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## Value and Accuracy of Multidetector Computed Tomography in Obstructive Jaundice

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### Summary

**Background:**

Objective; To find out the role of MDCT in the evaluation of obstructive jaundice with respect to the cause and level of the obstruction, and its accuracy. To identify the advantages of MDCT with respect to other imaging modalities. To correlate MDCT findings with histopathology/surgical findings/Endoscopic Retrograde CholangioPancreatography (ERCP) findings as applicable.

**Material/Methods:**

This was a prospective study conducted over a period of one year from August 2014 to August 2015. Data were collected from 50 patients with clinically suspected obstructive jaundice. CT findings were correlated with histopathology/surgical findings/ERCP findings as applicable.

**Results:**

Among the 50 people studied, males and females were equal in number, and the majority belonged to the 41–60 year age group. The major cause for obstructive jaundice was choledocholithiasis. MDCT with reformatting techniques was very accurate in picking a mass as the cause for biliary obstruction and was able to differentiate a benign mass from a malignant one with high accuracy. There was 100% correlation between the CT diagnosis and the final diagnosis regarding the level and type of obstruction. MDCT was able to determine the cause of obstruction with an accuracy of 96%.

**Conclusions:**

MDCT with good reformatting techniques has excellent accuracy in the evaluation of obstructive jaundice with regards to the level and cause of obstruction.

**MeSH Keywords:**

**Biliary Atresia • Jaundice, Obstructive • Multidetector Computed Tomography**

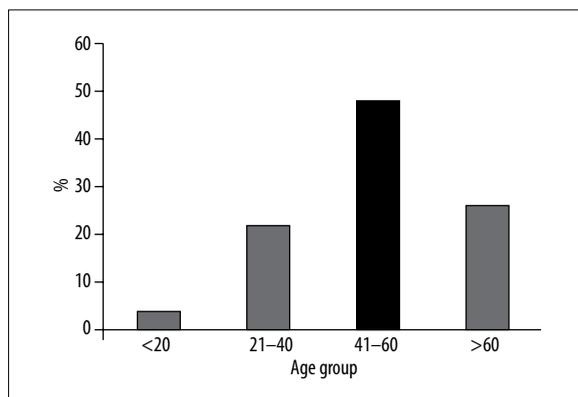
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### Background

Jaundice resulting from the blockage of bile flow from the liver to the intestine leading to redirection of excess bile and its by-products like bilirubin into the blood is known as obstructive jaundice. This can lead to complications such as ascending cholangitis, malabsorption and hepatorenal syndrome, thereby requiring urgent surgical intervention. The vital role of a radiologist therefore lies not only in the early diagnosis but also in accurately identifying the level and cause of obstruction, thus helping in staging and pre-op evaluation of tumour resectability. Endoscopic Retrograde CholangioPancreatography (ERCP) is an invasive, expensive and physician-centred investigation. Although Ultrasonography (USG) is a non-invasive and cost effective modality for evaluating biliary obstruction,

it has a sensitivity and specificity of 55–95% and 71–96% respectively [1,2]. Magnetic Resonance Cholangiography (MRCP) is considered the most reliable non-invasive technique, but it has certain disadvantages. MRCP is contraindicated in patients with pacemakers and ferromagnetic implants, as well as claustrophobic patients. It is expensive, involves long examination time and is not readily available. It is also susceptible to artifacts [3,4]. MDCT's ability to obtain volume dataset with sub-millimeter spatial resolution allows it to display the bile duct optimally by using Multiplanar Reconstruction (MPR) and Minimal Intensity Projection (MinIP) without compromising image quality. The combined use of MPR and MinIP techniques significantly improves the visualization of the biliary ducts and their site of confluence compared with those obtained by axial CT [5].



