ORIGINAL ARTICLES

Usefulness of abdominal ultrasound and magnetic resonance cholangiopancreatography (MRCP) in the diagnosis of hepatobiliary disorders: A comparative study

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Abstract

Objective: The aim of this work was to compare the usefulness and sensitivity of ultrasonography (US) and magnetic resonance cholangiopancreatography (MRCP) in the diagnosis of different hepatobiliary disorders.

Methods: The study included 65 patients with various hepatobiliary disorders such as cholelithiasis, post cholecystectomy complications, neoplastic, inflammatory and developmental conditions of the pancreatico-biliary system. All patients underwent an initial abdominal US followed by MRCP, allowing a direct comparison of the results obtained by these two modalities. Correlation was also made with available clinical records, other imaging modalities, intraoperative findings and histopathology results.

Results: While both modalities proved equally sensitive in revealing developmental and inflammatory diseases of the pancreatico-biliary system (values between 90%-100%), MRCP showed a higher sensitivity for detecting pancreatico-biliary tumors (100% *vs.* 14.2%; $p < .05$) and cholelithiasis (96.2% *vs.* 74.0%; $p < .05$). MRCP also demonstrated a slightly higher sensitivity in revealing post cholecystectomy complications (92.8% *vs*. 78.5%), even though the difference did not reach statistical significance ($p = .317$). A variety of other findings and anatomical variants of the biliary and pancreatic ducts were revealed only by MRCP.

Conclusions: MRCP showed an overall higher sensitivity for revealing hepatobiliary disorders compared to abdominal US. The modality is especially useful when the findings revealed by abdominal US are inconclusive or when clinical suspicion persists despite negative US results.

Keywords

Magnetic resonance cholangiopancreatography, Abdominal ultrasound, Hepatobiliary disorders

1 Introduction

Diseases of the biliary system are common in medical practice. Due to this fact, diagnostic studies of the biliary system should be performed to rule them out. US is used for decades as a primary modality of investigation. It is an inexpensive,

accurate, accessible, safe, dynamic and noninvasive imaging modality, which has a fast acquisition time with no contraindications. Indications for the US of the gall bladder (GB) and biliary system include patients with jaundice, abnormal liver function tests, suspected cholangitis or suspected gallstones. It has been proven that ultrasonography (US) has a high diagnostic accuracy (> 90%) for detecting a variety of conditions such as biliary strictures, cholelithiasis, cholangiocarcinoma and periampullary cancers. US is also a useful modality for evaluating patients with suspected acute and chronic cholecystitis, biliary dilatation, as well as for defining the level of biliary obstruction [1]. At the same time the modality is highly operator dependent and may provide limited information in obese individuals, patients with surgical dressings or gaseous distention of the abdomen.

MRCP is another non-invasive technique used for imaging the biliary system. It is commonly employed when relevant diagnostic questions could not be answered by abdominal US or before proceeding to more invasive techniques like ERCP. Common indications include suspected diseases of the liver, gall bladder, biliary and pancreatic duct system of various etiologies as well as evaluation of postoperative results after hepatobiliary surgical procedures. MRCP is commonly performed on a 1.5T MRI scanner using abdominal phased array body coils. Heavily T2 weighted images are obtained using both breath-hold and non-breath-hold sequences. Special MRI protocols such as rapid acquisition and relaxation enhancement (RARE), fast-recovery fast spin-echo coronal oblique 3D respiratory triggered (FRFSE) and half-ourier acquisition single shot turbo spin echo (HASTE) are also frequently used for MRCP [2]. Even though MRCP is non-invasive and has the advantage of adding a 3D imaging and fast multiple planes, it represents a purely diagnostic technique without any options to correct or treat the identified problems during the procedure [3].

2 Materials and methods

2.1 Subjects

This retrospective study included 65 patients (41 females and 24 males), ranging in age from 1 to 88 years old, with various hepatobiliary disorders such as cholelithiasis, neoplastic, inflammatory and developmental conditions of the pancreatico-biliary system. Among these, 14 patients presented with post-cholecystectomy complications, most interventions being performed laparoscopically. All patients were referred for initial abdominal US followed by MRCP, allowing a direct comparison of the results obtained by these two modalities. Correlation was also made with available clinical records, other imaging modalities, intraoperative findings and histopathology results. The study was done between September 2014 and May 2015 at the diagnostic radiology department, KAUH after obtaining an ethical approval from the faculty of applied medical sciences ethical committee. All patients provided written consents before MRCP examination.

