Original article

Spectrum of MRCP findings: An Initial Experience with 3.0 Tesla Magnetic Resonance Imaging System in Nepal

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Abstract:

Introduction: Magnetic resonance cholangiopancreatography (MRCP) is a non-invasive magnetic resonance imaging (MRI) examination used in the evaluation of hepatobiliary and pancreatic tree. It is a non-invasive alternative to endoscopic retrograde cholangiopancreatography (ERCP). Here we attempted to summarize the spectrum of MRCP findings in a cohort of patients undergoing MRCP examination in a 3.0 Tesla MRI system, the first of its kind in Nepal.

Methods: The study was curried among patients undergoing MRCP in a 3.0 Tesla MRI system from November 24, 2014 to June 29, 2015. 167 patients (73 male and 94 female; age range,1-87 years, mean age, 49.8years) were identified who underwent MRCP. MRCP was performed on a 3.0 Tesla MR scanner (Ingenia, Philips Medical System) using a sixteen –element quadrature phased array body coil over the liver. The MRCP findings were reviewed and various imaging findings were recorded. The findings were analyzed using SPSS.

Results: MRCP was normal in 44(26.2%) patients. Various findings were found in the biliary ducts, liver, gall bladder, pancreas and outside the pancreas and liver. Commonest biliary duct pathology was choledocholithiasis (25.7%). Commonest liver pathology was chronic liver disease (3%). Commonest pancreatic parenchymal pathology was acute pancreatitis (4.2%). Commonest pancreatic duct pathology was dilated pancreatic duct (5.4%). Gall bladder was seen in 37 (22%) patients, and 30 patients were status post cholecystectomy (17.9%). Extra pancreaticobiliary findings included pleural effusion, ascites, splenomegaly, juxtapapillary duodenal diverticulum etc.

Conclusion: MRCP is the choice of investigation for the non-invasive diagnosis of pancreaticobiliary disorders. In the current review, we have summarized the spectrum of MRCP findings and shared an early experience with 3.0 Tesla MRCP system in Nepal. The findings are comparable to the existing literature in the subject.

Keywords: Bile ducts, Gall bladder, Magnetic resonance cholangiopancreatography (MRCP), Pancreas

Introduction

Magnetic resonance cholangiopancreatography (MRCP) is a noninvasive magnetic resonance imaging (MRI) examination that produces detailed anatomic, morphologic and pathologic images of the hepatobiliary and pancreatic ducts. It also images the liver, gall bladder and pancreatic parenchyma.[1]Wallner introduced MRCP as an accurate, non-invasive alternative to endoscopic retrograde cholangiopancreatography (ERCP) in the evaluation of biliary tract pathology.[2] ERCP cannot delineate liver and pancreatic parenchymal lesions. Computed tomography (CT) and ultrasonography (USG) may be diagnostic for the liver and pancreatic parenchymal lesions; however, they may not characterize the biliary and pancreatic duct abnormalities.[3]The common indications of MRCP are unsuccessful ERCP or contraindications to ERCP eg. biliary-enteric anastomoses like choledochojejunostomy, Billorth II anastomosis. MRCP is noninvasive, cheaper, lacks ionizing radiation, doesn't require exogenous

contrast material and anesthesia, less operator dependent, allows better visualization of ducts proximal to an obstruction and allows detection of extraductal disease. Major disadvantages are lack of therapeutic capability, costly equipment and non availability in every institution.[4] Heavily T2 weighted sequences are used for MRCP examination. It produces increased signal intensity from static or slow moving intraductal fluid resulting in increased duct to background contrast.[5] It is distinguished into single shot heavily T2 weighted sequence also known as 2D thick slab sequence (30 -50 mm slice thickness),[6] especially used for patients unable to hold breath (example very sick patient or small children)[7]; however, routinely used important technique is heavily T2 weighted 3D sequences with the slab in coronal orientation. Thick maximum intensity projection (MIP) images can be reconstructed in different planes.[7] 3D-imaging techniques provide better image quality compared to 2D-sequences[1, 8, 9], even though the combination of different MRCP sequences has proven to be valuable in the assessment of bile duct anatomy, morphology and pathology.[10]

The purpose of this study was to compare MRCP imaging findings of hepaticbiliary and pancreatic tree with clinical findings. In this article, we present the spectrum of bile and pancreatic duct abnormalities seen at MRCP.

