

# Assessment of reflux-induced esophageal compliance using concurrent magnetic resonance imaging and high-resolution manometry

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## Introduction:

In recent years, the prevalence of gastro-esophageal reflux disease (GERD) has increased and there is a strong correlation between acid reflux and the increasing incidence of esophageal cancer [1]. The gastro-esophageal junction (GEJ) is the key defense mechanism against acid reflux. In a recent study the structure and function of the GEJ was assessed by concurrent magnetic resonance imaging (MRI) and high-resolution manometry (HRM) [2]. It was shown that MRI is feasible to detect reflux events and assess structure of the reflux barrier. However, little is known about the effect of GERD on the muscles of the esophagus and with it on the compliance of the esophageal body [3]. The unique combination of the two techniques, MRI and HRM, provides a large amount of information. The mixture of structural information provided by MRI and pressure information of the HRM throughout the whole esophagus and proximal stomach allows calculation of the esophageal compliance during recorded reflux events. Many studies have shown that the compliance of the esophagus and the lower esophageal sphincter (LES) can be assessed using isobaric recording device (barostat) and compliance bag or in combination with standard radiological methods [3-4]. In this study due to lack of ionizing radiation in the MRI, the measurements could be repeated at will and thus overall 27 reflux events were recorded which in turn enabled the calculation of the compliance of the esophagus in healthy volunteers and GERD patients during corresponding reflux events.

## Methods:

The compliance of the esophageal body was analyzed using concurrent MRI and HRM. MRI measurements were performed using 1.5T whole-body MRI system (Philips Healthcare, Best, NL) and HRM measurements using 21-channel water-perfused HRM system (Advanced Manometry Systems, Melbourne, AUS). Dynamic MR sequence (3 oblique coronal slices, 3x380 dynamics, 330ms/slice, balanced fast-field echo (bFFE) sequence, FOV=360x285mm<sup>2</sup>, scan matrix=192x190, slice thickness=8mm, SENSE factor=1.6) was applied to detect reflux events after high-volume, high-caloric meal and intra-luminal pressure activity in the esophagus and proximal stomach was recorded continuously using HRM [2]. Reflux events recorded in 9 healthy volunteers (14 events) and 7 GERD patients (13 events) were examined. On the dynamic MR scans the esophageal diameter change was calculated as the difference between the esophageal diameter immediately before the reflux event and during the reflux event, 5cm above the LES [figure 1A]. In the HRM the pressure difference was calculated as the difference between the esophageal pressure, 5cm above LES, immediately before the reflux event and the esophageal pressure during reflux event i.e. during common cavity [figure 1B]. From these data the compliance of the esophageal body was calculated according to:  $C = \Delta V / \Delta P$ . Where  $\Delta V$  was the change in esophageal volume before and during reflux induced

by the  $\Delta P$ , change in esophageal pressure before and during reflux. Esophageal volume was approximated as a cylinder with a height of 5cm:  $V = \pi \cdot 5 \cdot (d / 2)^2$  where d is esophageal diameter calculated from MR images. Volumes before and during reflux, volume difference, pressure difference and compliance are presented as mean  $\pm$  SD and students T-test was conducted on the results.

