Original Article

Role of multidetector computed tomography in differentiating benign and malignant common bile duct strictures

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Abstract

Objective: To evaluate the diagnostic features in differentiating malignant from benign common bile duct (CBD) strictures using contrast-enhanced multidetector computed tomography (MDCT).

Patients and Methods: An ambispective study from January 1, 2008 to December 31, 2010, on fifty patients with liver function tests suggestive of obstructive jaundice and an ultrasound showing biliary obstruction were included. A nonenhanced computed tomography (CT) was done before the administration of the contrast medium and then scans were routinely obtained in four phases: early arterial , late arterial, portal venous, and delayed phases. The CT scans acquired were reviewed on a picture archiving and communication system workstation. CT findings were interpreted with regard to wall thickness, the location, length involved, enhancement pattern, presence of invasion, and margins of the stricture. These were compared with the attenuation of the normal CBD wall, the maximum CBD diameter proximal, and pancreatic duct dilatation.

Results: The mean age ± standard deviation of patients was 62.84 ± 11.61 years (range: 38–82 years). Among the fifty patients included in the study, 31 (62%) had malignant CBD stricture. The involved segments of malignant CBD strictures were significantly longer with significantly larger maximum proximal CBD diameter, considerably thicker and irregular stricture wall and showing more enhancement during delayed phase. No significant differences were found between malignant and benign CBD strictures with respect to stricture location.

Conclusions: Presence of irregular margins, invasion into neighboring tissues, long-segment involvement, more proximal CBD dilatation, and hyperenhancement in delayed and portal venous phases in contrast-enhanced MDCT helps in the differentiation of malignant from benign CBD strictures.

Keywords: Benign common bile duct strictures, malignant common bile duct strictures, multidetector computed tomography

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INTRODUCTION

Stricture of bile duct is a commonly encountered condition in the day-to-day radiological practice and can be benign or malignant. Imaging modalities such as ultrasonography (USG), contrast-enhanced computed tomography (CECT), magnetic resonance imaging (MRI),

Access this article online	
Quick Response Code:	Website: www.wajradiology.org
	DOI: 10.4103/wajr.wajr_57_16

How to cite this article: Agrawal P, Bo GJ, Bhattarai M, Shah SP, Agrawal M. Role of multidetector computed tomography in differentiating benign and malignant common bile duct strictures. West Afr J Radiol 2018;25:21-7.

magnetic resonance cholangio-pancreaticography (MRCP), endoscopic retrograde cholangio-pancreatography (ERCP), and percutaneous transhepatic cholangiography are used for the evaluation of these patients, which provides information regarding the level of obstruction, extent of biliary dilatation, and the presence of a mass or distant metastasis.[1,2]

Multidetector CT (MDCT) is a noninvasive imaging modality for evaluation of patients with biliary obstruction,[3] to localize the cause of obstruction, detect the presence of mass lesion, and define its extension and identify remote metastasis. CECT shows irregular stenosis in the pancreatic segment of the common bile duct (CBD), papillary tubercles which intrude the lumen, and the upper CBD dilatation without the pancreatic duct dilatation, which are helpful to distinguish between cholangiocarcinoma (CC) and ampullary carcinoma.[4] Moreover, thin-section MDCT can effectively distinguish ampullary carcinoma from benign papillary stricture.[5] The CT findings in benign strictures also include diffuse bile duct dilatation and an abrupt narrowing of the dilated duct,[6] whereas infiltrative CC can be detected as focal wall thickening, usually with early or late enhancement or both, in addition to the same CT findings as seen in benign CBD strictures.[7] This study was undertaken with an objective to evaluate the diagnostic features in differentiating between malignant and benign CBD strictures using contrast-enhanced MDCT.

PATIENTS AND METHODS

This ambispective study was done in the CT department of the First Affiliated Hospital of Zhengzhou University, Henan, China. A computerized search of the hospital's radiology and pathology files from January 1, 2008 to December 31, 2010 revealed 200 patients found to be suffering from obstructive jaundice. Patients with liver function tests suggestive of obstructive jaundice and an ultrasound showing biliary obstruction were included in the study. Patients in whom a CECT was not performed, obstructive jaundice not confirmed by means of laboratory tests or direct cholangiography, patients who had undergone biliary interventional procedures, such as biliary stent insertion, endoscopic biliary drainage, or percutaneous transhepatic biliary drainage, and biopsy done prior to CT study were excluded. This summed up to 150 patients.

