SIIM CMIMI24
Oct 21-22 | Boston, MA
Conference On Machine Intelligence In Medical Imaging

Automated Pancreatic Perivascular Adipose Tissue Detection on Abdominal CT as a Biomarker for Type 2 Diabetes

Anisa V. Prasad, National Institutes of Health; Tejas S. Mathai, PhD; Pritam Mukherjee, PhD; Abhinav Suri, MPH; Jianfei Liu; Ronald M. Summers, MD, PhD

Introduction/Background

Early diagnosis of diabetes mellitus is critical for preventing disease and improving health outcomes. Intrapancreatic fat deposition has previously been established as a biomarker for diabetes, but little is known about the role of pancreatic perivascular adipose tissue (PVAT), adipose tissue surrounding blood vessels supplying the pancreas. We developed a deep learning framework to quantify pancreatic PVAT on abdominal CT scans and applied it to identify CT biomarkers for type 2 diabetes.

Methods/Intervention

1350 contrast-enhanced CT (CECT) scans with ground truth labels from the public PANORAMA dataset were used to train a 3D nnUNet model to segment pancreatic anatomy (parenchyma, vasculature, ducts, pancreatic ductal adenocarcinoma lesions). It was then applied to an internal dataset containing 606 CECT scans with corresponding diabetes outcomes. Pancreatic adipose tissue (AT) and PVAT were derived from the predicted segmentations and used to measure several biomarkers, such as volume and attenuation. These biomarkers were then correlated to diabetes status using univariate and multivariate logistic regression. Metrics such as AUC were assessed to determine the best set of predictors for diabetes outcomes.

Results/Outcome

Four pancreatic PVAT biomarkers were measured: volume, mean attenuation, standard deviation (SD) attenuation, and fat fraction. Significant differences ($p < 0.001$) were found across diabetic and non-diabetic patients for all four biomarkers, with mean attenuation demonstrating a decrease in diabetic patients while the other three metrics were increased. Similar findings were observed for the corresponding pancreatic AT measurements. Among all combinations of the eight biomarkers measured, the best set of predictors for diabetes was (1) pancreatic AT mean attenuation, (2) pancreatic PVAT mean attenuation, and (3) pancreatic PVAT fat fraction, achieving a maximum AUC of 0.88 with sensitivity 0.90 and specificity 0.71.

Conclusion

We present a framework to automatically identify pancreatic PVAT. Our analysis suggests that metrics derived from these segmentations, such as pancreatic PVAT mean attenuation and fat fraction, are viable biomarkers for type 2 diabetes.

Statement of Impact

We provide an automated method for quantifying pancreatic PVAT that can be implemented to elucidate its role in disease progression. The biomarkers identified using this tool underscore the potential for opportunistic screening of diabetes mellitus using abdominal CT scans.

