Preoperative ultrasonography (US) alone versus combined ultrasonography and magnetic resonance cholangiopancreatography (MRCP) in assessment of patients with cholecystitis and/or gall bladder stones prior to laparoscopic cholecystectomy: Could combined procedure become a routine?

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Corresponding Author: Dr Mahmoud Abdel Latif Bahram, MD

Corresponding Author's Institution: Shibin El Kom facualty of Medicine

First Author: mahmoud A Bahram, MD

Order of Authors: mahmoud A Bahram, MD; Mahmoud Abdel Latif Bahram, MD; Ahmed M Ghandour, MD; Hesham Y Al Gazzar, MD

Abstract: A b s t r a c t

Objective:

To evaluate the value of preoperative combined US and MRCP versus US alone on the post operative outcome of patients with cholecystitis and/or gall stones.

Patients & methods:

This prospective study was carried on 202 patients during a period of 3 years who were planned to undergo laparoscopic cholecystectomy. Preoperative combined US and MRCP was performed in 90 patients included in group I with age range of 20-65 years. Remainder of the study population (112 patients) were included in group II with preoperative US alone -and without pre-operative MRCP- with age range of 22-64 years.

Results:

In group I; preoperative MRCP screening revealed clinically silent common bile duct (CBD) stones in 5 patients (5.6%) and mud and gravels in 2 patients (2.2%). Accessory cystic duct in 2 patients (2.2%), abnormal insertion of cystic duct in 2 patients (2.2%), trifurcation of the common hepatic duct (CHD) in 1 patient (1.1%), long serpentine cystic duct in 1 patient (1.1%), and pancreas divisum in another patient (1.1%). Postoperatively, in group I no residual CBD stones were revealed. On the other hand 6 patients with residual stones were detected in group II,

Conclusion

Combined MRCP and US procedure has proved to be a very useful tool in assessment of patients with cholecystitis and/or gall bladder stones prior to laparoscopic cholecystectomy in comparison to US alone, taking advantage of the high sensitivity and excellent negative test -negative predictive value- of MRCP. The use of the combined procedure has been justified in terms of cost/benefit relationship. Therefore, we recommend the combined procedure to be part of the routine workup before laparoscopic cholecystectomy in patients with cholecystitis and/or gall bladder stones.

Preoperative ultrasonography (US) alone versus combined ultrasonography and magnetic resonance cholangiopancreatography (MRCP) in assessment of patients with cholecystitis and/or gall bladder stones prior to laparoscopic cholecystectomy: Could combined procedure become a routine?

Ahmad Mohammad Ghandour, MD*; Hesham Youssef Al Gazzar, MD; Mahmoud Bahram, MD*****

***Department of Radiology, Faculty of Medicine, Ain Shams University, Egypt; ** Department of Radiology, Faculty of Medicine, Benha University, Egypt; ***Department of General Surgery, Faculty of Medicine, Menoufyia University, Egypt**

Corresponding author. Tel.: 0971551095027.
E-mail address: mahmoudbahreem@yahoo.com (Mahmoud Bahram).

Introduction

The prevalence of common bile duct (CBD) stones in patients who undergo cholecystectomy has been reported to be in the range of 10%–20%, and the frequency of undetected CBD stones is approximately 0%–4.2%.[15]
Choledocholithiasis may be asymptomatic; or symptomatic with potential complications including postoperative biliary leakage, recurrent biliary colics, cholangitis, and pancreatitis adding further to the burden of management in gallstone disease.[2]

Ultrasonography has been the traditional modality for evaluating gallbladder disease, primarily owing to its high sensitivity and specificity for both stone disease and gallbladder inflammation. However, US is limited by patient body habitus, with degradation of image quality and anatomic detail in obese individuals. With the advent of faster and more efficient imaging techniques, magnetic resonance (MR) imaging has assumed an increasing role as an adjunct modality for gallbladder imaging, primarily in patients who are incompletely assessed with US.[16]

Several studies were done to assess the importance of MRCP in reducing postoperative complications. However, the role of routine use of pre-operative MRCP is still a matter of debate.[3-6] So, this prospective randomized study was conducted to evaluate this role.

Patients & methods

This prospective study included 202 patients of them 196 patients underwent laparoscopic cholecystectomy and 6 patients were converted to open procedure. The study was conducted during a period of 3 years from January 2008 to January 2011. All patients presented with acute or chronic cholecystitis. All patients with symptoms suggesting common bile duct stone were excluded (pancreatitis, cholangitis, and obstructive jaundice) were excluded from the study.

