European Review for Medical and Pharmacological Sciences 2017; 21: 3549-3553

Multi-detector spiral CT diagnosis of common bile duct ampullary carcinoma

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Abstract. – OBJECTIVE: The aim of this project was to study the imaging characteristics of multi-detector CT (MDCT) in different types of malignant tumor in the common bile duct ampulla.

PATIENTS AND METHODS: We examined 30 cases of pancreatic head cancer, 35 of terminal cholangiocarcinoma, 26 of ampullary carcinoma, and 40 of benign lesions, all confirmed by pathology. We used 64-slice spiral CT plain scan and multi-phase enhanced scan with multi-planar reconstruction (MPR) and curved planar reconstruction (CPR) post-processing to obtain three-dimensional images. From these images, we analyzed intrahepatic and extrahepatic bile ducts, gallbladder and common bile duct dilation, and morphology and enhancement pattern of lesions and surrounding tissue.

RESULTS: The dilatation rate of intrahepatic, extrahepatic bile duct and gallbladder in terminal cholangiocarcinoma was the highest. The double duct sign was most evident in pancreatic head cancer. Ampullary carcinoma fell in between, and the benign lesions had no intrahepatic or extrahepatic bile duct and pancreatic duct dilation. Pancreatic cancer had a larger diameter, a higher internal rate of necrosis, and the surrounding tissues had a higher vulnerability to invasion. Terminal cholangiocarcinoma had a smaller diameter and a thicker wall. Benign lesions showed isodensity and hyperdensity shadow in the lumen, but no other significant changes were observed. Pancreatic head carcinoma had lower enhancement degree than normal pancreatic tissue, no enhancement in the internal necrotic area, and the borderline was unclear. Thickened ductal wall of the terminal cholangiocarcinoma showed equal density, enhancement and commonly delayed enhancement. The enhancement degree was higher than in the cancer of the pancreatic head and slightly lower than in ampullary cancer. Ampullary cancer had a regular margin and a significant enhancement, with enhancement degree higher than in pancreatic cancer and lower than in common bile duct cancer. Arterial and venous phases showed enhancement, but benign lesions did not show enhancement.

CONCLUSIONS: MDCT imaging and post-processing techniques have significant application in the diagnosis of benign and malignant lesions, as well as a malignant tumor of the common bile duct ampulla.

Key Words:
Common bile duct ampulla, Malignant tumor, Multi-detector CT.

Introduction

Pancreatic head cancer, terminal cholangiocarcinoma, and ampullary carcinoma (duodenal papillary carcinoma) are common types of bile duct malignant tumors. The early stages for these tumors lack typical clinical manifestations, which complicate the early diagnosis. When discovered in late stages, these tumors show low surgical resection rates and poor prognoses, with the 3-year survival rate around 30%[1]. The clinical manifestations are mainly biliary obstruction, jaundice, and abdominal pain. Detecting methods include ultrasonography, magnetic resonance cholangiopancreatography (MRCP), endoscopic retrograde cholangiopancreatography (ERCP), percutaneous transhepatic cholangiography (PTC), computed tomography (CT) and cholangiography imaging. ERCP and PTC can directly visualize the biliary tree, obtain tissue specimens for pathological diagnosis (gold standard), and perform interventional therapy[2,3]. However, these are invasive and highly traumatic methods, and usually not considered as the preferred method of examination. Ultrasound imaging is susceptible to intestinal gas interference, which decreases sensitivity and specificity[4]. MRCP is non-radioactive and more sensitive to soft tissue imaging, but shows decreased ability to identify stones, inflammation, and other benign lesions[5]. Multi-detector CT (MDCT) has the advantages of high scanning

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speed, thin slice, high resolution, and isotropy. MDCT can reconstruct the biliary duct three-dimensional shape by combining with multi-phase enhancement and volumetric scan. This imaging method clearly shows the structure of the bile duct and the surrounding soft tissue. This is called negative CT bile duct imaging[6,7]. The aim of this study is to analyze MDCT imaging characteristics for different types of malignant tumors in the common bile duct ampullary region, and to provide a reference for accurately diagnosing early stage tumors, designing therapeutic regimens, and improving survival prognosis.

