, which was defined as the arterial period. At 60 s to 65 s after injection, patients were requested to hold their breath during the scanning of the entire liver.
Liver, which was defined as the portal period. The obtained raw data were used for reconstruction to have a layer thickness of 2 mm, a layer interval of 1 mm and a matrix of 512 x 512. Hepatic artery angiography and portal vein angiography were conducted using maximal intensity projection (MIP) and volume rendering technique (VRT).

**Angiography.** A DSA instrument (Toshiba, model number 8000) was used. A catheter was inserted through a puncture in the femoral artery and DSA was performed for abdominal arteries, superior mesenteric artery, renal artery and phrenic artery. Iopamidol (21–28 ml) was injected using a high-pressure injection apparatus at a speed of 7 ml/s to 8 ml/s.

**Assessments of images.** Three-dimensional reconstruction of the blood vessels was uploaded to picture archiving and communicating system (PACS) for two experienced radiologists to analyze and assess. Images of DSA were analyzed by doctors from the Department of Imaging and Interventional Radiology. Assessment indices included structural and anatomical classification of hepatic arteries, the source of supplying blood vessels for the tumor, direct or collateral blood supply by the hepatic artery and portal vein anatomy and the involvement of the portal vein. The anatomy of hepatic arteries was categorized into ten types according to the Michels classification.6

**Statistical analysis.** Using DSA as the gold standard, anatomical classification of hepatic arteries and the source of blood supply for tumors displayed by MSCTA were compared with those displayed by DSA, and the conformity between the two methods were analyzed. Data were processed using SPSS 11.0 software. The $\chi^2$-test with the RxC table of diffuse variables was used. The consistency test was performed using calculated Kappa indices. $p < 0.05$ indicated statistical significance.

**Results**

**Anatomical classification of hepatic arteries.** Among 50 HCC patients, 46 cases matched the anatomical types of hepatic artery in Michels classification, among which 32 cases (64%, 32/50) were of type I, seven cases (14%, 7/50) were of type II, three cases (6%, 3/50) were of type III, one case (2%, 1/50) was of type V, one case (2%, 1/50) was of type VII, one case (2%, 1/50) was of type VIII and one case (2%, 1/50) was of type X (Table 1). Four cases did not match the Michels classification (8%, 4/50). The median hepatic arteries of two patients were seen arising from the gastroduodenal artery, and the communicating arteries of the gastroduodenal artery and the right hepatic artery were seen originating from the superior mesenteric artery in the other two patients (Fig. 1). All the above findings were completely matched (100%) with those displayed by DSA. The variation between the two methods had no statistical significance ($p = 1.00$).

**Origin of tumor feeding arteries.** Forty-six cases of HCC had apparent feeding arteries, among which 38 cases (83%, 38/46) were of type I, seven cases (15%, 7/46) were of type II, three cases (6%, 3/46) were of type III, one case (2%, 1/46) was of type V, one case (2%, 1/46) was of type VII, one case (2%, 1/46) was of type VIII and one case (2%, 1/46) was of type X (Table 1). Four cases did not match the Michels classification (8%, 4/50). The median hepatic arteries of two patients were seen arising from the gastroduodenal artery, and the communicating arteries of the gastroduodenal artery and the right hepatic artery were seen originating from the superior mesenteric artery in the other two patients (Fig. 1). All the above findings were completely matched (100%) with those displayed by DSA. The variation between the two methods had no statistical significance ($p = 1.00$).
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Figure 2. Images of HCC fed by the right inferior phrenic artery (IPA) after transcatheter arterial chemoembolization (TACE). (A) MIP image shows various branches of the abdominal artery and the HCC compactly laden with lipiodol (arrow) from the first session of TACE. (B) Celiac angiogram shows staining of an extensive hypervascular tumor. No staining of the tumor (arrow) appears at the dome of the right hepatic lobe. (C) Celiac angiogram shows the right IPA (arrow) originating from the celiac trunk. (D) The staining of the hypervascular tumor (arrow) is corresponding to the non-staining region on the celiac angiogram. MIP, maximal intensity projection.

Display of arteriportal shunt (APS). MIP images of MSCTA and DSA images both showed 12 cases of APS, in which four were the central type and eight were the peripheral type. The characteristic manifestations of these two methods were consistent (Fig. 4).

Display of portal vein tumor thrombus (PVTT). Infiltration of tumors into the portal vein can be classified into several types, including embedment, compression and tumor thrombus formation. Radiological presentations include interruption, stenosis and filling defect. Portal vein involvement was identified in 15 patients, the portal vein was not clearly displayed due to tumor thrombus in 13 cases and the portal vein was compressed by the tumor in two cases. In 13 cases of PVTT, three cases had tumor thrombus in both the primary branch and the left/right branch of the portal vein, two cases had tumor thrombus in the left branch of the portal vein, five cases had tumor thrombus in the right branch of the portal vein and three cases had the tumor embedded in the right branch of the portal vein. Five cases had cavernous transformation in the portal vein of HCC. The primary branch of the hepatic portal vein was interrupted or shrunken, and many winding collateral vessels surrounding the portal vein were expanded to develop cavernous transformation (Fig. 5). The PVTT displayed by DSA mainly showed a filling defect or a thread-like sign of the primary branch and closed branches of the portal vein. Portal vein images, especially the images of side branches of grade below 2 or 3, of some patients were faint and not well displayed by DSA, as compared to 3D MIP reconstruction images.