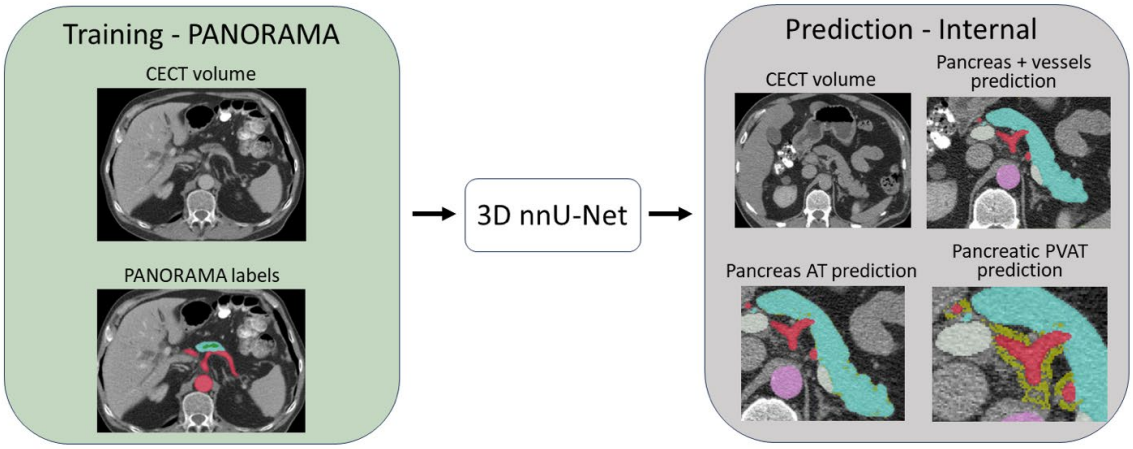

Fig. 1 Framework for the proposed approach to segment pancreatic anatomy and predict PVAT. A 3D nnU-Net model was trained on the publicly available PANORAMA dataset (*n = 1350*) using a 5-fold cross validation. The trained model was then applied to an internal dataset (*n = 606*) consisting of contrast-enhanced CT scans (CECT). The perivascular region was obtained by dilating the predicted arteries (red). Adipose tissue (gold) in both the perivascular region and the pancreas parenchyma (light blue) was identified using a [-190, -30] Hounsfield unit (HU) range. AT - adipose tissue.

