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A Study of Anatomical Variations of Extra-hepatic Biliary System by Pre-operative Magnetic Resonance Cholangio-Pancreatography and that Encountered during Laparoscopic Cholecystectomy: A Prospective Observational Study

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ABSTRACT

Introduction: The variations in cystic duct anatomy are of considerable importance during surgical excision of the gallbladder (cholecystectomy). Preoperative MRCP assessment of possible anatomical variations helps the surgeon to formulate appropriate strategies and operative planning.

Objective: To assess the usefulness of pre-operative MRCP assessment of anatomical variations of extra-hepatic biliary tree in surgical planning and validate the MRCP findings with surgical findings.

Material and Method: A total 120 patients of ultrasonography proven gallstone disease were included in the study, further evaluated preoperatively by magnetic resonance cholangio-pancreatography for delineation of extra-hepatic biliary anatomy and that was compared with findings during Laparoscopic Cholecystectomy performed in the same patients. Seven patients had frozen Calot's triangle per-operatively and were excluded from the study.

Results: Majority of patients was in age group of 51-60 years (28.4%) and females (85.84%). on MRCP, Posterior insertion of Cystic duct was noted in 58.41% patients, Lateral insertion in 35.39% patients while on per-operatively Posterior insertion was noted in 50.44% and lateral insertion in 38.94 % patients. Most common intra-op complication was Bile spill in 19.4% patients, Stone spill in 9.7% patients and there was no bile duct injury noted.

Conclusion: There is a definitive role of magnetic resonance cholangio-pancreatography prior to laparoscopic cholecystectomy in gallstone disease for precisely delineating the extra hepatic biliary tree anatomy and predicting difficult surgery thus helping the surgeon to be prepared for the eventualities during surgery and to prevent biliary injury. However still intra-op picture can vary and overall, there is reduction in patient morbidity.

Key Words: Extra-hepatic Biliary Anatomy, Pre-operative MRCP, Cystic duct insertion, Laparoscopic Cholecystectomy, Biliary injury

INTRODUCTION

The cystic duct drains the gallbladder into the common bile duct. In adults, it is usually between 2 and 4 cm long and has a luminal diameter of 2–3 mm.[1] Cystic duct unite with the common hepatic duct in variable fashion to form the common bile duct. Anatomic variants of the cystic duct insertion into the extra-hepatic bile duct are:

(a) Right lateral insertion
(b) Anterior spiral insertion
(c) Posterior spiral insertion
(d) Low lateral insertion with a common sheath,
(e) Proximal insertion or low medial insertion.

The cystic duct joins the middle third of the combined lengths of the common hepatic and common bile ducts in most of the patients,[2] but it may also drain by variable insertion into the distal common bile duct (CBD) usually joins the right lateral aspect by making oblique angle or run parallel with common hepatic duct in the free edge of the lesser omentum for a variable distance before merging.[3] These variations of cystic

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duct anatomy are identified by preliminary cholangiogram of considerable importance to prevent biliary injury during cholecystectomy.

In adults, the common hepatic duct descends approximately 3 cm before being joined obliquely on its right by the cystic duct to form the common bile duct. In adults common bile duct divided into supraduodenal, retroduodenal and pancreatic segments and is usually between 6 and 8 cm long and its luminal diameter, as measured by ultrasound, is no more than 7 mm.[4] The supraduodenal segment of the common bile duct is the most accessible at surgery. Calot's triangle, which is an isosceles triangle based on the common hepatic duct, with the cystic artery and cystic duct forming its sides.[5] Understanding the variations in biliary and arterial anatomy as they relate to the triangle is of considerable importance during excision of the gallbladder in order to avoid injury to the common hepatic or common bile duct or right hepatic artery.[6,7] (Figure 1)

