IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 15, Issue 6 Ver. IX (June. 2016), PP 34-39
www.iosrjournals.org

Non-Contrasted Computed Tomography Hounsfield Unit For Characterization Liver Segments

Khalda Mohammed Ahmed [1], Caroline Edward Ayad[1], Samih Awad Kajoak[2]
[1]*(College of Medical Radiological Science, Sudan University of Science and Technology, Khartoum, Sudan)*
[2]*(College of Applied Medical Science, Diagnostic Radiology Department, Hail University-Saudi Arabia)*

Abstract : *The Objectives of this study are to measure the Hounsfield units (HU) for each liver segment to be as standard values for normal liver as segmental anatomy as well as to compare the (HU) of the segments in different hepatic disorders that may affected the liver attenuation.*
In the present study, 248 patients were evaluated by means of non-contrast-enhanced computed tomography. Sixty three patients had hepatic diseases and 185 were control subjects. Hounsfield was calculated in both cases for the eight liver segments using non-contrast-enhanced computed tomography as the reference standard.
The overall normal mean of CT number(HU) of liver segments was found to be ranged between 58.99 ±7.11and 60.22 ±4.09 (HU) and the Liver SD was 15.39.
The study showed the CT (HU) are useful for determining the presence of underlying liver disease, and is useful for diagnosis patients with alcohol fatty liver, obstructive biliary pathology, neoplastic diseases, metastases, cirrhosis, Hepatitis, Ascites and can be used to screen for identify patients with cardiac, diabetes and hypertension problems . The changes in (HU) between the diseased groups were found to be significantly different after applying the ANOVA test at $p<0.005$.
Liver can be reliably diagnosed using non-enhanced CT scans (HU) measures. This study is a trial to introduce this non-invasive radiologic study which may replace the more invasive liver biopsy in the future for accurate diagnosis.
Keywords: *Fatty Liver; Liver Disease, Computed Tomography, Non-Enhanced CT Scans*

I. Introduction

The Hounsfield scale (HU) or Computerized Tomography numbers (CT NO), is a quantitative scale for describing radio density. Normal liver (HU) is +40 to +60, fats−100 to −50, air-1000 and water is zero.[1] A practical application of this is in evaluation of tumors, where, an adrenal tumor with a radio density of less than 10 (HU) is rather fatty in composition and almost certainly a benign adrenal adenoma.[2]

Fatty liver disease is a very common condition, with a prevalence of 20–30% in the adult population [1] and 70% in diabetes patients [2]. Among patients who develop nonalcoholic steatohepatitis, half will evolve to fibrosis, 10–15% to cirrhosis and 5.4% to hepatic insufficiency [1].

Fatty liver may present with different patterns of deposition and sparing. Six patterns of liver steatosis: diffuse, geographic, focal, sub capsular, multifocal and perivascular. [3]The advancements in the medical imaging now allow the detection of this condition noninvasively while avoiding the use of invasive diagnostic liver biopsy. Though ultrasonography is widely used in clinical practice to image the liver without radiation exposure and make the diagnosis of fatty infiltration of liver, [9] Diffuse forms may be graded subjectively according to severity or quantitatively with magnetic resonance based methods [4].On unenhanced computed tomography (CT), liver density less than 40 Hounsfield units (HU) [5] or a density difference of more than 10 (HU) between spleen and liver indicates fatty liver [6]. Alternatively, liver parenchyma hypodensity relative to vessels establishes the presence of moderate to severe fatty liver disease [7]. On portal phase contrast-enhanced CT with a standardized protocol, a density difference greater than 25 (HU) between spleen and liver suggests fatty liver deposition [6]. CT with contrast material was previously thought to be less reliable in detecting fatty liver. However, recent data suggest that portal phase contrast-enhanced CT using blood-subtracted hepatic attenuation may have a similar accuracy to or even greater accuracy than unenhanced CT in the diagnosis of fatty liver [8].

Some unusual focal forms may be misdiagnosed as infiltrative or nodular liver lesions. Therefore, previous knowledge of their (HU) appearance may prevent unnecessary investigations or allow non-invasive diagnosis. Our study aimed to measure the HU for each liver segment to be as standard values for normal liver as segmental anatomy as well as to compare the (HU) of the segments in different hepatic disorders that may affected the liver attenuation.