Methods

This was a retrospective review of patients referred for MRCP for suspected pancreaticobiliary diseases fromNovember 24, 2014 to 29 June 2015. 167 patients (73 men and 94 women; age range,1-87 years, mean age, 49.8years) were identified who underwent MRCP. The indications for the MRCP referrals were, pain in abdomen (n=63), jaundice (n=38), pain and jaundice (n=5), pancreatitis (n=16), hepatobiliary and pancreatic pathology in USG and CT (n=45).

MRCP was performed on a 3.0 T MR scanner (Ingenia, Philips Medical System) using a sixteen element quadrature phased array body coil over the liver. The standard MRCP protocol consisted of the following imaging sequences and parameters:

1. Respiratory triggered T2 SPAIR axial and T2 coronal sequence with slice thickness 5mm (TR 800ms, TE 70ms) in the region of liver to pancreatic parenchyma, so that the whole of the liver down to the duodenal ampulla is visualized. These sequences were used as reference sequence for planning of 2D and 3D MRCP.
2. 2D MRCP images were obtained using breath-hold thick-slab heavily T2-weighted fat saturated single-shot fast spin-echo images (TE 740ms and TR 5100ms) with a slab thickness of 30-50 mm (centering at CBD) in 12 para coronal planes constituting an angle of 180 degree for the acquisition of each plane, patients held their breath for about 5 seconds.This detects entire pancreatico-biliary tree and no post-processing is required.
3. Respiratory triggered 3D MRCP with TE of 650ms (heavily T2 weighted) and shortest possible TR in the coronal oblique plane centering at the level of CBD covering whole intrahepatic bile ducts and gall bladder. The patients were asked to breathe regularly throughout this acquisition, which takes about 4 minutes to acquire. A stack of 90 slices are obtained, which are contiguous and each of 0.9 mm in thickness. As the images are heavily T2-weighted, the pancreatico-biliary tree is displayed as high signal intensity, whilst adjacent structures are of reduced signal intensity. This sequence is useful in detecting small filling defects or strictures in the biliary or pancreatic ducts.

   From this volume of data, a MIP reformat was generated. This displays only the pixel with the highest signal intensity along a ray perpendicular to the plane of projection. It thus highlights bile-filled and fluid-filled structures very well. We conventionally created 16 MIP reformats at about 12-degree intervals to each other over a radial array of 180 degrees.

In addition to above mentioned sequences, in order to evaluate mass lesions, the duct walls, and any focal parenchymal pathology, diffusion weighted sequence and mDixion sequences after intravenous contrast administration were also performed.

All images were loaded to a workstation (Intellispace Portal, Philips Medical Systems) and reviewed by a radiologist with more than 12 years of experience in interpreting MRCP.

On MRCP, the caliber of the common bile ducts, the intrahepatic bile ducts, and the main pancreatic duct, the presence and length of strictures and the presence of stones in the CBD, main pancreatic duct, and gallbladder lumen were evaluated. Hepatomegaly was considered when the greatest vertical height exceeded 15 cm. Gall bladder wall thickening was determined when the wall thickness exceeded 3mm. Transverse diameter of more than 4 cm was considered as distended gall bladder. Only centrally located intrahepatic bile ducts are normally visualized in MRCP, diameter upto 3mm is considered normal. IHBD dilatation was graded as, grade I, centrally dilated more than 3mm, grade II, dilatation up to mid part of liver

parenchyma, and grade III, dilatations up to periphery of liver.

