

6-1983

## The Exclusion of Restrictive Lung Disease by Spirometric Criteria in Patients with a Reduced Forced Vital Capacity

Michael S. Eichenhorn

John Popovich Jr.

Richard K. Beauchamp

John Armstrong

Joseph C. Ward

Follow this and additional works at: <https://scholarlycommons.henryford.com/hfhmedjournal>



Part of the [Life Sciences Commons](#), [Medical Specialties Commons](#), and the [Public Health Commons](#)

---

### Recommended Citation

Eichenhorn, Michael S.; Popovich, John Jr.; Beauchamp, Richard K.; Armstrong, John; and Ward, Joseph C. (1983) "The Exclusion of Restrictive Lung Disease by Spirometric Criteria in Patients with a Reduced Forced Vital Capacity," *Henry Ford Hospital Medical Journal* : Vol. 31 : No. 2 , 101-103.  
Available at: <https://scholarlycommons.henryford.com/hfhmedjournal/vol31/iss2/8>

This Article is brought to you for free and open access by Henry Ford Health System Scholarly Commons. It has been accepted for inclusion in Henry Ford Hospital Medical Journal by an authorized editor of Henry Ford Health System Scholarly Commons.

# Clinical Reports

## The Exclusion of Restrictive Lung Disease by Spirometric Criteria in Patients with a Reduced Forced Vital Capacity

Michael S. Eichenhorn, MD,\* John Popovich, Jr, MD,\*

Richard K. Beauchamp, R-CPT, John Armstrong, MD, and Joseph C. Ward, MD\*

*Reductions in forced vital capacity (FVC) as determined by spirometry may result from restrictive or obstructive disease, either alone or in combination. Restrictive disease is implied when measures of forced expiratory flow are relatively maintained, and obstructive disease is present when flow measurements are disproportionately reduced. In the presence of air flow obstruction, the possibility of concomitant restrictive disease contributing to the reduction in FVC is difficult to assess from spirometry alone. Static lung volumes are usually necessary to establish this diagnosis.*

The patient's forced vital capacity (FVC) as determined by spirometry may be reduced as a result of obstructive or restrictive lung disease or combinations of these two conditions. Poor terminal effort by the patient may also reduce the FVC, but this can usually be recognized by visual inspection of the spirometric tracing. Obstructive disease is considered to be present when the reduction in forced expiratory volume in one second ( $FEV_1$ ) is greater than the reduction in FVC, i.e., the  $FEV_1/FVC\%$  is decreased. Obstructive disease is also present when the forced mid-expiratory flow ( $FEF_{25-75}$ ) is reduced, even if the  $FEV_1/FVC\%$  is maintained. It is, however, not likely that air flow obstruction confined to the peripheral airways as manifested by reductions in terminal flow could result in reductions in forced vital capacity (1). Restrictive disease may be implied from the spirogram when the  $FEV_1/FVC\%$  and  $FEF_{25-75}$  are maintained despite the reduction in FVC, although total lung capacity (TLC) must be reduced to less than 80% of its predicted value to establish this diagnosis definitely (2).

When the FVC and  $FEV_1/FVC\%$  are both markedly reduced, it is difficult to determine from the spirogram alone

*We evaluated the  $FEV_1/FVC\%$  obtained at spirometry compared to its predicted normal value. We found it to be useful in eliminating the need for additional testing in many cases in which the question of mixed obstructive and restrictive disease had been raised. Specifically, in patients with obstructive disease and a reduced FVC, an  $FEV_1/FVC\%$  of less than 81% of the age-, height-, and sex-matched predicted value largely excluded the possibility that concomitant restrictive disease was also present ( $p < .05$ ). Higher values had no predictive value.*

whether some element of restrictive disease is also present. While visual inspection of simultaneous flow volume curves may provide some information, this method is not exact and requires extra technical apparatus. If a method could be devised that would permit the clinician to accurately diagnose restrictive lung disease from the spirogram in these situations, it would help eliminate concern about the existence of concomitant unsuspected disease. It would also save the pulmonary laboratory from performing unnecessary static lung volume determinations. We have found the  $FEV_1/FVC\%$  as compared to its predicted value to be useful in this regard.

### Methods

We reviewed studies of all patients referred to the Pulmonary Function Laboratory for testing in two consecu-

---

Submitted for publication: January 13, 1983

Accepted for publication: April 19, 1983

\*Department of Internal Medicine, Divisions of Pulmonary and Critical Care Medicine, Henry Ford Hospital

Address reprint requests to Dr. Eichenhorn, Pulmonary Medicine, Henry Ford Hospital, 2799 W Grand Blvd, Detroit, MI 48202.

tive years. From 4,240 studies, 435 patients were identified with airflow obstruction and a reduced FVC (less than 80% predicted), for whom static lung volumes by plethysmography were also performed at the same sitting. Patients with reductions in the FEV<sub>1</sub>/FVC% below that predicted for their height and age (by Morris's standards) (3) were considered to have air flow obstruction. Patients with a TLC less than 80% of predicted (Goldman's standards) (4) were classified as restricted. In addition to routine spirometric analysis, we also calculated the ratio of the FEV<sub>1</sub> to the FVC actually obtained to that predicted. We then performed discriminant analysis of the above data.

