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Evaluation of Liver in Type 2 Diabetes Mellitus Using Unenhanced Computed Tomography

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Abstract

Background: Chronic liver disease occurs due to different etiologies. Most diabetic patients are unaware that the effective control of hyperglycemia might reduce complications and mortality rates. Fatty liver disease is considered a risk factor of hepatic cirrhosis and cancers.

Methods and Results: We conducted a case-control study to assess the impact of type 2 diabetes mellitus (T2DM) on the liver using a CT scan. A total of 100 patients with T2DM and 96 non-diabetic patients as a control group were selected using a convenient sampling method. There was a significant difference in liver attenuation in diabetic and control groups. The CT attenuation values of the liver, pancreas, and spleen were significantly lower in patients with T2DM than in non-diabetics (P<0.001). There was a significant negative correlation between the duration of T2DM and CT attenuation of the liver, pancreas, and spleen (P<0.01).

Conclusion: The CT attenuation of the liver was significantly lower in T2DM than in the non-diabetic patients, and liver attenuation decreased as the duration of T2DM increased. (**International Journal of Biomedicine. 2020;10(4):402-406.**)

Key Words: diabetes mellitus • nonalcoholic fatty liver disease • liver attenuation • unenhanced computed tomography

Abbreviations

BMI, body mass index; **CT**, computed tomography; **DM**, diabetes mellitus; **HS**, hepatic steatosis; **HU**, Hounsfield Unit; **HbA1c**, glycosylated hemoglobin; **L/S**, liver-to-spleen ratio; **LP**, liver-to-pancreas ratio; **LLL**, left liver lobe; **NAFLD**, nonalcoholic fatty liver disease; **PACS**, picture archiving and communication system; **RLL**, right liver lobe; **T2DM**, type 2 DM.

Introduction

Type 2 diabetes mellitus (T2DM) is a metabolic disorder that can affect most parts of the body, including the liver. Insulin resistance mainly causes hyperglycemia, which affects the metabolism of carbohydrates, lipids, and proteins leading to nonalcoholic fatty liver disease (NAFLD). The fatty liver may progress to steatohepatitis, hepatic cirrhosis, fibrosis, and hepatocellular carcinomas. Several studies have found that DM is associated with several hepatic abnormalities, such as NAFLD, cirrhosis, fibrosis, cancers, acute liver disease, unusual elevated hepatic enzymes, and hepatitis. Furthermore, increased fat accumulation in the hepatocytes may affect insulin

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resistance and end in severe metabolic dysfunction. A fatty liver and hyperglycemia can damage the hepatocytes and lead to severe morbidity and mortality among T2DM patients.[1]

CT is considered a reliable method for assessing fatty liver. CT is capable of calculating the liver-to-spleen (L/S) ratio, which is defined as the ratio of the intensities of the liver parenchyma and splenic texture. It is considered an accurate imaging modality for quantifying HS with 90% accuracy.[2,3]

The estimated CT attenuation values of liver parenchyma on an unenhanced CT scan show a strong correlation with the degree of HS seen on histopathologic examination. The measured CT attenuation value of liver parenchyma on an unenhanced CT scan has been reported to show a strong association with the severity of HS shown on histopathological analysis.[4]

The attenuation of a healthy normal liver on unenhanced CT is denser than the spleen and the hepatic vasculature, and it ranges from 50HU to 65HU.[5,6] Non-enhanced CT is established as an accurate imaging method for diagnosing moderate to severe fatty liver than it is for mild conditions of steatosis. HS is diagnosed when liver attenuation is less than spleen attenuation or when liver attenuation less than 48HU.[6] The degree of HS can be diagnosed when liver attenuation is less than 40-42HU, and L/S attenuation ratio is less than 0.8, or L/S ratio difference is equal or less than 10HU.[7,8]

CT is a useful modality for measuring fat in the liver for patients at risk of metabolic syndromes, such as T2DM. Therefore, this study aimed to assess the liver in T2DM using unenhanced CT, focusing on assessing CT attenuation of the diabetic liver, compared to the non-diabetic individuals.

Materials and Methods

The study was conducted in the Medical Imaging Department – CT scan department in Jeddah Hospitals. This study was approved by the ethics committee of the Sudan University of Sciences and Technology. Written informed consent was obtained from each patient.

The cases were retrospectively studied from the reviewed database of all patients who had undergone abdominal CT examinations from March 2018 to March 2020. The exclusion criteria were fibrosis, alcohol consumption, and history of hepatic surgery. A total of 196 patients were selected using a convenient sampling method. Among them, 100 subjects had T2DM regarded as cases, and 96 were non-diabetics as controls.

Unenhanced CT scans of the liver were performed for all participants included in the study. The abdominal CT examinations were done using TOSHPA CT Machine, at 120kVp, 50mA-100mA, 5-mm slice thickness (1mm for Axial, 1mm for Coronal). Collimation was 0.5×80, pitch of 0.8. Every patient was examined in supine positioning, typically feet first, scanning from above the diaphragm (top of the liver) to the level of the iliac crests. The patients were asked to hold their breath at the end of inspiration.