2.2 US technique

US of the biliary system was performed using a Philips 22 machine and a curved array transducer with C5-10 MHz frequency in sagittal and axial plans. Imaging the intrahepatic biliary system was performed starting from the left lobe of liver then proceeding to the right lobe. Then, the common bile duct and gallbladder were scanned. Doppler application was used to identify the CBD from the portal vein and hepatic artery. Then the pancreas was scanned for identifying the pancreatic duct. Patients were asked to fast 6-8 hours before US examination to facilitate distention of the gallbladder and to minimize image degradation by gaseous distention of the bowel.

2.3 MRCP technique

MRCP was performed on a 1.5 T Siemens MRI scanner using a phased-array coil.

(1). Three plan localizing images were obtained and used to plan MRCP sequence.

(2). AX-T2-FS-NAV

- Field of view = 330 mm

- Slice thickness = 5 mm

(3). AX-T2- BH
- Field of view = 330 mm
- Slice thickness = 5 mm

(4). AX-T2_HASTE290_TE

(5). AX T1 IN-OUT PHASE_ABD
- Field of view = 330 mm
- Slice thickness = 5 mm

(6). COR HASTE THICK
- Field of view = 250 mm
- Slice thickness = 50 mm

(7). T1-fL2D-TRA-P2-MBH
- Field of view = 330 mm
- Slice thickness = 4 mm

(8). COR 3D-MRCP
- Field of view = 300 mm
- Slice thickness = 1.30 mm

The coverage area extended from the nipple line to the iliac crest. To promote gallbladder filling, patients were asked to fast for 4 to 6 hours. All sequences were acquired during a single breath-hold. The whole examination was regularly completed within 20 minutes with the patient in the supine position. No anesthesia or contrast agents were used.

2.4 Image interpretation

US was done by expert sonographers and reviewed by radiologists specialized in abdominal US, while MRCP examination was interpreted by expert radiologists specialized in body MRI. The following parameters were studied: the gall bladder distension, wall thickness, pericholecystic fluid collection and the presence of stones or masses. The intra and extrahepatic biliary radicles were evaluated regarding their diameter, the presence of stones, stents or anatomical variations. During US examinations, Murphy's sign was applied in cases of clinically suspected acute cholecystitis. Associated findings such as pancreatic or hepatic masses, liver cirrhosis or abdominal collection were also recorded.

2.5 Follow up and clinical outcomes

Follow up of patients was done till reaching a final definitive diagnosis. Some patients required further investigation using a more invasive diagnostic procedure like endoscopic retrograde cholangiopancreatography (ERCP) (15 patients), percutaneous transhepatic pancreatography (PTC) (1 patient), or computed tomography (CT) (3 patients). Other patients were subjected to surgical intervention through laparoscopic cholecystectomy (19 patients), laparotomy (4 patients) or partial hepatectomy (2 patients). One patient with a malfunctioning biliary stent underwent repeated stenting for biliary obstruction. In 2 patients, biopsy and histopathology results were obtained to reach a final diagnosis. Follow up by US or MRCP was asked for 7 patients. The remaining patients required only medical treatment before they were discharged from the hospital (11 patients). All patients provided written consents before invasive procedures and operative intervention.

2.6 Statistical analysis

The results obtained by the two imaging modalities were compared using McNemar's test. The required statistical calculations were performed using a specially designed DTCompair package [4]. A p-value < .05 was considered significant. The specificity values have not been calculated in this study because there were no true negative cases among the admitted patients.

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3 Results

About 2/3 of our patients (63.1%) were females and about 1/3 (36.9%) were males, the data suggesting a relatively higher frequency of biliary pathology in females. The types of detected disorders are provided in Figure 1, while the number of encountered cases for different entities is shown in Table 1. Cholelithiasis represented the most frequent pathology (41%), followed by a variety of post-cholecystectomy complications (19%), inflammatory disorders (15%) and neoplastic conditions (11%). Most conditions were detected by both US and MRCP, even though the sensitivity of MRCP was significantly higher compared to that of US (93.8% *vs.* 72.3%, $p = .001$).

