Introduction/Purpose
Abdominal fat is associated with an increased risk for metabolic and cardiovascular diseases. MRI is well suited for a selective depiction of fat and a quantification of subcutaneous (SAT) and visceral adipose tissue (VAT). A manual segmentation is relatively accurate but rather time consuming [1]. An automatic analysis is user-independent but also prone to errors caused by anatomical variations and imaging artifacts seen in obese patients [2]. Therefore, we have developed a custom-made software for automatic quantification of abdominal fat that allows manual correction and have performed a preliminary evaluation on the data of 10 obese patients.

Materials and Methods
Ten (9 female, 1 male) obese patients with an average BMI of 35 and an average age of 19 underwent MRI examinations of the entire abdomen in a 1.5T scanner (Intera, Philips, The Netherlands) with a T1-weighted, fat-selective gradient echo (GRE) sequence (two stacks with 40 transverse slices each, slice thickness/gap = 8/2 mm, TR/TE = 83/6 ms, field of view = 500×500 mm², matrix = 512×512). A custom-made software was developed under Matlab (Mathworks, MA) that uses active contours (Snakes) to automatically define the boundaries between background, SAT and VAT in each image. The VAT volume is separated from lean tissue by setting an intensity threshold in the corresponding histogram of the VAT mask [1, 2]. The user interface allows to adjust the VAT and SAT contours as well as the threshold (Fig. 1). The results of the manual segmentations by two independent observers were compared with those after automatic analysis. Percent deviations with respect to the mean observer (manual) value were analyzed by paired two-sided t-tests (significance level 5%). A Kolmogorov-Smirnov (KS) test was performed to test for the normal distribution of the percent deviations between automatic and manual volumes. The fat content Vfat of a reference phantom (Fig. 2) was determined both automatically and manually to estimate the absolute accuracy of the method.

Results and Discussion
Manual analysis of the reference sample (Fig. 2) was very accurate; the fat volume of the tissue phantom was overestimated by only 1.2%. Tab. 1 shows the detailed results after manual and automatic analysis of the patient data. The interobserver variations of the manual analysis were not significant with mean values of +0.6% for SAT (p=0.338) and 2.6% for VAT (p=0.081). Automatic analysis (segmentation and thresholding) took an average of 6 minutes per patient. On average, the automatic VAT and SAT volumes were (rounded) 17±8% (p=0.001) and 1±3% (p=0.397) higher than the manually derived. Statistical analysis of the VAT differences suggest a normal distribution (KS p=0.824) with an acceptable standard deviation of 8% around a highly significant bias. This bias can be explained by a systematic underestimation of the VAT threshold and thus an overestimation of the VAT volume. The outlying VAT and SAT values for patient #2 are probably due to the celiac association of fatty tissue in males, which should be the subject of further studies. The large VAT error observed for patient #9 was due to severe banding artifacts that lead to false contours.

Conclusion
These preliminary results suggest that the combined approach holds great promise for a fast (6 min) and sufficiently accurate fat quantification.