Also patients who had any contraindication to MRCP examination (i.e. claustrophobic, pace maker, non-MR compatible metallic implants, or morbidly obese) were excluded (38 patients). Patients were divided into two groups; group I included 90 patients (27 males and 63 females) in whom pre-operative MRCP and US followed by laparoscopic cholecystectomy was done. Their age ranged from 20 to 65 years with mean age of 38.2. Group II included 112 patients (32 males and 80 females) managed by laparoscopic cholecystectomy with pre-operative US only. Their age ranged from 22 to 64 years with mean age

of 39.1. We obtained institutional review board approval from our hospital and informed consent from the patients before the study.

All patients were subjected to full history taking, general and abdominal examination. Liver functions (including SGOT, SGPT, PT time and concentration, total and direct bilirubin, and alkaline phosphatase), random blood sugar and kidney functions were also done.

Imaging techniques:

MRCP was performed for all patients with 1.5 T superconducting unit (Magnetom Espree, Syngo, MR B15, Siemens, Erlangen, Germany) using a phased-array multi-coil. All MRCP examinations were performed within two weeks of ERCP or surgery. Patients were fasting for a minimum of 4 hours prior to examination to promote filling of gall bladder and gastric emptying. No contrast agents or antiperistaltic drugs were used. MRCP was performed for all patients as follows; T1-weighted imaging using FLASH-2D in-phase and out-of-phase sequences in transverse and coronal planes with parameters TR of 100 msec, TE1 of 4.83 msec, TE2 of 2.31 msec, slice thickness of 6 mm, acquisition matrix size of 256 x 256, flip angle of 70^{o}, and field of view of 330 mm. T2-weighted imaging using HASTE sequence in transverse and coronal planes with parameters TR of 900 msec, TE of 87 msec, slice thickness of 6 mm, acquisition matrix size of 256 x 256, and field of view of 380 mm. T2-weighted imaging in axial plane using HASTE sequence fat-sat thick slap with parameters TR of 4500 msec, TE of 853 msec, slice thickness 40 mm, acquisition matrix size of 384 x 512, and field of view of 350 mm. T2-weighted imaging in coronal plane using HASTE sequence fat-sat thick slap with parameters TR of 1200 msec, TE of 80 msec, slice thickness 40 mm, acquisition matrix size of 256 x 384, and field of view of 330 mm. T2-weighted imaging in coronal plane using triggered 3D sequence with parameters TR of 1500 msec, TE of 620 msec, slice thickness 1.5-2 mm (if single slice acquisitions are to be made) or 40-50 mm (if slap acquisition is to be made), acquisition matrix size of 384 x 512, and field of view of 330 mm.

All abdominal ultrasounds were performed with GE Logic 9 machine, using 2.8-5 MHZ frequency transducer, obtaining grey scale B mode.

Image analysis

MRI and MRCP 3D images & their individual source images were initially evaluated for the global quality of the image. The images were assessed for the extra-biliary disease state and the presence of CBD and gall bladder stones. A CBD stone was defined as a nodular area of low –or signal void- signal intensity within a high signal intensity lumen. Calculi were usually differentiated from a polypoid tumor mass of the bile duct by their angulated contours (Fig 1 & 2) and dependent location in the bile duct and by being surrounded by high-signal- intensity bile. The anatomy of biliary tree was also checked for anomalous course and/or origin.

Results

All patients had no abnormalities in their liver profile. Preoperative MRCP was done for 90 patients (group I). Common bile duct stones were detected by MRCP in 7 patient; 5 of them were revealed to be harboring true CBD stones, while 2 patients had biliary mud and gravels. Other MRCP findings that affected surgical procedure were; accessory cystic (Cysto- hepatic) duct to the liver in 2 patients, long serpentine cystic duct in 1 patient (Fig. 3), and in another two patients the cystic duct entered the CBD at an atypical location (from left lateral and ventral side). In the first 3 patients, the accessory cystic ducts and long serpentine cystic duct were meticulously followed and identified with safe clipping. In the other 2 patients, extra care was followed till dissection of the cystic duct and clipping. Other biliary system abnormalities were found on MRCP; 1 patient was having trifurcation of the common hepatic duct (CHD) (Fig. 5) and 1 patient was found to have pancreas divisum (Fig. 6). Biliary system abnormalities detected in preoperative MRCP in group I are enlisted in Table 1. On MRCP, other abdominal organs were also checked. Several pathologies were observed as follows; 9 haemangiomata of the liver, fatty hepatomegaly in 40 patients, fatty liver in 17 patients, splenomegaly in 15 patients, and 70 simple renal cysts, and all are enlisted in Table 2. Notably, none of these finding was of clinical importance so that it would not change the decision or procedure of laparoscopic or open surgery cholecystectomy.

