The Value of Magnetic Resonance Cholangiopancreatography in the Detection of Choledocholithiasis

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ABSTRACT

Background: Magnetic resonance cholangiopancreatography (MRCP) is a noninvasive radiological investigation, performed rapidly, and does not expose the patients to ionized radiation or iodinated contrast material. The present study was conducted to evaluate the role of MRCP in detection of common bile duct (CBD) stones in patients with suspected choledocholithiasis. **Materials and Methods:** This prospective study included 30 patients with suspicion of choledocholithiasis based on clinical evaluation, biochemical, or radiological investigations. Ultrasonography and MRCP were performed in all patients. All patients underwent open surgery. CBD exploration was performed in all patients, either due to presence of palpable stones or due to the presence of dilated CBD (>7 mm). Demonstration of CBD stones intraoperatively was considered the "gold standard" for their presence, defined as stones visualized, and extracted or attempted for extraction during surgical CBD exploration. **Results:** Intraoperatively, 21 (70%) out of 30 patients had cholelithiasis. 26 (86.67%) out of 30 patients had dilated CBD intraoperatively. In 20 (66.67%) out of 30 patients, choledocholithiasis was detected intraoperatively. The sensitivity, specificity, positive, and negative predictive values of ultrasonography in detecting CBD stones in the present study were 65%, 60%, 76.47%, and 46.15%, respectively. The sensitivity, specificity, positive, and negative predictive values of MRCP in diagnosis of CBD stones in the present study were 95%, 90%, 95%, and 90%, respectively. **Conclusions:** MRCP is a noninvasive investigation without complications and has high sensitivity, specificity, positive, and negative predictive values in detecting CBD stones. MRCP should be done in all cases with suspicion of CBD stones, where facilities and expertise are available.

Key words: Choledocholithiasis; endoscopic retrograde cholangiopancreatography; magnetic resonance cholangiopancreatography

Introduction

Cholelithiasis is the most common biliary pathology. The incidence of choledocholithiasis in patients with cholelithiasis varies between 5% and 15%, out of which 5% are asymptomatic.[1] Although common bile duct (CBD) stones may be silent, the development of complications, such as cholangitis and acute pancreatitis, is associated with major morbidity and mortality. Therefore, the detection and treatment of CBD stones are mandatory.

Usually, the diagnosis of choledocholithiasis is based on a combination of clinical suspicion (biliary colic, jaundice, and cholangitis), biochemical analysis (raised conjugated bilirubin and alkaline phosphatase levels), and imaging findings. Unfortunately, all of these individually have a varying diagnostic accuracy and none is a completely reliable method of identifying bile duct stones.[2] Intraoperative cholangiography (IOC) was standard procedure during open cholecystectomy to detect CBD stones with a sensitivity of 98% and a specificity of 100%. It is an invasive investigation with intraoperative and postoperative morbidity of 6.3% and 15.9%, respectively. Its routine use is associated with increased costs and increased operating time.[3]

Endoscopic retrograde cholangiopancreatography (ERCP) is able to detect CBD stones with high accuracy in patients with suspected stones.[1] ERCP can be applied both as a diagnostic and therapeutic tool. It also allows direct visualization of duct anatomy. However, ERCP has a significant mortality and morbidity of 1% and 7%, respectively.[1] Ductal cannulation is difficult or impossible in patients with previous surgery, including Billroth Type-II gastrectomy, and hepatico-enterostomy.

Access this article online	
Quick Response Code:	Website: www.wajradiology.org
	DOI: 10.4103/1115-1474.117907

In many institutions, magnetic resonance cholangiopancreatography (MRCP) is replacing ERCP as a diagnostic procedure in the investigation of benign biliary obstruction and chronic pancreatitis. MRCP has an advantage because of its technical versatility, multiplanar capability, and superior soft-tissue resolution. Unlike ERCP, MRCP is noninvasive, performed rapidly, and does not expose the patients to ionized radiation or iodinated contrast material. The present study was conducted to evaluate the role of MRCP in detection of CBD stones in patients with suspected choledocholithiasis.