Extra-hepatic biliary system has wide anatomical variations which might have a detrimental role on the successful culmination of a Laparoscopic Cholecystectomy procedure. Although incidence and frequency of these different anatomical variations vary substantially yet these anatomical variations from normal anatomy make the Laparoscopic Cholecystectomy procedure difficult and might result in biliary tract injury.[7,8] Incidence of extra-hepatic biliary tree anatomical variations is seen less than 50%.[9] Preoperative assessments of possible anatomical variations helps the surgeon to formulate appropriate strategies and operative planning. Failure to recognize some of the clinically important variants may lead to complication. In the recent years magnetic resonance cholangio-pancreatography (MRCP) has come up as an optimal non-invasive imaging modality for evaluation of anatomical variations of extra-hepatic biliary tree. In the present study anatomical variations of extra-hepatic biliary system assess by preoperative MRCP and that encountered during Laparoscopic Cholecystectomy

MATERIAL AND METHOD

Study type-This was a prospective observational study.

Study population- A total of 120 patients included in the study.

Inclusion criteria- Patient aged 18 to 80 years of both sex, belonging to different socioeconomic conditions and various geographical locations of India and who had ultrasonography proven symptomatic cholelithiasis were further evaluated preoperatively by magnetic resonance cholangiopancreatography for delineation of extra-hepatic biliary anatomy, underwent laparoscopic cholecystectomy.

Exclusion criteria- Patients who were unwilling to participate in the study, in which MRI was contraindicated, acute calculus cholecystitis, empyema gall bladder, pancreatitis and frozen Calot's triangle preoperatively were excluded from the study.

Place of study: This study was conducted at 7 Air Force Hospital Kanpur, India,

Duration of study: The study duration was from January 1, 2018, to December 31, 2018.

Objectives of study

1. To find out by MRCP frequency and types of anatomical variations of extra-hepatic biliary tree in patients supposed to undergo Laparoscopic Cholecystectomy.
2. To validate the MRCP findings with surgical findings.
3. To assess the usefulness of pre-operative MRCP assessment of anatomical variations of extra-hepatic biliary tree in surgical planning.

Methodology: In the present study, 120 patients with ultrasonography proven gallstone disease were further evaluated preoperatively by Magnetic Resonance Cholangio-pancreatography using Magnetic Resonance Image (MRI) unit on MRI scanner and images obtained by using Philips Achieva® 1.5 TESLA MRI. The MRCP images were evaluated by an experienced radiologist for presence of different anatomical variations of extra-hepatic biliary tree. Preoperative workup general blood picture, assessment of liver functional test, renal functional test and fitness for general anesthesia was done. Informed written consent was obtained from all the patients before the operative procedures. The participation in the study was entirely voluntary giving the patient right to withdraw from study whenever he/she wishes to do so.

This study was approved by the Institutional Ethical Committee (7AFH/24Apr/2018). Demographic information, personal and medical history was obtained. Preoperative MRCP for delineation of extra-hepatic biliary anatomy were noted. All the patients underwent Laparoscopic Cholecystectomy. Anatomic variations in extra-hepatic biliary tree were observed and recorded during the procedure. Seven patients had frozen Calot's triangle per-operatively and were excluded from the study. Preoperative MRCP findings were compared with Laparoscopic Cholecystectomy findings in the same patients. Impact of MRCP assessment of extra-hepatic biliary tree variations was assessed with respect to reduction in intra-operative and postoperative complication.

Data Collection Method

The data was collected on a semi-structured questionnaire. Records of all the test reports maintained. Observations were made under direct supervision. The data so collected were fed into computer using MS Excel 2013 or compatible software.

STATISTICAL METHODS

The data was analyzed using Statistical Package for Social Sciences version 21.0 or above. Chi-square test, ANOVA and Independent Samples 't'-test was used for comparison of data. A p-value less than 0.05 was considered to indicate statistically significant association. Sensitivity, Specificity, PPV, NPV and accuracy of MRCP were also assessed.

RESULTS

Age of the patients: Majority of patients were of age group 51-60 years (28.4%) followed by age groups 31-40 years and 41-50 years (20.3% each) and the mean age was 47.32±13.58 (Figure 2a).

