

DIAPHRAGM FUNCTION IN GERD PATIENTS: PFT assessment with extended esophageal manometry

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Background: Crural diaphragm (CD) is currently suggested as an external esophageal sphincter (EES) localized in a high-pressure zone (HPZ) area. Impaired CD function is an independent predictor of gastro-esophageal reflux disease (GERD). Abnormalities of diaphragm function in GERD patients have not been ever followed. Moreover, a function of crural (posterior) part of diaphragm in HPZ during maximum inspiratory/expiratory manoeuvres (PI_{max}/PE_{max} measurement) has not been followed, too.

Aims and objective: Hypothesis 1: Patients with GERD have impaired both total diaphragmatic function and PI_{max}/PE_{max} values. Hypothesis 2: Subnormal intraesophageal pressures of LES part during PI_{max}/PE_{max} maneuvers will be detected in those subjects in whom reduced respiratory muscle strength was primarily detected. Hypothesis No. 3: Possibly, we might discriminate a pattern of diaphragmatic response during PI_{max}/PE_{max} maneuvers. Hypothesis No. 4: The maximum force of crural part of the diaphragm encompassing the LES part of esophagus might be quantified (by a manometrical approach).

Methods and patients: Twenty patients with endoscopically/pH-metrically verified GERD were tested at the age of 43.6 ± 11.1 (mean \pm SD) yrs. EES activity during standard PI_{max}/PE_{max} manoeuvres (respiratory drive measurement, RDM) was used. An extended multi-probe esophageal manometry was used; pressure changes in the HPZ area of the esophagus were assessed. After the exclusion of manometric probe/sonde by the probands was also performed classical spirometry.

The following methods PFT were used: standard spirometry including FV curve, respiratory muscle (RM) drive measurements (maximum inspiratory (PI_{max})/expiratory (PE_{max}) pressures. Spirometric recordings of PFTs were performed on the same day for all subjects with a spirometer MasterScope Jaeger (version 4.5, Jaeger, VIASYS, Wuerzburg, Germany) with a special module for the respiratory muscles (RM) drive assessments. All subjects were properly instructed and coached by an experienced technician. Procedures and quality criteria of the American Thoracic Society and were used for these measurements. The following PFT parameters were measured: FEV1, FVC, FEV1/FVC, PI_{max} , PE_{max} . PFT results are presented as percentages of reference values.

Esophageal manometry is an additional, non-invasive imaging method, which aims to determine the pressure in the lower esophageal sphincter (LES), including the relaxation response to swallowing, and to describe esophageal peristalsis. Currently is implemented so-called high-resolution manometry. Technological advances allow 20-36 channel scanning of esophageal motility. The information from this manometry is converted into three-dimensional maps, where can be easier identified also very minute changes of the esophageal motility.

The benefit of HRM is: 1. easy of the realisation of the examenes 2. reproducibility of the examination 3. completely interception of the whole esophagus, including the upper and lower esophageal sphincter with the possibility of online assessment and coordination/dyscoordination before-mentioned structures, as well as clear identification of the so-called transition zone, 4. more detailed observation of the LES.

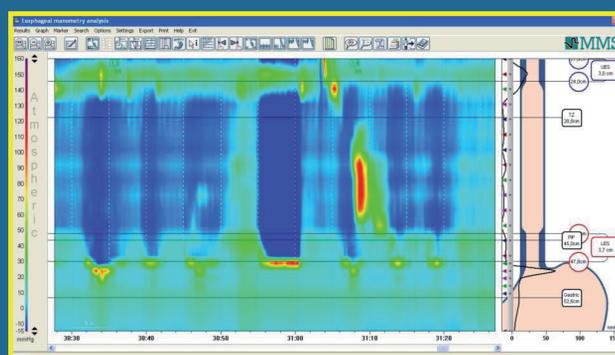
Results: Twenty patients with endoscopically/pH-metrically verified GERD were tested at the age of 43.6 ± 11.1 (mean \pm SD) yrs. EES activity during standard PI_{max}/PE_{max} manoeuvres (respiratory drive measurement, RDM) was used. An extended multi-probe esophageal manometry was used; pressure changes in the HPZ area of the esophagus were assessed. **Decreased PI_{max} ($p < 0.00001$)** and just slightly diminished PE_{max} ($p = 0,053$) was found.

The pressure in the esophagogastric junction (EGJ) increased from rest value (of 14.6 ± 7.1 mm_{Hg}) during both PI_{max} and PE_{max} . **PI_{max} to 62.5 ± 24.6 mm/Hg, $p < 0.00001$; PE_{max} 55.4 ± 22.5 mm_{Hg}, $p < 0.0001$.**

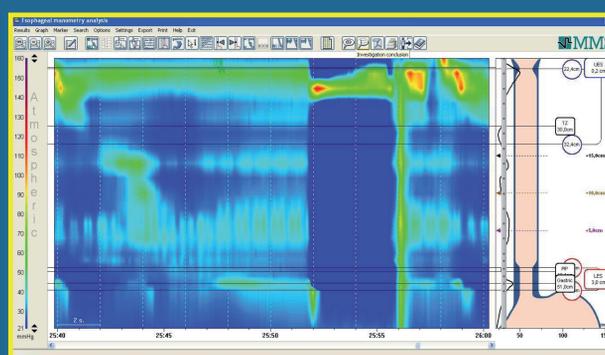
Correlation of the spirometric and manometric data showed a correlation between PE_{max} and a positive increase in LES pressure ($p = 0.0104$). Correlation between PI_{max} and an increase in LES pressure was not statistically significant ($p = 0.47$).

