In vivo imaging of mouse pancreas utilizing ultra high field of 14T and manganese enhanced MRI

R. J. Immonen[1], S. Lamprianou[2], L. Lecomte[1], L. Vinet[2], P. Meda[2], and R. Gruetter[1,3]

[1]Laboratory for functional and metabolic imaging, Ecole Polytechnique Fédérale de Lausanne, Lausanne, CH-1015, Switzerland, [2]Department of Cell Physiology and Metabolism, University of Geneva, Geneva, CH-1210, Switzerland, [3]Department of Radiology, University of Geneva and Lausanne, Geneva/Lausanne, CH-1210/CH-1015, Switzerland

Purpose

In vivo imaging of pancreas with high resolution is a challenge. In diabetes the gradual loss of pancreatic β–cell mass and function leads to impaired regulation of blood glucose levels due to insufficient insulin secretion. There is a great need of a MRI methodology to monitor in vivo the pancreas β–cell functionality. We utilized ultra high field of 14.1T and manganese enhanced MRI to image the mouse gland in vivo, and to examine the changes in manganese signal during β–cell stimulation by glucose.

Materials and Methods

MRI was performed in 14.1T 26cm horizontal bore scanner using quadrature half-volume coil 20mm in diameter in a healthy adult male mouse (b.w.=37g) instrumented with a tail vein catheter for i.v. infusion of 50mg/kg $MnCl_2$ and a i.p. catheter for 1.5mg/g glucose (glucose activates the β–cells, and promotes Mn^{2+} uptake) and anesthetized with 1.5% isoflurane. High resolution images with combination of T2*- and T1-wt contrast were acquired using respiratory gating and gradient echo multi slice sequence: TR ~750ms (80 breaths/min, trigger cycle~750ms), TE=3.7ms, flip=60°, 14 consecutive 0.3mm-thick slices, 28*25mm, data matrix 256*256 (109*98*300μm resolution) covering the mouse abdomen cross-section was acquired with two averages in ~7min, and 512*512 (54*49*300μm resolution), TE=6.3ms, 3 averages in ~20min. T1-wt images to verify manganese accumulation were measured using gradient echo inversion recovery, 1mm-thick single slice, inversion time 700ms, TR=3200ms, TE=2.17ms, data matrix of 96*96. Baseline images were acquired before any infusions. Then a $MnCl_2$ bolus was given and manganese accumulation was monitored with T1-wt approach. Eventually, a glucose bolus was given together with a second $MnCl_2$ bolus (identical to the first bolus) and the signal changes were followed for 2h using T1-wt lower resolution technique with ~15min temporal resolution. Then high resolution post-contrast images were taken.

Results and Conclusions

Figure 1 A-E high resolution images, essentially free of movement artifacts, show that the pancreas can be accurately located in the living mouse, and its main structures identified. Thus, main vessels and ducts can be seen without contrast enhancement (E), and bright spots, possibly corresponding to pancreatic islets with activated β–cells, can be seen after Mn and glucose enhancement (E). This technique holds great promise in experimental diabetes studies once correct islet recognition is verified by histology. As comparison, T1-wt time series is displayed (Fig.1, F). Images do show further pancreas signal increases during 2h after glucose stimulation, but also the limitations and difficulties in ROI analysis. As compared to the Mn baseline pancreas/muscle signal ratio increased about 10-30%, and pancreas/liver ratio about 0-5% 30min, 1h and 2h after the glucose bolus (pilot, n=1). In conclusion, while T1-wt lower resolution approach shows stronger Mn-effect, the new, high resolution approach presented here is needed to detect a moderate deterioration of β–cell function with better coverage of pancreas.