### Results

Patients ranged in age from 11-89 years, with a mean age of 55.3 years. There were 264 men and 171 women. Of 435 patients, 344 had a normal or elevated total lung capacity, while 91 were restricted as defined above (Fig. 1). We then applied parametric discriminant analysis to this population using the methodology of Mardia (5) and Morrison (6). In these patients with a reduced FVC,  $\bar{x}_1$  was assigned to the mean FEV<sub>1</sub>/FVC% of predicted for those patients with a TLC <80% of predicted, and  $\bar{x}_2$  represented the FEV<sub>1</sub>/FVC% of predicted for those with a TLC ≥80% of predicted. Statistical analysis could then be determined; the cut-off point was one half ( $\bar{x}_1 + \bar{x}_2$ ),

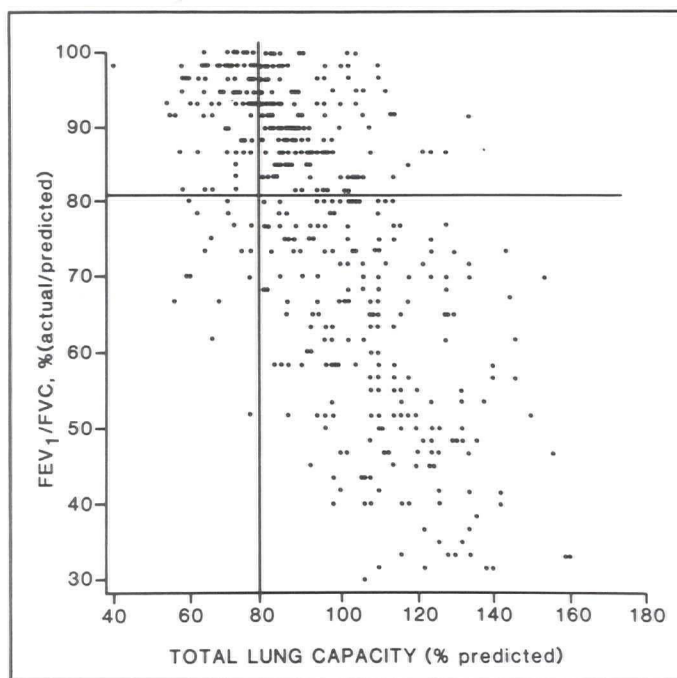


Fig. 1

FEV<sub>1</sub>/FVC% (actual/predicted) vs total lung capacity (TLC).

and an associated variance was equal to one fourth ( $\text{var } \bar{x}_1 + \bar{x}_2$ ). This revealed an estimated cut-off point of 0.81 at a 95% confidence level and a standard error of 0.01. Hence, when the FEV<sub>1</sub>/FVC% was less than 81% of predicted, only 7% (17/228) of our patients had a reduced TLC. When the FEV<sub>1</sub>/FVC% was greater than 81% of predicted, no clearcut discrimination could be made between those with or without concomitant restrictive disease.

We then studied the 17 cases which had low TLC values despite an FEV<sub>1</sub>/FVC% less than 81% of predicted. Unfortunately, the records of three patients could not be located. Two other patients had diagnoses of "old tuberculosis," but their records did not contain enough information to deduce the extent of such disease.

A definitive cause for restrictive disease could be found in each of the remaining 12 cases. Four patients had roentgenographic evidence of significant prior granulomatous disease, with a thoracoplasty in one case, a thoracoplasty and phrenic nerve section in one case, extensive pleural and parenchymal scarring in one case, and prior left upper lobectomy and complicating aspergilloma in one case. Three patients had carcinoma; one had a six cm right upper lobe mass together with a large right pleural effusion and interstitial infiltrates compatible with lymphangitic spread, while two others had undergone earlier lobectomies for cancer. One additional patient had undergone earlier resection for bullous emphysema, with prominent areas of persistent bullous change still evident.

Four remaining patients had widespread parenchymal disease by clinical and roentgenographic analysis sufficient to account for the observed reductions in TLC. There was one case each of Stage III sarcoidosis, conglomerate silicosis, Wegener's granulomatosis with extensive reticulonodular infiltrates, and sickle cell anemia with repeated pneumonias and pulmonary infarcts resulting in extensive fibrotic changes bilaterally.

