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Quantitative Assessment of Liver Fat in an Obese Patient Population Using Non-contrast CT Fat Percent Index

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Abstract

Objective—To develop a simplified method to quantify liver fat using CT fat % index (CT_{FPI}) compared to liver spleen method (CT_{L/S}, CT_{L-S})

Methods—Non-contrast CT of the liver was performed in 89 patients (overweight, obese, severely obese) to quantify fat, using: CT_{FPI} = [(65-patient HU)/65] × 100, normal liver = 65 HU.

Results—There was strong linear correlation between CT_{FPI} and the standard method of assessing liver fat using CT_{L/S} (r = -0.901), CT_{L-S} (r = -0.911). Hepatic HU and CT_{FPI} were significantly different in the severely obese group compared to other two groups (p < 0.05).

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Conclusion—Significant correlation indicates equal diagnostic accuracy of the two methods in appropriately calibrated scanners.

Keywords

Non-contrast CT; Hepatic steatosis assessment; Metabolic syndrome; Fat percent index; Obesity; NASH

Introduction

The incidence of obesity in the United States population over the past two decades has risen from 22.9% to 37.5% [1, 2]. This increase in obesity has resulted in a rise in atherosclerosis, type II diabetes, hyperglycemia, insulin resistance, hypertension, coronary artery disease and fatty infiltration of the liver, also termed non alcoholic steatohepatitis [1, 2]. Hepatic steatosis, typically classified as nonalcoholic fatty liver disease (NAFLD), has a spectrum ranging from microsteatosis which progresses to macrosteatosis when the accumulation of fatty acids and triglycerides compress the nucleus. NAFLD may also progress to steatohepatitis, steatonecrosis and even cirrhosis [3, 4]. Approximately 20–30% of patients with NAFLD have histological signs of fibrosis indicating the presence of nonalcoholic steatohepatitis (NASH) [5–9]. NAFLD is associated with all of the components of the metabolic syndrome which is also highly prevalent in the population (22%) and varies by age, sex, postmenopausal status and ethnicity [10]. NAFLD is also relevant to the increasing liver transplantation practice of today as the presence of significant steatosis is a major cause of primary non function (PNF) in the recipient [11, 12].

For many years the most reliable determination of the fat content of the liver has been made from needle biopsy which may require hospital stay and is associated with a small but significant risk of complication [13, 14]. New quantitative non-invasive imaging techniques using ultrasound (US), magnetic resonance imaging (MRI) and non-contrast computed tomography (CT) offer alternatives to quantify liver fat while avoiding complications associated with biopsy. In the clinical setting, biopsy and histology for estimating fat content has been used as the gold standard. Chemical shift imaging and gradient echo techniques with MRI may be a more appropriate non invasive method because it can separate fat, copper and iron overload in hemochromatosis; however, MRI is costly, time consuming and has not been widely performed [15–17].

Quantitative CT has the capability to quantify the degree of the fat content in the liver by using liver attenuation in Hounsfield unit (HU) in a given volume of interest. Liver fat percentage can be determined by using a calibration phantom with known concentrations of simulated fat/liver tissue. In addition, the scanner must also be checked daily for accuracy in the expected HU using various materials including water in an appropriate phantom. Alternatively, dual energy CT and the attenuation of abdominal organs such as the spleen, portal vein or aorta compared to the HU derived from the liver can be used [18–25]. Kodama et al. [24] has demonstrated excellent results using unenhanced CT versus enhanced studies. Liu et al. [20] has proposed an equation to determine liver fat in patients with > 5% fat. The equation modifies HU attenuation data with the patients BMI to correlate

HU values with hepatic macrovesicular steatosis (HMS). More recently, Speliotes et al. [21] used a calibrated phantom and spleen as internal reference standard and demonstrated the CT measurement of the fatty liver to be reproducible. Shores et al. [22] have demonstrated excellent correlation of liver fat with liver-spleen ratio ($CT_{L/S} = \text{mean hepatic HU} / \text{mean splenic HU}$) as well as liver-spleen attenuation difference ($CT_{L-S} = \text{mean hepatic HU} - \text{mean splenic HU}$). They report excellent correlations between CT_{L-S} and liver triglyceride concentration distributed widely from 54–2,203 mg/g of liver protein as determined from needle and wedge liver biopsy [22].

