

# Magnetic resonance cholangiopancreatography in the evaluation of pancreatic and biliary disorders

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Received: April 2022 Accepted: May 2022; Published: June 1, 2022.

Citation: Shaza Youssef, Thamin Alassaad. Magnetic resonance cholangiopancreatography in the evaluation of pancreatic and biliary disorders. World Family Medicine. 2022; 20(6): 72 - 77. DOI: 10.5742/MEWFM.2022.9525073

## Abstract

The use of magnetic resonance cholangiopancreatography (MRCP) as a non-invasive alternative to diagnostic retrograde cholangiopancreatography (ERCP) is rising. The purpose of this visual review is to show how MRCP can be used to assess pancreatic and biliary system problems, because of the newly created technologies.

MRCP has been shown to be useful in a range of pancreatic and biliary system disorders because it improves spatial resolution and allows imaging of the whole pancreaticobiliary tract during a single breath-hold. It is the newest method for pancreatic and biliary duct imaging, and it uses MR imaging to view fluid in the biliary and pancreatic ducts as high signal intensity on T2 weighted sequences. The clinical uses of MRCP in a range of pancreaticobiliary system problems are presented here, and we conclude that it is a useful diagnostic tool for imaging the pancreaticobiliary ductal system.

**Keywords:** Bile ducts abnormalities; Bile ducts calculi; Bile ducts neoplasms; MR cholangiopancreatography; Pancreatic ducts; Pancreas; Neoplasms.

## Introduction

The non-invasive imaging technique magnetic resonance cholangiopancreatography (MRCP) accurately portrays the morphological features of the biliary and pancreatic ducts. The signal of static or slow-moving fluid-filled structures like the bile and pancreatic ducts is considerably increased by utilizing strongly T2 weighted sequences, resulting in increased duct-to-background contrast. Recent research has found that MRCP is comparable to invasive retrograde cholangiopancreatography (ERCP) for the diagnosis of extrahepatic bile and pancreatic duct abnormalities such as choledocholithiasis [1-3], malignant obstruction of the bile and pancreatic ducts [1,2], congenital anomalies [1,4], and chronic pancreatitis [5,6].

Unsuccessful ERCP or a contraindication to ERCP, as well as the existence of biliary-enteric anastomoses (Billroth 2 anastomosis, choledochojejunostomy, etc.), are common indications for MRCP. In certain hospitals, MRCP is replacing ERCP as the primary imaging tool for the biliary system, with ERCP being used only for therapeutic purposes. In this article, we discuss how MRCP can be used to diagnose choledocholithiasis, biliary strictures, chronic pancreatitis, benign and malignant pancreatic neoplasms, pancreatic pseudocysts, congenital anomalies, and postsurgical biliary tract modifications in the pancreaticobiliary system.

Endoscopic retrograde cholangiopancreatography (ERCP) is the gold standard for both diagnosis and treatment of CBD stones. It also allows direct visualization of duct anatomy. However, the procedure is associated with an overall complication rate of 5%-10% and a mortality rate of 0.02%-0.50% [6-8].

Ductal cannulation is difficult or impossible in patients who have undergone previous surgery, which includes Billroth type II gastrectomy and hepaticoenterostomy.

Early ERCP and stone extraction after endoscopic sphincterotomy decrease morbidity in patients with severe biliary pancreatitis. However, ERCP and endoscopic sphincterotomy are invasive procedures that may cause serious complications [7,9] and can potentially exacerbate acute pancreatitis [6]. Therefore, an accurate, safe, and efficacious method is needed to diagnose CBD stones in a definitive manner.

