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Original Article

Radiology Section

Correlation of Liver Attenuation with Visceral Fat Area on Computed Tomography Scan: An Analytical Study

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ABSTRACT

Introduction: In the modern world, owing to rapid urbanisation and changes in lifestyles and dietary habits, obesity has emerged as a leading problem. As a result, various morbid conditions have come into the picture which have severe effects on an individual's life expectancy. Visceral fat plays an important role in causing fatty liver.

Aim: To determine the relationship between visceral fat area and liver fat using Computed Tomography (CT).

Materials and Methods: A retrospective analytical study was conducted at Dr. D. Y. Patil Medical College, Hospital, and Research Centre Pune, Maharashtra, India. The CT scans of 134 patients who underwent CT scans of the abdomen pelvis and CT KUB/CT IVU between January 2022 and June 2022 were assessed by two experienced body imaging medical doctors. Subjects aged between 18 and 75 years were included without any co-morbidities like diabetes or hypertension. Waist circumference, subcutaneous fat area, and visceral fat area were calculated at the umbilical level. The CT attenuation value was measured in the right hepatic lobe, devoid of focal lesions and vessels, using a standard ROI of approximately 200 mm^2. Similarly, as an internal control, splenic attenuation was also recorded. Statistical tests were employed to determine the significance of the obtained values, including Spearman's coefficient and Cohen's criteria.

Results: The CT attenuation of the liver (fatty liver) showed a moderate correlation with visceral fat (Spearman's coefficient: 0.329). The association was statistically significant (p-value=0.0001). The CT attenuation of the liver (fatty liver) showed a weak correlation with subcutaneous fat (Spearman's coefficient: -0.269). The association was statistically significant (p-value=0.0016). The CT attenuation of the liver (fatty liver) demonstrated a weak-moderate correlation with waist circumference (Spearman's coefficient: -0.305). The association was statistically significant (p-value=0.0003).

Conclusion: Visceral fat area has a stronger correlation with fatty liver than waist circumference and subcutaneous fat. Visceral fat should be considered a risk factor in the development of fatty liver, which may further lead to metabolic syndrome, in order to reduce mortality and morbidity related to it.

Keywords: Hepatic steatosis, Spearman's correlation, Visceral fat quantification

INTRODUCTION

Obesity is escalating in developing countries due to urbanisation and sedentary lifestyles, despite lingering undernutrition [1]. This shift leads to increased risks of dyslipidemia, type II diabetes, and cardiovascular diseases [1,2]. Visceral fat, exceeding 100 cm, heightens the risk of metabolic syndrome and fatty liver [2-4]. Elevated portal free fatty acids, correlated with visceral fat, exacerbate hepatic gluconeogenesis and insulin levels. Obesity, coupled with these fatty acids, impedes insulin function [5]. Visceral fat adipocytes release triglycerides, leptin, and Tumor Necrosis Factor (TNF) α, contributing to metabolic syndrome. Fatty liver, a prevalent liver disease, can precede hepatocellular carcinoma [6]. Considering visceral fat in the etiopathogenesis of fatty liver and metabolic syndrome is of utmost importance and in the present scenario with the advent of non-invasive methods like CT, the authors can effectively quantify visceral fat and predict and diagnose the progression and presence of fatty liver, respectively. With this background, the present study was conducted with the aim to determine the relationship between the visceral fat area and liver fat using CT and compare them with subcutaneous fat and waist circumference.

MATERIALS AND METHODS

A retrospective analytical study was conducted at Dr. D. Y. Patil Medical College, Hospital, and Research Centre, Pune, Maharashtra, India. CT scans of 134 patients who underwent CT scans of the abdomen pelvis and CT KUB/CT IVU for pathologies not involving the liver between January 2022 and June 2022 were assessed. Liver attenuation and visceral fat on CT scans were assessed by two experienced body imaging medical doctors.

