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RESEARCH ARTICLE

Using Abdominal CT Data for Visceral Fat Evaluation

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Background: Quantitative assessment of body fat is important for the diagnosis and treatment of diseases related to obesity, Computed tomography (CT) becoming the standard procedure for measuring the abdominal fat distribution.
Material and method: The retrospective study included 111 inpatients, who underwent routine abdominal CT exams in the Radiology Laboratory of SCJU Tg.Mures (2013). MPR MDCT (SOMATOM AS 64) data was processed using a custom written MATLAB R2009b software, ImageJ being used for tracing of the visceral fat area (VFA). Patient data (including blood glucose, cholesterol and triglycerides) were analyzed using MO Excel and GraphPad Inprism5.
Results: Visceral Fat percentage varied in population from 14.59–68.69 (SD = 11.83) with significant difference between sexes (male vs. female, 46.98 vs. 31.62, p <0.05). Cholesterol values >220 mg% and triglycerides >150 mg% are significantly associated with the VF percent (p <0.05). Overall there is a weak correlation between the lab variables and the measured fat, the strongest one being between triglycerides and the VFA (r = +0.23) and between age and VFA percentage (certain samples).
Conclusions: The technique used should decreases the human error in marking of the fat areas providing a better estimation of the VF/VF percentage. CT measured VF relates with certain lab tests. Further analysis, is required for a better use of CT in obesity related pathology diagnosis and treatment.

Keywords: computed tomography, obesity, visceral fat, MATLAB, ImageJ

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Introduction

Body fat quantitative assessment is important for the diagnosis, treatment and prognosis [1] of diseases related to obesity. The standard obesity evaluation methods such as weight and height ratio, waist and hip circumference ratio, and subcutaneous fat thickness by clipper, have a weak point that they do not measure body fat quantitatively, computed tomography being proven [2–4] as a better measure of metabolic risk [5]. In addition to quantitative assessment of body fat, there is a need of assessment of visceral fat since it has been proven as a negative prognostic factor in surgery [6] and metabolic obesity complications [7].

Computed tomography (CT) is becoming the standard procedure for measuring the abdominal fat distribution, various methods [8,9] and software being used [3,9,10].

The CT images are displayed as a grayscale, using the Hounsfield Unit (HU) scale – a linear transformation of the original linear attenuation coefficient measurement in one in which the radiodensity of distilled water at standard pressure and temperature (STP) is defined as zero Hounsfield units (HU), while the radiodensity of air at STP is defined as –1000 HU.

In our study we opted for a free software, NIH ImageJ being considered for a consistent [11] quantification of the fat tissue and measurements.

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Material and method

The retrospective study was performed on 111 inpatients, analyzing data obtained from routine abdominal CT examinations in the Radiology Laboratory of the County Emergency Clinical Hospital of Tîrgu Mureş. Subjects were randomly selected in order to include a wide range of muscular mass and visceral fat, informed consent was obtained upon hospital admission.

Computed Tomography (SOMATOM AS 64 MDCT, Siemens Medical Solutions, Forchheim, Germany) was performed with all subjects supine (120 kV, 200 mAs, slice thickness of 3 mm, 1 mm pitch, with adaptable field of view and 1 mm reconstruction interval using the default kernel – B31 Medium Smooth).

Multiplanar reconstructions (MPR's) were done as part of the diagnostic protocol and, with regards of both clinical and literature visceral fat measurements, we choose a section linking the posterior-inferior aspect of L4/L5 intervertebral disc and the umbilicus.

Acquired images were processed using a custom written MATLAB R2009b (Mathworks, Natick, MA, USA) software by creating a histogram with –30 and –190 HU bordering, using the standard fat-differentiation procedure. In order to simplify the procedure, the images were further processed, assigning to all the pixels outside of interval the value of 0 and 100 to those corresponding to fat (2 bit images).