In this pilot study, we report a simplified approach for the estimation of liver fat using this formula: CT liver fat percent index $CT_{FPI} = [(65 - \text{HU patient}) / 65] \times 100$ in properly calibrated CT scanners. The CT_{FPI} can be calculated immediately and included in the clinical report. We have selected 65 as the normal value of HU based upon the work of Kodama et al. [24] who showed that the HU for biopsy-proven 0% fat was 64.4 ± 3.1 HU and the work of Pickhardt et al. [25] who showed that HU values for normal liver ranged between 60–70 HU. We have used this approach to quantify the relative liver fat in a group of overweight and obese patients and compared it to the accepted method of multiple regions of interest (ROI) using the spleen and aorta as reference organs as demonstrated by others [19, 22, 24, 25].

Materials and Methods

Patient Selection

In the period from September 2009 to April 30 2012, 291 patients were studied by computed tomography for assessment of liver fat in the NIH NHLBI SCCOR Grant (Targeting Metabolic Syndrome, Inflammation and Vascular Remodeling, P50-HL083813 (HEARTS Trial). All patients provided written consent on the protocol approved by the Institutional Review Board at the Beth Israel Deaconess Medical Center. In the current report, a total of 89 patients (76 males and 13 females) were selected based on criteria of BMI category of over weight, obese and severe to assess the degree of hepatic fat.

Inclusion criteria included subjects with at least 3 of the 5 components of the metabolic syndrome (ATPIII guidelines [26]); presence of established coronary artery disease including at least one of the following: previous myocardial infarction, stable angina, at least one > 50% narrowing of one coronary artery, abnormal exercise tolerance test or nuclear imaging procedure, angioplasty or documentation of coronary atherosclerosis at prior CT scan. Exclusion criteria included; allergy to contrast material or shell fish, creatinine ≥ 1.6 mg/dl or abnormal liver function test (AST or ALT > 3 times the upper limits of normal).

MDCT Scanning

Patients were scanned using the Aquilion-One 320 row-detector CT (Toshiba, Nasu, Japan) in the supine position after calibration of the scanner each morning with a Toshiba Quality Assurance phantom composed of air -995 ± 20 , bone mineral 340 ± 10 , oral contrast 130 ± 10 , tissue 100 ± 10 , fat -105 ± 10 and water 0 ± 5 HU densities, each with ROI of 25 mm². The non enhanced liver was scanned at 135 kVp in a helical (64 row, 0.5 mm detector)

mode using 350 mA, gantry rotation 350-msec, large field of view to accommodate patient size (FOV 330–400) with voxel 0.42mm^3 – 0.61mm^3 and slice thickness of 3.2 cm with pitch factor 1.484. Quantitative accuracy of the scanner was tested daily using the Toshiba lucite body- phantom with tubes for water, pure fat, tissue, bone and air with no deviation of linearity. Images were reconstructed in 5 mm slices and transferred to ADW 4.3 (General Electric, Waukesha, WI) work station for analysis. The mean effective CT dose was $24.4\text{ mGy} \times 0.015 = 3.6\text{ mSv}$. Although there was no difference in HU values between 120 kVp and 135 kVp at 350 mA using the Toshiba calibration scanner, we repeated the same values scanning our RM 457 “solid water” phantom (Gammex-RMI, Middleton, WI). The phantom contains separate tubes representing concentrations of 25%, 35%, 50% and 60% fat. We then transferred the findings for analysis to the vitrea work station (Vital Images, Minnetonka, MN) (Figure 3 a,b).

Quantitative measurements

The 3.2 mm slices were reconstructed into 5mm slices at the imaging work station and sent to GE PACS (General Electric) work station and Vital Images work station. The CT fat percent index (CT_{FPI}) in the liver (proportional to fat volume) is calculated as a percentage below the reference attenuation of 65 HU for reference liver by:

