

# Is routine MR cholangiopancreatography (MRCP) justified prior to cholecystectomy?

C. A. Nebiker · S. A. Baierlein · S. Beck · M. von Flüe ·  
C. Ackermann · R. Peterli

Received: 11 May 2008 / Accepted: 16 September 2008 / Published online: 16 December 2008  
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## Abstract

**Purpose** We investigated routinely the bile ducts by magnetic resonance cholangiopancreatography (MRCP) prior to cholecystectomy. The aim of this study was to analyze the rate of clinically inapparent common bile duct (CBD) stones, the predictive value of elevated liver enzymes for CBD stones, and the influence of the radiological results on the perioperative management.

**Methods** In this prospective study, 465 patients were cholecystectomized within 18 months, mainly laparoscopically. Preoperative MRCP was performed in 454 patients.

**Results** With MRCP screening, clinically silent CBD stones were found in 4%. Elevated liver enzymes have only a poor predictive value for the presence of CBD stones (positive predictive value, 21%; negative predictive value, 96%). Compared to the recent literature, the postoperative morbidity in this study was low (0 bile duct injury, 0.4% residual gallstones).

**Conclusions** Although MRCP is diagnostically useful in the perioperative management in some cases, its routine use in the DRG-era may not be justified due to the costs.

**Keywords** Cholecystectomy · Laparoscopy ·  
Cholelithiasis · Magnetic resonance cholangiography ·  
Elevated liver enzymes

## Introduction

The goal of cholecystectomy is to remove the gallbladder and all gallstones including those in the biliary tract, thereby safely reducing the likelihood of residual stones, which can cause recurrent biliary colics, cholangitis, and pancreatitis. Common bile duct (CBD) stones often occur in patients with gallbladder stones. Some authors have mentioned a frequency up to 11–25% [1].

In the era of open cholecystectomy, intraoperative cholangiography was performed to detect CBD stones. With the introduction of laparoscopic cholecystectomy at our institute in 1990, routine preoperative intravenous cholangiography with conventional tomography (IVC) was used to detect CBD stones. In addition, further information about the presence of cholecystitis (lack of contrast media in the gallbladder) and anatomical variations to increase the safety of the procedure was obtained. Using this procedure, it was possible to detect CBD stones in 5% of patients in a series of 5,000 cholecystectomies [2], despite normal laboratory values and abdominal ultrasound. We have called these stones biochemically “silent” CBD stones. After detection, CBD stones were extracted by endoscopic retrograde cholangiopancreatography (ERCP) prior to cholecystectomy. With the routine use of IVC, a rate of residual stones of 1% and a rate of bile duct injuries below 0.1% was observed [3, 4]. Since 2005, we started to use magnetic resonance cholangiopancreatography (MRCP) instead of IVC for preoperative investigation to reduce ionizing radiation, the risk of allergic reaction to contrast agent, and costs. Previous reports have demonstrated equal accuracy of MRCP in detecting CBD stones compared with ERCP or IVC. MRCP is currently recommended as diagnostic tool for CBD stones [5–12].

C. A. Nebiker · S. A. Baierlein · M. von Flüe · C. Ackermann ·  
R. Peterli (✉)  
Department of Surgery, St. Claraspital,  
Kleinriehenstrasse 30,  
CH-4016 Basel, Switzerland  
e-mail: ralph.peterli@claraspital.ch

S. Beck  
Institute of Radiology, St. Claraspital,  
Basel, Switzerland

The primary aim of this study was to analyze the rate of CBD stones, the predictive value of laboratory findings and the influence on the perioperative management when using MRCP preoperatively.

## Materials and methods

Data was prospectively collected from all patients cholecystectomized because of a gallstone disease between June 2005 and December 2006 at the St. Claraspital, Basel, Switzerland. Patients who had their gallbladder removed in combination with another surgical intervention, such as pancreatic, hepatobiliary, bariatric, colorectal surgery, had no preoperative bile duct imaging and were, therefore, excluded from the study.

