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ORIGINAL ARTICLE

Prevalence of airflow obstruction according GOLD, ATS and ERS criteria in symptomatic ever-smokers referring to a Pulmonary Rehabilitation Department

N. Barbarito[1], A. Vaghi[1], E. De Mattia[2]

ABSTRACT: ***Prevalence of airflow obstruction according GOLD, ATS and ERS criteria in symptomatic ever-smokers referring to a Pulmonary Rehabilitation Department. N. Barbarito, A. Vaghi, E. De Mattia.***

Aim. **To evaluate in a Pulmonary Rehabilitation (PR) setting the prevalence of airflow obstruction (AO) in either current or former smokers ≥ 45 years old both with dyspnoea and with chronic productive cough, using European Respiratory society (ERS) statement (FEV_1/SVC < 88 and < 89 %predicted in men and women, respectively), American Thoracic Society (ATS) statement (FEV_1/FVC < 75%), and Global Initiative for Chronic Obstructive Lung Disease (GOLD) statement (FEV_1/FVC < 70%).**

Methods. **Lung function tests were performed in each patient who was referred to our PR department due to respiratory diagnosis or symptoms. For analysis, in patients showing AO we used post-bronchodilator lung function values.**

Results. **In 184 ever-smoker patients with symptoms of chronic obstructive pulmonary disease (COPD), the prevalence rates of AO were as follows: ERS = 89.7%, ATS = 76.6%, and GOLD = 63.6%. Patients with AO according ERS criteria showing moderate to severe (M/S) obstruction (i.e., FEV_1 < 70 % predicted) were 119. Patients with ERS M/S AO but without AO using either ATS or GOLD criteria were 8.4% and 19.3%, respectively.**

Conclusions. **Prevalence of AO is highly dependent on which guidelines it is based. ATS and particularly GOLD statement can cause a large under-diagnosis even of moderate to severe COPD. Diagnosis of COPD may be overlooked if SVC is not performed.**

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Keywords: Chronic Obstructive Pulmonary Disease (COPD), Forced Expiratory Volume in One Second (FEV_1), Forced Vital Capacity (FVC), Slow Vital Capacity (SVC).

[1] Respiratory Unit, Santa Corona Hospital, AO Salvini, Garbagnate Milanese (MI),
[2] Pulmonary Rehabilitation, Villa Esperia, Salice Terme (PV), Italy.

Correspondence: Nicola Barbarito, Respiratory Unit, Santa Corona Hospital, AO Salvini, V.le Forlanini 121, 20020 Garbagnate Milanese (MI), Italy; email: nicola.barbarito@yahoo.it

Introduction

Chronic obstructive pulmonary disease (COPD) is a common cause of morbidity and mortality worldwide [1]. The prevalence of COPD is strongly associated with smoking habits and age distribution of the studied population [2, 3], occurring rarely in individual < 40 yeas old, and less frequently in non-smokers [4].

Common symptoms of COPD are cough, sputum production, and dyspnoea. Spirometry is required to diagnose COPD, which is defined as airflow obstruction (AO) that is not fully reversible [5]. However, the spirometric criteria for diagnosis of AO differ considerably between guidelines, making it difficult to quantify the morbidity of COPD.

The most important guidelines on diagnosis and treatment of COPD are edited by the European Respiratory Society (ERS) [6], the American Thoracic Society (ATS) [7] and the Global Initiative for Chronic Obstructive Lung Disease (GOLD) [8].

The aim of this study was to evaluate the differences in the prevalence of COPD based on the spirometric criteria of COPD according to ERS, ATS, and GOLD guidelines in a group of smoker or ex-smoker adults, ≥ 45 years old, both with dyspnoea and with chronic productive cough, consecutively referred to our Pulmonary Rehabilitation department.

Materials and Methods

A spirometry was performed in each patient referred to our Pulmonary Rehabilitation department due to respiratory diagnosis or symptoms.

Spirometry was performed by using a computerised pneumotachograph (MasterScreen Pneumo, Jager, Germany). The test procedure were performed by experienced and specially trained technicians, following the ATS recommendations [9], with the patient in the setting position and using a noseclip. Short acting and long acting bron-

chodilator medications were withheld six and twelve hours before testing, respectively.