Materials and Methods

This prospective study was conducted on 30 patients in Department of Surgery, Indira Gandhi Medical College, Shimla from July 2006 to January 2009 after obtaining permission from the institute ethics committee. Informed consent for the study was taken from all the patients. The study included 30 patients who were suspected of having choledocholithiasis on the basis of any of the following criteria:

1. History or presence of any of the following:
   - Intermittent jaundice
   - Cholangitis: Defined as the presence of fever (>37.3°C), chills, colicky right upper quadrant pain, and leucocytosis
   - Status of post biliary pancreatitis: Defined according to a history of biliary pancreatitis of not more than 2 months duration prior to admission, with subsided pancreatitis at the time of admission
   - Post cholecystectomy syndrome
2. Total bilirubin >1.2 mg/dL ALP >220 IU/L
3. CBD diameter at sonography >7 mm or CBD stone suspected/diagnosed at sonography.

All cases of obstructive jaundice where the cause proved to be other than CBD stones (e.g., carcinoma head of pancreas, periampullary carcinoma, CBD strictures, and cholangiocarcinoma) were excluded from the study.

The patients were initially evaluated by a detailed history, thorough physical examination, complete blood counts, and liver function tests. Ultrasound was done on GE RT 3200/Toshiba core-vision pro-diagnostic ultrasound system SSA - 350 machine with transducer of 3.5 MHz or 5 MHz frequency. Study was done after overnight fast for 8-12 h. Scans were done in longitudinal, transverse, and oblique planes.

MRCP was performed for all patients on a 1.5-Tesla Magnetom Avanto system (Siemens, Erlangen, Germany). The patients fasted for 6 h before MRCP. All patients were imaged with a body phased-array receive coil. 5-mm-thick sections were taken from right dome of diaphragm to lower edge of liver. Following are the sequences used after the localizer: T2 HASTE AXIAL free breath, T2 HASTE FS AXIAL free breath, T1 FLASH AXIAL breath hold, T2 HASTE CORONAL free breath, 3-D MRCP free breath (PACE), Single shot HASTE MRCP, and Single shot HASTE different angle. 3-D reconstruction was performed by MIP post processing. MIP image and thick angled coronal sections provided views of pancreatico–biliary tree similar to conventional ERCP.

All cases with choledocholithiasis suspected on clinical evaluation, biochemical, or radiological investigations were subjected to open surgery. All patients with a CBD dilated more than 7 mm (measured by vernier callipers) or palpable CBD stones underwent CBD exploration. Demonstration of CBD stones intraoperatively was considered the "gold standard" for their presence, defined as stones visualized, and extracted or attempted for extraction during surgical CBD exploration.

All patient data were prospectively collected and entered into a database. Radiographic studies were interpreted by a radiologist. All patients were followed up for complications and outcome.

Results

This study included 30 patients with clinical, biochemical, or radiological suspicion of choledocholithiasis. The age ranged from 25 to 80 years with mean age of 54 years. The majority of the patients (63.3%) were above 50 years of age. Out of 30 patients, 17 (56.67%) were females and 13 (43.33%) were males. The female-to-male ratio was 1.3:1 [Table 1].

The most common presenting complaint was upper abdominal pain, present in 27 (90%) patients. The next common complaint was of dyspepsia present in 23 (76.67%) patients. 12 (40%) patients had complaints of intermittent jaundice and high colored urine. Seven (23.33%) patients complained of clay colored stools and six (20%) patients had pruritis. Fever with chills was present in only four (13.33%) patients [Figure 1]. Three (10%) patients had a past history of cholecystectomy. Six (20%) patients had a past history of cholangitis. Presenting complaint of jaundice had sensitivity, specificity, positive, and

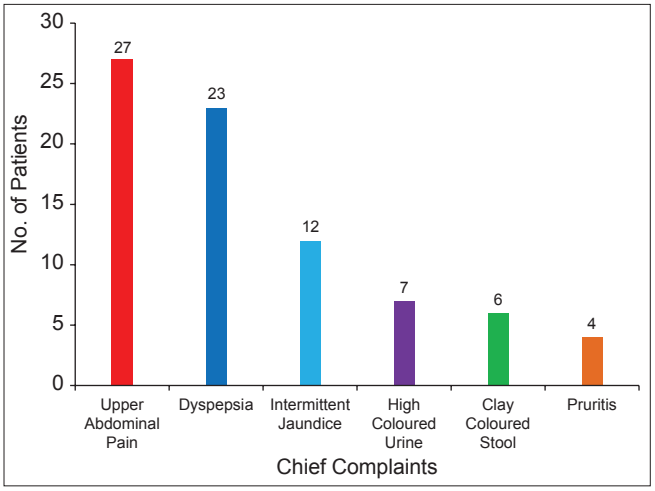

Figure 1: Chief complaints in the study population

negative predictive values of 45%, 70%, 75%, and 38.89%, respectively, in the diagnosis of CBD stones.