CBD diameter up to 7 mm is considered normal, up to 10mm is considered normal in post cholecystectomy patients.[11]

Results

Total 167 patients underwent MRCP examination on the basis of clinical judgement and other radiological (USG and CT) findings of hepatobiliary and pancreatic pathology.

Male were 73(43.7%) and female were 94(56.3%). Minimum age was one year and maximum age was 87 years with mean age being 49.8 years (Standard deviation 19.6)

MRCP was normal in 44(26.2%) patients. The various MRCP abnormalities are presented in the tables (Tables 1 to 4). Representative image of choledocholithiasis is also presented (Figure1).

Biliary ducts findings included, choledocholithiasis in 43(25.7%), cholelithiasis and choledocholithiasis in 19(11.3%), benign strictures at common hepatic duct in 5(3%), Caroli's disease in 1(0.6%), ascaris in CBD in 1(0.6%), intrahepatic bile ducts calculi in 3(1.8%), sclerosing cholangitis in 1(0.6%), choledochal cyst in 8(4.8%), hilar cholangiocarcinoma in 9(5.4%), distal cholangiocarcinoma in 2(1.2%), ampullary pathology in 7(4.2%), stricture at the lower end of CBD in 5(3%), and prominent cystic duct stump with calculus in 2(1.2%).

Liver findings included chronic liver disease in 5(3%), liver metastasis in 3(1.8%), liver cysts in 2(1.2%), hepatocellular carcinoma in 1(0.6%), hydatid cyst in 1(0.6%), hemangioma in 1(0.6%), and hepatomegaly with cholangitic abscess in 1(0.6%).

Pancreatic duct pathology included dilated pancreatic duct in 9(5.4%), and dilated pancreatic duct with intraductal calculi in 1(0.6%).

Pancreatic parenchymal findings included, acute pancreatitis in 7(4.2%), chronic pancreatitis in 8(4.8%), pancreatic mass in 9(5.4%), pancreas divisum in 4(2.4%), and complete transection of pancreas in 1(0.6%).

Gall bladder findings included, normal gall bladder in 37(22%), status post cholecystectomy in 30(17.9%), non visualization of GB in 13(7.7%), small GB in 2(1.2%), distended GB with sludge in 10(6%), thickened GB wall in 3(1.8%), acalculous cholecystitis in 3(1.8%), cholelithiasis in 44(26.2%), cholelithiasis with distended GB in 2(1.2%), cholelithiasis with cholecystitis in 19(11.3%), GB mass with hilar extension in 1(0.6%), and cholelithiasis, GB mass with liver extension in 4(2.4%).

Extra hepaticopancreatic findings were left pleural effusion in1 (0.6%), bilateral pleural effusion in 6(3.6%), ascites in 8(4.8%), splenomegaly in 1(0.6), juxtapapillary duodenal diverticulum with suspicious Lemmel syndrome in 1(0.6%), portal vein dilatation in 2(1.2%), diffuse T2 high signal in intra and extraportal tract in 1(0.6%), right renal cortical cyst in 1(0.6%), bilateral renal cortical cysts in 2(1.2%) and bilateral atrophic kidney in 1(0.6%).

Table 1 Common bile duct pathology

CBD pathology (n= 87)		
	Frequency	**Percent**
Choledocholithiasis	43	25.7
Benign stricture at lower end of CBD	5	3
Common hepatic duct stenosis	5	3
Caroli's disease	1	0.6
Ascaris in CBD	1	0.6
Intrahepatic bile ducts	3	1.8
Sclerosing cholangitis	1	0.6
Choledochal cyst	8	4.8
Hilar cholangiocarcinoma	9	5.4
Distal cholangiocarcinoma	2	1.2
Ampullary /periampullary pathology	7	4.2
Prominent cystic duct stump with calculus	2	1.2