Using the free NIH image processing tool (Image J) we traced the contour of visceral fat area(VFA) and total fat

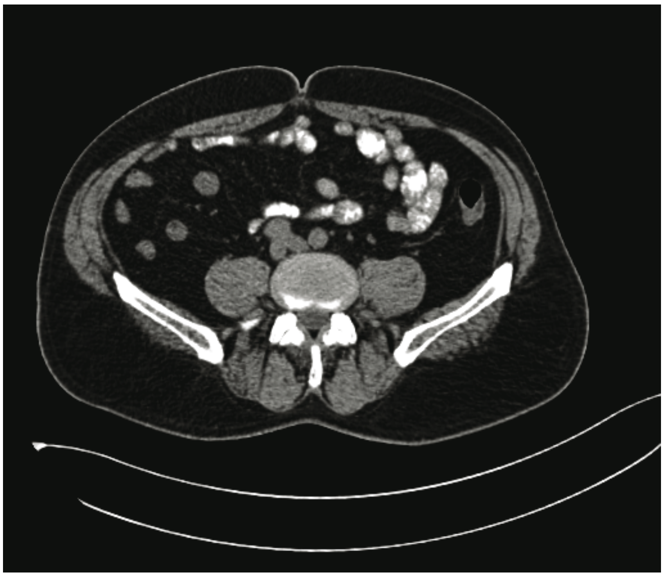

Fig. 1. Multiplanar reconstruction linking the posteroinferior aspect of the L4/L5 joint and the umbilicus- the approximate line used for measuring abdominal circumference. The image is visualized using abdominal window/level settings (60/400). Abdominal and visceral fat is interlaced with both bone and muscular structures. The tracing of the visceral fat is difficult. Below the patient is noted the scanner table (its data was removed in the final phase).

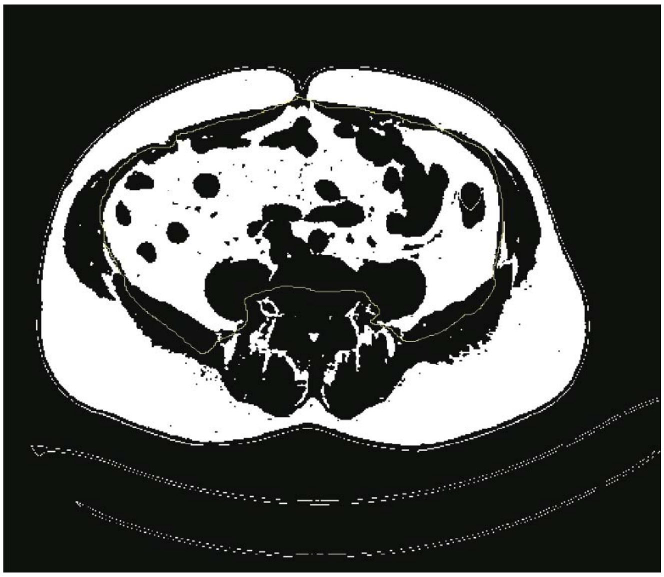

Fig. 2. Post-process image. The fat has become clearly distinguishable using the protocol bordering (-30 to -190 Hounsfield Units) and the image is ready to be processed. ImageJ. Marking of the visceral fat (VF) preparing the selected region for analysis.

area(TFA) measuring the pixel surface of corresponding areas of interest. The subcutaneous fat area (SFA) was computed as the difference between TFA and VFA.

Patient data (including blood sugar, cholesterol and TG) were statistically analyzed using MS Office Excel and GraphPad Inprism 5.

Results

While the Visceral Fat percentage varied in population from 14.59 to 68.69 (SD = 11.83), we found that males tended to have a statistically significant larger VF percentage (46.98 vs. 31.62, $p < 0.01$).

Due to the assignment of patient selection, although the proportion of males vs. females was close to 1, we found that in the group where the visceral fat percentage was between 40 and 50%, the females highly outnumbered the males (more than 2:1).

Also in the group with high VF proportion (>60% of total abdominal fat) we found that the patients from urban areas were four times as much as those from rural areas. We can consider this as a result of a better addressability of the urban population affected by obesity.

There was a statistically significant difference between the visceral fat in males vs. females ($p < 0.05$).

