

## A Comparison of Impulse Oscillometry and Spirometry Values in Patients with Gastroesophageal Reflux Disease

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### ABSTRACT

#### BACKGROUND

The relationship between gastroesophageal reflux (GERD) and airway diseases is still a matter of debate. Oscillometry is an objective, independent tool for the evaluation of airway resistance. The main purpose of this study is to compare spirometry and oscillometry results before and after treatment by a proton pump inhibitor (PPI) in a group of GERD patients who have no respiratory symptoms.

#### METHODS

This study was performed on patients with endoscopically diagnosed reflux esophagitis who had no pulmonary symptoms. Patients received omeprazole 40 mg, twice a day for 12 weeks. Spirometry and oscillometry were performed before and after treatment. Impulse oscillometry (IOS) was performed by a force oscillation instrument. We recorded respiratory resistance at 5 Hz (R5) and 20 Hz (R20), resonant frequency (Fres), and distal capacitive reactance (X5) for each patient.

#### RESULTS

Included were 30 patients (17 males; 13 females) whose mean age was 32 years. According to the Los Angeles Classification, 16 patients had grades B or C esophagitis and 14 had grade A. Although all patients had normal spirometry results, 50% had increased airway resistance according to oscillometric findings. After treatment with omeprazole, only 16.3% had abnormal oscillometry results ( $p=0.004$ ). Spirometry results [forced expiratory volume at the first second (FEV1); forced vital capacity (FVC); FEV1/FVC; and mean forced expiratory flow 25%-75% (FEF 25%-75%)] showed significant further improvement compared to pretreatment normal values ( $p<0.001$  for all).

#### CONCLUSION

Abnormal airway resistance may be present in GERD patients even when there is no obvious respiratory symptom. Oscillometry seems to be more sensitive than spirometry in reporting abnormal pulmonary function in patients with GERD.

#### KEYWORDS

Oscillometry; Spirometry; Gastroesophageal reflux

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## INTRODUCTION

Gastroesophageal reflux disease (GERD) is a common gastrointestinal (GI) disease that affects about one third of the Western world.<sup>1,2</sup> The reported prevalence of GERD in Iran ranges from 15.4% to 39.7%.<sup>3-6</sup> The most common endoscopic diagnosis in a referral center of Iran is endoscopic esophagitis.<sup>7</sup> GERD can lead to several increasingly recognized 'atypical' or 'extra-esophageal' manifestations such as laryngitis, dental erosions, hoarseness, non-cardiac chest pain, chronic cough, asthma, recurrent pneumonia, subglottic stenosis, and laryngeal cancer.<sup>8,9</sup> The prevalence of GERD in asthmatic patients is reported to be as high as 70.6% to 80% in the Western population.<sup>9-11</sup> However, it is difficult to establish a causal relationship.<sup>12,13</sup> Both asthma and GERD are common worldwide diseases. In Iran, the prevalence of wheezing varies throughout different parts of the country and ranges from 7.6% to 40.2%, whereas the prevalence of asthma is estimated to be 3.2%.<sup>14,15</sup>

The efficacy of proton pump inhibitors (PPIs) on asthma outcomes in patients with GERD is controversial.<sup>16-19</sup> Some investigators have proposed that anti-reflux surgery may be more effective than medical therapy.<sup>20</sup> Microaspiration of gastric acid and acid induced vagal nerve stimulation are considered to be important underlying mechanisms.<sup>21</sup> Most patients with GERD may have some degree of respiratory abnormality. In order to evaluate these abnormalities more sensitive tools that are not dependent on patient effort are needed. Recently, the impulse oscillation system (IOS) has been introduced as a new system for the forced oscillation test. It is a noninvasive test, not dependent on the patient's effort and measures airway resistance and compliance using electrical impulses.<sup>22</sup> It has been shown that the accuracy of IOS is comparable to plethysmography.<sup>23</sup> Results may be abnormal in patients with increased airway resistance despite normal spirometry test results.<sup>24</sup> The present study aims to assess airway abnormalities in GERD patients before and after

anti-reflux therapy by using both the oscillometry and spirometry tests.