**Figure 1.** Bar graph showing patient age distribution.

## Material and Methods

This was a prospective study conducted over a period of one year from August 2014 to August 2015 in the Dept. of Radio-Diagnosis, Father Muller Medical College, Mangalore, India. Data were collected from 50 patients (25 males and 25 females), with majority belonging to the 5<sup>th</sup> to 6<sup>th</sup> decade age group, with clinically suspected obstructive jaundice, who were evaluated by MDCT (GE BRIGHT SPEED 16 SLICE). Plain abdominal CT images were acquired at 120 kV and 200 mAs to determine baseline HU value and to look for any calcium-containing biliary calculi. Post-contrast images were obtained after administration of 90 mL of non-iodinated contrast agent (350 mg% w/v) injected at a rate of 3 mL/second with the help of a Mallinckrodt pressure injector. Arterial, porto-venous and delayed-phase images were acquired at 18–22 sec, 60–65 sec, and 10–15 min, respectively. The 3D reconstruction with thin planar slicing (1 mm) and MPR were performed in coronal and sagittal planes for better depiction of biliary tract intraluminal and wall lesions. CT findings were correlated with histopathology/surgical findings/ERCP findings as applicable. All patients with clinically suspected obstructive jaundice were included in the study, while all non-obstructive cases of jaundice and patients with obstructive jaundice but having contraindications to CT scanning such as contrast hypersensitivity were excluded. Collected data were analyzed for sensitivity, specificity,

positive predictive value, negative predictive value, accuracy and test of significance.

## Results

In our study, there was uniform distribution between male and female patients (50%) with the majority of the patients belonging to the 5<sup>th</sup> to 6<sup>th</sup> decade (48%) age group (Figure 1). Regarding age distribution among individual etiologies, the majority of patients with choledocholithiasis were in the age range of 21–40 years (Tables 1, 2). All of the patients with pancreatic mass were >40 years, patients with gall bladder mass were >60 years and most of the cases (62%) with cholangiocarcinoma were >60 years of age. Among the three cases of choledochal cyst two cases were <20 years and one case was >40 years.

**Table 2.** Causes of biliary obstruction based on final diagnosis (histopathology/surgery/ERCP).

Final diagnosis of cause of obstruction	Frequency	%
1. Choledocholithiasis	11	22
2. GB neck calculus with CBD obstruction	2	4
3. Benign distal CBD stricture	5	10
4. Choledochal cyst	3	6
5. Cholangiocarcinoma	9	18
6. GB carcinoma	1	2
7. Pancreatic pseudocyst	3	6
8. Lymphoma	3	6
9. Pancreatic head mass	10	20
10. Recurrent pyogenic cholangitis	1	2
11. Pancreatic-duodenal artery pseudoaneurysm	1	2
12. Distal CBD sludge	1	2
<b>Total</b>	<b>50</b>	<b>100</b>

**Table 1.** Lesion characteristics on MDCT vs. final diagnosis (histopathology/surgery/ERCP).

Lesion characteristics	CT diagnosis	%	Final diagnosis	%
1. Mass				
– Present	29	58	30	60
– Absent	21	42	20	40
2. Enhancement				
– Present	30	60		
– Absent	20	40		
3. Calcification				
– Present	23	46		
– Absent	27	54		
4. Benign	28	56	27	54
5. Malignant	22	44	23	46

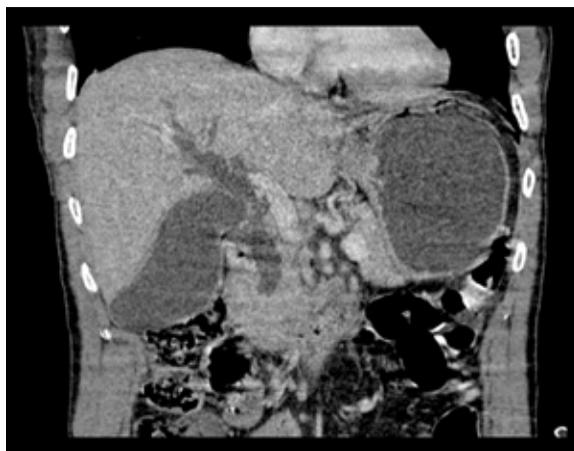
**Table 3.** Various causes of biliary obstruction as seen on MDCT.

CT diagnosis of cause of obstruction	Frequency	%
1. Choledocholithiasis	12	24
2. GB neck calculus	2	4
3. Benign distal CBD stricture	6	12
4. Choledochal cyst	3	6
5. Cholangiocarcinoma	8	16
6. GB carcinoma	1	2
7. Pancreatic pseudocyst	3	6
8. Lymphoma	3	6
9. Pancreatic head mass	10	20
10. Recurrent pyogenic cholangitis	1	2
11. Pancreatic-duodenal artery pseudoaneurysm	1	2
<b>Total</b>	<b>50</b>	<b>100</b>



**Figure 2.** Axial MDCT image showing distal CBD calculi (white arrow) with central dense calcification in a 52-year-old female patient.

