

Comparative Role of Ultrasonography and Magnetic Resonance Imaging in Evaluation of Biliary Tract Anomalies and Pericholecystic Adhesions in Patients with Gall Bladder Stone Disease.

Asif Majid Wani¹, Rajul Rastogi², Vijai Pratap³, Obaid Ashraf⁴, Neha⁵

¹Senior Resident, ⁴Lecturer, Department of Radiodiagnosis & Imaging, Government Medical College, Srinagar, Jammu & Kashmir, India

²Associate Professor, ³Senior Professor, ⁵PG Resident, Department of Radiodiagnosis, Teerthanker Mahaveer Medical College & Research Center, Moradabad, Uttar Pradesh, India

Abstract

Gallbladder stone disease is the commonest pathology of the biliary tract and the commonest indication for cholecystectomy. Prior to laparoscopic era, all cholecystectomies were done by open surgery and were associated not only with high risk of anesthesia but also procedure related morbidity & complications. Recently, laparoscopic cholecystectomy has become the mainstay of managing the symptomatic gallbladder stone disease. But laparoscopic cholecystectomy is limited by dense pericholecystic adhesions, suboptimal/non-visualization of Calot's triangle and biliary tract anomalies that are associated with difficult intraoperative manipulation of instruments and often conversion into open cholecystectomy. This conversion may lead to increased procedure related morbidity as well as increased risk of longer duration of anesthesia. However, in the modern era of imaging attempts have been made to preoperatively predict such difficult laparoscopic cholecystectomy requiring open mode of surgery.

Ultrasonography is the commonest and one of the most reliable imaging modalities for assessment of biliary tract pathologies including gallbladder stone disease. Though magnetic resonance imaging is now considered as a gold-standard tool for preoperative evaluation in the biliary tract, yet it has some limitations mainly in form of limited availability and financial expenditure. Hence, in this article we tried to compare the ultrasonography and magnetic resonance imaging in preoperative assessment of gallbladder stone disease.

Key words: Ultrasonography, Magnetic Resonance Imaging, Biliary Tract Anomalies, Pericholecystic Adhesions, Gallbladder Stone Disease

Introduction

Optimal preoperative imaging is a key to uneventful surgical management of gall bladder stone disease (GBSD) especially when associated with chronic cholecystitis. A prior assessment of the pericholecystic region is helpful for identification of factors that may complicate its surgical management. These factors include pericholecystic adhesions, anatomical variations in the biliary tract and inconspicuous anatomy of Calot's triangle. The knowledge of above factors aids the clinician in deciding the mode of cholecystectomy i.e., laparoscopic or open type.

Address for Correspondence

Dr. Rajul Rastogi, Associate Professor, Department of Radiodiagnosis, Teerthanker Mahaveer Medical College and Research Center, Moradabad, Uttar Pradesh - 244001, India E-mail: eesharastogi@gmail.com

Received: August 2020

Accepted: December 2020

Laparoscopic cholecystectomy (LC) is considered as the standard mode of surgical management for symptomatic gallstones in appropriate clinical settings [1]. While the procedure is technically more demanding than the classical open cholecystectomy (OC), especially in difficult cases, it has significant advantages in terms of a shorter patient hospital-stay, fewer procedure related risks, minimal residual scars and later complications.

Many factors may complicate the LC leading to intraoperative difficulties and subsequent conversion into an OC with increased anesthesia & procedure-related risks. Presence of dense pericholecystic adhesions and inconspicuous Calot's triangle anatomy may be the cause of unexpected bleeding from GB fossa, viscus perforation and difficult retrieval of GB through the port. Majority of these difficulties can be predicted on preoperative imaging and well-managed thereafter.

Preoperative imaging evaluation may be done by

ultrasonography (USG) or magnetic resonance imaging (MRI). Each of them has their distinct merits & demerits. USG offers high sensitivity in detection of gallbladder stones along with its dynamic character, high speed, and portability [2]. MRI however, is considered as the gold standard imaging tool for preoperative assessment because of its superior soft tissue contrast resolution, multiplanar capability and better delineation of anatomy as well as pathology.

USG parameters such as wall thickness of GB, mobility of gallstone, distension, and presence of pericholecystic fluid or wall edema are helpful in assessing recent status of GBS. Mural thickening of >4mm, distension of GB, fluid in or around the GB fossa, mural air and the presence of sonographic Murphy's sign are all important factors affecting the decision of mode of management. Gallbladder wall thickness more than 3 mm; impacted neck calculus; contracted GB; presence of pericholecystic adhesions and inconspicuous visualization of Calot's triangle anatomy signify difficult laparoscopic management. Impaired visualization of Calot's triangle may be secondary to presence of pericholecystic adhesions; excessive fluids in extra or intramural location; gallbladder wall fibrosis and variations in the anatomy of the biliary apparatus [3].

