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Utilizing of MRCP/MRI in differentiation between benign and malignant biliary obstruction

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ABSTRACT

Obstruction is one of the most common problems in biliary tree pathology, combined magnetic resonance imaging (MRI) and Magnetic Resonance Cholangiopancreatography (MRCP) regarded as accurate imaging modalities in diagnosis the cause of obstruction and treatment planning due to information obtain from MRCP about biliary and pancreatic ducts, information obtains from MRI cross sections about surrounding parenchyma. This study was aimed to investigate the efficacy of combined MRCP and MRI in differentiation between benign and malignant causes of biliary dilatation and their sensitivity in detection specific cause of biliary dilatation. This study involved 72 patients and conducted in Al-Diwaniyah Teaching Hospital, Iraq during a period from February 2013 to June 2017, the diagnosis of biliary dilatation was done by abdominal ultrasound to all patients followed by MRCP/MRI, the results of MRCP/MRI was compared with final diagnoses done by endoscopic retrograde cholangiopancreatography (ERCP), surgical, histopathological and laboratory results. The results revealed that a strong correlation between MRCP/MRI and other gold standard tools in differentiation between benign and malignant causes of obstruction. Sensitivity, specificity, and accuracy of MRCP in differentiation between malignant and benign causes of biliary dilatation were 98.4%, 100% & 99.7% respectively. There was a strong correlation (0.990) between MRCP/MRI & final diagnosis to determine the specific cause of obstruction, correct diagnosis the cause of obstruction in 68 patients out of 72 with a sensitivity of 94%. This study concluded that combined MRCP/MRI plays an important role in differentiation benign & malignant causes of biliary obstruction and in differentiation the specific cause of obstruction.

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INTRODUCTION

Magnetic resonance cholangiopancreatography (MRCP) is a medical imagining technique that uses magnetic resonance imaging (MRI) to visualize the biliary and pancreatic ducts in a noninvasive manner which is first described in 1991, the technique has improved over the years (Prased SR *et al.,* 2001). Today, MRCP is almost comparable to endoscopic retrograde cholangiopancreatography (ERCP) which is the other, invasive modality for the biliary tree. Compared with ERCP, surgical and histo-pathological results, MRCP has the advantage of adding a 3-dimensional imaging and fast multiple imaging planes capability (Romagnuolo *et al.,* 2003). Moreover, MRCP has negligible morbidity and mortality and MRCP is much less invasive investigation when compared to endoscopic retrograde cholangiopancreatography and other invasive techniques also MRCP/MRI allow imaging of surrounding parenchyma MRCP provides additional information by cross-sectional MRI and its

regarded as an alternative to ERCP in study the anatomy of biliary and pancreatic ductal system (Hekimoglu K *et al.,* 2008; Barish MA *et al.,* 1999). Several previous articles reported a significant number of patients who underwent surgical exploration with a clinical and radiographic diagnosis of tumors that was subsequently proven to be benign strictures (Gerhards *et al.,* 2001; Koea *et al.,* 2004).

To differentiate benign from malignant causes of biliary dilatation isn't always sufficiently with MRCP alone because it is not enough to evaluate the biliary ducts and extension of the malignancy (Worawattanakul *et al.,* 1998). A few previous studies have shown that intravenous (IV) contrast-enhanced images are able to diagnose inflammatory and neoplastic biliary ductal wall changes; therefore, IV contrast gives added value to differentiate various underlying malignant and benign causes compared to the use of MRCP alone (Park *et al.,* 2004). There is a high challenge in the evaluation of periampullary tumor and MRI regard as a problem-solving tool because it offers an excellent soft tissue contrast (Soto *et al.,* 2000). MRI with MRCP was significantly more accurate than CT (computed tomography) in differentiating between malignant and benign lesions in patients with suspected periampullary tumors mainly due to the information obtained on the MRCP images of the biliary and pancreatic duct anatomy (Andersson *et al.,* 2005; Arslan *et al.,* 2000; Hänninen *et al.,* 2005; Nikolaidis *et al.,* 2014; Park *et al.,* 2004). The purpose of this study was to investigate the efficacy of MRCP/MRI in differentiation between benign and malignant causes of biliary dilatation and their sensitivity in detecting the specific cause of biliary dilatation.