Majority (90%) of patients with malignant biliary obstruction (periampullary carcinoma, cholangiocarcinoma, gall bladder mass) were >40 years. Regarding gender distribution among individual etiologies in our study, there was a predominant (90.9%) distribution of choledocholithiasis in females whereas cholangiocarcinoma was more predominant (77.7%) in males. There was also male preponderance (63.6%) in gender distribution for malignant lesions. In our study; most of the cases were benign causes of biliary obstruction (56%) with malignant causes constituting 44% (Table 3). As far as individual causes were concerned, the major cause for obstructive jaundice was (Figure 2) choledocholithiasis (22%) followed by (Figure 3) pancreatic head adenocarcinoma (20%) and (Figure 4) cholangiocarcinoma (18%). In our study, a mass was picked up as the cause for biliary obstruction in 29 out of 30 cases with sensitivity of 96.67%, specificity of 100%, and accuracy of 98%. One case we missed by CT was a case of cholangiocarcinoma

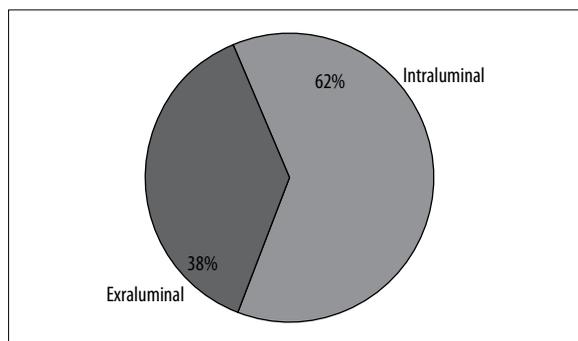


**Figure 3.** Coronal reformatted MDCT image showing a pancreatic head mass with dilated CBD and GB in a 48-year-old male patient.



**Figure 4.** MDCT axial section shows a Klatskin tumor (white arrow) with bilobar IHBR dilatation in a 55-year-old male patient.

which was diagnosed as CBD stricture. Regarding the ability of MDCT to differentiate a benign lesion from a malignant one, in our study CT correctly identified 22 out of 23 cases as malignant with sensitivity of 100%, specificity of 95.65%, and accuracy of 98%. With respect to levels of obstruction in our study, the majority of the cases (70%) had obstruction at the periampullary level. There was 100% correlation between the CT diagnosis and the final diagnosis regarding the level of obstruction, giving sensitivity and specificity of 100% with the level of obstruction being correctly diagnosed in all 50 cases. In our study the majority of the cases (62%) were intraluminal causes of obstruction (Figure 5). There was 100% correlation between the CT diagnosis and the final diagnosis regarding the type of obstruction giving sensitivity and specificity of 100%. With respect to determining the cause of obstruction in our study, 48 out of 50 cases were diagnosed correctly, giving an accuracy of 96%. One case of lower CBD cholangiocarcinoma causing stricture was wrongly diagnosed as a benign stricture and one case of distal CBD sludge was misdiagnosed as CBD calculus which was confirmed on ERCP. With regards to the sensitivities of individual etiologies (Table 4), there was 100% accuracy in diagnosing all causes except two. The sensitivity was 88.89% for diagnosing cholangiocarcinoma with one case of lower CBD growth having been



**Figure 5.** Doughnut chart showing the rate of intraluminal vs. extraluminal obstruction.

missed. This can be avoided if thinner sections are taken in the lower CBD region and adequate distension of the second part of the duodenum is obtained. However, there was 100% accuracy with diagnosis of the hilar type of cholangiocarcinoma using the criteria of non-union of the right and left hepatic ducts and delayed enhancement. Benign lower CBD strictures had a sensitivity of 100% and a specificity of 97.8% with a PPV of 83.3%. This was because in one case malignant stricture was wrongly diagnosed as benign stricture. This can again be avoided if thinner sections are taken in the lower CBD region and adequate distension of the second part of the duodenum is obtained. As far as the missed calculi were concerned, they were neither radio-opaque nor cholesterol calculi, and they can be picked up if a maximal kV(p) [generally 140 kV(p)] is used because cholesterol increases its attenuation with increasing kV(p)<sup>23</sup>. Diagnosis of choledocholithiasis gave a sensitivity of 100% and specificity of 97.4% in our study. CT correctly diagnosed common bile duct stones in 19 (90%) of 21 surgically proven cases. CT demonstrated calculi in all 11 patients with calcium bilirubinate stones and of the common duct and six of eight patients with predominantly cholesterol stones.