Informed patient consent

According to the hospital's institutional review board, it is not required to have formal approval or informed patient consent for the limited and anonymous review of patient data required for this study.

CT examinations were performed with a 64-ranked light-speed Volumetric CT scanner (GE, USA). Prior to scanning of the abdomen, every patient was injected 2 mL of intramuscular hyoscine butyl bromide to reduce the intestinal motility during the scan. Patients with fasting were asked to drink 800–1000 mL of water before the scan. Water was preferred as an oral contrast agent. Each patient received 100 mL of a nonionic contrast material (iohexol 350 mgI/mL) intravenously through a power injector at the rate of 3.5–4 mL/s. Smartprep software was used to control the scan at real time. A nonenhanced CT was done before the administration of the contrast medium. CT scans were routinely obtained with the patient in the supine position during full inspiration. When the concentration of contrast agent in the abdominal aorta had reached the threshold (150 Hounsfield units [HU]), scanning was started. This scan included four phases: early arterial phase (delay about 20 s), late arterial (delay about 35 s), portal venous (delay about 65 s), and delayed phases (delay about 125 s). Helical CT (hCT) was performed from the dome of the diaphragm to the third lumbar vertebra. After the scan, the data were transmitted to the workstation AW4.3 (Sun Micro-system Advantage Windows 4.3GE Medical Systems).

Computed tomography scan analysis

The CT scans acquired in the fifty patients were reviewed on a picture archiving and communication system workstation. The CBD was considered to be involved when a narrow duct followed by a dilated proximal duct was encountered; wall thickness, the location and length of the involved CBD, the enhancement pattern of the involved CBD wall during hepatic arterial, portal venous, and delayed phases, presence of invasion into the neighboring tissues, and margins of the stricture were also analyzed. These were compared with the attenuation of the normal CBD wall, the maximum CBD diameter proximal to the site of the involved CBD, and the presence of pancreatic duct dilatation.

The maximum transverse thickness was recorded, and a thick CBD wall was defined if more than 1.5 mm. The location of the involved duct was described as suprapancreatic, intrapancreatic, or both supra- and intra-pancreatic. Using multiplanar reconstruction (MPR) and curved planar reconstruction (CPR) techniques, the axial images were reconstructed into sagittal, coronal, and oblique images; the margins of the stricture were analyzed whether being smooth or not, and length of the stricture was measured. These techniques were also useful in finding the presence of invasion into the surrounding tissues.

CT numbers in HUs were obtained by means of region-of-interest (ROI) cursors placed on CBD wall with lesion and on the dilated upstream CBD wall. The cursors were carefully placed to encompass as much of the CBD wall and to avoid adjacent structures. In all cases, CT scans were later reviewed by author himself, and ROI measurements were obtained for each CBD lesion and for the upstream CBD. The postcontrast HU of the involved CBD wall and the upstream CBD wall were measured, a difference between them was recorded, and enhancement pattern of abnormal CBD wall was further classified as hyperenhanced, isoenhanced, or hypoenhanced in comparison with that of the normal CBD wall.

Statistical analysis

To assess the statistical parameters, SPSS 18.0 software (SPSS version 18.0. Chicago: SPSS Inc) was used. Independent sample *t*-test was used to determine whether values were normally distributed. Statistical differences in the CT features of malignant and benign strictures were analyzed with the Chi-square test. For all tests, $P < 0.05$ was considered statistically significant.

RESULTS

The mean age ± standard deviation of patients was 62.84 ± 11.61 years (range: 38–82 years). Among the fifty patients included in the study, 31 (62.0%) had malignant CBD stricture. The patients included thirty (60%) men and twenty (40%) women. Malignant strictures were seen in 64.5% of males and 35.5% of females, and benign strictures were seen in 52.6% of males and 47.4% of females. The difference in gender distribution of biliary strictures was not statistically significant ($P > 0.05$).