## MATERIALS AND METHODS

Between November 2010 and February 2011 we selected cases from among patients who attended the Gastrointestinal Clinic at Ahwaz Imam Khomeini Hospital and had complaints of reflux symptoms. The diagnosis of GERD was established by endoscopy. Patients who smoked in addition to those with known respiratory diseases, ischemic heart disease, heart failure, liver disorders, or malignancies were excluded from the study. Also excluded were pregnant or lactating females and those who refused to have an upper GI endoscopy performed.

All enrolled patients underwent an upper GI endoscopy conducted by an expert gastroenterologist using Olympus 160 equipment. Reflux esophagitis was defined as the presence of a mucosal break at the distal part of the esophagus and classified according to the Los Angeles Classification System.<sup>25</sup> Excluded were patients with normal endoscopy results or those with any other endoscopic diagnosis except for reflux esophagitis.

All patients with reflux esophagitis underwent IOS testing by a force oscillation instrument (Enrich Jaeger, Hoechberg, Germany). For the IOS test, patients were instructed to remain in an upright position, with their heads in neutral alignment or mildly extended. Tight clothing or belts were removed prior to the IOS. Patients were asked to hold the oral plastic piece of the oscillometer tightly between their teeth, above the tongue, with their lips and nose completely closed. Short-time electrical impulses within a power range of 0-100 Hz at a duration of 45 ms and intervals of 0.2 s generated by a loudspeaker in the patients' mouths were used.

Total impedance of the respiratory system determines the magnitude and phases of flow oscillation that result from pressure fluctuation. According to the relationship between flow and pressure, "respiratory impedance" can be subdivided into "resistance and reactance" where "resistance" rep-

resents the total effect of the lung and chest wall and ‘reactance’ shows the net effect of two opposite forces (elastic and inertial). We measured respiratory impedance for 30 s during tidal breathing. Respiratory resistance was measured at a low frequency (5Hz=R5) for total respiratory resistance and at a high frequency (20Hz or R20) for proximal respiratory resistance. Respiratory reactance was measured at the 5 Hz frequency (Xr5). Resonant frequency (F<sub>res</sub>) was determined as the oscillatory frequency at which the respiratory reactance was zero. The system’s software calculated all values. After comparing R5 and R20 to normal values, they were reported as the percent of predicted value. Oscillometry parameters are interpreted according to Table 1.

Spirometry was performed at the beginning of the study for each patient in order to measure forced vital capacity (FVC), forced expiratory volume at the first second (FEV1), forced expiratory flow 25%-75% (FEF 25%-75%), and peak expiratory flow rate (PEFR). FEV1 >80% of predicted value, FVC >80% of predicted value, FEV1/FVC >70%, an FEF 25%-75% value that was >80%, and a PEFR >80% were all considered normal.

After baseline IOS and spirometry, patients were given omeprazole (40 mg, Abidi Co., Ltd., Tehran, Iran) twice a day for 12 weeks. Patients were followed at the clinic every four weeks. Patient compliance to therapeutic treatment was monitored by telephone contact. Spirometry and oscillometry were performed again at the end of treatment.

The Research Ethics Committee of Ahwaz Jundishapour University of Medical Sciences approved this study on 09/23/2010 with the registration number 3135 and IRCT code of 201102035749.

### Statistical Analysis

Data are presented as mean±standard deviation (SD) or percentage as appropriate. Chi-square and Fisher’s exact tests were used for comparison of dichotomous data. Assessment of mean between both groups was performed using the paired sample independent t-test. A p-value less than 0.05 was considered significant.

**Table 1: Interpretation of oscillometry test results.**

Variable	R5 (%)	R20 (%)	X5	F <sub>res</sub> (Hz)
Normal	<150	<150	-0.2< and <0.2	10
Increased proximal (central) airway resistance	>150	>150	-0.2< and <0.2	10
Increased distal (peripheral) airway resistance	>150	<150	< -0.2	> 10
Restrictive lung disease	>150	>150	< -0.2	> 10

### RESULTS

There were 13 females (43%) and 17 males (57%) in this study. Patients’ mean age was 32±2 years (range: 18-47). There were 14 (46.6%) patients with grade A esophagitis, 15 (50%) had grade B esophagitis and one (3.3%) had grade C esophagitis.