Vital capacity, defined as the difference between total lung capacity (TLC) and residual volume (RV), was measured as a slow (slow vital capacity, SVC) or a forced (forced vital capacity, FVC) maximal expiration from TLC to RV.

We used the criteria of AO definition edited by ERS, ATS and GOLD guidelines. The ERS guidelines state that AO is present when the ratio between forced expiratory in the first second (FEV_1) and SVC is less than 88% and 89% of the predicted value in men and women, respectively [6]. The ATS guidelines indicate as definition of AO a ratio between FEV_1 and FVC less than 75% [7]. The GOLD guidelines state that AO is present when the FEV_1/FVC ratio is less than 70% [8].

In patients showing AO according to at least one of the three criteria, we assessed a reversibility test, performing in the same day a second spirometry 15 minutes after inhalation of four puffs of salbutamol (Ventolin™, GlaxoSmithKline), each containing 100 mcg (total dose administered was 400 mcg), using a spacer mouth-piece. For analysis, we used only post-bronchodilator lung function values, in order to exclude from the study the patients showing an AO fully reversible (i.e., without any AO after bronchodilator according to at least one of the three criteria).

Smoking habits, respiratory history and symptoms were collected using an assisted interview.

All patients gave written informed consent to treatment of all data collected during their hospital stay.

During the study period, amounting to 28 months (January 1 2008 to April 30 2010), we assessed by lung function tests 573 patients referred to our department. Of these, 389 dropped out: 49 were repeated admissions to our department, 9 were not able to perform an acceptable spirometry, 269 complained only of symptoms of obstructive sleep apnoea syndrome, 11 were affected by neuromuscular diseases or central hypoventilation, 34 complained of dyspnoea or wheezing without chronic productive cough, 4 were less than 45 years old, 13 were never-smokers.

Results

Analysis was performed on a group of 184 subjects (32.1% of overall patients admitted in our department, age range = 45-91 years, male/female ratio = 1/0.7), smokers or ex-smokers, both with dyspnoea and with chronic productive cough. Anthropometric and spirometric characteristics of the analysed patients are showed in table 1.

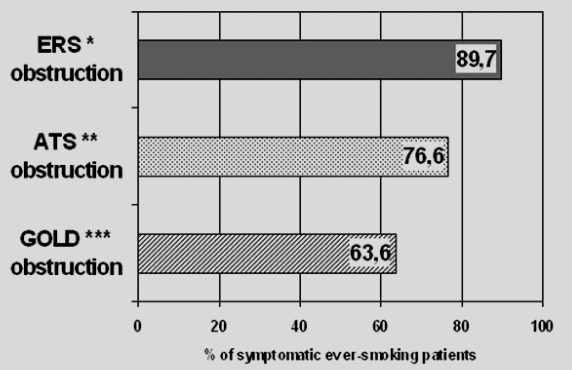
Prevalence rates of AO for such patients were as follows: ERS = 89.7%, ATS = 76.6%, and GOLD = 63.6% (figure 1). All patients with AO according to either ATS or GOLD criteria fulfilled also ERS guidelines.

Among the 165 patients with AO according to ERS criterion, distribution of severity grading of AO according the same ERS COPD-guidelines was the follow (as figure 2 shows): 46 (27.9%) mild (i.e. $FEV_1 \geq 70\%$pred), 48 (29.1%) moderate (i.e. FEV_1 = 50-69%pred), and 71 (43.0%) severe (i.e. $FEV_1 < 50\%$pred).

Table 1. - Basic characteristics of study population (every-smokers with both chronic productive cough and dyspnoea)

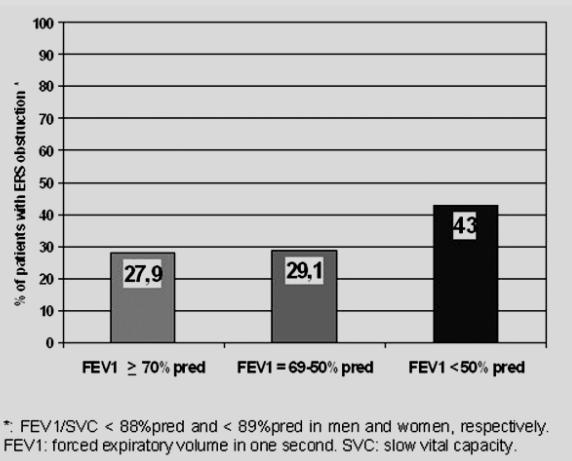
Patients *(n)*	184
Gender *(Men:Women, n)*	109:75
Age *(years)**	68 ± 10
BMI *(Kg/m^2)**	32 ± 9
FEV_1 *(% of predicted value)**	71 ± 20
FEV_1/FVC *(%)**	63 ± 15

* Data are presented as mean ± SD.
BMI: body mass index: FEV_1: forced expiratory volume in one second; SVC: slow vital capacity; FVC: forced vital capacity.



