Correlation between Computed Tomography and Ultrasonography Findings in Patients with Fatty Liver

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ABSTRACT

Background

Fatty liver disease, linked to obesity, alcohol consumption, and insulin resistance, is characterized by pathological fat deposition exceeding 5%. Its rising global prevalence, particularly in Southeast Asia, highlights the need for effective diagnostic modalities.

Objective

To find the correlation between computed tomography and ultrasonography findings in patients with fatty liver.

Method

A prospective cross-sectional study was conducted on 211 patients from December 2016 to October 2017. Patients referred for computed tomography chest and abdomen were included, excluding those with diffuse or focal liver disease other than fatty liver. Computed tomography attenuation values were measured using non-contrast sequences, with participants showing mean hepatic attenuation less than +48 Hounsfield units subjected to further ultrasound and shear wave elastography examinations. Data were analyzed using Microsoft Excel and SPSS, with associations examined through Pearson correlation, ANOVA and Shapiro-Wilk test.

Result

The study included 100 males and 111 females, aged 21 to 65 years. The mean computed tomography attenuation was +40.31 Hounsfield units. A moderately strong negative correlation was found between Computed Tomography attenuation and ultrasound grades of fatty liver (Spearman's coefficient = -0.775, $p = 0.005$). No significant correlation was observed between computed tomography attenuation and shear wave elastography values, nor between patient age and hepatic attenuation.

Conclusion

This study demonstrates a significant correlation between computed tomography attenuation and ultrasound grades of fatty liver, highlighting their complementary roles in diagnosing fatty liver disease. However, no significant correlation was found between computed tomography attenuation and shear wave elastography values.

KEY WORDS

Attenuation, Computed tomography, Elastography, Fatty liver, Ultrasound

INTRODUCTION

Fatty liver, commonly associated with obesity, alcohol consumption, and insulin resistance, is characterized by macroscopic fat deposition exceeding 5%, which is considered pathological.[1,2] Monitoring fatty liver is essential due to its prevalence and potential health impacts.[1] The global prevalence of fatty liver disease is on the rise, driven by varying rates of obesity, genetic predispositions, and socioeconomic factors.[3] Notably, higher prevalence rates are observed in Southeast Asian countries such as India and Nepal.[4,5]

Ultrasonography (USG) is a readily available method for detecting fatty liver, identifiable by increased liver echogenicity.[6] In computed tomography (CT), it has increased fat content resulting in decreased liver attenuation.[7] Magnetic resonance imaging (MRI) with in-phase and out-phase imaging is likely the best method for detecting small amounts of fat infiltration, though it is costly.[8] Ultrasound elastography, used to measure tissue elasticity, shows inconsistent results regarding the effect of steatosis on liver stiffness, with some studies indicating no correlation and others reporting an effect on fibrosis measurement.[9]

Histopathology is the gold standard for diagnosing fatty liver; however, it is semi-quantitative, and liver biopsy carries significant morbidity risks.[10]

Understanding the correlation between different diagnostic methods is beneficial. There is a scarcity of literature examining the relationships between US, CT, and elastography findings in the liver. Therefore, conducting a study to correlate these modalities is important for enhancing diagnostic accuracy and clinical management.

METHODS

This study was a prospective cross-sectional study conducted on 211 patients in the Department of Radiology and Imaging of Tribhuvan University Teaching Hospital (TUTH) between December 2016 to October 2017. The study was conducted on 211 patients referred to the radiology department for CT chest and abdomen. Ethical clearance for the study was obtained from the Institutional Review Board, [Ref. No. 212 (6-11-E) 073/074], and informed written consent was obtained from all participating patients after explaining the study. Out of the selected 225 patients, individuals presenting with diffuse or focal liver disease (except fatty liver) and non-ambulatory patients were excluded, resulting in a final sample size of 211. Inclusion criteria for this study include the patients undergoing CT of the abdomen including both sexes, more than 18 years of age, and CT attenuation of the liver less than HU+48.

The CT examinations were conducted using the standard protocol in Multidetector Computed Tomography (Somatom Definition AS, Siemens). CT attenuation values of the liver were measured in non-contrast sequences with a one-square-centimeter region of interest (ROI) circle placed in a vessel-free zone (Fig. 1). Attenuation values were obtained from both the right and left lobes of the liver, and the mean attenuation was calculated. Participants with a mean hepatic attenuation of less than +48 HU were subsequently subjected to an ultrasound (US) study.