## Technical considerations

During the MRCP examinations, respiratory motion-induced blurring has a limited demonstration of the biliary and pancreatic ductal system and different approaches have been considered to overcome this problem. As a result, the technical history of MRCP parallels the evolution of progressively faster T2 weighted imaging sequences, i.e., from gradient-echo, to fast spin-echo (FSE), to single-shot fast spin-echo (SSFSE) [7]. SSFSE is a recently developed ultrafast T2 weighted sequence, which allows

sub-second slice acquisition. This largely overcomes the problem of motion artifact in MRCP, because physiologic motion is "frozen", and imaging of the biliary and pancreatic ducts can be performed in a single breath-hold [8]. SSFSE is the current sequence of choice for MRCP because it essentially eliminates the problem of motion artifact, and because of greater contrast-to-noise ratio and increased spatial resolution when compared with FSE or gradient-echo-based T2 weighted sequences [9]. MRCP is usually performed by using SSFSE software and both a thick-collimation (single-section) and thin-collimation

(multisection) technique with a torso phased-array coil. The coronal plane is used to provide a cholangiographic display, and the axial plane is used to evaluate the pancreatic duct and the distal common bile duct. In addition, we perform three-dimensional reconstruction by using a maximum intensity

projection (MIP) algorithm on the thin-collimation source images. Although the thick-collimation and MIP images more closely resemble conventional cholangiograms and are familiar to many clinicians, spatial resolution is degraded because of volume-averaging effects. Diagnostic decisions are usually made on the basis of the thin-collimation source images; however, MIP images often allow the depiction of a greater length of the duct on a single image than on any thin-collimation source image. In addition, MIP images are useful in the three-dimensional depiction of ductal anatomy and in planning surgical procedures and radiation therapy. On the other hand, the source images, which provide greater spatial resolution, must be carefully scrutinized so as not to overlook small luminal filling defects and strictures, which may be obscured on the thicker-collimation images.

With a variety of biliary and pancreatic diseases, bile duct stenoses, dilatation, and stones were all better seen on source thin slices than on either MIP reconstruction or single thick slice MRCP[10].

Another disadvantage of such techniques is that periductal structures are deliberately excluded from the final images, even though extraluminal detail may be of critical importance, as in the assessment of neoplastic duct obstruction.

## Patient preparation

To enhance gallbladder filling and stomach emptying, patients should fast for 4-6 hours before the evaluation. Although some authors advocated for the use of glucagon to stop peristalsis, the utilization of quick pulse sequences eliminated this need. The pancreatic and biliary ducts can be seen without the use of an exogenous contrast. Fluid has a lengthy T2 compared to surrounding soft tissues and calculi, which provides enough intrinsic contrast. The use of a negative oral contrast reduces the intensity of the signal caused by overlapping fluid in the stomach and duodenum.

## MRCP in Choledocholithiasis

In the identification of choledocholithiasis, MRCP is equivalent to ERCP and superior to CT and US [2,3]. Sensitivities of 81 percent to 100 percent and specificities of 85 percent to 100 percent have been reported in numerous studies [11]. On MR images, biliary stones nearly always have a low signal intensity, regardless of calcium content.

As a result, the stone is identified as a round or oval-shaped “filling defect” within the common bile duct (CBD), which is surrounded by bile with a high signal intensity.

Although MRCP has a lower spatial resolution than ERCP, the superior contrast resolution allows 2 to 3 mm stones to be spotted easily [12]. Because the sensitivity for detecting small stones declines with increasing section thickness due to volume averaging of high signal intensity bile surrounding the stone, it is critical to examine the thin, source pictures.

However, there are a variety of traps that must be identified correctly in order to avoid incorrect diagnosis. A-artifacts on MIP reconstructed pictures, B-CBD entirely filled with stones, C-pneumobilia, and D-differential diagnoses between air bubbles and small stones are all examples. This study demonstrates that postoperative ERCP is highly effective in both confirming and treating choledocholithiasis. However, there is a significant risk of short-term complications that must be taken into consideration when deciding on management.