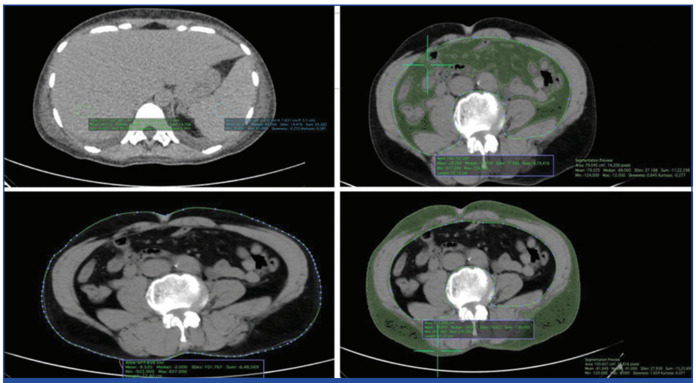
Inclusion criteria: Subjects between the ages of 18 to 75 years without any co-morbidities like diabetes or hypertension were included.

Exclusion criteria: Subjects with liver diseases were excluded from this study.

Waist circumference, subcutaneous fat area, and visceral fat area were calculated at the umbilical level. Total visceral volume is highly correlated to visceral fat calculated at the umbilicus according to several studies [3,7-9]. Liver attenuation was measured in the right hepatic lobe, devoid of focal lesions and vessels, with a standard ROI of approximately 200 mm^2. Similarly, as an internal control, splenic attenuation was also recorded [Table/Fig-1-4] [10,11]. A CT attenuation value of the liver less than 40 HU and a difference of >5 HU between the attenuation values of the liver and spleen were considered to diagnose fatty liver [12].

STATISTICAL ANALYSIS

The data were entered in Microsoft Excel 2019 and analysed using MedCalc v18.2.1 (MedCalc Statistical Software version 18.2.1, MedCalc Software, Ostend, Belgium; http://www.medcalc.org; 2018). Categorical variables were expressed in terms of frequency and percentages (where applicable), and continuous variables were expressed as mean and Standard Deviation (SD); median, and Interquartile Range (IQR) where applicable. Normal distribution was verified by the Shapiro-Francia test. Spearman's correlation was performed between liver attenuation and the study parameters.



[Table/Fig-1]: Computed Tomography images showing- Measurement of liver attenuation and spleen attenuation of a 59-year-old patient without any liver disease. **[Table/Fig-2]:** Measurement of the visceral fat area of the same patient. **[Table/Fig-3]:** Measurement of waist circumference of the same patient. **[Table/Fig-4]:** Measurement of the subcutaneous fat area of the same patient. (Images from left to right)

A p-value <0.05 was considered statistically significant. Cohen's criteria were used to determine the effect size (strength of the relationship) [13].

RESULTS

A retrospective review of CT scans of 134 patients was done. The mean age of the study participants was 40.38 (15.72) years. The median age and IQR were 36 years and 29-52, respectively. Total Males were 72 (53.73%) and 62 females (46.27%).

There was a statistically significant difference between visceral fat, subcutaneous fat, waist circumference between fatty and non-fatty liver respectively [Table/Fig-5].

