OBESITY ASSESSMENT USING IMAGEJ AND MATLAB PROCESSED ROUTINE ABDOMINAL COMPUTED TOMOGRAPHY DATA

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Abstract: The present paper represents a research into the problem of devising cheaper software needed to elaborate a measurement methodology for quantifying visceral fat and creating a tool for standardizing visceral fat measurement as a valid measurement. In this respect we consider promoting the inclusion of VF measurements in the regular computed tomography report. It is a cost-effective and scalable method, though not so laborious, using both free and low cost commercial available software.

Keywords: obesity assessment, visceral fat measuring, computed tomography

Background

Obesity represents a health issue world-wide, being one of the leading morbidity causes and, in association with other risk factors, one of the most alarming mortality sources.

Obesity diagnosis/evaluation implies clinical methods, the international guidelines mentioning anthropometric indices (waist circumference, body mass index) but also paraclinical measurements (triglycerides, cholesterol, HDL-cholesterol and blood glucose being the most important ones).

An important part of the total body fat content is the abdominal fat, composed of subcutaneous and visceral fat. The latter is a recognized cardiovascular risk factor with an influence on the quality of life and its duration. Therefore, it is an important parameter to be evaluated as part of the obese patient’s management.

Various methods are used for quantifying visceral fat: dual X-ray absorptiometry, magnetic resonance, ultrasound or computed tomography. The latter has been considered as the election method in recent years.

Dedicated software tools are being used for the measurement of the visceral fat via computed tomography. These are developed by the companies producing radiology equipment. They are specific for each equipment, without the possibility of communication between them. The values are obtained by measuring the radiodensity values of fat and by mapping them on CT sections. Unfortunately, these facts lead to a small number of options and to a non-competitive mechanism that resulted in high financial burden for the paraclinical contractors.

Hypothesis

Our main hypothesis was the question if there is possible, using open-source and cheaper software to elaborate a measurement methodology that replicates the results of proprietary software.

As part of our secondary objectives we considered the relations between the visceral fat and some laboratory values and (in the long term) using our in-house developed tools in order to standardize visceral fat measurement as a valid measurement tool (including the calculation of standard values for visceral fat percentage).

Material and method

The convenience sample we used included patients examined in Radiology and Medical Imagining Laboratory of Tg.Mures Clinical Emergency Hospital during February-may 2013 which had also underwent laboratory examinations for cholesterol, triglyceride and blood sugar. Age, sex and location were recorded also, the patients being identified with a unique ID.

The patients referred for various pathologies, underwent routine abdominal computed tomography exams, using the same acquisition protocols (120 kV, 200 mAs, slice thickness of 3 mm, 1 mm pitch) on a 64 slice Siemens Somatom AS Computed tomography system.

Multiplanar reconstructions were obtained using the default kernel- B31 Medium Smooth with an oblique section between the anterior-superior aspect of the L4 vertebrae and the umbilicus. Due to various sections being described in literature we considered as optimal the section parallel to the one used by clinicians in measuring the abdominal circumference.

Figure 1.

Sagittal Multiplanar reconstruction. With blue- the oblique plan used for Multiplanar reconstruction. On the sagittal incidence are visualized, among others, the heart, aorta and SMA, liver, pancreas, lower thoracic, lumbar and superior sacral vertebral bodies and abdominal fat.

The reconstruction provided us with a 512x512 pixels image saved in DICOM format, as a grayscale image, each pixel of the representing the radiodensity of corresponding tissue (Hounsfield values). As fat HU varies between -190 and -30 UH we imported our data into Matlab in order to process the images further.

With a cycle, as part of the workout protocol, we modified the values of the pixels, so that each pixel that corresponds to fat values would become 1 and the rest would become 0, obtaining a “binary” image with a great differentiation between fat and non-fat structures.

Figure 2

Pre-processed axial image. Since using different window levels produces different grayscale images it's difficult to differentiate with high certitude the abdominal and visceral fat

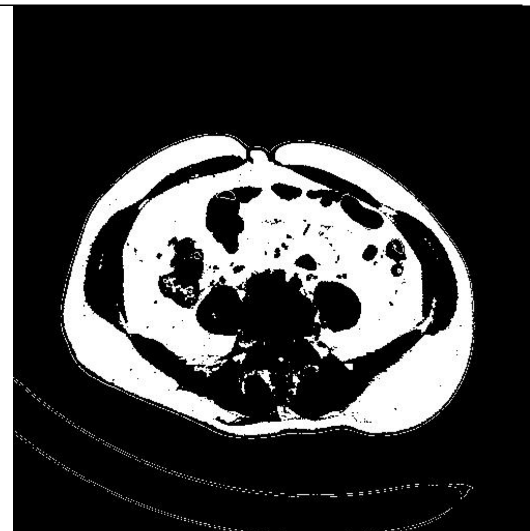

Figure 3.

Post-processed axial image. The abdominal and visceral fat are with high contrast differences allowing an easier visualization of fat structures.

Using ImageJ, a free Java software, developed by National Institute of Health, the contour for visceral fat and total was outlined and the pixels counted so that further calculations were possible (in order to compute the visceral fat as proportion of total fat).

