

MR Hydrometry to assess exocrine function of the pancreas: A quantitative approach

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Introduction:

Assessment of the exocrine function of the pancreas remains difficult, since tube tests yielding the highest sensitivity and specificity are invasive, time-consuming and expensive. We sought to evaluate magnetic resonance hydrography, which is a method of quantifying fluid amounts by using MRI and a specially developed algorithm, to assess the exocrine function of the pancreas after stimulation with secretin.

Material:

All investigation were carried out in a 1.0 T clinical scanner (Magnetom Expert, Siemens, Germany) using a quadrature body-array-coil. Images were acquired following the protocol listed below.

Measurement protocol:

- Localizer
- HASTE (TR: 10,9ms; TE: 87ms)
This sequence was used for the definition of the imaged volume
- native RARE (TR: 2800ms; TE: 1100ms) -Baseline
- i. v. application of 1cu/kg bodyweight secretin
- dynamic RARE (19 measurements; 1 every 30 seconds)

Protocol: Matos et al. [1].

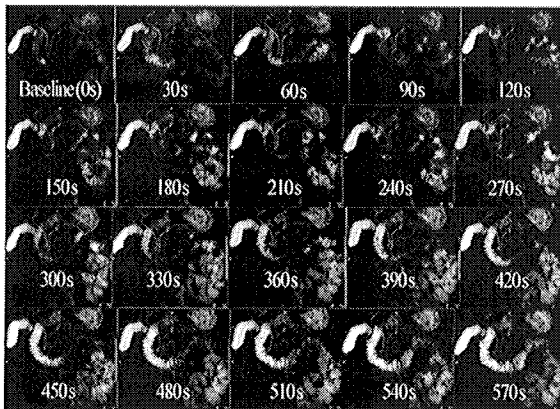


Figure 1: Investigation of one sample patient

After transferring the images to a workstation (Indigo2, Silicon Graphics, Mountain View, USA), the quantitative evaluation was performed with a specially designed histogram algorithm (ImageLab™, MeVis, Bremen, Germany). All images were translated into histograms. Each histogram value was multiplied with the number of pixels demonstrating this value. All resulting products were added providing a value ΔQ_F .

First the reproducibility, the linearity of signal increase, the influence of saturation effects due to former excitations and the importance of slice thickness were tested in water filled phantoms. Thereby the coefficient c that correlates the increase in ΔQ_F with real increase in fluid volume V was calculated by

$$c = \Delta Q_F / V$$

For in vivo measurements the algorithm was calibrated by an investigation of ten healthy volunteers (six male/four female; mean age: 23 ± 2.2 years) who were intubated with a duodenal probe. During the MR investigation 95 mL of saline solution were instilled. The coefficient c was corrected for in vivo measurements.

In five patients (one female/four male; mean age: 47 ± 5.4 years) the algorithm with secretin stimulation was evaluated in comparison with the gold standard, the secretin-tube-test.

Results:

The reproducibility measurements revealed a coefficient of variation of 0.18%. Furthermore, the measurements showed a linear correlation between the real amount of fluid in the imaging volume and ΔQ_F .

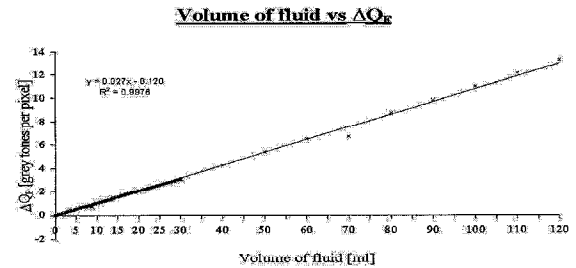


Figure 2: Linear correlation between ΔQ_F and the increase of fluid in the imaging volume reveals a gradient of regression line of 0.027 grey tones per pixel per ml of fluid. Scattergram of differences of grey tones per pixel for defined increasing fluid volumes. From 0 to 30 mL the volume increased in steps of 0.25 mL.

Saturation effects could be obviated with delay times longer than 11 seconds between two measurements. Neither pixel size nor volume thickness did influence the correlation of ΔQ_F and the quantum of fluid in the imaged volume.

The mean ΔQ_F in ten volunteers at the end of the investigation was 4.1 ± 0.22 grey tones per pixel. With 95 mL instilled saline solution this a coefficient c of 0.043 grey tones per pixel per mL.

Comparison with the secretin-tube test revealed a correlation of $r = 0.946$ ($p < 0.05$; Pearson) for the five patients.

Conclusion:

Our in vitro experiments showed the possibility of quantifying fluid volumes using the single-shot TSE sequence analyzed with a histogram algorithm.

The volunteer investigation enabled adaptation of the association between ΔQ_F and the real volume changes to humans in vivo. Variations from the in-vitro measurements can be explained by the greater mass in the scanner in respect of the phantom measurements.

The first experiences with five patients showed promising results.

In general it can be concluded that MR hydrometry has to face some restrictions. It is not able to quantify a steady volume of fluid; only changes in volume can be measured. The characteristics of different scanners, coils, sequences and measurement parameters (TR, TE, flip angle, ...) necessitate adjustment of the coefficient c calculating the real fluid increase in the measured volume.

Variations of c with different sequences and imaging parameters make it mandatory to recalculate c for every institution. However, this can be easily done if our protocol and an investigation of a cohort (about ten) of healthy volunteers is carried out. Administering a known amount of fluid and calculating ΔQ_F allows validation of a protocol for fluid measurements.

In conclusion, this study proves the technical feasibility of quantifying duodenal fluid volume output by MR hydrography and stimulates further studies assessing the role of this new technique as a tool to investigate exocrine pancreatic function.

References:

- [1] Matos et al. Radiology 1997; 203:227-232