Quantification of liver fat in the presence of iron and iodine: an ex-vivo dual-energy CT study

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PURPOSE
Iodinated contrast media (CM) and iron in the liver are known to hinder an accurate quantification of liver fat content (LFC) with single-energy computed tomography (SECT). The purpose of this study was to evaluate the feasibility and accuracy of dual-energy CT (DECT) for ex vivo quantification of LFC, in the presence of iron and CM, compared with SECT.

MATERIALS AND METHODS
Sixteen phantoms with a defined LFC of 0%, 10%, 30%, and 50% fat and with varying iron content (0, 1.5, 3, and 6 mg/mL wet weight liver) were scanned with a second-generation dual-source 128-slice CT system. Phantoms were scanned unenhanced and contrast-enhanced after adding 1.0 mg/mL iodine to each phantom. Both SECT (120 kV) and DECT (tube A: 140 kV, using a tin filter 228 mAs; tube B: 80 kV, 421 mAs) data were acquired. An iron-specific dual-energy 3-material decomposition algorithm providing virtual noniron images (VNI) was used to subtract iron and CM from the data. CT numbers (Hounsfield units) were measured in all data sets, including 120 kV from SECT, as well as 140 kV, 80 kV, 50%:50% weighted 80 kV/140 kV, and VNI derived from DECT. The dual-energy index was calculated from 80 kV and 140 kV data. SECT and DECT measurements (Hounsfield units) including the dual-energy index of unenhanced and contrast-enhanced phantoms were compared with the known titrated LFC, using Pearson correlation analysis and Student t test for related samples.

RESULTS
Inter-reader agreement was excellent for all measurements of CT numbers in both SECT and DECT data (Pearson r, 0.965-1.0). For fat quantification in the absence of iron and CM, CT numbers were similar in SECT and DECT (all, P > 0.05), showing a linear correlation with titrated LFC (r ranging from 0.981 to 0.999; P < 0.01). For fat quantification in the presence of iron but without CM, significant underestimation of LFC was observed for all measurements in SECT and DECT (P < 0.05), except for VNI. Measurements in VNI images allowed for an accurate LFC estimation, with no significant differences compared with measurements in iron-free phantoms (all, P > 0.25). For fat quantification in
the presence of iron and CM, further underestimation of LFC was seen for measurements in SECT and DECT (P < 0.015), except for VNI. Measurements in VNI images showed a high accuracy for estimating the LFC, with no significant difference compared with measurements in iron- and CM-free phantoms (P > 0.2).

CONCLUSIONS
Our ex vivo phantom study indicates that DECT with the use of a dedicated, iron-specific 3-material decomposition algorithm allows for the accurate quantification of LFC, even in the presence of iron and iodinated CM. VNI images reconstructed from DECT data equal nonenhanced SECT data of liver without CM by eliminating iron and iodine from the images. No added value was seen for DECT as compared with SECT for quantification of LFC in the absence of iron and iodine.

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