Table 2 Gall bladder pathology

Gall Bladder pathology (n=150)		
	Frequency	**Percent**
Cholelithiasis	44	26.2
Cholelithiasis with choledocholithiasis	19	11.3
Cholelithiasis with distended GB	2	1.2
Thickened GB wall	3	1.8
Acalculous cholecystitis	3	1.8
Small GB	2	1.2
Cholelithisiswithcholecystitis	19	11.3
GB mass with hilar extension	1	0.6
Cholelithiasis, GB mass with liver extension	4	2.4
Cholecystectomy	30	17.9
Nonvisualised GB	13	7.7
Distended GB with sludge	10	6

Table 3 Pancreatic pathology

Pancreatic pathology (n=43)		
	Frequency	**Percent**
Acute pancreatitis	7	4.2
Chronic pancreatitis	8	4.8
Pancreatic mass	9	5.4
Complete transection of pancreas at neck region	1	0.6
Pancreatic divisum	4	2.4
Dilated pancreatic duct	9	5.4
Dilated pancreatic duct with calculus	1	0.6
Pancreatic divisum	4	2.4

Table 4 Other associated pathologies

Other associated disease (n=35)		
	Frequency	percent
Chronic liver disease	5	3
Liver metastasis	3	1.8
Liver cysts	3	1.8
HCC	1	0.6
Hydatid cyst	1	0.6
hemangioma	1	0.6
Hepatomegaly with cholangitic abscess	1	0.6
Pleural effusion	7	4.2
Ascites	8	4.8
Splenomegaly	1	0.6
Renal cortical cysts	3	1.8
Bilateral atrophic kidney	1	0.6

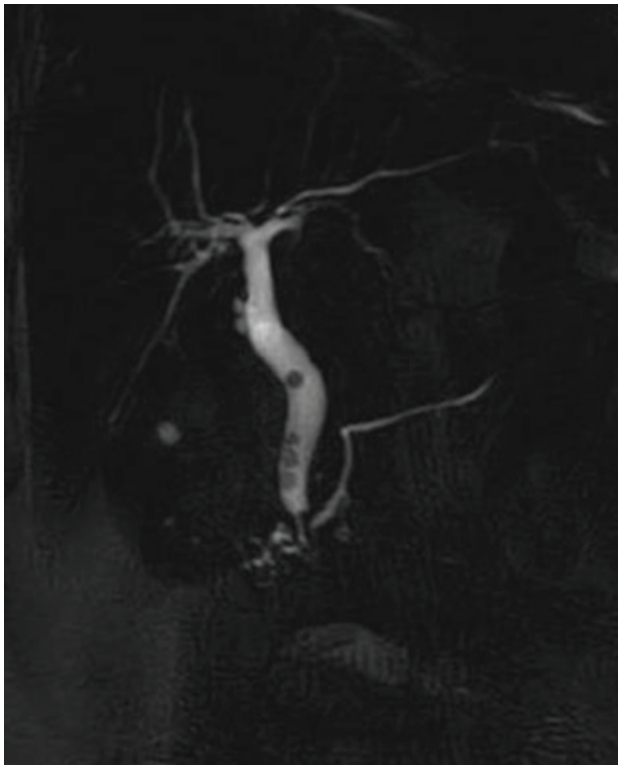

Figure 1 MRCP image showing multiple common bile duct calculi

Discussion: The spectrum of hepatobiliary and pancreatic imaging findings on 3T.0 MRCP was not different from previous reports of clinico- pathologic and radiologic assessment with associated clinical symptoms. **Choledocholithiasis:** MRCP is superior to ultrasonography or CT scan for detection of choledocholithiasis and equivalent with ERCP.[12,13] Fulcher AS and colleagues studies have shown sensitivity of 81%-100% and specificity of 85%-100% for MRCP.[14] We found choledocholithiasis in our study in 43 cases (25.7%) and combined cholelithiasis and choledocholithiasis in19 cases (11.3%).

