

# Images in Allergy and Immunology

## Obesity and pulmonary function testing

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**Editor's note:** This feature, Images in allergy and immunology, is designed to highlight current concepts of the immunopathology of allergic diseases and other common immunologically mediated diseases. The presentation will appear as sets of images that involve cross-pathology, histopathology, and molecular pathology and will cover a range of topics of interest to allergists and immunologists.

Obese patients frequently present with respiratory symptoms, including dyspnea, explained in part by the fact that obese individuals tend to breathe rapidly and shallowly as an adaptation to the increase in total respiratory work and resistance caused by obesity.<sup>1</sup> However, the clinician is frequently asked to determine whether these findings are simply caused by obesity alone or whether they represent a respiratory illness.

Accurate interpretation of spirometry performed on obese patients requires an understanding of the effect of obesity severity and distribution on lung volumes and airway size. In mild obesity, results of spirometry might be normal or might suggest a restrictive process, with a symmetric reduction in FEV<sub>1</sub> and forced vital capacity (FVC).<sup>2</sup> Some investigators have observed a disproportionate reduction in FVC with obesity, demonstrating that body mass index (in kilograms per square meter) is significantly associated with the FEV<sub>1</sub>/FVC ratio ( $P < .01$ ).<sup>3</sup> In contrast, individuals with extreme obesity can demonstrate airflow limitation on spirometry. In one study of subjects with a body

mass index of greater than 62 kg/m<sup>2</sup>, there was a reduction in the FEV<sub>1</sub>/FVC ratio and midexpiratory flow rate.<sup>4</sup> Differences in body fat distribution are also important. For example, in one study FVC, FEV<sub>1</sub>, and total lung capacity (TLC) were significantly lower in patients with a waist-to-hip ratio of 0.95 or greater compared with values in those with a waist-to-hip ratio of less than 0.95 ( $P < .05$ ).<sup>2,3</sup>

Full pulmonary function tests are often necessary to better characterize the spirometric abnormalities seen in the obese patient (Fig 1). The most sensitive indicator of obesity is a low expiratory reserve volume (ERV) and functional residual capacity.<sup>4</sup> Restriction is seen in more severe obesity, with reductions in TLC and FVC. However, residual volume is often preserved because of the relative high closing volume in relation to ERV.<sup>5</sup> These effects of obesity have been confirmed in studies of obese patients before and after bariatric surgery. In a study of 34 obese women before and 1 year after gastric banding, resulting in a mean weight loss from 113 to 82 kg, TLC, functional residual capacity, and ERV increased significantly from 93%, 77%, and 64% of predicted value to 98%, 98%, and 109% of predicted value, respectively ( $P < .001$  for each measure).<sup>6</sup> There are conflicting data on whether diffusing capacity is normal or increased in obesity, but this study showed that although PaO<sub>2</sub> increased approximately 6% after surgery ( $P < .001$ ), there was no significant change in diffusing capacity.

The definition of asthma (reversible airflow limitation, airway hyperresponsiveness [AHR], and airway inflammation) requires no modification for obese patients with asthma, but proper interpretation of pulmonary function tests in this population might require a careful examination of lung volumes. As in nonasthmatic patients, obesity might cause a restrictive pattern on pulmonary function tests, with a symmetric reduction in airflow and a reduction in lung volume. When this physiology is combined with the airflow limitation and hyperinflation seen with asthma, a mixed pattern can result, resulting in a pseudonormalization of lung volumes. Obese asthmatic patients should still demonstrate a postbronchodilator improvement in FEV<sub>1</sub> of at least 12% (Fig 2).

Although an increased prevalence of asthma has been reported in the obese,<sup>7</sup> there are conflicting data on whether obesity causes AHR or airway inflammation. In general, obesity is associated with low lung volumes and therefore smaller airway caliber, and airway narrowing has been shown to worsen AHR.<sup>8</sup> Airway smooth muscle stretch is a potent bronchodilator, and because obese patients breathe small tidal volumes at low lung volumes, they might have reduced airway smooth muscle stretch and therefore worsening AHR.<sup>9</sup> Additionally, some investigators have observed a stronger association between obesity and asthma in women,<sup>10</sup> which has been theorized to be the result of either an increase in estrogen levels or a smaller airway caliber in

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From the National Jewish Medical and Research Center, University of Colorado Health Sciences Center, Denver, Colo.

