Value and accuracy of multidetector Computed Tomography in obstructive jaundice

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Abstract:
The present study was carried out to find out the role of MDCT in the evaluation of obstructive jaundice with respect to cause and level of the obstruction and to correlate CT findings with histopathology/surgical findings/Endoscopic Retrograde Cholangio Pancreatography (ERCP) findings as applicable. This was a prospective study conducted over period of one year from August 2013 to August 2014. Data were collected from 50 patients with clinically suspected obstructive jaundice. CT findings were correlated with histopathology / surgical findings/ ERCP findings as applicable. Among the 50 people studied, males and females were equal, and majority belonged to 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 from 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%. MDCT with good reformatting techniques has excellent accuracy in the evaluation obstructive jaundice with regards to level and cause of obstruction

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Introduction

Jaundice resulting from the blockage of bile flow from the liver to the intestine leading to redirection of excess bile and it's 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 respectability. Endoscopic Retrograde Cholangio-pancreatography (ERCP) is an invasive, expensive and physician centered 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, however it has certain disadvantages. MRCP is contraindicated in patients with pacemakers and ferromagnetic implants, claustrophobic patients. It is expensive, involves long examination time and 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 of bile duct optimally by using Multiplanar Reconstruction (MPR) and Minimal Intensity Projection (MinIP) without compromising on 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).

Material and Methods

This was a prospective study conducted over a period of one year from August 2013 to August 2014 in the Dept. of Radio-Diagnosis, Father Muller Medical College, Mangalore, India. Data were collected from 50 patients with clinically suspected obstructive jaundice who were evaluated with MDCT (GE BRIGHT SPEED 16 SLICE). CT findings were correlated with histopathology/ surgical findings/ ERCP findings as applicable.

Inclusion Criteria: All patients with clinically suspected obstructive jaundice.

Exclusion criteria: All non-obstructive cases of jaundice and Patients with obstructive jaundice but having contraindications for Computed Tomography scanning such as contrast hypersensitivity.

Data Analysis: Collected data was analyzed for sensitivity, specificity, positive predictive value, negative predictive value, accuracy and test of significance.

Results

Among the 50 people studied, there were equal number of males and females and majority of the patients were in the age group of 41-60 years. 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 from 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%. The sensitivity for diagnosing cholangiocarcinoma was 88.9% and the diagnosis of choledocholithiasis gave a sensitivity of 100% and specificity of 97.4%.There was 100% sensitivity and specificity in diagnosing pancreatic head mass as cause for biliary obstruction (Table 1).

Table 1: Lesion characteristics on MDCT vs. Final Diagnosis (histopathology/ surgery/ ERCP)

LESION CHARACTERISTICS	CT DIAGNOSIS	%	FINAL DIAGNOSIS	%
Mass				
+ive	29	58	30	60
-ive	21	42	20	40
Enhancement				
+ive	30	60		
-ive	20	40		
Calcification				
+ive	23	46		
-ive	27	54		
Benign	28	56	27	54
Malignant	22	44	23	46

Discussion

In our study, the majority of patients belonged to the age group of 5th to 6th decade (48%) (Fig. 1).

