Diagnostic value of the choledochal sphericity index in the diagnosis of obstructive cholestasis using magnetic resonance cholangiopancreatography

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Abstract

***Background and study aims* : Dilatation of common bile duct (CBD) is the first sign in the diagnosis of obstructive jaundice. On magnetic resonance cholangiopancreatography (MRCP), the measurement of the CBD diameter is commonly performed on the widest part of the duct, and the long axis diameter is used in clinical practice. It is aimed to investigate the role of long axis, short axis and sphericity index (SI) of CBD in the diagnosis of obstructive cholestasis.**

***Patients and methods* : MRCP images of 68 patients who had a bile duct diameter of ≥6 mm were retrospectively evaluated. The cases with a direct bilirubin value >0.4 mg/dl were determined to be cholestasis. Using the curved planar images, the long and short axis measurements were obtained from the widest portion of the bile duct in the transverse section and SI were obtained by calculating the ratio of the long axis over short axis. Short axis, long axis and SI was compared between cholestatic and non-cholestatic group.**

***Results* : The mean age of the patients was 58.97 ± 17.84. Long axis, short axis, and SI showed statistically significant difference between groups (p=0.034, p=0.001, and p=0.014, respectively). Sensitivity and specificity were 60.7% and 80% for long axis, %53.6 and 82.5% for short axis, 65% and 71.4% for SI, respectively.**

***Conclusions* : In addition to the long axis measurement, evaluation of the short axis measurement and calculation of the SI on MRCP examination will help exclude physiological dilatation in the suspicion of cholestasis.** (Acta gastroenterol. belg., **2020**, 83, **571-575**).

Keywords : Obstructive cholestasis, MRCP, common bile duct, jaundice

Introduction

Cholestasis is a decrease in the common bile duct flow due to pathologies in the biliary tree, as well as bile acid uptake, conjugation, or secretion. It is classified as intrahepatic or extrahepatic (1). Various factors, such as benign and malignant pathologies, trauma, pregnancy, and iatrogenic causes, such as drug side effects and surgical complications, may cause congestion of the biliary tree. Ultrasonography (US) is the first choice of imaging modality in the investigation of biliary obstructive diseases because it is a widely available, fast, non-invasive, and low-cost technique (2). However, the presence of gas in the gastrointestinal tract, especially in the peripancreatic area, technically limits the efficacy of the US examination ; thus, for most cases, this method is insufficient for the diagnosis of the etiology of biliary obstruction. Visualization of stones in the common bile duct (CBD) can be difficult, especially in cases where there is no dilatation of the biliary tract. Endoscopic retrograde cholangiopancreatography (ERCP) is currently considered to be the gold standard for the evaluation of the pancreatobiliary system (3) ; however, magnetic resonance cholangiopancreatography (MRCP) is a safe, non-invasive diagnostic alternative that can be used to evaluate the biliary tract. For more than two decades, MRCP has been used to assess biliary tract pathologies (4). Involving the extensive use of T2-weighted sequences, this examination draws attention to fluid-filled biliary structures ; thus, it has an important role in the non-invasive evaluation of pancreaticobiliary pathologies. Dilatation of CBD is the first sign in the diagnosis of obstructive jaundice. Therefore, the CBD diameter is routinely measured on US, MRCP, or computed tomography (CT) imaging in cases with cholestasis. On MRCP, the measurement of the CBD diameter is commonly performed on the widest part of the duct, and the long axis diameter is used in clinical practice. Typically, the short axis diameter is not evaluated, and its contribution to the diagnosis of cholestasis is unknown. Moreover, the fact that the CBD is in a flat or round configuration may be a marker to indicate the intra-luminal pressure and obstructive extrahepatic cholestasis. For this purpose, we determined the choledochal sphericity index (SI) using MRCP, and we investigated the role of these imaging parameters in the diagnosis of obstructive extrahepatic cholestasis.