*: FEV_1/SVC < 88%pred and < 89%pred in men and women, respectively. **: FEV_1/FVC < 75%. ***: FEV_1/SVC < 70%. FEV_1: forced expiratory volume in one second; SVC: slow vital capacity; FVC: forced vital capacity.

Fig. 1. - Prevalence of airflow obstruction among every-smokers, ≥ 45 years old, with both chronic productive cough and dyspnoea (184 patients).



*: FEV1/SVC < 88%pred and < 89%pred in men and women, respectively. FEV1: forced expiratory volume in one second. SVC: slow vital capacity.

Fig. 2. - Distribution of severity grading of COPD among the patients with airflow obstruction according ERS criteria * (165 patients).

Patients showing a moderate to severe AO according to the ERS criterion for grading (i.e., FEV_1 < 70%pred) were 119 (72.1% of patients with ERS-AO). We did not find any AO using either ATS or GOLD guidelines in 10 (8.4%) and 23 (19.3%) subjects among such patients, respectively. Figure 3 shows the percentage of patients with AO by ERS guidelines but without AO using ATS criterion in each group of severity. Figure 4 shows the percentage of patients with AO by ERS guidelines but without AO using GOLD criterion in each group of severity.

In table 2 we compare prevalence rates of AO in our present study with results of some previous studies [10-12].

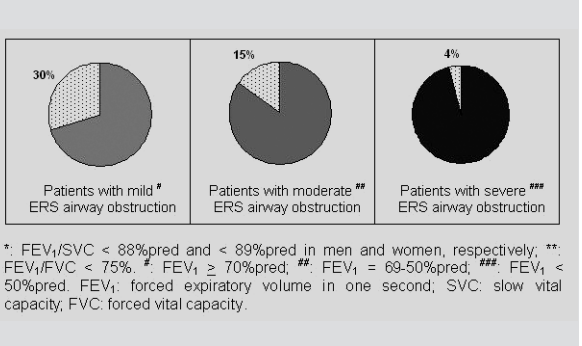


Fig. 3. - Percentage of patients fulfilling ERS COPD-guidelines * (165 patients) but without airflow obstruction using ATS criteria **.

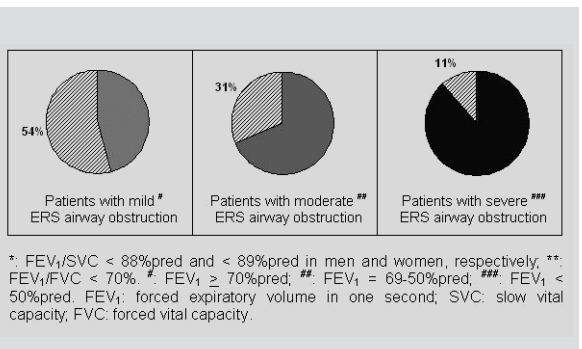


Fig. 4. - Percentage of patients fulfilling ERS COPD-guidelines * (165 patients) but without airflow obstruction using GOLD criteria **.

Discussion

Estimates of COPD prevalence vary widely, probably reflecting differences in the populations studied, and the rules used to define AO.

In the present study, among ever-smokers ≥ 45 years old both with dyspnoea and with chronic productive cough, the prevalence of AO varied depending on what definition was used, from 89.7% with the ERS criteria, to 76.6% with the ATS criteria, up to 63.6% with the GOLD criteria.

To our knowledge, this is the first study evaluating prevalence of AO using different guidelines in a Pulmonary Rehabilitation setting. Therefore, we can compare our results only with previous studies on general populations.

Our prevalence rates of AO exceed somewhat was demonstrated in several previous studies on general populations [10-12]. As showed in table 2, our prevalence rates remain higher even when such previous studies taken into account only people ≥ 45 years old, or only ever-smokers, or only subjects with chronic productive cough, or only subjects with dyspnoea.

