Quantification of Intrapancreatic Fat (IPF) using 1H-MR Spectroscopy and Multi-Echo Dixon: A Feasibility Study

Annelise M Silva[1,2], Anshuman Panda[3], Raul Pannala[4], Vijay P Singh[4], Krutika Patel[4], Vishnu T Kommineni[4], Teresa Wu[5], Yinlin Fu[5], and Alvin C Silva[3]

[1]Research, Mayo Clinic, Phoenix, Arizona, United States, [2]Arizona State University, Tempe, Arizona, United States, [3]Radiology, Mayo Clinic, Phoenix, Arizona, United States, [4]Gastroenterology, Mayo Clinic, Phoenix, Arizona, United States, [5]School of Computing, Informatics, and Decision Systems Engineering, Arizona State University, Tempe, Arizona, United States

Target Audience: The results of the study are intended to aid clinicians and researchers investigating noninvasive fat quantification of the pancreas.

Introduction: Characterization of fat has a significant role in the evaluation of patient risk burden. In light of increasing evidence regarding the association between IPF and diseases such as diabetes and the metabolic syndrome, there is need for a non-invasive method for precise pancreatic fat assessment.[1,2] Unlike for hepatic fat evaluation, pancreatic parenchymal biopsy is neither practical nor routinely performed due to relative increased morbidity, including post-biopsy pancreatitis. Furthermore, this method cannot assess the organ in its entirety as only the biopsied tissue sample is available for histopathologic analysis. MR imaging (^{1}H MR spectroscopy (MRS) and multi-echo Dixon (me-Dixon)) has been shown to have value in the noninvasive measurement of liver fat, but has yet to be sufficiently validated for pancreatic fat assessment.[3-5] The goal of this study was to optimize and evaluate the feasibility of utilizing MRS and me-Dixon for an accurate estimate of whole organ fat quantification in porcine pancreata, with histologic correlation.

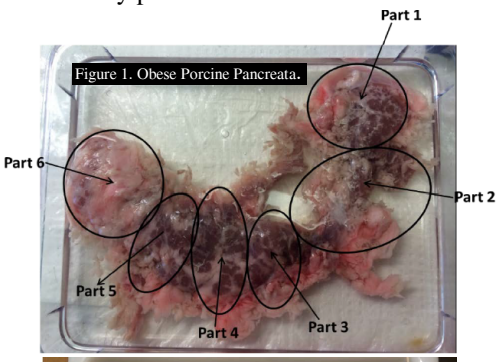
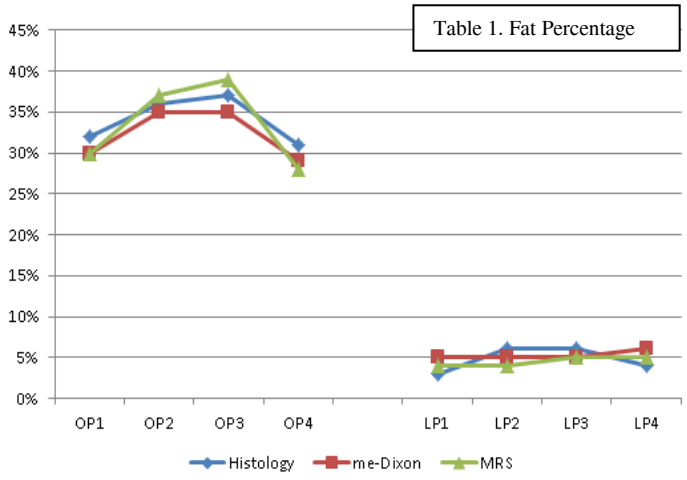


Figure 1. Obese Porcine Pancreata.

Materials and Methods: Fat fraction phantoms (0%-100%) were prepared for evaluation using previously established guidelines in order to optimize MR protocol parameters and calibration curves for fat quantification.[6-7] Following IACUC approval, pancreata of four 2-3 month old lean pigs (LP; 20-30 kg) and four 5-6month old high fat diet-induced obesity pigs (OP; 80-100kg) were harvested and analyzed *ex-vivo,* after dividing into discrete samples dependent on organ size. (Fig 1) All pancreata samples (LP=21; OP=19) were scanned on a 3T magnet using MRS (TR: 3000 ms; TE: 12 ms, 24 ms, 36 ms, 48 ms, 72 ms; TM: 10 ms; Average: 1; Flip Angle: 90 deg; Acq time: 15 sec) and me-Dixon (TR: 9.20 ms; TE: 1.23 ms, 2.46 ms, 3.69 ms, 4.92 ms, 6.15 ms, 7.38 ms; Average:1; Flip Angle: 4 deg; Voxel size: 2.2x2.2x3.0 mm; Acq time: 15 sec). In addition, MRS acquisitions were repeated for each sample using 3, 5, 7, and 10 averages, and me-Dixon was repeated using 5 averages. Histologic analysis was performed on H&E stained pancreata samples that directly correlated with each imaged region. (Fig 2) Total fat area was measured and calculated as a percentage of total pancreatic tissue area using "ImageJ" software.

Table 1. Fat Percentage



Results/Discussion: MRS and me-Dixon correlated well with histology for both the *obese* pancreata (OP1-4; histology: 31-37%; MRS: 28-39%; me-Dixon: 29-35%) and *lean* pancreata (LP1-4; histology: 3-6%; MRS: 4-5%; me-Dixon: 5-6%). (Table 1) For MRS, decreased variability in quantitative measurements were seen with ≥ 3 averages, however, there was no significant difference in variability for me-Dixon ($p \leq 0.05$).

Conclusion: This pilot study suggests that MR evaluation for IPF in a porcine model is feasible, with good agreement between MRS and me-Dixon with histology. For MRS, one average is typically used so as to minimize the acquisition time; however, three averages may be needed to decrease variability. Future direction is to investigate our optimized algorithms for human IPF assessment.

References:

1. Acharya C, Cline RA, Jaligama D, et al. Fibrosis Reduces Severity of Acute-on-Chronic Pancreatitis in Humans. Gastroenterology. Aug 2013;145(2):466-475.
2. Wong VW, Wong GL, Yeung DK, et al. Fatty Pancreas, Insulin Resistance, and β-Cell Function: A Population Study Using Fat-Water Magnetic Resonance Imaging. Am J Gastroenterol 2014; 109:589–597.
3. Sijens PE, Edens AM, Bakker SJ et al. MRI-determined fat content of human liver, pancreas and kidney. World J Gastroenterol. 2010 April 28; 16(16).
4. Hu HH, Kim H, Nayak KS, et al. Comparison of Fat–Water MRI and Single-voxel MRS in the Assessment of Hepatic and Pancreatic Fat Fractions in Humans. Obesity (Silver Spring). 2010 April; 18(4): 841–847
5. Patel NS, Peterson MR, et al. Association between novel MRI-estimated pancreatic fat and liver histology-determined steatosis and fibrosis in non-alcoholic fatty liver disease.Aliment Pharmacol Ther. 2013 Mar;37(6):630-9.
6. Hines CD, Yu H, et al. T1 Independent, T2* Corrected MRI with Accurate Spectral Modeling for Quantification of Fat: Validation in a Fat-Water-SPIO Phantom. J Magn Reson Imaging. 2009 November; 30(5): 1215–1222
7.. Cheng CH, Pradhan PM, Mitchell JR. Approach for Fast Time-Frequency Analysis. IET Signal Processing, 2013, available at http://digital-library.theiet.org/content/journals/10.1049/iet-spr.2013.0157