A total of 211 participants underwent B-mode US and elastography. Liver echogenicity was compared to that of the kidneys and spleen, and the visibility of the intrahepatic vessel walls and diaphragmatic outlines was noted (Fig. 2). Increased liver echogenicity with diaphragm obscuration indicated Grade III (severe) fatty liver. If the diaphragm was visible but the hepatic and portal veins were not echogenic, it was classified as Grade II (moderate) fatty liver. Vertically oriented hepatic and portal vein walls were specifically assessed for echogenicity to avoid false increase in echogenicity when veins are horizontally oriented. Grade I (mild) fatty liver was diagnosed when liver echogenicity exceeded that of the kidneys but the hepatic and portal veins were normally visualized.

US real-time shear wave elastography (SWE) was performed using a Phillips-iU-22 USG unit with a curvilinear 1-5 MHz probe by a single examiner. The right lobe of the liver was examined intercostally with the patient in a supine position and the right arm maximally abducted. The left lobe was examined in a supine position. The right hepatic lobe measurements were preferred to prevent inadvertent liver tissue compression by the probe.

After identifying target areas with an appropriate sonic window and uniform gray-scale imaging, shear wave imaging sequences were applied to measure liver elasticity. Scanning was conducted with minimal pressure, and patients were asked to hold their breath momentarily to reduce motion artifacts. The SWE box was set to an area of 1 cm x 0.5 cm, positioned in vessel-free liver parenchyma at least 1 cm below the liver capsule to avoid erroneous measurements. Three consecutive liver elasticity measurements were obtained for each subject, using similar scanning views for each lobe, with each measurement performed during a separate breath hold.

The data were recorded in Microsoft Excel (2016), and analysis was done with Microsoft Excel as well as SPSS (Version 22). The mean and standard deviation (SD) were calculated for continuous variables. Categorical variables were reported using frequencies and proportions. The "Shapiro-Wilk Test" was applied for normality of distribution. One way ANOVA test used to find any difference in mean CT attenuation values in various grade of fatty liver.

The association between variables was examined using an independent sample t-test and chi-square test. Multivariate regression analysis was also performed to measure the association among variables.

The study involved patients and the public in the research objectives, design, and outcome measures. They facilitated recruitment, provided feedback, and participated in meetings, dissemination, and knowledge translation activities

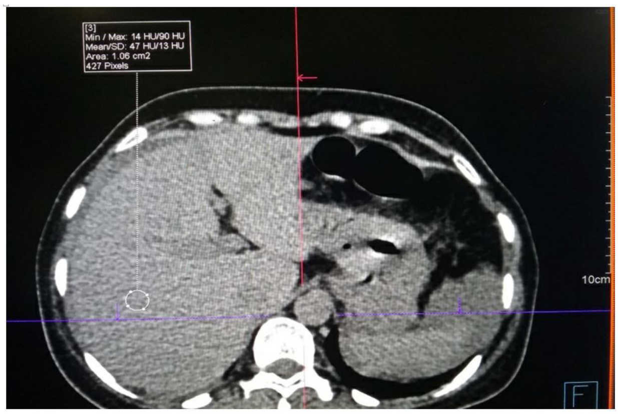

Figure 1. Measurement of attenuation of the right lobe of the liver

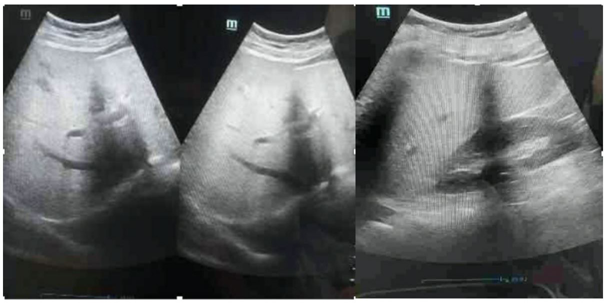

Figure 2. Greyscale ultrasound images showing increased echogenicity of the liver parenchyma.