Like USG, MRI is also extremely helpful in delineating GB stones, the anatomy of Calot's triangle, visualization of the interface between hepatic parenchyma & GB wall in addition to other factors like gallstone impaction in neck; GB wall thickening/edema; overdistention/contraction of GB; and fluid around liver or GB [2,4]. Failure to assess many of the above factors are highly reflective of unclear intraoperative anatomical visualization. Moreover, presence of pericholecystic adhesions can often be predicted by these same parameters. Pure cholesterol stones are hypointense on T1-weighted images (T1WI) whereas T1-hyperintense stones signify pigment stones [5]. This can be especially important in cases of stone impaction because impacted pigment stones may still be treated laparoscopically. Cholesterol stones, being harder, need to be managed by open surgery.

Hence, we planned this study to determine the strengths and weakness of preoperative USG and MRI in predicting the successful outcome of laparoscopic removal of gallbladder.

Material and Methods

The observational, prospective and analytical study was performed after approval from the Institutional Ethics Committee of Teerthanker Mahaveer Medical College & Research Centre. Seventy patients meeting the inclusion criteria and who gave consent for participation were included in the study over a period from November 2014

to June 2016.

Inclusion Criteria

Patient of both sexes diagnosed with gallbladder stone disease on ultrasonography.

Exclusion Criteria

- Previous partial cholecystectomy;
- Debilitated patients;
- Children <15 years and patients unable to give consent;
- Contraindications to MRI.

Patients diagnosed with cholelithiasis on Siemens, Acuson S2000 ultrasound scanner were examined with Siemens 1.5T Magnetom Avanto in the same hospital visit. On USG abdomen, data recorded was presence or absence of pericholecystic adhesions; visualization or non-visualization of Calot's triangle and anomalies of the biliary tract. The same parameters were evaluated by MRI. Data obtained was compared with data obtained during laparoscopic / open cholecystectomy. Further data evaluation was done to see if the final management was affected due to the imaging findings.

Ultrasonography technique and patient preparation.

The patient was examined in fasting state (at least 8 hours prior to the examination) with only drinking water allowance. Patient were examined primarily in supine posture with the patient holding breath in or with abdomen "pushed out" in full expiration. Other positions were used wherever required for optimal imaging. A 3.5MHz curvilinear transducer was used in patients with average habitus while for thin patients, 5 MHz linear transducer was preferred.

MRI Scan Protocol

MRI protocol included respiratory-triggered, T1W & T2W axial; T2W coronal & sagittal; fat-suppressed, T2W axial & coronal and 3D Coronal MRCP image sequences. Maximum intensity projection (MIP) algorithm was used for multiplanar evaluation of 3D cholangiogram.

Observations & Results

Out of 70 patients included in our study, 14 patients did not undergo final operative management at our institute, hence they were excluded. One patient could not have complete MRI study due to claustrophobia, hence it was also excluded. Hence, final data calculation and correlation was based on 55 patients.

Demography

Females (n=44, 80%) outnumbered males in our study with mean age of 42.9years. Majority males were older than majority females in our study with age of maximum occurrence being 50-60years and 40-50years, respectively. Though GBSD was seen from less than 20 to 80 years of age in our study yet maximum patients were in 40-50years followed 50-60years, 30-40years and 20-30years in the decreasing order of frequency.

Pericholecystic Adhesions (Figure 1, Image 1-3)

Pericholecystic adhesions between the gallbladder wall and hepatic parenchyma were considered dense or significant on imaging, when there was significant & diffuse, diminution or complete loss of distinct intervening interfaces. On surgery, pericholecystic adhesions were considered significant when it posed a significant problem in separating the GB from its fossa. In our study, pericholecystic adhesions were noted in 43.6% (n=24) patients on USG and 47.3% (n=26) on MRI. On surgery, it was noted in 49.1% (n=27) of patients.

Calot's Triangle (Figure 2, Table 1, 2 and Image 3)

Optimal visualization of the Calot's triangle is a prerequisite for successful cystic duct ligation and an uneventful LC. Its non-visualization is indirectly correlated with pathology in the region especially dense adhesions near the cystic duct, common bile duct or the cystic artery all of which are liable to complicate LC. In our study, Calot's triangle was optimally visualized in 60% cases on MRI against 47.3% on USG. However, when conversion to open surgery was considered, USG non-visualization of Calot's triangle was a better predictor than MRI, being able to predict 86% against 79% on MRI.

