Visceral Fat Assessment with 3D Dual Echo Dixon Technique

K. B. Krishnan[1], R. Mullick[1], U. Patil[1], A. Narayanan[1], A. T. Vu[2], and P. Hervo[3]

[1]Imaging Technologies, GE Global Research, Bangalore, Karnataka, India, [2]GE Healthcare, WI, United States, [3]GE Healthcare, Buc, France

Introduction: Central obesity linked to higher abdominal visceral fat is known to be an indicator of metabolic syndrome [1]. A **M**ulti-**E**cho acquisition with 2-point Dixon reconstruction for **D**ecomposition of **A**qua/**L**ipid (MEDAL) simultaneously provides four images per slice – in-phase, out-phase, fat-only and water-only images [2]. The fat and water only images have higher SNR, permit the possibility of fat quantification and the water-only images reliably achieve excellent fat suppression [3]. In this study, we demonstrate the use of fat-only images of a 3D abdominal MEDAL acquisition to evaluate the visceral fat present within the peritoneal cavity.

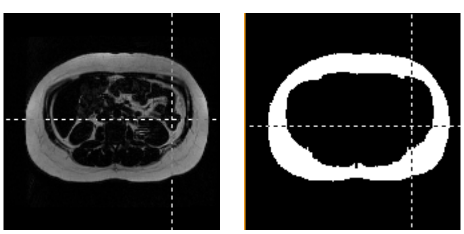
Methods: We assume a representative fat pixel on a fat image slice to have an intensity value 70% of the maximum intensity. We use the MEDAL acquisition parameters of TR = 7 ms, TE=2.4, /4.8 ms, flip angle = 12 degree; a range of relaxation times T1 and T2 for fat and muscle reported in the literature; apply the signal intensity for gradient echo to compute the minimum intensity threshold above which the pixels in the fat image may be used for quantification as a ratio of the intensity value of the representative fat pixel on a slice-by-slice basis. We utilize this threshold to de-bridge the subcutaneous fat from the visceral fat in a row-based operation on every slice in an automated Matlab code.

We apply the threshold to seven fat-only datasets from a study in which patients were imaged on a 1.5T Signa® HDx whole body scanner (GE Healthcare, Waukesha, WI) using multiple acquisitions including MEDAL. The threshold provides both the total count of fat pixels and the number of subcutaneous fat (SF) pixels and the difference is a measure of visceral fat.

In an alternate approach, we have a Radiologist manually delineate the visceral region-of-interest (ROI) on water-only images on a slice-by-slice basis in accordance with current clinical practice [4]. We place these masks on the thresholded fat-only images to demarcate the visceral region. The pixel count inside the ROI gives an independent measure of visceral fat.

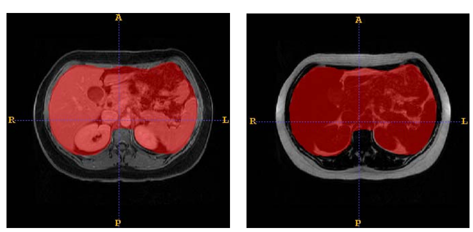
Results: The total fat (TF) pixel count is the same in both the automated and manually assisted methods, The automated algorithm applied to fat-only image systematically overestimates the visceral fat (VF) fraction VF/TF within a fraction of 0.1 compared to the manually-assisted method based on the ROI visceral mask drawn on the water-only image. The VF/SF values ranging from 0.23-1.08 for the assessment drawn from water images are typical of the VF/SF ratios reported in literature [5].

Discussion: We have devised a simple intensity-independent automated Matlab algorithm to assess visceral fat in fat-only MEDAL images in less than a second per slice. Based on a set of seven datasets of patients with varying age (28-85), varying sex (2 males, 5 female) and varying body weight (57-100 kg) in a clinical setting, we have found the method to provide a consistent assessment of visceral fat fraction. The estimate tends to include the fat present in the muscle that forms the peritoneal lining that is clinically considered to be a part of the subcutaneous fat.



(a) (b)

Fig. 1(a) Fat-only MEDAL image slice
(b) SF from Automatic Algorithm



(a) (b)

Fig. 2 (a) Visceral Mask on the Water-only MEDAL
(b) Visceral ROI Fat-only Image

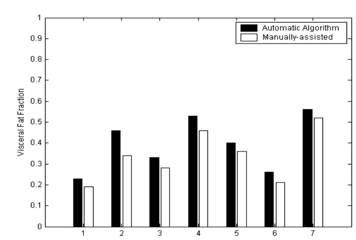


Fig. 3 Visceral Fat Fraction
from two methods

References: [1] S. Klein, J Clin Invest. 113(11): 1530–1532, 2004. [2] J. Ma, MRM 52: 415-419, 2004. [3] R. Low et al. Proc. Intl. Soc. Mag. Reson. Med. 726, 2007. [4] K. Miller et al, The Lancet 351: 871-875, 1998. [5] T. Gomi et al. Rad. Med. 23(8): 584 – 587, 2005.