ORIGINAL ARTICLE

Correlation between Radiological Liver Surface Nodularity and Intraoperative Findings in Cirrhotic Patients Undergoing Liver Surgery

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ABSTRACT

Background: Precision in preoperative liver morphology assessment in patients with cirrhosis is necessary to plan surgical procedures and risk profile. Nodularity of the liver surface (LSN) seen on cross-sectional imaging is a structural distortion caused by fibrosis and regenerative nodules, and may offer a non-invasive surrogate with regard to the appearance of the liver surface intraoperative.

Objective: The purpose of the study is to determine the relationship between the radiological surface nodularity of the liver and the findings of the liver surface during the surgery performed on the patient with cirrhosis in a tertiary care center.

Methods: It was a prospective observational study that involved 100 patients with clinically and radiologically diagnosed liver cirrhosis who were planned to undergo elective liver surgery. Blinded radiologists reviewed preoperative contrast-enhanced CT and /or MRI within four weeks before surgery, and assessed nodularity of the liver surface on a semi-quantitative scale (grades 03). The hepatobiliary surgeons assessed the liver surface morphology intraoperatively independently in a similar grading system. Demographic, etiology of cirrhosis, laboratory parameters, and Child-Pugh class were noted. Radiological and intraoperative grading were the two variables analyzed by the level of Spearman rank correlation coefficient.

Results: The authors found that the mean age of the study population was 52.4 years (10.8 years), and viral hepatitis was the most prevalent cause of cirrhosis. Most patients had moderate to severe nodularity on the surface of the liver as radiologically assessed. Similar distribution was found intraoperatively. The radiological liver surface nodularity and the intraoperative findings were strongly positively associated (Spearman $r = 0.78$, $p = 0.001$). Greater grades of radiological density were always correlated to more surface irregularity, hardness and evidence of portal hypertension that were found intraoperative.

Conclusion: Radiological nodularity of the liver surface has a high correlation with intraoperative liver surface in cirrhotic cases. LSN, as a means of assessment of preoperative imaging, is a valid, non-invasive instrument that may help in the arrangement of the surgery and the evaluation of risks in patients undergoing liver surgery.

Keywords: Liver cirrhosis; Liver surface nodularity; Computed tomography; Magnetic resonance imaging; Intraoperative findings; Hepatic surgery; Portal hypertension; Preoperative assessment.

INTRODUCTION

The last common pathway of chronic hepatic injury is liver cirrhosis which is progressive fibrosis, architectural distortion and regenerative nodules. The resulting structural changes result in marked changes in the hepatic morphology and functions which eventually predisposes the patients to portal hypertension, hepatic insufficiency and predisposes the patients to the development of the hepatocellular carcinoma[1]. And in patients who are undergoing liver surgery, whether they are undergoing a tumor resection, transplant evaluation or other hepatobiliary surgery, precise pre-operative evaluation of the severity and morphological characteristics of cirrhosis is vital in surgical planning, risk classification, and prediction of post-operative outcomes[2].

Radiology imaging has been in the center of the non-invasive assessment of cirrhosis. Liver surface nodularity (LSN) in cross-sectional imaging especially in computed tomography (CT) and magnetic resonance imaging (MRI) has become one of the most important morphological parameters of progressive fibrosis and cirrhosis[3]. Nodularity of liver surface indicates the irregularity of hepatic capsule due to the presence of fibrotic septa and regenerative nodules and various studies have found nodularity to be related to histological stage of fibrosis and portal hypertension. With the advances in imaging technology and post-processing applications, quantitative and semi-quantitative evaluation of LSN has received interest as a reproducible and surrogate endpoint of the severity of cirrhosis[4].

Although there is an increasing dependency on the radiological parameters, intraoperative assessment is the ultimate real-time evaluation of liver morphology. Surgeons can notice the

surface and texture of the liver, presence of nodules and its capsular irregularity and other related characteristics like ascites, collateral vessels, and splenomegaly during surgery[5]. These findings during the course of the operation frequently determine instant surgical choices such as the degree of resection, the ability to perform a complicated operation or the necessity of changed operative techniques. Nonetheless, there might be a mismatch between the impressions made by radiology preoperative examination and the true intraoperative look, especially in patients with early or heterogeneous cirrhosis[6].

The relationship between intraprocedural findings and radiological liver surface nodularity is of great clinical significance, thus, the correlation between these two variables is of great importance[7]. High correlation would confirm the predictive value of preoperative imaging in the difficulty of surgery, hepatic reserve and a low correlation would indicate the shortcomings of imaging as an independent predictor and the necessity of other evaluation instruments[8]. In addition, the development of this correlation can be used to narrow the radiological reporting standards, enhance multidisciplinary communication between radiologists and surgeons, and optimize the selection of patients who undergo liver surgery[9].