In group I, laparoscopic cholecystectomy was successful in all but 2 patients who were converted to open cholecystectomy; both cases because of severe adhesions. In group II, laparoscopic cholecystectomy was accomplished in 108 patients while 4 were converted to open cholecystectomy; one case was due to bleeding, other case due to adhesions, and the remaining 2 cases were due to unclear anatomy.

All patients in group I revealed smooth post-operative period but one who developed post-operative haematoma in the surgical bed which was treated conservatively. There were no symptoms suggesting residual stones in CBD in group I. In group II, three patients developed early bile leakage. In two pateints of them, ERCP was performed (4 and 7 days postoperatively); CBD stone was detected and extracted and the leak stopped on the 10^{th} and 15^{th} day respectively. In the third, no stone detected but leakage of contrast from the CBD, so a stent was inserted and bile leak started to decrease gradually till stopped on the 14^{th} day.

In group II, two patients complained of cholangitis at after 15 days and 1 month respectively, abdominal US and MRCP revealed dilated CBD with a stone at its lower end and ERCP extraction was successful. Another patient developed jaundice after 10 days and MRCP revealed stone in CBD that was successfully extracted through ERCP as well. Finally, three patients developed an attack of pancreatitis after 1 month and 45 days that needed readmission of the patients to the hospital; MRCP was done and revealed stones in CBD, for which ERCP extraction was performed.

In the present study the sensitivity of MRCP in detecting CBD stones was 100%, while its specificity was 98%, its positive predictive value (PPV) is 71%, and the negative predictive value (NPV) is 100% (Table 3).

As regarding the cost; it was estimated using the cost for total days of hospital stay (one day = 100 $), for each group, the cost for pre or post operative MRCP (MRCP = 100 $) and ERCP (ERCP = 1000 $), the cost for re-operation (Table 5)

Fig. 1: T2WI coronal section of a patient with faceted signal void stone seen impacted in the terminal portion of the CBD with consequent ductal dilatation

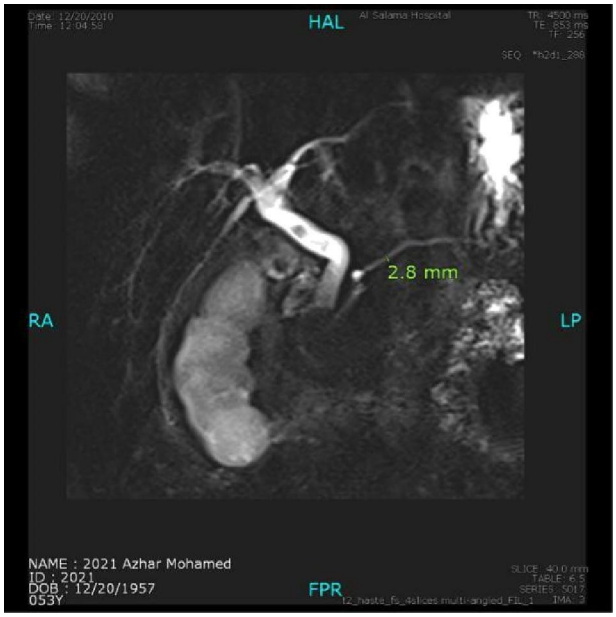

Fig. 2: MIP image of a patient with gall bladder neck hypointense stone as well as dilated CBD harbouring two stones; larger stone seen impacted in the distal CBD segment and smaller stone more proximally