## Discussion

Imaging modalities available for evaluation of the hepatobiliary tree include Ultrasound, MDCT, MRCP, and ERCP. Each technique has its own limitations. Ultrasound has a sensitivity of 20–80% for detection of choledocholithiasis. MRCP although having a high diagnostic accuracy for evaluation of biliary ductal pathology is limited by high cost, restricted availability and prolonged image acquisition time. ERCP with its unique advantage of providing a tissue diagnosis and therapeutic intervention at the same setting is limited by the fact that it cannot provide extraluminal information. ERCP with a failure rate of 3–10% also has its complications such as pancreatitis, GI tract perforation, bleeding, cholangitis, sepsis etc. Recent advances in MDCT with post-processing reconstruction techniques (e.g. MPR, MinIP etc.) have improved better visualization of the hepatobiliary tree. MPR technique allows multiplanar visualization of the biliary ductal anatomy, while MinIP technique enables better depiction of a small biliary or pancreatic duct.

In our study most of the cases were benign causes of biliary obstruction (56%) with malignant causes forming 44% (Table 3). As far as individual causes were concerned, the major cause for obstructive jaundice was (Figure 4) choledocholithiasis (22%) followed by (Figure 5) pancreatic head adenocarcinoma (20%) and (Figure 4) cholangiocarcinoma (18%). This is similar to the findings of Shimizu H. et al. [6] who also found choledocholithiasis to be the major cause of obstructive jaundice in their study (33.3%). In our study, a mass was picked up as the cause for biliary obstruction in 29 out of 30 cases with sensitivity of 96.67%, specificity of 100%, and accuracy of 98%. One case we missed by CT was a case of cholangiocarcinoma which was diagnosed as CBD stricture. Reiman TH et al. [7] identified a mass in 24 of 27 cases of malignant biliary obstruction. Nesbit GM et al. [8] in a retrospective study detected a mass on CT in 69% of bile duct malignancy cases with 10-mm sections.

**Table 4.** Sensitivity and specificity of MDCT in diagnosing various causes of biliary obstruction.

Diagnosis	Sensitivity	Specificity	PPV	NPV	Accuracy
1. Choledocholithiasis	100	97.4	91.7	100	98
2. GB neck calculus	100	100	100	100	100
3. Benign CBD stricture	100	97.8	83.3	100	98
4. Choledochal cyst	100	100	100	100	100
5. Cholangiocarcinoma	90	100	100	97.5	98
6. GB carcinoma	100	100	100	100	100
7. Pancreatic pseudocyst	100	100	100	100	100
8. Lymphoma	100	100	100	100	100
9. Pancreatic head mass	100	100	100	100	100
10. Recurrent pyogenic cholangitis	100	100	100	100	100
11. Pancreatic-duodenal artery pseudoaneurysm	100	100	100	100	100

