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Characterization of Patients with Diabetes Mellitus Type 2 and Fatty Liver Diagnosed by Liver/spleen Hounsfield Units on CT scan

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Abstract: *The main objective of the study was to characterize patients with diabetes mellitus Type 2 (DM type 2)and fatty liver diagnosed by liver/spleen Hounsfield units using computed tomography (CT). The study was conducted in the Medical Imaging Department – CT scan department in Jeddah Hospitals (Kingdom Saudi Arabia). AN abdominal CT scan was performed for all patients; the study was obtained during the period from March 2018 to March 2020. About 100 diabetic patients of age (31-85 years) who attended to computed tomography for abdominal CT. Results: the males were more than women, males were 54% and females were 46%, elderly patients age between 51-60 years old were 33% of the total sample is most affected by DM Type2. By calculating and correlation of Mean and Stander deviation between duration and means HU for liver and spleen, we found that liver HU upper was 48.03 in mean and Std deviation was 9.736 inpatient duration disease was 11-17 years correlation at the level of The p-value of less than 0.005 was considered to be statistically significant. we found correlation was significant at the 0.01 level (2-tailed), measurement at liver HU upper was -.369 which is low than the 0.001 level and liver HU middle -.422,-.421 spleen HU middle, and -.640 for pancreas HU in middle and correlate theses value by 0.01 level was significant.*

Keywords: *diabetes mellitus Type 2, fatty liver, CT scan, Hounsfield unit.*

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I. Introduction

Diabetes mellitus (DM) is referred to as a group of metabolic conditions characterized by increased glucose levels in the blood (hyperglycemia). These metabolic conditions should not be confused with diabetes insipid us which is clinically distinct and not related to hyperglycemia in the blood. If a patient with DM requires insulin drugs then this may be described as insulin-dependent diabetes mellitus (IDDM), conversely, if insulin is not required for the patient, then non-insulin-dependent diabetes mellitus (NIDDM). [1, 2]

DM is recognized as a major health problem in the world and there are many types of Diabetes mellitus. Common percentage documented in studies was ninety-nine percent of diabetics suffer from type 2 DM and 10% from type 1 and other types of DM. The number of diabetic patients worldwide is expected to reach 380 million over the next 15 years. The duration of diabetes is an important factor in the pathogenesis of disease complications, but other factors frequently coexisting with Type 2 DM, such as hypertension (high blood pressure), obesity (increased body mass index BMI), and dyslipidemia, also contribute to the development of diabetic angiopathy. Some associated diseases with diabetes mellitus can be microvascular complications include retinopathy, nephropathy, and neuropathy. Macroangiopathy complications mainly affect coronary arteries, common carotid arteries, and arteries of the lower extremities. Eighty percent of deaths in the diabetic population result from Macroangiopathy complications such as cardiovascular incidents. DM is considered an equivalent of congestive heart disease (CHD), Stroke and peripheral artery disease (PAD) are other main manifestations of diabetic macroangiopathy. The greater susceptibility of diabetic patients to infections and inflammation completes the spectrum of the main consequences of DM. The serious complications of DM make it more essential for physicians to be aware and know what the best tool of the screening guidelines, allowing for earlier patient diagnosis and treatment. [3, 4]

The prevalence of diabetes mellitus is rapidly increasing worldwide. In 2011, there were 366 million patients diagnosed with diabetes mellitus globally, and this number is expected to increase to 552 million by 2030 according to some previous studies. [5]

Regarding Computed tomography (CT) imaging for measuring liver attenuation, in Normal patient, liver CT density (attenuation) measures approximately 55 HU (Hounsfield units), about 10 HU higher than the

(normal) spleen. As fat has low attenuation (− 100 HU), a proportionate decrease in density is seen with increasing fat accumulation in the liver. Liver to spleen ratio less than 0.8–1.1 and a liver minus spleen attenuation less than −9 HU for that spleen is used as a reference value to minimize variations across different CT scanner modality.