Fig. 3: MIP image of a patient with long serpiginous cystic duct

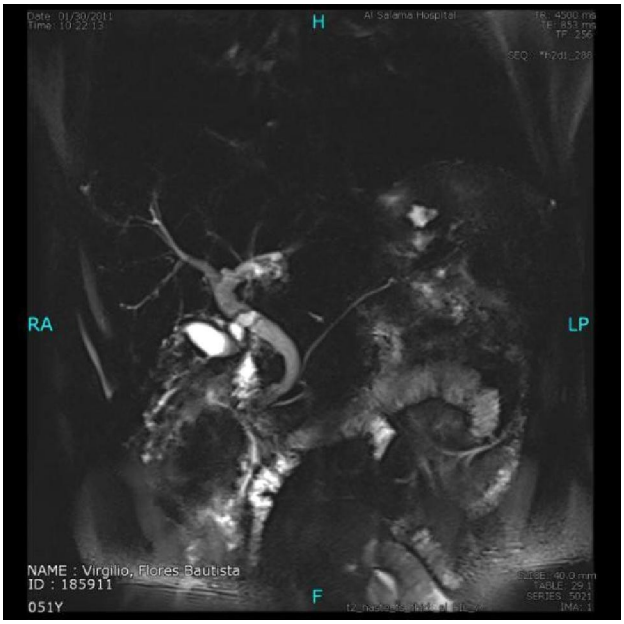

Fig. 4: MIP image of a patient with left lateral insertion of the cystic duct into CBD

Fig. 5: MRCP of a patient with dilated CBD showing trifurcation of the CHD

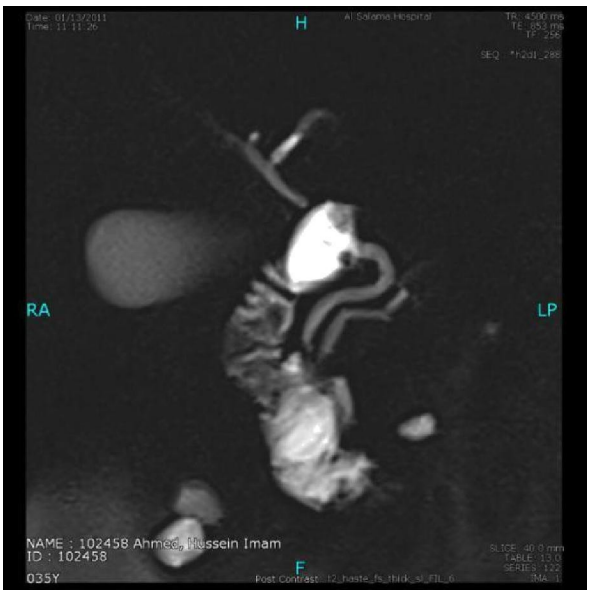

Fig. 6: MIP image of a patient with separate draining openings of the CBD and pancreatic duct into second part of the duodenum in major and minor papillae (Pancreas divisum)

Table 1
Biliary abnormalities detected with MRCP

Abnormality	No. of patients	% of patients
Accessory cystic duct	2	2.2%
Abnormal cystic duct insertion	2	2.2%
Long serpentine cystic duct	1	1.1%
Trifurcation of the CHD	1	1.1%
Pancreas divisum	1	1.1%

Table 2
Extrabiliary abnormalities detected with MRCP

Abnormality	No.
Simple renal cyst	70
Fatty hepatomegaly	40
Fatty liver	17
Splenomegaly	15
Hepatic hemangioma	9

Table 3
Statistical results of MRCP-detected CBD stones

	%
Sensitivity	100 %
Specificity	98%
PPV	71%
NPV	100%

Table 4
Postoperative complications

	Group I	Group
II Conversion to open (unclear anatomy)	0	
2		
Biliary leakage	0	3
Injury to CBD	0	0
Jaundice	0	1
Pancreatitis and/or cholangitis	0	4
Re-admission due to complication	0	5
Total	0	10

Table 5
Total patient cost

	Hospital stay				MRCP	ERCP	Total	Mean ± SD	p value
	MIN	MAX	MEAN SD	TOTAL					
I No = 90	1D	5D	1.7 ± 0.32	15300 $	900 $	7000 $	31300 $	347.7 $	> 0.05
II No = 112	1D	5D	2.2 ± 0.54	24640 $	500 $	8000 $	31340 $	295.89 $	

Discussion

Residual stones after cholecystectomy not only have the risk of recurrent gall stones-associated disease, as early biliary leakage, recurrent biliary colic, cholangitis, and pancreatitis, but can also induce patients' dissatisfaction. Therefore, MRCP was suggested to detect CBD stones and target them for elimination before the operation.[7-9] Consequently, the European Association for Endoscopic Surgery (EAES) consensus development conference committee recommends common bile duct investigation to rule out choledocholithiasis in all patients with symptomatic cholelithiasis.[10]