The lower prevalence rates found in these previous studies may be due to our selected group of patients consecutively referred to our Pulmonary Rehabilitation department, who were ever-smokers, ≥ 45 years old, and complained both of chronic productive cough and of dyspnoea.

Furthermore, the highest prevalence of AO was estimated by using either ATS or GOLD criteria in the previous studies [10-12], as reported in table 2, whereas it was obtained by ERS criteria in our present study. Again, our different result may be due to the figure of our patients, but not be the only reason.

The limitations of using a fixed FEV_1/FVC ratio as a cut-off to define AO have been highlighted recently [13-15]. Several previous studies showed that use of the lower limit of normal (LLN) criterion instead of the fixed ratio criterion minimises known age biases and better reflects clinically significant irreversible AO [15-17]. Using FEV_1/FVC < LLN criterion, the prevalence of AO in subjects ≥ 40 years old was as follows: 8.6% to 30.6% for male (4.3% to 6.1% for female) ever-smokers in Spain [18], 29.3% for male and female smokers in Poland [19], and 18.6% for male and female smokers in Hong Kong [12]. A recent analysis of the international Burden of Obstructive Lung Disease (BOLD) study [20, 21] confirmed that adjusting the FEV_1/FVC ratio for normative ageing effects appears to reduce the rate of false-positive diagnoses of COPD in older individuals [22].

In the present study, using FEV_1/SVC < LLN (i.e., the ERS criterion), we found a higher AO prevalence rate (i.e., 89.7%) than the previous studies reported above [12, 18, 19, 22]. Our result may be due both to the selection of ever-smokers only with symptoms of COPD and to the use of SVC instead of FVC.

As a matter of fact, SVC was found to exceed FVC in patients with an impaired lung function, whereas the opposite was found in subjects with normal lung function [23-25]. These effects, that results to be attenuated but not abolished by inhalation of a bronchodilator [26], can explain the results of our present study, performed on ever-smokers ≥ 45 years old both with chronic productive cough and with dyspnoea.

The expiratory flows at lower lung volumes are largely determined by the collapsing of peripheral non-cartilaginous airways, which function as the rate-limiting step to airflow as the lung empties [27]. Therefore, a diagnosis of COPD may be overlooked if SVC is not performed in patients with symptoms of COPD, as the present study shows, because in COPD patients the large airways, although inflamed, do not contribute directly to the airflow limitation. The pathological hallmark of COPD is inflammation of the small air-

Table 2. - Prevalence rates of airflow obstruction (%) in our present study on pulmonary rehabilitation patients and in previous studies on general population

	ERS guidelines	ATS guidelines	GOLD guidelines
Our present study*	89.7	76.6	63.6
Viegi *et al.* [10]			
≥ 46 years old	12.2	57.0	28.7
ever-smokers 25-73 years old #	12.0 - 13.9	32.1 - 49.7	10.5 - 27.7
with chronic productive cough #	14.4 - 18.0	33.4 - 46.3	16.1 - 26.8
with dyspnoea #	9.1 - 11.6	40.9 - 50.0	20.9 - 41.7
Lindeberg *et al.* [11]			
≥ 45 years old	15.4	41.7	17.1
ever-smokers 23-72 years old #	15.9 - 24.6	40.7 - 43.9	17.6 - 24.0
with chronic productive cough #	44.0	34.8	47.1
with dyspnoea #	46.6	36.4	49.4
Chung-Wing Lou *et al.* [12]			
smokers ≥ 40 years old	18.6	43.9	25.7

* Ever-smokers, ≥ 45 years old, both with dyspnoea and with chronic productive cough; # Prevalence was lower for female than for male subjects.

ways (bronchilolitis) and destruction of lung parenchyma (emphysema). Bronchiolitis narrows and obliterates the airways lumen and actively constricts the airways; emphysema reduces the elastic recoil of the lung and the elastic load applied to the small airways [28]. The functional consequence of both these abnormalities is the not fully reversible AO characteristic of COPD. In such patients with small-airway collapse, the FVC can be smaller than the SVC.