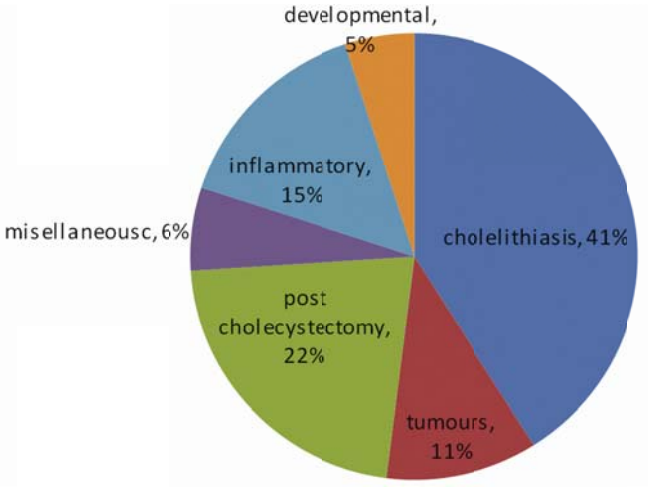

Figure 1. General distribution of biliary disorders among the study population

3.1 Cholelithiasis

From a total of 27 patients with cholelithiasis (see Table 1), 20 were diagnosed correctly by both US and MRCP. In another 6 patients, gallstones could be detected only by MRCP (5 of these showing negative findings on US and 1 case being misdiagnosed as a calcified gallbladder polyp). One case of cholelithiasis was missed by both modalities, being diagnosed as acalculous cholecystitis; however, the intra-operative findings subsequently reported biliary stones. Thus, the overall sensitivity for detecting cholelithiasis was 74.0% for US and 96.2% for MRCP, the difference being statistically significant ($p = .014$). Representative examples of imaging findings obtained by both modalities are provided in Figure 2.

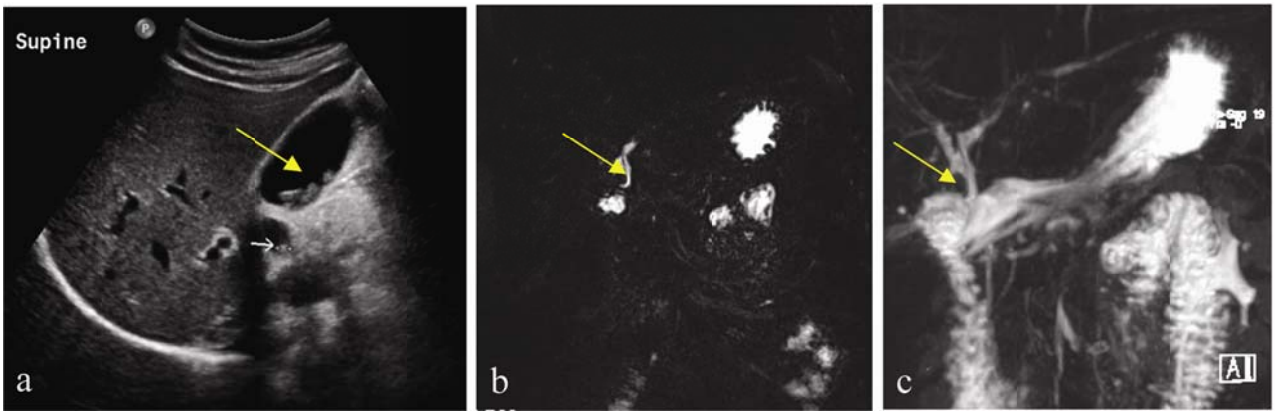

Figure 2. Abdominal US in supine position showing multiple biliary stones in the gallbladder (panel a, yellow arrow), including a small gallstone in the gallbladder neck (panel a, small white arrow). MRCP images displaying a gallstone in the common hepatic duct, seen as a filling defect (panels b-c, arrows)

3.2 Inflammatory diseases of the pancreatico-biliary system

From a total of 10 patients with cholecystitis or pancreatitis (see Table 1), 8 were diagnosed correctly by both US and MRCP. One case of associated chronic cholecystitis in a patient with gallstones was described only by US (MRCP revealing only the gallstones) and one case of chronic pancreatitis was diagnosed only by MRCP (no significant changes in pancreatic parenchyma described on US). Hence, US and MRCP showed similar sensitivities (90%) for detecting inflammatory diseases of the pancreatico-biliary system in this study.