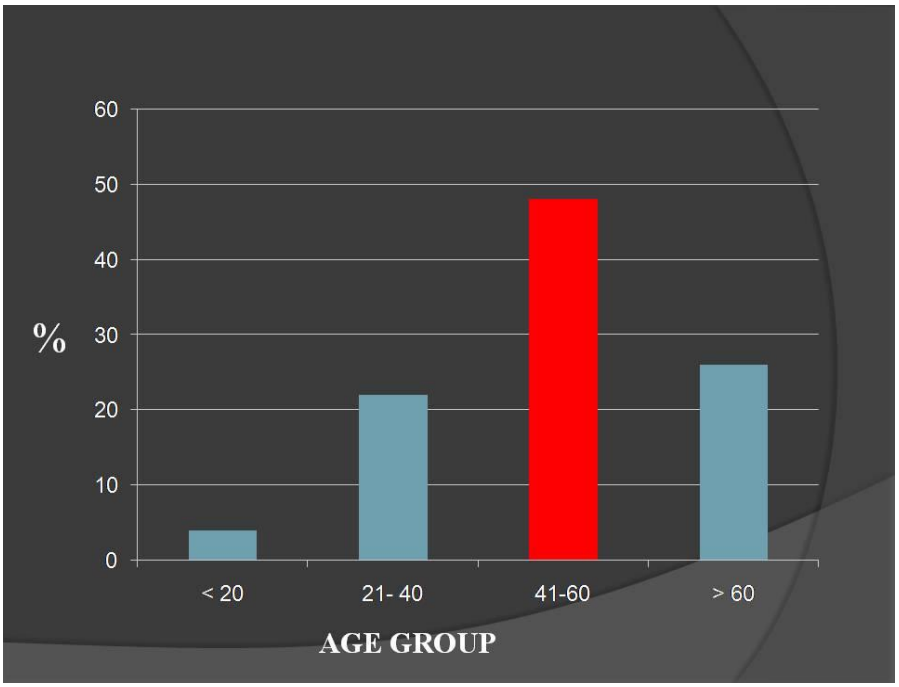

Fig. 1: Bar graph showing patient age distribution

Regarding age distribution among individual etiologies in our study, majority of the patients of choledocholithiasis was in the age range of 21- 40 years (Table 2 and 3).

Table 2: Various causes of biliary obstruction as seen on MDCT

CT Diagnosis of Cause of Obstruction	Frequency	%
1. Choledocholithiasis	12	24
2. GB neck calculus with CBD obstruction	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. Pancreatico- Duodenal Pseudoaneurysm	1	2
TOTAL	50	100%

Table 3: Causes of biliary obstruction based on final diagnosis (histopathology/ surgery/ ERCP)

FINAL DIAGNOSIS	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. Pancreatico- Duodenal Pseudoaneurysm	1	2
12. Distal CBD sludge	1	2
TOTAL	50	100%

All of the patients with pancreatic mass were >40 years, patients with gall bladder mass was >60 years and majority of the cases (62%) of cholangiocarcinoma were >60 years. Among the three cases of choledochal cyst two cases were <20 years and one case was >40 years. Majority (90%) of the patients with malignant biliary obstruction (Periampullary carcinoma, cholangiocarcinoma, gall bladder mass) were >40 years. In our study, there was uniform distribution between male and female patients (50%). 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 forming 44% (Table 2). As far as individual causes were concerned, the major cause for obstructive jaundice was (Fig. 2) choledocholithiasis (22%) followed by (Fig. 3) pancreatic head adenocarcinoma (20%) and (Fig. 4) cholangiocarcinoma (18%).

