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REVIEW OF ROLES OF MAGNETIC RESONANCE CHOLANGIOPANCREATOGRAPHY (MRCP)

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Abstract:
Magnetic resonance cholangiopancreatography (MRCP) is a method that has developed during the last twenty years. It still plays a crucial role in the non-invasive examination of several pancreatico-biliary illnesses. We evaluated the efficacy of MRCP as a noninvasive diagnostic instrument in individuals with various conditions. Magnetic Resonance Cholangiopancreatography (MRCP) is a diagnostic technique that is both safe in terms of ionizing radiation exposure and does not require the use of iodinated contrast agents. It effectively visualizes the biliary tree by utilizing a combination of projectional and cross-sectional imaging methods.

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INTRODUCTION:

Magnetic resonance cholangiopancreatography (MRCP) is now the established noninvasive method for examining the biliary tree in order to observe ductal dilatation, strictures, and intraluminal filling defects [1].

While endoscopic retrograde cholangiopancreatography (ERCP) has traditionally been the preferred method for identifying pancreaticobiliary illnesses, its routine usage has been restricted due to the occurrence of complications such as pancreatitis, cholangitis, bleeding, and duodenal perforation. Therefore, MRCP has largely supplanted its use in the diagnosis of hepatobiliary diseases [2].
The benefits of this approach are its avoidance of contrast media and ionizing radiation, its noninvasive and complication-free nature, its ability to provide multiplanar imaging, and its very short examination duration. The drawbacks of magnetic resonance imaging (MRI) encompass limited accessibility, high expenses, and challenges encountered with claustrophobic individuals or patients possessing ferromagnetic metallic implants such as aneurysm clips [3].

Magnetic resonance cholangiopancreatography (MRCP) accurately portrays the expansion of the ducts with a sensitivity of 95% [4]. One further advantage of MRCP is its capability to precisely determine the location, extent, and underlying cause of obstruction. Strictures are observed as a localized constriction of the duct, accompanied with dilation in the proximal region. The lack of proximal dilatation may indicate a widespread ductal pathology, such as sclerosing cholangitis, or a lack of duct distensibility, as seen in cases of cirrhosis [4]. Choledocolithiasis is the most prevalent disorder affecting the biliary system. T2-weighted cholangiography is recognized for its great sensitivity and specificity in detecting biliary filling abnormalities, especially stones [5]. Postcholecystectomy problems are uncommon, although their occurrence is rising due to the widespread adoption of laparoscopic cholecystectomy. MRCP is frequently utilized to illustrate postsurgical complications [6].
This research aimed to provide an overview of the various therapeutic and diagnostic roles of Magnetic Resonance Cholangiopancreatography (MRCP) in different illnesses.

Review:

Exactly twenty years have passed since the initial description of magnetic resonance cholangiopancreatography (MRCP) [7]. During this period, the method has undergone significant advancements, facilitated by enhancements in spatial resolution and acquisition speed. It currently plays a recognized role in the examination of many biliary pathologies, functioning as a non-invasive substitute for endoscopic retrograde cholangiopancreatography (ERCP). This technique utilizes T2-weighted pulse sequences extensively, taking advantage of the inherent disparities in T2-weighted contrast between immobile fluid-filled structures in the abdomen (which exhibit a lengthy T2 relaxation time) and neighboring soft tissue (which has a significantly shorter T2 relaxation time). Fluids that are not in motion or are moving slowly within the biliary tree and pancreatic duct provide a strong signal on MRCP, while the surrounding tissue shows a weaker signal [8].