Cholecystitis: MRI findings of acalculous cholecystitis has been repoted.[15] Mehmet Bilgin and coworkers observed one case of acute acalculous cholecystitis that was best shown with increased enhancement and thickening of the gallbladder wall.[3] We found similar findings of GB wall without calculus in 3 cases (1.8%). Fink AS observed that approximately 15%-25% of patient with acute calculous cholecystitis had cholelithiasis and 10%-15% had unsuspected choledocholithiasis at surgery[16]. In our study calculous cholecystitis was seen in 19 cases (11.3%).
GB mass: Gallbladder carcinoma presents as a mass in a various morphologic patterns like completely replacing the gallbladder lumen/completely occupying the lumen, focal or diffuse asymmetric gall bladder wall thickening or polypoidal lesion.[17] Mass forming type is the commonest which might extend to hilum causing obstructive jaundice.[18] Kondo et al. [19] classified the modes of tumor spread in GBCA into six distinct patterns: (1) hepatic hilum type (tumor in the neck infiltrating the hepatic hilum); (2) hepatic bed type (tumor penetrates the liver with or without contiguous spread to the gastrointestinal tract); (3) bed and hilum type (huge mass involving both the gallbladder bed and the hepatic hilum); (4) lymph node type (enlarged metastatic lymph nodes while the primary tumor remains limited to the gallbladder) (5) cystic duct type (small mass arising from the cystic duct) and (6) localized type tumor localized to the gallbladder).
Kondo et al.classified the modes of tumor spread in to the surrounding structures into six patterns:(1) hepatic hilum type (2) hepatic bed type (3) bed and hilum type (4) lymph node type (5) cystic duct type (6) localized type tumor localized to the gallbladder.19 In our cases we found GB mass with hilar extension in 1(0.6%) and GB mass, cholelithiasis with liver extension in 4 (2.4%).
Choledochal Cyst: Choledochal cyst is a congenital anomaly involving biliary tree characterized by cystic dilatation of bile ducts manifesting usually after the age of 10 years. Clinical diagnosis is difficult, however a classical triad of jaundice, pain, and right upper quadrant palpable lump is seen in 30–60 % of patients diagnosed before the age of 10 and diagnosed in adulthood in 10 % of the cases.[20] In our study we found 8 cases of choledochal cyst (4.8%), minimum age was 1 year, maximum age was 55 years, mean age being 25.1 years (standard deviation of 16.8).
Benign biliary strictures: Benign strictures present with smooth regular margin, symmetric narrowing and involve short segment. Lee MG and coworkers found sensitivity of MRCP for detection of benign stricture (site and extent of the stricture) to be 91-100%.[21] In our cases benign stricture was found in10 cases (6%). **Malignant biliary strictures:** A malignant extrahepatic bile duct stricture presents with irregular margin, asymmetric narrowing and involves long segment. On MRCP, the periductal type of cholangiocarcinoma is seen as biliary stricture, involving the CBD, common hepatic duct, biliary bifurcation or intrahepatic ducts. Suspicious features include increased wall thickness (>3mm), and increased signal intensity on T2 weighted images and progressive enhancement of the bile ducts in post contrast study.[11]In our study cholangiocarcinoma was found in 11 cases. Among them 9 cases (5.4%) were found in hilar region and 2 (1.2%) in distal region. **Chronic pancreatitis:** Chronic inflammation of the pancreas results in parenchymal destruction with fibrosis, fat necrosis and dystrophic calcification. Strictures in the main pancreatic duct may eventually develop with alternating stenosis and dilatation ('chain-

