

Title: STUDIES OF LUNG WASH-OUT WITH A FAST ANALYZER FOR SULPHUR HEXAFLUORIDE

Authors: C. Jonmarker, M.D., R. Castor, B.Sc., B. Drefeldt, B.Sc., L. Jansson, B.Sc., B. Jonson, M.D., O. Werner, M.D.

Affiliation: Departments of Anaesthesia and Clinical Physiology, University of Lund, S-221 85 Lund and the Siemens-Elema Co., S-171 95 Stockholm, Sweden

Introduction. Wash-out of insoluble tracer gases may be used for diagnosis of uneven ventilation and for measuring functional residual capacity (FRC). Apart from general demands such as reliability and ease of use, desirable qualities in an analyzer for tracer gas are: a. High sensitivity. b. Fast response. c. Insensitivity to other gases (e.g. CO₂, H₂O, N₂, O₂, N₂O). We present an analyzer for sulphur hexafluoride (SF₆), a gas with a very low solubility in blood and lung tissue. The analyzer, which is based on the infrared absorption principle was tested in respect to the above demands. One of the advantages with a fast analyzer is that total expired volume of tracer gas may be obtained through electronic computation on signals representing instantaneous flow and gas concentrations. This permits measurement of FRC by wash-out techniques without the use of collection systems for mixed expired gas. This concept was tested on a lung model.

Methods. The SF₆ analyzer is similar to the Siemens-Elema CO₂ analyzer 930. It is connected to a Servo-ventilator (Siemens-Elema, Stockholm) which provides power and timing pulses. The transducer is placed over a cuvette with glass windows close to the Y-piece (fig. 1). An interference filter transmits light with a wavelength of 10.6 nm at which SF₆ has a major absorption peak. Since CO₂ causes a slight interference, a CO₂ analyzer is included in the circuit (fig. 1). Linearization and CO₂-compensation are performed electronically. The resultant electric signal represents concentrations between 0 and 0.8 % SF₆. Zero adjustment of the SF₆ analyzer is automatically performed at the end of each inspiration. SF₆ is supplied through a catheter with its tip placed so that no SF₆ is present inside the transducer during inspiration (fig. 1). The SF₆ infusion is governed by a magnetic valve which is open from start to end of inspiration during wash-in. Since the ventilator is set to give a constant flow during inspiration, a constant concentration of SF₆ will reach the patient. **FRC-measurement:** Wash-in of SF₆ stops when it is judged to be complete (after 3-10 min). A computer calculates instantaneous SF₆ flux as the product: (SF₆-fraction x expiratory flow). The flow signal is obtained from the ventilator. The total volume of SF₆ washed-out (V-SF₆) is obtained by integration. FRC is calculated as: V-SF₆/alveolar SF₆ concentration at the start of wash-out.

Results. Response time was tested by sudden introduction of SF₆ into the cuvette. A ninety percent response was reached within 30 ms. 4.9 and 10.1 % CO₂ gave the same responses as 0.01 and 0.02 % SF₆, respectively. This was compensated for electronically. The response to 100 % N₂O was the same as that of 0.01 % SF₆. Because of the method for zero adjustment, this disturbance disappears when inspired and expired N₂O concentrations are equal. Neither O₂, nor dry or humid air at 37°C yielded any response. Interference due to infrared absorption by other

gases, as described above, must be differentiated from interference, due to intermolecular interaction between SF₆ and the carrier gas. No interference of the latter type was observed when identical concentrations of SF₆ in O₂, N₂ or N₂O were prepared with a precision gas mixer. Measurement of FRC on lung model gave the following regression equation: Measured FRC (l) = -0.02 + 0.94 x actual FRC (l); 1.00. The coefficient of variation at duplicate determinations was 0.02 - 1.6 % at eight different FRC volumes between 0.4 and 5 l. Fig. 2 shows wash-out curves from a subject with healthy lungs. The calculated FRC was 3.9 and 5.2 l at zero and +10 cm H₂O of end-expiratory pressure, respectively.

Discussion. The sensitivity of the analyzer allows minute amounts of SF₆ to be used. Therefore, the supply of e.g. O₂ or N₂O and the response of the ventilator flowmeter are not interfered with. The method for infusing SF₆ allows us to precisely define the start of wash-out. FRC measurement on a lung model yield a good reproducibility and a high correlation with actual FRC. However, a 6 percent systematic error has yet to be explained. Testing of the FRC method in patients still remains to be done.

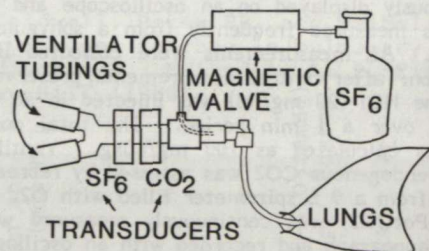


FIG 1.

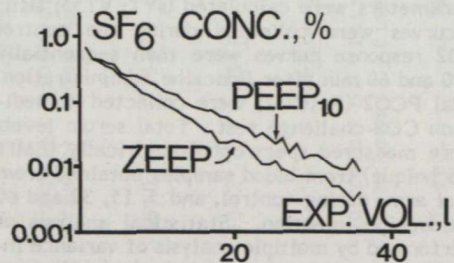


FIG 2.