The acquisition of heavily T2-weighted images was initially accomplished by the utilization of a gradient-echo (GRE) balanced steady-state free precession approach [9]. Subsequently, a rapid spin-echo (FSE) pulse sequence was implemented, with a prolonged echo duration (TE). This technique has several benefits, including an increased signal-to-noise ratio and contrast-to-noise ratio, as well as reduced susceptibility to motion and susceptibility artifacts. Several altered FSE sequences have been documented, such as rapid acquisition with rapid enhancement (RARE), half-Fourier acquisition single-shot turbo spin-echo (HASTE), and fast-recovery fast spin-echo (FRFSE) sequences. Both breath-hold (employing a single shot approach) and non-breath-hold procedures (utilizing respiratory triggering) have been employed, resulting in pictures acquired either as a two-dimensional (2D) or three-dimensional (3D) acquisition [10,11]. A 3D approach offers an increased signal to noise ratio, but at the expense of thinner consecutive slices. Obtaining images with nearly equal dimensions in all directions enables enhanced manipulation of the images using techniques such as multi-planar reconstruction, maximum intensity projection (MIP), and volume rendering. The implementation of accelerated gradients and a parallel acquisition technique has led to improved spatial resolution and reduced acquisition times. Recently, it has become feasible to test biliary excretion and pancreatic exocrine function by utilizing hepatobiliary contrast media and secretin, respectively [12,13].

The MRCP approach relies on T2-weighted images, which generate a significant contrast enhancement between immobile fluids (such as bile) and the surrounding structures (such as hepatic and pancreatic parenchyma, and abdominal fat). Consequently, the bile exhibits a significantly higher signal intensity in

comparison to the low signal intensity background. Furthermore, there is no signal detected from the movement of blood [14].

No intravenous contrast agent is necessary for the test. Prior to conducting an MRCP, it is advised that patients abstain from eating for a duration of 3-4 hours. This practice aims to minimize the amount of fluid in the stomach, restrict movement in the duodenum, and facilitate the filling of the gall bladder. Magnetic Resonance Cholangiopancreatography (MRCP) is conducted utilizing both breath-hold and non-breath-hold sequences. The breath-hold sequence captures a solitary segment of information, with a thickness ranging from 40 to 80 mm, within a time frame of 1 to 2 seconds. This yields comparable projection images to those obtained using ERCP [**Figure 1**]. The text is enclosed in the tags [15]. Thin slabs with a thickness of 4 mm can be obtained utilizing breath-hold T2-weighted half Fourier acquisition single-shot turbo spinecho (HASTE) sequences. These are acquired by coronal or oblique coronal perspectives. Furthermore, the MRCP procedure includes obtaining numerous thin collimation slices using a non-breath-hold, respiratory-triggered 3D turbo spin-echo (TSE) T2-weighted sequence with a thickness of 1.5 mm. These slices can then be processed on an imaging workstation [15].