### Discussion

Spirometry remains a useful screening test for pulmonary disease. Reductions in forced expiratory flow rates establish the presence of air flow obstruction, while maintenance of flow rates together with reductions in FVC imply a restrictive process. This latter diagnosis can be established only when TLC as judged by static lung volume measurements is also reduced. As air flow obstruction worsens, the FVC may also fall as a result of air trapping. In the presence of severe obstructive disease and a reduced FVC, it is often difficult to determine whether some element of restrictive disease is also pres-

## Reduced FVC by Spirometry

ent. We have found the  $FEV_1/FVC\%$  to be a useful index in excluding, with a relatively high degree of certainty, a concomitant restrictive disorder in this subset of patients, based on spirometric analysis alone. As expected, as the  $FEV_1/FVC\%$  decreased, there was a greater tendency toward hyperinflation as manifested by increasing lung volumes ( $R = .65$ ). In fact, as shown by parametric discriminant analysis, when the  $FEV_1/FVC\%$  was less than or equal to 81% of predicted, only 7% of patients had a total lung capacity of less than 80%. Of the 17 cases with restrictive lung disease in addition to air flow obstruction and a low  $FEV_1/FVC\%$ , clinical and roentgenographic evaluation disclosed a definite cause for restrictive disease in the 12 (100%) patients for whom we had adequate clinical and roentgenographic data.

Thus, the  $FEV_1/FVC\%$  as compared to its predicted value provides a useful, accurate means of detecting restric-

tive disease from spirometry alone. It is particularly valuable in the presence of airflow obstruction when the FVC may be markedly reduced. Thus, when airflow obstruction is most severe, concomitant restrictive disease is highly unlikely, even in the presence of a reduced FVC, unless strong clinical and/or roentgenographic evidence indicates its presence. This finding counters the common clinical spirometric interpretation, which may often suggest mixed restrictive and obstructive disease. When airflow obstruction is less severe, spirometry provides little discrimination. The use of the  $FEV_1/FVC\%$  provides the clinician with a reasonable means of predicting static lung volume determinations without requiring their actual performance. The reassurance provided by this measurement together with the associated savings in cost should reinforce the utility of this ratio as a routine spirometric calculation.

## References

1. McFadden ER, Linden DA. A reduction in maximum mid-expiratory flow rate: A spirographic manifestation of small airway disease. *Am J Med* 1972;52:725-37.
2. Kanner RE, Morris AH. Clinical pulmonary function testing. Salt Lake City: Intermountain Thoracic Society, 1975:III-5.
3. Morris JF, Koski A, Johnson LC. Spirometric standards for healthy non-smoking adults. *Am Rev Resp Dis* 1971;103:57-67.
4. Goldman HI, Becklake MR. Respiratory function tests. *Am Rev Tuberculosis* 1959;79:457-67.
5. Mardia KV. Multivariate analysis. London: Academic Press, 1979.
6. Morrison DF. Multivariate statistical methods. New York: McGraw-Hill, 1976.

## Invasive Otitis Externa

In 1959, an elderly diabetic man died from a pseudomonas osteomyelitis of the mandible and zygoma. Ten years later 13 patients were reported who had an external otitis following pseudomonas infections which spread to the adjacent soft tissues and bony structures of the skull. Because of the severity of the infection and its indolently invasive course, the term "malignant otitis externa" was coined. Recently an extensive review added another 21 cases, and the term, invasive external otitis, was suggested. (Doroghazi RM, Nadol JB, Hyslop NE, Baker AS, Axelrod L. Invasive external otitis: Report of 21 cases and review of the literature. *Am J Med* 1981;71:603-14).

Unilateral aural pain, ear canal drainage, local granulation tissue, and occasionally a perforated tympanic membrane occur. A persistent infection may extend to the soft tissues and bony structures adjacent to the ear canal. Cranial nerve palsies, especially the facial, are present in one of three patients. The facial nerve palsy is

usually permanent. Ninety percent of the patients with invasive external otitis are elderly diabetics, and men predominately. *Pseudomonas aeruginosa* is uniformly cultured. Although the pathogenesis is poorly understood, local diabetic microangiopathy and poor local tissue perfusion seem to favor the spread of the pseudomonas infection.

Recognition and early diagnosis are mandatory. Successful therapy includes a three-to-six-week parenteral course of an aminoglycoside (tobramycin or gentamicin) and a semisynthetic penicillin (ticarcillin or carbencillin). Surgical treatment is required when soft and bony tissue involvement is extensive. Mortality may be 15%.

Jean O. Partamian, MD  
Department of Internal Medicine,  
Division of Metabolic Diseases  
Henry Ford Hospital