Biliary Tract Anomalies (Figure 3)

Anatomical variations of the biliary tract are likely to change the operative approach used by the surgeon. Lack of preoperative information about variant anatomy can complicate LC with propensity of injuring biliary tract and other organs. In our study, anatomical variations of the biliary tract were detected in 16.3% i.e., 9 out of 55 patients on MRI: triple confluence in 5, variant right posterior duct insertion in two, long and short cystic duct in one patient each. USG abdomen detected 4 of these 9 cases. While 4 of these 9 patients were managed by open cholecystectomy, it is significant to note that the remaining 5 were still managed by laparoscopic procedure. However, prior knowledge of the operative anatomy was helpful to the operating surgeon.

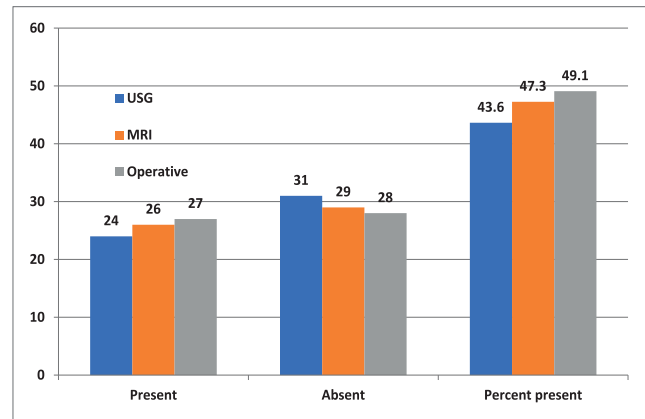


Figure 1: Detection of pericholecystic adhesions on USG & MRI compared to Surgery

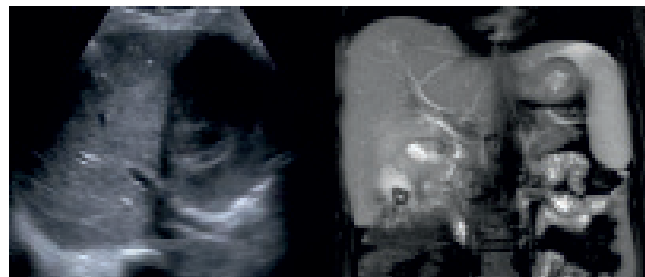


Image 1: USG (left) and MRI (right) images of adherent GB in same patient showing necrosis of wall, intraluminal sludge, cholelithiasis and subhepatic abscess

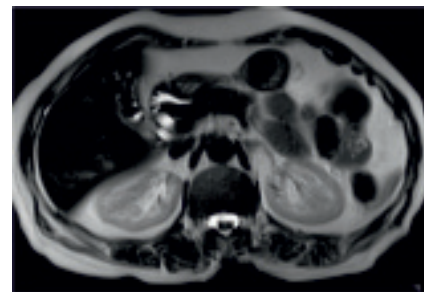


Image 2: Axial T2W MRI shows dense pericholecystic adhesions near body & fundus with triple confluence. Patient was managed by open cholecystectomy.

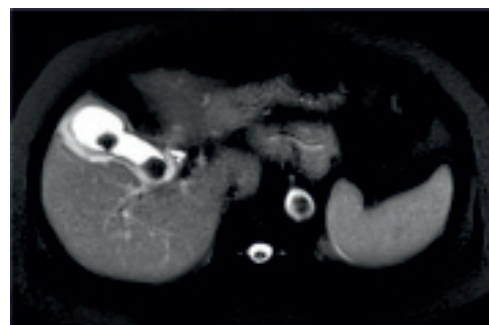


Image 3: Axial T2W fat-suppressed MRI shows diffusely thickened GB wall with intraluminal calculi and complete pericholecystic adhesions with liver. Signs of pericholecystic edema & non-visualization of Calot's triangle are also noted.

