Dynamic Non Invasive ASL Perfusion Imaging of the Pancreas with Secretin Augmented MR Imaging

Poster No.: C-2255
Congress: ECR 2015
Type: Scientific Exhibit
Authors: K. Schawkat, M. Ith, W. Kühn, Y. Chittazhathu Kurian Kuruvilla, L. Bains, J. Heverhagen; Bern/CH
Keywords: Abdomen, Gastrointestinal tract, Pancreas, MR, MR-Diffusion/Perfusion, Imaging sequences, Biological effects, Blood
DOI: 10.1594/ecr2015/C-2255

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method ist strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Aims and objectives

Analysis of tissue perfusion represents a sensitive physiologic marker in the diagnosis of pancreatic malfunction. The most common pathologies of the pancreas include inflammatory processes and neoplastic diseases. The distinction of these lesions has significant therapeutic and prognostic implication. It has been shown that pancreatic blood flow is altered in patients with chronic pancreatitis giving the idea that perfusion assessment can be used as an additional parameter to differentiate pancreatic pathologies (1). A first attempt to characterize and differentiate pancreatic pathologies by assessing perfusion differences has been reported by Delrue et al. (2) Against the expectation this research group reported a hypoperfusion of the pancreatic tissue also in acute pancreatitis due to generalized edema with consecutive release of pancreatic enzymes resulting in necrosis, destruction of small vessels and parenchymal hemorrhage (Fig. 1).

MRI has been established as a reliable method for detection of pancreatic diseases. Besides the standard diagnostic tools of endoscopic ultrasound and endoscopic retrograde cholangiopancreatography (ERCP), MRI can noninvasively provide both morphological tissue characterization as well as assessment of pancreatic function (3). Several methods have been proposed for noninvasively quantifying pancreatic perfusion (4-6). However, these previous reportings of pancreatic tissue perfusion quantification are all based on administration of contrast media. Moreover, CT and PET perfusion imaging are related to a substantial radiation exposure. In consideration of a high number of polymorbid patients with severe renal insufficiency the need for an alternative diagnostic tool rises.

In recent years arterial spin labeling (ASL) technique have been introduced as a tool for quantitative assessment of tissue perfusion without the need for contrast media administration. The aim of this study is to prospectively investigate the reproducibility of perfusion measurements of the pancreas using ASL as well as to quantify effect size and variability during secretin stimulation in healthy volunteers.
Fig. 1: Acute pancreatitis (hematoxylin and eosin stain) with parenchymal hemorrhage (asterisk), fat tissue necrosis (oval), parenchymal necrosis and edema (arrow head).

© Histopathology course, University of Basel
Methods and materials

Study Participants

This study is approved by the local ethics committee and written informed consent was obtained from all participants. Ten healthy volunteers (four men, six women; mean age 28.5±4.6; 25 - 40 years) were investigated with an adapted respiratory-gated flow-sensitive alternating inversion recovery (FAIR)-TrueFISP ASL sequence to determine pancreatic perfusion (3T Verio; Siemens Erlangen, Germany) after fasting for 6h. All individuals were placed in the magnet equipped with a phased-array surface coil in the supine position. To reduce motion artefacts the single data sets were performed in breath hold.

MR Imaging Protocol

The imaging parameters were as follows: 5mm thick sections; field of view, 360x360 mm²; matrix, 128x128; spatial resolution, 0.36 pixel/mm; TI/TR/TE, 1200/4.04/2.02 ms; flip angle, 70°. 80 consecutive ASL data sets were measured for dynamic tracking of the secretin effect in the pancreas. The ASL measurements were divided in four stacks. Each stack contains 20 data sets. Each data set contains two measurements with a acquisition time of 13.2sec. Total examination time for perfusion imaging of the entire organ was 17min and 36sec. The first of the resulting four stacks represented the baseline value (BL) whereas the following 3 stacks (P1 - P3) were measured immediately after secretin injection (1E/kg body weight) for dynamic tracking of the secretin effect in the pancreas. To investigate repeatability of pancreatic perfusion each volunteer was studied twice with an interval of 1 week between measurements.

Based on an anatomical T2 haste axial sequence slices for ASL measurements were chosen and perfusion imaging were performed on the pancreatic head with slice position angulated along the axis of the pancreatic head. A T1-map was acquired. The tissue equilibrium magnetization (called M0) was added by acquisition of an image without inversion. Baseline and post secretin series were made on the same slice orientation.

Data Analysis

On the 80 ASL data sets the region of interest (ROI) was positioned manually along the outline of the pancreatic head. We included as much pancreatic tissue as possible with careful exclusion of large surrounding vessels and ducts at the same time (Fig. 2).

Quantitative perfusion calculations were based on the extended Bloch equation using a self-written MatLab program (Fig 3). Two inversion recovery images were acquired, one recorded with a nonslice selective global inversion pulse and another with a slice selective
inversion pulse. Perfusion values were calculated from the analysis of the magnetization difference $M$ between slice selective and global inversion images. All measurements were performed by two experienced radiologists.
**Fig. 2:** The ROI was positioned manually in the pancreatic head, including as much pancreatic tissue as possible by avoiding large vessels and ducts at the same time.

