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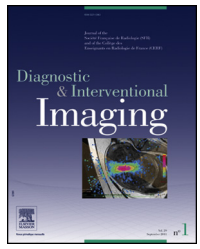

ORIGINAL ARTICLE / *Gastrointestinal imaging*

Quantification of the visceral and subcutaneous fat by computed tomography: Interobserver correlation of a single slice technique

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KEYWORDS
Computed tomography;
Subcutaneous fat;
Visceral fat;
Area;
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Abstract
Purpose: To assess the interobserver reproducibility of the quantification of the visceral and subcutaneous fat by computed tomography from an umbilical slice and study the effect of the level of the slice (slice going through the navel versus a slice going through disc L3—L4).
Materials and methods: Forty-four breast cancer patients who had a CT-scan were included in this study. This is a double blind (junior versus senior) retrospective study to determine the interobserver reproducibility. A junior observer studied the variation between two levels of slice by selecting an image going through L3—L4 and the navel.
Results: The measurement of the fat obtained from an umbilical slice seemed to be well correlated and consistent with that obtained from a slice with a disc reference (L3—L4). The interobserver reproducibility is good for the quantification of the umbilical fat (Spearman and Lin at 0.9921 and 0.985 [$P < 0.001$] for the visceral fat).
Conclusion: The interobserver reproducibility of the single slice CT-scan measurement going through the navel (easily detected) is excellent and may therefore be used in oncology as a predictive tool to measure a characteristic of the host and not the tumor.

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Obesity, and more specifically the accumulation of visceral fat, is a factor of risk associated with a great many cancers [1,2]. It is also associated with a higher risk of recurrence after treatment [3] and death [4,5]. Visceral fat is even thought to be a factor of risk independent of the development of cancer of the colon and pancreas [6].

More recently, visceral fat has been shown to be the first predictive biomarker of the efficacy of antiangiogenics in cancer of the colon and kidney [7,8]. Its evaluation is therefore of major importance in the treatment.

Several studies have been carried out on the methodology to quantify and measure abdominal fat by computed tomography [9—15]. In particular, a calculation based on a single slice area has been shown to be sufficient [16]. In some studies, the naval was used as a point of reference [9,11,13—15] while in others, a bone or disc was used as point of reference [17,18]. As far as we are aware, the interobserver reproducibility of the calculation of the area of visceral fat by computed tomography has never been studied in the literature. However, it is a basic element in the reliability of a predictive marker.

The purpose of this study is to assess this interobserver reproducibility by computed tomography from an umbilical slice and study the effect of the level of the slice on the quantification of the fat by comparing this umbilical area with that of one going through disc L3—L4.

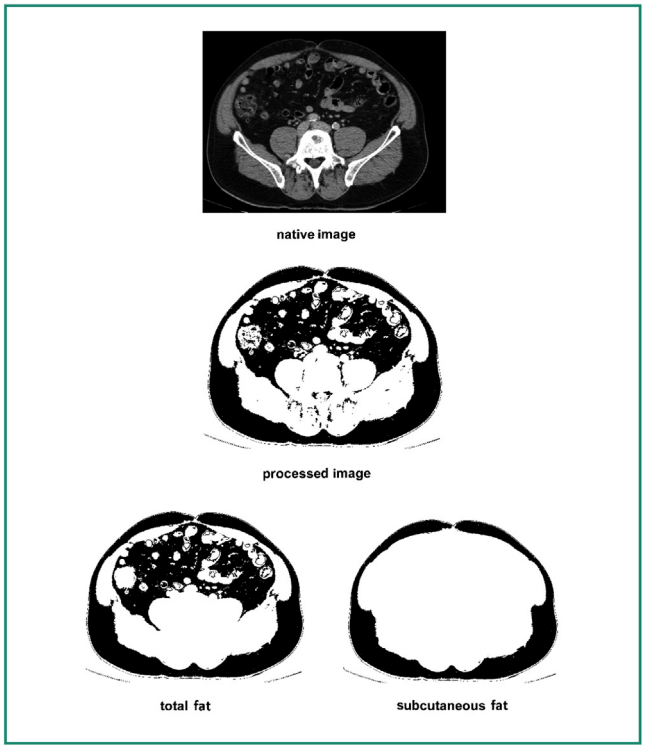

Figure 1. Computed tomography image in axial slice passing through the navel showing the different steps in the calculation of the total fat and subcutaneous fat after segmentation of the fat density pixels (−190 HU to −30 HU) with Image J software. The visceral fat is obtained by subtraction.