Attenuation measurements

We delineated five regions of interest: LLL (segment III), RLL (segment V), RLL (segment VI), middle of the spleen, and the body of the pancreas on the CT scans of each patient. The attenuation measurements were obtained for each ROI, which include a larger area of the liver and spleen. Regions excluded were of non-uniform parenchymal attenuation, including apparent hepatic vessels. The 2D axial and coronal images were used to measure the size of the liver and spleen. All the images were interpreted by a single observer with 15 years of experience in CT scan and PACS.

Statistical analysis was performed using statistical software package SPSS version 23.0 (SPSS Inc, Chicago, IL). For descriptive analysis, results are presented as mean ± standard deviation (SD). Means of 2 continuous normally distributed variables were compared by independent samples Student's t test. Group comparisons with respect to categorical variables are performed using chi-square test. Pearson's correlation coefficient (r) was used to determine the strength of the relationship between the two continuous variables. A probability value of $P<0.05$ was considered statistically significant.

Results

The study included 100 patients with T2DM (case group) (54% males and 46% females) and 96 non-diabetic patients (control group) (42.7% males and 57.3% females). The age of T2DM patients ranged from 31 to 85 years (mean age of 58.91±11.1 years); mean BMI was 30.74±7.25 kg/m^2. The results showed that in T2DM, the mean level of HbA1c was 7.4%±1.9%. The mean age of non-diabetic patients was 45.96 years; mean BMI - 27.59±5.9 kg/m^2 (Table 1).

Table 1.

Characteristics of the study groups

Variables	T2DM patients	Non-diabetic patients	*P*-value
Male	54(54%)	41(42.7%)	0.668
Female	46(46%)	55(57.3)	
Age, years	58.91)	45.96	0.001
BMI, kg/m^2	30.74±7.25	27.59±5.90	0.001
HbA1c,%	7.47±1.91	--	
Duration, ,years	14.62±7.19	--	

Concerning T2DM, the study clarified that the attenuation of the liver in the different segments was as follows: 44.62±9.93 HU in segment III of LLL, 43.46±9.77HU in segment V of RLL, and 41.29±9.63 HU in segment VI of RLL. The CT attenuation of the spleen was 51.88±9.13 HU, and the pancreas was 34.58±8.74 HU. The liver indexes were 203.08 ±22.92 mm in axial one, 117.15±4.62 mm in axial two, and 165.85±28.75 mm in coronal one. The spleen indexes were 96.32±17.50 mm in axial 1, 42.76±9.71mm in axial 2, and 87.84±20.72 mm in coronal section (Table 2).

Table 3 summarizes the correlation between attenuation (HU) of liver and spleen and duration of DM. The study

shows a moderate, negative, significant correlation between the attenuation and DM duration. In contrast, a strong, negative significant correlation was found between pancreas HU and DM duration (r=-574, P<0.01). Thus, CT attenuation decreased as the duration of T2DM increased. HbA1c values also had a moderate, negative, significant correlation with the liver, spleen, and pancreas attenuation (P<0.01).

Table 2.

Means measurement for age, BMI, duration, liver HU and indexes in T2DM patients

Variables	Mean±SD
LLL, HU (segment III)	44.62±9.93
RLL, HU (segment V)	43.46±9.77
RLL, HU (segment VI)	41.29±9.63
Spleen, HU (middle)	51.88±9.13
Pancreas, HU (body)	34.58±8.74
Liver Index (Axial 1)/mm	203.08 ±22.92
Liver Index (Axial 2)/mm	117.15 ±14.62
Liver Index (Coronal)/mm	165.85±28.75
Spleen Index (Axial 1)/mm	96.32±17.50
Spleen Index (Axial 2)/mm	42.76±9.71
Spleen Index (Coronal)/mm	87.84±20.72
L/S ratio	0.83
L/P ratio	1.2

Table 3.

Correlation between the duration of DM and HU of liver, spleen, and pancreas.

Correlations		Liver (upper)	Liver (middle)	Liver (lower)	Spleen (middle)	Pancreas (middle)
Duration	Pearson Correlation	-0.375*	-0.430*	-0.415*	-0.411*	-0.574*
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	<0.001
HbA1c	Pearson Correlation	-0.402*	-0.484*	-0.505*	-0.459*	-0.453*
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	<0.001

**- Correlation is significant at the 0.01 level (2-tailed).*

A comparison of the HU attenuation of liver and spleen in DM and non-DM patients clarified that the liver's attenuation in diabetic patients is significantly lower than in non-diabetic patients. The CT attenuation of LLL (segment III) in T2DM patients was significantly lower than in non-diabetics (56.2±10.69 HU vs. 44.62±9.93 HU, P<0.01). In T2DM patients and non-diabetic patients, the CT attenuation of RLL (segment V) was 43.46±9.77HU and 56.02±10.65HU, respectively, (P<0.01) and 44.62±9.93HU and 56.2±10.69HU, respectively, for segment VI (P<0.01) (Table 4).

Table 4.