Routine preoperative bile duct examination was done with MRCP. The imaging was performed on a 1.5T scanner (Siemens Avanto, Germany) using routine MRC sequences in two dimensions, respiratory-triggered. For the 3D-analyses, T2-weighted turbo spin-echo was applied. No contrast agents were administered. In cases of claustrophobia, IVC was conducted instead of MRCP. A standardized protocol was filled out by the radiologist preoperatively. It contained information about the size and the contents of the gallbladder and the thickness of its wall. In addition, we looked for CBD stones and/or a dilatation of the bile ducts. The liver, pancreas, and lymph nodes were also checked for pathologies. If a CBD stone was found, preoperative extraction by ERCP was attempted. Perioperative data was filled out by the surgeon shortly after the operation. It included preoperative laboratory findings (bilirubin (Bili), alkaline phosphatase (aP),  $\gamma$ -glutamyl transferase ( $\gamma$ GT), alanine aminotransferase (ALAT), aspartate aminotransferase (ASAT), amylase, lipase, white blood cell count and c-reactive protein (CRP)) and intraoperative presence of inflammation and complications. The surgeon was required to quantify how helpful the MRCP was, intraoperatively, in identifying the anatomy. Thirty-day morbidity was protocolled and checked for completeness according to the general morbidity statistics of the institute.

## Results

In the above-mentioned period, 465 patients had their gallbladder removed due to gallstone disease. Three hundred thirteen of these patients were female and 152 were male. Their ages ranged from 20 to 100 years, with a mean age of 57.2 years. From this population, 431 patients had MRCP and 23 IVC. The majority of the remaining 11 patients had signs of acute cholecystitis in computed tomography and were operated without MRCP or IVC.

A total of 32 CBD stones (7%) were detected using preoperative bile duct imaging. All stones were found using MRCP; none were found using IVC (Table 1). Twenty-five of 32 CBD stones were cleared preoperatively by ERCP. Seven patients had small CBD stones exclusively and their spontaneous excretion was expected, therefore, no ERCP was performed.

Regarding the preoperative laboratory findings, 278 patients had normal liver enzymes. Eleven of these patients (4.0%) had CBD stones. These patients had no history of previous jaundice, cholangitis, or pancreatitis. The detection of these CBD stones was the result of preoperative MRCP. In 21 cases, at least one laboratory parameter was elevated. To detect “silent” CBD stones in one patient, 25 MRCP or IVC were necessary. At our institute, the cost of one MRCP is approximately 422 SFr. A liver function test costs 22 SFr. Elevated biochemical parameters were found in 21 patients (66%) with CBD stones ( $n=32$ ), but also in 155 patients (37%) with no CBD stones ( $n=422$ ) (Table 2). In case of elevated alkaline phosphatase the probability for having CBD stones was only 21% (positive predictive value of aP). On the other hand, if no parameter was elevated, the probability of a clear bile duct was 96% (negative predictive value) (Table 3). When we excluded all patients with signs of cholecystitis in preoperative MRC or intraoperatively, the sensitivity and predictive value did not change. Interestingly, CBD stones were more frequent in patients with acute cholecystitis compared to those without signs of active inflammation (9.1% vs. 6.6%,  $p=0.28$ ).

The radiological examination of the gallbladder with MRCP or IVC showed calculi in 390 patients (86%). Twenty-five (5%) had only sludge and 31 (7%) a combination of both. Eight patients (2%) had neither stones nor sludge in their gallbladder. They were operated on as a result of previous cholecystitis with typical symptoms or previous episodes of biliary colic. Radiological signs of cholecystitis were described in 84 patients: 59 acute and 25 chronic. However, the radiological diagnosis of cholecystitis could not be confirmed in every case at the time of operation. Signs of acute or chronic cholecystitis could be found in only 37 or 20 cases, respectively (Table 4).

According to preoperative imaging, 13 patients with CBD stones had an enlarged bile duct diameter; 19 were normal-sized.

**Table 1** Common bile duct stones

	Number	CBD stones	Percent
Normal liver enzymes	278	11	4
Elevated liver enzymes	176	21	12

In 278 patients with normal serum parameters, 11 CBD stones (4%) were found using MRC or IVC

**Table 2** Relation between CBD stones found in MRC or IVC and elevated liver enzymes

	Elevation of					
	Bili	AP	yGT	ASAT	ALAT	Any parameter
CBD stone found ( <i>n</i> =32) (%)	11 (34)	13 (41)	20 (63)	14 (44)	16 (50)	21 (66)
No CBD stone found ( <i>n</i> =422) (%)	54 (13)	48 (11)	113 (27)	58 (14)	79 (19)	155 (37)

*Bili* bilirubin, *aP* alkaline phosphatase, *y-GT*  $\gamma$ -glutamyl transferase, *ALAT* alanine aminotransferase, *ASAT* aspartate aminotransferase

The radiological examination revealed accessory bile ducts to the liver in 11 patients (2.6%). In two (0.5%) cases the radiologists detected an aberrant hepatic duct. In four (0.9%), the cystic duct entered the CBD at an atypical localization (not from lateral right).