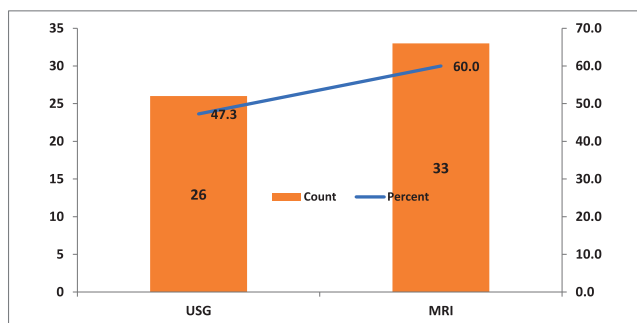


Figure 2: Preoperative visualization of Calot's triangle on USG & MRI

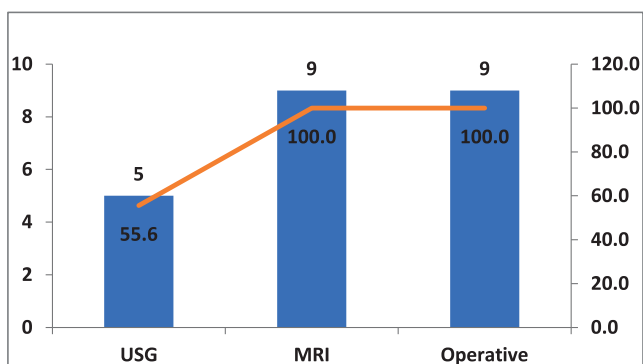


Figure 3: Distribution of Biliary Tract Anomaly cases on USG & MRI

Table 1: Management of patient based on Calot's Triangle Visualization on USG

Calot's Triangle on USG	Seen	Not Seen	Total
Laparoscopic Cholecystectomy	58.54%	41.46%	100.00%
Open Cholecystectomy	14.29%	85.71%	100.00%

Table 2: Management of patient based on Calot's Triangle Visualization on MRI

Calot's Triangle on MRI	Seen	Not Seen	Total
Laparoscopic Cholecystectomy	75.61%	24.39%	100.00%
Open Cholecystectomy	21.43%	78.57%	100.00%

Triple confluence was managed by open cholecystectomy in 60% cases. Triple confluence (2 of 5 cases), long and short cystic duct were detected on USG. Two out of the 5 patients whose biliary tract anomalies were not detected on USG but were noted on MRI were converted to OC.

Combined USG and MRI correlation with Operative Findings (Table 3)

USG and MRI findings in combination correlated well with operative findings across all pathologies in at least 85% of cases with maximum agreement in biliary tract anatomy. Latter may be primarily because biliary tract anatomy was normal in 83.6% (n=46) of our cases.

Test Predictors (Table 4, 5)

In our study, USG revealed a sensitivity, specificity & accuracy of 70.4%, 82.1% & 76.4% respectively in preoperative prediction of pericholecystic adhesions while for detecting biliary tract anomalies, it revealed a sensitivity, specificity, and accuracy of 55.6%, 97.8% and 89.1% respectively.

On the other hand, MRI revealed a sensitivity, specificity & accuracy of 96%, 100% and 98.2% respectively in the preoperative detection of pericholecystic adhesions while for detecting biliary tract anomalies, it revealed a sensitivity, specificity, and accuracy of 100%.

Table 4 :Test predictors for USG

USG	Adhesions	Biliary Tract Anomalies
Sensitivity	70.4	55.6
Specificity	82.1	97.8
Positive Predictive Value	79.2	83.3
Negative Predictive Value	74.2	91.8
Accuracy	76.4	89.1

Table 5: Test predictors for MRI

MRI	Adhesions
Sensitivity	96
Specificity	100
Positive Predictive Value	100
Negative Predictive Value	97
Accuracy	98.18%

Table 3: Correlation between Imaging and Operative Findings

	Adhesions	Calot's Anatomy	Biliary Tract Anomaly	Total
Corresponded	43(78.2%)	46(83.6%)	50(90%)	139(84.2%)
Did not correspond	12(21.8%)	09(16.4%)	05(10%)	26(15.8%)
Grand Total	55(100%)	55(100%)	55(100%)	165(100%)

Conversion to Open Surgery

Fourteen out of 55 patients i.e. 25.4% were managed by OC against 41 who were managed by LC. The most important reason for OC was non-visualization of Calot's triangle noted in 52.3% of patients. However, since the prevalence of adhesions was quite high (49%, 27 of 55), pericholecystic adhesions were seen in 13 patients managed by OC. Patients with fine or minimal adhesions were predominantly managed via laparoscopic surgery, while those who converted to open surgery principally had moderate to severe adhesions.

