Characterizing Pancreatic Fat Distribution in Children with Nonalcoholic Fatty Liver Disease using MRI

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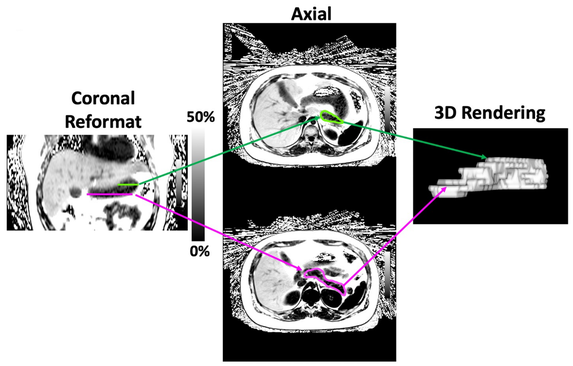
Background

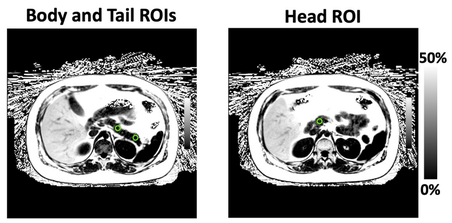
Pancreatic fat may be associated with metabolic dysfunction in children[1-3], but this is difficult to study due to methodological limitations

The most reliable method of pancreatic fat measurement in adults is full segmentation in MRI, which involves tracing the entire pancreas in a proton density fat fraction (PDFF) map (0-100%)[4], as seen below:



However, this method is time-consuming and difficult due to anatomic variation

An alternative method uses 3 small regions of interest (ROIs) to estimate pancreatic fat (see below), but this fails to account for fat heterogeneity



To address this issue, we must first understand the distribution of fat within the pancreas in children

Aims

1. Use free-breathing radial MRI to measure pancreatic PDFF using full segmentation and 3-ROI
2. Use full segmentation to retrospectively quantify pancreatic fat heterogeneity in children
3. Relate pancreatic PDFF to clinical markers of metabolic dysfunction in children

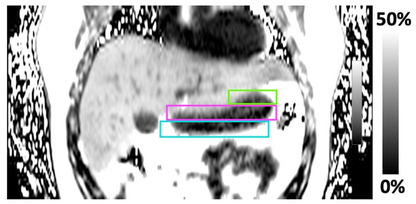
Methods

This prospective study enrolled children with and without nonalcoholic fatty liver disease (NAFLD)

Full segmentation tracings on free-breathing MR images[5] and PDFF maps were obtained by a pediatric radiologist

PDFF distribution within each tracing was characterized, and axial slices were separated into superior, middle, and inferior thirds, as seen below:

Superior, Middle, and Inferior Regions



The 3-ROI method was performed by using three 1-cm2 ROIs in the pancreas head, body, and tail by a pediatric radiologist

Histograms of PDFF within each voxel were made for healthy and NAFLD subjects to demonstrate heterogeneity of fat distribution

Differences between pancreatic PDFF based on measurement method and along the superior to inferior axis were compared with the 1-way repeated measures ANOVA with post hoc analysis

Pancreatic PDFF based on NAFLD status and the presence of acanthosis nigricans on exam were compared with the independent-samples *t* test or the Mann-Whitney U test

Relationship between pancreatic PDFF and BMI was compared with Spearmann's rank order sum

Demographics

	Healthy (N = 16)	NAFLD (N = 18)	P Value
Age, Years	12.9 ± 2.8	14.9 ± 2.4	0.03
Male	8 (50%)	13 (72%)	0.06
White	7 (44%)	16 (89%)	<0.001
Hispanic/Latino	3 (19%)	13 (72%)	0.004
BMI, kg/m^2	18.9 ± 2.4	34.3 ± 9.5	<0.001
Liver PDFF	2.2 ± 1.0%	19.1 ± 10.9%	<0.001
Pancreatic PDFF	5.1 ± 1.6%,	14.6 ± 5.1%	<0.001
Pancreatic Volume, cm^2	29.9 ± 10.91	49.2 ± 21.3	0.002
Number of Axial Slices Containing Pancreas	6.6 ± 1.9	7.4 ± 2.3	0.33

Results

Figure 4. Heterogeneity of Pancreatic Fat Distribution Between Healthy Children and Children with NAFLD

A. Histograms of PDFF from full segmentation tracings in representative subjects from the healthy and NAFLD cohorts

B. Children with NAFLD have a higher mean PDFF and a larger inter-quartile range compared to healthy children. This suggests that the higher fat content among children with NAFLD is driven by focal regions of high fat, while healthy children have a more homogenous fat distribution

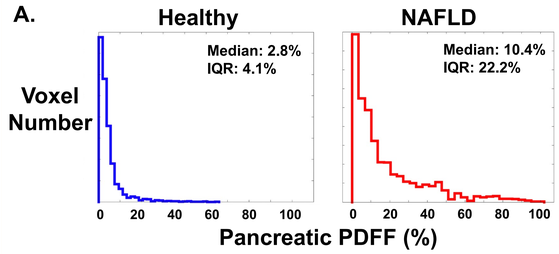
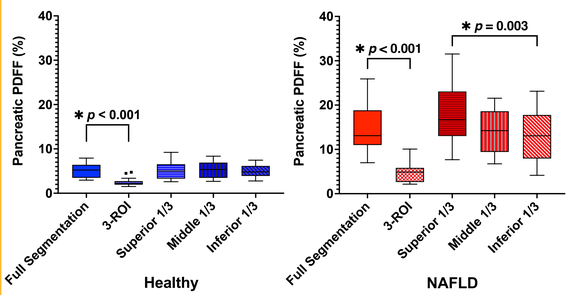


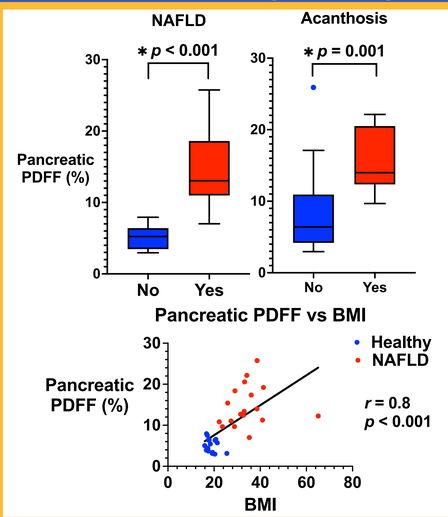
Figure 5. Pancreatic Fat Based on Measurement Method and Location Along the Superior and Inferior Axis

Full Segmentation produced higher fat estimates than 3-ROI for healthy and NAFLD subjects

NAFLD subjects had higher PDFF in the superior regions of the pancreas compared to the inferior regions



Results (cont.)



Conclusion

Pancreatic fat has a heterogenous distribution among children with NAFLD, but not among healthy children

Localization of fat to the superior pancreas in children with NAFLD may be related to similarities in blood flow between the upper pancreas and liver, as both receive arterial blood from the celiac trunk

Pancreatic fat is associated with markers of metabolic dysfunction in children

Focal regions of high fat may drive clinical relationships, and therefore fat heterogeneity itself may be a useful biomarker

References

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Acknowledgements

This research was supported by University of California Los Angeles Radiology Department Exploratory Research Grant (#16-0002), NIH R01DK124417