Multidetector computed tomography findings

Postcontrast scan showed that benign strictures are enhanced more during the arterial phase, followed by portal venous and delayed phases, whereas malignant strictures showed more enhancement during delayed phase followed by portal venous and arterial phases [Figure 1].

The involved segments of malignant CBD strictures were significantly longer (25.11 mm ± 11.56) than those of benign strictures (13.18 mm ± 9.03) ($P < 0.001$) [Figures 2 and 3]. Maximum CBD diameters measured proximal to malignant strictures were also significantly larger (17.93 mm ± 3.64) than those measured proximal to benign strictures (14.41 mm ± 3.3) ($P < 0.001$). CBD stricture walls were considered thick (>1.5 mm) in 30 of 31 patients with a malignant stricture and in 2 of 19 patients with a benign stricture, and this difference was also statistically significant ($P < 0.001$). No statistically significant differences were found between malignant and benign CBD strictures with respect to stricture location ($P = 0.147$).

Pancreatic duct dilatation was seen in 11 and 5 patients with malignant and benign CBD strictures, respectively ($P = 0.5$). The margins of the strictures were significantly not smooth in 22 patients with malignant CBD strictures and no such findings were observed in patients with benign CBD stricture ($P < 0.001$) [Figures 4 and 5]. Presence of invasion into the neighboring tissues was seen in 20 of 31 patients with a malignant CBD stricture and no such invasion was noted in patients with a benign CBD stricture ($P < 0.001$) [Table 1].

Histopathological correlation

The study revealed that 38.71% (12) of malignant patients had highly differentiated adenocarcinoma, followed by 29.03% (9) with moderately differentiated, and 25.81% (8) with poorly differentiated adenocarcinoma. Among the 31 malignant patients, 2 patients had extensive metastases, and

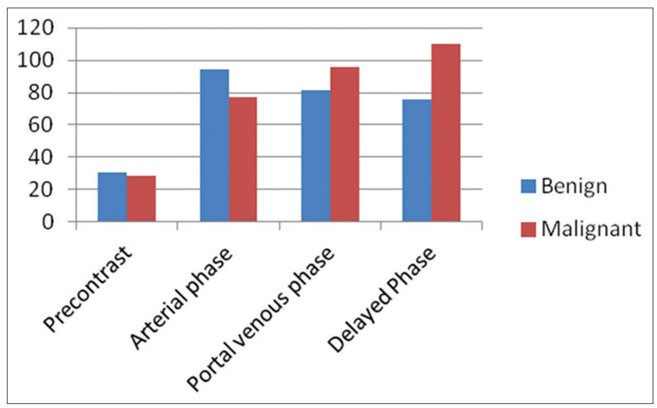

Figure 1: Enhancement pattern of common bile duct strictures. X-axis - Contrast enhancement pattern during all the phases. Y-axis - Computed tomography density in Hounsfield Units

Table 1: Computed tomography findings in malignant and benign common bile duct strictures

Finding	Malignant stricture (*n*=31)	Benign stricture (*n*=19)	*P*
Stricture length (mm)	25.11±11.56	13.18±9.032	<0.001
Ductal diameter proximal to stricture (mm)	17.93±3.64	14.41±3.30	<0.001
Ductal thickness			
Thick (>1.5 mm)	30	2	<0.001
Thin (≤1.5 mm)	1	17	
Location of stricture			
Suprapancreatic	19	9	0.147
Intrapancreatic	7	9	
Supra- + intra-pancreatic	5	1	
Pancreatic duct dilatation	11	5	0.5
Margins of stricture			
Smooth	9	19	<0.001
Not smooth	22	0	
Presence of invasion into neighboring tissue	20	0	<0.001

as CT features were sufficient to confirm the malignancy, biopsy was not done.