The magnitude of vital capacity depends on the determinants of TLC and RV: in healthy subjects TLC is determined primarily by the lung elastic recoil [29], and the RV primarily by the elastic recoil of the chest wall and the pressure of expiratory muscles [30], whereas in presence of airways obstruction RV is also determined by dynamic factors, such as expiratory flow limitation [31] and airway closure [30]. Therefore, vital capacity reflects parenchimal properties in normal individual, but also airway properties in obstructed patients. Brusasco and coworkers [24] found that increasing the expiratory flow from TLC to RV resulted in a significant decrease in vital capacity in patients with chronic airway obstruction (SVC = 3.93, FVC = 3.75), depending on the severity of bronchial obstruction. The authors hypothesised that an increase in airflow may increase viscous pressure losses within narrowed peripheral airways, thus causing the transmural pressure to be less and airway closure to occur at somewhat higher lung volume [24]. The higher prevalence of AO we found in our symptomatic patients using SVC rather than FVC may be in keeping with this dependence of vital capacity on flow history: the greater the bronchoconstriction, the lower the vital capacity after forced expiration.

The clinical implication of our results is that a diagnosis of COPD may be overlooked if SVC is not performed.

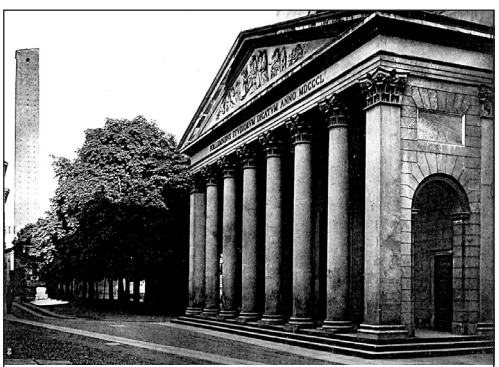
We found that such risk is especially high in patients with mild disease: among patients with mild AO according to the ERS criteria (i.e., $FEV_1 \geq 70\%$pred), we did not found any AO using either ATS or GOLD guidelines in 30.4% and 54.3%, respectively. Similar results werefound in the study by Nathell et al. [26]. However, we did not found any AO using either ATS or GOLD guidelines even in a large percentage of patients with moderate to severe AO according to the ERS criteria for COPD grading, particularly using GOLD criteria (19.3%).

Our results stress the need for a clear spirometric definition of COPD, suggesting that the SVC manoeuvre be performed when patients at high risk of COPD are examined.

References

1. Hurd S. The impact of COPD on lung health worldwide, epidemiology and incidence. *Chest* 2000; 117 (suppl 2): 1S-4S.
2. Viegi G, Scognamiglio A, Baldacci S, *et al*. Epidemiology of chronic obstructive pulmonary disease (COPD). *Respiration* 2001; 68/1: 4-19.
3. British Thoracic Society. BTS guidelines for the management of chronic obstructive pulmonary disease. *Thorax* 1997; 52 (suppl 5): 1S-28S.
4. Halbert RJ, Isonaka S, George D, *et al*. Interpreting COPD prevalence estimates. What is the true burden of disease? *Chest* 2003; 123: 1684-1692.
5. Pauwels RA, Buist AS, Ma P, *et al*. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: National Heart Lung, and Blood Institute and World Health Organization Global Initiative for Chronic Obstructive Lung Disease (GOLD): Executive summary. *Am J Respir Crit Care Med* 2001; 46: 798-825.
6. Siafkas NM, Vermiere P, Pride NB, *et al*. ERS Consensus Statement. Optimal assessment and management of chronic obstructive pulmonary disease (COPD). *Eur Respir J* 1995; 8: 1398-1420.