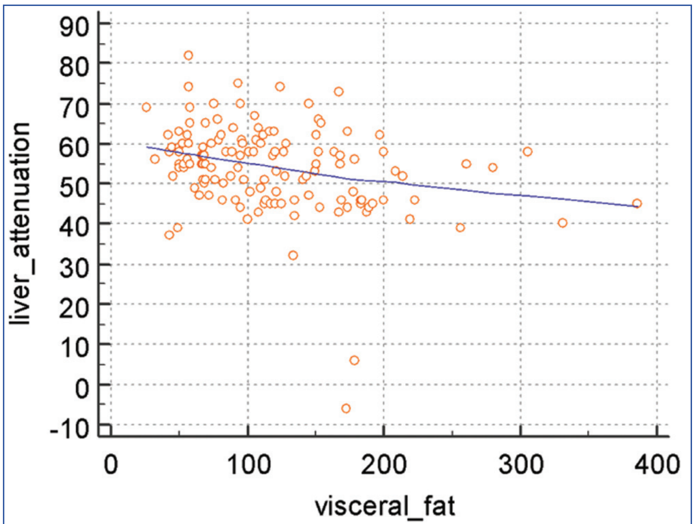
Parameter	Category	Mean	SD	Median	IQR	Min	Max	Significance
VF	Fatty liver (49)	137.8306	73.0894	122	86.5-180	43	386	U=1534.50, Z=2.620, **p=0.0088**
	Non-fatty liver (85)	106.5581	53.5473	95	67-145	26	280	
SCF	Fatty liver (49)	216.4898	112.5263	196	135.25-278.75	40	506	U=1600.50, Z=2.318, **p=0.0205**
	Non-fatty liver (85)	170.4360	92.8652	151.50	100-235	25.5	501	
Waist C	Fatty liver (49)	88.6531	16.0137	87	78-97	57	140	t=-3.515, df=133, **p=0.0006**
	Non-fatty liver (85)	80.1977	11.7411	80	73-88	50	105	

[Table/Fig-5]: Comparison of visceral fat, subcutaneous fat, waist circumference between fatty and non-fatty liver. (Mann Whitney for visceral and subcutaneous fat and t-test for waist circumference) were used)

The CT attenuation of the liver (fatty liver) showed a moderate correlation with visceral fat (Spearman's coefficient: 0.329). The CT attenuation of the liver (fatty liver) showed a weak correlation with subcutaneous fat (Spearman's coefficient: 0.269). The CT attenuation of the liver (fatty liver) demonstrated a weak-moderate correlation with waist circumference (Spearman's coefficient: 0.305) [Table/Fig-6-9].

Liver attenuation vs	Spearman's coefficient (rho)	95% CI of rho	p-value
Visceral fat	-0.329	-0.472 to -0.170	**0.0001**
Subcutaneous fat	-0.269	-0.419 to -0.105	**0.0016**
Waist circumference	-0.305	-0.451 to -0.144	**0.0003**

[Table/Fig-6]: Spearman's correlation between liver attenuation and visceral fat, subcutaneous fat, waist circumference.

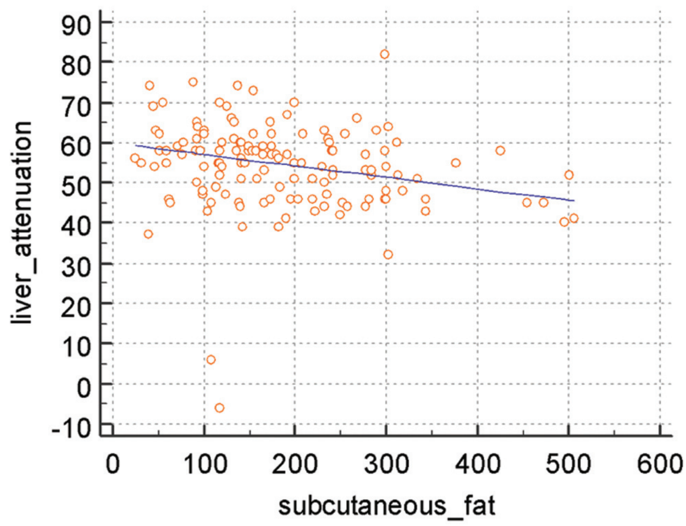


[Table/Fig-7]: Relationship between CT attenuation of liver and visceral fat which is non linear.