PATIENTS AND METHODS

A prospective study was done during a period of February 2014 to January 2018 in Al-Diwaniyah Teaching Hospital, Iraq. This study involved 72 patients presented with clinical and biochemical features of obstructive jaundice. Biliary tree obstruction was confirmed by transabdominal ultrasonography that's done by the same radiologist using Acuson X300 diagnostic ultrasound system (Siemens) with 2-5MHz convex probe follow by MRI and MRCP within days (1-7 days) ERCP or laboratory assessment (included serum amylase and alkaline phosphatase) or open abdominal surgery or biopsy was done. In a patient that diagnosed to have pancreatitis, serum amylase analyzed and ERCP was done with follow up the patient to about 8 months to confirm the diagnosis. MRCP was done according to standard protocol in the (1.5 –T Avanto Siemens, Erlangen Germany machine), field of view read 357 mm, slice thickness 1mm, TR 2500, TE 698 coil element BO1,2, SP2,4 phase direction from Rt. to Lt. flip angle 140 degrees, we do IV contrast-enhanced MRI in 12 patients when mass is predicted in precontrast MRI, using TI coronal, axial and same sections after IV contrast. Patients with non-obstructive causes of jaundice, who had no dilatation in a biliary tree in ultrasonography, MRI claustrophobia, metal implant and MRCP bad images like patients with ascites were excluded from this study also all patient who refused ERCP or open surgery was excluded.

We exclude the patients in whom surgical, histopathological, ERCP, and laboratory correlation with MRCP/MRI results could not be performed for any cause so we exclude the patient when we missed his/her follow up. We gave the patients oral contrast agent (fresh pineapple juice about 100ml) for about 10-15min before the MRI scan.

MRI interpretation

MRCP/MRI findings were reviewed by two radiologists included observation MRCP if the obstruction caused by signal void lesion inside the lumen or there is a narrowing of the lumen caused by pressure effect of external mass or wall thickness. All images where analyses by MRI coronal, sagittal and axial sections to detect whether there is mass (pancreatic or liver mass) and its nature whether it's solid or cystic.

Statistical analysis

Data were analyzed using SPSS version 22.0 and Microsoft Office Excel 2010. The numeric variable was expressed as mean ± SD whereas categorical variables were expressed as number and percentage. Sensitivity, specificity and accuracy analyses were performed to compare between MRCP/MRI findings and ERCP, surgical, laboratory and histopathological findings. The level of significance was considered at P-value of ≤0.05. Chi-square test was used to compare the MRCP findings with a final diagnosis to differentiate causes of obstruction whether it's benign or malignant.

RESULTS

A number of the patients was 72 patients; female patients were 50(69.4%) & male patients were 22 (30.6%) (Figure 1).

Age of the patients range from 23 years -72 years with mean standard deviation 54±12.487 (Table1).

In table 2 According to surgical, ERCP, histopathological findings which regard as a gold standard for final decision making, benign causes of biliary obstruction were 61(84.7%) and malignant causes were 11(15.3%) while according to MRCP/MRI there were 60 (83.3%) diagnosed as benign cause

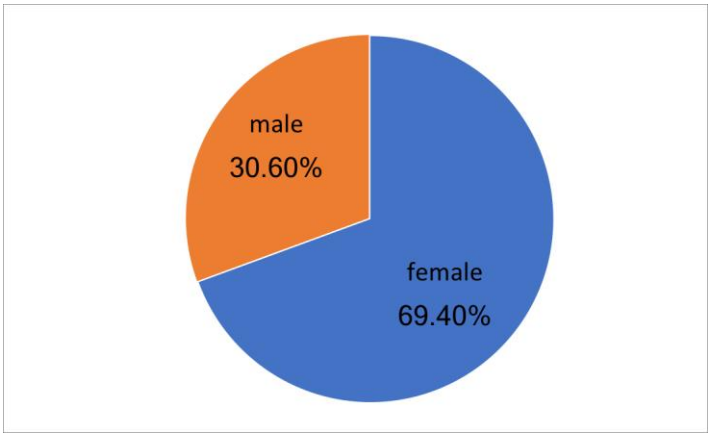

Figure 1: Percent of male and female presented with biliary obstruction

Table 1: Number and percent of the patients according to their age

Age	Frequency	Percent
23-35 year	5	6.9%
36-47 year	15	20.8%
48-59 year	23	31.9%
60-71 year	24	33.5%
72- 83year	5	6.9%
Total	72	100%

Table 2: Number and percent of the patients with benign and malignant cause in MRCP/MRI and final diagnosis