$$\text{CT}_{\text{FPI}} = [(65 - \text{HU}_{\text{patient}}) / 65] \times 100$$

The HU of 65 is the reference value and it represents the CT value of liver with normal fat [25]. HU values below 65 will have an index (CT_{FPI}) that reflects the percent change from the reference normal HU value varying according to HU values above and below 65 (Table 1). To determine fat content, an area in the mid section of the liver was selected to avoid the chest area with the liver and spleen on the same slice if possible. However, on occasion the spleen could be in a higher or lower position predicated a slightly different level for spleen ROIs. A total of six regions of interest (ROIs) were taken in the liver from segments II, III, IV near the junction of V–VI/VII–VIII [27] while three ROIs were taken in the spleen and one in the aorta. All liver ROIs varied from 220 mm^2 to 280 mm^2 depending upon size of the aorta and configuration of the spleen. The ROIs in the liver and spleen were taken to avoid fatty areas outside these organs and adjacent to bone as in the spleen and aorta also keeping in mind the hemoglobin values of the aorta [28]. The liver-spleen ratio ($\text{CT}_{\text{L/S}}$) and liver-spleen difference ($\text{CT}_{\text{L-S}}$) were calculated to compare the HU density of both organs. The same measurements were repeated for the CT liver/aorta ratio ($\text{CT}_{\text{L/A}}$) and the liver-aorta difference ($\text{CT}_{\text{L-A}}$).

Two experienced independent readers analyzed the same set of data independent of each other and blinded to patient characteristics for inter-reader variability. One reader repeated the analysis to determine intra reader variability.

Statistical Analysis

Categorical data are presented as counts and percentages. Continuous data are presented as mean $\pm$ standard deviation and had no significant violations of normality. Differences across the three categories of BMI were evaluated using the f-test and differences between the

categories were evaluated using the Bonferroni correction for multiple comparisons. Inter- and intra-observer variation was assessed using Pearson correlation. The absolute difference between separate observations is also presented. The relationship between other continuous parameters was evaluated using Pearson correlation and standard linear regression. Statistical analysis was performed using SAS for Windows (v9.3, Cary, NC, USA).

Results

A total of 89 subjects, 76 (85%) men and 13 (15%) women, with mean age 62 ± 7 years and mean BMI of 32.4 ± 4.3 were studied. There were 28 (31%) subjects in the overweight BMI category (mean BMI 27.7 ± 1.3), 31 (35%) subjects in the obese group (mean BMI 31.9 ± 1.5) and 30 (34%) in the severely obese category (mean BMI 37.5 ± 1.8 , Table 2).

The mean splenic HU and the mean aortic HU values were not significantly different between the three BMI groups ($p=0.38$ and $p=0.66$, respectively) (Table 3). In contrast, the liver HU values and the liver fat percent index were significantly different for the three BMI categories $p=0.003$ (Table 3). The value for the liver HU measurement was significantly lower in the severely obese category compared to the other weight categories ($p<0.05$). Similarly, CT_{FPI} demonstrated a significantly larger value for the estimation of liver fat for the severely obese category compared to the other weight categories ($p<0.05$).

The mean liver spleen ratio ($CT_{L/S}$) was 1.05 ± 0.22 and the mean liver spleen difference (CT_{L-S}) was 2.29 ± 10.56 . The mean liver aorta ratio ($CT_{L/A}$) was 1.27 ± 0.29 and the mean liver aorta difference (CT_{L-A}) was 7.60 ± 10.33 . For each of these measures, the value for those subjects in the severely obese category was significantly smaller compared to the other weight categories (Table 4).

There was a strong linear relationship of CT_{FPI} with $CT_{L/S}$ ($r = -0.901$), CT_{L-S} ($r = -0.911$), $CT_{L/A}$ ($r = -0.731$) and CT_{L-A} ($r = -0.873$) (Figures 1 & 2).

Figure 3 shows excellent correlation of the HU values across the 4 tubes representing different fat components in the phantom. The difference in HU values between 120 kVp and 135 kVp varied from 0.6 HU, 2.0 HU, 0.7 HU and 1.7 HU across the phantom demonstrating that both scanning values (120 kVp and 135 kVp) are comparable, (Figure 3 a,b, Table 5). Figure 4 shows that the HU density ranges from 23 HU to 40 HU throughout the liver in one individual.

Evaluation of inter and intra-observer variability showed very good correlation with minimal differences in the measurements (range 0.89 to 0.99; table 6).

Discussion

Although ultrasound and MRI can be used to estimate the degree of hepatic steatosis, ultrasound is limited by its qualitative nature and MRI is time-consuming and expensive. Therefore, non-contrast CT may be the preferred non-invasive method to aid in the clinical diagnosis and management [18, 20, 22]. Previous attempts to estimate the degree of liver fat have compared CT findings with a histological diagnosis and graded into mild, moderate