Gender of patients: On the basis of their gender, the majority of patients were females (85.84%) followed by males (14.16%) (Figure2b).

Cystic duct and Common bile duct diameter: It was noted that mean cystic duct diameter in females was 1.60±0.79 mm and in males it was 1.35mm±0.44mm while mean CBD diameter in females was 5.88±1.67mm and in males it was 5.88±1.26mm (Table 1a, 1b).

Cystic duct insertion:

(a) On MRCP: Posterior insertion was noted in 58.41% patients, lateral insertion in 35.39% patients, anterior insertion in 2.66% patients and medial insertion in 3.54% patients (Table 2a, Figure3).

(b) On Per-operative: Posterior insertion was noted in 50.44% patients, lateral insertion in 38.94 % patients, anterior insertion in 9.74% patients and medial insertion in 0.88% patients (Table 2b, Figure 4).

MRCP was able to predict correct anatomical variation in 70 cases out of the 113 that were evaluated giving a rate of 61.94%. The errors in detection can be due to multiple causes like observer sensitivity, technical skill in image acquisition, stage of disease process leading to changes in nature of image and body characteristics of the patient. Each of these factors needs to be evaluated separately in future studies with a larger sample size.

Table (Table 3a, 3b) analyses usefulness of MRCP preoperatively to screen the cases planned for Laparoscopic Cholecystectomy. Considering Cystic duct insertion noted during preoperative MRCP and that noted intra-operatively, Lateral (a) and Posterior insertion(c) were most common finding and considering these findings to be normal, Anterior (b) and Medial insertion(d) were considered as anatomical variation and the following results were obtained.

Intra-op complications: Most common intra-op complication was bile spill in 19.4% patients, stone spill in 9.7% patients and vascular injury (cystic artery) during dissection in 7.96% patients. No bile duct injury, trocar injury, bowel injury or port site bleeding was noted (Table 4).

Operative time: Time taken for performing laparoscopic cholecystectomy was less than 60 minutes in 82(72.56%) cases and more than 60 minutes operative time in 31(27.43%) cases.

DISCUSSION

The frequency and types of extra-hepatic biliary tree anatomical variations is quite high and owing to these variations, there is difficulty during operative procedures and often there is a high incidence of intra-operative and postoperative complications. In recent years, Magnetic Resonance Cholangio-pancreatography (MRCP) has emerged as a useful modality to assess these variations non-invasively prior to surgery itself. The present study was conducted to assess the usefulness of pre-operative MRCP, assessment of frequency and types of anatomical variations of extra-hepatic biliary tree in patients supposed to undergo Laparoscopic Cholecystectomy and compare with surgical findings.

In a study by Al Ghamdi A S et al. 10, the mean age was 41 years (range 10-100 years) in the age group 31-40 years while in present study the mean age was 47 years (range 22-76) with highest incidence was in 6th decade. The youngest male was 22 years old and female 24 years. In a study by Sakorafas et al.[11] female gender was associated with higher prevalence, 16% compared to 9% for males. IJ Beckingham[12] studied that female gender carried twice the risk of gallstone disease as compared to men, which was especially prominent at young age, mainly because of hormonal factors. Present study results correlated with their findings with a female: male ratio of 6.06: 1 (97 female's vs 16 males). In present study mean cystic duct diameter was 1.60 mm with a SD of 0.79mm in females and in males it was noted to be 1.35 mm with a SD of 0.44mm.No other study in the past has noted this particular parameter. This may be due to non-availability of detailed MRCP findings or due to non-availability of expertise. Kim H J et al.,[13] in a study of normal structure, variations and anomalies of the pancreaticobiliary ducts found that the mean maximal and mid-portion diameters (mm) of the common bile duct were 6.4mm (1.8) and 5.5mm (1.7) respectively while dilated CBD was described to have an association with difficult surgery and conversion to open surgery by Liu et al.[14] In present study, mean diameter of CBD in females was 5.88 mm with an SD of 1.67 mm and in males it was noted to be 5.88 mm with an SD of 1.26mm. In a study by Sarawagi R et al.,[15] the accuracy of MRCP evaluated in the diagnosis of anatomic variants of biliary tree in 224 patients, MRCP demonstrated the cystic duct in 198 patients, including a low cystic duct insertion