Methods

In this study, the patients who underwent MRCP in our clinic due to a dilated common bile duct between January 2015 and October 2018, and that were found to have a bile duct diameter of ≥6 mm, were screened from the hospital's medical records. Blood parameters were also examined to evaluate these cases for cholestasis. Thus, a total of 68 patients, for whom MRCP images and serum direct bilirubin results were available, with less than 24 hours between these two procedures, were included in the study. The MRCP images and laboratory results were evaluated retrospectively. Ethic committee

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approval and informed consent from the patients in all cases were obtained before the study began.

MRCP was performed in 1.5-Tesla MRI units (Achieva SE, Philips Healthcare, Best, The Netherlands) using a torso phased-array coil. Two MRCP sequences were used. The first sequence was a single-shot radial MRCP (TR/TE, 8000/800 ms ; echo-train length, 256 ; flip angle, 90° ; FOV, 300 mm^2 ; section thickness, 40 mm ; sections passing through the porta hepatis and rotating around a point anterior to the portal vein). The first coronal oblique image was obtained through the tail of the pancreas, and the second image was a straight coronal image ; the subsequent sections were 15° apart. The second sequence was an MRCP high-resolution sensitivity encoding (SENSE) sequence (TR/TE, 1204/650 ; flip angle, 90° ; FOV, 260 mm^2 ; section thickness, 1 mm ; interval, 0.8 mm ; straight coronal sections). Maximum-intensity-projection sets of the MRCP high-resolution SENSE sequence images were generated in the coronal plane. The MRCP images were assessed at the workstation, and curved planar reconstruction images were obtained to measure the diameter of the common bile duct. Using the curved planar images (Fig. 1a), the long and short axis measurements were obtained from the widest portion of the bile duct in the transverse section (Fig. 1b), and the SI values were obtained by calculating the ratio of the long axis measurements over short axis measurements (Fig. 2). Elevated serum bilirubin levels were considered, and the cases with a direct bilirubin value >0.4 mg/dl were determined to be cholestasis.

For statistical analysis, IBM SPSS Statistics for Windows, version 21.0 (IBM Corp., Armonk, NY, USA) was used. The Shapiro-Wilk test was performed to assess whether the numerical data were normally distributed. The categorical data were expressed as number and percentage, and the numerical data with a normal distribution were obtained as mean and standard deviation. Pearson's chi-square and Fisher's exact tests were used to compare the categorical data. The Mann-Whitney U test was used to conduct an intergroup comparison of the data that did not show a normal distribution. In cases where there was a significant difference between the groups, the sensitivity, specificity, and Youden index values were calculated at optimal cut-off values using the area under the curve in the receiver operating characteristics (ROC) analysis. p values <0.05 were considered to be statistically significant.

Results

Of the 68 patients included in the study, 23 (33.8%) of the patients were male and 45 (66.2%) were female. The mean age of the patients was 58.97 ± 17.84 ; the minimum age was 16 years and the maximum age was 92 years. Cholestasis was present in 28 patients (41.2%) and absent in 40 patients (58.8%). Thirteen patients (19.1%) had a history of cholecystectomy. When classified according to the last surgical and clinical diagnosis,

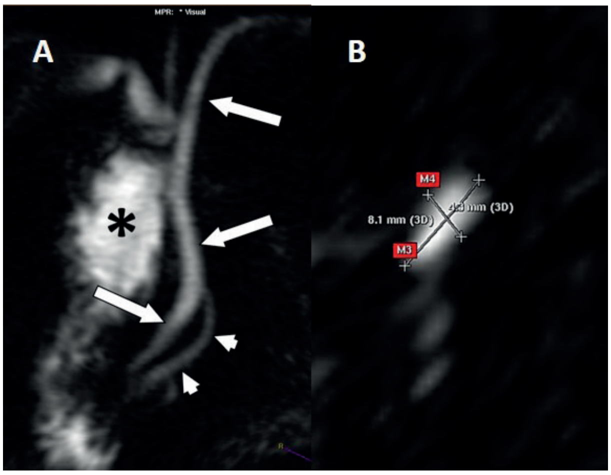

Figure 1. — Curved planar reconstructed images of MRCP belong to a 54-year-old female. Common bile duct (long arrows) is seen throughout its length (a). Pancreatic duct (short arrows) and duodenum (asterisk) are also partially visualized (a). Short axis and long axis diameter measurement from the widest part of common bile duct is demonstrated (b).