Out of 29 histopathologically confirmed malignancies, 8 were poorly differentiated adenocarcinoma, among which 3 cases had well-defined margins. Among nine moderately differentiated adenocarcinomas, four had well-defined margins and five had ill-defined margins. Twelve cases were highly differentiated adenocarcinomas, two had well-defined margins and ten had ill-defined margins. The margins of the stricture were not statistically significant in differentiating between the malignant histopathological findings (P = 0.126). Seven out of eight poorly differentiated adenocarcinomas and eight out of nine moderately differentiated adenocarcinomas had a ductal thickness >1.5 mm, while one had a ductal thickness of ≤1.5 mm. Highly differentiated adenocarcinomas had a ductal thickness >1.5 mm in all the cases. The ductal thickness was not statistically significant in differentiating between the malignant histopathological findings (P = 0.217). Almost all the adenocarcinomas showed significant enhancement during the delayed phase, so it was also found to be not statistically significant (P = 0.312) in differentiating the histopathological findings. This study did not find any statistical significance with the dilatation of the CBD proximal to the stricture (P = 0.263) [Table 2].

DISCUSSION

Obstructive jaundice due to biliary strictures can be a diagnostic dilemma, as preoperative differentiation between CC and benign biliary stricture (BBS) is often difficult. This study found that patients with both benign and malignant strictures belonged to similar age groups. Similar findings have been reported by Kim *et al.*[8] Few studies in

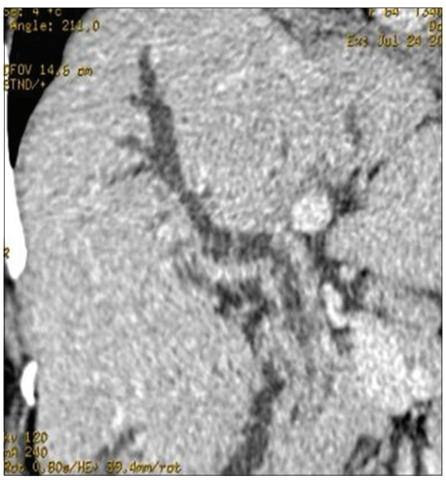

Figure 2: Malignant CBD Stricture: Curved planar reconstruction image showing enhancing long segment irregular thickening of CBD wall causing luminal narrowing and proximal tree dilatation

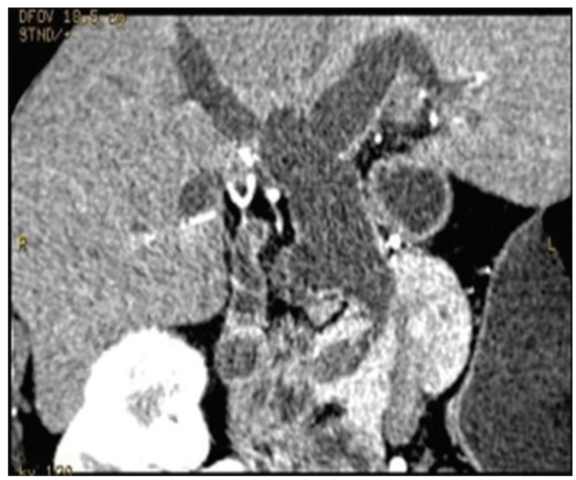

Figure 3: Benign CBD stricture: Curved planar reconstruction image showing enhancing short segment smooth regular thickening of CBD wall causing luminal narrowing and proximal biliary tree dilatation

Table 2: Relationship between the computed tomography features and histopathological classification of common bile duct strictures

CT features	Benign (n=19)	Malignant			P
		Poorly differentiated adenocarcinoma	Moderately differentiated adenocarcinoma	Highly differentiated adenocarcinoma	
Density					
Homogeneous	19				
Nonhomogeneous		8	9	12	
Margins					
Well defined	19	3	4	2	0.126
Ill defined		5	5	10	
Ductal thickness					
Thick >1.5 mm		7	8	12	0.217
Thin ≤1.5 mm	19	1	1		
Postcontrast enhancement					
Arterial phase	19		1	1	0.312
Venous phase				1	
Delayed phase		8	8	10	
CBD dilatation proximal to stricture	14.41±3.30	17.04±3.72	17.18±4.42	18.96±3.04	0.263