II. Materials And Methods

1.1 Technique and interpretation

The present study was approved by the Ethics Committee of the Research council, College Of Medical Radiological Science. The abdominal CT images were analyzed regardless of clinical indication, in the period between May(2013) and February (2015), until the arbitrarily established number of 248 patients, 185 called “cases”, and 63 called “controls”, was reached ,utilizing non-contrast-enhanced CT as a reference imaging method. The Study was obtained at Madani Hospital (Radiology Department)

Sample included patients with mean age (51.25 ±18.88), Median (52.50), Minimum (12.00) Maximum (98.00) years old. Requests for abdominal CT were integrated in the present study. Exclusion criteria for the controls were the following: a) heterogeneous liver; b) patients with innumerable lesions in both liver lobes; c) images with artifacts .which would make density measurements inaccurate or unreliable.

In all patients, unenhanced axial CT images (7-mm slice collimation; 120 kVp; tube current, 280-320mA) were initially acquired through the Liver at the proximal level of the main portal vein. Attenuation values of the liver were measured on the operator defined circular or elliptic region of interest cursor. These regions of interest each encompassed were placed in approximately the same location on every slice, avoiding vessels and artifacts.

All the images were interpreted by single observer with three-year experience in imaging diagnosis. At the moment of the interpretation; none of the clinical data were available to the observer. The differentiation between the two groups (control and diseased) was based on the diagnostic criteria established for non-contrast enhanced CT, utilizing the analysis of hepatic attenuation values in Hounsfield units (HU).

2.2 Statistical Analyses

All data obtained in the study were documented and analyzed using SPSS program version16. Descriptive statistics, including mean ± standard deviation, were calculated. ANOVA test was applied to test the significance of differences, p-value of less than 0.05 was considered to be statistically significant.

I. TABLES

Table (1): Distribution of the study sample according to (Diagnosis):

Diagnosis	Frequency	Percentages (%)
Normal	185	74.6
Abnormal	63	25.4
Total	**248**	**100.0**

Table (2): Descriptive statistics of the Normal liver segments CT number (Measured in Hounsfield), and Liver SD of the control group (normal subjects)

CT Number of Liver Segments	N	Mean	Std. Deviation	Minimum	Maximum
Segment (1)	185	60.2162	±4.09	45.00	67.00
Segment (2)	185	59.5892	±5.29	30.00	68.00
Segment (3)	185	58.9946	±7.11	14.00	69.00
Segment (4)	185	59.6432	±4.85	32.00	67.00
Segment (5)	185	59.7838	±4.93	32.00	67.00
Segment (6)	185	59.7027	±4.92	32.00	68.00
Segment (7)	185	60.0108	±3.9	38.00	67.00
Segment (8)	185	59.7081	±4.94	32.00	68.00
Liver SD		15.39	±4.716	4.10	29.40

Table (3): Descriptive statistics of the liver segments CT number (Measured in Hounsfield) of the patient group

CT Number of Liver Segments	CT diagnoses	N (63)	Mean	STDV	Minimum	Maximum
Segment (1)	Liver Mass	16	43.18	13.24	28.00	60.00
	Liver Cirrhosis	7	19.85	7.67	13.00	32.00
	Fatty Liver	12	55.41	7.74	45.00	63.00
	Patients With Cardiac Problems	3	50.00	0.00	50.00	50.00
	Patients With Diabetes Problems	5	57.20	6.57	50.00	62.00
	Hepatitis	4	20.00	2.31	18.00	22.00
	Patients With Hypertension	5	53.40	2.19	51.00	55.00
	Obstruction	2	25.00	0.00	25.00	25.00
	Patients With Ascites	2	30.00	0.00	30.00	30.00
	Metastases	2	63.00	0.00	63.00	63.00
	Cancer	2	39.00	0.00	39.00	39.00
	Alcoholic Liver Disease	3	28.00	0.00	28.00	28.00
	Total	63	55.77	11.55	13.00	67.00
Segment (2)	Liver Mass	16	38.00	12.65	19.00	53.00

