Time-effective MRI-based quantification of visceral adipose tissue (VAT) in morbidly adipose patients

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Introduction/Purpose: Obesity is a growing health-care problem in most industrialized countries and is strongly associated with a variety of disorders, such as insulin resistance, type 2 diabetes or cardiovascular disease. Body fat has been shown to be a better disease predictor than anthropometric measures like BMI or waist circumference and visceral adipose tissue (VAT) is a key factor in risk assessment. While MRI-based VAT assessment is common, image acquisition and tissue segmentation are generally time consuming. Simplified methods, often based on partial data analyses have been reported for less obese subjects [1, 2], but evidence on the performance in morbidly obese patients (BMI > 40 kg/m²) is still lacking. This study aimed to evaluate whether VAT volumes of representative slice positions can be used to estimate total VAT in such patients.

Materials and Methods: Seventy morbidly obese patients (mean BMI 47.2 kg/m², 47 females) were scanned at 1.5 T (Philips Achieva XR, two-point Dixon sequence, 50 slices, thickness 10 mm, gap 0.5 mm, acquisition time 160 s plus breathing intervals) before and after a two-week, low-energy diet (mean intake around 900 kcal/day). A semi-automated software tool [3] was used for fat segmentation (Fig. 1). VAT estimates of single slices (VAT1) and blocks of five adjacent slices (VAT5) centered at the level of spinal landmarks (lumbar discs L1/2–L5/S1) and at the umbilicus were compared to total volume VATT (from diaphragm to pelvic floor, reference value). Statistical measures of agreement were the coefficient of determination R² of a linear regression through the origin as well as the standard deviations σ1 / σ5 of the differences between volume predictions from VAT1 / VAT5 , respectively, and the actual VATT (Bland-Altman analysis).

Results: VAT could be segmented successfully in all 70 patients. Total VAT analysis per patient involved an average of 37 slices and took approximately 20 minutes. Measurements of VAT1 and VAT5 were required around 2 and 5 minutes, respectively. Total VAT values ranged from 1.4 to 9.2 (mean 5.1) L for females (n=47) and from 3.0 to 15.0 (mean 8.7) L for males (n=23). The best agreement for VAT1 estimates of VATT was found at the level of L3/4 for females (R²=0.86, σ1=761 ml) and at L1/2 for males (R²=0.86, σ1=1,092 ml, Figs. 2 and 3). At these slice levels, VAT1 made up an average fraction f1=4.6 % and f1=3.9% of VATT for female and male subjects, respectively. Corresponding VAT5 estimates agreed slightly better in both groups (R²=0.86, σ5=681 ml and R²=0.91, σ5=919 ml, respectively). Agreement at the umbilical level was generally poor (σ5=1,740–2,284 ml) with levels being located between 7 slices above and 16 slices (spacing 10.5 mm) below L4/S (n=140). Individual changes after diet ranged from +614 to -1,168 (mean -160) ml for females and from +327 to -1,020 (-321) ml for males.

Discussion: As already observed in less obese patients [1], single-slice volume estimates at the level of lumbar discs were a good VAT predictor in morbidly obese patients. Overall accuracy varied with disc level and gender; absolute (relative) volume deviations were smaller for female (male) subjects. Best 1- and 5-slice agreements were found at L3/4 for female and at L1/2 for male patients. Analysis of more slices was found to be beneficial in both genders, in slight contrast to previous results in less obese women [2]. The resulting absolute accuracies are not suited to determine small VAT volume differences as previously reported by others [4].

Conclusion: VAT volumes of morbidly obese patients can be reliably analyzed within 2 minutes by single-slice estimates at lumbar disc levels L3/4 (females) or L1/2 (males). Accuracy may be slightly improved at the expense of 3 more minutes needed for the processing of 5 slices. The assessment of volume changes as those encountered under minor therapeutic interventions like diets, however, requires a full quantification of all abdominopelvic MR images.

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Target audience: Radiologists, MR physicists and other researchers interested or working in the field of MRI-based fat quantification.

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