Computed tomography can detect hepatic fat content in a fatty liver patient, but only at a threshold of 30%, and it involves ionizing radiation. Magnetic resonance (MR) spectroscopy is probably the most accurate and fastest method of detecting fat nowadays as an advanced modality, but it is expensive and the necessary software is still not easily available in most MRI units.[6,7,8]

All Radiographic imaging tools are limited in their ability to detect coexisting hepatic disease associated with DM type2. In this review, we discuss the radiological techniques currently used to detect hepatic fat content in DM type 2 patients by using computerized tomography. [9, 10]

However, the best method for predicting the pathological fat content of the liver whose patient suffers from diabetic specific DM Type 2 with CT is the simple measurement of liver attenuation on unenhanced CT scans. Therefore, the attenuation measurement of the spleen does not contribute to the prediction of hepatic fat content. The use of these criteria can help avoid invasive biopsies for livers. Other considerations in the use of CT include differences in the attenuation values of CT scanners obtained from different vendors. Even when using the same CT scanner, the attenuation of fat varies with the patient's size (BMI) and position, and with imaging artifacts, and can vary between images from a single patient. [10]

II. MATERIALS AND METHODS

2.1Material

2.1.1Area and duration

Retrospective Scientific Analytical study was performed in the Medical Imaging Department – CT Scan department in Jeddah Hospitals. AN abdominal CT scan was performed for all patients; the study was obtained during the period from March 2018 to March 2020.

2.1.2 Sample study

The sample of this research consisted of 100 diabetic patients with type 2 DM. The males were more than women, 54% of the sample were males while 46% of the sample were females.

Inclusion criteria: Patients with diabetic type 2 undergo an unenhanced abdominal CT scan.

Exclusion criteria: normal patients, patients below 20 years, pts who had a history of hepatectomy, hepatic cirrhosis, fibrosis, and alcohol consumption.

2-2 Methods

2-2-1 Technique used

By using (TOSHPA) CT Machine, at 120 kVp, 50mA-100mA (AP&LAT), 5-mm slice thickness was used to perform an abdominal CT scan. The patient position was supine positioning, typically feet first, scanning from above the diaphragm (top of the liver) to the level of the iliac crests. The patients were told to hold his/her breath at the end of inspiration. We measured five regions of interest (ROIs) within the liver: Left Liver Lobe (segment 3), right liver lobe (segment 5), right liver lobe (segment 6), 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. Also, the size for the liver and spleen in two dimensions' axial Coronal obtained.

2.2.2 Statistical analyses

By using the SPSS program version16 all data and variables are analyzed. Descriptive statistics, including frequency and percentages, were calculated. An ANOVA test was applied to test the significance. Data are presented as means + Sdt or frequencies and The covariates for the multivariable regression analysis were chosen as potential confounding factors based on their significance in univariate analysis (i.e., HbA1c) or based on their biological plausibility (age, sex, BMI ..etc). The *p*-value of less than 0.005 was considered to be statistically significant.

III. Results

All collected data analyzed and tabulated in tables and graphs as follows:

Table no (1) show Age distribution among a sample of the study

Age \years	Frequency	Percent
31-40	7	7%
41-50	16	16%
51-60	33	33%
61-70	32	32%
71-85	12	12%
Total	100	100%

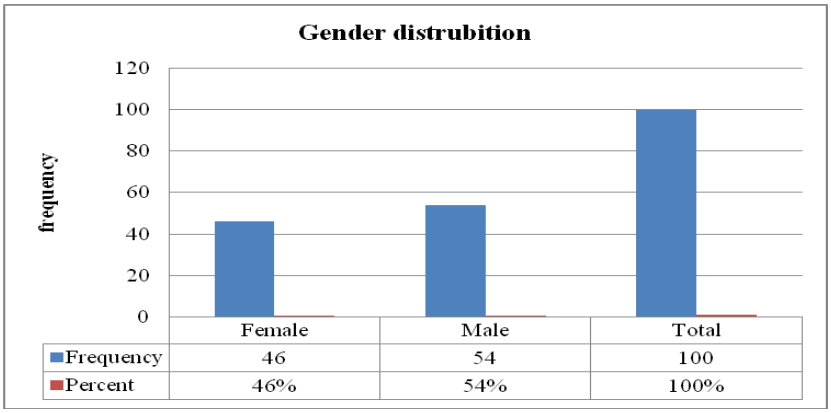

Figure no 1: chart display gender distribution.