	Liver Cirrhosis	7	20.85	7.24	15.00	33.00
	Fatty Liver	12	55.75	3.91	50.00	59.00
	Patients With Cardiac Problems	3	60.00	0.00	60.00	60.00
	Patients With Diabetes Problems	5	57.00	2.74	55.00	60.00
	Hepatitis	4	14.50	0.58	14.00	15.00
	Patients With Hypertension	5	52.00	2.74	50.00	55.00
	Obstruction	2	18.00	0.00	18.00	18.00
	Patients With Ascites	2	19.00	0.00	19.00	19.00
	Metastases	2	53.00	0.00	53.00	53.00
	Cancer	2	40.00	0.00	40.00	40.00
	Alcoholic Liver Disease	3	12.00	0.00	12.00	12.00
	Total	63	54.67	12.79	12.00	68.00
Segment (3)	Liver Mass	16	38.00	12.66	19.00	53.00
	Liver Cirrhosis	7	24.28	15.47	12.00	55.00
	Fatty Liver	12	55.75	3.91	50.00	59.00
	Patients With Cardiac Problems	3	60.00	0.00	60.00	60.00
	Patients With Diabetes Problems	5	57.00	2.74	55.00	60.00
	Hepatitis	4	14.50	0.57	14.00	15.00
	Patients With Hypertension	5	52.00	2.74	50.00	55.00
	Obstruction	2	18.00	0.00	18.00	18.00
	Patients With Ascites	2	19.00	0.00	19.00	19.00
	Metastases	2	53.00	0.00	53.00	53.00
	Cancer	2	40.00	0.00	40.00	40.00
	Alcoholic Liver Disease	3	12.00	0.00	12.00	12.00
	Total	63	54.33	13.22	12.00	69.00
Segment (4)	Liver Mass	16	38.00	12.45	19.00	52.00
	Liver Cirrhosis	7	20.28	7.29	13.00	32.00
	Fatty Liver	12	55.58	3.08	52.00	59.00
	Patients With Cardiac Problems	3	50.00	0.00	50.00	50.00
	Patients With Diabetes Problems	5	57.80	1.09	57.00	59.00
	Hepatitis	4	15.50	0.57	15.00	16.00
	Patients With Hypertension	5	52.40	3.28	50.00	56.00
	Obstruction	2	18.00	0.00	18.00	18.00
	Patients With Ascites	2	20.00	0.00	20.00	20.00
	Metastases	2	50.00	0.00	50.00	50.00
	Cancer	2	38.00	0.00	38.00	38.00
	Alcoholic Liver Disease	2	12.00	0.00	12.00	12.00
	Total	63	54.58	12.65	12.00	67.00
Segment (5)	Liver Mass	16	38.00	12.45	19.00	52.00
	Liver Cirrhosis	7	19.85	7.67	13.00	32.00
	Fatty Liver	12	55.58	3.09	52.00	59.00
	Patients With Cardiac Problems	3	50.00	0.00	50.00	50.00
	Patients With Diabetes Problems	5	57.80	1.09	57.00	59.00
	Hepatitis	4	15.50	0.57	15.00	16.00
	Patients With Hypertension	5	52.40	3.28	50.00	56.00
	Obstruction	2	18.00	0.00	18.00	18.00
	Patients With Ascites	2	20.00	0.00	20.00	20.00
	Metastases	2	50.00	0.00	50.00	50.00
	Cancer	2	38.00	0.00	38.00	38.00
	Alcoholic Liver Disease	2	12.00	0.00	12.00	12.00
	Total	63	54.67	12.75	12.00	67.00
Segment (6)	Liver Mass	16	38.00	12.45	19.00	52.00
	Liver Cirrhosis	7	20.28	7.83	13.00	33.00
	Fatty Liver	12	55.58	3.08	52.00	59.00
	Patients With Cardiac Problems	3	50.00	0.00	50.00	50.00
	Patients With Diabetes Problems	5	57.80	1.09	57.00	59.00
	Hepatitis	4	15.50	0.57	15.00	16.00
	Patients With Hypertension	5	52.40	3.28	50.00	56.00
	Obstruction	2	18.00	0.00	18.00	18.00
	Patients With Ascites	2	20.00	0.00	20.00	20.00
	Metastases	2	50.00	0.00	50.00	50.00
	Cancer	2	38.00	0.00	38.00	38.00
	Alcoholic Liver Disease	2	12.00	0.00	12.00	12.00
	Total	63	54.62	12.69	12.00	68.00
Segment (7)	Liver Mass	16	37.68	11.85	18.00	53.00
	Liver Cirrhosis	7	21.28	6.57	15.00	32.00
	Fatty Liver	12	54.08	1.37	52.00	56.00
	Patients With Cardiac Problems	3	53.00	0.00	53.00	53.00
	Patients With Diabetes Problems	5	56.20	1.64	55.00	58.00
	Hepatitis	4	16.00	0.00	16.00	16.00