Choi JY [9] found that the confidence level of the presence and conspicuity of a mass was raised when the MPR images were added to the standard axial-only images. These findings suggest that the ability of CT to identify obstructing biliary masses has improved over time with the advent of isotropic scanning through MDCT allowing high quality multiplanar reconstructions and minimizing breath-holding artifacts. Regarding the ability of MDCT to differentiate a benign lesion from a malignant one, in our study CT correctly identified 22 out of 23 cases as malignant, with sensitivity of 100%, specificity of 95.65%, and accuracy of 98%. Reiman TH et al. [7] correctly predicted malignancy in 25 (92%) of 27 patients and benign disease in 13 (77%) of 17 individuals in their study. Ali Ahmetoglu et al. [10] conducted a study on MDCT cholangiography with volume rendering for the assessment of patients with biliary obstruction. For the diagnosis of malignant obstruction, sensitivity and specificity were both 94%. Ishimaru Keiko et al. [11] used Multidetector Computed Tomography (MDCT) with MultiPlanar Reconstruction (MPR) images to differentiate benign from malignant lesions. The mean area under the receiver operating characteristic curve for differentiating benign from malignant lesions was significantly greater with MDCT (0.98) when compared to MRI/MRCP (0.86). Choi SH et al. [12] conducted a retrospective study to differentiate a malignant common bile duct stricture from a benign one, with multiphase helical CT. They showed that hyper-enhancement of the involved CBD during the portal venous phase was the only variable that could be used to independently differentiate malignant from benign strictures. With respect to the levels of obstruction in our study, the majority of the cases (70%) had obstruction at the perampullary level. There was 100% correlation between the CT diagnosis and the final diagnosis regarding the level of obstruction giving sensitivity and specificity of 100%, with the level of obstruction being correctly diagnosed in all 50 cases. Pedrosa CS et al. [13] diagnosed a correct level in 65 of 67 patients with overall accuracy of CT in determining the exact level being 97%. Baron RL et al. [14] conducted a prospective comparison of biliary obstruction using computed tomography and ultrasonography. The precise level of obstruction was identified by CT in 88% of cases. Bhargava SK et al. [15] conducted a study on 100 cases of obstructive jaundice and CECT could detect the presence and level of obstruction in all cases (100%). It provided additional information with respect to the extent of the lesion. Gibson RN et al. [16] conducted a prospective study of 65 patients with bile duct obstruction and correctly identified the level of obstruction by CT in 90% of the cases. Ishimaru K. et al. [11] compared the diagnostic accuracy of MDCT with multiplanar reconstruction (MPR) images to MRI with MRCP (MRI/MRCP) for evaluating obstructive jaundice. Both MDCT and MRI/MRCP showed almost perfect agreement with DC in two readers in the determination of the obstruction level. Upadhyaya V et al. [17] got an overall diagnostic accuracy for detection of the level of obstruction with CT of 85.71%. These observations suggest that CT is a highly sensitive modality to assess the level of biliary obstruction and the sensitivity has steadily improved with the introduction of MDCT.

In our study the majority of the cases (62%) were intraluminal causes of obstruction (Figure 3). There was 100%

correlation between the CT diagnosis and the final diagnosis regarding the type of obstruction giving sensitivity and specificity of 100%. With respect to determining the cause of obstruction in our study, 48 out of 50 cases were diagnosed correctly, giving an accuracy of 96%. One case of lower CBD cholangiocarcinoma causing stricture was wrongly diagnosed as a benign stricture and one case of distal CBD sludge was misdiagnosed as CBD calculus which was confirmed on ERCP. Havrilla TR et al. [18] conducted a study on forty-four patients with confirmed biliary diseases to determine the value of computed tomography (CT) in the diagnosis of biliary pathology. Of the cases with proved obstruction, 88% were correctly identified. In addition, the underlying cause of the occlusion was determined in the majority of cases. Pedrosa CS et al. [19] in their retrospective analysis determined the correct cause in 94% (63 of 67) of the cases. Shimizu H et al. [6] made the correct CT diagnosis in 41 of 51 patients (80.4%) with obstructive biliary disease. Baron RL et al. [20] in their prospective study accurately predicted the cause of obstruction by CT in 70% of the cases. Sajjad Z et al. [21] conducted a retrospective review of 61 patients who had undergone CT cholangiography to determine the technical efficacy and the clinical utility of the technique. In 59 of the 60 cases, subsequent investigations and follow-up supported the CT cholangiographic diagnosis, giving an accuracy of up to 98.3%. Ali A et al. [10] conducted a study on MDCT cholangiography with volume rendering for the assessment of patients with biliary obstruction. The accuracy of the technique for the diagnosis of the cause of biliary obstruction was 83.3%. Persson A et al. [22] conducted a study to evaluate the diagnostic potential of prolonged drip infusion CT cholangiography (DIC-CT) and 3D volume rendering in patients with suspected obstructive biliary disease. The use of volume rendering technique (VRT) improved diagnostic certainty in 28/198 (14%) of the evaluations.

With regards to the sensitivities of individual etiologies (Table 4), there was 100% accuracy in diagnosing all causes except two. The sensitivity was 88.89% for diagnosing cholangiocarcinoma with one case of lower CBD growth having been missed. This can be avoided if thinner sections are taken in the lower CBD region and adequate distension of the second part of the duodenum is obtained. However, there was 100% accuracy with diagnosis of the hilar type of cholangiocarcinoma using the criteria of non-union of the right and left hepatic ducts and delayed enhancement. Manfred T et al. [23] conducted a study on multiphase helical CT in diagnosis and staging of hilar cholangiocarcinoma. Ten (34%) of the 29 hilar cholangiocarcinomas were detected on unenhanced images. All hilar cholangiocarcinomas (100%) were seen on hepatic artery dominant phase scans, and 25 (86%) of 29 hilar cholangiocarcinomas were seen on portal vein dominant phase scans, regardless of the morphologic appearance. Benign lower CBD strictures had a sensitivity of 100% and a specificity of 97.8% with a PPV of 83.3%. This was because in one case malignant stricture was wrongly diagnosed as benign stricture. This can again be avoided if thinner sections are taken in the lower CBD region and adequate distension of the second part of the duodenum is obtained. As far as the missed calculi were concerned, they were neither radio-opaque nor cholesterol calculi, and they can be picked up if a maximal kV(p)