## MRCP in benign biliary strictures

In 90% to 95% of cases, benign biliary strictures are caused by surgical injury (laparoscopic cholecystectomy, gastric and hepatic resection, biliary-enteric anastomoses, post-liver transplantation), external penetrating or blunt trauma, inflammation associated with lithiasis, chronic pancreatitis, stricture of the papillary region, toxic or ischemic lesion of the hepatic artery or primary infection such as in primary sclerosing cholangitis [13].

MRCP has been proven to be equivalent to ERCP in detecting the location and extent of extrahepatic bile duct strictures, with sensitivities ranging from 91% to 100% [14]. The accuracy of detecting strictures of the intrahepatic bile ducts, on the other hand, is being investigated.

ERCP is particularly useful in the management of patients with biliary obstruction due to choledocholithiasis and other benign diseases of the biliary tract such as biliary strictures and postoperative biliary leaks. Successful endoscopic cholangiography with relief of biliary obstruction should be technically achievable in more than 90% of patients.

Adjunctive cholangioscopy at the time of ERCP can be helpful in the management and treatment of choledocholithiasis and for assessing indeterminate strictures.

ERCP with bile duct stenting and/or biliary sphincterotomy is the preferred treatment strategy for bile leaks.

## Sclerosing Cholangitis and MRCP

Sclerosing cholangitis is a fibrosing, inflammatory condition that causes sclerosis and stenosis of the bile ducts, both intrahepatic and extrahepatic. Strictures are multifocal and alternate with minor dilation or normal-caliber bile ducts, giving the appearance of a beaded or “pruned tree”.

Because MRCP is less sensitive than ERCP to early sclerosing cholangitis peripheral ductal alterations, it should be used only for complications or follow-up in more advanced cases.

## MRCP in Cholangiocarcinoma

Cholangiocarcinoma can show as a stricture affecting the CBD (30%-36%), the common hepatic duct (15%-30%), the biliary bifurcation (10%-26%), and the intrahepatic ducts (8% -13%) with no signs of a mass lesion or as a nodular process with an intrahepatic solid mass. The MRCP features are a sudden biliary obstruction with dilatation of bile ducts above. In the case of Klatskin tumors, information regarding the involvement only of the right or left biliary system or both can be easily obtained, with important consequences on the therapeutic approach. Similar to other neoplastic lesions, conventional MR images are needed for correct lesion identification and staging. In particular, for cholangiocarcinoma, T1 weighted images after contrast medium injection can be very helpful in correct identification of the lesion and of its relationship with surrounding organs, although, in the case of stenosing lesion, no expansile process is usually identified.

## MRCP in biliary injuries

Initial studies suggest that iatrogenic biliary injuries are well demonstrated at MRCP [15]. Bile leaks cause fluid to accumulate in the subhepatic area, which is easily seen by MRCP. However, MRCP cannot tell if a leak is active. Mangafodipir, a selective hepato-biliary contrast agent, has recently been reported to be used. Hepatocytes process this substance, which is then eliminated in the bile. Although prospective trials have not yet been reported, this agent may prove effective in the noninvasive detection of active bile leaks [16].

## MRCP in biliary and pancreatic ducts with congenital anomalies

Several congenital biliary duct architecture variants are surgically important because they have been found to enhance the risk of bile duct injury during cholecystectomy. A low cystic duct insertion, a medial cystic duct insertion, a lengthy parallel course of the cystic and common hepatic ducts, a short cystic duct, and an aberrant right posterior sectorial duct draining to the cystic or common hepatic duct are examples of such variants [4].