The total leucocyte count (TLC) was raised in 7 (23.33%) out of 30 patients and ranged from 11,000 to 14,950/mm^3. The most common biochemical abnormality was raised serum alkaline phosphatase, which was raised in 22 (73.33%) patients and ranged from 235 to 2291 IU/L. Total serum bilirubin was elevated in 10 (33.33%) patients, ranging from 4.6 to 17.2 mg%. Serum ALT and AST were elevated in 16 (53.33%) and 18 (60%) patients respectively and serum amylase was raised in only 3 (10%) patients [Table 2].

On ultrasonography (USG), cholelithiasis was diagnosed in 19 (63.3%) patients and choledocholithiasis in 13 (43.3%) patients. USG showed dilated CBD (>7 mm) in 23 (76.7%) patients [Table 3]. MRCP diagnosed cholelithiasis in 20 (66.7%) patients and choledocholithiasis in 19 (63.3%) patients. Dilation of CBD was diagnosed in 25 (83.3%) patients [Table 3].

Intraoperatively, 21 (70%) out of 30 patients had cholelithiasis. 26 (86.7%) out of 30 patients had dilated CBD intraoperatively. In 20 (66.7%) out of 30 patients, choledocholithiasis was detected intraoperatively [Table 4]. Cholelithiasis and choledocholithiasis were most commonly seen in patients above 50 years of age [Table 4]. The most commonly performed operative procedure in these 20 patients was cholecystectomy with choledocholithotomy with T tube drainage, which was performed in 14 patients. In three patients, cholecystectomy with choledochoduodenostomy was performed due to the presence of multiple small calculi. In three post-cholecystectomy patients with choledocholithiasis, two underwent choledochoduodenostomy for multiple small calculi and one patient underwent choledocholithotomy with primary closure. In the remaining 10 patients without choledocholithiasis, CBD exploration was performed in all due to presence of dilated CBD intraoperatively. All these 10 patients underwent cholecystectomy with choledochotomy with T tube drainage or primary closure.

The correlation between various clinical, biochemical, and imaging findings and intraoperative findings was studied and recorded [Table 5]. Among the 20 patients with choledocholithiasis, 9 (45%) patients presented with history of jaundice and 17 (85%) presented with history of upper abdominal pain. Serum alkaline phosphatase has the highest sensitivity (65%) in the diagnosis of choledocholithiasis among the biochemical parameters studied. USG could diagnose choledocholithiasis in 13 (65%) out of 20 patients with choledocholithiasis. MRCP demonstrated CBD stones in 19 (95%) out of 20 patients found to have choledocholithiasis intraoperatively [Table 5].

USG could diagnose choledocholithiasis in only 13 (65%) out of 20 patients with choledocholithiasis found per operatively giving a sensitivity of 65% [Figure 2]. USG correctly diagnosed

Table 1: Age-sex distribution pattern of study population

Age (years)	Male	Female	Total
<30	2	3	5
30-50	2	4	6
>50	9	10	19
Total	13	17	30

Table 2: The pattern of biochemical abnormalities in the study population

Biochemical parameters (normal range)	Number of patients with abnormal values of biochemical parameters (range of abnormality)	Percentage (*N*=30)
TLC (4000-11000/mm^3)	7 (11,000-14,950)	23.33
Serum bilirubin (0.1-1.2 mg%)	10 (4.6-17.2)	33.33
Serum ALP (20-230 IU/L)	22 (235-2291)	73.33
Serum ALT (10-43 IU/L)	16 (46-232)	53.33
Serum AST (10-36 IU/L)	18 (40-247)	60
Serum amylase (0-175 IU/L)	3 (199-589)	10

TLC - Total leucocyte count; ALP - Alkaline Phosphatase; ALT - Alanine aminotransferase; AST - Aspartate aminotransferase

Table 3: Percentage of cholelithiasis and choledolithiasis in ultrasound and MRCP in the study population

