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Imaging findings and complications of transcatheter interventional treatments via the inferior phrenic arteries in patients with hepatocellular carcinoma

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ABSTRACT

Objective: To evaluate imaging findings and complications from transcatheter interventional treatment of hepatocellular carcinoma via the inferior phrenic arteries.

Material & Methods: 40 procedures in 25 patients (19 men; age range, 57–89 years) were retrospectively reviewed in this study. In all procedures, a micro-catheter was selectively inserted in the right inferior phrenic artery (n = 39) or left inferior phrenic artery (n = 1), and transcatheter arterial chemoembolization (n = 39) or transcatheter arterial embolization (n = 1) was performed. Imaging findings and patient charts were reviewed, and complications until time of discharge (median hospitalization period, 10.5 days; range, 3–21) were assessed.

Results: On angiography or computed tomography during angiography, collateral circulation from the right inferior phrenic artery to the pulmonary artery was seen in eight of 39 procedures (seven patients, 28%). In seven of these procedures, Lipiodol deposition was seen on the unenhanced computed tomography just after the procedure (post-procedure computed tomography) in the pulmonary arteries or pleura, and in six procedures, the deposited Lipiodol was noted to have spread into adjacent lung fields on the one week follow-up computed tomography. Branches of the right inferior phrenic artery were seen along the right margin of the heart in 18 procedures, and Lipiodol deposition was seen along the right margin of the heart on post-procedure computed tomography in four procedures. Complications occurred in 21 of 39 procedures of right inferior phrenic artery intervention (53%): shoulder pain in 18 (45%), pleural effusion in 14 (35%), basal atelectasis in 11 (28%), paroxysmal atrial fibrillation in two (5%) and hemoptysis in one (3%). In 14 procedures (35.9%), pleural effusion was seen on follow-up computed tomography examinations, and 11 (28.2%) of these procedures also showed basal atelectasis. However, only three procedures with pleural effusion showed Lipiodol deposition on the post-procedure computed tomography. In one patient who underwent transcatheter arterial chemoembolization twice via the right inferior phrenic artery, atrial fibrillation occurred after both procedures.

Conclusions: Transcatheter arterial chemoembolization or transcatheter arterial embolization via the inferior phrenic artery in patients with hepatocellular carcinoma was relatively safe. Shoulder pain was the most frequent complication, and required only conservative treatment. There was no clear connection between pleural effusion or basal atelectasis and collateral circulation from the right inferior phrenic artery to the pulmonary artery depicted on angiography, computed tomography during angiography or post-procedure computed tomography.

1. Introduction

Transcatheter treatment procedures, such as transcatheter arterial chemoembolization (TACE), transcatheter arterial embolization (TAE) and transcatheter arterial infusion (TAI) have been widely used to treat hepatocellular carcinoma (HCC) [1,2]. Since HCCs are occasionally multicentric and frequently relapse after treatment, many patients require repeated treatment to prolong survival time [1,2].

Abbreviations: IPA, inferior phrenic artery; HCC, hepatocellular carcinoma; TACE, transcatheter arterial chemoembolization; TAE, transcatheter arterial embolization; AG, angiography; CT-AG, CT during angiography; CT, computed tomography; CTCAE, Common Terminology Criteria for Adverse Events

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Tumors are generally thought to develop collateral arterial circulation as transcatheter treatment is repeated [3], and HCC protruding from the liver may be fed by extrahepatic arteries even without past treatment [3–6]. In these cases, the interventional radiologist must sometimes treat tumors via various collateral arteries such as the inferior phrenic artery (IPA), internal mammary artery and intercostal artery [3–5,7,8], in addition to the usual treatment via the hepatic arteries. The IPA is the artery most frequently involved in collateral circulation [3–5], and various complications related to transcatheter IPA treatment have been reported [3,5,6,9–15]. Collateral circulation between the IPA and extrahepatic arteries are common and considered a cause of extrahepatic complications [3,5,6,9,15].

The aim of this study was to evaluate the imaging findings–angiography (AG), computed tomography (CT) during angiography (CT-AG), unenhanced CT just after the procedure (post-procedure CT) and follow-up CT–and complications of transcatheter treatment via the IPA in patients with HCC.

2. Material & methods

The institutional ethical committee approved our research protocol. Written informed consent was obtained from all patients before treatment, but informed consent related to this study was waived because of its retrospective nature.

The diagnosis of HCC was made by a combination of imaging findings and evaluation of specific tumor markers, or by needle biopsy. The radiological imaging included contrast-enhanced CT, contrast-enhanced magnetic resonance imaging (MRI) using gadolinium-ethoxybenzyl-diethylenetriamine penta-acetic acid (Gd-EOB-DTPA; EOB·Primovist®, Bayer Yakuhin Co. Ltd., Tokyo, Japan), and ultrasonography with or without contrast media (Perflubutane, Sonazoid®, Daiichi-Sankyo Co. Ltd., Tokyo, Japan). The treatment strategies of HCC were selected through discussion by hepatologists, surgeons, pathologists, diagnostic radiologists and interventional radiologists. Therapeutic chemoembolization was selected based on performance status, hepatic functional reserve, the size or number of tumors and patients' wishes.