and severe disease [29–31]. Kodama et al [24] compared the amount of hepatic fat at liver biopsy to that estimated from non-contrast CT. He showed that liver attenuation of 40 HU predicted hepatic fat content for moderate to severe steatosis of approximately 30% and HU of 30 for 50% hepatic fat content. Moreover, the HU for biopsy-proven 0% fat was a mean of 64.4 ± 3.1 . Our value for 30 HU estimates liver fat per cent to be similar (53.85 %) however our 40 HU is slightly higher, 38.46 %. Most studies have used the constant relationship between liver and spleen defined as the spleen having an attenuation of minus 10 HU compared to the liver. The relationship comparing the liver HU with the spleen HU using the L/S ratio ($CT_{L/S}$) and L-S difference (CT_{L-S}) has also shown excellent correlation with fat content with histology and liver tissue samples, Shores et al [22]. Using these parameters ($CT_{L/S}$) and (CT_{L-S}), one can reliably comment upon the status of the liver condition [18–20]. More recently, Shores et al [22] have used 200–500 mg wedge biopsies from the left hepatic lobe and correlated the value of liver triglyceride to values obtained from the $CT_{L/S}$, CT_{L-S} ($r = -0.79$, $p < 0.001$) and histology for macrosteatosis ($r = -0.88$, $p < 0.001$).

In the current study, we used a simple fat percent index formula to estimate the % fat content of the liver with non-contrast CT. We used a reference value of 65 HU for the normal liver because it is the average of the range of 60 to 70 reported by others [21, 24, 25, 32] and because Kodama et al [24] showed that the HU for biopsy-proven 0% fat was 64.4 ± 3.1 HU. We chose 65 rather than 70 because 70 may include iron deposition suggested by Pickhardt et al. [25] and demonstrated by Liu et al [20].

The average hepatic HU value in our three study groups ranged from 54.9 ± 6.6 for the overweight group to 46.1 ± 13.9 for the severely obese group with a significant difference only in the severely obese group, $p = 0.003$, compared to the other two groups. Likewise, the liver fat percent index was significantly higher in the severely obese group ($p = 0.003$) compared to the other two groups. The difference of HU values for the spleen and aorta did not reach significance, $p = 0.376$ and 0.661 respectively (table 3).

We then compared the ratios and differences of the liver to the spleen ($CT_{L/S}$ and CT_{L-S}) and aorta ($CT_{L/A}$ and CT_{L-A}) in the three BMI groups. A significant difference was found only for the severely obese group in comparison to the overweight and obese groups, $p = < 0.001 - 0.006$ (table 4). The correlation between $CT_{L/S} / CT_{FPI}$ ($r = -0.90$) and CT_{L-S} / CT_{FPI} ($r = -0.91$) were excellent. (Figure 1 a,b), a finding suggesting similar diagnostic accuracy between the hepatic HU and the liver/spleen measurements. Also an excellent correlation was found between $CT_{L/A} / CT_{FPI}$ ($r = -0.73$) and CT_{L-A} / CT_{FPI} ($r = -0.87$) demonstrating the utility of aortic HU as an internal reference standard if spleen HU cannot be used as in splenectomized patients (Figure 2 a,b)

The $CT_{L/S}$ ratios in our overweight and obese groups (1.13 ± 0.14 & 1.1 ± 0.17) are similar to those reported by Iwasaki et al [33] for mild to moderate steatosis, a finding suggesting that our overweight group has mild steatosis (liver fat percent index of 15.6 ± 10 %) and the obese group has moderate steatosis (liver fat percent index of 18.4 ± 7.9 %). Also, the $CT_{L/S}$ ratio of 0.93 ± 0.27 in our severely obese group is consistent with the results of Iwasaki et al [33], a finding suggesting that this group has > 30 % fat. The mean liver-spleen difference in

the severely obese group was -3.82 ± 13.01 which is different from a level of -9 reported for severe steatosis by Park and others [19]. In our severely obese group, 9 of the 11 subjects had an HU < 40 . In this group of 9 subjects, the HU values were 9 HU to 39 HU with an average fat percentage of 40 to 85%. The remaining 2 of the 11 subjects appeared to be outliers with an average liver HU of 66 to 73, respectively, which translated to a negative fat percent of -1% and -12% using our formula. The negative fat percentages can be explained by a possible deposition of iron or other confounding factors which may increase liver attenuation and under estimate CT based fat percent. The values for these two subjects may account for the difference in the mean liver-spleen difference in our group of severely obese compared to that of Park et al. [19].