in 18 patients (9%) and a parallel course of the cystic and hepatic ducts in 7.5% patients. There were three common variants in the anatomy of the cystic duct region: low cystic duct insertion with distal third of the CBD (9%); medial insertion, where the cystic duct drains into the left side of CBD (10-17%); and a parallel course and less angular entry into CBD (1.5-25%). In present study, patterns of cystic duct insertion noted during preoperative MRCP were lateral insertion in 35.40%, posterior insertion in 58.41%, anterior insertion in 2.65% and medial insertion in 3.54% patients. When these patients were taken up for Laparoscopic Cholecystectomy, the intra-operative patterns of cystic duct insertion were found to be lateral insertion in 38.93%, posterior insertion in 50.44%, anterior insertion in 9.73% and medial insertion in 0.88% patients. In this study it was tried to analyze the usefulness of MRCP preoperatively to assess the extra hepatic biliary tree anatomy for the case planned for Laparoscopic Cholecystectomy. To calculate the results, intraoperative findings have been used as Gold Standard. The sensitivity of MRCP was 97.12% with a 95% confidence interval (91.8%-99.4%). This implies that the sensitivity of MRCP was at least 91.8%, which was quite high and chances of missing a case of anatomical variation was low, thus making MRCP a useful imaging modality for preoperative assessment of anatomical variations. The specificity was 44.4% with 95% confidence interval (13.7%-78%). The specificity was low which implies that there were fair chances of false positive cases where MRCP highlights a variation, which actually was not present. However, this is clinically not very important as this would mean taking more precaution during surgery which is never a bad idea in such cases. I J Beckingham[12] in his study found that biliary tree injury with laparoscopic cholecystectomy was 0.2 – 0.4 % as compared to 0.1% with open cholecystectomy while in present study, there were no bile duct injuries. This may be attributed to the fact that centre has highly trained senior faculty and each patient had undergone extensive pre-operative evaluation which was far beyond the standard of care. Al Ghamdi A S et al.,[10] in the study of 751 patients, the mean operative time was 65.52 minutes, seven patients (0.93%) converted to Open Cholecystectomy (OC) and mortalities of 02 patients (0.26%). In present study, the mean operative time was 54.13±25.71min and there was no conversion or mortality. In view of the smaller sample size in study group, the difference in mortality rates was also not statistically significant.

CONCLUSION

The present study attempts to determine the role of magnetic resonance imaging and magnetic resonance cholangio-pancreatography prior to laparoscopic cholecystectomy in gallstone disease. However, laparoscopic cholecystectomy carries a higher risk of injury to biliary tree than conventional surgery. Significant number of these injuries is caused by variations in the biliary tree anatomy. By precisely delineating the biliary tree anatomy, magnetic resonance imaging and magnetic resonance cholangiopancreatography can assist the surgeons in predicting difficult surgery thus helping the surgeon to be prepared for the eventualities during surgery and to prevent biliary injury. However still intra-op picture can vary and overall, there is reduction in patient morbidity.

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Drafting, Review, Editing of the manuscript: Dr. Hari Mohan, Dr.Vikram Trehan.

Critical revision & Final approval: Dr.Anurakshat Gupta, Dr.Vikram Trehan.

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Table 1a: Gender wise distribution of mean cystic duct diameter

Gender	Number of patients	Mean(in mm)	S.D.
Female	97	1.6041	±0.79
Male	16	1.3500	±0.44

't' = 1.24; p = 0.22 N.S.

Table 1a showing cystic duct diameter mean among male and female.