Materials and methods

Eligible patients

In a study on the antiangiogenic treatment of breast cancer, forty-four successive patients with histologically-proven breast cancer benefited from pre-therapeutic computed tomography imaging and were thereby included in this study. These patients provided their written consent to use the clinical data and imaging while respecting their anonymity.

This is a double blind retrospective study (junior versus senior) on interobserver reproducibility. The variation between two areas was studied by a single junior observer who selected an image going through L3—L4 and an image through the navel.

Measurement of the visceral and subcutaneous fat

The segmentation of the fat was determined by computer tomography (CT) before treatment on the entire abdomen in patients placed in decubitus dorsal. The two levels of slice were selected, at the umbilical level and at L3—L4, enabling single slice segmentation of the fat. The images acquired were then post processed with Image J software (http://rsb.info.nih.gov/ij/). With this software, it was possible to measure the pixels in densities between −190 and −30 Hounsfield units (HU) in order to define the fat compartments (subcutaneous, visceral) and define an area in mm^2 for each of them (Figs. 1 and 2).

Statistical analysis

The main purpose of this study was to show that a CT slice passing through the navel was a reproducible method in the determination of the area of visceral fat.

The slice passing through disc L3—L4 was chosen because it represents the limit of the upper abdomen, a fixed marker by definition (disc marker). The upper levels from T12—L2 were not selected because the liver is a too big part of the image, thereby limiting the study of the visceral fat. As to the lower levels, as of L5, this is the area of subcutaneous fat which is highly influenced by the fat from the buttocks.

The navel level has been validated in several studies [9,11,13—15] and is very easily found during the scrolling of the axial slices (as opposed to the inter-vertebral discs). For this reason, this level was used to study the visceral fat. For certain authors, the position of the navel may vary according to the patient's morphotype.

The mean, minimum and maximum values of the area of total, subcutaneous and visceral fat were compared. Their coefficient of correlation (Spearman's coefficient) and the concordance (Lin's coefficient) were also studied.

Results

Comparative study of two levels of slice with different markers

The total fat (Fig. 3), subcutaneous fat (Fig. 4) and visceral fat (Fig. 5) as well as their correlation (Spearman's coeffi-

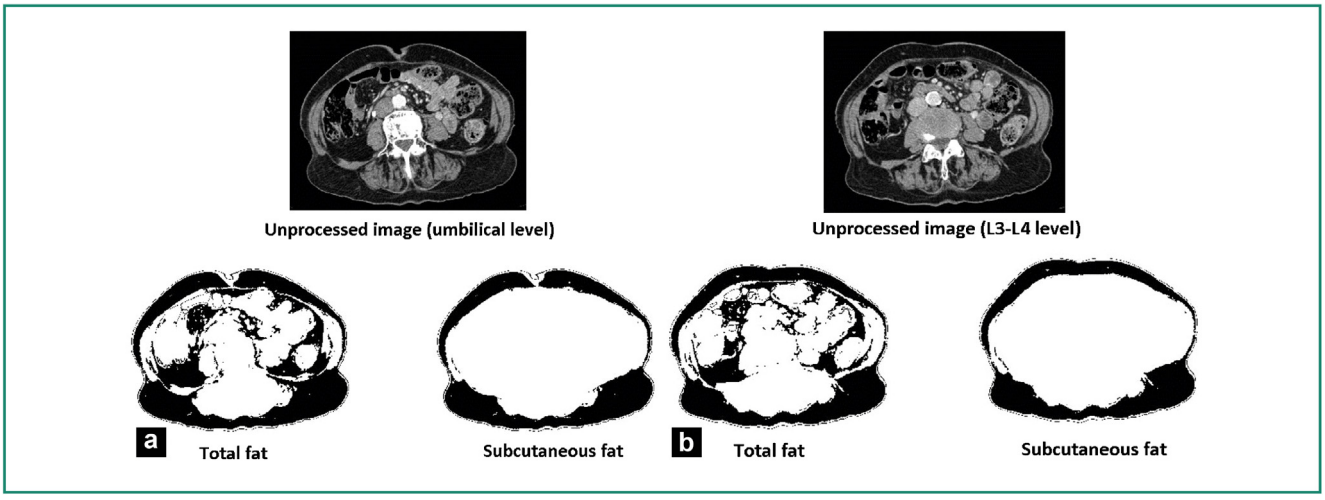

Figure 2. Computed tomography images in axial slice passing through the navel (a) and L3—L4 disc (b) with results after segmentation of the fat density pixels with Image J software and determination of the total and subcutaneous fat. The visceral fat is obtained by subtraction.

Table 1 Areas of total, subcutaneous and visceral fat assessed at the slice passing through the navel and by a L3—L4 disc reference.