of-lakes' appearance). Side branch ectasia and intraductal calculi occur. In advanced cases it might simulate the 'double duct' sign. Soto et al demonstrated a sensitivity of 87–100% for pancreatic duct dilatation, and a sensitivity and specificity of 75% and 81%, respectively, for stricture detection.[22] In our study chronic pancreatitis was noted in 8 cases (4.8%), among which dilated duct with intraductal calculi was found in 3 cases (1.8%). Acute pancreatitis was present in 7 cases (4.2%). **Pancreatic mass:** Pancreatic adenocarcinoma most often involves pancreatic head and usually appears as a focal mass. It encases the pancreatic duct/or CBD which produces dilatation of the both ducts and approximately 75% of cases appear as the 'double duct' sign on MRCP, on the other hand, periampullary carcinoma shows abrupt termination with upstream marked dilatation of CBD and GB with minimal dilatation of pancreatic duct in MRCP. Cystic pancreatic tumors include serous cystadenomas, mucinous cystic neoplasms and intraductal papillary mucinous neoplasm (IPMN). MRCP delineates the morphology of these cystic tumor more clearly.[11] In our study pancreatic mass was seen in 9 cases (5.4%). **Pancreatic divisum:** Pancreatic divisum is failure of union of the dorsal and ventral pancreatic ducts. The larger dominant dorsal pancreatic duct drains the tail, body and superior head of the pancreas and open into the minor duodenal papilla. Smaller ventral duct drains the inferior pancreatic head and uncinate process and opens into the major duodenal papilla, along with CBD. MRCP has 100% accuracy in detecting pancreas divisum. Bret PM and coworkers found 25 cases of pancreas divisum out of 268 cases (9%).[23] In our study, we found 4 patients of pancreatic divisumamong 167 cases (2.4%).

Conclusion:

MRCP is the choice of investigation for the non-invasive diagnosis of pancreaticobiliary disorders. Technological advances in both acquisition and post processing have reduced time, increasing contrast resolution and image quality. The diagnostic potential of MRCP is comparable with ERCP in detection of extrahepatic bile ducts abnormalities. Other newer associated advanced techniques eg. Functional MR cholangiography, secretin- stimulated MRCP, DWI, MR perfusion and MR elastography, are the part of the MR protocol for specific indications to differentiate pseudo obstruction, to evaluate the exocrine function of pancreas, assessing the malignant potential of the cystic neoplasm and evaluating the severity of chronic pancreatitis.

Conflict of interests: None declared.

References

1. Sodickson A, Mortele KJ, Barish MA, Zou KH, Thibodeau S, Tempany CM. Three-dimensional Fast-Recovery Fast Spin-Echo MRCP: Comparison with Two-dimensional Single-Shot Fast Spin-Echo Techniques 1. Radiology. 2006; 238(2):549-59.
2. Wallner B, Schumacher K, Weidenmaier W, Friedrich J. Dilated biliary tract: evaluation with MR cholangiography with a T2-weighted contrast-enhanced fast sequence. Radiology. 1991; 181(3): 805-8.
3. Bilgin M, Balci NC, Erdogan A, Momtahen AJ, Alkaade S, Rau WS. Hepatobiliary and pancreatic MRI and MRCP findings in patients with HIV infection. AJR. 2008; 191(1):228-32.
4. Vitellas KM, Keogan MT, Spritzer CE, Nelson RC. MR Cholangiopancreatography of Bile and Pancreatic Duct Abnormalities with Emphasis on the Single-Shot Fast Spin-Echo Technique 1. Radiographics. 2000; 20(4):939-57.
5. Laubenberger J, Büchert M, Schneider B, Blum U, Hennig J, Langer M. Breath Hold Projection Magnetic Resonance Cholangio Pancreaticography (MRCP): a New Method for the Examination of the Bile and Pancreatic Ducts. Magn Reson Med. 1995; 33(1):18-23.
6. Bilgin M, Shaikh F, Semelka RC, Bilgin SS, Balci NC, Erdogan A. Magnetic resonance imaging of gallbladder and biliary system. Top Magn Reson Imaging. 2009; 20(1):31-42.
7. Chavhan GB, Babyn PS, Manson D, Vidarsson L. Pediatric MR Cholangiopancreatography: Principles, Technique, and Clinical Applications 1. Radiographics. 2008; 28(7):1951-62.
8. Yoon LS, Catalano OA, Fritz S, Ferrone CR, Hahn PF, Sahani DV. Another dimension in magnetic resonance cholangiopancreatography: comparison of 2-and 3-dimensional magnetic resonance cholangiopancreatography for the evaluation of intraductal papillary mucinous neoplasm of the pancreas. J Comput Assist Tomogr. 2009; 33(3):363-8.
9. Yun EJ, Choi CS, Yoon DY, Seo YL, Chang SK, Kim JS, et al. Combination of magnetic resonance cholangiopancreatography and computed tomography for preoperative diagnosis of the Mirizzi syndrome. J Comput Assist Tomogr. 2009; 33(4):636-40.
10. Kinner S, Dechêne A, Ladd SC, Zöpf T, De Dechêne