	Patients With Hypertension	5	51.00	2.73	49.00	54.00
	Obstruction	2	19.00	0.00	19.00	19.00
	Patients With Ascites	2	24.00	0.00	24.00	24.00
	Metastases	2	49.00	0.00	49.00	49.00
	Cancer	2	44.00	0.00	44.00	44.00
	Alcoholic Liver Disease	3	13.00	0.00	13.00	13.00
	Total	63	54.85	12.23	13.00	67.00
Segment (8)	Liver Mass	16	38.00	12.44	19.00	52.00
	Liver Cirrhosis	7	20.28	7.82	13.00	33.00
	Fatty Liver	12	55.58	3.08	52.00	59.00
	Patients With Cardiac Problems	3	50.00	0.00	50.00	50.00
	Patients With Diabetes Problems	5	57.80	1.09	57.00	59.00
	Hepatitis	4	15.50	0.57	15.00	16.00
	Patients With Hypertension	5	52.40	3.28	50.00	56.00
	Obstruction	2	18.00	0.00	18.00	18.00
	Patients With Ascites	2	20.00	0.00	20.00	20.00
	Metastases	2	50.00	0.00	50.00	50.00
	Cancer	2	38.00	0.00	38.00	38.00
	Alcoholic Liver Disease	3	12.00	0.00	12.00	12.00
	Total	63	54.62	12.70	12.00	68.00

Table (4): ANOVA Test of the liver segments CT number (Measured in Hounsfield) of the patient groups

CT Number of Liver Segments & Age		Sum of Squares	df	Mean Square	F	P value
Segment (1)	Between Groups	26023.24	14	2001.78	67.63	.000
	Within Groups	6925.563	234	29.59		
	Total	32948.80	248			
Segment (2)	Between Groups	32351.30	14	2488.56	71.88	.000
	Within Groups	8100.886	234	34.61		
	Total	40452.19	248			
Segment (3)	Between Groups	29765.21	14	2289.63	40.03	.000
	Within Groups	13381.67	234	57.18		
	Total	43146.88	248			
Segment (4)	Between Groups	32414.58	14	2493.43	81.81	.000
	Within Groups	7131.799	234	30.47		
	Total	39546.38	248			
Segment (5)	Between Groups	32886.41	14	2529.72	80.88	.000
	Within Groups	7318.125	234	31.27		
	Total	40204.54	248			
Segment (6)	Between Groups	32526.13	14	2502.01	80.26	.000
	Within Groups	7293.994	234	31.17		
	Total	39820.12	248			
Segment (7)	Between Groups	31634.91	14	2433.45	106.26	.000
	Within Groups	5358.561	234	22.900		
	Total	36993.48	248			
Segment (8)	Between Groups	32536.28	14	2502.79	79.816	.000
	Within Groups	7337.583	234	31.35		
	Total	39873.87	248			

III. Discussion and Conclusion

We examined scans of all participants in the study. The attenuation measurements of the 8 liver segments were available in all the normal subjects (185).The final analysis was performed on the normal Sudanese participants where images of liver was available on the CT scans ,this was presented in table (1, 2).The normal mean attenuation of the liver the segments from (1-8) were 60.2162±4.09, 59.5892±5.29, 58.9946±7.11, 59.6432±4.85, 59.7838, ±4.93, 59.7027±4.92, 60.0108±3.9, 59.7081±4.94 Hounsfield (HU) respectively where the liver SD mean values was 15.39±4.716.