Table 1b: Gender wise distribution of mean CBD diameter

Gender	Number of patients	Mean	S.D.
Female	97	5.8856	1.67077
Male	16	5.8875	1.26800

Table 1b showing CBD diameter mean among male and female.

Table 2a: Cystic Duct Insertion on MRCP

Cystic Duct Insertion (MRCP)	Number of patients	%
Lateral	40	35.39
Posterior	66	58.41
Anterior	3	2.66
Medial	4	3.54
Total	113	100

Table 2b showing percentage of variable cystic duct insertion on preoperative MRCP

Table 2b: Per-op cystic duct insertion

Cystic Duct Insertion (Per-op)	Number of patients	%
Lateral	44	38.94
Posterior	57	50.44
Anterior	11	9.74
Medial	1	0.88
Total	113	100

Table 2b showing percentage of variable cystic duct insertion on per-operatively.

Table 3a: Comparison of Cystic Duct Insertion on preoperative MRCP and Per-Operative Finding.

Cystic Duct Insertion (MRCP)	Cystic Duct Insertion Per- Operative				Total
	Lateral (%)	Posterior (%)	Anterior (%)	Medial (%)	
Lateral	25(22.12%)	12	3	0	40
Posterior	16(14.15%)	43	7	0	66
Anterior	02(1.76%)	0	1	0	3
Medial	01(0.88%)	2	0	1	4
Total	44(38.93%)	57	11	1	113

Chi-Square (X_2) = 47.43 'p' = 0.0001 (Highly Significant)

Table 3b: Comparison of Cystic Duct Insertion (MRCP) and Cystic

Duct on Operative Finding

MRCP Findings/ Per-operative Finding	Normal	Variation	Total
Normal	101(a)	5(b)	106
Variation	3(c)	4(d)	07
Total	104	09	113

Statistic	Formula	Value	95% CI
Sensitivity	$\frac{a}{a+b}$	97.12%	91.80% to 99.40%
Specificity	$\frac{d}{c+d}$	44.44 %	13.70% to 78.80%
Disease prevalence	$\frac{a+b}{a+b+c+d}$	92.04%	85.42% to 96.29%
Positive Predictive Value	$\frac{a}{a+c}$	95.28%	91.84% to 97.32%
Negative Predictive Value	$\frac{d}{b+d}$	57.14 %	26.01% to 83.49%
Accuracy	$\frac{a+d}{a+b+c+d}$	92.92%	86.53% to 96.89%

Table 3b: Comparison variation from normal cystic duct insertion on preoperative MRCP on per-operatively and different parameters (sensitivity, specificity, prevalence , predictive value and accuracy)

Table 4: Intra-Op Complications

Intra-op complications	No. of Patients	%
Bile Spill	22	19.4
Stone Spill	11	9.7
Vascular Injury (Cystic Artery)	9	7.96
Biliary Injury	0	0
Trocar Injury	0	0
Bowel Injury	0	0
Port Site Bleeding	0	0

Table 4 showing percentage of different complications occurs during per-operatively.

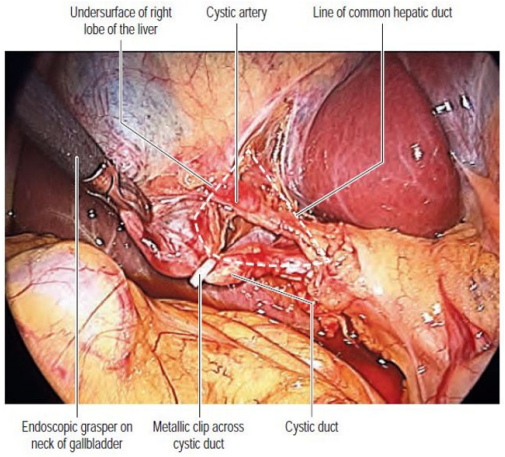

Figure 1: A view of the Hepato-biliary Triangle (dashed line) at laparoscopic cholecystectomy. In this, the cystic artery can be seen crossing the triangle superficially en route to the gallbladder.