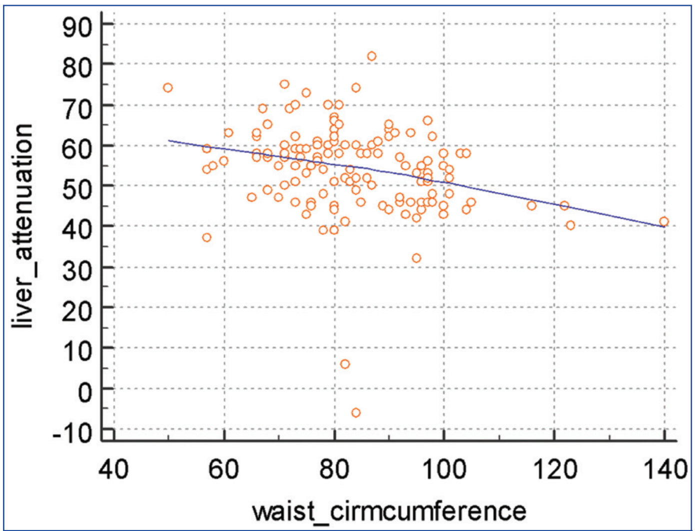
DISCUSSION

The results of this study demonstrated that CT attenuation of the liver is inversely correlated with the visceral fat area, indicating that visceral fat has a higher likelihood of being associated with fatty liver. Subcutaneous fat and waist circumference also showed some correlation, but they were weaker than visceral fat. In a study by Pickhard PJ et al., involving 474 patients, of which 168 had metabolic syndrome (prevalence of 35.4%) [10], patients with metabolic syndrome had greater visceral fat than those without metabolic syndrome (p-value <0.001). In a study by Eguchi Y et al., which included 129 USG-diagnosed fatty liver patients, the liver spleen ratio and visceral fat area calculated by CT showed a significant negative correlation (r=–0.605, p<0.0001) [2]. Previously, it was believed that BMI and visceral fat both played a role in fatty liver. However, BMI alone is insufficient to accurately assess health risks associated with increased adiposity, as it can vary significantly among individuals of the same weight with different levels of visceral fat [14]. Research has shown that body fat composition provides a more precise indication of health than BMI or body weight [15].

In the present study, the authors have demonstrated that the visceral fat area has a better correlation with fatty liver than waist circumference and subcutaneous fat. The Insulin Resistance index (HOMA-IR) shows a positive correlation with the severity of fatty liver [2]. Metabolic fat is a further indicator of cardiovascular disease. Central obesity is currently measured using waist circumference, but direct visceral fat measurements are more appropriate [1]. Fatty liver disease (hepatic steatosis) can be quantified by CT using the CT attenuation value of the liver. CT is a non-invasive method [1]. CT quantification of visceral fat is especially important for metabolic syndrome, which is related to both visceral and central obesity. Although simpler, non-specific fat metrics like body weight, belly circumference, and body mass index are more commonly employed, they cannot identify the exact location of fat [13]. With the non-invasive measurement of visceral fat and hepatic steatosis, new CT and Magnetic Resonance Imaging (MRI) techniques have the potential to improve the diagnosis of metabolic syndrome with high accuracy. Understandably, calculating visceral fat area, subcutaneous fat area, and waist circumference with CT is not practically possible, hence they are not yet part of the metabolic syndrome definition [14]. In conclusion, the result of the present study indicated that the visceral fat area has a strong correlation with fatty liver on CT, which makes it an important factor in the development of metabolic syndrome. Hence, CT evaluation of fatty liver is an indicator of metabolic syndrome.



[Table/Fig-8]: Relationship between CT attenuation of liver and subcutaneous fat which is non linear.



[Table/Fig-9]: Relationship between CT attenuation of liver and waist circumference which is non-linear.

Limitation(s)

Along with the retrospective nature of the present study, the small sample size was a limitation. To draw broader inferences, patients with known metabolic syndrome and diagnosed cases of fatty liver can be helpful.

CONCLUSION(S)

Patients with larger waist circumferences, visceral fat areas, and subcutaneous fat are more likely to develop hepatic steatosis. The authors have shown that there is a stronger correlation between fatty liver and visceral fat than there is between waist circumference and subcutaneous fat. In order to lower the mortality and morbidity associated with metabolic syndrome, visceral fat should be regarded as a risk factor for the development of fatty liver, which may then progress to it.

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