There were ethnic differences present in the previous studies regarding liver CT (HU) changes as Caucasians and African Americans, Hispanics and Chinese. Our findings authenticate what was mentioned previously [10]

Fatty liver disease is a fairly common clinical entity in the general population. The advancements in the medical imaging now allow the detection of this condition noninvasively while avoiding the use of invasive diagnostic liver biopsy in asymptomatic patients. Our study showed that CT scanning may be a useful means of diagnosing liver fat and can be used in clinical and research settings. These measures are shown to be highly reproducible and easy to obtain. Prevalence of fatty liver in our Sudanese population was found to be 12 of the 63 patients (19%) of the sample. this value is similar to a study done previously [10]

The identification of liver fat by CT as a predictor of health risk was first described by Banerji et al. [11] and Goto et al. [12] in 1995. 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 (13).However, although extremely low (HU) values have been measured in livers infiltrated with fat, an overlap exists between normal and abnormal liver (HU) values (14).Table (2) and table (3) reflects the findings of the normal and diseased groups.

CT findings of the liver in hepatitis have been reported as follows: atrophy of the liver, localized, or diffuse decrease of CT number, dilatation of portal vein, splenomegaly, Ascites, shrinkage or disappearance of hepatic vein and increase of CT number during the recovery stage. [15,16,17,18].

Among the findings mentioned above, decreases of hepatic CT numbers are found in our study. We suggest that the changes in the segments CT Hounsfield are to be particularly important to estimate the therapy and to follow the clinical course of hepatitis this gives an important value in measuring CT number in cases of hepatitis this also was mentioned previously [15, 16, 18]

Therefore, measurement of a conventional parameter such as mean hepatic CT number of all segments might reflect the exact functioning reserve of the whole liver. In order to obtain a more reliable parameter by CT examination, we calculated the CT number of the 8 liver segments and evaluated its clinical significance. Among cases of hepatitis, CT (HU) was found to be the lowest in cases of hepatitis, Decreases of CT attenuation (HU) in hepatitis were highly significant when compared to controls.

The reduction of the mean CT (HU) in cases of metastases and cancers and liver masses can be justified as follows: The water content of the non-tumor region in livers with metastases had almost the same level as that of the normal livers. However, the water content of the tumor was higher than that of the normal livers. Moreover, in 2of 63cases in which a tumor was observed and 2 of 63 cases of metastases as well as 16 of 63 cases with liver masses at CT as a low density area, the water content was higher in the tumor than in the non-tumor region. These findings suggest that the increase in the water content of the tumor plays a major role in demonstration of this region as a low-density area on CT. the same justification was mentioned and found in a study done by Ueda J,et al.1988[19]

This previous study had mentioned that the increase in the water content, the decrease in the metal contents in the tumors, and the difference in the metals content between the tumors and non-tumor regions were considered to be factors associated with a low-density area of the tumors as observed on CT.[19]

Therefore our study suggested that water may be the factor that causes the tumors as a low-density area on CT. Computed tomography scan as one of the imaging modalities for the liver scan is widely used. Studies showed the CT are useful for determining the presence of underlying liver disease, and can be useful for excluding other causes of abnormal liver tests in patients who abuse alcohol such as infiltrative disease, obstructive biliary pathology and neoplastic diseases of the liver [20]. CT Imaging can also aid in the diagnosis of cirrhosis and can be used to screen for and identify tumors. In our study the CT scan was used and are able to diagnose all these disease and by measuring the CT (HU) values they showed valuable results and we can predict the changes by these measurement and the differences between groups was found to be significantly different after applying the ANOVA test (table 4).

Our study showed that hepatic steatosis was easily detected by a non-contrast CT scan which can be a particularly useful technique to detect fats in the liver also the result showed that CT (HU) can detect and quantify hepatic cirrhosis. Our results is consistent with the previous studies that mentioned the measurement of attenuation of the liver is used to identify and predict of hepatic steatosis[21,22] .