[generally 140 kV(p)] is used because cholesterol increases its attenuation with increasing kV(p) [23]. Diagnosis of choledocholithiasis gave a sensitivity of 100% and specificity of 97.4% in our study. Baron RL et al. [20] did a retrospective review of CT scans in 69 consecutive patients with proven biliary obstruction due to both malignant and benign causes to define and differentiate CT changes. The authors also found CT to be accurate in detecting common duct stones with a sensitivity exceeding 80%. Jeffrey RB et al. [24] conducted a study on CT of choledocholithiasis. CT correctly diagnosed common bile duct stones in 19 (90%) of 21 surgically proven cases. CT demonstrated calculi in all 11 patients with calcium bilirubinate stones of the common duct and six of eight patients with predominantly cholesterol stones. Baron RL [25] conducted a study to evaluate the specificity of previously suggested computed tomographic (CT) criteria for diagnosing common bile duct (CBD) stones. The CBD stone was directly visualized as a target sign or densely calcified structure in 29 of 38 patients with stones (76%). Neitlich JD et al. [26] showed that CT had a sensitivity of 88%, a specificity of 97%, and an accuracy of 94% in the diagnosis of common bile duct stones. Soto JA et al. [27] performed helical CT oral cholangiography on 31 patients referred for endoscopic retrograde cholangiography of suspected choledocholithiasis. Sensitivity and specificity of oral contrast-enhanced CT cholangiography for detection of choledocholithiasis were 92.9% and 100%, respectively, for observer 1 and 85.7% and 100%, respectively, for observer 2. Soto JA et al. [28] studied fifty-one patients referred for endoscopic retrograde cholangiography of suspected biliary stones with unenhanced helical CT, MR cholangiography, and helical CT performed after oral administration of a cholangiographic contrast agent (iodic acid). Sensitivity was 65% for unenhanced helical CT and 92% for CT cholangiography. Specificity was 84% for unenhanced helical CT and 92% for CT cholangiography. Persson A et al. [29] conducted a study to evaluate the diagnostic potential of prolonged drip infusion CT cholangiography (DIC-CT) and 3D volume rendering in patients with suspected obstructive biliary disease. The consensus sensitivity and specificity for diagnosing biliary stones was

88% and 94%, respectively (with sensitivities ranging from 88% to 94% for individual observers, and specificities from 86% to 96%). Anderson SW et al. [30] conducted a study to evaluate the diagnostic performance of contrast-enhanced and unenhanced MDCT in detecting choledocholithiasis. In their study, they achieved a sensitivity of 69–87%, specificity of 83–92%, and accuracy of 84–88% in the CT diagnosis of choledocholithiasis. Lee JK et al. [31] the results of prospective CT interpretation regarding the presence of bile duct stones were compared with results of endoscopic stone removal, PTC and with surgical results. The sensitivity and specificity of combined CT were 73% and 98% for diagnosis of intrahepatic stones and 71% and 97% for common duct stones. Eleven of 24 cholesterol stones, 21 of 25 black pigment stones, and 15 of 21 brown pigment stones were detected on combined CT. In general, the sensitivities of picking up biliary calculi have gone up with the evolution of MDCT. CT cholangiography has given excellent results as seen above.

## Conclusions

Although MDCT cannot replace ERCP in terms of tissue diagnosis and therapeutic potential, MDCT using reconstructive techniques such as MinIP and MPR constitutes a fast and alternative non-invasive imaging technique with high diagnostic accuracy in detection of biliary calculi and for differentiating benign from malignant tumors. In addition to this, MDCT is also useful in preoperative planning when tissue diagnosis or therapeutic interventions are not required, or even when ERCP is inconclusive or has failed. Given MDCT's low cost, easy availability, short acquisition time and even comparable diagnostic accuracy to MRCP, the former may be used as an excellent alternative for a non-invasive one-stop-shop imaging of the hepato-biliary tree.

## Conflict of interest

None.

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