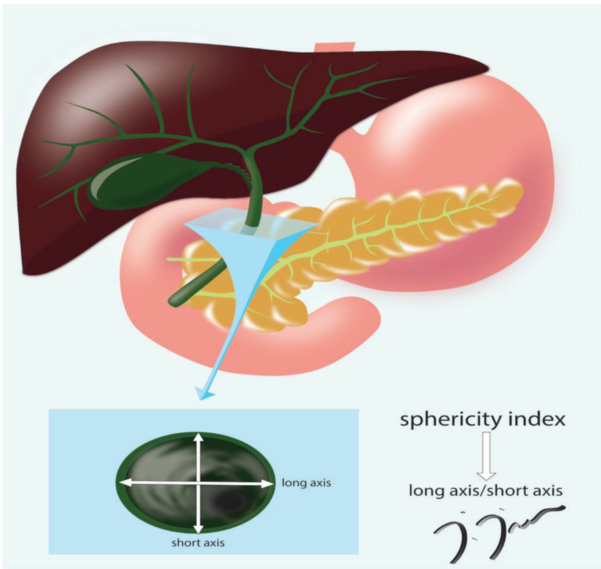

Figure 2. — Demonstration of the long axis and short axis measurements with an illustration performed on the widest portion of the common bile duct to calculate the sphericity index.

37 of the patients (54.4%) had physiological dilatation (obstructive pathology was not found), 18 (26.5%) had choledocholithiasis, seven (10.3%) had benign biliary stricture, three (4.4%) had a periampullary tumor, two (2.9%) had elevated bilirubin levels related to chronic liver disease, and one was diagnosed with Mirizzi syndrome (1.5%). A summary of the descriptive statistics of the remaining numerical data are presented in Table 1.

In the comparison of numerical data between the cholestatic and non-cholestatic groups, all the parameters obtained from the diameter measurements showed a

Table 1. — **Descriptive statistics of numerical data obtained from the patients***

N = 68	Minimum	Maximum	Median
Short axis (mm)	3.3	23.4	6.95
Long axis (mm)	6	28	9.9
Sphericity index	1.01	2.91	1.44
Total bilirubin (mg/dl)	0.18	20.08	0.92
Direct bilirubin (mg/dl)	0.1	14	0.39

*Data without a normal distribution (the Shapiro-Wilk test, <0.0001 for all parameters.

Table 2. — **Comparison of the bile duct diameters between acute cholestatic and non-cholestatic group***

	Acute cholestatic cases	Non-cholestatic cases	p value
Short axis (mm)	9.51 ± 4.27	6.73 ± 3.37	0.001
Long axis (mm)	12.51 ± 5.53	10.14 ± 4.17	0.034
Sphericity index	1.34 ± 0.27	1.59 ± 0.43	0.014

*Mann-Whitney U test.

statistically significant difference. A ROC analysis was undertaken to determine the diagnostic performance of these parameters in the differentiation of cholestasis and to calculate the cut-off values. According to these statistics, the area under the curve was calculated as 73.5% for the short axis, 67.6% for the SI, and 65.2% for the long axis. In patients with cholestasis, the short axis and long axis measurements were significantly higher (p = 0.001 and p = 0.034, respectively), and the SI value was significantly lower (p = 0.014) than the non-cholestatic cases (Table 2). At the optimal cut-off value (8.5 mm), the short axis measurement had lower sensitivity (53.6%) but higher specificity (82.5%) than the other parameters (Table 3).