7. American Thoracic Society. Standards for the diagnosis and care of patients with chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 1995; 152 (suppl 5): 77S-120S.
8. Global Initiative for Chronic Obstructive Lung Disease. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease. Updated 2008. http//www.goldcopd.com/. Accessed June 10, 2009.
9. Standardization of Spirometry, 1994 Update. American Thoracic Society. *Am J Respir Crit Care Med* 1995; 152: 1107-1036.
10. Viegi G, Pedreschi M, Pistelli F, *et al*. Prevalence of Airways Obstruction in a General Population: European Respiratory Society vs American Thoracic Society Definition. *Chest* 2000; 117: 339S-345S.
11. Lindberg A, Jonsson AC, Rönmark E, Lundgren R, Larsson LG, Lundbäck B. Prevalence of Chronic Obstructive Pulmonary Disease according to BTS, ERS, GOLD and ATS Criteria in Relation to Doctor's Diagnosis, Symptoms, Age, Gender, and Smoking Habits. *Respiration* 2005; 72: 471-479.
12. Chun-Wing Lau A, Sau-Man Ip M, Kei-Wai Lai C, *et al*. Variability of the Prevalence of Undiagnosed Airflow Obstruction in Smokers Using Different Diagnostic Criteria. *Chest* 2008; 133: 42-48.
13. Stanojevic S, Wade A, Stocks J. Reference values for lung function: past, present and future. *Eur Respir J* 2010; 36: 12-9.
14. Swanney MP, Ruppel G, Enright PL, *et al*. Using the lower limit of normal for the FEV1/FVC ratio reduces the misclassification of airway obstruction. *Thorax* 2008; 63: 1046-51.
15. Hansen JE, Sun XG, Wasserman K. Spirometric criteria for airway obstructrion: use percentage of FEV1/FVC ratio below the fifth percentile, not < 70%. *Chest* 2007; 131: 349-355.
16. Paoletti P, Carrozzi L, Viegi G, *et al*. Distribution of bronchial responsiveness in a general population: effect of sex, age, smoking and level of pulmonary function. *Am J Respir Crit Care Med* 1995; 151: 1770-1777.
17. Hardle JA, Buist AS, vollmer WM, ellingsen I, Bakke PS, Morkve O. Risk of over-diagnosis of COPD in asymptomatic elderly never-smoker. *Eur Respir J* 2002; 20: 1117-1122.
18. Peña VS, Miravitlles M, Gabriel R, *et al*. Geographic variations in prevalence and underdiagnosis of COPD: results of the IBERPOC multicentre epidemiological study. *Chest* 2000; 118: 981-9.
19. Zieliñski J, Bednarek M. Know the Age of Your Lung Study Group. Early detection of COPD in a high-risk population using spirometric screening. *Chest* 2001; 119: 731-6.
20. Buist AS, Vollmer WM, Sullivan SD, *et al*. The Burden of Obstructive Lung Disease Initiative (BOLD): rationale and design. *COPD* 2005; 2: 277-83.
21. Buist AS, McBurnie MA, Vollmer WM, *et al*. BOLD Collaborative Research Group. International variation in the prevalence of COPD (the BOLD Study): a population-based prevalence study. *Lancet* 2007 1; 370 (9589): 741-50.
22. Vollmer WM, Gíslason T, Burney P, *et al*. Comparison of spirometry criteria for the diagnosis of COPD: results from the BOLD study. *Eur Respir J* 2009; 34: 588-97.
23. Chhabra SK. Forced vital capacity, slow vital capacity, or inspiratory vital capacity: which is the best measure of vital capacity? *J Asthma* 1998; 35: 361-365.
24. Brusasco V, Pellegrino R, Rodarte JR. Vital capacities in acute and chronic airway obstruction: dependence on flow and volume histories. *Eur Respir J* 1997; 10: 1316-1320.
25. Gove RI, Shepherd J, Burge PS. Variability and reversibility of the slow and forced vital capacity in chronic airflow obstruction. *Br J Dis Chest* 1987; 81: 182-185.
26. Nathell L, Nathell M, Malmberg P, Larsson K. COPD diagnosis related to different guidelines and spirometry techniques. *Respir Res* 2007; 8: 89.
27. Mead J. Expiratory flow limitation: a physiologist's point of view. *Fed Proc* 1980; 39: 2771-2775.
28. Cosio Piqueras MG, Cosio MG. Disease of the airways in chronic obstructive pulmonary disease. *Eur Respir J* 2001; 18 (suppl 34): 41s-49s.
29. Anthonisen NR. Tests of mechanical function. *In*: Macklem PT, Mead J, eds. Handbook of Physiology. Section 3, Vol. III, Part 2. The Respiratory System: Mechanics of Breathing. Bethesda, MD, American Physiological Society, 1986; pp. 753-784.
30. Sutherland PW, Katsura T, Milic-Emili J. Previous volume history of the lung and regional distribution of gas. *J Appl Physiol* 1968; 25: 566-574.
31. Leith DE, Mead J. Mechanisms determining residual volume of the lungs in normal subjects. *J Appl Physiol* 1967; 23: 221-227.



Pavia - Università, Aula Magna