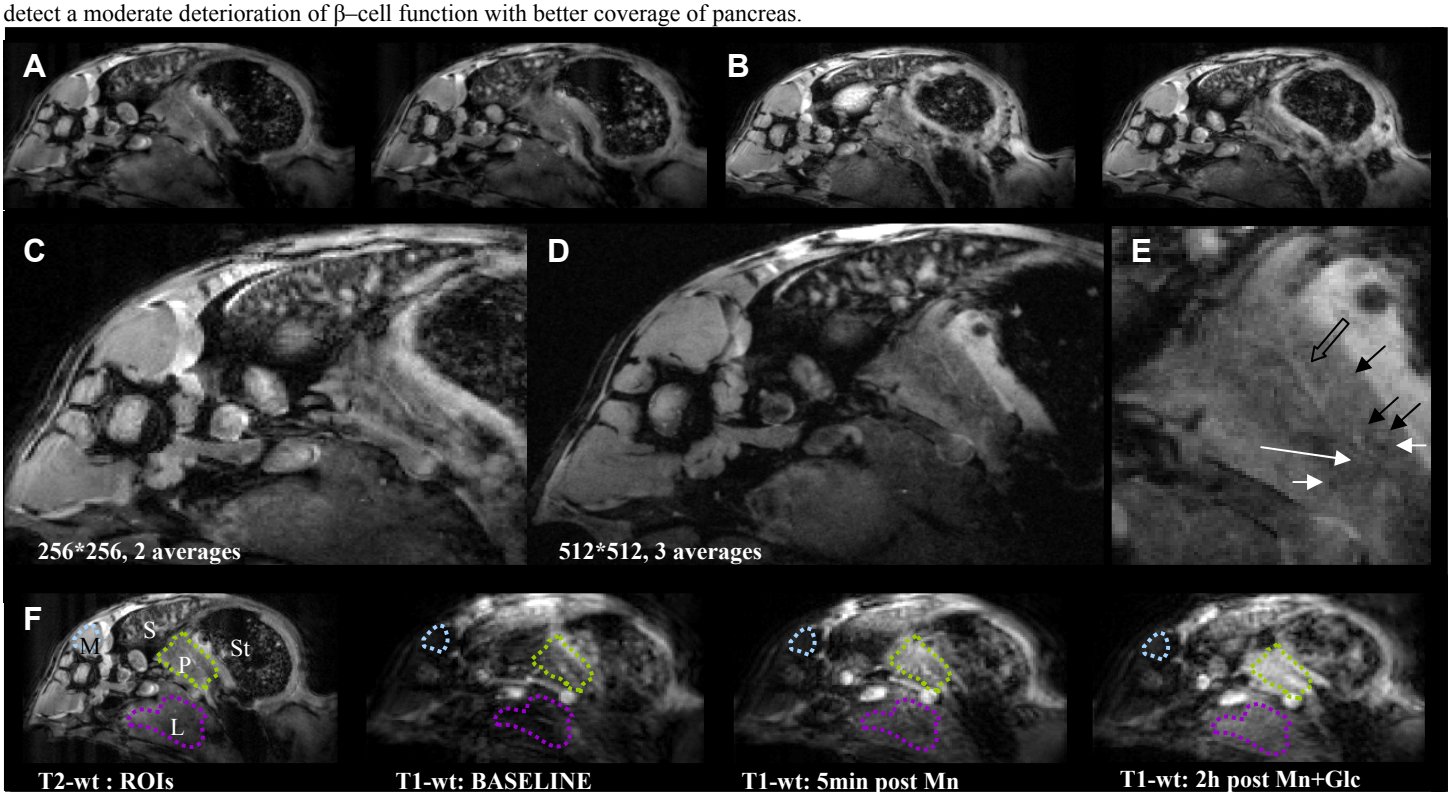

Figure 1. High resolution MRI shows the location of pancreas (A) before addition of any contrast agent, (B) after infusion of Mn and glucose. C-E are post-contrast images with 256*256 (C), and 512*512 (D) data matrix. E (zoom of D) reveals the exocrine duct system (white arrows), large vessels (open arrow) and bright structures, possibly representing the endocrine islets (black arrows). F) Time series of T1-wt images shows the signal enhancement due to the first Mn bolus, and then to glucose stimulation. Pancreas (P), liver (L) and muscle (M) are outlined, spleen (S), stomach (St).

Acknowledgement Supported by CIBM of the UNIL, UNIGE, HUG,CHUV, EPFL and the Leenaards and Jeantet Foundations