Discussion

Cholestasis is impaired bile formation and/or flow clinically manifesting with fatigue, itching, and jaundice. Asymptomatic patients often present with conjugated hyperbilirubinemia in the early stages of the condition, followed by increased serum alkaline phosphatase and γ-glutamyltranspeptidase in the later stages. Patient history and physical examination are important in the diagnostic process ; they can provide valuable information for predicting the development of cholestasis (5).

Cholestasis is classified as intrahepatic or extrahepatic (1). The causes of extrahepatic cholestasis include choledocholithiasis, cholangiocarcinoma, ampullary carcinoma, pancreas head carcinoma and other pancreas diseases, CBD stricture, duodenal diverticulum, and parasitosis (6, 7). US, CT, and MRCP provide satisfactory information about the bile ducts as well as the gallstones. Other methods, such as ERCP, endoscopic US (EUS), and percutaneous transhepatic cholangiography (PTC), are invasive and they are primarily used for therapeutic purposes or to obtain further imaging (8). Additionally, although biliary scintigraphy can be used to show the presence of obstructive cholestasis, it is not a routine practice in the current clinical settings (9).

Typically, abdominal US is the first procedure that is used to exclude dilated intrahepatic and extrahepatic bile ducts and mass lesions (2). US is a highly sensitive and specific, non-invasive, portable, and relatively inexpensive modality ; however, it has the disadvantage of being dependent on the skill of the operator and it is unable to fully demonstrate the lower portions of the common bile duct (5). Furthermore, the sensitivity of US is low (50–80%) for determining the etiology of CBD obstruction (6). While abdominal CT is less dependent on the operator’s skill, it exposes patients to ionizing radiation, and the definition of the biliary tree is not always as good in CT as it is in US and MRCP (5). Therefore, different imaging methods, such as MRCP, ERCP, and EUS, are needed. With these tests, the sensitivity increases to 55–100% (6, 8).

ERCP is still the gold standard imaging method for diagnosing such biliary tract pathologies ; however, it remains a challenging procedure with error rates ranging from 3% to 10% due to the high dependency on the operator’s skill and experience (3, 5). After MRCP was introduced to clinical use, the number of ERCP examinations decreased, especially for diagnostic purposes. MRCP is a safe and non-invasive alternative to ERCP for the evaluation of CBD obstruction due to gallstones, stricture, and cholangiocarcinoma (3, 10). With MRCP, there is no risk of complications associated with pancreatic duct procedures. Furthermore, MRCP allows a cross-sectional evaluation, providing data about adjacent tissues (3).

Pasanen et al. found ERCP to be the best imaging modality for detecting benign extrahepatic CBD obstruction (11). CT and ERCP were similar in their ability to detect malignant obstruction. US and CT were more successful than ERCP in the evaluation of

Table 3. — **Results of the ROC analysis**

	Area under the curve (%)	p value	Cut-off value	Sensitivity	Specificity	Youden index
Short axis (mm)	73.5%	0.001	8.5	53.6%	82.5%	0.36
Long axis (mm)	65.2%	0.034	10.8	60.7%	80%	0.41
Sphericity index	67.6%	0.014	1.45	65%	71.4%	0.36

intrahepatic biliary tract diseases. This result suggests that these tests are complementary methods for evaluating CBD obstruction. However, that study did not evaluate MRCP and EUS, which are relatively new tests (11). Zidi et al. evaluated the accuracy of MRCP in the diagnosis of biliary stones in 70 cases (12) ; they reported that MRCP was accurate with 57.1% sensitivity, 100% specificity, 100% positive predictive value, and 50% negative predictive value. However, that study concluded that MRCP was not successful in the diagnosis of biliary stones that are <6 mm in diameter (12). Urban et al. assessed MRCP's accuracy in the diagnosis of CBP stones. Subjects with an alkaline phosphatase (ALP) value >250 U/L, a serum bilirubin value of >1.5 mg / dl, or a CBD diameter >8 mm were included in that study. MRCP was shown to be successful in detecting CBD stones with high interobserver agreement, similar to ERCP (13).