Discussion

Significance of MSCTA in hepatic artery catheterization. There are many anatomical variations of the hepatic artery, which is classified into 10 types by Michels. Type I is the typical hepatic artery anatomy, accounting for approximately 55% of all types. The other nine types are variations, accounting for approximately 45%. The origin of feeding arteries in HCC varies. Besides normal blood supply by the hepatic artery, the incidence rate of blood supply by variant hepatic arteries is around 15 to 24%. In this study, MIP and VRT images of MSCTA clearly displayed the beginning and the flow pattern of the hepatic artery in 50 HCC patients. The results were 100% consistent with the findings exhibited by DSA. Therefore, before designing interventional therapy and conducting TACE, it is necessary to examine MIP and VRT images of MSCTA to completely understand the anatomy and variations of the hepatic arteries, thus to achieve a better therapeutic effect. Because it is difficult for DSA to clearly reveal the filling defect in stained tumor tissues and completely display tumor feeding arteries, it is required to perform DSA on each possible blood supply route, if the anatomy or variation of the
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HePatic artery and the entire blood supply of HCC have to be displayed. MSCTA is a non-invasive approach, with fast scanning speed and clear reconstruction images. Additionally, MSCTA can reconstruct MIP and VRT vascular 3D images to entirely reveal the blood feeding arteries for HCC, to display the hepatic artery, the portal vein and the hepatic venous system from multiple angles, which is important in guiding artery catheterization of variant feeding vessels and embolization during TACE therapy for HCC (Figs. 1 and 2).

**Significance in displaying hepatic APS.** HCC can easily invade the portal vein and cause APS. APS is an abnormal pathway formed between the hepatic artery and the portal vein. There are two types of APS: central APS and peripheral APS. The central type is presented with the appearance of the primary portal vein branch during the arterial period, or stained tumor after the development of the portal vein. This type of APS has a high flow rate and high-capacity. The peripheral type is presented with the manifestation of a portal branch in parallel along the artery during the arterial period, which is also known as the “double track” sign. Peripheral APS has a low flow rate and low-capacity. The diagnosis and flow rate of APS have great influence on the design for interventional therapy of HCC. Determination of central APS is extremely important, because the high capacity of APS could induce or worsen high pressure in the portal vein, thus to cause in hemorrhage in the upper digestive tract and ascites. The interventional therapy for HCC with central APS is to use coaxial microcatheterization for TACE before coil and gelfoam particles with ethanol are used to seal the fistulae. This method not only benefits TACE therapy, but also definitely reduces high pressure in the portal vein and improves the hepatic function. The accuracy of MSCTA for the diagnosis of central APS is as good as DSA, with the sensitivity, specificity and accuracy rates of 100%, 95.2% and 96.4%, respectively.

**Significance in displaying PVTT.** Zhang et al. believe that for detection of infiltration to the portal vein in HCC, the display of the portal vein by MSCTA is more sensitive and specific compared to DSA, which is a indirect trans-arterial approach. MIP 3D vascular reconstruction of the portal vein allows direct assessment of the portal vein position, diameter of the portal vein and the degree of thrombosis. MSCTA can clearly display tumor infiltration into the portal vein and other conditions, such as compression/dislocation of portal vein branches, interruption and occlusion, filling defect of the portal vein and low density tumor thrombus. Also, MSCTA makes it possible to directly observe portal vein obstruction, as well as the cavernous degeneration and conditions of the collateral circulation. In this study, multislice CT during arterial portography (MSCTAP) of two patients showed cavernous degeneration in the portal vein caused by tumor.
thrombus in the primary branch, while an abundant collateral circulation from adjacent tissues were observed. Satisfactory therapeutic effects were achieved for these patients after interventional therapy with TACE. However, the prognostic outcomes were poor for patients with tumor thrombus in the primary branch of the portal vein, but without the collateralcirculations. When a tumor thrombus is located at the portal vein segment, it is an absolute indication for TACE therapy. Superselective catheterization should be applied to perform TACE at the hepatic segment or the sub-segment. When a tumor thrombus is situated in the primary branch or in branches of grade 1, it is considered a contradiction for TACE therapy. However, recent studies have shown that if the tumor thrombus does not completely block the primary branch of the portal vein, or the hepatic collateral circulation is formed although the thrombus completely blocks the branch, TACE therapy can be considered to perform, especially when the tumor lesion is limited to a segment of the liver. Segmental TACE therapy is safe and has certain therapeutic efficacy on PVTT.

Guidance for designing further treatment plans after TACE therapy for HCC. After multiple trials of TACE therapy for HCC, stenosis or collateral supply of the supply artery usually forms, which would become the potential source of blood supply for residual lesions and affect the therapeutic outcome. Common origins of collateral vessels include right internal thoracic artery, right intercostal artery, left gastric artery, right inferior phrenic artery, gastroepiploic artery, superior mesenteric artery and right adrenal or capsular artery. Therefore, when MSCTA exhibits arterial stenosis or collateral blood supply of tumor tissues, angiography and TACE therapy are necessary to perform using a micro-catheter through the external collateral hepatic artery. If MSCTA shows an occlusion in the blood vessel without the formation of collateral branches, physical or chemical ablation is required for the residual lesion of the tumor. In this study, CT and PET/CT images showed residual tumor tissues in four patients underwent two to three trials of TACE therapy. MSCTA displayed an occlusion in the blood supply artery for the tumor. These patients received percutaneous puncture with anhydrous ethanol ablation, which completely eliminated the tumor tissues (Fig. 3).

In conclusion, MSCTA is non-invasive and easy to perform. The 3D reconstruction images give a strong sensation, and are easy for postediting. They make it possible to observe the origin, flow pattern and branches of the hepatic artery from multiple angles, positions and layers, as well as neighboring structures. Additionally, MSCTA helps design interventional therapy for HCC and guide catheterization to improve the therapeutic effect for HCC.

References