MRCP had a sensitivity and specificity of 86 percent and 100 percent in the identification of cystic duct variations, and 71 percent and 100 percent in the diagnosis of aberrant right hepatic duct, respectively, when compared to conventional cholangiography. The main pancreatic duct (Wirsung duct) drains through the major papilla in healthy people; this duct is the pancreas' principal drainage pathway in 91 percent of cases. The auxiliary pancreatic duct (Santorini duct) drains through the minor papilla and is found in 44% of people. The most frequent anatomic variant of the pancreas is the pancreas divisum, which occurs when the dorsal and ventral pancreatic ducts fail to fuse and is linked to an increased risk of acute pancreatitis [5]. The dominant dorsal pancreatic duct, which drains the pancreatic tail, body, and superior head, runs anterior to the CBD and empties into the minor papilla, which is superior to the major papilla, separately from the CBD. The CBD is carried into the major papilla by the smaller ventral duct, which drains the inferior pancreatic head and uncinata process. The accuracy of MRCP in the diagnosis of pancreas divisum was found to be 100 percent by Bret et al [17].

### MRCP in chronic pancreatitis

For chronic pancreatitis, the MRCP diagnostic criteria includes duct dilatation, narrowing, stricture, or irregularity [7]. Other imaging abnormalities include pancreatic contour irregularities, pseudocysts, and ductal filling deficiencies caused by stones, debris, or mucinous plugs. The duct dilatation is more prominent in advanced chronic pancreatitis, and it can be accompanied by CBD dilatation, resulting in a "double duct sign," as seen in pancreatic head carcinoma.

Intraductal calculi may be observed in chronic pancreatitis. These calculi appear as low signal filling defects surrounded by pancreatic fluid with a high signal intensity (meniscus sign). The lateral branches of the pancreas exhibit a "chain of lakes" look in severe pancreatitis. According to Soto et al [18], MRCP has a sensitivity of 87 percent to 100 percent for dilatation, 75 percent for narrowing, and 100 percent for ductal calculi. The authors conclude that in chronic pancreatitis, MRCP can accurately detect pancreatic duct anomalies.

Because MRCP is probably not sensitive to detect early side-branch alterations in chronic pancreatitis, it should be used only for complication diagnosis or follow-up in more advanced instances. Because of its higher spatial resolution, ERCP is more sensitive to early side-branch alterations.

### Pancreatic pseudocyst

Pancreatic pseudocysts are encapsulated fluid collections that develop in the pancreas as a result of acute or chronic pancreatitis. Because less than half of pseudocysts fill with contrast material during ERCP, MRCP is more sensitive than ERCP in detecting them [19]. MRCP, on the other hand, is less sensitive in determining the location of communication with the pancreatic duct. Although

up to 60% of pseudocysts may resolve spontaneously, infection or hemorrhage can exacerbate the situation. MRI and MRCP are useful in demonstrating pseudocysts and possibly their ductal communications as well as in establishing the presence of associated hemorrhage without the risk of infecting the pseudocyst as may occur at ERCP.

### MRCP in pancreatic duct obstruction or neoplastic biliary obstruction

Approximately 90% of malignant pancreatic neoplasms are ductal in origin, with adenocarcinomas accounting for the majority. In 95% of instances, pancreatic cancer appears as a localized mass, while the other 5% of patients have diffuse gland involvement [20]. Of these focal carcinomas, 62% are located in the pancreatic head, with the remainder located in the body (26%) and tail (12%) of the pancreas [20].

Encasement and obstruction of the pancreatic duct or bile duct are MRCP findings of pancreatic carcinoma. The "double duct sign" is a dilatation of both ducts that is strongly suggestive of, but not diagnostic for, malignancy [14]. Dilatation of the biliary and pancreatic ducts occurred in 77 percent of pancreatic head cancer cases, biliary duct dilatation in 9%, and pancreatic duct dilatation in 12% [20]. However, a normal-sized pancreatic duct should not cause this diagnosis to be excluded because the caliber will be normal in up to 20% of patients with pancreatic malignancy causing bile duct obstruction.

MRCP can also be used to assess intraductal papillary mucinous cancers. The epithelium of the main pancreatic duct or its side branches gives rise to these malignancies.