## Results:

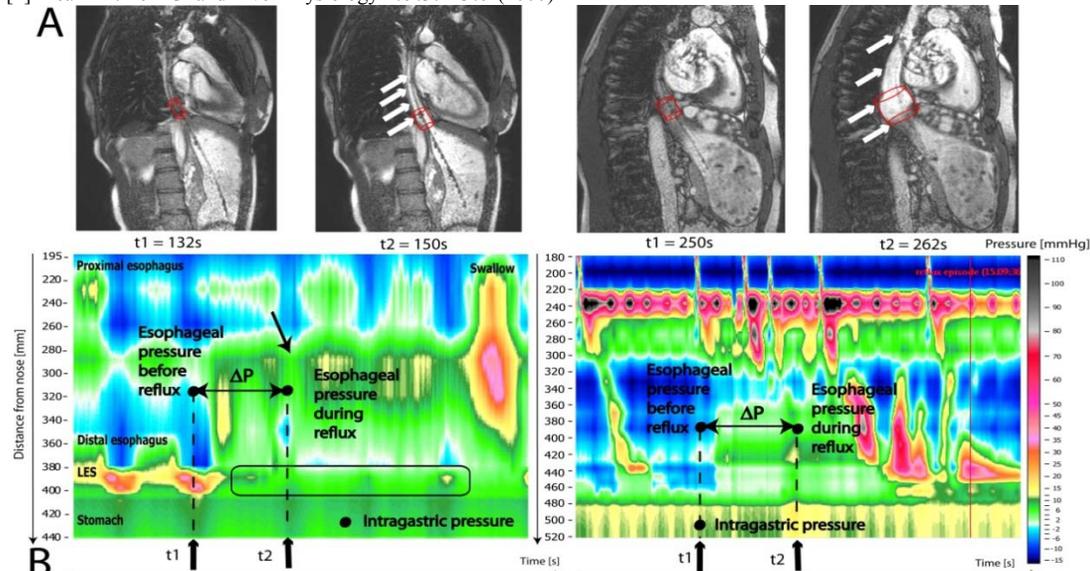
Results are presented in table 1. Baseline (V1) and reflux (V2) volume as well as the volume difference ( $\Delta V$ ) are significantly ( $p < 0.05$ ) higher in GERD patients than in healthy volunteers (22.8ml vs. 13.2ml). The pressure difference, however, is similar in both groups (GERD patients 9.2mmHg vs. 8.9mmHg). Due to the high variability observed in the patient data, calculated compliance shows only a tendency towards larger values for GERD patients (2.4ml/mmHg vs. 1.6ml/mmHg). Postprandial intra-gastric and LES pressures are 2.4mmHg vs. 2.9mmHg and 22.4mmHg vs. 28.4mmHg in GERD patients and healthy volunteers respectively.

## Discussion:

The applied combination of MRI and HRM techniques allows the assessment of compliance of the lower esophageal body in healthy volunteers and GERD patients. The results show that in GERD patients the esophageal distention is a significant and sensitive parameter for compliance whereas the induced local pressure difference is similar in both groups. This indicates that esophageal MRI may be a valid tool for the assessment of esophageal compliance even without concurrent invasive manometry. Further reflux events in GERD patients must be analyzed (and are work in progress) to further validate the sensitivity of the technique.

## References:

- [1] Fox M. et al. BMJ 332:88-93 (2006); [2] Curcic J. et al. ISMRM 2009; [3] Jenkinson A.D. Dig Dis Sci 46(9):1937-1942 (2001); [4] Mearin F. AJP-GI and Liver Physiology 279:374-379 (2000)



**Figure 1:** A Two representative MR image slices of one reflux event at two different time points, left of one healthy volunteer, right of GERD patient. Reflux event is marked with white arrows. Overlaid in red are virtual cylinders for calculation of volume difference. B Color-coded HRM plots of the same reflux event as presented in A of a healthy volunteer and GERD patient, left and right, respectively. Two time points before and during the reflux event corresponding to MR images are marked with t1 and t2. The pressure difference induced during reflux is given as the pressure difference between these two points 5cm cranially from the LES.

	$\Delta P$ [mmHg]	V1 [ml]	V2 [ml]	$\Delta V$ [ml]	C [ml/mmHg]
Volunteers	8.9 $\pm$ 3.0	5.3 $\pm$ 1.4	18.5 $\pm$ 6.4	13.2 $\pm$ 6.2	1.6 $\pm$ 0.8
Patients (GERD)	9.2 $\pm$ 2.3	8.2 $\pm$ 4.8	31.0 $\pm$ 22.5	22.8 $\pm$ 18.0	2.4 $\pm$ 1.6

**Table 1:** Average pressure difference in the esophagus induced by a reflux event, average volume difference of the esophageal body induced by reflux and esophageal compliance for healthy volunteers and GERD patients.