CLINICAL RESEARCH STUDY

THE AMERICAN JOURNAL of MEDICINE®

Lung Function in Young Adults Predicts Airflow Obstruction 20 Years Later

Ravi Kalhan, MD, MS,[a] Alexander Arynchyn, MD, PhD,[b] Laura A. Colangelo, MS,[a] Mark T. Dransfield, MD,[b] Lynn B. Gerald, PhD, MSPH,[c] Lewis J. Smith, MD[a]

[a]Northwestern University, Chicago, Ill; [b]University of Alabama at Birmingham; [c]University of Arizona, Tucson.

ABSTRACT

OBJECTIVE: The burden of obstructive lung disease is increasing, yet there are limited data on its natural history in young adults. To determine in a prospective cohort of generally healthy young adults the influence of early adult lung function on the presence of airflow obstruction in middle age.

METHODS: A longitudinal study was performed of 2496 adults who were 18 to 30 years of age at entry, did not report having asthma, and returned at year 20. Airflow obstruction was defined as an forced expiratory volume in 1 second/forced vital capacity ratio less than the lower limit of normal.

RESULTS: Airflow obstruction was present in 6.9% and 7.8% of participants at years 0 and 20, respectively. Less than 10% of participants with airflow obstruction self-reported chronic obstructive pulmonary disease. In cross-sectional analyses, airflow obstruction was associated with less education, smoking, and self-reported chronic obstructive pulmonary disease. Low forced expiratory volume in 1 second, forced expiratory volume in 1 second/forced vital capacity ratio, and airflow obstruction in young adults were associated with low lung function and airflow obstruction 20 years later. Of those with airflow obstruction at year 0, 52% had airflow obstruction 20 years later. The forced expiratory volume in 1 second/forced vital capacity at year 0 was highly predictive of airflow obstruction 20 years later (c-statistic 0.91; 95% confidence interval, 0.89-0.93). The effect of cigarette smoking on lung function decline with age was most evident in young adults with preexisting airflow obstruction.

CONCLUSION: Airflow obstruction is mostly unrecognized in young and middle-aged adults. Low forced expiratory volume in 1 second, low forced expiratory volume in 1 second/forced vital capacity ratio, airflow obstruction in young adults, and smoking are highly predictive of low lung function and airflow obstruction in middle age.

 • *The American Journal of Medicine (2010) 123, 468.e1-468.e7*

KEYWORDS: Airflow obstruction; CARDIA; Chronic obstructive lung disease; Chronic obstructive pulmonary disease; Natural history

Chronic obstructive pulmonary disease is the fifth leading cause of death in the world and is projected to be the fourth by the year 2030.[1] Chronic obstructive pulmonary disease prevalence increases with age and is typically diagnosed after age 50 years, but symptoms and airflow obstruction precede the diagnosis by 10 or more years.[2,3] Several studies have reported the prevalence of airflow obstruction in population samples, but most were cross-sectional[3-6] or had follow-up periods of only a few years.[7] A recent international survey identified airflow obstruction (forced expiratory volume in 1 second/forced vital capacity ≤ 0.70)[8,9] in approximately 4% of young adults ages 20 to 44 years.[4] In addition, chronic cough and sputum were associated with an increased risk for developing airflow obstruction over a 10-year period.[10] However, these studies are limited by lack of stratification by age, short follow-up, and use of a fixed cut-point to define airflow obstruction, which underdiag-

Funding: Supported by National Heart, Lung, and Blood Institute contracts N01-HC-48047, N01-HC-48048, N01-HC-48049, N01-HC-48050 (CARDIA field centers), N01-HC-95095 (CARDIA Coordinating Center), and N01-HC045134 Reading Center (CARDIA Pulmonary Reading Center).

Conflict of Interest: None of the authors have any conflicts of interest associated with the work presented in this manuscript.

Authorship: All authors had access to the data and played a role in writing this manuscript.

Reprint requests should be addressed to Lewis J. Smith, MD, Pulmonary and Critical Care Medicine, Northwestern University, 750 N. Lake Shore Drive; Suite 707, Chicago, IL 60611.

E-mail address: ljsmith@northwestern.edu

0002-9343/$ -see front matter
doi:10.1016/j.amjmed.2009.07.037

noses it in younger subjects and overdiagnoses it in older individuals.[11-13]

Stern and colleagues[14] observed that reduced airway function shortly after birth is a risk factor for airflow obstruction in young adults. Other studies have reported that lung function in school-aged children tracks over time such that those with low lung function at the initial examination had low lung function throughout childhood.[15,16] The Busselton Health Study provided similar findings in adults, but the data were derived from a mix of cross-sectional and longitudinal observations.[17] No study has reported the influence of early adult lung function on the presence of airflow obstruction in middle age in a young adult population followed for a prolonged time.