© Department of Diagnostic, Interventional and Pediatric Radiology, University Hospital of Bern, Inselspital Bern
Fig. 3: Extended Bloch equation: ASL is based on the analysis of magnetization differences (#M) between slice selective and global inversion pulse, determined by the TI. We choose a TI of 1200 ms. T1 is the longitudinal relaxation time of pancreatic tissue which was set to 600ms based on values published in the literature (3, 7). By applying this equation the perfusion map was calculated. Perfusion values were analyzed by using a self-written MatLab program.

© Department of Diagnostic, Interventional and Pediatric Radiology, University Hospital of Bern, Inselspital Bern
Results

Perfusion images showed diagnostic image quality in the pancreatic head with limited motion artefacts. Precise delineation of the pancreas was feasible by the aid of anatomical axial T2w images. All healthy volunteers were free of visible pancreatic pathologies.

Mean BL perfusion was 285±96 ml/100g/min. When we compared pancreatic perfusion values obtained at the first MR imaging session with the second measurement after one week we found an intraindividual variability of 14.4% for the BL perfusion value for repeated measurements without secretin stimulation. Mean ASL perfusion values of the pancreatic head are provided in Fig. 4. Regarding the mean pancreatic perfusion values obtained without and during secretin stimulation (P1) pancreas perfusion significantly (p<0.05) increased by 81% to 486±156 ml/100g/min after secretin stimulation. This effect showed an intraindividual variability of 63% for the pancreatic perfusion during secretin stimulation. For the following post secretin stacks (P2, P3) a return to baseline values was observed (Fig. 4).

After secretin stimulation an indirect sign of the secretin effect can be observed as the duodenum fills continuously with pancreatic fluid (Fig. 5).
Fig. 4: Mean BL perfusion was 285±96 ml/100g/min with a intraindividual variability of 14.4% for repeated measurements. After secretin stimulation (P1) pancreas perfusion significantly (p<0.05) increased by 81% to 486±156 ml/100g/min. A return to BL perfusion values could be observed for the following post secretin stacks (P2, P3).

© Department of Diagnostic, Interventional and Pediatric Radiology, University Hospital of Bern, Inselspital Bern
**Fig. 5:** Baseline and post secretin measurements were acquired on the same slice orientation. One data set contains two measurements: one scan with a slice selective (A) and one scan with a global inversion pulse (B). ASL is based on the analysis of the magnetization differences between slice selective (portal vein labeled, green oval) and global inversion pulse (portal vein not labeled, red oval). An indirect sign of the secretin effect can be observed as the duodenum fills continuously with pancreatic fluid (blue arrows). 

© Department of Diagnostic, Interventional and Pediatric Radiology, University Hospital of Bern, Inselspital Bern
Conclusion

Dynamic non-invasive ASL imaging of the pancreas used in our study permits quantification of pancreas perfusion on the pancreatic head in a clinically applicable setting with good reproducibility for BL measurements. BL values obtained in our study (285±96 ml/100g/min) were higher than those previously reported but in the same order of magnitude (3, 4, 8). However, due to lack of a reference standard for quantitative pancreatic perfusions measurements these calculated BL perfusion values can not be considered as absolute values and served us as reference values for accuracy survey of our method.

Results from previous reported studies performed by using secretin with more invasive technics, e.g. contrast-enhanced MRI or contrast-enhanced CT, have demonstrated that secretin application increases pancreatic perfusion (4, 9, 10). We achieved secretin stimulation by using a dose of 1 U/kg which is known to be responsible for a maximal response of the exocrine pancreas (11). In our study after secretin stimulation healthy volunteers showed indeed a significant increase of pancreas perfusion on the pancreatic head by 81% with reasonable reproducibility. The intraindividual variability for repeated measurements performed during secretin stimulation was much higher (63%) than compared with studies for baseline perfusion (14%). A possible explanation for that could be due to physiological variable response of the exocrine pancreas to secretin stimulation influenced by factors we didn't control, for example volunteers physical activity prior to the examination; this is one limitation of our technique. However, the secretin effect responsible for 81% increase of the perfusion in the pancreatic head showed higher amplitudes than the intraindividual variability for repeated measurements after secretin administration.

One other limitation of this study could be the relative young age of the volunteers in good health condition providing full cooperation. A patient population with pancreatic disease would be considered older.

In summary perfusion measurements with ASL sequences render a promising method to differentiate pancreatic disorders without the risk associated with the invasive alternatives. This method can be combined with the routinely performed diagnostic MR protocol as valid perfusion imaging for the assessment of pancreatic tissue perfusion.
Personal information

Corresponding author

Khoschy Schawkat, MD, khoschy.schawkat@insel.ch

Department of Diagnostic, Interventional and Pediatric Radiology, University Hospital of Bern, Inselspital, CH-3010 Berne, Switzerland
References