They are slow-growing tumors characterized by mucin production in enormous quantities. Benign adenomas and a limited cystic parenchymal lesion are commonly linked with side-branch ductal involvement. Diffuse duct dilatation, excessive mucus production, and micropapillary studding are all symptoms of main pancreatic duct involvement, which is usually linked with malignancy [23,24]. Traditionally, the diagnosis was made via an ERCP procedure. Because of its capacity to show the full level of ductal involvement, MRCP is now considered preferable to ERCP [25], especially when obstructive mucus prevents complete ductal opacification by ERCP. Furthermore, MRCP can show stenosis and dilatation of the main ductal and side branch ducts, as well as related cystic lesions and communication between these lesions and the ductal system [26]. It's also possible to show how papillary projections produce filling faults.

### Trauma of the pancreas

Pancreatic damage occurs in 2% to 12% of people who have had blunt abdominal trauma [27]. The disruption of the pancreatic duct is a critical prognostic signal, thus it's crucial to diagnose it early. Although CT is a sensitive approach for detecting parenchymal injury, ERCP is

frequently required to demonstrate duct injury [28]. The use of MRCP as a noninvasive approach for assessing pancreatic ductal damage has lately gained popularity [29]. Soto et al [30] revealed that MRCP accurately demonstrated the state of the duct and the site of duct transaction in all seven trauma patients. Though CT will almost certainly remain the gold standard for pancreatic damage diagnosis, MRCP has shown potential in the planning of therapeutic surgical or endoscopic procedures in this setting [30].

### MRCP in biliary tract alterations after surgery

Biliary-enteric anastomoses, such as choledochojejunostomy, hepaticojejunostomy, and Billroth 2 anastomosis, make accessing the main papilla at endoscopy difficult or impossible. MRCP is the imaging modality of choice for the work-up of suspected pancreaticobiliary illness in individuals with such anastomoses. MRCP has been shown to be 100% sensitive in the diagnosis of anastomotic strictures and 90% sensitive in the detection of biliary tract stones proximal to the anastomosis [31]. After a Whipple surgery, MRCP is likewise 100 percent sensitive in demonstrating the choledochojejunal anastomosis [1]. Because the biliary-enteric anastomosis and stones can be concealed on thick-section and MIP pictures by the high signal strength of the surrounding bile and intestinal fluid, careful examination of the source images is required. On MIP pictures, strictures may be overestimated [31].

### Benefits and limitations

The lack of intrusiveness is a significant advantage of this strategy. MRCP is also not limited to patients with changed anatomy (choledochal or pancreaticojejunostomy, Billroth 2 syndrome, etc.) and is not operator-dependent.

The present limitation of MRCP is its low spatial resolution, which makes it difficult to visualize non-dilated pancreatic duct side branches and characterize strictures. As a result, MRCP is unable to detect tiny duct disease. Small duct disease includes sclerosing cholangitis' minor intrahepatic duct changes and moderate chronic pancreatitis' side branch modifications. The lack of duct distension at MRCP also contributes to this limitation.

### Conclusions

In conclusion, MRCP is a non-invasive diagnostic method for biliopancreatic disorders that is comparable to ERCP in terms of accuracy. Early assessments of diagnostic performance suggest that MRCP can (1) reliably demonstrate normal and abnormal pancreatic and biliary ducts, (2) accurately diagnose the cause and site of obstruction, and (3) be of diagnostic value when ERCP is unsuccessful, despite its lower spatial resolution when compared to ERCP.

When the biliary-enteric anastomosis extends beyond the duodenum, as is commonly the case, ERCP is not possible. Similarly, ERCP cannot be performed after a Billroth 2 gastro-enterostomy. In patients with suspected solid extra

ductal masses or cystic masses that do not connect with the duct system, MRCP may be preferable to ERCP [21]. The patient's preference for non-invasive imaging may also be a factor in choosing MRCP over ERCP. MRCP is anticipated to overtake diagnostic ERCP as the preferred method of imaging the biliary and pancreatic ducts in the near future.

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