Type of obstruction	MRCP /MRI	Final diagnosis	P value
Benign cause	60(83.3%)	61(84.7%)	
Malignant cause	12(16.7%)	11(15.3%)	0.000
Total	72(100%)	72(100%)	

Table3 : MRCP/MRI and final diagnosis results of patients with bile obstruction

Causes of obstruction	MRI/MRCP results No.(%)	Final diagnosis No. (%)
Cholidocholithiasis	55(76.4%)	53(73.6%)
Biliary stenosis	1(1.4%)	4(5.6%)
Hepatic hydatid cyst	1(1.4%	1(1.4%)
Pancreatitis	3(4.2%)	3(4.2%)
Ampullary tumor	7(9.7%)	5(6.8%)
Pancreatic head tumor	4(5.6%)	4(5.6%)
Cholangiocarcioma	1(1.4%)	2(2.8%)
Total	72(100)	72(100%)

of obstruction and 12(16.7%) as malignant causes of obstruction. Sensitivity, specificity and diagnostic accuracy of MRCP in differentiation between malignant and benign causes of biliary dilatation were 98.4%, 100% & 99.7%, respectively and according to Chi-square test to differentiate between malignant and benign causes of obstruction $\chi 2$ =64.9; p-value 0.000.

According to table 3, a number of the patients that had choledocholithiasis was 53 while it was 55 in MRCP/MRI with two false positive cases, each ratio of MRI /MRCP with final diagnosis was 96.4%. Only one patient diagnosed with MRI/MRCP to have biliary stricture while four patients diagnosed in ERCP to have a stricture. Both surgery and MRI/MRCP diagnosed only one patient to have hepatic hydatid cyst. Three patients diagnosed to have acute pancreatitis according to elevated serum amylase enzyme level, patient follow up and ERCP findings all of them had pancreatitis in MRI/MRCP. There were 7 patients in MRCP/MRI diagnosed to have an ampullary tumor and according to histopathological results only 5 patients had an ampullary tumor with 2 false positive cases. Pancreatic head tumor diagnosed in 4 patients all of them diagnosed correctly in MRCP/MRI. Two cases diagnosed as cholangiocarcinoma in histopathology results, MRCP diagnosed only one of them.

The cause of obstruction was correctly diagnosed in 68 patients out of 72 with sensitivity 94% and according to Chi-square test in differentiation different specific causes of obstruction $\chi 2$ =302.762; p-value < 0.000.

Table 4: Number and percent of the male and female patients according to the cause of obstruction (benign or malignant)

Type of obstruction	Male no. %	Female	Total
Benign cause	10(13.8%)	50(69.4%)	60(83.2%)
Malignant cause	12(16.8%)	0	12(16.8%)
Total	22(30.6%)	50(69.4%)	72(100%)

Statistically, the association between gender and type of obstruction in Chi-square test was χ^2 =32.727; p-value <0.000 with a male preponderance of malignant causes.

Table 5: Type of obstruction (benign or malignant) according to the age of the patients

Age	23-35	36-47	48-59	60-71	72-80	Total
Benign cause	4(5.5%)	13(18.1%)	19(26.3%)	19(26.3%)	5(6.9%)	60(83.4%)
Malignant cause	1(1.4%)	2(2.8%)	4(5.5%)	5(6.9%)	0	12(16.6%)
Total	5(6.9%)	15(20.9%)	23(31.8%)	24(33.2%)	5(6.9%)	72(100%)

In table 5 and according to statistical analysis using chi-square test, the association between type of obstruction whether its benign or malignant & age of the patients, χ^2=1.469; p <0.832.

According to statistical analysis, the correlation between MRCP/MRI and final diagnosis in differentiation between benign & malignant causes of obstruction was (R=0.950) and the correlation between MRCP/MRI & final diagnosis to determine the specific cause of obstruction was (R=0.990).

DISCUSSION

As MRCP /MRI is superior to abdominal ultrasonography and computed tomography in studying malignant and benign lesions of biliary obstruction and many studies were done to confirm this fact (Andersson *et al.,* 2005; Safa O *et al.,* 2007; Rösch *et al.,* 2002), this study is designed to compare MRI/MRCP findings with final diagnosis decided by surgery, ERCP, histopathology, and patient follow up. In current study, the number of female present with biliary obstruction was more than male which is close to many studies like Rösch *et al.,* (2002), Hurter *et al.,* (2008) and Richard *et al.,* (2013) but not similar to Suthar *et al.,* (2015).