While performing preoperative MRCP other abdominal organs were checked. Several anomalies were observed, and a few lesions required further examination. Benign hepatic cysts were found with the highest frequency (Table 4). Pancreatitis, pancreatic cysts, one adenoma of the adrenal gland, splenomegaly, round spots in the lung, and diverticulosis of the duodenum were also found.

In 445 patients (96%) the operation began laparoscopically. Of these patients, 18 (3.9%) required conversion to an open procedure, mostly due to adhesions or unclear anatomical situation (13 patients). Twenty patients (4.3%) were operated on directly in an open manner.

Over half of the operations (51%) were performed by the senior staff surgeons, one third (32%) by residents, and 17% by staff surgeons. If radiological findings revealed an active inflammation or difficult bile duct anatomy (34 patients, 9%), the operation was performed by a more experienced surgeon instead of a licensed medical intern. In 22% of the cases, the surgeons viewed the MRCP as helpful in identifying the anatomy.

During this study few complications (2%) were seen in patients undergoing cholecystectomy (Table 5). One colon lesion occurred by installation of the pneumoperitoneum. Open revision was necessary to treat this lesion. No bile duct injuries occurred. In one case, cardiac arrest occurred during the awakening period after the operation. Immediate cardiac resuscitation was successful. One reoperation was necessary during the postoperative period because of a persisting bleeding from the gallbladder bed.

Recurrent colics occurred twice during the observation period. Both patients had normal bile ducts in the

preoperative MRCP. When they became symptomatic, MRCP was repeated and CBD stones could be detected in both cases. These stones were extracted by ERCP.

## Discussion

Common bile duct stones are a frequent problem, occurring in 10–15% of patients with symptomatic cholelithiasis [13–15]. Their frequency tends to increase with the patient's age. The prevalence of CBD stones in patients over 60 years of age with cholelithiasis is 15–60% [14]. During the last two decades, several preoperative examinations have been proposed to detect CBD stones. Preoperative ultrasound is able to detect only 33% to 55% of the CBD stones [16]. ERCP can not be recommended as a routine examination, because of its well-documented complications including pancreatitis, cholangitis, perforation, and bleeding. Overall, ERCP has a morbidity rate of 3–10% and a mortality rate of 0.1–3% [17]. However, once a CBD stone is found, it can be cleared during the same procedure. On the other hand, IVC and computed tomography can induce allergic reactions and both are associated with ionizing radiation. In contrast, MRCP is a non-invasive examination without ionizing radiation. Several studies have shown that MRCP is an ideal device for preoperative bile duct exploration with a sensitivity and specificity comparable to those of ERCP or intraoperative cholangiography among patients with high risk for choledocholithiasis (Table 6) [5–12, 16, 18]. Since 1990, St. Claraspital, Basel has used intravenous cholangiography to detect CBD stones and to get more information about anatomical variations and the presence of cholecystitis. To reduce the risk of allergic reactions to contrast agent and the ionizing radiation we changed from IVC to MRCP 2 years ago to investigate the bile ducts preoperatively.

**Table 3** Predictive values of laboratory findings shown as percentages

	Bili	AP	y-GT	ASAT	ALAT	Any parameter
Positive predictive value	17	21	15	19	17	12
Negative predictive value	95	95	96	95	96	96

*Bili* bilirubin, *aP* alkaline phosphatase, *y-GT*  $\gamma$ -glutamyl transferase, *ALAT* alanine aminotransferase, *ASAT* aspartate aminotransferase

**Table 4** MRC findings

Organ	Findings/diagnosis	Number	Percent	
Biliary	Acute cholecystitis	in MRCP	59	13.7
	CBD stone detected	Dilated CBD	13	40.6
		Normal-sized CBD	19	59.4
		Anatomical variants	Accessory bile duct	11
		Aberrant hepatic duct	2	0.5
	Atypical entry of cystic duct	4	0.9	
Liver	Cyst(s)	70	16.2	
	Steatosis	10	2.3	
	Hemangioma	8	1.9	
	Others	4	0.9	
Additional organs <sup>a</sup>	Various findings	31	7.2	