RESULTS

A total of 211 patients were enrolled in the study. The age of the participants ranged from 21 years to 65 years with mean age of 46.5 years and median age of 48 years. Among 211 patients, 100 (47.4%) were male and 111 (52.6%) were female.

The mean and median CT attenuation of the liver were +40.31HU and +42.00HU respectively. In patients with mean CT attenuation of +48HU or less, 30 had normal echogenicity of the liver in the US, while 113 had Grade I, 58 had Grade II, and 10 had Grade III fatty liver. Of 211 patients, who underwent shear wave elastography US, the mean elastography value of the liver was 4.708 kPa. The mean CT attenuation values of Grade 0, Grade I, Grade II, and Grade III fatty liver were +45.8 HU, +42.79 HU, +35.90 HU, and +23.90 HU respectively (Fig. 3) and there was a moderately strong negative correlation between mean CT attenuation and US grade of liver with Spearman's correlation coefficient of -0. 775. (p-value =0.005) (Fig. 4).

There was no significant correlation between CT attenuation of the liver and elastography/SWE values of the liver. The Pearson's correlation coefficient between the mean attenuation of liver and SWE values was 0.126 (Significance: 0.069). The mean SWE values of the liver for Grade 0, Grade I, Grade II, and Grade III fatty liver were 4.758 kP, 4.760 kP, 4.648 kP, and 4.317 kPa respectively. There was no significant correlation between US grades of fatty liver and SWE values with Spearman's correlation coefficient (Rho) of -0.073 (P= 0.292) (Fig. 5).

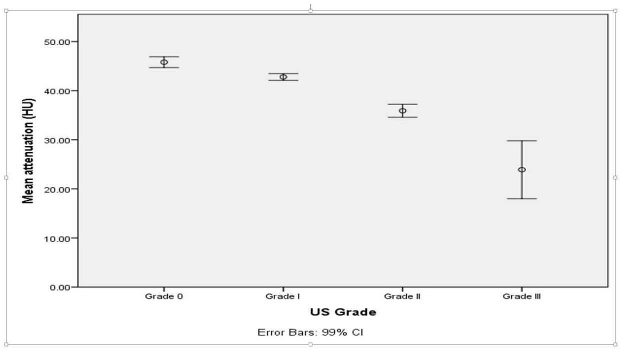

Figure 3. Scatter plot diagram of CT attenuation of the liver with a 95% confidence interval

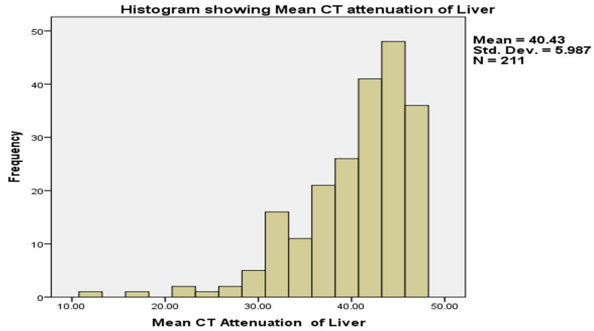

Figure 4. Mean CT attenuation of participants

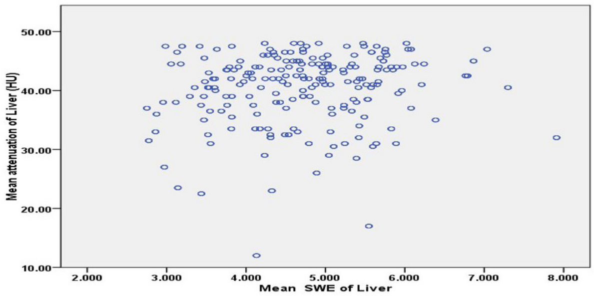

Figure 5. Scatter plot diagram of SWE values of liver and mean CT attenuation

There was no significant correlation between patient age and the mean attenuation of liver parenchyma (correlation coefficient of 0.071, P=0.300) and shear wave elastography (correlation coefficient of 0.072, P=0.296). The Shapiro-Wilk Test showed no significant distribution from normal distribution (P=0.129, df=211). Hence, the mean SWE values of liver was found to be normally distributed. Also significant difference in mean CT attenuation of liver observed among grades of fatty liver (P=0.0001). However, no significant difference (P=0.490) among mean SWE values of different grade of fatty liver in ANOVA.