EM, Gerken G, et al. Comparison of different MRCP techniques for the depiction of biliary complications after liver transplantation. Eur Radiol. 2010; 20(7) :1749-56.

11. Griffin N, Charles-Edwards G, Grant A. Magnetic resonance cholangiopancreatography: the ABC of MRCP. Insights Imaging. 2012;3(1):11-21.
12. Guibaud L, Bret PM, Reinhold C, Atri M, Barkun AN. Bile duct obstruction and choledocholithiasis: diagnosis with MR cholangiography. Radiology. 1995; 197(1):109-15
13. Regan F, Fradin J, Khazan R, Bohlman M, Magnuson T. Choledocholithiasis: evaluation with MR cholangiography. AJR. 1996; 167(6):1441-5.
14. Fulcher AS, Turner MA, Capps GW. MR cholangiography: technical advances and clinical applications. Radiographics. 1998; 19(1):25-41; discussion -4.
15. Altun E, Semelka RC, Elias Jr J, Braga L, Voultsinos V, Patel J, et al. Acute Cholecystitis: MR Findings and Differentiation from Chronic Cholecystitis 1. Radiology. 2007; 244(1):174-83.
16. Fink AS. Commentary - Controversies in the Management of Common Duct Calculi. Surg Clin North Am. 1994; 74(4):949-52.
17. Levy AD, Murakata LA, Rohrmann Jr CA. Gallbladder Carcinoma: Radiologic-Pathologic Correlation 1. Radiographics. 2001; 21(2):295-314.
18. Szklaruk J, Tamm E, Charnsangavej C. Preoperative imaging of biliary tract cancers. Surg Oncol Clin N Am. 2002; 11(4):865-76.
19. Kondo S, Nimura Y, Kamiya J, Nagino M, Kanai M, Uesaka K, et al. Mode of tumor spread and surgical strategy in gallbladder carcinoma. Langenbecks Arch Surg. 2002; 387(5-6):222-8.
20. Marx FW, Gray RK, Duncan AM, Bakhtiar L. Angiodysplasia as a source of intestinal bleeding. Am J Surg. 1977; 134(1):125-30.
21. Lee M-G, Lee H-J, Kim MH, Kang EM, Kim YH, Lee SG, et al. Extrahepatic biliary diseases: 3D MR cholangiopancreatography compared with endoscopic retrograde cholangiopancreatography. Radiology. 1997; 202(3):663-9.
22. Soto JA, Barish MA, Yucel EK, Clarke P, Siegenberg D, Chuttani R, et al. Pancreatic duct: MR cholangiopancreatography with a three-dimensional fast spin-echo technique. Radiology. 1995; 196(2):459-64.
23. Bret PM, Reinhold C, Taourel P, Guibaud L, Atri M, Barkun AN. Pancreas divisum: evaluation with MR cholangiopancreatography. Radiology. 1996; 199(1):99-103.