CT – Computed tomography; CBD – Common bile duct

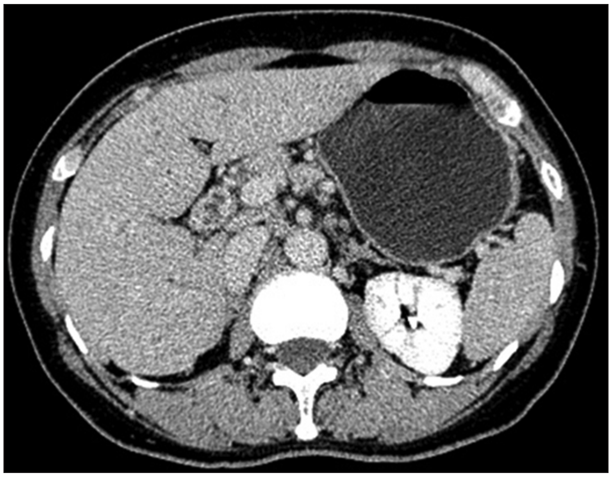

Figure 4: Malignant CBD Stricture: CECT axial image showing enhancing irregular thickening of proximal CBD wall causing luminal narrowing

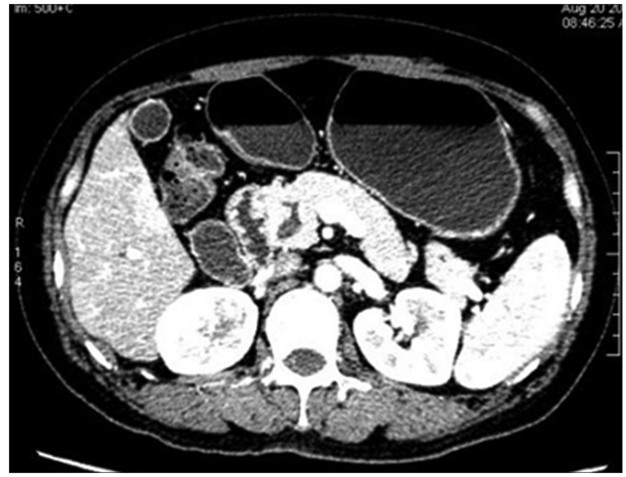

Figure 5: Benign CBD Stricture: CECT axial image showing enhancing smooth regular thickening of CBD wall causing luminal narrowing

the literature have shown that patients with a malignant stricture were older than patients in the benign group.[9,10]

Evaluation of patients suspected of having a biliary tract obstruction has conventionally involved a variety of diagnostic imaging techniques. In our hospital, MDCT is used as a major diagnostic modality for patients suspected of having obstructive jaundice. Kim *et al*. had reported that minimum intensity projection (MinIP) and MPR images using MDCT can effectively demonstrate CC involving the common duct and the biliary hilum. In cancer of the distal CBD, abrupt termination of the duct with proximal dilatation is visualized in MinIP images. Moreover, detailed features of the tumor in the distal CBD can be well demonstrated in MPR and CPR images.[11] In this study, we also found that, using the MPR and CPR techniques of MDCT, the whole length of the biliary tract could be reconstructed. Thus, the location, length of the strictures, margins of the stricture, and presence of invasion into the surrounding tissues could be easily analyzed and measured.

Although radiological findings suggestive of malignant or benign CBD strictures have been reported, to our knowledge, most of these have concerned conventional CT findings. However, a small number of reports have described the use of multiphasic hCT findings for this differentiation.[12-14] Rösch *et al*. found that the presence of a mass (62.5%) and lymph node enlargement >1 cm (45.4%) were significant ($P < 0.001$ and 0.009, respectively) findings in determining the malignant nature of the stricture.[1] Han *et al*. found a mass with hyperenhancement in 17 of 21 patients with hilar CC.[7]