Prior to treatment, patients’ mean percent predicted spirometry measurements were as follows: FEV1 (92.14±11.24); FVC (88.12±7.16); FEV1/FVC (92.09±8.36); FEF 25%-75% (92.09±8.36); and PEFR (109.59±21.07), all of which were within normal limits (Table 1). Oscillometry results at baseline indicated that 50% of patients had R5 levels that were >150% of predicted, of whom 65% of these were male. Additionally, there were 54% of patients who had R20 levels >150% of predicted, of whom 71% were male. All X5 values ranged from -0.2 and 0.0 KPa/L/s (Table 2). Based on these findings, approximately 50% of patients demonstrated increased proximal (central) airway resistance. There was no restrictive pattern observed.

All patients completed the treatment period with no significant complications reported. Spirometry measurements improved following 12 weeks of treatment by omeprazole (Table 2). The oscillometry test results showed the following: R5 >150% in 17% of patients and normal R20 and X5 levels in all patients. Furthermore, a significant improvement in mean R5, R20, and X5 values were observed (Table 3). Treatment by omeprazole did not significantly affect PEFR and R5 values in females, nor did it affect X5 values in males. The level of improve-

**Table 2: Comparison of spirometry test results before and after treatment.**

Variable (% predicted)	Before treatment	After treatment	p-value
<b>FEV1</b>			
All patients	92.14 ± 11.24	99.44 ± 12.02	< 0.001
Men	92.33 ± 12.22	98.90 ± 11.19	0.001
Women	91.91 ± 10.30	100.15 ± 13.46	<0.001
<b>FVC</b>			
All patients	88.12 ± 7.16	94.68 ± 8.16	<0.001
Men	90.44 ± 7.52	94.39 ± 7.30	0.018
Women	85.09 ± 5.57	95.06 ± 9.46	<0.001
<b>FEV1/FVC</b>			
All patients	92.09 ± 8.36	104.59 ± 10.49	<0.001
Men	92.85 ± 8.13	108.60 ± 9.81	<0.001
Women	91.10 ± 8.89	99.34 ± 9.24	<0.001
<b>FEF 25%-75%</b>			
All patients	101.70 ± 19.31	110.48 ± 19.24	<0.001
Men	99.01 ± 14.49	109.05 ± 16.85	<0.001
Women	105.20 ± 24.44	112.35 ± 22.57	<0.001
<b>PEFR</b>			
All patients	109.59 ± 21.07	117.53 ± 18.68	0.025
Men	113.34 ± 18.40	125.54 ± 15.10	0.002
Women	104.68 ± 23.99	107.07 ± 18.66	0.714

Data are presented as % of predicted ± standard deviation.

ment in spirometric indices and oscillometric indices did not significantly differ in patients with GERD grade A compared to those with GERD grades B and C as seen in Figure 1: FEV1 ( $p=0.9$ ); FVC ( $p=0.46$ ); FEV1/FVC ( $p=0.57$ ); FEEF 25%-75% ( $p=0.15$ ); FEER ( $p=0.10$ ); R5 ( $p=0.89$ ); R20 ( $p=0.16$ ); and R5 ( $p=0.79$ ).

## DISCUSSION

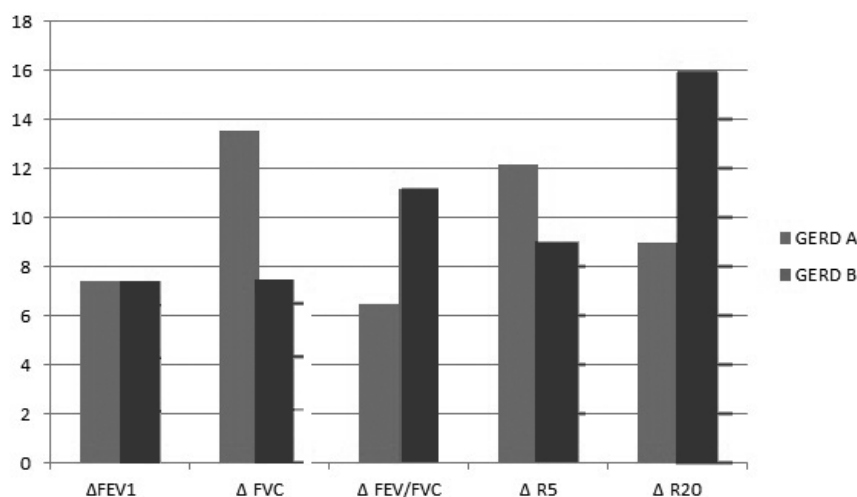
Because the oscillometry test does not take long to perform and is not dependent on patient effort, it may be of more benefit than spirometry, particularly for children and the elderly. In the present study we have used both oscillometry and spirometry to evaluate GERD patients who had no respiratory symptoms. We observed that all patients had normal respiratory values. However the oscillometry findings revealed that airway resistance was high at 5 Hz and 20 Hz frequencies (R5 and R20) in at least 50% of patients. According to our results patients with GERD, even in the absence of respiratory symptoms, might have increased airway resistance. Several studies reported the superiority of IOS for detecting ab-