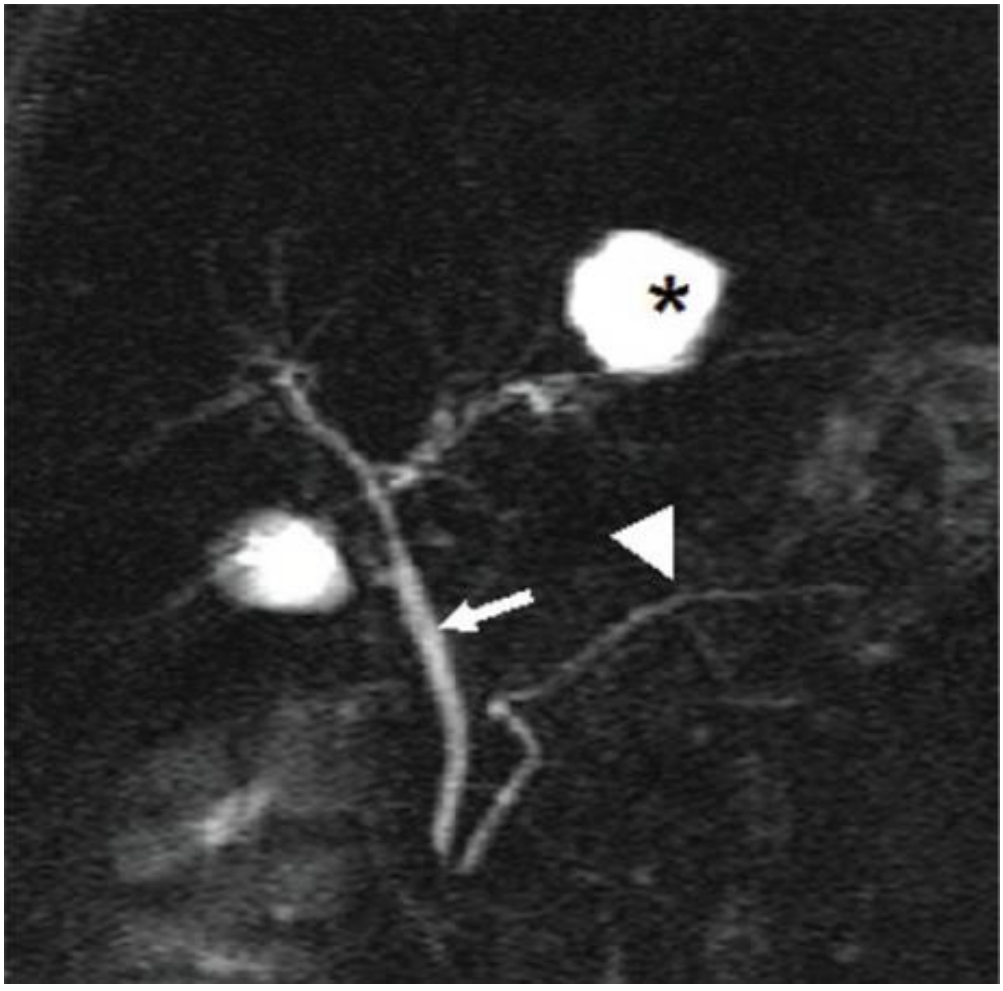

Figure 1: Thick slab image of magnetic resonance cholangiopancreatography RCP examination. The common bile duct (straight arrow) is normal in calibre. The intra-hepatic biliary radicals are not dilated, hence not well visualised. The main pancreatic duct (arrow head) is well delineated. The structure (asterisk) is a hepatic cyst.

There is a limited amount of research on the efficacy of performing magnetic resonance (MR) cholangiography utilizing a high field strength of 3 Tesla (T) in comparison to the more regularly utilized 1.5 T. When comparing MR cholangiography at 1.5 T to MR cholangiography at 3.0 T, the latter provides a better contrast-to-noise ratio and a higher level of confidence in showing intrahepatic variations. However, there is no substantial improvement in image quality. Enhanced progress can be attained through the optimization of sequences and the enhancement of coil design [16,17].

Administering secretin externally induces the exocrine pancreas to secrete fluid and bicarbonate, while also enhancing the tone of the sphincter of Oddi. As a result, the amount of fluid that is not moving in the pancreatic duct increases and its visibility may be enhanced during MRCP. Following the injection of 1ml of secretin for every 10kg of body weight through a vein, a thick slab MRCP is conducted in the coronal plane. This procedure is repeated at intervals of 15-30 seconds for a duration of 10-15 minutes. Secretin enhances the visualization of the entire pancreatic duct, decreases the occurrence of incorrect positive results for duct strictures, and improves the assessment of sphincter anatomy and identification of anatomical variations such pancreas divisum. This image shows the gradual filling of the duodenum with pancreatic fluid, which indirectly measures the pancreatic exocrine reserve [18].