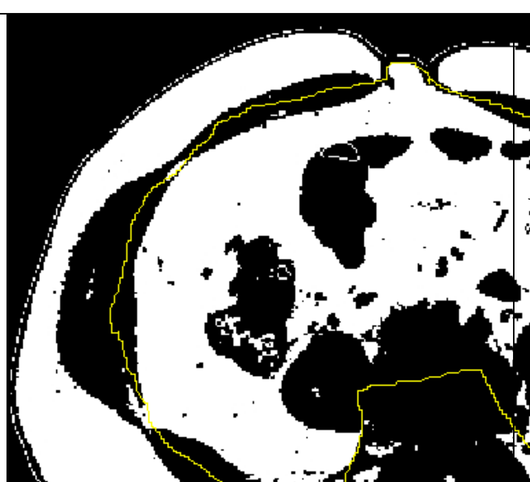

Figure 4

Detail: Visceral fat (marked area in ImageJ).

As a second step all the abdominal fat was selected and the VF% calculated.

Data, saved as number, was saved in a CSV file and later joined with other pre-recorded data in a MS Office worksheet for further statistical analysis.

Statistical analysis was performed using the data analysis tool from MS Office Excel.

Results

Our sample contained patients between 33 and 89 years of age, with a predominance of males (M:F= 1.15). Presumably due an easier access to high performance examinations the number of patients residing in urban were more frequent than those from rural areas (U:R=2.29).

	Urban	Rural
F	61.76(12.94)	69.78(12.14)
M	59.68(13.95)	65.5(9.27)

Table 1. Average age (standard deviation) of the sample as distributed by residence and sex.

The lab tests were found to be normal for most of the patients, with 43% having high blood sugar, 12.5% higher triglycerides (some risk) and for 16.04% we found an high cholesterol

- Glycaemia
  - Within normal limits for 32 patients (<110 mg/dl)
- Cholesterol
  - Normal: 35 patients (<200 mg/dl)
  - Borderline 12 patients (200-240)
  - High: 9 patients
- Triglyceride
  - Normal: 44 patients (<150 mg/dl)
  - Slightly above normal: 5 patients (150-199 mg/dl)
  - Some Risk: 7 patients (200-500 mg/dl)

The visceral fat as measured by our technique ranged from 15.27 to 68.69% with an average of 40.22%. There were statistical significant differences with $p<0.01$ between males (average of 48.82, standard deviation 9.71) and females (average of 30.29, standard deviation 7.76). The residence had little importance for VF percentage, providing no significant differences between patients residing in urban or rural areas (average of 40.32 vs. 39.97).

Age group	31-40	41-50	51-60	61-70	71-80	over 80
F	n/a	21.71(7.79)	28.88(7.56)	29.62(6.72)	33.33(5.37)	39.43(3.79)
M	39.33(6.47)	52.54(9.93)	49.46(6.99)	48.47(10.39)	52.66(14.35)	44.44(6.64)

Table 2. Visceral fat percentage as distributed by sex and age group.

As part of the statistical protocol we statistical significant associations between high cholesterol (over 200 mg/dl and VF% of more than 50%) and high triglyceride (over 150mg/dl and VF over 40%), both with a $p<0.05$.

Discussion

In our study we focused on developing a new approach, with a cost-effective method for visceral fat measuring, using routine computed tomography abdominal examinations and proven [1] free software.. Although several methods have been developed [2-5], using ultrasonography or MR imaging those are seldom used due reproducibility issues (ultrasonography) or higher costs (magnetic resonance). The regular anthropometric measurements (waist circumference, body mass index) are not always accurate[6] in evaluation of abdominal fat compartments.

The standard CT abdominal examination is evaluated using various window levels, displaying a grayscale with pixel values representing corresponding to radiodensity values. Due to human eye's inability to differentiate more than 64 shades of gray the evaluation is performed varying the window level in order to achieve the maximum resolution for the organ of interest.

In evaluating and establishing the Hounsfield Units value for the visceral fat we found large discrepancies in current literature; however even performing our work according to the most recent data we cannot exclude possible errors due to supposed individual variations.

Title	Lower margin (Hounsfield Units)	Upper margin (Hounsfield Units)
Adipose tissue volume determinations in women by computed tomography: technical considerations.[7]	-190	-30
Imaging techniques for measuring adipose-tissue distribution--a comparison between computed tomography and 1.5-T magnetic resonance.[8]	-190	-30
	-130	-10
	-125	-15
Subcutaneous Abdominal Fat and Thigh Muscle Composition Predict Insulin Sensitivity Independently of Visceral Fat[9]	-190	-30
Measurement of abdominal and visceral fat with computed tomography and dual-energy x-ray absorptiometry.[5]	-149+/- 12	68 +/- 7
Subcutaneous and visceral fat distribution according to sex, age, and overweight, evaluated by computed tomography.[10]	-250	-50
Establishing computed tomography–defined visceral fat area thresholds for use in obesity-related cancer research[11]	-150	-50
Visceral fat accumulation as a predictor of coronary artery calcium as assessed by multislice computed tomography in Japanese patients[12]	-150	-50
Abdominal Fat: Standardized Technique for Measurement at CT[13]	-190	-30

As previous studies have proved, further analysis, including different blood tests and clinical data are important for a better understanding of the computed tomography examinations in obesity related pathology diagnosis and treatment.

Conclusions

Measuring visceral fat, with all its compartments represents a useful tool in the obese patient's evaluation. We consider promoting the inclusion of VF measurements in the regular computed tomography report. Using our method for abdominal visceral fat we obtained results consistent with those from current literature. Our workout provided a cost-effective and scalable method, using both free and low cost commercial available software. Although with a more laborious procedure we can provide the clinician with useful information leading to a better patient management.

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