Table 1. Distribution of pathological findings among the study population

Diagnosis	Number of patients
Cholelithiasis	27
GB	21
CBD	2
CHD	1
GB sludge	2
IHBR	1
Developmental anomalies	3
Caroli disease	1
Choledocal cyst	2
Inflammatory disorders	10
Acute calcular cholecystitis	4
Acute pancreatitis	1
Chronic calcular cholecystitis	3
Chronic pancreatitis	2
Miscellaneous	4
Chronic cholangitis	1
Liver abscess	1
Malfunctioning stent	1
pneumobilia	1
Post cholecystectomy findings	14
Abdominal collection	3
Anastomotic stricture	1
Biliary dilatation	5
Biliary stricture	1
Non biliary cause of jaundice	2
Residual cholelithiasis	2
Tumors	7
Cholangiocarcinoma	4
Pancreatic head tumor	2
Periampullary adenocarcinoma	1

3.3 Pancreatico-biliary tumors

Pancreatico-biliary tumors were detected in 7 patients (see Table 1), the diagnosis being confirmed histologically in all cases (tissue sampling obtained by ERCP, CT guided biopsy and/or resected surgical specimens). All tumors were correctly diagnosed by MRCP. A certain diagnosis by US, however, was made only in one patient with a pancreatic head tumor. In the remaining 6 patients, the US findings were either equivocal or negative for neoplastic lesions. Thus, the sensitivity of MRCP for detecting pancreatico-biliary tumors in our study was 100%, whilst the sensitivity of US was only 14.2% (p = .014). An example of imaging findings obtained by both modalities in a patient with cholagniocarcinoma is shown in Figure 3.

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Figure 3. Abdominal US showing a non-specific hypoechoic mass in the left lobe of the liver (panel a, star) and adjacent biliary dilatation (panel b, yellow arrow). MRCP of the same patient reveals prominently dilated intrahepatic biliary system in the left hepatic lobe (panel c, red arrows). Cholagniocarcinoma was subsequently confirmed by histopathology

3.4 Post cholecystectomy complications

A total of 14 patients presented with various post-cholecystectomy complications (see Table 1). In 10 patients the complications were diagnosed correctly by both US and MRCP. In another 3 patients, the cause of their symptoms could be revealed only by MRCP (residual stones in the intrahepatic bile ducts, a stricture of the common hepatic duct and a stricture of the left hepatico-jeujenal anastomosis, which is also displayed in Figure 4). On the contrary, a case of biliary cirrhosis responsible for persistent postoperative jaundice was revealed only on the US exam. Even though the sensitivity of MRCP for revealing post-cholecystectomy complications appeared higher (92.8%) compared to the sensitivity of US (78.5%), the difference did not reach statistical significance in our study (p = .317).

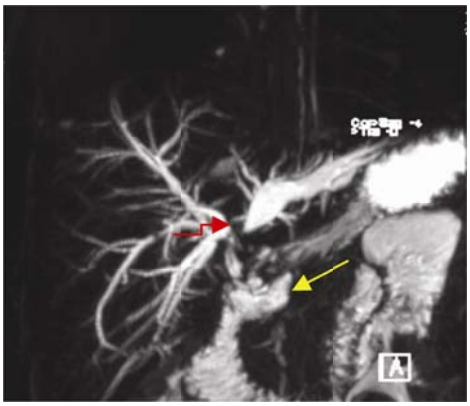

Figure 4. MRCP showing a stricture of the left hepatico-jeujenal anastomosis (red arrows) and dilated left intrahepatic biliary ducts. The yellow arrow points to the jejunum