Clinical Applications:

There are two main birth defects that affect the biliary tree: an abnormal pancreaticobiliary junction (APBJ) and congenital biliary cystic disease. Choledochal cysts are innate abnormalities of the bile ducts. They are characterized by cystic or elongated dilations of the biliary tree outside the liver, the small branches of the biliary system within the liver, or both. The Todani categorization [18] categorizes these into five primary kinds. The cysts can lead to various complications such as the formation of gallstones (cholelithiasis), the presence of stones in the bile duct (choledocholithiasis), the development of cancer (carcinoma), inflammation of the pancreas (pancreatitis), infection of the bile duct (cholangitis), and the bursting of the cyst. Magnetic Resonance Cholangiopancreatography (MRCP) is employed to precisely delineate the size of the cyst, ascertain the existence of an abnormal connection between the pancreas and bile duct (APBJ), and identify any related problems. The MRCP offers comparable information to that obtained through ERCP, but without the risk of potential problems, for the preoperative evaluation of choledochal cysts [19]. An anomalous pancreaticobiliary junction (APBJ) is a rare condition in which the common bile duct and major pancreatic duct are connected outside the wall of the duodenum, with the shared channel measuring more than 1.5cm in diameter. It increases the likelihood of individuals developing choledochal cysts, cholangitis, stones, and pancreatitis. Up to one third of the affected individuals may have an association with biliary tract cancer. MRCP has been documented to exhibit a sensitivity of around 75% and a specificity of 100% in identifying APBJ, as shown in [**Figure 2**] [15].

More than 50% of people exhibit deviations from the typically characterized anatomical structure of the biliary tree. Studies have demonstrated that MRCP has a diagnostic accuracy of 98% for identifying abnormal hepatic ducts and 95% for diagnosing variations in the cystic duct. In order to decrease the likelihood of bile duct injury, it is important to identify any abnormal anatomy prior to surgery, particularly during laparoscopic cholecystectomy. This procedure has twice the risk of bile duct injury compared to open cholecystectomy [20].

Multiple investigations have demonstrated that MR cholangiography has a sensitivity of around 95% for detecting focal strictures in the bile ducts [21,22]. In order to distinguish between benign and malignant causes of biliary strictures and dilatation, the principles used in conventional cholangiography can also be applied to MR cholangiography. Malignant lesions typically appear as irregular strictures with shouldered margins, while benign stenosis tends to have smooth borders with tapered margins. However, distinguishing between different conditions can be challenging when using MR cholangiography. It typically relies on identifying a mass or tumor in conjunction with the stricture during cross-sectional T1- or T2-weighted MR imaging. This discovery suggests a malignant origin. Although there is a restriction, MR cholangiography is useful for precisely assessing the condition of the biliary ductal system in patients with malignant obstruction. It achieves this by precisely detecting the specific location of the obstruction and measuring the extent of the narrowing. MR cholangiography can be used to assess if a patient is suitable for percutaneous transhepatic cholangiography with antegrade stent insertion or retrograde intervention. The avoidance of unnecessary hazards related to many invasive treatments is achieved [23].

The occurrence of malignant blockage at the porta hepatis is typically caused by cholangiocarcinoma, metastatic liver disease or periportal lymph nodes, invasive hepatocellular carcinoma, or invasive gall bladder carcinoma [24]. Lesions such as lymphadenopathy or direct extension of malignancies from nearby organs (e.g. gall bladder, pancreas, stomach, colon) can block the biliary tract outside the liver and above the pancreas. Neoplastic blockage of the part of the common bile duct within the pancreas can result from pancreatic head carcinoma, cholangiocarcinoma, or ampullary carcinoma.