Choi *et al*. in a retrospective analysis found a wall thickening >1.5 mm suggestive of a mass, rim-like contrast enhancement in either the arterial or portal phase (60%), long stricture (1.8 cm vs. 0.7 cm, respectively), higher proximal dilatation (2.2 cm vs. 1.8 cm, respectively) and lymph node enlargement >1 cm as significant findings on multiphasic spiral CT to diagnose a malignant stricture.[14] Previous studies done also showed that malignant CBD strictures show hyperenhancement on CECT scans or MRI, as well as a thickened wall and a relatively longer segment.[12] Choi *et al*. calculated the predictive value using a hyperenhancement pattern only during the portal venous phase to be 93.8% in patients with malignant CBD strictures (30 of 32 patients), 83.3% in those with benign strictures (15 of 18), and 90% overall (45 of 50 patients). They also reported that malignant strictures were longer than benign strictures, upstream CBD diameters were larger in malignant cases than in benign cases, and concluded that hyperenhancement pattern of the involved CBD wall during the portal venous phase was the main feature distinguishing malignant from benign CBD strictures.[14]

Using univariate analysis, we found a number of significant differences between malignant and benign CBD strictures, namely, the margins, presence of invasion into the surrounding tissue, the length, enhancement pattern, and dilatation of the duct proximal to the stricture. In this study, a malignant CBD stricture was characterized by strong enhancement or high attenuation during the delayed phase followed by the portal phase and then the arterial phase. We also found that malignant biliary strictures (MBSs) were longer (25.11 mm vs. 13.18 mm), had CBD wall thickness >1.5 mm, ductal diameter proximal to the stricture (17.93 mm vs. 14.41 mm), had irregular margins, and there was a presence of invasion into the neighboring tissues as compared to BBSs. No significant difference between MBSs and BBSs in regard to the location of the stricture was found. The results of this study correlated well with those of previous studies, which showed that malignant CBD strictures show hyperenhancement on CECT scans or MRI, as well as a thickened wall and a relatively longer segment.[7,12,15,16]

CECT shows irregular stenosis in the pancreatic segment of the CBD, papillary tubercles which intrude the lumen, and the upper CBD dilatation without the pancreatic duct dilatation, which are helpful to distinguish between CC and ampullary carcinoma.[4] CT also shows the localization and extension of the carcinoma, and the presence or absence of remote metastasis. Moreover, the thin-section MDCT can effectively distinguish ampullary carcinoma from benign papillary stricture.[5]

In the literature, only few studies have reported the ability of CT to differentiate benign from malignant CBD obstruction.[14] This study found that the MDCT features such as margins of the stricture, ductal thickness of the involved CBD, the enhancement pattern of the malignant lesions, and CBD dilatation proximal to the stricture site were unable to differentiate the histopathological classification as being a poorly, moderately, or highly differentiated adenocarcinoma. In the literature, none of the studies have reported the ability of MDCT in confirming the histopathology.

Familiarity with the radiological appearances of the duct lumen, wall, and surrounding structures is also important for accurate image interpretation.[17] Intraductal USG and percutaneous biliary endoscopy are promising new modalities for the diagnosis and treatment of biliary strictures.[18] CT is known to be more accurate for demonstrating the location and extent of the involved CBD than MRCP and ERCP.[1] We believe that CT evaluation of the extent of CBD cancer is sometimes limited by pancreatic enhancement, which can mask bile duct enhancement or microscopic infiltration by CC, the latter of which causes subtle changes in enhancement pattern. The diagnostic accuracy of MDCT for tumor location and vertical invasion was satisfactory, but ductal spread was underestimated in comparison with microscopic measurements.[19]

The results of this study suggest that MDCT is useful for characterizing and revealing the locations of CBD strictures. Compared with MRI and ERCP, MDCT scanning is both faster and readily available. Therefore, MDCT plays a major role in the diagnostic workup of biliary stricture.

Apart from the intrinsic limits of any ambispective study, several other limitations should be mentioned. First, this study lacked pathologic proof in some patients with a benign CBD stricture. Second, because our patient population represented a subset of all patients with biliary obstruction at our institution, the effects of selection bias must be considered. Third, the data used in the present study were acquired at section thickness ranging from 2.5.to. 5.0 mm, and the CBD is not exclusively perpendicular to the transverse plane. Thus, this study had a limitation with respect to the CT evaluation of the involved CBD length.

CONCLUSIONS

Presence of irregular margins, invasion into neighboring tissues, long-segment involvement, more proximal CBD dilatation, and hyperenhancement in delayed and portal venous phases in contrast-enhanced MDCT help in the differentiation of malignant from benign CBD strictures.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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