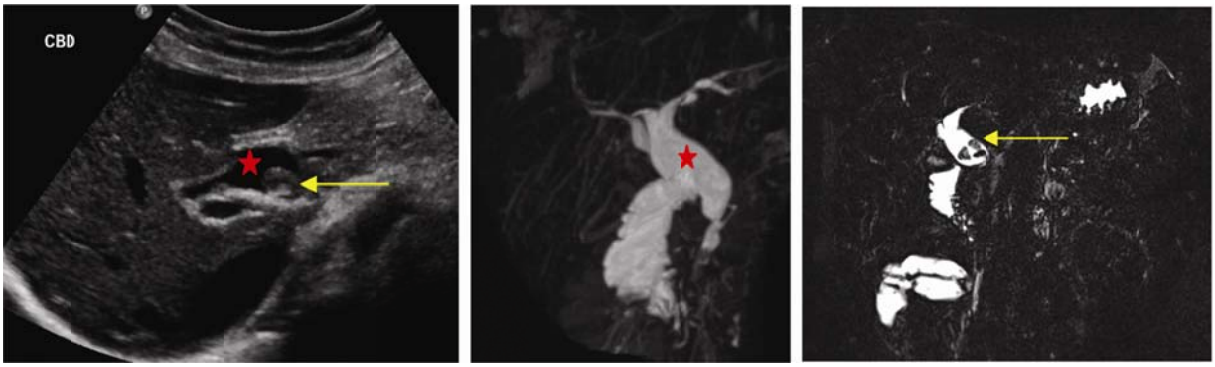

Figure 5. Liver US (panel a) showing a fusiform dilatation of the common bile duct (star) that contains a distinct filling defect (arrow). MRCP performed in the same patient also demonstrates a fusiform dilatation of the common bile duct panel b, star) with multiple signal void structures (panel c, arrow). The patients had a choledochal cyst containing multiple stones

3.5 Developmental anomalies

Developmental anomalies of the biliary system were detected in 3 patients: one patient included in this study had Caroli Disease and two patients had choledochal cysts type I (one of them being displayed in Figure 5). All 3 cases were correctly diagnosed by both US and MRCP, reflecting a sensitivity of 100% for both modalities. However, given the small number of cases included in this study, the results may need confirmation in larger cohorts.

3.6 Miscellaneous cases

Miscellaneous hepatobiliary pathology in this study was represented by such entities as pneumobilia (1 patient), chronic cholangitis (1 patient), a malfunctioning biliary stent and a hepatic abcess (see Table 1). Pneumobilia was diagnosed only by US, the chronic cholangitis was diagnosed only by MRCP, while the hepatic abscess and the malfunctioning biliary stent were revealed by both modalities. The overall sensitivity for detecting hepatobiliary pathology was 75% for both modalities. However, given the small number of cases included in this study, these results also need confirmation in larger cohorts. Moreover, a variety of other findings and details were revealed by MRCP only (see Figure 6), underlying the usefulness of this modality and the advantages it may have in certain categories of patients. A representative case is shown in Figure 7.

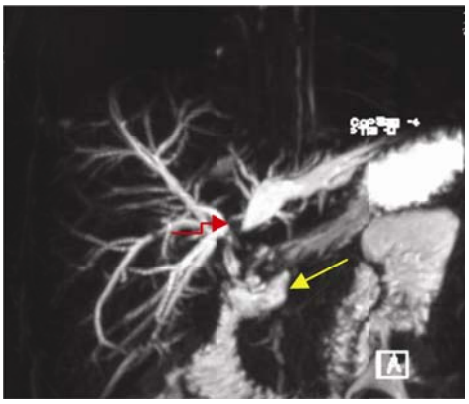

Figure 6. Relevant findings detected by MRCP only

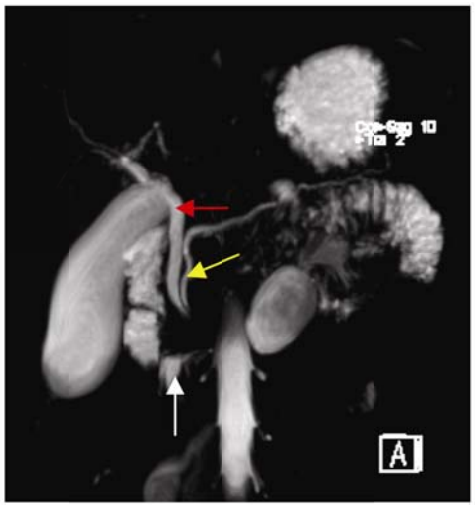

Figure 7. MRCP revealing an elongated vertical course of the pancreatic duct (yellow arrow), which subsequently joins the common bile duct (red arrow) before their insertion into the third part of the duodenum (white arrow)

4 Discussion

In this study, MRCP showed an overall higher sensitivity for revealing hepatobiliary disorders compared to abdominal US. The study design also allowed comparing the usefulness of the two imaging modalities in patients with specific hepatobiliary entities such as cholelithiasis, post cholecystectomy complications, neoplastic, inflammatory and developmental conditions of the pancreatico-biliary system.