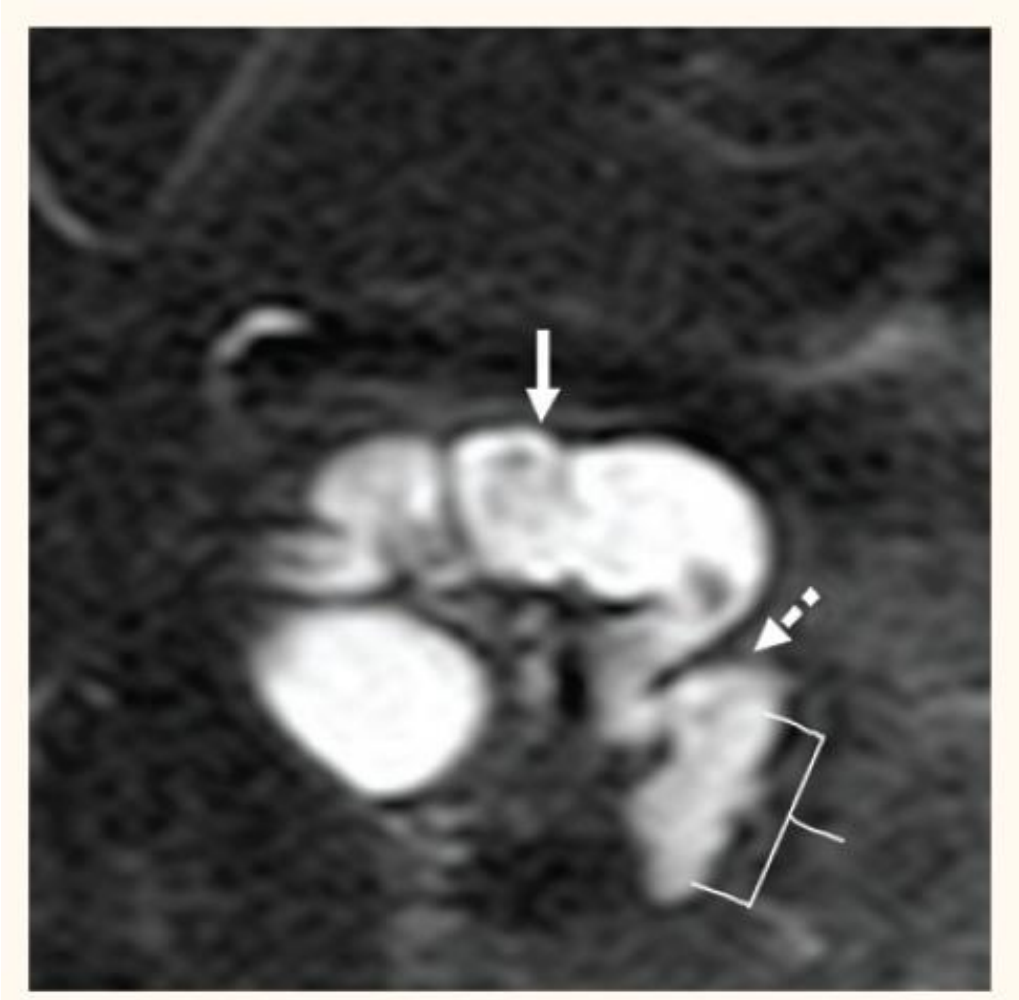

Figure 2: Choledochal cyst. Maximum intensity projection image showing tortuous dilated common bile duct (solid arrow) without associated intrahepatic biliary ducts dilatation.

CHOLANGIOCARCINOMA

Most cholangiocarcinomas are ductal adenocarcinomas that arise from both the epithelium of the bile ducts within the liver and those outside the liver. The tumors commonly have growth patterns that can be described as exophytic, infiltrative, polypoid, or a combination of these [23]. The Hilar cholangiocarcinoma, sometimes referred to as Klatskin tumour, is a typically small and difficult-to-detect lesion. Its identification by ultrasonography or computed tomography (CT) presents hurdles. Magnetic resonance imaging (MRI) has proven to be effective in precisely determining the size and extent of malignant tumors. Magnetic resonance cholangiography is a valuable imaging technique for assessing the extent of dilatation in the intrahepatic ducts, as well as precisely defining the position and dimensions of the stricture. Scirrhous tumors commonly exhibit a reduction in signal intensity at the core and variable enhancements in signal intensity in the periphery. Conversely, well-differentiated cholangiocarcinomas may have increased signal

intensity on T2-weighted imaging. The parameters used to assess the condition of being non-surgically removable generally include the following: 1) Bilateral spread of bile ducts within the liver to secondary or segmental biliary branches; 2) Involvement of the main trunk of the portal vein, unless there are unusual circumstances; 3) Involvement of both lobes of the liver's arterial and/or portal venous branches; 4) A combination of one-sided arterial involvement and extensive spread of ducts on the opposite side, as shown by cholangiography [25].
Magnetic resonance imaging (MRI) and magnetic resonance cholangiography (MRC) are highly successful in detecting additional abnormalities related to cholangiocarcinoma. These abnormalities include satellite lesions in the liver, regional lymphadenopathy in pancreaticoduodenal and portocaval nodes, intraductal tumor development, and peritoneal tumor invasion. The use of gadolinium contrast material can assist in precisely demarcating the boundaries of the tumor [15].

