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This Week's Citation Classic

DuBois A B, Botelho SY& Comroe J H, Jr. A new method for measuring airway resistance in man using a body plethysmograph: values in normal subjects and in patients with respiratory disease. J. *Clin. Invest.* 35:327-35, 1956. [Department of Physiology and Pharmacology, Graduate School of Medicine, University of Pennsylvania, Philadelphia, PA]

This method provides a specific measurement of airway resistance (alveolar pressure/airflow) in man. The alveolar pressure can be measured by seating the person inside a closed chamber and recording pressure fluctuations of the air in the chamber during the breathing cycle. The box pressure change is converted to alveolar pressure change using Boyle's law and appropriate calibration constants. Normal airway resistance was 0.6 to 2.4, whereas in patients with obstructed airways it was as much as 10.8 cm H_2O/liter per sec. [The ***SCI***® indicates that this paper has been cited over 730 times since 1961.]

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"A physics text which I read while stationed at the US Naval Academy in 1948 said that if you know the length and diameter of a hollow tube, you can calculate its resistance to airflow. I reasoned that if one could measure human airway resistance, it would be possible to tell whether the airways were narrowed. Fenn allowed me to pursue this idea in his laboratory in the department of physiology, University of Rochester Medical School, where I began to display pressure against flow using the X and Y axes of a cathode ray oscillograph (CRO). And I explored higher breathing frequencies with an oscillating pump made from an aircraft piston and cylinder.

"Later, in Comroe's department at the University of Pennsylvania I turned to a problem which Comroe and Botelho had begun, but which had been set aside because of theoretical and technical difficulties. They had constructed an airtight chamber which was intended to allow the measurement of compressible gas volume (FRC) in the chest, using Boyle's law to calculate the volume from the degree of volume change resulting from a pressure change generated during the subject's effort to compress the alveolar gas. They also hoped to record volume changes of the alveolar gas due to its compression and decompression during breathing, and to calculate alveolar pressure changes from those volume changes. However, the obstacles were that alveolar air also changes its volume due to rapid warming and wetting of the air during inspiration, and due to CO_2 coming out of solution from the lung tissue during inspiratory airflow. The capacitance manometers were unstable radio frequency bridges, and the method of recording and replotting data was cumbersome.

"I displayed box pressure against mouth pressure on a CRO, and at once found that the lung volume calculated from the slope of the line generated during voluntary straining equalled the FRC. Next day, I set up a flowmeter channel (Y axis) vs. box pressure (X axis) on the CRO, rebreathed through the flowmeter into a hot water bottle, and found an S-shaped line of alveolar pressure vs. airflow. Then, I discovered that with panting, the hot water bottle could be removed, simplifying the method.

"It took only one day to set up the plethysmographic FRC method, and another day for the airway resistance methods. But the outcome hinged on: a) an earlier hobby of amateur radio, b) a spare time reading of physics, c) the measurement of instantaneous gas exchange, and d) the exploration of lung mechanics at rapidly oscillating frequencies. All these had been necessary to prepare for those two successful days. Similarly, it had taken Comroe and Botelho years to conceive of[1] and build[2] the body plethysmograph which was then used to make the actual measurements.

"I consider it a tribute to Comroe's foresight and skill[3] that this manuscript was subsequently chosen for *Citation Classics."*

1. **Comroe J H, Jr.** Retrospectroscope: Man-Cans (conclusion). *Amer. Rev. Resp. Dis.* **116:1091-9,** 1977.
2. **Comroe J H, Jr., Botelho S Y & DuBois A B.** Design of a body plethysmograph for studying cardiopulmonary physiology. J. *Appl. Physiol.* 14:439-44, 1959.
3. **DuBois A B.** Introduction. (DuBois A B & van de Woestijne K P, eds.) *Progress in respiration research,vol. 4: body plethysmography.* Basel: S. Karger, 1969. p. VII-XI.