At the same time we observed the reaction of CD in the LES part of esophageus by maximum respiratory maneuvers. During PI_{max} maneuver were observed two types of reactions in diaphragm: in the first case during a maneuver occurred increase of pressure on the LES – the diaphragm made a concentric contraction. In the second case, there was a significant reduction of pressure in LES during inspiration maneuver - the diaphragm made an eccentric contraction.

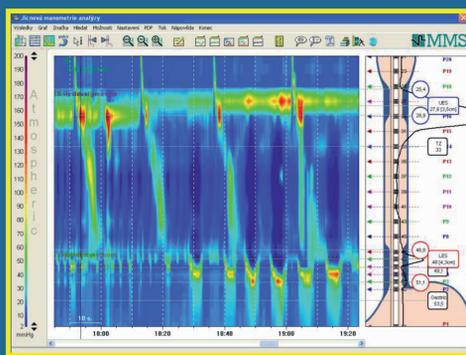
During PI_{max} maneuver was the reaction of CD a constant concentric contraction. Only at the beginning of the maneuver (by maximum tinge), 7 of the probands (35%) were observed following a paradoxical decrease of pressure in LES (eccentric contraction).



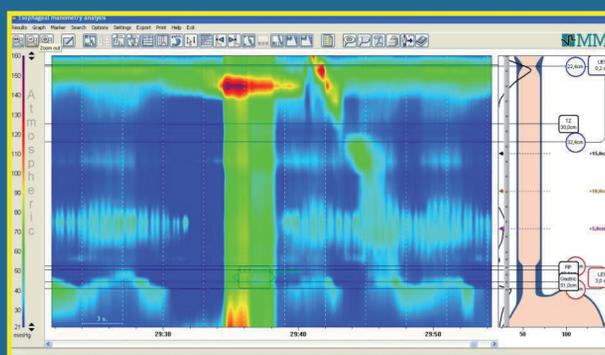
Normal type of diaphragm activity in low esophageal sphincter area during PI_{max} maneuver.



Paradoxical (eccentric contraction) type of diaphragm activity in low esophageal sphincter area during PI_{max} maneuver.



The facilitated abdominal tidal breathing in the right half of figure.



Classical type of diaphragm activity in low esophageal sphincter area during PE_{max} maneuver.

Table with spirometric data ($PI_{max} - PE_{max}$) in patients with gastroesophageal reflux disease.

probands	PI_{max}			PE_{max}		
	kPa	kPa	%	kPa	kPa	%
	ref.	act.	pred.	ref.	act.	pred.
1.	10,57	3,91	37,00	6,19	5,87	94,90
2.	10,71	5,37	50,20	6,82	4,05	59,40
3.	10,83	8,48	78,30	6,88	7,39	107,50
4.	10,48	5,48	52,30	13,57	8,17	60,10
5.	10,81	6,65	61,50	7,51	10,69	142,30
6.	10,81	8,41	77,80	7,70	10,22	132,80
7.	10,81	6,65	61,50	7,95	7,96	100,10
8.	10,57	7,11	67,20	13,99	8,80	62,90
9.	10,71	8,57	80,00	13,99	12,63	90,20
10.	10,59	8,61	81,30	14,07	10,71	76,10
11.	10,95	7,20	65,70	8,33	13,95	167,50
12.	10,74	7,84	73,00	14,22	8,41	59,20
13.	10,95	7,89	72,00	8,39	7,91	94,30
14.	10,85	12,05	111,10	14,29	13,71	96,00
15.	10,90	9,83	90,10	14,33	11,57	80,80
16.	10,69	7,36	68,90	14,40	8,10	56,30
17.	10,67	4,17	39,10	14,07	6,58	46,80
18.	11,32	4,97	44,00	9,40	5,47	58,00
19.	10,75	4,47	41,60	7,57	3,63	47,90
20.	10,81	2,66	24,60	7,57	5,39	71,70
mean	10,78	6,88	63,86	10,56	8,56	85,24
SD	0,18	2,25	20,74	3,35	3,00	32,87
median	10,78	7,16	66,45	8,90	8,14	78,45
p =	0,000 000 01			0,053830198		

Discussion:

The diaphragm activation is decisive for proper EGJ function. There is a significant increase of the pressure in EGJ during PI_{max} and PE_{max} maneuvers. The maximum peak of pressure in EGJ was 179mm/Hg. The diaphragm has the function of the external esophageal sphincter and therefore, is serving as an anti-reflux barrier. There is significant impairment of respiratory muscles strength (especially of the diaphragm) during PI_{max} manoeuvre in GERD patients. PE_{max} was also decreased, but not significantly. There is no correlation between the decrease of PI_{max} and the degree of CD strength impairment in GERD patients. On the contrary, there was a significant correlation between CD and PE_{max} - the more PE_{max} is reduced, the more reduced was the strength of CD and also its effect to EGJ pressure and vice versa. Paradoxically, the decrease of EGJ pressure during PI_{max} was observed in 8 patients. This may be explained as a paradoxical eccentric contraction of the diaphragm during PI_{max} maneuver, associated with defective breathing patterns. There was also recorded an impaired diaphragm activity and defective breathing patterns during the normal respiration by manometric examination. The majority of these pathological findings were normalized during the facilitation of abdominal breathing (by special RHB technique). Diaphragm dysfunction in GERD patients is evident.