CHOLEDOCHOLETHIASIS

Choledocholithiasis is the main cause of biliary blockage and is a significant diagnostic when considering laparoscopic cholecystectomy. Patients with symptomatic cholelithiasis, acute cholecystitis accompanied by jaundice, cholangitis, gall stone pancreatitis, or a common bile diameter larger than 6–7mm on sonography are classified as being at a high risk of choledocholithiasis. Patients diagnosed with choledochlithiasis experience improved outcomes when undergoing ERCP-guided sphincterotomy and stone extraction before laparoscopic cholecystectomy [26].

The sensitivity of MRCP in detecting common bile stones ranges from 81% to 93%, while its specificity ranges from 91% to 95%. It has similar levels of sensitivity and specificity as ERCP for assessing common bile duct stones. On magnetic resonance cholangiopancreatography (MRCP), calculi are observed as areas of reduced signal strength, regardless of their composition [27].
Acute cholecystitis typically occurs when the cystic duct or gall bladder neck becomes blocked. For a patient suspected of having acute cholecystitis, ultrasonography (US) and/or computed tomography imaging are typically the preferred imaging methods. Nevertheless, proving the presence of a stone lodged in the cystic duct or gall bladder neck is frequently challenging. Magnetic resonance imaging (MRI) exhibits greater sensitivity compared to ultrasound (US) in the detection of acute cholecystitis [28].

POST LIVER TRANSPLANTATION

Although orthotropic liver transplantation (OLT) has seen significant advancements in recent years, such as the development of more effective immunosuppressants, improved graft preservation solutions, and updated surgical procedures, biliary system problems continue to be a common source of morbidity. The biliary tract issues encompass leakage, blockage, the production of stones, and the development of strictures [29]. Anastomotic biliary leaks and bilomas frequently occur within the initial 30 days after transplantation. Biliary blockage, typically resulting from a stricture, is the second most prevalent cause of liver impairment, following rejection. Non-anastomotic strictures typically result from biliary alterations caused by ischemia, such as those that occur when the hepatic artery is blocked. The T tube or plastic biliary stent does not produce any distortions on MRCP images.

Magnetic Resonance Cholangiopancreatography (MRCP) can offer imaging that is comparable to Endoscopic Retrograde Cholangiopancreatography (ERCP) and can consistently detect and measure biliary strictures in patients who have had orthotopic liver transplantation (OLT). The sensitivity of MRCP in this example was reported to be between 87.5% and 100%, while the specificity ranged from 87.5% to 92.3% [30].

CONCLUSION:

The MRCP approach has undergone significant advancements in the past 20 years, with improvements in both data collection and data analysis. It continues to be the preferred method of examination for the non-invasive diagnosis of numerous pancreatico-biliary illnesses. This review aims to refresh the reader's understanding of the fundamental principles of MRCP, the various sequences that can be utilized, the potential challenges to be mindful of, and the reasons why it continues to be a suitable test for the radiological examination of biliary pathology, even in the present era. MRCP is the most effective method for visualizing both normal and narrowed bile ducts, and it enables the distinction between those without any health issues and those suffering from sclerosing cholangitis. While endoscopic retrograde cholangiopancreatography was once considered the standard method, MR cholangiopancreatography has been found to be superior in seeing the intrahepatic biliary ducts. Hence, this method holds significance in the identification and monitoring of individuals with sclerosing cholangitis.

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