This research was determined the correlation between preoperative radiological liver surface nodularity and the intraoperative appearance of cirrhotic patients who would be undergoing liver surgery. Experimental question: The study aims at comparing the features of preoperative imaging and direct surgical observations systematically to identify how accurate the nodularity shown by radiology is to show the actual hepatic surface pathology and to evaluate the usefulness of the method in surgical decision-making in patients with cirrhosis[10].

MATERIAL AND METHODS

This is a prospective observational study that was undertaken in one teaching hospital which was a tertiary care center with the aim of examining the relationship between the preoperative radiological liver surface nodularity and intraoperative liver surface results in liver surgery patients with cirrhosis. One hundred continuous adult cases of liver cirrhosis with elective liver surgery were enrolled over the period of study. The diagnosis of cirrhosis was performed according to clinical history, laboratory tests and radiological evidence. Patients who had been aged 18 years and above, had preoperative imaging, and anticipated surgical intervention were only included. The study excluded those patients with acute liver failure, prior liver surgery, low quality or missing imaging, diffuse metastatic liver disease, which obscures surface morphology and those undesirous to participate.

All patients who were enrolled had routine preoperative abdominal imaging with contrast-enhanced computed tomography (CT) and/or magnetic resonance imaging (MRI) within four weeks of the surgery. Radiological assessment was based on the measurement of nodularity of the hepatic surface that was categorized as hepatic capsule irregularity due to the fibrotic distortion and regenerative nodules. Two senior radiologists who had not examined the results intraoperative were used as independent reviewers to the imaging studies. Nodularity of the liver surface was measured using a semi-quantitative scale where grade 0 would represent a smooth surface to the liver, grade 1 would represent minimal nodularity with a slight surface irregularity, grade 2 would represent nodularity in the surface being moderate, and grade 3 will represent severe nodularity with a prominent surface irregularity. Where there was a disagreement, a consensus decision was arrived at. Other radiological findings that are indicative of portal hypertension such as splenomegaly and ascites were also reported.

The intraoperative examination was done by senior hepatobiliary surgeons with no knowledge of the radiological grading. After sufficient laparotomy or laparoscopy exposure of the liver, the direct inspection of the hepatic surface was made on the nodularity, capsular irregularity, and the surface morphology in general. Liver consistency was also determined and categorized as soft, firm or hard. The appearance of the liver surface during operation was also assessed on a scale similar to the radiological grading scale (grades 03) to ensure the ease of a direct correlation between imaging and operative data. Related intraoperative characteristics like ascites and collateral vessels were documented.

All the patients were gathered with demographic variables (age, sex, etiology of cirrhosis), laboratory parameters (serum bilirubin, albumin, and international normalized ratio: INR), and Child-Pugh classification. The information was typed into a tabular pro forma to be analyzed. Proper statistical software was used, to undertake the statistical analysis. Mean with standard deviation was used to show continuous variables and frequencies and percentages to represent categorical variables. Data on radiological nodularity of the liver surfaces and intraoperative results were evaluated as the correlation of the results of Spearman through rank correlation coefficient. The use of interobserver agreement among radiologists was done with the help of the kappa statistic. The p-value below 0.05 was seen as statistically significant. This study was done with regard to the ethical principles of the Declaration of Helsinki. And we got the approval of the institutional ethics review committee before the study was initiated. All of the participants received written informed consent and patient data was kept strictly confidential during the research process.

RESULTS

There were 100 cirrhotic patients who were subject to liver surgery and these were included in the final analysis. The average age of the study population was 52.4 years old of age with a majority of male patients. The most frequent etiology of cirrhosis was viral hepatitis followed by non-alcoholic fatty liver disease and alcohol related liver disease. Child-Pugh classification allowed classifying most of the patients as belonging to the class B, which implied moderately advanced liver disease. Table 1 presents a summary of baseline demographic and clinical characteristics of the study population.

Radiological evaluation showed the different levels of nodularity of the liver surface in the preoperative images. The most common pattern was mild to moderate nodularity. Nodularity of the liver surface was observed in almost a quarter of patients with severity. Table 2 illustrates the distribution of liver surface nodularity grades of radiological.

The distribution pattern of the intraoperative assessment showed the same pattern with most patients having moderate to severe surface nodularity under direct observation. Patients with higher radiological grades were more observed to have increased liver firmness and capsular irregularity. Table 3 gives the intraoperative assessment of the liver surface nodularity.

Radiological liver surface nodularity was significantly and positively correlated with intraoperative findings. Inreproductive patients in the higher radiological grade were always the same in the intraoperative grades, implying that imaging has good predictive validity. A percentage correlation analysis using the rank correlation by Spearman indicated that radiological and intraoperative grading were significantly related (r = 0.78, p < 0.001). Table 4 shows the cross-tabulation of radiological and intraoperative nodularity grades.