Investigations	Normal *N* (%)	Cholelithiasis *N* (%)	Choledocholithiasis *N* (%)	Dilated CBD *N* (%)
Ultrasound				
Male	3	7	5	10
Female	4	12	8	13
Total	7 (23.3)	19 (63.3)	13 (43.3)	23 (76.7)
MRCP				
Male	2	8	8	11
Female	3	12	11	14
Total	5 (16.7)	20 (66.7)	19 (63.3)	25 (83.3)

MRCP – Magnetic resonance cholangiopancreatography; CBD – Common bile duct

absence of choledocholithiasis in 6 out of 10 patients, i.e., the specificity of USG for choledocholithiasis in the present study was 60%. The positive predictive value of USG to detect choledocholithiasis in the present study was 76.47% and negative predictive value was 46.15% [Table 6]. MRCP diagnosed choledocholithiasis in 19 (95%) out of 20 patients with a sensitivity of 95% [Figure 3]. MRCP correctly diagnosed absence of choledocholithiasis in 9 out of 10 patients without choledocholithiasis. The specificity of MRCP to diagnose choledocholithiasis in the present study was 90%. The positive predictive value of MRCP to diagnose choledocholithiasis in the present study was 95% and negative predictive value was 90% [Table 6].

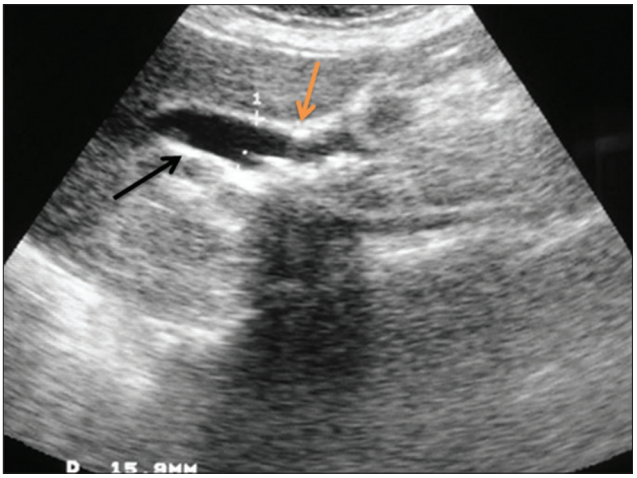

Figure 2: USG abdomen showing dilated CBD (black arrow), measuring 16.4 mm with single echogenic focus at its lower end (colored arrow)

Table 4: Intraoperative findings

Age	Normal *N* (%)	Cholelithiasis *N* (%)	Choledocholithiasis *N* (%)	Dilated CBD *N* (%)
<30	1	3	2	4
30-50	1	3	3	5
>50	2	15	15	17
Total	4 (13.3)	21 (70)	20 (66.7)	26 (86.7)

CBD – Common bile duct

Discussion

Although MRCP has been shown to provide an accurate diagnosis of CBD stones, only a few investigators have evaluated the utility of MRCP in the preoperative evaluation of symptomatic gallstones, and accordingly, the precise role of MRCP in this regard has yet to be determined. Some authors have recommended MRCP for patients with a moderate risk of CBD stones and have recommended ERCP before any other imaging examination for patients with a high risk,[4,5] while others have recommended MRCP for patients with high or moderate risk for CBD stones and have recommended ERCP for patients in whom stones had been depicted by other imaging modalities.[6]

In our study, all the clinical predictors of CBD stones individually had a varying diagnostic accuracy and none was completely reliable in identifying bile duct stones [Table 5]. Age above 50 years had sensitivity, specificity, positive, and negative predictive values of 55%, 80%, 84.62%, and 47.06%, respectively, in predicting CBD stones. Female sex as a predictor of choledocholithiasis had a sensitivity, specificity, positive and negative predictive value of 60%, 50%, 70.59%, and 38.46%, respectively. In part, this lack of accuracy may have stemmed from the inability to forecast the rates at which gallstones pass from the gallbladder, poor understanding of how long stones reside in the CBD, and that stones may pass from the CBD into the duodenum either with or without symptoms or other evidence of cholestasis. The natural history of CBD stones is still largely unknown.[7]