<sup>a</sup> Pancreas, kidney, adrenal gland, spleen, duodenum

During the last two decades several authors have sought predictive values for the presence of CBD stones in case of gallstone disease. Clinical findings such as cholangitis or jaundice, dilated CBD with evidence of stones on ultrasound, and elevated liver enzymes were significant predictive factors [17, 19]. When the predictors were combined, the probability of having stones in the CBD was 99% [17]. Some authors have developed scoring systems with the intent to rationalize the number of preoperative examinations using ERCP or MRCP [19, 20]. The system introduced by Menezes, for example, reached a sensitivity of 82% and specificity of 80% [19]. Nevertheless, among all patients undergoing cholecystectomy, bile duct stones are undetected in 1–10% of patients due to lack of symptoms and clinical signs [9, 16, 17, 21].

During the observation period, we found CBD stones in 32 patients. Eleven of them had clinically silent CBD stones (4%). Although most of these CBD stones were small and were likely to pass spontaneously, some patients can develop recurrent gallstone-related disease, such as biliary colics [17]. In a study of Collins et al., one third of the calculi passed spontaneously within 6 weeks, whereas others needed to be retrieved by ERCP [22]. Ausch et al. found in a similar conducted study to ours, clinically silent CBD stones (no clinical signs of jaundice) in 6% of the patients. In their study laboratory parameters were not taken into account, thus this could explain their higher rate of “silent” CBD stones [18]. Menezes et al. mentioned that

retained stones can also lead to a secondary obstruction and later cystic stump leakage due to increased pressure [19]. To achieve maximum patient satisfaction a low rate of residual stones should be attempted by using routine MRCP. In contrary to our patients, Jendersen et al. had less than 1% asymptomatic CBD stones and therefore did not recommend a screening for CBD stones [20].

In earlier reports, bilirubin and alkaline phosphatase were the best predictors of CBD stones [23]. Another trial found a similar predictive value for ASAT [15]. However, the sensitivity and positive predictive value of all laboratory findings in previous studies is low; about 40% and 30–60%, respectively [15, 17]. Our data showed the best sensitivity for  $\gamma$ GT (63%). However, the probability of having CBD stones in case of elevated laboratory values (positive predictive value) was higher for alkaline phosphatase (21%). In contrast, in case of normal liver function tests, there was a low risk for having CBD stones (4%, negative predictive value 96%). These calculations confirmed our rate of clinically unapparent stones.

Cholecystitis was diagnosed preoperatively in some of our patients. Because elevated liver enzymes are normally seen in these cases, we might expect them to influence our calculations. However, when we excluded all patients with signs of acute inflammation in the MRCP or in the postoperative histological investigation, no difference in the sensitivity or the predictive values could be seen. Patients with cholecystitis, nonetheless had more frequent

**Table 5** Early morbidity (30 days)

Complications	Number	Percent	
Intraoperative 30 days morbidity	Colon lesion (primary open repair)	1	0.2
	Bleeding out of gallbladder bed (revision necessary)	1	0.2
	Biliary pancreatitis	1	0.2
	Cardiopulmonary complications	4	0.9
	Residual gallstones (endoscopic stone retraction)	2	0.4
Total	9	2.0	

**Table 6** Accuracy of MRCP in detecting CBD stones

Study	Patients No.	Sensitivity (%)	Specificity (%)	Pos. predictive value (%)	Neg. predictive value (%)
Hallal Ali et al. 2005	29	100	91	50	100
Ke et al. 2003	78	100	96.3	91.8	100
Mussack et al. 2002	58	100	83.3	55.6	100
Urban et al. 2002	85	93	74	89	82
Laokpessi et al.2001	113	93	100	100	81
Demartines et al. 2000	70	100	95.6	92.6	100
Liu et al. 1999	99	85	90	77	94
Dwerryhouse et al. 1998	40	88	93	78	97
Pavone et al. 1997	45	90	100	100	90

CBD stones (9.1%) than those without signs of acute inflammation (6.6%).