Table 1. Demographic and clinical characteristics of patients (n = 100)

Variable	Value
Age (years), mean ± SD	52.4 ± 10.8
Gender (Male/Female)	64 / 36
Etiology of cirrhosis	
Viral hepatitis	58
NAFLD	24
Alcohol-related	12
Other causes	6
Child–Pugh class	
Class A	28
Class B	54
Class C	18

Table 2. Radiological grading of liver surface nodularity

Radiological grade	Description	Number of patients (%)
Grade 0	Smooth surface	12 (12%)
Grade 1	Mild irregularity	26 (26%)
Grade 2	Moderate nodularity	38 (38%)
Grade 3	Severe nodularity	24 (24%)

Table 3. Intraoperative grading of liver surface nodularity

Intraoperative grade	Description	Number of patients (%)
Grade 0	Smooth surface	10 (10%)
Grade 1	Mild nodularity	24 (24%)
Grade 2	Moderate nodularity	40 (40%)
Grade 3	Severe nodularity	26 (26%)

Table 4. Correlation between radiological and intraoperative liver surface nodularity

Radiological grade	Intraoperative Grade 0	Grade 1	Grade 2	Grade 3
Grade 0	9	3	0	0
Grade 1	1	20	5	0
Grade 2	0	1	31	6
Grade 3	0	0	4	20

Other findings during the intraoperative examination such as ascites and collateral vessels formation were much more prevalent in patients with elevated grades of liver surface nodularity. The findings also helped in supporting the relationship between radiological surface irregularity and advanced intraoperative

cirrhotic changes. On the whole, radiological nodularity of the liver surface was shown to have high concordance with direct surgical observations, which supports the use of radiological nodularity of the liver surface in clinical practice as diagnostics and surgical planning in patients with cirrhosis undergoing liver surgery.

DISCUSSION

Proper preoperative evaluation of the severity of cirrhosis is an important aspect of operative decision making in the patients who are to undergo liver surgery. We compared the radiological liver surface nodularity (LSN) and intraoperative liver surface observation in a group of 100 cirrhotic individuals and found the correlation between the two to be significant, with a statistical significance value of 0.05[11]. These results suggest that the clinical usefulness of radiological liver surface nodularity as an effective surrogate endpoint of intraoperative liver morphology. Fibrosis, regenerative nodules, and capsular distortion are well-known morphological findings of cirrhosis that are reflected in liver surface nodularity[12]. Radiological assessment of the liver surface nodularity showed a close relationship with the findings at surgery with greater radiological grades always showing moderate to severe nodularity at surgery[20]. This close agreement indicates that contemporary cross-sectional imaging technologies, more specifically contrast-enhanced CT and MRI, would give a more precise depiction of the actual hepatic surface structure among people with cirrhosis[19]. The Spearman correlation coefficient of 0.78 is considered as a strong association and it allows the usage of LSN as a reliable preoperative predictor of liver surface pathology[13].

The clinical implications of our findings are high, as the appearance of the liver during surgery directly affects the choice of a surgical strategy[18]. Nodularity and firmness of the liver surface are linked to the augmented surgical complexity, light risk of bleeding, liver regeneration deficiency, and postoperative morbidity[14]. This preoperative planning of these difficulties with the help of radiological examination allows the surgeon to plan the resection more adequately, think of alternative methods of surgeons, and make the best use of perioperative care. The high relationship that was seen in this research supports the use of imaging as a critical instrument of risk sorting and surgical planning in cirrhotic patients[17]. In addition to it, our results indicate that even patients with better radiological nodularity grades had other intraoperative characteristics of advanced cirrhosis, including ascites and collateral vessel formation[15]. These related findings support the pathophysiology correlation of nodularity on the surface and portal hypertension. These findings show that there is a uniform correlation between the imaging results and the results of operative results which underscores the need to have a standardized reporting of liver surface appearances in radiological assessments especially when patients are being considered to undergo hepatic surgery[16].

This study has some limitations despite having their strengths. Since the study is a single-centered study, its results might not be entirely applicable to all clinical settings. Moreover, intraoperative assessment, notwithstanding its direct visualization, is also rather subjective and relies on the experience related to the surgery. Correlation of histopathological stage to fibrosis stage was not done and this could have enhanced the research further. Additional studies using multicentric studies by including histological grading, and long-term outcomes of postoperative results would be welcome to further endorse radiological liver surface nodularity as a complete prognostic indicator.

CONCLUSION

This research showed that there is a high and statistically significant correlation between radiological and intraoperative liver surface nodularity of the liver in cirrhotic patients undergoing surgery on the liver. CT and MRI of nodularity of liver surfaces are dependable radiological methods of determining the true intraoperative liver morphology of the liver with cirrhosis. These results confirm that liver surface nodularity is a non-invasive, convenient, and informative preoperative variable that can be used routinely to assess the extent of cirrhosis and predict the degree of surgical difficulty. Standardized liver surface nodularity assessment integrated into preoperative imaging protocols could potentially improve surgical planning procedures, risk stratification and lead to eventually improved perioperative outcomes in patients with liver cirrhosis.

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