Although there are established criteria for grading severity of hepatic steatosis [29–31], an accurate and consistent method is needed to screen for hepatic steatosis and to assess progression of clinical disease in individual patients. Hepatic steatosis can best be described as heterogeneous - homogeneity which is depicted by variations in (ROI) density from close and adjacent areas in liver parenchyma that is reflective of histology. These variations reflect the heterogeneous distribution seen microscopically and are supported by our findings shown in Figure 3 which demonstrates the heterogenous nature of hepatic steatosis with areas ranging from 23 HU to 40 HU throughout the liver. This heterogeneity in the distribution of hepatic fat is one reason we were interested in developing a method to quantitate % hepatic fat content with non-contrast CT. Our findings suggest that non-contrast CT may be a better technique to assess fat content as compared to needle biopsy which has the limitations of one or two sample sites which are inadequate for a disease that is not homogenous [6, 12, 13].

Most centers report use of 120 kVp; however, others have shown similar results using 140 kVp [22, 34]. We selected 135 kVp for higher energy photons, to attain greater penetration in obese patients that facilitates less noise and better image quality compared to 120 kVp in our institution which has 0.5 mm detectors. Thus, there may be a slight variation in our values compared to those using 120 kVp. To evaluate the possible difference in attenuation values we separately scanned our RM 457 “hard water” phantom using 120 kVp and 135 kVp. The HU attenuation values varied from 0.6 HU, 2.0 HU, 0.7 HU and 1.7 HU across the four tubes containing fat and were not significantly different. Tube current was maintained at 350 mA (Figure 3 a,b, Table 5). Selection of tube current is also not standard with variation between 200, 350 and 400 mA [21, 22, 33]. The slice thickness for analysis has varied from 2.5 to 5 mm [20, 22, 25, 33, 35]. Acquisition of the data is either step-and-shoot or helical scanning with pitch factor of 1.48 or 1.5. Beam collimation is also an important factor. Studies have included scanners using 8, 16 and 64-row detectors with voxel 0.42 mm^3 – 0.61 mm^3 . In addition, the spatial resolution of all scanners is excellent. The resolution of our 320-row detector scanner is 0.45 mm with good 175 msec temporal resolution and little or no tissue motion.

Thus, in spite of the variation in imaging techniques, the data is reasonably consistent for estimating the degree of steatosis based on HU values using $CT_{L/S}CT_{L-S}$ [21, 22] because of the spatial resolution of the scanner. The value of each ROI is a true reflection of histology in a non fat containing organ such as the spleen or a fat containing organ such as

the liver. There is variation in the degree of fat throughout the liver resulting in variation in HU value for each of the six ROIs with the average value being selected (Figure 4). We as others [21, 22,24, 35] believe the liver/spleen ratio is an important reference for liver fat and the aorta can serve as a reference if the spleen is absent. The field size of an ROI varies from 220 to 280 mm² which is 2.2 to 2.8 times the field of view of 200 × microscopic lens. The ROIs thus offer an advantage over one sample by needle biopsy as multiple areas can be sampled non-invasively. In addition, the ROI method is reproducible and has been correlated with tissue samples [21, 22].

We acknowledge that our study is based only on HU values and have selected 65 HU since it bridges the value 60–70 HU [24, 25] to avoid iron, glycogen, copper and fibrosis as confounding factors. Liver biopsies could not be justified in our study because our patients were undergoing CT angiography for coronary artery disease and did not have symptomatic liver disease. Using our formula, our values are similar to the values of Kodama with 40 HU being sufficient to predict hepatic fat content of 30% and 30 HU for 50% hepatic fat content. The advantage of this technique is to arrive at a reasonably accurate estimation of fat percentage in a reportable numeric value that can be used immediately in the clinical setting. The CT_{FPI} method is convenient as it avoids the issue of calculating indices which then require a metric such as liver biopsy or comparison to a linear plot to relate to fat quantity. The ROI method and HU density is an actual representation of fat content in each ROI that can be calculated from the simple formula.

A limitation of our study is that it does not give absolute values for fat per cent in grams per cubic millimeters. Furthermore our approach may not be accurate with CT scanners that are not calibrated daily for accuracy and consistency in the HU. Further studies are needed to compare the method we have used with MRI, or histopathology from liver biopsies.

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Figure 1a : $CT_{L/S} / CT_{FPI}$ ($r = -0.90$, $p < 0.001$)

Figure 1b : CT_{L-S} / CT_{FPI} ($r = -0.91$, $p < 0.001$)

Figure 1.

Figure 1a: Correlation of liver spleen index ($CT_{L/S}$) to liver fat percent index (CT_{FPI}).