normal airway resistance. Evans compared spirometry and IOS parameters in normal volunteers at rest and after hyperventilation with cold air and an exercise challenge. He observed that oscillometry test results were more sensitive than spirometry in the detection of post-challenge increased airway resistance.<sup>24,26,27</sup> In an interesting study by Bidad et al., IOS was more sensitive than spirometry in diagnosing asthma among pregnant women.<sup>28</sup> A study by Kanda compared IOS and spirometry in a group of patients with COPD or asthma and normal individuals who were non-smokers. In that study IOS was more sensitive than spirometry for detecting abnormal airway resistance.<sup>24</sup> It has been reported that IOS has increased sensitivity in detecting certain occupational induced airway hypersensitivities.<sup>29</sup> Thus, it is reasonable to presume that patients with GERD have subtle airway hyper-responsiveness, of which a minority of them progress to asthma.

We evaluated the effect of treatment with high dose omeprazole on the objective parameters. After treatment, 16.3% of patients still had abnormal oscillometry results. However at the end of treatment all patients had normal

**Table 3: Comparison of oscillometry test results before and after treatment.**

Variable	Before treatment	After treatment	p-value
<b>R5</b>			
All patients (% predicted)	124.58 ± 43.12	112.77 ± 36.76	0.004
Men (% predicted)	131.31 ± 42.79	120.51 ± 37.10	0.030
Women (% predicted)	115.78 ± 43.65	102.65 ± 35.15	0.072
<b>R20</b>			
All patients (% predicted)	140.95 ± 26.47	128.02 ± 22.26	<0.001
Men (% predicted)	150.62 ± 16.77	137.78 ± 11.86	0.002
Women (% predicted)	128.30 ± 31.83	115.25 ± 26.41	0.013
<b>X5</b>			
All patients (KPa/L/s)	-0.283 ± 0.193	-0.168 ± 0.173	0.004
Men (KPa/L/s)	-0.305 ± 0.172	-0.201 ± 0.219	0.072
Women (KPa/L/s)	-0.254 ± 0.214	-0.125 ± 0.072	0.026

**Fig. 1: Comparisons of differences in spirometric and oscillometric values before and after treatment in patients with GERD A and GERD B.**

spirometry results. Although oscillometry was more sensitive in detecting increased airway resistance, spirometric indices that were already within normal limits at the beginning of the study improved by the end of treatment. Oscillometry measurements showed a significant improvement in airway resistance as well.

Numerous clinical trials have studied the correlation between GERD and asthma. Although they have evaluated the role that GERD treatment plays in reducing asthma symptoms, this treatment remains debatable.<sup>30</sup> Numerous reviewed articles have used spirometry to assess pulmonary function.

There are several theories regarding the mechanism of respiratory hypersensitivity in the setting of GERD, which include microaspiration of gastric secretions,<sup>31</sup> a vagally mediated neurologic reflex-induced bronchospasm,<sup>32</sup> a sensitized vagal neural system-induced airway hyper-responsiveness.<sup>12,33</sup> The last issue has been supported by observations of the overlap with GERD and irritable bowel syndrome (IBS), which may show a common underlying mechanism.<sup>34</sup>

The first limitation of the current study is that it is an open-label trial. The lack of a control group may lead to some difficulties in interpreting the results. Additionally,



the final sample size was small.