		Mean (min—max)	Coef. Correl. (Spearman)	Coef. Concord. (Lin)
Total fat	Navel	40,059 mm^2 (6456—81,498 mm^2)	0.9215 ($P < 0.0001$)	0.903 ($P < 0.001$)
	Disc L3—L4	35,786 mm^2 (6168—69,841 mm^2)		
Subcutaneous fat	Navel	27,431 mm^2 (5425—64,003 mm^2)	0.8778 ($P < 0.0001$)	0.832 ($P < 0.001$)
	Disc L3—L4	23,212 mm^2 (5000—47,355 mm^2)		
Visceral fat	Navel	12,636 mm^2 (1031—32,508 mm^2)	0.9376 ($P < 0.0001$)	0.930 ($P < 0.001$)
	Disc L3—L4	12,574 mm^2 (955—34,293 mm^2)		

Coef.: coefficient; Correl.: correlation; min: minimum; max: maximum.

cient) and concordance (Lin's coefficient) are presented in Table 1.

The measurement of the fat determined from an umbilical slice seems to be well correlated and well concordant with that determined from a slice with a L3—L4 disc marker (fix by definition).

Study of the interobserver reproducibility

The total fat (Fig. 6), subcutaneous fat (Fig. 7) and visceral fat (Fig. 8) obtained by each observer as well as the study of their correlation (Spearman's coefficient) and their concordance (Lin's coefficient) are presented in Table 2.

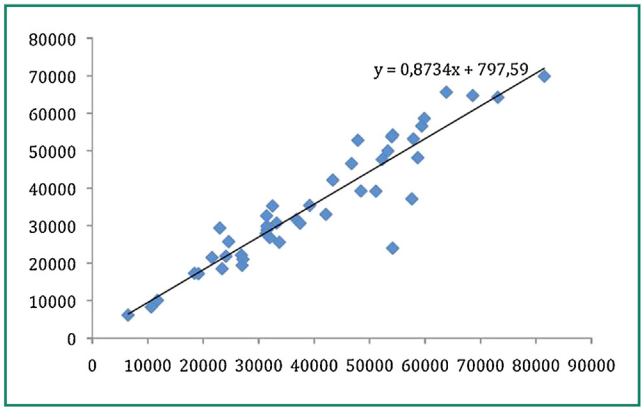

Figure 3. Correlation between the umbilical slice and the L3—L4 disc (total fat vs. total fat).

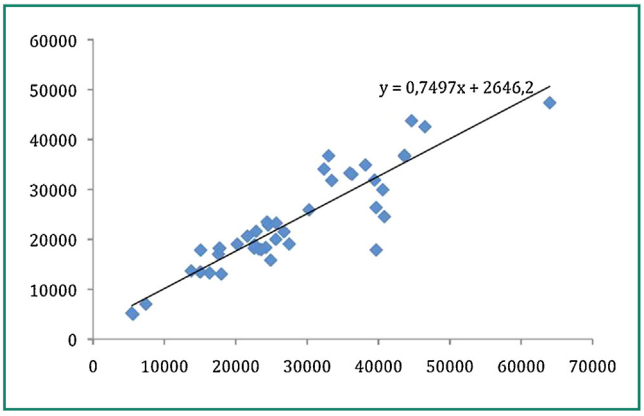

Figure 4. Correlation between the umbilical slice and the L3—L4 disc (subcutaneous fat vs. subcutaneous fat).

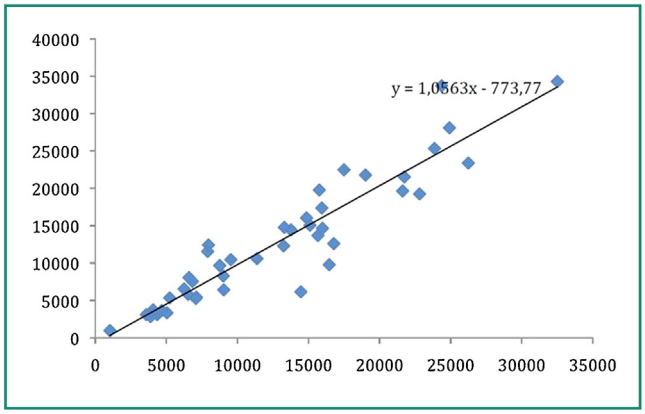

Figure 5. Correlation between the umbilical slice and the L3—L4 disc (visceral fat vs. visceral fat).