DISCUSSION

The incidence of fatty liver disease is increasing globally as well as in Southeast Asian countries.[3] Although histopathological examination is the gold standard for diagnosis, it is often declined by patients due to its invasiveness.[11] With the measurement of attenuation value, non-enhanced CT can be reliably used to diagnose fatty liver.[7] Ultrasound has high sensitivity and specificity for diagnosing moderate to severe fatty liver disease.[12] This study aimed to establish the correlation between ultrasound and CT in fatty liver imaging.

In our study, as the grades of fatty liver increase in ultrasound (USG), there is a decrease in the mean attenuation of the liver. A moderately strong negative correlation exists between mean CT attenuation of the liver and USG grades of fatty liver. This finding aligns with other researchers. Shannon et al. found that 90% of patients with USG grade II and III fatty liver exhibited moderate to severe steatosis in histological examination.[13] Kodama et al. suggested that if the liver attenuation on plain CT is +40 HU, the predicted hepatic fat content is approximately 30%. Furthermore, if the liver attenuation is +30 HU, the predicted fat content is about 50%.[14] However, our study indicates an overlap in the mean attenuation values of the liver and the grades of fatty liver in ultrasound, making it difficult to identify a definitive "cut-off" point for grading as Grade 0, I, II, or III.[14]

In this study, the mean shear wave elastography (SWE) values, along with their standard deviations, for grade 0, grade I, grade II, and grade III fatty liver were 4.758 ± 0.941 kPa, 4.760 ± 0.872 kPa, 4.648 ± 1.043 kPa, and 4.317 ± 0.920 kPa, respectively. Although there was a trend of decreasing mean SWE values with increasing grades of fatty liver, no statistically significant differences were observed among the mean SWE values across the various grades. Furthermore, no correlation was identified between SWE values and the grades of fatty liver. Suh et al. found that the mean liver elasticity values for steatotic and non-steatotic livers were 4.4 ± 1.0 and 4.3 ± 0.9 kPa, respectively, with no significant differences.[15] Similarly, Beland et al. reported no correlation between the degree of steatosis and SWE values of the liver.[16] As we know that CT attenuation values are inversely related to degree of steatosis. We can see in our study that there is no correlation between CT attenuation values and SWE values of liver. The Pearson's correlation coefficient was +0.126, however significance level was 0.069 (Significant correlation is seen at significance level below 0.001). Similarly, in a study conducted by Kramer et al. a negative correlation was found between CT attenuation and ultrasound SWE.[17]

In our study, no significant correlation between the age of the patient and hepatic attenuation was seen which aligns with the longitudinal study conducted by Hahn et al. in asymptomatic adults.[18]

There are conflicting data regarding the effect of BMI with liver elasticity. Sporea et al. found that there is decrease in reliability of elastography values in patients with higher BMI.[19] Also Petta et al. found that elastography value were less reliable in patients with BMI >25 kg/m^2.[20] However, these abovementioned study used transient elastography as method of determining elasticity of liver which may not be applicable for SWE. Suh et al. who used SWE method for elasticity measurement, found that there was no relation between BMI of patient and elasticity of liver.[15] Suh et al used SWE as method of determining liver elasticity.[15] However, too much fatty tissue between the skin and liver precludes the use of SWE as elasticity cannot be calculated beyond certain distance.

The present study had several limitations, notably the absence of a gold standard method for diagnosing fatty liver. While biopsy is the most reliable diagnostic tool, it is rarely performed due to its painful nature and associated morbidity and mortality risks. Since CT, US, and elastography measurements were all performed by the same individual, blinding the investigator to the findings was not possible, introducing potential observer bias. Additionally, despite existing guidelines for grading fatty liver, the subjective nature of this assessment may lead to inter-observer variability.

There is significant correlation between US grade of fatty liver and hepatic steatosis. Hence our study was in congruence with most of the published study. However, data regarding relation between CT attenuation value and US grade as well as liver elasticity values are lacking.

CONCLUSION

Our study demonstrates a moderately strong negative correlation between CT attenuation and USG grades of fatty liver, while no significant correlation was found between CT attenuation and SWE values. These findings highlight the complementary roles of CT and USG in diagnosing fatty liver disease.

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