In addition, accessory bile ducts were found in 2.4% of patients, aberrant hepatic ducts in 0.4%, and an atypical entry to the common bile duct in 0.9%. In all of these cases the anatomical variant was recognized preoperatively and the operation could proceed with more caution. In the series described by Ausch et al., more variants of the cystic duct were detected (9.5%). This rate is higher than earlier reported in the literature (3–5%) [24]. In their opinion preoperative recognition of variations of the cystic duct are helpful in preventing bile duct lesions [18]. Furthermore, we were able to detect an enlarged common bile duct only in 41% of the patients with CBD stone. It is possible that the calculi were often too small or too recent to lead to an obstruction and an enlargement of the CBD. However, a normal-sized CBD is no guarantee of a clear bile duct.

In some cases with typical symptoms of cholecystitis, a thickened and edematous gallbladder wall could be seen in MRCP. In only 60%, an acute inflammation could be confirmed by the histological analysis.

Bile duct injuries are serious complications occurring during cholecystectomy [25, 26] and are always the result of technical error or misidentification. After the introduction of laparoscopic cholecystectomy in the 1990s, injuries to the major bile duct increased two- to threefold [27]. Intraoperative cholangiography helped to prevent these. The authors of the above-mentioned study assumed a reduction of one third by universal use of intraoperative cholangiography. In a broad National US survey from 1993, bile duct injury occurred in 0.6% of patients [26]. A previous study at our institute reported an in-house rate of 0.1% between 1990 and 2002 [2]. In the present study, no bile duct injury was observed. In total, we had a low rate of perioperative complications among our patients and no deaths (Table 5). The actual data were comparable with earlier surveys at our institute [2].

We believe that the low rate of complications is a consequence of the improved preoperative comprehension of the bile duct anatomy; using MRC as well as the

experience of our surgeons. In 22% of the cases, the surgeon considered retrospectively the MRCP as helpful for the surgical procedure. If intraoperative difficulties were expected, such as an active inflammation of the gallbladder, the operation was performed by a staff or senior staff surgeon instead of a licensed medical intern. Therefore, over half of the colecystectomies were performed by a senior staff surgeon.

With preoperative MRCP or IVC the frequency of residual stones after cholecystectomy can be markedly lowered. In our group, two cases of residual stones occurred (0.4%), which were extracted by ERCP. As patients had normal bile ducts in the preoperative MRCP, the stones must have been mobilized from the gallbladder during the operation. In the era before MRCP, when only IVC was used at our institute, residual stones occurred at a frequency of 1% [3, 4]. Residual stones not only have the risk of recurrent gallstones-associated disease, as mentioned before, they can also make patients dissatisfied. Therefore, our aim should be to detect CBD stones and target them for elimination before the operation.

So far, we didn't mention the intraoperative cholangiography which is still routinely used in different countries. In our opinion the intraoperative finding of CBD stones does not really change the surgical procedure in most hospitals. Most of the surgeons would arrange postoperative ERCP to clear the bile ducts instead of immediate bile duct exploration. Performing preoperative MRCP has the advantage to retrieve gallstones preoperatively and allows bile duct revision if ERCP failed. It is worth to mention that intraoperative cholangiograms can be false-positive in 26%. In addition to spontaneously passing calculi, unnecessary interventions can result in 50% of the patients [22].

Regarding the costs, to detect "silent CBD stones" in one patient, 25 MRCP were necessary. At our institute one MRCP costs approximately 422 CHF. Without routine use of MRCP preoperatively a certain number of patients would have possibly developed symptomatic residual stones, even with a risk of complications such as cholangitis or pancreatitis. The costs of their treatments are difficult to

estimate but may exceed the costs of MRCP performed on patients without any effect on the perioperative management. The economic consequences of postoperative treatment of residual stones are difficult to evaluate especially in the DRG-era.

We conclude that with the routine use of MRCP we were able to find CBD stones in 4% of the patients with normal liver enzymes and without a history of clinical signs of jaundice. Elevated liver enzymes have only a poor predictive value concerning the presence of CBD stones and are, therefore, of limited help in detecting CBD stones. After preoperative clearance of the bile duct stones, residual stones became rare (0.4%). MRCP is helpful to increase the safety of the perioperative management in some cases. At our institution, we continue to perform routine preoperative MRCP but facing the DRG-era also in Switzerland, its routine use will probably be omitted due to the costs. Possibly this procedure will be limited to patients with a higher probability of CBD stones (history of jaundice, pancreatitis, and cholangitis). Preoperative MRCP is very useful to have but probably not a “must” in every patient.

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