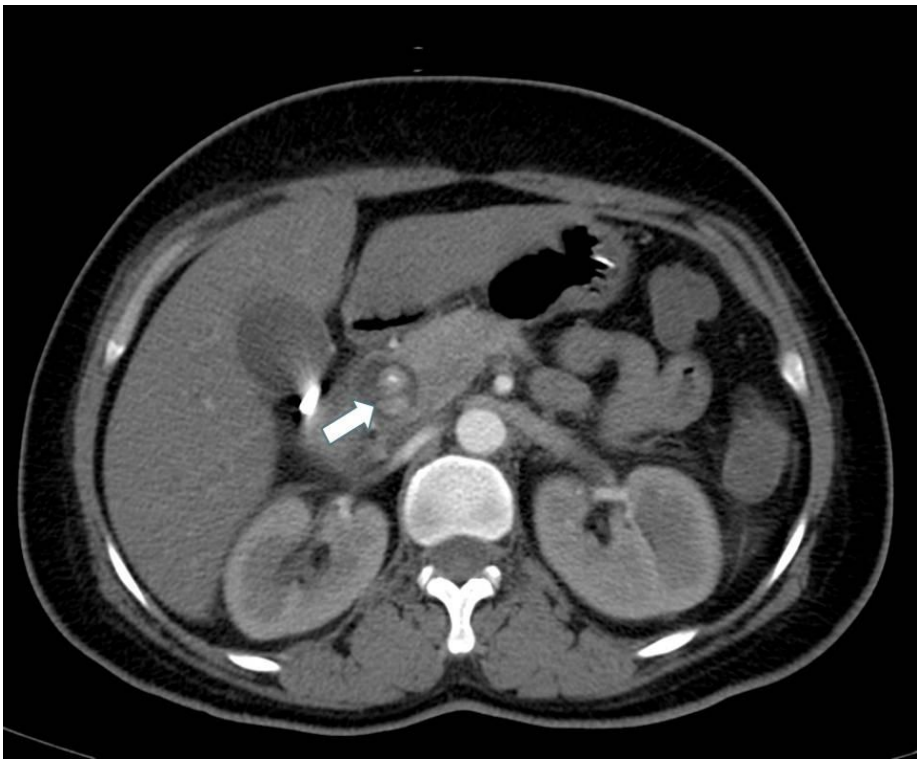

Fig. 2: Distal CBD calculi (white arrow) with central dense calcification

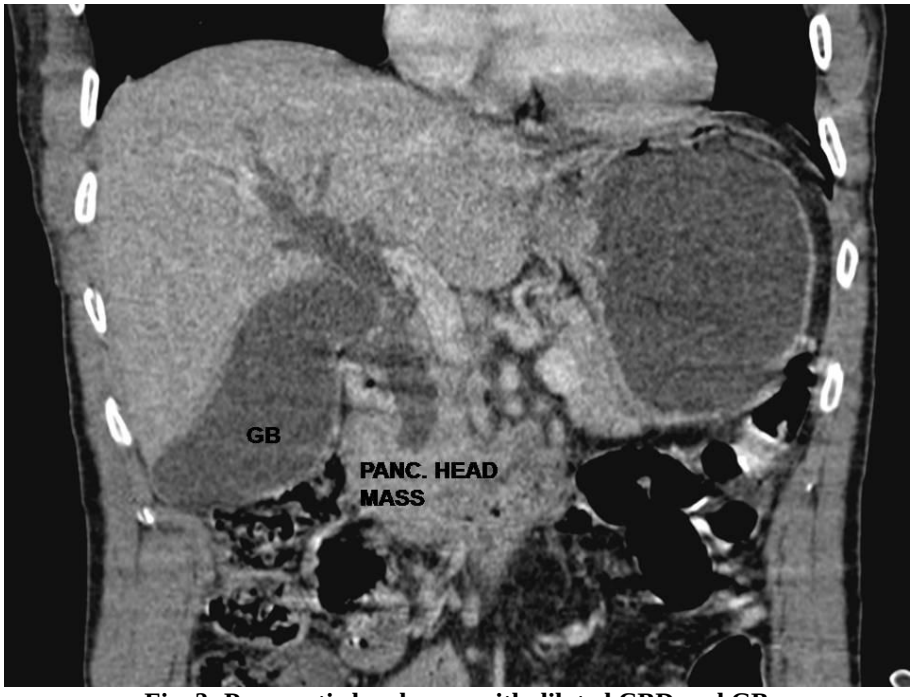

Fig. 3: Pancreatic head mass with dilated CBD and GB

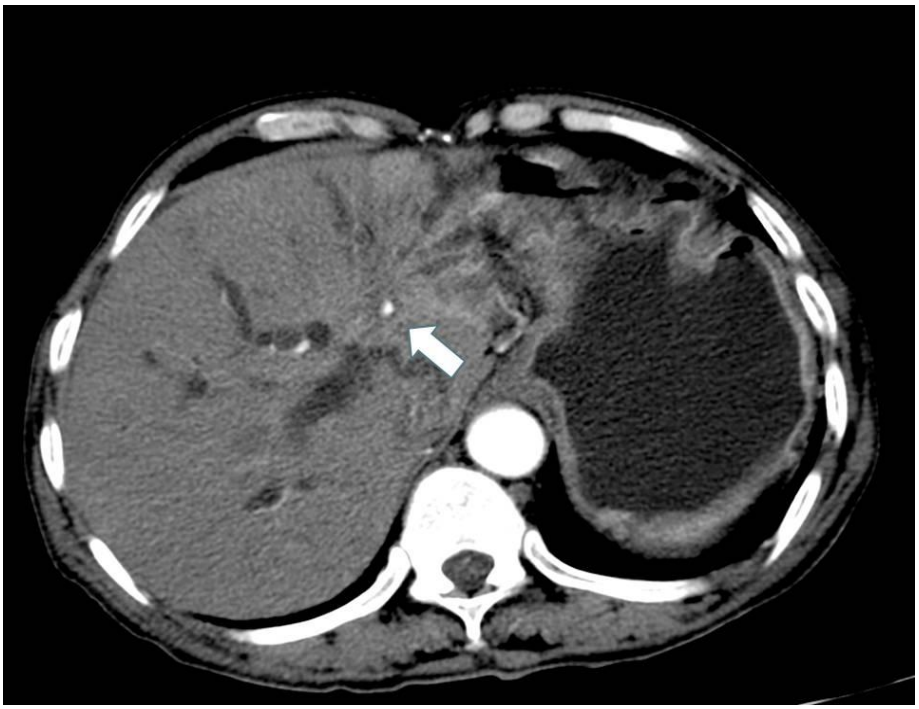

Fig. 4: Klatskins tumor with bilobar IHBR dilatation

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 had detected mass on CT in 69% of bile duct malignancy cases with 10 mm sections. Choi JY (9) found that the confidence level of the presence and conspicuity of a mass were 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 ability of MDCT to differentiate a benign from malignant lesion, 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 Malignant from Benign Common Bile Duct Stricture 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 levels of obstruction in our study, 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. Pedrosa CS et al (13) diagnosed the 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 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 obstruction level. Upadhyaya V et al (17) got an overall diagnostic accuracy for detection of 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 majority of the cases (62%) were intraluminal causes of obstruction (Fig.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 right and left hepatic ducts and delayed enhancement.