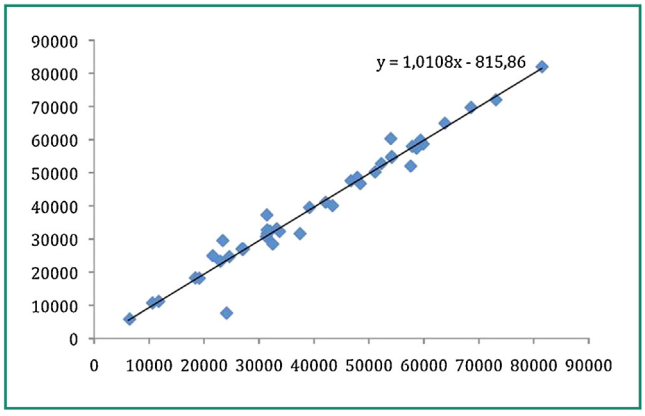

Figure 6. Interobserver correlation for the umbilical slice (total fat vs. total fat).

The interobserver reproducibility is good for the quantification of the fat at the navel level.

Only one point on these different curves does not appear to be correlated and concordant. This involves the unblinding of one patient for which the observers analyzed two CT-scans obtained at different dates.

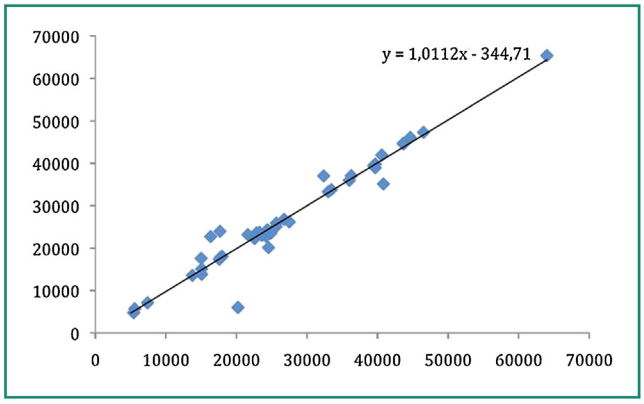

Figure 7. Interobserver correlation for the umbilical slice (subcutaneous fat vs. subcutaneous fat).

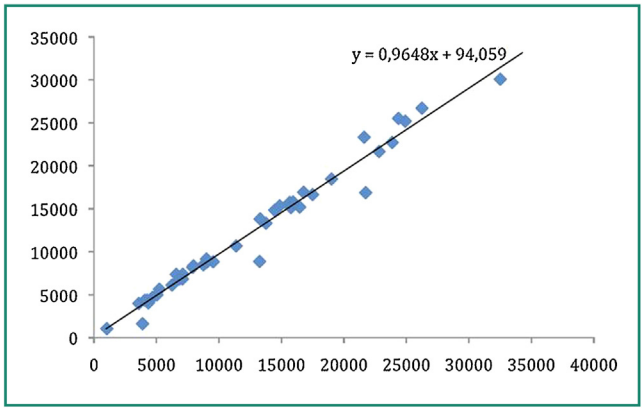

Figure 8. Interobserver correlation for the umbilical slice (visceral fat vs. visceral fat).

Discussion

Obesity is now considered to be a factor of risk for a great many cancers. The increased incidence may in part account for their increase [2]. Abdominal fat and, in particular, the visceral contingent contain ''metabolically active'' adipocytes that secrete pre-angiogenic and proliferative adipokins (proteins secreted by the adipose tissue). These endocrine and paracrine secretions in part account for this obesity-related increased risk of cancer [6].

Table 2 Interobserver reproducibility of the total, subcutaneous and visceral fat assessed in a slice passing through the navel.

		Mean (min—max)	Coef. Correl. (Spearman)	Coef. Concord. (Lin)
Total fat	Observer 1	40,059 mm^2 (6456—81,498 mm^2)	0.9726 ($P < 0.0001$)	0.981 ($P < 0.001$)
	Observer 2	39,436 mm^2 (5828—82,004 mm^2)		
Subcutaneous fat	Observer 1	27,431 mm^2 (5425—64,003 mm^2)	0.9535 ($P < 0.0001$)	0.971 ($P < 0.001$)
	Observer 2	27,067 mm^2 (4786—65,358 mm^2)		
Visceral fat	Observer 1	12,636 mm^2 (1031—32,508 mm^2)	0.9921 ($P < 0.0001$)	0.985 ($P < 0.001$)
	Observer 2	12,369 mm^2 (1042—30,083 mm^2)		

Coef.: coefficient; Correl.: correlation; min: minimum; max: maximum.