CLINICAL SIGNIFICANCE

- Low lung function and the presence of airflow obstruction in asymptomatic young adults is mostly missed by physicians and other health care providers and is predictive of low lung function and airflow obstruction in middle age.
- The adverse effects of cigarette smoke seem to be greatest in those who have airflow obstruction as young adults.

The Coronary Artery Risk Development in Young Adults (CARDIA) study was initiated in 1985 and 1986 and has followed randomly selected, generally healthy individuals who were ages 18 to 30 years at study entry.[18,19] Lung function was measured, and information obtained on pulmonary signs, symptoms, and diagnoses at entry, year 20, and several times in between. At year 20, participants were 38 to 50 years of age, an age when symptoms and airflow obstruction are usually present in those who are subsequently diagnosed with airflow obstruction.[2,3]

The present study determined the prevalence of airflow obstruction and the association between lung function at study entry and airflow obstruction at year 20. Our hypotheses were that airflow obstruction is mostly undiagnosed in otherwise healthy young and middle-aged adults and that low lung function in young adults predicts low lung function and airflow obstruction 20 years later.

MATERIALS AND METHODS

Participants and Measurements

The CARDIA study is a multicenter cohort study. Participants were recruited from the general population, by telephone from populations in Birmingham, Al; Chicago, Ill; and Minneapolis, Minn; and randomly sampled from a prepaid health plan in Oakland, Calif. The detailed methods, instruments, and quality-control procedures have been described.[18,19] In 1985 and 1986 (year 0), 5115 individuals were recruited for the initial examination. They included approximately equal numbers of participants who were black and white, men and women, aged 18 to 24 years and 25 to 30 years, who had more than, less than, or equal to a high school education.

At year 20, 3549 (69%) of the original cohort returned for the year 20 examination. We included all participants who returned for this examination, had lung function measured, and were not pregnant (N = 3253). Participants with a diagnosis of asthma at any visit were excluded (N = 660) because we were interested in those with undiagnosed airflow obstruction, and it was shown that asthmatics with low lung function as young adults continue to have low lung function in middle age.[20] Asthma diagnosis was made if the participant had a physician diagnosis of asthma or was taking asthma medication.[21] Participants with a current or previous diagnosis of asthma were included, however, if they reported a diagnosis of chronic obstructive pulmonary disease, emphysema, or chronic bronchitis at year 20 (N = 28). We also excluded participants who were missing data on baseline body mass index (BMI), smoking status, or secondhand smoke exposure (N = 31); had poor quality lung function tests at year 20 (N = 65); or were transgender (N = 1). This left a sample size of 2496.

Demographic characteristics, lifestyle habits (eg, smoking history), secondhand smoke exposure, and medical history were collected by questionnaire.

Lung function at years 0 to 10 was measured using a Collins Survey 8-liter water-sealed spirometer and Eagle II Microprocessor (Warren E. Collins, Inc, Braintree, Mass). At year 20, lung function was measured using a dry rolling-seal OMI spirometer (Viasys Corp, Loma Linda, Calif). Spirometer accuracy was validated using the Pulmonary Waveform Generator (MH Custom Design and Manufacturing, Midvale, Utah), a computer-driven simulator that is accurate to within 0.5%. The results obtained on the OMI spirometers exceeded American Thoracic Society criteria for accuracy and precision,[22] as did the 4 Collins spirometers that were used at the earlier visits and were still functional. A comparability study performed on 25 volunteers at the LDS Hospital (Salt Lake City, Utah) demonstrated an average difference between the Collins and OMI spirometers of 6 mL for forced vital capacity and 21 mL for forced expiratory volume in 1 second. Standard quality-control and testing procedures are detailed in the manual of operations.[8,23,24]

Lung function was analyzed using the largest forced vital capacity and forced expiratory volume in 1 second from 5 satisfactory maneuvers. Airflow obstruction was diagnosed using the lower limit of normal for the forced expiratory volume in 1 second/forced vital capacity ratio.[25] We chose this definition rather than an forced expiratory volume in 1 second/forced vital capacity less than 0.7[26] to reflect airflow obstruction across different ages.[11-13] Bronchodilator testing was not performed.

Participants were categorized on the basis of the presence or absence of airflow obstruction and the presence or