Figure 1b: Correlation of liver spleen difference (CT_{L-S}) to liver fat percent index (CT_{FPI}).

Figure 2a : $CT_{L/A} / CT_{FPI}$ ($r = -0.73$, $p < 0.001$)

Figure 2b : CT_{L-A} / CT_{FPI} ($r = -0.87$, $p < 0.001$)

Figure 2.

Figure 2a: Correlation of liver aortic index ($CT_{L/A}$) to liver fat percent index (CT_{FPI}).

Figure 2b: Correlation of liver aortic difference (CT_{L-A}) to liver fat percent index (CT_{FPI}).

Fig 3a **Fig 3b****Figure 3.**

Figure 3a: Comparison of Phantom HU values scanned at 120kVp and 135kVp

Figure 3b: Comparison of Phantom fat% measured at 120kVp and 135kVp

Figure 4.

CT (135 kVp) through the mid section of liver selected to include the spleen. Note areas of hypodensity consistent with focal fat deposits ranging from 23.8 ± 22 HU to 40.0 ± 20 HU.

Table 1Hounsfield Units / fat percent indices (CT_{FPI})

CT Hounsfield Units	CT _{FPI}
0	100
5	92.30769
10	84.61538
20	69.23077
30	53.84615
40	38.46154
50	23.07692
60	7.692308
65 *	0
> 70 **	

* Normal liver HU

** HU values above 70 may be related to fibrosis, iron or copper overload.

Table 2

Demographics of population

	Overweight (BMI 25–29.9)	Obese (BMI 30–34.9)	Severely Obese (BMI 35)	P value
Subjects	28	31	30	
Gender (M:F)	25:3	24:7	27:3	0.362
Mean Age (years)	64 ± 6	62 ± 8	60 ± 7	0.134
Mean BMI (kg/m²)	27.7 ± 1.3 *	31.9 ± 1.5 *	37.5 ± 1.8 *	<0.001

* Significantly different compared to the other categories of weight (p<0.05).

Table 3Quantification of liver fat by CT_{FPI} method

	Overweight	Obese	Severely Obese	p-value
Splenic HU	48.7 ± 3.5	48.4 ± 4.3	49.9 ± 5.4	0.38
Aortic HU	41.6 ± 6.2	40.1 ± 5.3	41.1 ± 7.4	0.66
Hepatic HU	54.9 ± 6.6	53.1 ± 7.9	46.1 ± 13.9*	0.003
Liver fat% (CTFPI)	15.6 ± 10.1	18.4 ± 12.2	29.1 ± 21.4*	0.003
Hemoglobin (mg/dl)	14.48 ± 1.09	14.21 ± 0.94	14.23 ± 0.86	0.607

* Significantly different compared to the other categories of weight (p<0.05).

Table 4

Comparison of L/S, L-S, L/A, L-A

	Overweight	Obese	Severely Obese	P value
Liver/Spleen Ratio (CT_{L/S})	1.13 ± 0.14	1.10 ± 0.17	0.93 ± 0.27*	<0.001
Liver-Spleen Difference (CT_{L-S})	6.19 ± 7.09	4.70 ± 7.79	-3.82 ± 13.01*	<0.001
Liver/Aorta Ratio (CT_{L/A})	1.34 ± 0.21	1.34 ± 0.24	1.14 ± 0.36*	0.006
Liver-Aorta Difference (CT_{L-A})	10.89 ± 7.12	10.23 ± 8.09	1.79 ± 12.47*	<0.001

* Significantly different compared to the other categories of weight (p<0.05).

Table 5

Phantom HU values and fat% at 120kVp and 135kVp

120 kVp HU	59.3±16	45.8±15	22.8±14.7	6.4±15.6
120 kVp Phantom Fat %	8.7	29.5	64.9	90.1
135 kVp HU	59.9±13	43.8±13.2	23.5±15.7	7.5±22.6
135 kVp Phantom Fat %	7.8	32.6	63.8	88.4

Table 6

Inter- and Intraobserver agreement

	Interobserver		Intraobserver	
	Correlation	Difference	Correlation	Difference
Hepatic HU	0.97	0.24 ± 2.70	0.99	0.15 ± 1.67
Liver Fat%	0.97	0.37 ± 4.16	0.99	0.22 ± 2.57
L/S Ratio	0.94	0.00 ± 0.08	0.98	0.01 ± 0.05
L/A Ratio	0.89	0.00 ± 0.14	0.94	0.01 ± 0.11