Ultrasonography is the most commonly used modality in the evaluation of gallstone disease, with a high specificity (95%) and sensitivity (95%) for

stones larger than 2 mm.[16] However, the distal CBD may not routinely be examined if there is no extrahepatic biliary dilatation.[6] Shanmugam et al[2] found that US was able to diagnose CBD stones in only 31% of patients subsequently diagnosed by ERCP, and was not able to visualize CBD in 12% as it was obscured by gases. Although US has a high sensitivity and specificity for the detection of gallstones, transabdominal US has a sensitivity of only 21%–63% for intrabiliary stones due to the limited acoustic window, absence of bile duct dilatation, and complex anatomy. Furthermore, up to one-half of patients with biliary stones have nondilated ducts at the time of imaging. It is believed that intermittent obstruction of the ducts may result in their being imaged during intervals of relative nonobstruction. As a result, the diagnosis of CBD stones is frequently delayed and may not be made until months or even years after the onset of symptoms.[19]

Magnetic resonance cholangiopancreatography is increasingly replacing diagnostic ERCP in the initial assessment of patients with suspected biliary obstruction, with ERCP being reserved for the removal of confirmed stones in choledocholithiasis. [12] Many reports have been issued regarding the usefulness of MR cholangiography in the detection of CBD stones. Even with current imaging techniques, the accuracy of MR cholangiography in the diagnosis of CBD stones has varied widely, with reported sensitivities ranging from 57% to 100% and specificities ranging from 73% to 100%.[15] In the present study; MRCP has showed excellent sensitivity value (100%) as well as excellent NPV (100%), while the PPV was 71% and specificity 97%. This shows that MRCP is a highly sensitive and – almost- specific test for CBD stones and an excellent negative test.

Although US is an excellent modality for the initial evaluation of the patient with acute right upper quadrant pain and will often suffice to direct treatment decisions, there are situations where additional imaging may be required. The combination of US and magnetic resonance (MR) imaging or MRCP provides excellent potential for diagnosis of acute biliary ductal disease. On the other hand, if choledocholithiasis is suspected but cannot be confirmed with US, MRCP is an excellent choice for further investigation, with a sensitivity of 95% and specificity of 100%.[18]

In our study, we reduced the incidence of post-operative residual stone in group I down to zero compared to the study done by two independent group of investigators[4,5] found clinically silent stones in 4% and 6% of their studied populations who did not undergo pre-operative MRCP and they recommended MRCP as a screening technique before laparoscopic cholecystectomy. On the contrary, Jendersen et al[6] had less than 1% asymptomatic CBD stones and therefore denied its significance as a routine

investigation. Nebiker et al[4] reported residual stones after cholecystectomy in only two cases (0.4%).

In this work, abnormalities in biliary radicles that affected the surgical procedure were diagnosed by MRCP in 5 patients; representing 5.6%. These findings allowed the surgeon to be more cautious during surgery through careful dissection to identify accessory cystic duct and long serpentine cystic duct and CBD insertion and proper clipping. Nebiker et al[4] diagnosed accessory bile ducts in 2.4% of patients, aberrant hepatic ducts in 0.4%, and an atypical entry to the common bile duct in 0.9%. In all of these cases the anatomical variant was recognized preoperatively and the operation could proceed with more caution. In the series described by Ausch et al[5] more variants of the cystic duct were detected (9.5%). In their opinion pre-operative recognition of variations of the cystic duct are helpful in preventing bile duct injury. [5] Nebiker et al[4] reported a rate of 0.1% bile duct injury between 1990 and 2002. Generally, in 22% of the cases, the surgeon considered retrospectively the MRCP as helpful for the surgical procedure through improved pre-operative comprehension of the bile duct anatomy.[4]

The cost of health care is a major concern in today's world. The true cost of MRCP varies from place to place. However, as compared to ERCP, MRCP has a clear advantage in that the patient does not have to stay in hospital for at least 2 days after ERCP.[6] In this study, comparing the cost for both groups (I & II) we found that; the increase in cost utilizing the combined procedure is slightly higher than the single evaluation technique i.e. US alone, together with the dramatic reduction of the post-operative complications i.e. one patient in group I compared to 15 patients in group II; combined technique reveals greater advantage (Tables 3,
4, and 5).