In conclusion, there appears to be mild increased airway resistance in some patients with GERD even in the absence of respiratory symptoms. Oscillometry may be more sensitive than spirometry in the identification of these subtle abnormalities. However to establish the efficacy of GERD treatment on pulmonary functions, it is necessary to conduct additional randomized, controlled studies with larger populations.

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#### CONFLICT OF INTEREST

The authors declare no conflict of interest related to this work.

#### REFERENCES

- Locke GR TN, Fett SL, Zinsmeister AR, Melton LJ 3rd. Prevalence and clinical spectrum of gastroesophageal reflux: a population-based study in Olmsted County, Minnesota. *Gastroenterology* 1997;**112**:1448-56.
- Howard PJ, Heading RC. Epidemiology of gastroesophageal reflux disease. *World J Surg* 1992;**16**:288-93.
- Ehsani MJ, Maleki I, Mohammadzadeh F, Mashayekh A. Epidemiology of gastroesophageal reflux disease in Tehran, Iran. *J Gastroenterol Hepatol* 2007;**22**:1419-22.
- Saberi-Firoozi M, Khademolhosseini F, Yousefi M, Mehrabani D, Zare N, Heydari ST. Risk factors of gastroesophageal reflux disease in Shiraz, southern Iran. *World J Gastroenterol* 2007;**13**:5486-91.
- Mostaghni A, Mehrabani D, Khademolhosseini F, Masoumi SJ, Moradi F, Zare N, et al. Prevalence and risk factors of gastroesophageal reflux disease in Qashqai migrating nomads, southern Iran. *World J Gastroenterol* 2009;**15**:961-5.
- Delavari A, Birjandi F, Elahi E, Saberifiroozi M. The Prevalence of Gastroesophageal Reflux Disease (GERD) in the Islamic Republic of Iran: A Systematic Review. *Middle East J Dig Dis* 2012;**4**:5-15.
- Ghajarie Sepanlou S, Abdollahzadeh N, Noori F, Malekzadeh F, Malekzadeh R. Time Trends of Gastro-esophageal Reflux Disease (GERD) and Peptic Ulcer Disease (PUD) in Iran. *Middle East J Dig Dis* 2010;**2**:78-83.
- Shaker R, Castell DO, Schoenfeld PS, Spechler SJ. Night-time heartburn is an under-appreciated clinical problem that impacts sleep and daytime function: the results of a Gallup survey conducted on behalf of the American Gastroenterological Association. *Am J Gastroenterol* 2003;**98**:1487-93.
- Bisaccioni C, Aun MV, Cajuela E, Kalil J, Agondi RC, Giavina-Bianchi P. Comorbidities in severe asthma: frequency of rhinitis, nasal polyposis, gastroesophageal reflux disease, vocal cord dysfunction and bronchiectasis. *Clinics (Sao Paulo)* 2009;**64**:769-73.
- Sontag SJ, O'Connell S, Khandelwal S, Miller T, Nemchausky B, Schnell TG, et al. Most asthmatics have gastroesophageal reflux with or without bronchodilator therapy. *Gastroenterology* 1990;**99**:613-20.
- Goldman J, Bennett JR. Gastro-oesophageal reflux and respiratory disorders in adults. *Lancet* 1988;**2**:493-5.
- Astarita C, Gargano D, Cutajar M, Napolitano A, Manguso F, Abbate GF. Gastroesophageal reflux disease and asthma: an intriguing dilemma. *Allergy* 2000;**55 Suppl 61**:52-5.
- Boskabady MH, Kolahdoz GH. Prevalence of asthma symptoms among the adult population in the city of Mashhad (north-east of Iran). *Respirology* 2002;**7**:267-72.
- Zobeiri M. Prevalence, risk factors and severity of asthma symptoms in children of Kermanshah, IRAN: ISAAC phase I, II. *Acta Med Iran* 2011;**49**:184-8.
- Shakurnia AH, Assar S, Afra M, Latifi M. Prevalence of asthma among schoolchildren in Ahvaz, Islamic Republic of Iran. *East Mediterr Health J* 2010;**16**:651-6.
- Harding SM, Richter JE, Guzzo MR, Schan CA, Alexander RW, Bradley LA. Asthma and gastroesophageal reflux: acid suppressive therapy improves asthma outcome. *Am J Med* 1996;**100**:395-405.
- Katz PO CD, Chen Y, Andersson T, Sostek MB. Intragastric acid suppression and pharmacokinetics of twice-daily esomeprazole: a randomized, three-way crossover study. *Aliment Pharmacol Ther* 2004;**20**:399-406.
- Richter JE. Gastroesophageal reflux disease and asthma: the two are directly related. *Am J Med* 2000;**108 Suppl 4a**:153S-8S.
- Matyasova Z, Novotna B, Matulova M, Dolina J, Kroupa R, Lanikova Z, et al. The relation of GERD, bronchial asthma and the upper respiratory tract. *Vnitř Lek* 2005;**51**:1341-50.
- Bowrey DJ, Peters JH, DeMeester TR. Gastroesophageal reflux disease in asthma: effects of medical and surgical antireflux therapy on asthma control. *Ann Surg* 2000;**231**:161-72.
- Canning BJ, Mazzone SB. Reflex mechanisms in gastroesophageal reflux disease and asthma. *Am J Med* 2003;**115 Suppl 3A**:45S-8S.
- Frei J, Jutla J, Kramer G, Hatzakis GE, Ducharme FM, Davis GM. Impulse oscillometry: reference values in children 100 to 150 cm in height and 3 to 10 years of age. *Chest* 2005;**128**:1266-73.
- Hellinckx J, Cauberghs M, De Boeck K, Demedts M. Evaluation of impulse oscillation system: comparison with forced oscillation technique and body plethysmography. *Eur Respir J* 2001;**18**:564-70.