Regarding differentiation between malignant and benign biliary obstruction, the current study revealed a strong correlation (R=0.950) between MRI/MRCP and final diagnosis with Sensitivity, specificity and diagnostic accuracy of MRCP/MRI in differentiation between malignant and benign causes of biliary obstruction 98.4%, 100% and 99.7%, respectively which is slightly higher than other many studies like Domagk *et al.,* (2004) study who found that the diagnostic accuracy of MRCP in correct differentiation of malignant from benign lesions was 88%. Suthar *et al.,* (2015) found high sensitivity, specificity and diagnostic accuracy of MRCP to differentiation of benign from malignant causes of biliary obstruction 85.7%, 96.3% and 93.3% respectively. MRCP sensitivity, specificity, and diagnostic accuracy for biliary obstructive in Saluja *et al.,* (2007) study were 87.5%, 85.3% & 82.7% respectively, while in Park *et al.,* (2004) study they were 81%, 70%, and 76%, respectively. The higher accuracy in current study may explain by Hänninen *et al.,* (2005) who found the accuracy of MRCP is increase by evaluating MRI cross-sectional images together with MRCP also high sensitivity and specificity of MRCP/MRI in differentiation malignant from benign causes of biliary dilatation may be due to high sensitivity of MRCP/MRI for Choledocholithiasis (Guarise *et al.,* 2005; Lammert *et al.,* 2016).

Regarding specific causes of biliary obstruction, in benign biliary causes, the commonest cause of biliary obstruction in our study was benign causes (84.7%) and the commonest cause of benign obstruction was choledocholithiasis (73.6%) follow by postcholecystectomy stricture or stenosis (5.6%), pancreatitis (4.2%) and hydatid cyst (1.4%), these findings go with Suthar *et al.,* (2015) who found that the commonest cause of benign obstruction was choledocholithiasis follow by post–cholecystectomy strictures. In benign causes of obstruction choledocholithiasis, MRCP/MRI diagnosed all cases of biliary stones with 2 false positive cases both of them had postcholecystectomy strictures according to ERCP result, we found high match ratio of MRI /MRCP with final decision in biliary stone detection (96.4%) that is go with many studies (Guarise *et al.,* 2005; Lammert *et al.,* 2016; Amandeep S *et al.,* 2014).

There is an increasing demand for MRI/MRCP to be used in patients with suspected postcholecystectomy strictures (Girometti *et al.,* 2010), MRI/MRCP diagnosed 1 out 4 cases of postcholecystectomy stricture, two of them diagnosed wrongly as choledocholithiasis and third one diagnosed by histopathology as a small ampullary tumor.

A large hepatic hydatid cyst may cause pressure effect on the bile ducts or may rupture into their lumen, obstructing the biliary tree although hepatic hydatid cyst that causes biliary tree dilatation is uncommon problem even in the endemic areas, but an incidence of 16 % has been reported from our country (Grainger *et al.,* 2001), in this study there was only one patient present with large hepatic hydatid cyst 6cm in the Rt. hepatic lobe that caused pressure effect on the bile duct and biliary tree dilatation, its removed surgically, MRI/MRCP were accurate in its diagnosis and precise localization. MRI is an excellent imaging modality for diagnosis of acute pancreatitis and its complication (Xiao *et al.,* 2010). In this study, MRI/MRCP was accurate in diagnosis all 3 cases of acute pancreatitis which is caused biliary dilatation, one of them had focal pancreatitis and other two had diffused acute pancreatitis all of them were correctly diagnosed in MRCP/MRI.

In malignant causes of biliary obstruction, there were 11(15.3%) patients had malignant causes of biliary obstruction, the commonest cause of malignant obstruction was ampullary tumor 6.8% follow by pancreatic head tumor 5.6% and by cholangiocarcinoma 2.8%. MRCP /MRI correctly diagnosed 5 ampullary tumors with 2 false positive cases, one of them had cholangiocarcinoma at the distal end of common bile duct and diagnosed falsely as ampullary tumor, another one is biliary stricture diagnosed by MRI/MRCP as ampullary tumor and this may be explained by David V *et al.,* (1998) who found that ampullary lesions may be wrongly diagnosed as a result of interference from bowel gas and due to complexity of this region. MRCP/MRI correct diagnosed all 4 cases of the pancreatic head tumor which goes with Takakura *et al.,* (2011) who found that MRI has high sensitivity in detection of pancreatic masses 84%. One case out of 2 cases of cholangiocarcinoma that have a typical site in the perihilar region and typical MRI criteria (Vilgrain *et al.,* 1997) was diagnosed correctly by MRCP/MRI.