EUS is an invasive diagnostic test that can be used to diagnose distal CBD obstructions ; it has been reported to be a more successful method than ERCP. However, in general, similar success is achieved with EUS and ERCP (14).

Studies have used different cut-off values for the CBD diameter. In the literature, a CBD diameter >5 mm is indicative of CBD obstruction (6, 9, 15). Zidi et al. used a 7 mm cut-off value for patients with gallbladder and a 9 mm cut-off value for cholecystectomized patients (12). Urban et al. used a 9 mm cut-off value (13). However, neither study used short axis measurements. We obtained short axis and long axis measurements, and calculated the SI value. We also included all cases with a CBD diameter of 6 mm or more. In our study, the minimum short axis diameter was 3.3 mm and specificity of short axis was higher than those of long axis and SI. The specificity of short axis was 82.5% when the cut off value was 8.5 mm. Urban et al. also used the following criteria : an ALP value >250 U/L and a serum bilirubin value >1.5 mg/dl (13). We only used the criterion of 0.4 mg/dl of direct bilirubin to determine the cases of obstructive extrahepatic cholestasis.

Physiological dilatation in CBD can be detected in elderly individuals (6). In an MRCP-based study, Peng et al. reported that the bile duct diameter increased in correlation with age (16). Physiological biliary tract dilatation may also occur in cholecystectomized cases. In these patients, US may be insufficient due to the limitations in its ability to differentiate between cholestasis with obstructive causes and physiological dilatation of CBD. In case of clinical suspicion, invasive methods, such as ERCP and EUS, may be needed where MRCP is insufficient to distinguish between physiological dilatation and obstruction. In such cases, the short axis diameter and the SI value may contribute to the diagnosis of obstructive cholestasis.

It is known that the diameter can be measured differently depending on the type of test being used (15). Therefore, the validity of these data on US examination is questionable. Planning prospective studies with US and other imaging modalities in order to evaluate the short axis diameter and calculate the SI value may provide more useful information.

In some cases, obstructive cholestasis may be seen without CBD dilatation. For instance, CBD stones that allow passage can be accompanied by transient jaundice leading to no CBD dilatation (6). Muhletaler et al. evaluated 29 patients with jaundice without CBD dilatation ; that study concluded that CT and US did not contribute to the diagnosis in these cases (17). PTC has been shown to be useful in a limited number of cases (17). Further studies should be performed to assess the role of SI in these cases.

The present study has some limitations. First, the number of cases is limited even if the findings are statistically significant. A prospective study with more cases would provide more accurate results. Second, interobserver agreement was not taken into account in the short and long axis measurements. Measurements can vary from person to person and result in different values. Third, the disease group is heterogeneous in obstructive jaundice cases, and different findings can be obtained in different diseases. In our study, we did not compare the different disease groups due to the small number of cases. Additionally, SI is not an independent data, indeed. The results regarding the diagnostic power of the SI may be influenced by short axis or long axis data. CBD with different short and long axis measurements can have the same SI values. Nevertheless, to evaluate the diagnostic capacity of SI without being affected by short and long axes, further studies comparing SI values of common hepatic ducts with similar short and long axes in the cases with and without cholestasis are needed. Finally, we only evaluated patients in which the long axis of CBD was 6 mm or more ; however, obstructive cholestasis with non-dilated CBD is also a problem for some patients. We did not include patients with a normal CBD diameter in order to distinguish physiological dilatation from obstructive cholestasis. In the future, studies that include patients with a normal CBD diameter may be designed to assess the diagnostic power of the SI.

In conclusion, in addition to the long axis measurement, evaluation of the short axis measurement and calculation of the SI on MRCP examination will help exclude physiological dilatation in the presence of cholestasis and significantly contribute to the differential diagnosis. Based on the present study's findings, in cases of possible obstructive cholestasis, a combined evaluation will enable radiologists and clinicians to quickly obtain an accurate diagnosis.

Conflict of Interest

The authors declared no conflict of interest.

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