Abdominal fat may be quantified in several ways: measurement of the BMI, anthropometry (little used) or imaging. The use of the BMI is not appropriate because a high figure is not necessarily associated with an increase in visceral fat [10]. In fact, the different anthropometric measurements (measurement of the circumference of the hip, waist or abdominal sagittal diameter) are not reliable [10,15,19] and often confuse visceral fat with subcutaneous fat. In reality, only imaging allows both compartments to be studied: subcutaneous and visceral fat.

Sonography, an easily accessible technique, can be used to study the visceral fat quickly in everyday clinical practice [10]. Nevertheless, it is not reproducible since it is very operator dependent. These measurements are difficult to obtain and not very reliable [15] since it is difficult to obtain the same plane of slice in all patients, in particular in obese patients where the sonography examination is generally very limited.

Computed tomography is the imaging technique most often used since, although irradiating, it is very accessible and reliable. MR imaging may also be used [20] and has the advantage that it is not irradiating. Nevertheless, MRI may present several disadvantages when compared with the CT-scan: the cost (more expensive than the CT), accessibility and technical obligations (specific sequences to limit non-homogeneity of field for the segmentation of the fat). The last disadvantage is major since it is not possible to quantity to visceral fat retrospectively in MRI. In fact, quantification is only possible with sequences acquired in a specific manner.

Several studies, especially those about the relationship between visceral fat and the metabolic syndrome, or visceral fat and factors of cardiovascular risk [9,11,13—15], have studied the quantification and measurement of abdominal fat by CT-scan in order to determine the most reliable method (level of slice, volume acquisition...).

In these different studies, the level of slice was debated. The one most often used was in the umbilical situation, varying from one individual to another, but in general located at L4—L5. A great many other levels were studied, in particular those passing through the inter-vertebral discs from L1—L5. The L4—L5 level was not found to be most representative of the risk of obesity or cardiovascular risk [12].

Measurement of the visceral fat on a target single slice was found to be equal that carried out on several slices during volumetric CT acquisitions as regards the obesity-related risk [16]. Certain authors have shown that the measurement of visceral and subcutaneous fat, carried out at L4—L5, L4—L5 +5 cm or L3—L4 differ very little [18]. We wanted to specifically study the umbilical level as it is very easy to detect on a CT-scan and therefore very easy in everyday practice, by comparing it with a reputedly less variable level with a disc reference.

In addition, the interobserver reproducibility is an important aspect in the reliability of a predictive marker. However, as far as we are aware, the interobserver reproducibility of the area of visceral fat has never been studied in the literature.

Our work revealed that the measurement of the fat based on an umbilical slice was well correlated and well concordant with that based on a slice with a L3—L4 reference (fix by definition) and that there is a very good interobserver correlation for the visceral fat.

The interobserver correlation, as regards the subcutaneous fat (Spearman at 0.9535 with $P < 0.0001$) and total fat (Spearman at 0.9726 with $P < 0.001$), does not seem to be as good even if the power of the study did not allow for a statistical comparison. This may be due to the presence of intramuscular fat observed in case of sarcopenia. In fact, the subcutaneous (and total) fat compartment may include these fatty muscular pixels that theoretically require specific outlines (exclusions). These specific outlines, related to the subcutaneous compartment (and therefore total) are able to account for the differences between the two observers.

An important point in the discussion is the existence of a variation in fat over time and during the disease and the treatment that may affect the distribution and quantity of fat. In fact, during our study, one patient presented considerable variations in fat (subcutaneous, visceral and total) between the two observers. After rereading the CT imaging (double blind study), we noted that the two examinations carried out at different dates were post-treatment.

Rapid variations in weight generally account for a change in the quantity of subcutaneous fat. The evolution of the neoplastic disease often induces a change in the general state, accounting for a weight loss with changes in the fat compartments. The same is true of the toxicity of certain treatments. Therefore, it is important to study the visceral fat on the baseline CT-scan, before treatment, if we want to use it as a predictive marker.

The CT-scan seems to be a very good technique for the segmentation of the abdominal fat with an umbilical slice as this has several advantages: savings in time (the navel is easily detected on an axial slice), reproducibility in a standardized activity, accessibility, and very low exposure to radiation (only one slice is necessary) which, considering the constant increase in the number of CT-scans in current practice and the number of patients suffering from a tumoral disease, is a crucial parameter.

The limits of our study consist of a relatively low number of patients included and the limited comparison at only two levels of slice, even if these two levels are most often used in the literature. As far as we are aware, this study is the first to assess the interobserver reproducibility of a single slice technique.

Conclusion

By way of conclusion, this work shows that the single slice CT measurement technique determined from a slice passing through an easily detected level (the navel) has an excellent interobserver reproducibility and may therefore be used in oncology as a predictive tool to measure a characteristic of the host and not the tumor.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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