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4.1 Cholelithiasis

Cholelithiasis accounts for most cases of obstruction of bile ducts. Direct cholangiography is generally still considered to be the ideal method for diagnosing CBD calculi [5]. On US, calculi typically appear as echogenic structures within the GB with posterior acoustic shadows. On MRCP calculi are identified as signal voids within the high signal intensity fluid in the bile ducts. The differential diagnosis of these signal voids includes air bubbles, blood clots, sludge ball, flow voids and susceptibility artifacts from surgical clips [6]. In our study, from a total of 27 patients with cholelithiasis, 26 were diagnosed correctly by MRCP and only 20 by US, translating into a sensitivity of 96.2% for MRCP and 74.0% for US. Even though the abdominal US has a relatively high sensitivity for detecting biliary stones, the even higher values obtained for MRCP in the current study are directly related to the ability of MRCP to detect stones of the biliary radicles that were missed by US. In the literature, the reported US sensitivity to detect biliary stones is variable, ranging from 20% to 80% [7]. Nevertheless, US remains the imaging method of choice for diagnosis of gall bladder pathology. Although MRCP demonstrated a higher sensitivity in the current study, additional imaging studies may be also necessary for reaching a final diagnosis in selected patients.

4.2 Inflammation of the pancreatico-biliary system

Imaging findings of acute cholecystitis include gallbladder over-distension with intra-luminal sludge or stones, mural thickening and edema, pericholecystic fluid, and positive Murphy's sign. Chronic cholecystitis, however, may be associated with less evident changes and evaluation of gallbladder contractility may be required in some cases. US is the primary imaging modality in suspected cholecystitis, with a reported sensitivity between 37.5%-91% and specificity between 60%-100%. MRCP is reported to have a higher accuracy in acute cholecystitis, with sensitivity between 88%-95% and specificity between 69%-89% [8]. Acute pancreatitis is another clinical condition that can be triggered by gallstones. The aim of imaging is not only to detect the pancreatitis, but also to localize the biliary stones responsible for the attacks. The sensitivity and specificity of abdominal ultrasound in diagnosing acute pancreatitis is around 73.6% and 97.7%, respectively [9]. MRCP has recently been evolving as an important tool for the evaluation of chronic pancreatitis with a sensitivity of 92% and a specificity of 75% for the demonstration of early chronic pancreatitis [10]. In the current study, US and MRCP showed similar sensitivities (90%) for detecting inflammatory diseases of the pancreatico-biliary system. However, due to a relatively small number of such patients (n = 10), the findings need confirmation in larger cohorts.

4.3 Pancreatico-biliary tumors

Cholangiocarcinoma is a malignant tumour arising from cholangiocytes in the biliary tree. It tends to have a poor prognosis and high morbidity [11]. Risk factors for cholangiocarcinoma are choledochal cysts, caroli's disease, liver cirrhosis, primary sclerosing cholangitis and hepatitis B virus infection [12]. The sensitivity of MRCP for concurrent cholangiocarcinoma reaches up to 87% [13]. In the current study we examined 7 patients with pancreatico-biliary tumors, including 4 cases of cholangiocarcinomas, the diagnosis being confirmed histologically in all patients. All tumors were correctly diagnosed by MRCP, the modality demonstrating 100% sensitivity. This was in contrast with the abdominal US exam, which demonstrated a sensitivity of only 14.2% (a certain diagnosis of a pancreatico-biliary tumor being made by US only in 1 patient). The results are in overall agreement with the findings reported by other authors. Thus, Tse *et al.* reported that MRCP is very useful in the diagnosis of cholangiocarcinoma, identifying the exact location, extent, and severity of the obstruction [14]. Miura *et al.* pointed out that the accuracy of conventional US for diagnosing pancreatic tumors is only 50%-70% [15]. Delden *et al.* further emphasized that in the detection of pancreatic cancers, US has an overall sensitivity of 75% and a specificity of 75%, while the sensitivity of US for detecting ampullary carcinoma is as low as 5% [16]. In our study we had one case of periampullary carcinoma, which was correctly diagnosed only by MRCP.