Conclusion

Combined MRCP and US procedure has proved to be a very useful tool in assessment of patients with cholecystitis and/or gall bladder stones prior to laparoscopic cholecystectomy in comparison to US alone, taking advantage of the high sensitivity and excellent negative test –negative predictive value- of MRCP. The use of the combined procedure has been justified in terms of cost/benefit relationship. Therefore, we recommend the combined procedure to be part of the routine workup before laparoscopic cholecystectomy in patients with cholecystitis and/or gall bladder stones.

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Table(s)

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Accessory cystic duct	2	2.2%
Abnormal cystic duct insertion	2	2.2%
Long serpentine cystic duct	1	1.1%
Trifurcation of the CHD	1	1.1%
Pancreas divisum	1	1.1%

Table 2: Extra-biliary abnormalities detected with MRCP

Abnormality	No. of patients
Simple renal cysts	14
Fatty hepatomegaly	40
Fatty liver	17
Splenomegaly	15
Hepatic haemangiomata	9

Table 3: Postoperative complications

	Group I	Group II
Conversion to open (unclear anatomy)	0	2
Biliary leakage	0	2
Injury to CBD	0	0
Jaundice	0	1
Pancreatitis and/or cholangitis	0	4
Re-admission due to complication	0	5
Total	0	9

Table 4: Statistical results of MRCP-detected CBD stones

	%
Sensitivity	100 %
Specificity	98%
PPV	71%
NPV	100%

Table 5: Total patient cost

	Hospital stay				MRCP	ERCP	Total	Mean ± SD	p value
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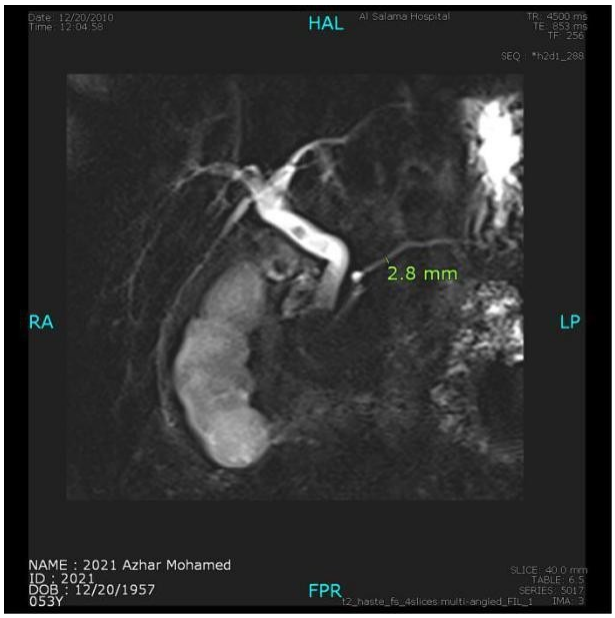
Figure(s)

Fig.1
T2WI coronal section of a patient with faceted signal void stone seen impacted in the terminal portion of the CBD with consequent ductal dilatation



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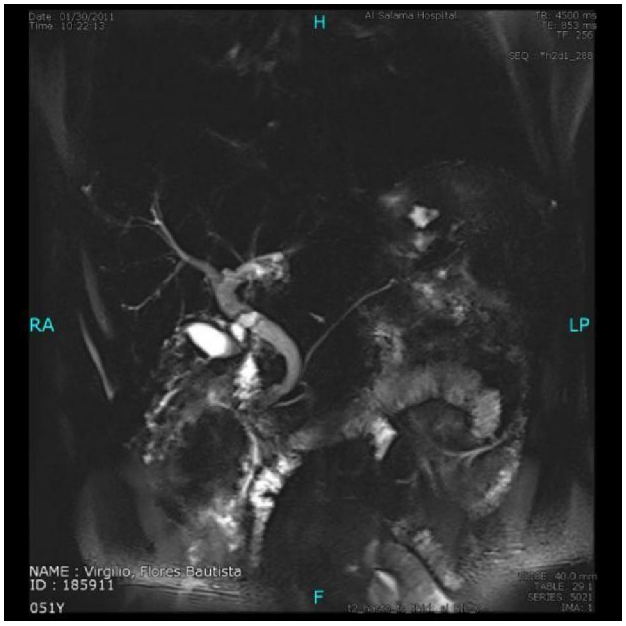

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