Alcoholic liver disease (ALD) is a general term used to refer to the spectrum of alcohol-related liver injuries [23,24].Excessive alcohol use is ranked as one of the top five risk factors for death globally[25] .Alcohol is a well established hepatotoxin associated with increased risk of development of ALD. Several risk factors have been identified for ALD including gender, ethnicity, age, obesity, co-existing chronic viral hepatitis, and other factor[26].Our study showed that 3out of 63 patients are with alcohol liver disease (4.8%) and shows changes in liver CT attenuation ;this was noticed in table (4). however our study didn't considered the gender or age or duration of consumption.

Changes have been shown to be associated with insulin resistance and are considered a part of the metabolic syndrome (27, 28). Studies are also looking at the association of changes with inflammatory markers and subclinical atherosclerosis, or cardiovascular evaluating its associations beyond the liver (29-31).Our study also suggested that the changes in the CT attenuation of the liver was detected in patients with cardiac problems, hyper tension and diabetes as seen in table(4)

Our study is a trial to introduce this non-invasive radiologic study which may replace the more invasive liver biopsy in the future for accurate diagnosis of liver diseases. Liver can be reliably diagnosed using non-enhanced CT scans (HU) measurements.

Acknowledgements

We sincerely thank the participants without whom the study would not have been feasible. The Sudan University of Science and Technology, College of Medical Radiological Science and Radiology Department – Madani Hospital Khartoum-Sudan are thankfully acknowledged.