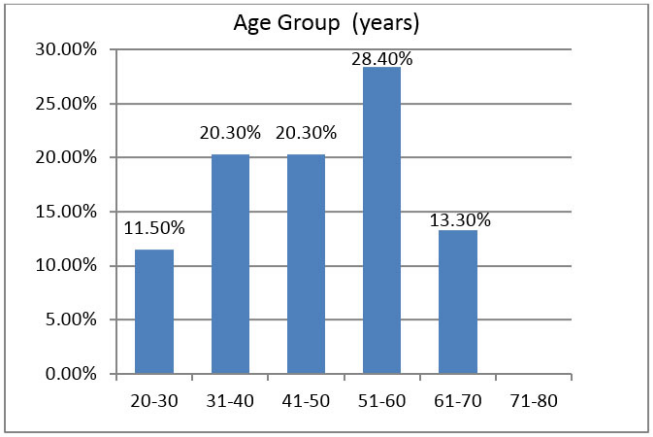

Figure 2a: Bar diagram showing percentage of patients distribution in different age group.

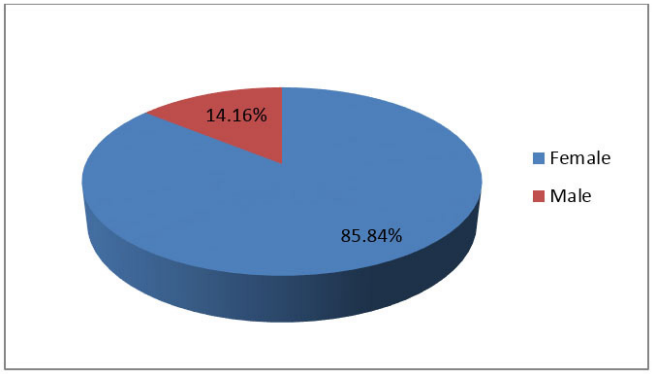

Figure 2b: Showing percentage of gender wise distribution of patients.

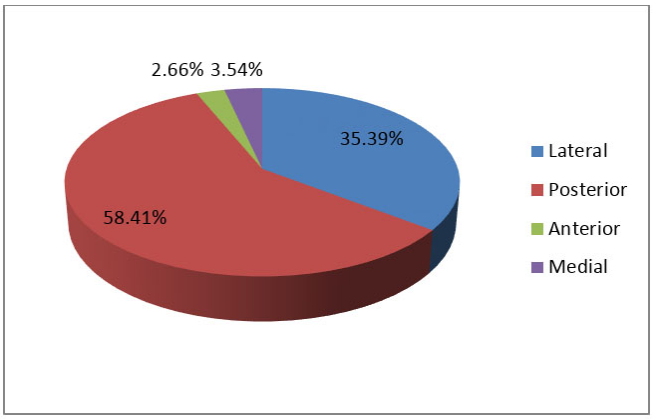

Figure 3: Pie diagram shows percentage of variable cystic duct insertions on pre-operative MRCP

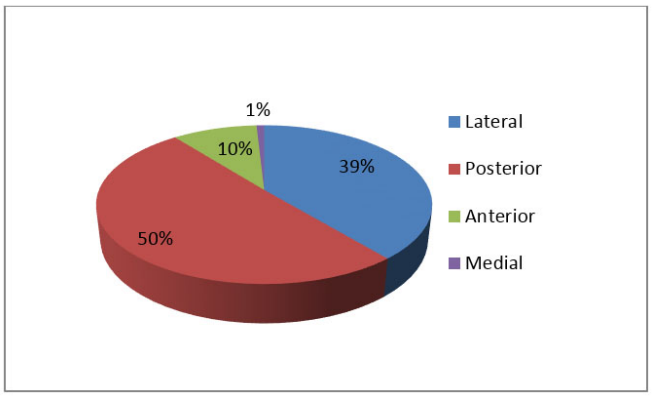

Figure 4: Pie diagram shows percentage variable cystic duct insertion on per-operatively