A 4- or 5-Fr sheath was inserted in the femoral artery. The celiac artery and superior mesenteric artery was selected with 4- or 5-Fr shepherd hook catheter or cobra catheter and enhanced. We performed CTs during hepatic arteriography (CTHA) and arterial portography (CTAP) in all procedures. Involvement of an extrahepatic artery as an HCC feeding artery was suspected if the HCC was not enhanced on CTHA and CTAP. We evaluated the origin of the IPA before procedures on enhanced CT. The IPA was carefully selected with a 1.9–2.1-Fr micro-catheter (Progreat Σ; Terumo, Tokyo, Japan in most cases) and selective AG was performed. CT-AG via the IPA was performed at the physician's discretion. If the tumor enhanced on AG or CT-AG of the IPA, the IPA was considered to be the feeding artery of the HCC. When performing TACE or TAE, we spared IPA branches that did not feed the targeted tumors as much as possible. TACE was performed by infusing an emulsion of Lipiodol (Fuji Pharma Co., Ltd., Tokyo, Japan) and chemotherapeutic agents (epirubicin (Epirubicin; Nippon Kayaku, Tokyo, Japan), miriplatin (Miripla; Dainippon Sumitomo Pharma, Osaka, Japan), and cisplatin (IA-call; Nippon Kayaku, Tokyo, Japan). Gelatin sponge particles (1mm-Gelpart; Nippon Kayaku, Tokyo, Japan) were frequently used as an adjuvant embolizing agent. When the tumors received additional vascular supply from branches of the hepatic arteries, TACE or TAE via these arteries was also performed in the same session. We did not perform coil embolization of the IPA.

All patients underwent unenhanced CT at the end of the procedure (post-procedure CT) and were carefully monitored in the ward. Follow-up CT of the upper abdomen was usually performed about a week after the procedure to evaluate deposition of Lipiodol in HCC following TACE. Additional CT or plain chest radiographs were obtained when patients developed symptoms such as prolonged fever or decreased 0_2 saturation following procedures.

We searched the interventional radiology reports of transcatheter procedures via IPAs for the treatment of HCC performed in our department from January 2010 to January 2015. We reviewed the imaging findings and patient charts. Complications until discharge were assessed, recorded and classified according to Common Terminology Criteria for Adverse Events (CTCAE) Version 4.0 [16]. In this study, only descriptive statistical analyses were performed.

3. Results

We found 39 TACE procedures and one TAE procedure via the right IPA (n = 39) or left IPA (n = 1) for the treatment of HCC in 25 patients (19 men and 6 women; mean age, 69.9 years; range, 57–89). 35 (87.5%) were classified as Child-Pugh class A, and five (12.5%) as class B at the time of treatment. Five (20%) patients had viral hepatitis B, 12 (48%) had viral hepatitis C, and three (12%) had alcoholic liver cirrhosis. The etiology of liver disease was not proved in 5 (20%) patients.

None of the patients showed any evidence of pleural effusion, pleural thickening or calcification suggestive of old pleuritis, or any evidence of previous thoracic surgery nor trauma on enhanced CT prior to the procedure. Eight (32%) patients had previous surgical resection of the liver. In one case, there was no history of previous TAE or TACE, but all other patients had undergone at least one previous TACE or TAE for HCCs (mean ± SD, 5.0 ± 3.2 times; range, 0–13). The targeted tumors were in segment 7 in 21 (52.5%) procedures, 8 in 10 (25%) procedures, 5 in three (7.5%) procedures, 4 in four (10%) procedures, 3 in one (2.5%) procedure and 1 in one (2.5%) procedure. The size of the tumor ranged 10–151 mm in maximum diameter (34 ± 23.8 mm).

Chemotherapeutic agents used were epirubicin in 22 (55%) procedures (mean ± SD, 28.3 ± 10.2 mg; range, 10–50), miriplatin in 16 (40%) procedures (mean ± SD, 92.8 ± 26.3 mg; range, 30–120), and cisplatin in one (2.5%) procedure (80 mg). The dose of Lipiodol (mean ± SD) was 4.2 ± 1.9 ml (range, 0–10). These volumes were the total dose used for TACE or TAE, and usually less than 20% was used for IPA administration. In 37 (92.5%) procedures, branches of the hepatic arteries were embolized simultaneously with gelatin sponge particles. In 10 (25%) procedures, an additional extrahepatic collateral artery was embolized, such as the intercostal artery (four procedures, 10%), right renal capsular artery (three procedures, 7.5%), right adrenal artery (one case, 2.5%) and right gastroepiploic artery (one case, 2.5%).

The hospitalization period (mean ± SD) was 11.5 ± 4.2 days (median, 10.5 days; range, 3–21). Patients underwent unenhanced (n = 15) or enhanced (n = 25) follow-up CT after the procedures (median, 7 days; range, 4–46).

3.1. IPA AG, CT-AG and post-procedure CT findings

Collateral circulation from the right IPA to the pulmonary artery was depicted on AG and/or CT-AG in eight (20.5%) procedures and in 7 (28%) patients. Three (12%) patients had undergone hepatectomy before interventional therapy to the IPA. In seven of these eight procedures in which collateral circulation was identified, Lipiodol deposition in the pulmonary arteries or pleura was depicted on the post-procedure CT. In six of these procedures, the deposition was seen to have spread into the adjacent lung fields on follow-up CTs (Figs. 1–3). In one procedure, collateral circulation from the right IPA was not depicted on AG or AG-CT, but the post-procedure CT showed Lipiodol deposition in the pleura and the inferior branch of the pulmonary artery.

There was one procedure in which collateral circulation from the right IPA to the pulmonary vein was recognized on AG and AG-CT, but no Lipiodol deposition was seen on the post-procedure CT (Fig. 4).

The pericardiacophrenic artery (a branch of the internal mammary artery) was depicted along the right margin of the heart in 19 (47.5%) procedures (13 patients, 52%) on AG and/or CT-AG, and four of these procedures showed Lipiodol deposition along the right margin of the