Discussion

Laparoscopic cholecystectomy (LC) is considered as gold standard management of symptomatic gallstones throughout the world. It offers the benefits of a shorter duration of hospitalization, reduced pain, cosmetically smaller scar, reduced morbidity as well as shorter duration of anesthesia. However, LC is not preferred in complicated cases as technically it is more demanding than classical OC. If an aberrant anatomy or obstructive pathology is present, LC becomes difficult due to restricted motion of the instruments with increased incidence of damage to the biliary tree and surrounding solid/hollow viscera. This makes an optimal preoperative imaging quite imperative. Imaging findings assists the surgeon in assessing the risk factors that are likely to alter the mode of management

In our study, we evaluated three risk factors responsible not only for complications during LC but also dictate conversion from LC to OC viz. pericholecystic adhesions, non-visualization of Calot's Triangle and anatomical variations in the biliary tract. Visualization of Calot's triangle is important for laparoscopy because its first step involves clipping of the cystic duct and artery. GB is subsequently removed after separating it from the hepatic bed. We evaluated patients with GBSD by both USG as well as MRI and compared their sensitivity, specificity, and accuracy.

In our study, nearly one-quarter (25.4%) patients were managed by open surgery. This is similar to studies done by other Indian authors Nidoni et al (24.4%) & Chand et al (24.4%) [6,7]. However, in a study done by Sharma et al, open cholecystectomy was done in up to 45% of patients [8]. Western studies however, had much lower reported rates of OC as 6.7% by Dinkel et al, 5.2% by Bingener et al, 7.5% by Ishizaki et al and 3.16% by Genc et al [9-12].

The leading causes for OC in our study was presence of pericholecystic adhesions and non-visualization of Calot's triangle. This was similar to previous studies done by Genc et al, Sharma et al, and Gupta et al where pericholecystic adhesions led to open cholecystectomy [8,12,13]. Non-visualization of the Calot's triangle was the most important

reason for OC in studies performed by Bingener et al, Nachnani et al, Gupta et al, Chand et al, Pavlidis et al [7,10,13-15].

Prediction using Imaging Parameters

In our study, presence of pericholecystic adhesions combined with non-visualization of Calot's anatomy was the leading cause for management by OC. Thirteen out of 14 patients managed by OC had pericholecystic adhesions while Calot's triangle was not visualized in 11 patients. Only 52.3% (n=11) whose Calot's triangle was not visualized on MRI were managed by OC. These findings in combination predicted management by OC in 78.6% of the cases (11/14). In 2 of the remaining 3 cases, adhesions were too dense to manage patients via laparoscopic surgery. OC was resorted to in remaining one patient due to excessive bleeding during surgery who also revealed a long cystic duct on USG. In summary, USG was able to predict the need for OC in 92.8% (13/14) patients. Similar results have been reported by Nidoni et al (96%) & Gupta et al (90%) [6,13]. Garg et al predicted OC in 71% cases using presence of pericholecystic adhesions as a sole criterion [16]. Several authors have used a combination of parameters on USG to predict open cholecystectomy as 97% by Katwala et al and 72% by Shamim et al [17,18].

Conclusions

- Gallbladder stone disease is commoner in females.
- Usual age range of GBSD is 20-60 years, with maximum prevalence between 40-50 years.
- Majority patients with GBSD can be managed by laparoscopic cholecystectomy with only one-quarter requiring open cholecystectomy.
- MRI is slightly superior to USG in predicting pericholecystic adhesions in GBSD.
- MRI is more accurate than USG for visualization of Calot's triangle, an important predictor for open cholecystectomy.
- Biliary tract anomalies are seen in 1/5th to 1/6th patients of GBSD with triple confluence being the most common and cystic duct anomalies, the least common.
- MRI is 100% accurate in detecting biliary tract anomalies in GBSD, against 50-60% accuracy of USG.
- MRI has an accuracy of more than 95% in predicting difficult laparoscopic cholecystectomy in GBSD against 70-80% accuracy of USG.

Summary

Magnetic Resonance Imaging is a gold standard imaging technique for predicting difficult laparoscopic

cholecystectomy in gall bladder stone disease patients using multiple factors like pericholecystic adhesions, visualization of Calot's triangle and biliary tract anomalies. *Ultrasonography* can also be used as quick, noninvasive, inexpensive, and ready-available imaging tool for similar assessment with fair degree of accuracy.

Conflict of interest:	All authors declare no COI
Ethics:	There is no ethical violation as it is based on voluntary anonymous interviews
Funding:	No external funding
Guarantor:	Dr. Rajul Rastogi will act as guarantor of this article on behalf of all co-authors.

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