Independent sample t-test to compare means of HU and indexes for liver, spleen, and pancreas in diabetic and non- diabetic patients

Variables	Mean±SD		P-value
	T2DM patients (n=100)	Non-diabetic patients (n=96)	
LLL, HU (segment III)	44.62±9.93	56.20±10.96	< 0.01
RLL, HU (segment V)	43.46±9.77	56.02±10.65	
RLL, HU (segment VI)	41.29±9.63	55.84±11.08	
Spleen, HU (middle)	51.88±9.13	47.15±8.84	
Pancreas, HU (body)	34.58±8.74	45.91±9.44	
Liver Index (Axial 1)	203.08 ±22.92	201.95±20.46	> 0.05
Liver Index (Axial 2)	117.15 ±14.62	114.35±20.03	
Liver Index (Coronal)	165.85±28.75	159.44±29.55	
Spleen Index (Axial 1)	96.32±17.50	95.2±15.74	
Spleen Index (Axial 2)	42.76±9.71	42.98±8.55	
Spleen Index (Coronal)	87.84±20.72	89.19±16.99	

The spleen attenuation values in T2DM patients were significantly higher than in non-diabetics (51.88±9.13 HU vs. 47.15±8.84 HU, P<0.001). On the other hand, the pancreatic attenuation values in T2DM were lower than those in non-diabetic patients (34.58±8.74 HU vs. 45.91±9.44 HU, P<0.01) (Table 4).

The study found no significant difference in liver and spleen indexes in T2DM patients versus non-diabetic patients. The liver indexes, in general, were slightly higher in T2DM- than in non-diabetic patients. In T2DM patients, the indexes were 203.08±22.92 mm, 117.15±14.62 mm, and 165.85±28.75 mm in axial 1, axial 2, and coronal section, respectively; in non-diabetic patients the indexes were 201.95±20.46 mm, 114.35±20.03 mm, and 159.44±29.55 mm in axial 1, axial 2, and coronal section, respectively.

Discussion

There are many imaging techniques to evaluate the liver. Several previous studies recommended unenhanced CT because of measurements of fat in the useful liver modality for patients at risk of metabolic syndrome, such as diabetes mellitus. CT allows quantitative assessment of the liver attenuation in HU.

In this study, we used CT since it is useful in diagnosing the presence of liver fat and assessing its severity safely.

The present study revealed that fatty infiltration of the liver was significantly correlated with T2DM. The prevalence of NAFLD is highest in populations with metabolic conditions such as obesity and T2DM. Specifically, T2DM and NAFLD are closely related. A study of patients with T2DM found that fatty liver is significantly associated with DM characteristics, even at younger ages.[9]

The present study found that the CT attenuation values of the liver were significantly decreased in T2DM more than in non-diabetic participants, in agreement with previous studies.[10,11] This decrease in attenuation value of the liver is attributed to the fact that the attenuation value of fat, usually about -100 HU, is much lower than that of soft tissue, which ranges from 30 HU to 40 HU. Therefore, the attenuation value of liver parenchyma decreases as HS develops and progresses. This finding indicates that CT assessment of liver parenchyma on an unenhanced CT scan is accurate since a strong correlation was reported between CT and histopathological analysis regarding the diagnosis of hepatic steatosis.[3]

It was found that the L/S ratio was 0.83 in T2DM patients. This finding is in agreement with previous studies, which reported approximately similar results.[12,13] On an unenhanced CT scan, the normal liver parenchyma is slightly higher than that of the spleen. As fatty hepatic infiltration progresses, the attenuation value of liver parenchyma decreases, and consequently attenuation of the liver to spleen decreases.[2,3] Therefore, the L/S ratio is a significant indicator of a CT assessment of NAFLD.

In this study, we found that a negative correlation existed between the duration of DM and attenuation values of the pancreas, liver, and spleen. As the duration of the DM increased, the attenuation of the liver, pancreas, and spleen decreased significantly (P<0.001). We also found that the most affected organ was the pancreas, which showed a strong, significant negative correlation.

Pancreatic fat density decreased accordingly as the duration of the disease increased.[14] Similarly, Lim et al.[15] stated that T2DM patients had excessive pancreatic fat content, compared to normoglycemic subjects. Ahbab et al.[16] reported that DM correlated with a decrease in the mean HU values of the pancreas (P=0.002). These decreased attenuation values were attributed to the fact that pancreatic fat content increased in T2DM, resulting in increased fat content in the pancreatic tissue. The negative correlations suggested that the values of these factors increase as the degree of pancreatic fatty infiltration increases. In general, these findings indicate that the duration of T2DM is a strong influencing factor affecting the CT attenuation of the pancreas, liver, and spleen.

Conclusion

The study determined that an unenhanced CT scan evaluation of the liver in T2DM is necessary to determine the degree of fatty infiltration. The CT attenuation values of the liver, pancreas, and spleen were lower in diabetic patients than non-diabetic ones. The attenuation values of the liver, spleen, and pancreas were significantly decreased as the duration of DM increased.

Competing Interests

The authors declare that they have no competing interests.

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