Serum alkaline phosphatase has the highest sensitivity (65%) in the diagnosis of choledocholithiasis among the biochemical parameters studied. It has specificity, positive and negative predictive values of 40%, 59.9%, and 42.5%, respectively. Total bilirubin has the highest specificity of 70% among the biochemical parameters studied. The sensitivity, positive, and negative predictive values of total bilirubin is 35%, 70%, and 35%, respectively Hepato-biliary alkaline phosphatase is secreted by biliary ductular epithelium. The increased serum levels found in acute biliary obstruction results from back diffusion.[8] Literature suggests that high serum levels

Table 5: Correlation of clinical, biochemical, and imaging findings with intraoperative findings

Clinical features and Investigations	Intraoperative findings (*N*=Total number of patients with positive intraoperative findings)		
	Cholelithiasis, number of patients (%)	Choledocholithiasis, number of patients (%)	Dilated CBD, number of patients (%)
Clinical features			
Pain	20 (95.2)	17 (85)	24 (92.3)
Jaundice	4 (19.1)	9 (45)	11 (42.3)
Biochemical			
Serum alkaline phosphatase >220 IU/L	12 (57.2)	13 (65)	19 (73.1)
Imaging			
USG	19 (90.5)	13 (65)	23 (88.5)
MRCP	20 (95.2)	19 (95)	25 (96.1)

MRCP – Magnetic resonance cholangiopancreatography; CBD – Common bile duct; USG – Ultrasonography

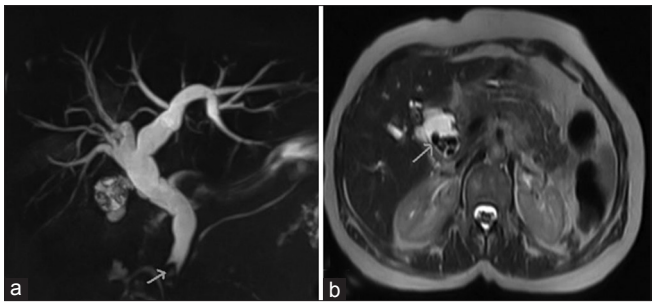

Figure 3: (a) Coronal MRCP projectional image showing dilated IHBR and CBD till lower end with a meniscus sign in its distal end suggestive of choledocholithiasis. (b) Axial HASTE MRCP image, showing dilated CBD with multiple signal voids within it, suggestive of choledocholithiasis

Table 6: Sensitivity, specificity, and predictive values for MRCP and Ultrasound in the detection of choledocholithiasis

Imaging tests of choledocholithiasis	Intraoperative choledocholithiasis		
	Present	Absent	Total
MRCP			
Present	19	1	20
Absent	1	9	10
Total	20	10	30
Ultrasound			
Present	13	4	17
Absent	7	6	13
Total	20	10	30

MRCP – Magnetic resonance cholangiopancreatography

of this enzyme more accurately predicts the likelihood of choledocholithiasis, while at the same time it is also reported that elevated serum bilirubin is more significant.

In the study conducted by Saltzstein *et al.*, alkaline phosphatase was a better indicator of common duct stones than bilirubin and the authors reported that higher is the level of alkaline phosphatase, greater is its predictive value.[9] In the study by Pereira-Lima *et al.*, alkaline phosphatase had a sensitivity of 74.7%, total bilirubin of 73.6%, and the least sensitive biochemical parameter was aspartate aminotransferase (AST).[10] In the study done by Yang *et al.*, alkaline phosphatase had a higher sensitivity than total bilirubin, total bilirubin had the highest specificity (87.5%), and both alkaline phosphatase and total bilirubin were found to be independent predictors of CBD stones.[11]

USG is the initial imaging test used in the evaluation of patients with suspected bile duct stones. The sensitivity of transabdominal ultrasound in the detection of choledocholithiasis is operator dependent and varies between 20% and 80%.[12-15] The stone detection rate is also influenced by patient factors such as the number, size and site of stones, patient body habitus, and presence of overlying bowel gas. The sensitivity, specificity, positive, and negative predictive values of USG in detecting CBD stones in the present study were 65%, 60%, 76.47%, and 46.15%, respectively.