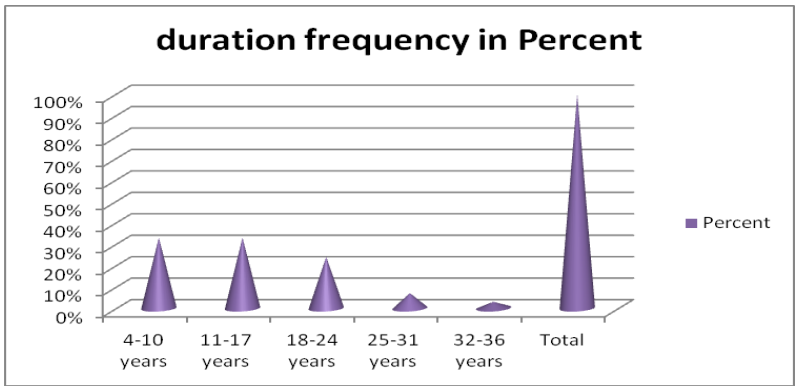

Figure no 2: pie graph frequency distribution of duration

Table (2) show the Mean and Stander deviation between duration and means HU for liver and spleen

Duration		Lt Liver Lobe HU segment (3)	Rt Liver Lobe HU segment (5)	Rt Liver Lobe HU segment (6)	Spleen HU (middle)	*p*-value
4-10	Mean	46.88	46.58	44.00	54.48	<0.001
	Std. Deviation	10.845	9.868	9.776	7.425	
11-17	Mean	48.03	46.79	44.73	54.58	
	Std. Deviation	9.736	9.707	9.412	8.074	
18-24	Mean	39.67	37.67	35.79	47.79	
	Std. Deviation	6.190	6.105	6.776	10.052	
25-31	Mean	38.14	35.71	34.14	45.43	
	Std. Deviation	4.880	5.251	4.220	4.467	
32-36	Mean	37.00	37.00	34.33	41.33	
	Std. Deviation	13.077	11.533	11.504	15.503	
Total	Mean	44.62	43.46	41.29	51.88	
	Std. Deviation	9.935	9.774	9.630	9.137	

Table (3) show the correlation between duration in the liver index and spleen index in the diabetic patient

Duration		Liver Index (Axial 1)	Liver Index (Axial 2)	Liver Index (coronal)	Spleen Index (Axial 1)	Spleen Index (coronal)	*p*-value
4-10	Mean	201.64	115.97	162.30	96.85	88.00	> 0.05
	Std. Deviation	25.722	16.573	32.116	19.985	15.802	
11-17	Mean	208.03	120.36	167.03	98.88	92.94	
	Std. Deviation	21.356	13.299	26.952	15.167	15.698	
18-24	Mean	198.67	113.96	166.25	94.71	80.50	
	Std. Deviation	24.216	13.560	26.019	13.550	21.036	
25-31	Mean	203.29	122.14	168.43	92.29	85.86	
	Std. Deviation	11.557	14.960	36.235	15.903	17.170	
32-36	Mean	199.33	108.67	182.67	84.67	93.33	
	Std. Deviation	17.010	8.083	19.858	42.724	78.818	
Total	Mean	203.08	117.15	165.85	96.32	87.84	
	Std. Deviation	22.923	14.624	28.753	17.507	20.724	

Table (4) correlation between age and means HU for liver, spleen, and pancreas

		Liver HU (upper)	Liver HU (middle)	Liver HU (lower)	Spleen HU (middle	Pancreas HU(middle only)
Age	Pearson Correlation	-.369**	-.422**	-.422**	-.421**	-.640**
	Sig. (2-tailed)	.000	.000	.000	.000	.000
	N	100	100	100	100	100

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

Table (5) correlation between age and means indexes for liver and spleen

		Age
Liver Index (Axial 1)	Pearson Correlation	-.157-
	Sig. (2-tailed)	.119
Liver Index (Axial 2)	Pearson Correlation	-.156-
	Sig. (2-tailed)	.122
Liver Index (coronal)	Pearson Correlation	.037
	Sig. (2-tailed)	.718
Spleen Index (Axial 1)	Pearson Correlation	-.133-
	Sig. (2-tailed)	.186
Spleen Index (Axial 2)	Pearson Correlation	-.159-
	Sig. (2-tailed)	.114
Spleen Index (coronal)	Pearson Correlation	-.015-
	Sig. (2-tailed)	.881
	N	100

**Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table (6) frequency distribution of other associated clinical findings

Disease	Frequency	Percent
Only Fatty liver	53	53%
Nephropathology and fatty liver	3	3%
Hypertension and fatty liver	22	22%
Hyperlipidemia and fatty liver	5	5%
heart diseases and fatty liver	9	9%
Hyperlipidemia, Hypertension, and fatty liver	5	5%
Other	3	3%
Total	100	100%

IV. Discussion

The sample of this research consisted of 100 patients with type 2 DM. Table (1) shows Age distribution among a sample of the study, an elderly patient age between 51-60 years old were 33% of the total sample while younger (31-40 years) is low affected by this type 2 DM were 7%. Compare this result with Masuoka, H.C, 2013 who discussed the relationship of non-alcoholic fatty liver disease (NAFLD) to obesity and diabetes (variables) BMI Obesity and dyslipidemia are well-established risk factors for NAFLD, though, in the multivariate analysis, only obesity, hypertriglyceridemia, and hypertension remained predictive. Similarly, a Korean study of living donors found obesity, and older age were independent risk factors for fatty liver and DM Type 2. [11]

Figure (1) shows that the males were more than women, 54% of the sample were males while 46% of the sample were females. Figure 2 shows the duration of diseases whom patients with DM from 4-10 years and 11-17 years were respectively high percentage more than whom duration of disease was 32-36 years.

A similar study by Vernon G et al, 2011 who concluded, Obesity is a reported risk factor for NAFLD (DM Type 2). In patients with morbid obesity, the prevalence of non-alcoholic fatty liver disease (DM Type 2) can be more than 90% and up to 5% of patients may have liver cirrhosis [12].Also, there is a significant correlation between the increase in BMI and the presence of NAFLD (56.1% of studied patients had overweight, whereas 49.1% were obese) however, no significant differences between the different BMI categories (P=0.360). Although the majority of participants (54% of study patients) had reported a longer duration of diabetes (10 years or more) as same as our result, These findings were consistent with what was reported in the previous studies done by Akbar DH,2006 and Merat S, 2009. [13,14]

Table (2) show Mean and Stander deviation (Std. Deviation) between duration and means HU for liver and spleen, we found that the left liver lobe (segment 3) was 48.03 in mean and Std. Deviation was 9.736 in patient duration disease was 11-17 years, right liver lobe HU (segment 5) in the same duration was 46.79 for mean and 9.707 Std, Deviation in right liver lobe HU (segment 6)was 44.73 for mean and 9.412 for Std. Deviation which is excited in spleen HU measurement was 54.58 means and low std was 8.074 for the same duration.

In 32-36 duration the left liver lobe HU (segment 3) was 37.00 in mean and Std.Deviation was 13.07, right liver lobe HU (segment 5) in the same duration was 37.00 for mean and 11.53 Std. Deviation, in right liver lobe HU (segment 6), was 34.33 for mean and 11.503 for StD which is excited in spleen HU measurement was 41.33 means and std. Deviation was 15.503 for the same duration. Similar results with Ricci C et al, 1997 who found that the CT method employed realizes that the lower the mean liver attenuation or CT number in Hounsfield units (HU), the lower the tissue density and hence the greater the fat content. Therefore, liver density (attenuation in HUs) is inversely related to liver fat and thus is a surrogate for it. [15]

In our study we take an abdominal unenhanced CT exam, the normal liver has slightly greater attenuation than the spleen and blood, and intrahepatic vessels are visible as relatively hypo attenuated structures in CT. On CT abdominal Fatty liver can be diagnosed if the attenuation of the liver is at least10HU less than that of the spleen. [16] Or if the attenuation of the liver is less than 40 HU.In severe cases of fatty liver, intrahepatic vessels may appear hyper attenuated relative to the fat-containing liver tissue .measured the liver-to-spleen attenuation ratio and interpreted a ratio of less than 1 as indicative of fatty liver as discussed in some previous study. [15.16]