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. Rec. Pyogenic Cholangitis	100	100	100	100	100
11. Panc-Duodenal Art. Pseudoaneurysm	100	100	100	100	100

Tillich M 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 a 140 kV(p)) is used because cholesterol, increases its attenuation with increasing kV(p) (23). Diagnosis of choledocholithiasis gave a sensitivity of 100%, 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 common duct stones 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 (iopodic 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. 11 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 resultsas seen above.

Conclusion

As per our study the major cause for obstructive jaundice was choledocholithiasis (Fig.1) followed by pancreatic head malignancy and cholangiocarcinoma. MDCT with reformatting techniques was very accurate in picking a mass as the cause for biliary obstruction with a sensitivity of 96.67% and specificity of 100%. Majority of the cases had obstruction at the periampullary level and most were intraluminal causes of obstruction. The advantages of MDCT include, the use of contiguous single breath- hold data acquisition, thereby decreasing or eliminating respiratory motion artifacts, the ability to perform thin-section scanning with small-interval reconstruction, which decreased partial volume artifacts and increased sensitivity of stone detection and the ability to perform three-dimensional SSD, MIP, VRT, curved planar reformatting and inversion techniques. Thus, MDCT with good reformatting techniques has excellent accuracy in the evaluation of obstructive jaundice.

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cohorts have been previously reported (in previous publications). Methodology: prospective, performed at one institution.