Patients and Methods

Patients

We examined retrospectively the common bile duct ampullary malignant tumor in the Henan Provincial People's Hospital (Zhengzhou University People's Hospital) pathologically diagnosed by obtaining tissue samples. The Ethic Committee of Henan Provincial People's Hospital approved this study. We analyzed 30 cases of pancreatic head cancer, 35 of terminal cholangiocarcinoma, and 26 of ampullary carcinoma. We also collected 40 cases of benign lesions in the same period, including 28 with stones, 12 with inflammation. 12 males and 18 females had pancreatic head cancer with an average age of 65.6 ± 13.2. The pathological types included ductal adenocarcinoma, clinical stage II (5 cases), stage III (13 cases), stage IV (12 cases). 15 cases showed poor differentiation, 9 with moderate differentiation, and 6 were well differentiated. Clinical manifestations were mainly jaundice, fever, and abdominal pain. Of the terminal cholangiocarcinomas, 20 were males and 15 females with an average age 63.5 ± 12.8 years. The pathological types included different stages of bile duct epithelial cell carcinoma: 6 cases in clinical stage II, 14 in stage III, and 15 in stage IV. 16 cases had poor differentiation, 14 moderate differentiated, and 5 were well differentiated. The clinical manifestations were mainly biliary obstruction, jaundice, and liver dysfunction. We examined 14 males and 12 females with ampullary carcinoma with an average age of 65.6 ± 14.7 years. The pathological types included different stages of adenocarcinoma: 4 cases in clinical stage II, 13 stage III, and 9 in stage IV. 12 cases had poor differentiation, 11 moderate differentiation, and 3 were well differentiated. The clinical manifestations were mainly abdominal pain, nutritional disorders, and intestinal obstruction. Benign lesions were diagnosed in 22 males and 18 females, with an average age of 60.86 ± 15.5 years. The clinical manifestations were biliary obstruction, jaundice, fever, and abdominal pain. There was no significant difference in sex and age distribution of patients with different types of lesions ($p>0.05$).

Research Methods

United States GE Lightspeed 64 slice spiral CT scanner, ADW4.2 post-processing station and double-syringe high-pressure injector were used. Scanning range was from the top of the right diaphragm to the lower pole of both kidneys. Conventional scanning parameters were set at slice thickness 5 mm, layer spacing 5 mm, 120 kV, 250 mA, pitch 1.5, bulb tube rotation time 0.8 sec 100 mL enhancing contrast agent Ultravist 370 was injected via intravenous bolus injection at a rate of 3.0 mL/sec, arterial, venous phase and equilibrium phase scanning were performed at 35, 80, and 180 sec delay with the same scan parameters as above. The data were input into post workstation and performed with thin-section reconstruction using multi-planar reconstruction (MPR) and surface reconstruction (CPR), parameters were set at 1.25 mm slice thickness and 1.25 mm slice increment. The research was divided into image scanning group, post processing group, imaging analysis group and data statistics group, each group had 2-3 professionals.

Observation Indexes

We analyzed image quality, focusing on dilatation of intrahepatic and extrahepatic bile duct, gallbladder and common bile duct, and morphology and enhancement pattern of lesions and surrounding tissues. We selected images without artifacts, clearly showing bile duct and surrounding structures.

Statistical Analysis

Statistical analysis was carried out using SPSS20.0 software (SPSS Inc., Chicago, IL, USA). Measurement data were expressed as mean ± standard deviation, single-factor ANOVA was used to compare two groups, The LSD-t method was used to compare between every two. Enumeration data were expressed as a number of cases or %; the $\chi 2$-test was performed for comparisons between the two groups. Differences were considered statistically significant when $p<0.05$.

Results

Analysis of Bile Duct Dilation

We observed intrahepatic and extrahepatic bile duct, and pancreatic duct dilation in pancreatic head cancer cases. 27 cases (90.0%) showed double duct sign and no significant dilatation of gallbladder. 13 cases (43.3%) were combined with pancreatic head and pancreatic duct atrophy. Severe intrahepatic and extrahepatic bile duct dilation were observed in terminal cholangiocarcinoma (bile duct diameter 1.9 ± 0.6 cm). 13 cases (37.1%) showed completely blocked distal bile duct and local lumen disruption. 12 cases (34.3%) showed moderate gallbladder dilation and no significant dilatation of the pancreatic duct. Light to moderate dilation of the intrahepatic and extrahepatic bile duct was observed in ampullary carcinoma with no obvious gallbladder dilatation. 8 cases (30.8%) showed pancreatic duct dilatation. 5 cases (19.2%) showed double duct sign. No obvious intrahepatic, extrahepatic bile duct, and pancreatic duct dilatation were found in benign lesions. Gallbladder dilation was observed in 10 cases (25.0%). The dilation rate of intrahepatic, extrahepatic bile duct, and gallbladder was the highest in terminal cholangiocarcinoma and pancreatic head carcinoma showed the most obvious double duct sign.