A CT with contrast Media (CM), the comparison of liver and spleen attenuation values is not as reliable for the diagnosis of fatty liver, because differences between the appearance of the liver and that of the spleen depend on scan timing and technique and because there is overlap between normal and abnormal attenuation value ranges. [17]

Table (3) show the correlation between duration in the liver index and spleen index in the diabetic patient as we see in the table we take mean and stander deviation for liver index axial 1 and axial 2and coronal compare that with means and stander deviation for spleen index coronal at correlation by *p*-value > 0.05 is

significant, we found correlation at 11-17 duration was 208.03 mean and 21.356 std for liver index axial while 120.36,13.299 for mean and std respectively for liver index axial 2.compare same previous duration (11-17) for spleen index in diabetic pts were 98.88for mean and std was 15.167 for axial 1 while 92.94 and 15.698 to means and std spleen index coronal. At 32-36 duration was low respectively means and std for liver and spleen index which were 199.33and 17.01 for liver index axial 1,108.67 and 8.083 for liver index axial 2, in spleen index at the same duration 32-36 was 84.67and 93.33 for means axial 1 and coronal respectively for mean, std was 42.724 and 78.818 for spleen axial 1 and coronal measurement.

Table (4)show the correlation between age and means HU for liver, spleen, and pancreas and we found correlation was significant at the 0.01 level (2-tailed), measurement at the left liver lobe (segment 3) was -.369 which is low than the 0.001 level, and right liver lobe HU (segment 5&6) -.422, -.421 spleen HU middle and -.640 for the body of the pancreas HU and correlate theses value by 0.01 level was significant. In the table (5) we measure the correlation between age and means indexes for liver and spleen in axial 1, axial 2, and coronal, our results were there was no significant at the 0.01 level (2-tailed.

Table (6) discuss the frequency distribution of other associated clinical findings with fatty liver diabetic type 2 patients the result was 53% of all patient had only fatty liver disease, pts who had fatty liver with Hypertension (high blood pressure)was 22% which is relatively high percentage and whom those with heart disease was 9%, Hyperlipidemia, Hypertension, and fatty liver was 5%. Compare Table 6 with the result of Stefano bonapace et al,2012 who resulted in Thirty-two patients (64%) had a fatty liver, and when compared with the other 18 patients, age, sex, BMI, waist circumference, hypertension, smoking, diabetes duration, microvascular complication status, and medication use were not significantly and concluded (NAFLD) are limited and conflicting. He assessed whether NAFLD is associated with abnormalities in cardiac function in patients with type 2 diabetes and he said all of these differences remained significant after adjustment for hypertension and other cardiometabolic risk factors. [18]

There are other studies performed to observe the relation of fatty liver with diabetes done by. Tilg H, Moschen AR, and Roden M (2016) who concluded there was A suggestive correlation between marked increases of lipids (Hyperlipidemia) and hepatomegaly was seen among the diabetes patients with our study in Table 6 mentioned Hyperlipidemia was 5% associated with fatty liver DM Type2 patients. [19]

The principal risk factors for developing NAFLD are obesity and insulin resistance .any metabolic syndrome such as type 2 diabetes, dyslipidemia, and hypertension (increased blood pressure) are linked to the development of NAFLD, and approximately 85% of patients with NAFLD have at least one metabolic syndrome.[20]

V. Conclusion

The results of this research were as expected conclusion elderly patients age between 51-60 years old were 33% most affected age. Male in our sample were more than female by fatty liver DM Type2.

Fatty liver is largely present in type 2 diabetes and correlates with a worse metabolic profile and with organ damage. When fatty liver is present in type2 diabetes co-morbidities and complications of diabetes mainly effect (hepatic, renal, and cardiovascular). In this study, we were able to confirm the above-mentioned association between the fatty liver, hypertension, and heart disease in a population of patients with type 2 diabetes. the associations were independent of age, sex, systolic blood pressure, and BMI.

From the finding of these studies, it's concluded that a strong and linear relationship exists between BMI and duration of disease and liver size measurement changes and Hounsfield units on CT scan.

Although computerized tomography is an invasive technique it gives the accurate and reliable measurement to assess and characterize liver and spleen in fatty liver DM type 2 patients.

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