References

[1]. Preiss D, Sattar N Non-alcoholic fatty liver disease: an overview of prevalence, diagnosis, pathogenesis and treatment considerations. Clin Sci (Lond) 115(5) (2008):141–150
[2]. Targher G, Bertolini L, Padovani R, Rodella S, Tessari R, Zenari L et al Prevalence of nonalcoholic fatty liver disease and its association with cardiovascular disease among type 2 diabetic patients. Diabetes Care 30(5): (2007) 1212–1218
[3]. Sanyal AJ, Chalasani N, Kowdley KV, McCullough A, Diehl AM,Bass NM et al Pioglitazone, Vitamin E, or placebo for nonalcoholic steatohepatitis. N Engl J Med 362(18): (2010) 1675–1685
[4]. Cassidy FH, Yokoo T, Aganovic L, Hanna RF, Bydder M,Middleton MS et al Fatty liver disease: MR imaging techniques for the detection and quantification of liver steatosis.Radiographics 29(1): (2009) 231–260
[5]. Boyce CJ, Pickhardt PJ, KimDH, Taylor AJ,Winter TC, Bruce RJ et al Hepatic steatosis (fatty liver disease) in asymptomatic adults identified by unenhanced low-dose CT. AJR Am J Roentgenol 194(3): (2010) 623–628
[6]. Alpern MB, Lawson TL, Foley WD, Perlman SJ, Reif LJ,Arevalos E et al Focal hepatic masses and fatty infiltration detected by enhanced dynamic CT. Radiology 158(1): (1986) 45–49
[7]. Hamer OW, Aguirre DA, Casola G, Lavine JE, Woenckhaus M,Sirlin CB (2006) Fatty liver: imaging patterns and pitfalls.Radiographics 26(6):1637–1653
[8]. Kim DY, Park SH, Lee SS, Kim HJ, Kim SJ, Kim MYet al.Contrast-enhanced computed tomography for the diagnosis of fatty liver: prospective study with same-day biopsy used as the reference standard. Eur Radiol 20(2): (2010)359–366
[9]. Patrick-Olivier Décarie & Luigi Lepanto & Jean-Sébastien Billiard & Damien Olivié ,Jessica Murphy-Lavallée & Claude Kauffmann & An Tang Fatty liver deposition and sparing: a pictorial reviewInsights Imaging (2011) 2:533–538
[10]. Irfan Zeb, Dong Li, Khurram Nasir, Ronit Katz, Vahid N.Larijani, , and Matthew J. Budoff, Computed Tomography Scans in the Evaluation of Fatty Liver Disease in a Population Based Study: The Multi-Ethnic Study of AtherosclerosisAcad Radiol. (2012)July ; 19(7): 811–818.
[11]. Banerji MA, Buckley MC, Chaiken RL, Gordon D, Lebovitz HE, andKral JG. Liver fat, serum triglycerides and visceral adipose tissue in insulin-sensitive and insulin-resistant black men with NIDDM. Int J Obes Relat Metab Disord 19: (1995)846–850,.
[12]. Goto T, Onuma T, Takebe K, and Kral JG. The influence of fatty liver on insulin clearance and insulin resistance in non-diabetic Japanese subjects. Int J Obes Relat Metab Disord 19: (1995)841–845,.
[13]. Ricci C, Longo R, Gioulis E, Bosco M, Pollesello P, Masutti F, Croce LS, Paoletti S, de Bernard B, Tiribelli C, and Dalla Palma L. Noninvasive in vivo quantitative assessment of fat content in human liver. J Hepatol 27: (1997)108–113,.
[14]. Pamilo M, Sotaniemi EA, Suramo I, Lahde S, and Arranto AJ.Evaluation of liver steatotic and fibrous content by computerized tomography and ultrasound. Scand J Gastroenterol 18: (1983)743–747,.
[15]. Moriwaki H, Ogiso K, Kumahara T, et al: Medical imaging of the liver in diffuse hepatic disorders. Kan Tan Sui (1982);5:121- 125
[16]. Yoshida H, Oyama M, Kumahara T, et al: Medical imaging and pathological findings of the liver in patient with fulminant hepatitis. Kan Tan Sui (1985);10:377-382
[17]. Komori H, Hirasa M, Ibuki Y, et al: Diagnostic value of liver scintigraphy, computed tomography and ultrasonography of acute hepatitis. Gastroenterol Endosc 1984;26:711-719
[18]. Kawano Y, Hayashi K, Futagawa S, et al: CT and scintigraphy in severe hepatic failure. J Med Imagings 1986;6:1087-1094
[19]. J. Ueda, Y. Kobayashi, Y. Kenko, H. Koike, T. Kubo, Y. Takano & K. Hara Distribution of water, fat, and metals in normal liver and in liver metastases influencing attenuation on computed tomography Acta Radiologica 29 (1988) Fax. 1pp33-39
[20]. Vilgrain V. Ultrasound of diffuse liver disease and portal hypertension. Eur Radiol 2001; 11: 1563-1577
[21]. Mortele KJ, Ros PR. Imaging of diffuse liver disease. Semin Liver Dis 2001; 21: 195-212
[22]. Piekarski J, Goldberg HI, Royal SA, Axel L, Moss AA. Difference between liver and spleen CT numbers in the normal adult: its usefulness in predicting the presence of diffuse liver disease. Radiology 1980; 137: 727-729 [PMID: 6934563]
[23]. O'Shea RS, Dasarathy S, McCullough AJ. Alcoholic liver disease. Hepatology 2010; 51: 307-328
[24]. European Association for the Study of the Liver. EASL clinical practical guidelines: management of alcoholic liver disease. J Hepatol 2012; 57: 399-420
[25]. World Health Organization. Global status report on alcohol and health 2011. Available from: URL: http://www.who.int/ substance_abuse/publications/global_alcohol_report/en
[26]. Anstee QM, Daly AK, Day CP. Genetics of alcoholic and nonalcoholic fatty liver disease. Semin Liver Dis 2011; 31: 128-146
[27]. Goto T, Onuma T, Takebe K, Kral JG. The influence of fatty liver on insulin clearance and insulin resistance in non-diabetic Japanese subjects. Int J Obes Relat Metab Disord. 1995; 19(12):841–5.
[28]. Zelber-Sagi S, Nitzan-Kaluski D, Halpern Z, Oren R. Prevalence of primary non-alcoholic fatty liver disease in a population-based study and its association with biochemical and anthropometric measures. Liver Int. 2006; 26(7):856–63
[29]. Lucero D, Zago V, Lopez GI, et al. Pro-inflammatory and atherogenic circulating factors in nonalcoholic fatty liver disease associated to metabolic syndrome. Clin Chim Acta. 2011; 412(1-2):143–7.
[30]. Crum-Cianflone N, Krause D, Wessman D, et al. Fatty liver disease is associated with underlying cardiovascular disease in HIV-infected persons(*). HIV Med. 2011
[31]. Targher G, Arcaro G. Non-alcoholic fatty liver disease and increased risk of cardiovascular disease. Atherosclerosis. 2007; 191(2):235–40.