Two possible explanations account for the comparative poor detection of CBD stones by ultrasound. First, in both dilated and nondilated ducts, the distal area of the CBD, where impacted stones usually lie, is often obscured by overlying gas from the duodenum or colon. Occasionally, in dilated ducts, one can still visualize the stone by placing the patient in the Trendelenburg position and observing the stone floating cephalad toward the liver. Second, the lack of bile pool in the dilated and nondilated distal duct preludes detection of obstructing stone. The situation is compounded with a nondilated system. In fact, it is probable that the stone that is detected sonographically in a dilated system is not the stone that is obstructing the distal duct, but a more proximal stone.[12]

MRCP has recently been developed as a noninvasive and yet highly sensitive method of diagnosing diseases of the biliary tract. MRCP promises to combine the sensitivity of ERCP with the ease and safety of USG in the accurate diagnosing of bile duct stones and its role in this application is being currently established. In our study, MRCP had a sensitivity of 95% (19 of 20 patients) in the demonstration of common duct stones and a specificity of 90% (9 of 10 patients). The positive predictive value of MRCP was 95% (19 of 20), whereas the negative predictive value was 90% (9 of 10 patients). There was one false positive and one false negative in the MRCP diagnosis of choledocholithiasis. The cause of the false-positive finding at MRCP was due to mistaking a prominent ampullary sphincter for lower bile duct stone. The false-negative diagnosis occurred as multiple, small intrahepatic duct stones were missed by MRCP. Stones were probably missed because of the lack of contrast between the stones and surrounding liver with no high signal bile outlining the stones.

Even with current imaging techniques, the accuracy of MRCP in the diagnosis of CBD stones has varied widely. Most large series have reported sensitivities ranging from 81% to 100%, specificities 85%-100%, and diagnostic accuracy 89%-100% in the MRCP diagnosis of choledocholithiasis.[16-20] In the studies in which MR cholangiography was performed with a two-dimensional fast or turbo spin-echo sequence and a standard body coil, the sensitivity of MR cholangiography in the detection of CBD stones was reported to range from 57% to 92%. A previous study, in which patients with small stones comprised more than half of the study population, produced the lowest sensitivity (57.7%) in the detection of CBD stones.[6] However, motion artifacts and blurring associated with the long acquisition times in the non-breath hold technique used would make the detection of small stones difficult and small stones may also move during MRCP when long acquisition times are required. Improved MR cholangiographic performance was achieved by using the

breath-hold single-shot half-Fourier sequence with a phased array coil. With this technique, the reported sensitivity was 92%-100%.[18] In the present study, a single-shot half-Fourier sequence and a phased-array coil were used in all patients, and results were similar to other studies in which a similar technique was used. Calculi which are missed by MRCP (MIP images) are most of the times picked up by the source images and conventional cross-sectional imaging as small filling defects within the bile filled dilated common duct.

Until recently, direct cholangiography in the form of IOC or ERCP was the gold standard for detecting stones in the intra and extra hepatic bile ducts. Intraoperative cholangiogrpahy was standard procedure during open cholecystectomy to detect CBD stones. It has a sensitivity of 98% and specificity of 100%, but is also associated with high rate of negative findings, i.e., up to 98% of unselected patients. Its routine use is associated with increased costs and increased operating time.[3] ERCP has sensitivity of 90% and specificity of 98%. ERCP morbidity is 1%-2% for a diagnostic procedure and up to 10%, when the procedure is combined with sphincterotomy. The mortality after ERCP is combined with sphincterotomy ranges between 0.7% and 0.9%.[21-23]

This study shows that MRCP has a diagnostic accuracy similar to that of direct cholangiography, in the diagnosis of choledocholithiasis. It provides images similar to those of ERCP without the use of contrast agent or sedation, is noninvasive, performed rapidly, and avoids the complications associated with ERCP. It has the potential to replace ERCP in the diagnosis of bile duct stones.

In conclusion, MRCP is an excellent primary tool for detecting or excluding CBD stones before cholecystectomy and could replace ERCP as a diagnostic instrument. In the present study, use of MRCP permitted purely noninvasive negative diagnosis for 9 (90%) of 10 patients in whom probability of CBD stones was high. Use of MRCP could therefore spare these patients invasive preoperative endoscopic procedures and likely reduce overall surgical costs. However, the potential application of MRCP in detection of CBD stones is limited by the expense and availability of technology due to its high cost and lack of expertise available in operating the machine.

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How to cite this article: Mandelia A, Gupta AK, Verma DK, Sharma S. The value of magnetic resonance cholangiopancreatography in the detection of choledocholithiasis. West Afr J Radiol 2013;20:23-9.

Source of Support: Nil, **Conflict of Interest:** None declared.