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DuBois A B, Botelho S Y, Bedell G N, Marshall R & Comroe J H, Jr. A rapid plethysmographic method for measuring thoracic gas volume: a comparison with a nitrogen washout method for measuring functional residual capacity in normal subjects. *J. Clin. Invest.* 35:322-6, 1956.
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This method employs Boyle's law for "spring of the air" to allow measurements of thoracic gas volume. The subject is seated inside a closed chamber (body plethysmograph) and makes small inspiratory and expiratory efforts against a closed breathing tube. The pressure change of gas in the chest is measured by use of a mouth pressure gauge. The change in volume of the gas in the lungs is measured from the small pressure change in the gas around the body. Thoracic gas volume is calculated using Boyle's law. The volumes were compared with those obtained by other methods in normal subjects and patients. [The *SCI*® indicates that this paper has been cited in over 1,000 publications since 1956.]

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On January 4, 1954, I did the last of a long series of experiments on oscillation mechanics of the lungs and chest in humans. But Comroe had placed the body plethysmograph, which he and Botelho had had built the previous year, in the same room of the Gates Pavilion that he assigned to me on January fifth.

My lab notebook contained the following entry on January seventh: "*Body Plethysmograph.* Subjects: Burgess and DuBois. Attempt to demonstrate FRC by compression of alveolar air, by Valsalva and Muller." (I then sketched a man in a box, a tube leading from his mouth to a Lilly capacitance manometer connected to the X-axis input of a CRO, and another Lilly manometer attached to the wall of the box and connected to the Y-axis input. A slanting line was drawn on the face of the CRO.)

"The subject strains against a venous pressure head recording on the Y axis. Body volume is recorded on the X axis. The slope of the line is the air capacitance in the lungs. It increases when the lungs are full, decreases when they are empty. No tracings were made. The method has been used by Botelho and Nims in cats." (The axes had been changed between experiments.)

My next note was a week later. I wrote: "*Body Plethysmograph.* To show airway resistance Botelho showed alveolar pressure by changes in body volume during airflow (unpublished). We are to try and clean this up. She had difficulty because on inspiration the volume increased unduly, so that on expiration the volume did not return to normal. This was not entirely due to metabolism, temperature or humidity.

"We set up as follows," (sketch shows CRO, two gauges—one to mouth side of flowmeter on X axis, the other to box wall on Y axis—and a man seated in a box), "giving P_{Box} and $\dot{V}$ mouth on the C.R.O.

"With deep breathing we find the same as Botelho. With rapid shallow breathing, we obtain a good line of resistance on the scope. This amounts to panting" (sketch of S shaped line on CRO face). "Adding tubing (dead space), rubber bag for rebreathing, and intermediate rate-volume studies showed an effect as follows (sketch). Adding tubing changed the intermediate to a slower rate, larger volume. Interpretation: Botelho's difficulty was probably that when the fresh air hits the alveoli it is warmed, wetted, and its CO_2/O_2 ratio increased. This is all counteracted by rebreathing the dead space.

"It is planned to test airway resistance by panting in the box. Sudden closure of a shutter will give the P-V ratio of the alveolar air itself, permitting calibration of V."

The next entry is January 16, 1954: "*Airway Resistance.* Subject: Ferdinand Kreuzer (sketch). The subject gives rapid shallow breaths. This results in S shaped line traced with Oscillotracer, mean slope of central portion is 1.7 inch/inch. The vertical gain is reduced 10 x, and shutter closed to obtain FRC (tracing, slope 0.60 inch/inch)." (There follow calibration factors and calculations showing $R = P/\dot{V} = 1.4$ cm H_2O/L/sec.)

Two research fellows, George Bedell (now at the University of Iowa) and Robert Marshall (Oxford University) did most of the meticulous comparisons between the plethysmographic method for thoracic gas volume and the seven-minute nitrogen washout method for FRC.

But it had been Comroe who had recognized that the plethysmographic methods for thoracic gas volume and airway resistance would have great clinical utility, and therefore that these methods would have to be proven accurate beyond any reasonable doubt.[1]

I was appointed the third Bowditch Lecturer of the American Physiological Society and received a Research Career Award partly as a result of these papers.

The latest use I made of the box was with Richard L. Day[2] to compare alveolar pressures during back blows and Heimlich maneuvers employed to treat choking.

There is a monograph on "Body plethysmography."[3] In addition, recent discussions of the methods have been published.[4,5]

1. **DuBois A B, Botelho S Y & 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. [See also: **DuBois A B.** Citation Classic. *Current Contents/Clinical Practice* 9(6):18, 9 February 1981.]
2. **Day R L, Crelin E S & DuBois A B.** Choking: the Heimlich abdominal thrust vs back blows: an approach to measurement of inertial and aerodynamic forces. *Pediatrics* 70:113-19, 1982.
3. **DuBois A B & van de Woestijne K P, eds.** *Body plethysmography.* Basel: Karger, 1969. 260 p. (Cited 45 times.)
4. **Rodenstein D O & Stănescu D C.** Frequency dependence of plethysmographic volume in healthy and asthmatic patients. *J. Appl. Physiol.* 54:159-65, 1983.
5. **Brown R & Slutsky A S.** Frequency dependence of plethysmographic measurement of thoracic gas volume. *J. Appl. Physiol.* 57:1865-71, 1984.