Morphology of Lesion and Surrounding Tissue

Pancreatic head cancer showed an enlarged pancreatic head. The average diameter of the tumor was 3.3 ± 0.8 cm. They showed significant lumen pressure and no significant thickening of the tube wall. 6 cases (20.0%) showed soft tissue mass in the pancreas contour, protruding to the outside of the pancreatic contour and the superior mesenteric vein. 18 cases (60.0%) showed low-density necrosis inside the tumor. Terminal cholangiocarcinoma showed 1.9 ± 0.7 cm average tumor diameter, tube wall eccentricity, ring thickening and soft-tissue density modules, and no obvious necrosis, liquefaction or calcification. 7 cases (20%) showed enlarged lymph nodes around the tumor, protruding towards the common bile duct wall. Ampullary carcinoma showed circular isodensity nodules. The average tumor diameter 2.5 ± 0.6 cm, with wall eccentricity, ring thickening, and stenosis. 4 cases (15.4%) showed peripheral lymphadenopathy. Benign lesions showed round, oval, or irregular hyperdensity shadow, no significant thickening of the lumen, and no significant changes in the surrounding tissue morphology. The pancreatic head cancer had a larger diameter, a higher rate of internal necrosis, and was more vulnerable to invading the surrounding tissues. Terminal cholangiocarcinoma had a smaller diameter and more thickening of the tube wall.

Enhancement Pattern Analysis

The plain scan density of pancreatic head carcinoma was slightly lower than pancreatic parenchyma. The arterial and venous phases had a slight early stage enhancement. The enhancement degree was lower than in normal pancreatic tissue. The internal necrotic area was not enhanced and the boundary was unclear. In terminal cholangiocarcinoma, the thickening of the wall showed isodensity. The enhancement was obvious, the delayed enhancement was more common. The intrahepatic and extrahepatic bile duct enhancement degree was significantly higher than in pancreatic head cancer and slightly higher than in ampullary carcinoma. The edge of ampullary carcinoma was significantly enhanced. The enhancement degree in ampullary carcinoma was higher than in pancreatic cancer and lower than in the common bile duct cancer. Arterial and venous phase enhancement were significant. Benign lesions did not show any significant enhancement.

Discussion

MDCT imaging and post-processing techniques can be used to examine tubular structures with a large curvature such as pancreatic duct and bile duct dilation, stenosis, and cross-sectional truncation changes[8]. Curved surface reconstruction can also show all or most of the left and right hepatic duct, cystic duct, common hepatic duct, and common bile duct. The structures can be shown in the same plane through the choice of different paths and angle rotation, or fractional reconstruction. The images can comprehensive display overall biliary morphology, clearly showing the location of obstructions, proximal obstruction, dilation, obstruction range, and spatial structure relationship with the adjacent tissue structure. Thus, MRCT-derived three-dimensional images can accurately identify the nature of these lesions[9,10]. According to our study, we conclude that benign lesions and different types of malignant tumors in the ampullary region show robust differences by MRCP.

The differences include the dilation of intrahepatic and extrahepatic bile duct, gallbladder, common bile duct, lesion size, wall and lumen morphology, surrounding tissue involvement, and enhancement patterns of lesions at different stages. Pancreatic head cancer mainly originates in the pancreatic duct epithelial cells, has a low blood supply and vulnerability to necrosis, forms cystic space, does not significantly enhance in arterial phase, and forms density difference with normal pancreatic parenchyma[11,12]. The tumors have high malignancy, fast proliferation rate, invade adjacent tissue, and metastasize easily at an early stage. Therefore, these tumors have large diameters and obvious internal necrosis13. The pancreatic head is located outside the lumen of the common bile duct ampulla. The luminal pressure is obvious, but wall thickening and stenosis are not obvious. The common pancreatic and bile ducts converge at the ampulla area to form a typical "double duct sign"[14]. The infiltrate type is more common in terminal cholangiocarcinoma showing markedly delayed enhancement, which may be related to the rich fibrous tissue in tumors[15]. The tumor cells grow along the inner tube wall. Therefore, the thickening of the wall is uneven and more obvious, distal lumen occlusion is common, and proximal common bile duct expansion is the most significant[16]. Ampullary carcinomas mainly present nodular masses in the inner wall of the descending duodenum below the pancreatic head, with significant enhancement in arterial phase[17]. CT findings of ampullary carcinoma mostly fall in between pancreatic cancer and terminal cholangiocarcinoma, which makes it harder to identify. Ampullary carcinoma has a significant dilatation of intrahepatic bile duct but no significant atrophy in pancreatic body and tail, which may contribute to the diagnosis[18].

Conclusions

MDCT imaging and post-processing techniques demonstrate a significant value in the diagnosis of bile duct ampullary benign and malignant lesions as well as malignant tumor characteristics, identifying from the bile duct dilatation, lesions, surrounding tissue and enhancement patterns.

Conflict of interest

The authors declare no conflicts of interest.

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