There was strong correlation [0.990] between MRCP/MRI & final diagnosis to determine the specific cause of obstruction and there was no difference between MRCP/MRI & final diagnosis in chi-square test in differentiation different specific causes of obstruction with $\chi 2$ =302.762; p-value <0.000. the current study succeeded incorrect diagnosis specific cause of obstruction in 68 patient out of 72 patients with sensitivity 94% that is very close to the study carried out by Safa O *et al.,* (2007) who found that MRI-MRCP correctly suggested the possible cause of obstruction with 96.25% sensitivity.

Suthar *et al.,* (2015), Saluja *et al.,* (2007) and Park *et al.,* (2004), concluded that high male preponderance to malignant lesion as a cause of biliary obstruction that's similar to our results in this study where there is highly significant association between gender and type of obstruction in Chi-square test with male preponderance to malignant causes, $\chi 2$ =32.727; p<value 0.000. There is no significant association between type of obstruction whether it's benign or malignant & the age of the patients with $\chi 2$=1.469; p <0.832.

We gave IV contrast study to 12 patients where mass is suspected in the pre-contrast scan, contrast demonstrations do not alter the diagnosis but it had an important role in estimation the extent of masses and treatment planning.

CONCLUSION

Although MRI/MRCP is expensive especially in private clinic and hospitals, its play an important role in differentiation benign and malignant causes of biliary obstruction and in differentiation the specific cause of obstruction. Choledocholithiasis is the commonest cause of biliary obstruction. Contrast-enhanced images didn't play role in detected masses but it still has an important role in tumor staging rather than diagnosis the cause of obstruction & has an important role in tumor respectability planning.

REFERENCES

Andersson, M., Kostic, S., Johansson, M., Lundell, L., Asztély, M., Hellström, M., 2005. MRI combined with MR cholangiopancreatography versus helical CT in the evaluation of patients with suspected periampullary tumors: A prospective comparative study. Acta Radiol. 46, 16–27.

Arslan, A., Geitung, J.T., Viktil, E., Abdelnoor, M., Osnes, M., 2000. Pancreaticobiliary diseases: Comparison of 2D single-shot turbo spin-echo MR cholangiopancreatography with endoscopic retrograde cholangiopancreatography. Acta Radiol. 41, 621–626.

David V, Reihold C,Hochman M, Chuttani R, McKee J, Waxman I.Pitfall in the interperitation of MR cholangiopancreaticography. AJR Am J Roentgenol. 1998;170:1055-9.

Domagk, D., Wessling, J., Reimer, P., Hertel, L., Poremba, C., Senninger, N., Heinecke, A., Domschke, W., Menzel, J., 2004.

Endoscopic retrograde cholangiopancreatography, intraductal ultrasonography, and magnetic resonance cholangiopancreatography in bile duct strictures: A prospective comparison of imaging diagnostics with histopathological correlation. Am. J. Gastroenterol. 99, 1684–1689.

Gerhards, M.F., Vos, P., Van Gulik, T.M., Rauws, E.A.J., Bosma, A., Gouma, D.J., 2001. Incidence of benign lesions in patients resected for suspicious hilar obstruction. Br. J. Surg. 88, 48–51.

Girometti, R., Brondani, G., Cereser, L., Como, G., Del Pin, M., Bazzocchi, M., Zuiani, C., 2010. Post-cholecystectomy syndrome: Spectrum of biliary findings at magnetic resonance cholangiopancreatography. Br. J. Radiol. 989, 351-361.

Grainger, R.G., Allison, D.J., Adam, A., Dixon, A.K., 2001. Diagnostic radiology; a textbook of medical imaging. UK Churchill Livingstone 556–565.

Guarise, A., Baltieri, S., Mainardi, P., Faccioli, N., 2005. Diagnostic accuracy of MRCP in choledocholithiasis. Radiol Med JT - La Radiol. medica. 109, 239–251.

Hänninen, E.L., Pech, M., Jonas, S., Ricke, J., Thelen, A., Langrehr, J., Hintze, R., Röttgen, R., Denecke, T., Winter, L., Neuhaus, P., Felix, R., 2005. Magnetic resonance imaging including magnetic resonance cholangiopancreatography for tumor localization and therapy planning in malignant hilar obstructions. Acta Radiol. 46, 462–470.