24. Kanda S, Fujimoto K, Komatsu Y, Yasuo M, Hanaoka M, Kubo K. Evaluation of respiratory impedance in asthma and COPD by an impulse oscillation system. *Intern Med* 2004;**49**:23-30.
25. Lundell LR, Dent J, Bennett JR, Blum AL, Armstrong D, Galmiche JP, et al. Endoscopic assessment of oesophagitis: clinical and functional correlates and further validation of the Los Angeles classification. *Gut* 1999;**45**:172-80.
26. Evans TM, Rundell KW, Beck KC, Levine AM, Baumann JM. Impulse oscillometry is sensitive to bronchoconstriction after eucapnic voluntary hyperventilation or exercise. *J Asthma* 2006;**43**:49-55.
27. Evans TM, Rundell KW, Beck KC, Levine AM, Baumann JM. Airway narrowing measured by spirometry and impulse oscillometry following room temperature and cold temperature exercise. *Chest* 2005;**128**:2412-9.
28. Bidad K, Heidarnazhad H, Kazemnejad A, Pourpak Z. Impulse oscillometry in comparison to spirometry in pregnant asthmatic females. *Eur Respir J* 2008;**32**:1673-5.
29. Gube M, Brand P, Conventz A, Ebel J, Goen T, Holzinger K, et al. Spirometry, impulse oscillometry and capnovolumetry in welders and healthy male subjects. *Respir Med* 2009;**103**:1350-7.
30. Kiljander TO, Junghard O, Beckman O, Lind T. Effect of esomeprazole 40 mg once or twice daily on asthma: a randomized, placebo-controlled study. *Am J Respir Crit Care Med* 2010;**181**:1042-8.
31. Boyle JT, Tuchman DN, Altschuler SM, Nixon TE, Pack AI, Cohen S. Mechanisms for the association of gastroesophageal reflux and bronchospasm. *Am Rev Respir Dis* 1985;**131**:S16-20.
32. Mansfield LE, Stein MR. Gastroesophageal reflux and asthma: a possible reflex mechanism. *Ann Allergy* 1978;**41**:224-6.
33. Harding SM, Schan CA, Guzzo MR, Alexander RW, Bradley LA, Richter JE. Gastroesophageal reflux-induced bronchoconstriction. Is microaspiration a factor? *Chest* 1995;**108**:1220-7.
34. Yarandi SS, Nasser-Moghaddam S, Mostajabi P, Malekzadeh R. Overlapping gastroesophageal reflux disease and irritable bowel syndrome: increased dysfunctional symptoms. *World J Gastroenterol* 2010;**16**:1232-8.