When grouped by VF% both cholesterol and TG average have shown a heterogeneous distribution, with highest variability coefficient being in for the TG values of subjects with more than 60% visceral fat. On the opposite, the middle values (closed to 50% of VF) have shown the highest homogeneity.

Our data shown association between the average VF percent and cholesterol values higher than 220 and the median VF percent and serum triglyceride higher than 150 ($p < 0.05$).

Overall there is a weak correlation between the laboratory data and the measured fat, the strongest one being between TG and the VF surface ($r = +0.23$).

The limitations we encountered were due mainly to the randomness of patients being included in the study; being a retrospective study, there was no control on the laboratory tests that we performed (not all the patients had all three tests — blood sugar, triglycerides and cholesterol).

Discussions

While almost three decades passed since the beginnings of the abdominal fat evaluation by CT, there have been enor-

Table I. Demographic data

Visceral Fat Percentage	Average Age (SD)	Male/Female proportion	Urban/Rural proportion
<30%	59.61 (11.98)	0.12	1.8
30–40%	64.81 (14.28)	0.52	1.29
40–50%	63.5 (12.58)	2.25	1.89
50–60%	60.2 (12.35)	N/A	1.14
60–70%	67.8 (10.5)	N/A	4
TOTAL	62.6 (12.87)	0.95	1.59

Table II. Visceral Fat percentage by age (males versus females)

Age	Males	Females
30–40 years	38.84 (4.65)	21.31 (6.83)
41–50 years	46.83 (7.92)	28.43 (7.51)
51–60 years	45.48 (12.24)	28.87 (8)
61–70 years	46.32 (10.11)	30.31 (7.53)
71–80 years	55.34 (10.56)	33.31 (8.04)
over 80 years	47.74 (7.16)	39.72 (3.23)
Grand Total	46.98 (10.09)	31.62 (8.12)

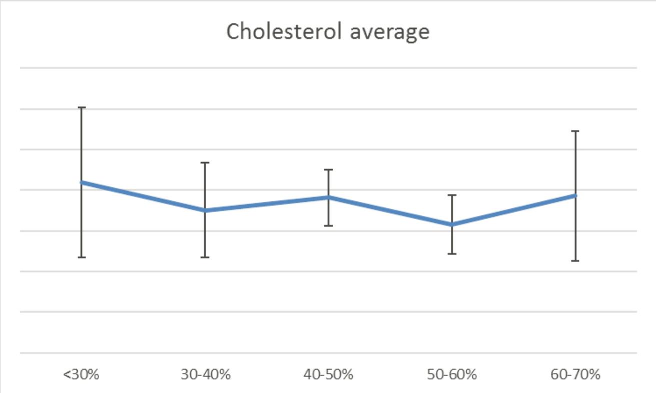

Fig. 3. Average Cholesterol values (SD) with regards to VF percentage

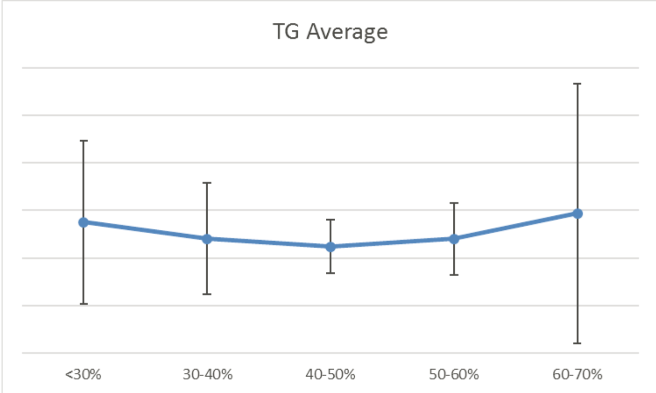

Fig. 4. Average Triglycerides values (SD) with regards to VF percentage

mous improvements in the acquisition technique, leading to a decrease in dose and improvement of spatial resolution [3]. There is still no consensus on the appropriate protocol to be used [4,12].

The protocol we're proposing is a new one and has the advantage of using free software [13] for abdominal fat segmentation. The values used for segmentation (–30 to –190 Hounsfield Units) were the most common used in literature, but the range for fat tissues HU differs according to authors.