Supported by National Institutes of Health grant K23 HL-04385 (Dr Sutherland).

Received for publication December 16, 2004; accepted for publication December 17, 2004.

Available online April 5, 2005.

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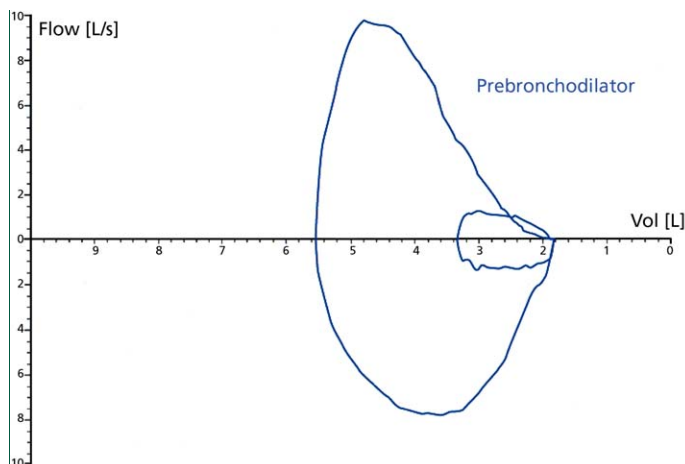
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J Allergy Clin Immunol 2005;115:1100-1.

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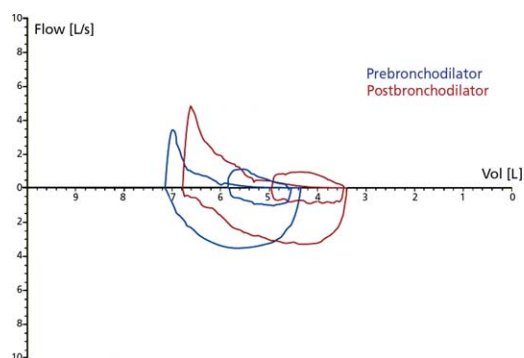
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doi:10.1016/j.jaci.2004.12.1141



	Pre(L)*	Predicted
TGV	2.02	50%
ERV	0.25	12%
RV	1.77	92%
FVC	3.68	75%
FEV <sub>1</sub>	3.28	88%
FEV <sub>1</sub> /FVC	89	118 %

**FIG 1.** Spirometry from a 61-year-old man with obesity (body mass index, 43 kg/m<sup>2</sup>). Residual volume is normal, but because ERV is severely decreased, TGV is also decreased, suggesting that this restrictive process is due to obesity. FVC is decreased disproportionately to FEV<sub>1</sub>, resulting in a high FEV<sub>1</sub>/FVC ratio, again suggesting a restrictive process. The carbon monoxide diffusion coefficient for this man was normal. *Pre(L)*, Volume in liters before administration of a bronchodilator; *TGV*, thoracic gas volume; *RV*, residual volume. \*FEV<sub>1</sub>/FVC data presented as percent rather than volume.



	Pre(L)*	Predicted	Post(L)*	Predicted	Change
TGV	4.66	128%	3.65	101%	-22%
ERV	0.38	18%	0.26	13%	-32%
RV	4.28	271%	3.39	215%	-21%
FVC	2.09	45%	2.93	63%	40%
FEV <sub>1</sub>	1.03	28%	1.50	41%	46%
FEV <sub>1</sub> /FVC	49	68%	51	71%	

**FIG 2.** Prebronchodilator and postbronchodilator spirometry from a 54-year-old man with severe asthma and obesity (body mass index, 42 kg/m<sup>2</sup>). Although the dominant feature of this patient's physiology is severe bronchodilator-responsive airflow limitation, the effects of obesity are still present. ERV is significantly diminished, and the lung volumes are remarkably normal for a patient with severe obstruction. In some asthmatic patients, obesity can cause a pseudonormalization of lung volumes, making obstructive disease more difficult to diagnose. *Pre(L)*, Volume in liters before administration of a bronchodilator; *Post(L)*, volume in liters after administration of a bronchodilator; *TGV*, thoracic gas volume; *RV*, residual volume. \*FEV<sub>1</sub>/FVC data presented as percent rather than volume.

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women. Obesity is a systemic inflammatory disorder associated with increased levels of leptin, TNF- $\alpha$ , and IL-6, but whether systemic or pulmonary inflammation has a role in asthma in patients with obesity remains to be determined.

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