Hurter, D., Vries, C. De, Potgieter, P., Barry, R., Botha, F., Joubert, G., 2008. Accuracy of MRCP compared to ERCP in the diagnosis of bile duct disorders. SA J. Radiol. 12, 14–22.

Koea, J., Holden, A., Chau, K., McCall, J., 2004. Differential diagnosis of stenosing lesions at the hepatic hilus. World J. Surg. 28, 466–470.

Lammert, F., Gurusamy, K., Ko, C.W., Miquel, J.-F., Méndez-Sánchez, N., Portincasa, P., van Erpecum, K.J., van Laarhoven, C.J., Wang, D.Q.-H., 2016. Gallstones. Nat. Rev. Dis. Prim. 2, 16024.

Nikolaidis, P., Hammond, N.A., Day, K., Yaghmai, V., Wood, C.G., Mosbach, D.S., Harmath, C.B., Taffel, M.T., Horowitz, J.M., Berggruen, S.M., Miller, F.H., 2014. Imaging Features of Benign and Malignant Ampullary and Periampullary Lesions. RadioGraphics 34, 624–641.

Park, M.-S., Kim, T.K., Kim, K.W., Park, S.W., Lee, J.K., Kim, J.-S., Lee, J.H., Kim, K.A., Kim, A.Y., Kim, P.N., Lee, M.-G., Ha, H.K., 2004. Differentiation of Extrahepatic Bile Duct Cholangiocarcinoma from Benign Stricture: Findings at MRCP versus ERCP. Radiology 233, 234–240.

Richard, F., Boustany, M., Britt, L.D., 2013. Accuracy of magnetic resonance cholangiopancreatography for diagnosing stones in the common bile duct in patients with abnormal intraoperative cholangiograms. Am. J. Surg. 205, 371–373.

Romagnuolo, J., Bardou, M., Rahme, E., Joseph, L., Reinhold, C., Barkun, A.N., 2003. Magnetic Resonance Cholangiopancreatography: A Meta-Analysis of Test Performance in Suspected Biliary Disease. Ann. Intern. Med. 924, 1059-1064.

Rösch, T., Meining, A., Frühmorgen, S., Zillinger, C., Schusdziarra, V., Hellerhoff, K., Classen, M., Helmberger, H., 2002. A prospective comparison of the diagnostic accuracy of ERCP, MRCP, CT, and EUS in biliary strictures. Gastrointest. Endosc. 55, 870–876.

Safa O, Mohammed R, Ather A. The role of ultrasound and magnetic resonance imaging in the diagnosis of obdtructive jaundice .Iraqi postgraduate medical journal. 2007; vol.6, No.1: 7-17.

Saluja, S.S., Sharma, R., Pal, S., Sahni, P., Chattopadhyay, T.K., 2007. Differentiation between benign and malignant hilar obstructions using laboratory and radiological investigations: A prospective study. HPB 9, 373–382.

Soto, J. a, Alvarez, O., Lopera, J.E., Múnera, F., Restrepo, J.C., Correa, G., 2000. Biliary obstruction: findings at MR cholangiography and cross-sectional MR imaging. Radiographics 20, 353–366.

Suthar, M., Purohit, S., Bhargav, V., Goyal, P.,

2015. Role of MRCP in differentiation of benign and malignant causes of Biliary obstruction. J. Clin. Diagnostic Res. 9, TC08-TC12.

Takakura, K., Sumiyama, K., Munakata, K., Ashida, H., Arihiro, S., Kakutani, H., Tajiri, H., 2011. Clinical usefulness of diffusion-weighted MR imaging for detection of pancreatic cancer: Comparison with enhanced multidetector-row CT. Abdom. Imaging 36, 457–462.

Vilgrain, V., Van Beers, B.E., Flejou, J.F., Belghiti, J., Delos, M., Gautier, A.L., Zins, M., Denys, A., Menu, Y., 1997. Intrahepatic cholangiocarcinoma: MRI and pathologic correlation in 14 patients. J. Comput. Assist. Tomogr. 21, 59–65.

Worawattanakul, S., Semelka, R.C., Noone, T.C., Calvo, B.F., Kelekis, N.L., Woosley, J.T., 1998. Cholangiocarcinoma: spectrum of appearances on MR images using current techniques. Magn. Reson. Imaging 16, 993–1003.

Xiao, B., Zhang, X.-M., Tang, W., Zeng, N.-L., Zhai, Z.-H., 2010. Magnetic resonance imaging for local complications of acute pancreatitis: a pictorial review. World J. Gastroenterol. 16, 2735–42.