We have to accept certain limitations of our protocol: while the access to data was easy (the study being based on examination performed routinely in the CT department, we have to admit the lack of anthropometric measurements, of which the waist circumference and weight would have been of high importance. Nevertheless, it has been proven that CT evaluation is superior to waist measurement [4], visceral fat area thresholds and CT images being used in a wide range of pathologies, ranging from cancer research [14] to cardiovascular diseases [15].

Conclusions

We consider that our technique (assigning 2 bit values to fat/non-fat pixels) decrease the human error in marking of the fat areas providing a better estimation of the VF and VF percentage.

Visceral fat measured by CT (whether regarded quantitative or as proportion of total fat) relates with certain blood tests.

Further analysis, including different blood tests and clinical data are required for a better understanding of the CT role in obesity related pathology diagnosis and treatment.

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References

1. Fox CS, Massaro JM, Hoffmann U, et al. Abdominal visceral and subcutaneous adipose tissue compartments: association with metabolic risk factors in the Framingham Heart Study. Circulation. 2007;116(1):39-48.
2. Kim S, Lee GH, Lee S, et al. Body fat measurement in computed tomography image. Biomed Sci Instrum. 1999;35:303-8.
3. Seidell JC, Bakker CJ, van der Kooy K. Imaging techniques for measuring adipose-tissue distribution – a comparison between computed tomography and 1.5-T magnetic resonance. The American Journal of Clinical Nutrition. 1990;51(6):953-7.
4. Kim YJ, Lee SH, Kim TY, et al. Body Fat Assessment Method Using CT Images with Separation Mask Algorithm. Journal of Digital Imaging. 2013;26(2):155-162.
5. Ng AC, Wai DC, et al. Visceral adipose tissue, but not waist circumference is a better measure of metabolic risk in Singaporean Chinese and Indian men. Nutrition & Diabetes. 2012;2(8):e38.
6. Ballian N, Lubner MG, Munoz A, et al. Visceral obesity is associated with outcomes of total mesorectal excision for rectal adenocarcinoma. J Surg Oncol. 2012;105(4):365-70.
7. Kissebah AH, Vydelingum N, Murray R, et al. Relation of Body Fat Distribution to Metabolic Complications of Obesity. Journal of Clinical Endocrinology & Metabolism. 1982;54(2):254-260.
8. Direk K, Cecelja M, Astle W, et al. The relationship between DXA-based and anthropometric measures of visceral fat and morbidity in women. BMC Cardiovascular Disorders. 2013;13(1):25.
9. Jensen MD, Kanaley JA, Reed JE, Sheedy PF. Measurement of abdominal and visceral fat with computed tomography and dual-energy x-ray absorptiometry. The American Journal of Clinical Nutrition. 1995;61(2):274-8.
10. Jensen MD, Kanaley JA, Roust LR, et al. Assessment of body composition with use of dual-energy x-ray absorptiometry: evaluation and comparison with other methods. Mayo Clinic Proceedings. 1993;68(9):867-873.
11. Irving BA, Weltman JY, Brock DW, et al. NIH ImageJ and Slice-O-Matic computed tomography imaging software to quantify soft tissue. Obesity (Silver Spring). 2007;15(2):370-6.
12. Yoshizumi T, Nakamura T, Yamane M, et al. Abdominal Fat: Standardized Technique for Measurement at CT1. Radiology. 1999;211(1):283-286.
13. Ferreira T, Rasband W. ImageJ User Guide. 2012; Available from: http://imagej.nih.gov/ij/docs/guide/.
14. Doyle SL, Bennett AM, Donohoe CL, et al. Establishing computed tomography–defined visceral fat area thresholds for use in obesity-related cancer research. Nutrition Research. 2013;33(3):171-179.
15. Kamimura MA, Carrero JJ, Canziani ME, et al. Visceral obesity assessed by computed tomography predicts cardiovascular events in chronic kidney disease patients. Nutr Metab Cardiovasc Dis. 2012.