4.4 Post-cholecystectomy complications

Post-cholecystectomy syndrome (PCS) consists of a group of abdominal symptoms that recur and/or persist after cholecystectomy including abdominal pain, dyspepsia, vomiting, gastrointestinal disorders and jaundice, with or without

fever and cholangitis. It may occur early or as late as months or years after cholecystectomy [17]. It includes a large number of disorders, both biliary and extra-biliary (gastrointestinal, extra intestinal or psychomotor) in origin that may be even unrelated to cholecystectomy. Moreover, in 5% of patients who undergo laparoscopic cholecystectomy, the reason for chronic abdominal pain remains unknown [17]. The reported prevalence of post cholecystectomy complications ranges from very low to 47% [17]. A relatively common finding after colecystectomy is biliary dilatation and a diameter of the CBD within 10 mm can be regarded as normal [18]. The reported sensitivity of MRCP for biliary strictures ranges from 78% to 100% [19]. In another study, the reported sensitivity, specificity and diagnostic accuracy of MRCP were 100%, 88.23%, and 94.87%, respectively [6]. In our study, 14 (21%) patients presented with post cholecystectomy complications. MRCP showed a relatively higher sensitivity for detecting these complications compared to abdominal US (92.8% *vs.* 78.5%), even though the difference did not reach statistical significance (p = .317). Post-operative fluid collections were easily diagnosed by both US and MRCP, even though MRCP could also detect a biliary fistula responsible for the collection in one case.

4.5 Developmental anomalies

Choledochal cysts represent congenital cystic dilatations of the biliary tree. Patients usually present with abdominal pain, jaundice and an abdominal mass. The two most frequent complications of choledochal cysts are stone formation and malignancies [20]. In the current research, 2 cases of choledochal cysts were diagnosed by both MRCP and US. The findings are consistent with those reported in the literature, indicating an overall detection rate of choledochal cysts by MRCP between 96%-100% [13, 21].

4.6 Malfunction stent

The commonest stent related complications are recurrent cholangitis and stent migrations, followed by pancreatitis and cholecystitis. Clinically it may present with recurrent signs of biliary obstruction and cholangitis [22]. Our study included one case of a malfunctioning biliary stent, which was correctly revealed by both imaging modalities. The patient, who had a pancreatic head tumor, presented with persistent obstructive jaundice after his biliary stent insertion. Both MRCP and US show marked biliary dilatation due to malfunctioning stent.

4.7 Anatomical variation of the biliary system

Apart from detecting hepatobiliary pathology, revealing anatomic variants of biliary and pancreatic duct system may be equally important, especially for patients considered for biliary surgery. MRCP can reveal a variety of anatomical variants such as low or medial cystic duct insertions, aberrant right hepatic ducts or a parallel course of cystic and hepatic ducts with an accuracy between 95%-98% [6]. Such information can be useful for planning the surgical intervention as well as for avoiding intraoperative complications [6]. Given the information it can provide and the non-invasiveness of the technique, MRCP is being increasingly considered as an alternative to ERCP in suitable patients [23]. In our study, MRCP was able to reveal anatomical variants of cystic duct insertion in 7 patients and an anatomical variant of pancreatic duct insertion in 1 patient. None of these could be visualized on abdominal US.

In summary, while both modalities proved equally sensitive in revealing developmental and inflammatory diseases of the pancreatico-biliary system (values between 90%-100%), MRCP showed a higher sensitivity for detecting pancreatico-biliary tumors (100% *vs.* 14.2%; $p < .05$) and cholelithiasis (96.2% *vs.* 74.0%; $p < .05$). MRCP also demonstrated a slightly higher sensitivity in revealing post cholecystectomy complications (92.8% *vs*. 78.5%), even though the difference did not reach statistical significance (p = .317). A variety of other findings and anatomical variants of the biliary and pancreatic ducts were revealed only by MRCP.

5 Conclusions

MRCP showed an overall higher sensitivity for revealing hepatobiliary disorders compared to abdominal US. The modality is especially useful when the findings revealed by abdominal US are inconclusive or when clinical suspicion

persists despite negative US results. Given its high sensitivity for revealing anatomical variants of hepatobiliary and pancreatic duct system, MRCP can be especially useful in patients considered for biliary duct surgery and may also serve as an alternative to ERCP in suitable patients.

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