References

1. Lalani T, Corey AC, Max PR, Mark EB, et al: ACR appropriateness criteria on jaundice. American College of Radiology 2012.
2. Guibaud L, Bret PM, Reinhold C, Atri M, Barkun AN. Diagnosis of choledocholithiasis: value of MR cholangiography. AJR Am J Roentgenol. 1994 Oct; 163(4):847-50.
3. David V, Reinhold C, Hochman M, Chuttani R, McKee J, Waxman I, Wang L, Li W, Kaplan R, Edelman RR. Pitfalls in the interpretation of MR cholangiopancreatography. AJR Am J Roentgenol. 1998 Apr;170(4):1055-9.
4. Moore KL and TVN Persaud: The Developing Human - Clinically Oriented Embryology, 7th ed. Elsevier Science (WB Saunders), Philadelphia (2003), p. 78.
5. Ferrari FS, Fantozzi F, Tasciotti L, Vigni F, Scotto F, Frasci P. US, MRCP, CCT and ERCP: a comparative study in 131 patients with suspected biliary obstruction. Med Sci Monit. 2005 Mar;11(3):MT8-18.
6. Shimizu H, Ida M, Takayama S, Seki T, Yoneda M, Nakaya S, Yanagi T, Bando B, Sato H, Uchiyama M, Okumura T, Miura S, Fujisawa M. The diagnostic accuracy of computed tomography in obstructive biliary disease: a comparative evaluation with direct cholangiography. Radiology. 1981 Feb;138(2):411-6.
7. Reiman TH, Balfe DM, Weyman PJ. Suprapancreatic biliary obstruction: CT evaluation. Radiology. 1987 Apr;163(1):49-56.
8. Nesbit GM, Johnson CD, James EM, Mac Carty RL, Nagorney DM, Bender CE. Cholangiocarcinoma: diagnosis and evaluation of resect ability by CT and sonography as procedures complementary to cholangiography. AJR Am J Roentgenol. 1988 Nov;151(5):933-8.
9. Choi JY, Lee JM, Lee JY, Kim SH, Lee MW, Han JK, Choi BI. Assessment of hilar and extrahepatic bile duct cancer using multidetector CT: value of adding multiplanar reformations to standard axial images. Eur Radiol. 2007 Dec;17(12):3130-8. Epub 2007 May 8.
10. Ahmetoğlu A, Koşucu P, Kul S, Dinç H, Sari A, Arslan M, Alhan E, Gümele HR. MDCT cholangiography with volume rendering for the assessment of patients with biliary obstruction. AJR Am J Roentgenol. 2004 Nov;183(5):1327-32.
11. Ishimaru K, Ishimaru H, Matsuoka Y et al. Multidetector-Row CT in Patients with Suspected Obstructive Jaundice: Comparison with Non-Contrast MRI with MR Cholangiopancreatography Acta Med Nagasaki Ensia2005; 50(4);147- 154.
12. Choi SH, Han JK, Lee JM, Lee KH, Kim SH, Lee JY, Choi BI. Differentiating malignant from benign common bile duct stricture with multiphasic helical CT. Radiology. 2005 Jul;236(1):178-83. Epub 2005 Jun 13.
13. Pedrosa CS, Casanova R, Rodriguez R. Computed tomography in obstructive jaundice. Part I: The level of obstruction. Radiology. 1981 Jun;139(3):627-34.
14. Baron RL, Stanley RJ, Lee JK, Koehler RE, Melson GL, Balfe DM, Weyman PJ. A prospective comparison of the evaluation of biliary obstruction using computed tomography and ultrasonography. Radiology. 1982 Oct;145(1):91-8.
15. Bhargava SK, Usha T, Bhatt S et al. Imaging in Obstructive Jaundice: A Review with Our Experience. JIMSA. January-March 2013;.26:12-14.
16. Gibson RN, Yeung E, Thompson JN, Carr DH, Hemingway AP, Bradpiece HA, Benjamin IS, Blumgart LH, Allison DJ. Bile duct obstruction: radiologic evaluation of level, cause, and tumor resect ability. Radiology. 1986 Jul;160(1):43-7.
17. Upadhyaya V, Upadhyaya DN, Ansari MA, Shukla VK. Comparative assessment of imaging modalities in biliary obstruction IJRI 2006: 16 (4): 577- 582.
18. Havrilla TR, Haaga JR, Alfidi RJ, Reich NE. Computed Tomography and obstructive biliary disease AJR, 1977; 128(5): 765-768.
19. Pedrosa CS, Casanova R, Lezana AH, Fernandez MC. Computed tomography in obstructive jaundice. Part II: The cause of obstruction. Radiology. 1981 Jun;139(3):635-45.
20. Baron RL, Stanley RJ, Lee JK, Koehler RE, Levitt RG. Computed tomographic features of biliary obstruction. AJR Am J Roentgenol. 1983 Jun;140(6):1173-8.
21. Sajjad Z, Oxtoby J, West D, Deakin M. Biliary imaging by spiral CT cholangiography--a retrospective analysis. Br J Radiol. 1999 Feb;72(854):149-52.
22. Persson A, Dahlström N, Smedby O, Brismar TB. Volume rendering of three-dimensional drip infusion CT cholangiography in patients with suspected obstructive biliary disease: a retrospective study. Br J Radiol. 2005 Dec;78(936):1078-85.
23. Tillich M, Mischinger HJ, Preisegger KH, Rabl H, Szolar DH. Multiphasic helical CT in diagnosis and staging of hilar cholangiocarcinoma. AJR Am J Roentgenol. 1998 Sep;171(3):651-8.
24. Jeffrey RB, Federle MP, Laing FC, Wall S, Rego J, Moss AA. Computed tomography of choledocholithiasis. AJR Am J Roentgenol. 1983 Jun;140(6):1179-83.
25. Baron RL. Common bile duct stones: reassessment of criteria for CT diagnosis. Radiology. 1987 Feb;162(2):419-24.
26. Neitlich JD, Topazian M, Smith RC, Gupta A, Burrell MI, Rosenfield AT. Detection of choledocholithiasis: comparison of unenhanced helical CT and endoscopic retrograde cholangiopancreatography. Radiology. 1997 Jun;203(3):753-7.
27. Soto JA, Velez SM, Guzmán J. Choledocholithiasis: diagnosis with oral-contrast-enhanced CT cholangiography. AJR Am J Roentgenol. 1999 Apr;172(4):943-8.
28. Soto JA, Alvarez O, Múnera F, Velez SM, Valencia J, Ramírez N. Diagnosing bile duct stones: comparison of unenhanced helical CT, oral contrast-enhanced CT cholangiography, and MR cholangiography. AJR Am J Roentgenol. 2000 Oct;175(4):1127-34.
29. Persson A, Dahlström N, Smedby O, Brismar TB. Volume rendering of three-dimensional drip infusion CT cholangiography in patients with suspected obstructive biliary disease: a retrospective study. Br J Radiol. 2005 Dec;78(936):1078-85.
30. Anderson SW, Lucey BC, Varghese JC, Soto JA. Accuracy of MDCT in the diagnosis of choledocholithiasis. AJR Am J Roentgenol. 2006 Jul;187(1):174-80.
31. Lee JK, Kim TK, Byun JH, Kim AY, Ha HK, Kim PN, Lee MG. Diagnosis of intrahepatic and common duct stones: combined unenhanced and contrast-enhanced helical CT in 1090 patients. Abdom Imaging. 2006 Jul-Aug;31(4):425-32. Epub 2006 Sep 12.