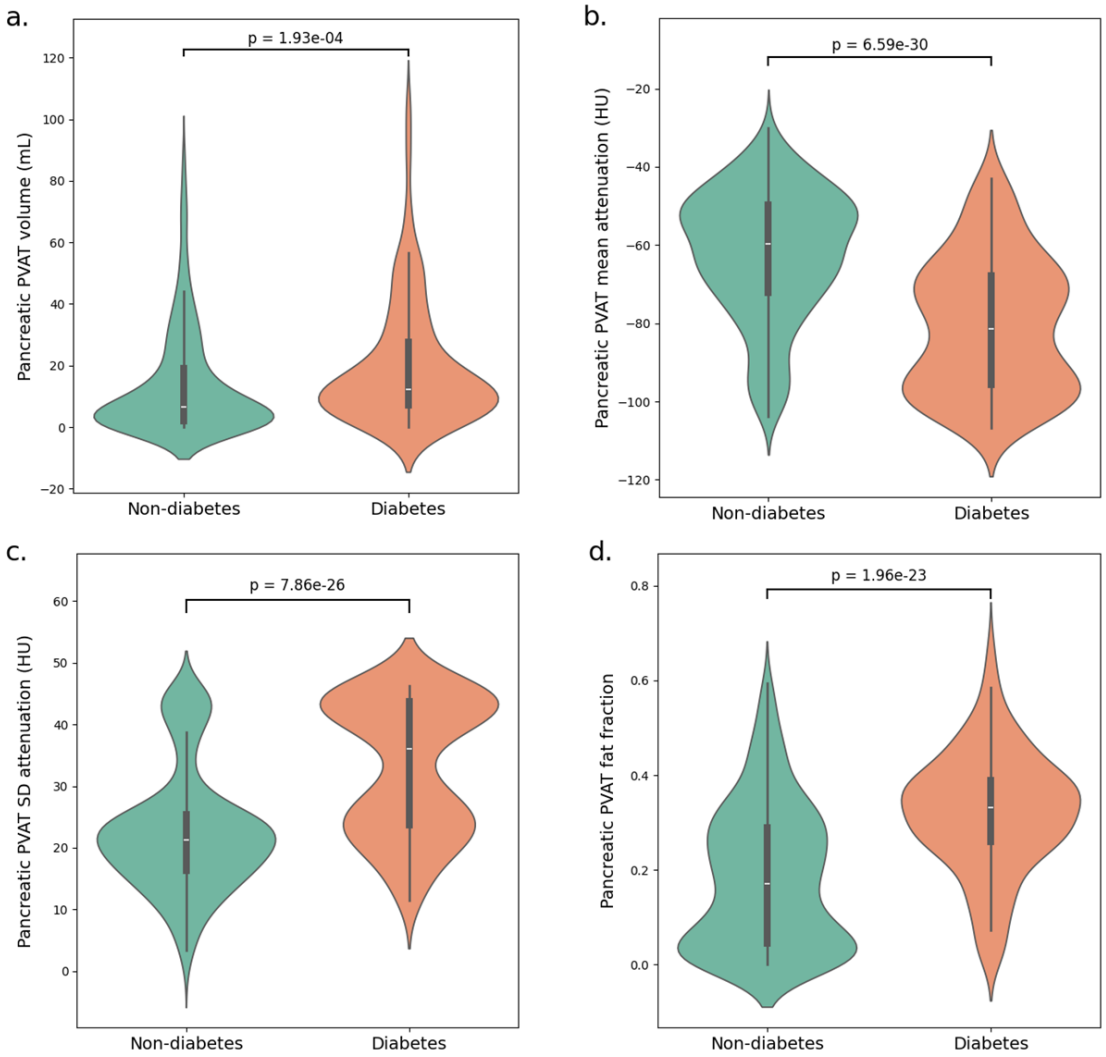

Fig. 2 Violin plots of pancreatic PVAT biomarkers stratified by diabetes status on CECT scans. (a) Volume, (b) mean attenuation, (c) standard deviation (SD) attenuation, and (d) fat fraction were calculated for pancreatic AT (not shown) and PVAT regions. Metrics were grouped by diabetes status and independent two-sample t-tests were performed to determine significance. Plots for mean and SD attenuation represent only patients with PVAT volume > 0.

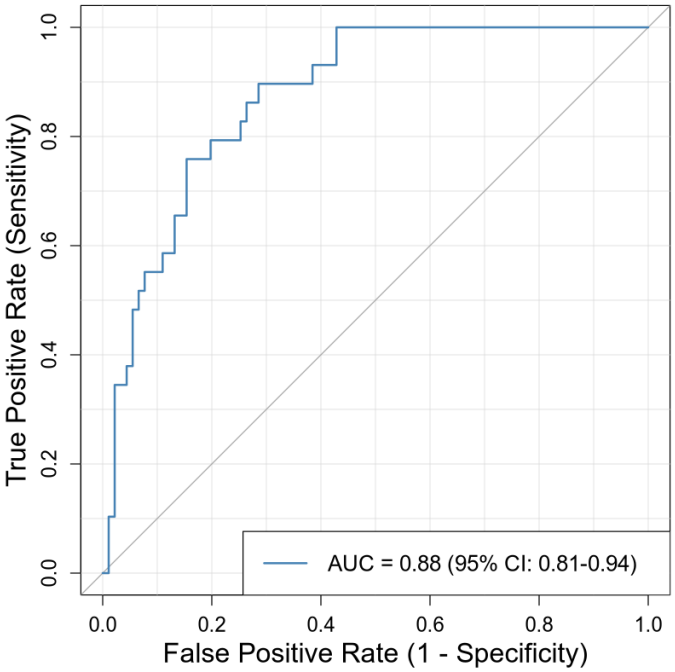

Fig. 3 ROC curve for best-performing multivariate logistic regression model. Univariate and multivariate models to predict diabetes outcome (diabetes/no diabetes) based on 8 biomarkers (volume, mean attenuation, SD attenuation, fat fraction for pancreatic AT and PVAT) were tested. The highest AUC achieved was 0.88 (95% CI: 0.81, 0.94) using 3 predictors: (1) pancreatic AT mean attenuation, (2) pancreatic PVAT mean attenuation, (3) pancreatic PVAT fat fraction. The associated sensitivity is 0.90 and specificity is 0.71

Keywords

Diabetes Mellitus; CT; Pancreas; Intrapancreatic Fat Deposition; Perivascular Adipose Tissue