A Modified EHN Spirometer for Oxygen Consumption

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While it is recognized that measurement of oxygen consumption during anesthesia would provide valuable information about the circulatory and metabolic status of the patient, this determination, which is technically difficult and requires extensive equipment, is performed only infrequently. We have found that the EHN spirometer provides a means for continuous measurement of oxygen consumption in the presence of anesthetic gases. This spirometer is designed to maintain a constant-volume, closed-circle ventilatory system in which ventilation is achieved by the Engstrom 200 ventilator.¹ Use of the EHN with the Engstrom ventilator has some practical disadvantages which decrease the overall usefulness of the instrument. The Engstrom is expensive, bulky and frequently difficult to free of air leaks. By introducing a constant-volume bag and a series of unidirectional valves, a manual system of ventilation which facilitates use of this instrument during anesthesia is achieved.

DESCRIPTION

The EHN functions as a constant-volume spirometer (fig. 1). Oxygen comes into the bellows via flowmeters under the control of the slide valve which matches inflow of oxygen to oxygen uptake by the patient. The volume of oxygen added to the system to maintain a constant volume is recorded on the upper writer of the kymograph. Rate of ventilation and constancy of volume within the system are depicted by the lower writer. When an inert gas is introduced into the inspired mixture, constant partial pressure of the gases in the system must be maintained by frequent adjustment of the flowmeter to make oxygen-consumption measurements possible. When nitrous oxide is used, the Beckman Oxygen Analyzer is used in the circle to ascertain the presence of a steady state.

The substituted part of the system is shown above the line in figure 1. The mixture to be inspired is drawn through the one-way valve into the constant-volume bag from the bellows by expansion of the self-inflating bag after it has been compressed. Compression of the bag causes a flow of gas through the Engstrom dome-valve to the patient, with the Engstrom dome-valve functioning to prevent gas flow into the expiratory limb during inspiration. Once inspiration is completed, expiration by the patient occurs through the dome-valve into

**LEGEND:**

1. Flow meter  
2. Slide valve  
3. One-way valve  
4. Self-inflating bag  
5. Engstrom one-way valve (Dome-valve)  
6. Pressure gauge  
7. In-circle vaporizer  
8. CO₂ absorber  
9. CO₂ absorber  
10. Blebs  
11. Tektronix  
12. Tektronix  
13. Upper and lower water cylinder  
14. Gas analyzer for anesthetic agent  
15. Beckman O₂ analyzer  
16. 3-way stopcock  
17. Filled and filled sampler

**FIG. 1.** Modified EHN spirometer.
the bellows of the spirometer. Airway pressure is recorded on a pressure gauge in the inspiratory limb and carbon dioxide absorption is achieved by a Water's canister introduced in the expiratory limb along with the CO₂-absorbing chamber of the EHN itself. Potent anesthetics e.g., halothane can be added by using an in-circle vaporizer and carefully monitoring the inspired concentration. Introduction of a Rahn end-tidal sampler on the endotracheal tube allows determination of the alveolar concentration of anesthetic gases. Oxygen consumption is read directly from the upper writer of the kymograph at equilibrium when the inspired concentration (concentration within this spirometer system) is essentially equal to the end-tidal concentration.

This instrument has been used to measure oxygen consumption in a small series of normal, healthy, unpremedicated patients at a constant depth of halothane anesthesia (1.1 to 1.2 MAC). Control oxygen consumption values were obtained on the day prior to surgery. Induction of anesthesia was carried out with halothane in oxygen. Intubation was accomplished after relaxation with 60 mg succinylcholine, and after 30 minutes of equilibration at a constant alveolar halothane concentration, experimental oxygen consumption was determined. Values are listed in Table 1. The results concur with findings previously reported by Theye and Tuohy.²

Rapid achievement of the desired steady state in the anesthetized patient can be accomplished by prior equilibration of the spirometer to a known nitrous oxide tension or to a known concentration of halothane by using a second bag in place of the patient's lungs and flushing this system a number of times.

With this simple modification of the EHN, a simple, mobile system for determination of oxygen consumption during anesthesia is achieved without bulky instruments and with minimal difficulty in achieving an airtight system.

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REFERENCES


Surgery

INTRAMUSCULAR INJECTION In Germany, intramuscular injections are made almost exclusively into the gluteal musculature. Accidental injection of almost any drug into or immediately beside the sciatic nerve may result in injection palsy. The safest site for injection is not in the upper, outer quadrant of the buttock but rather into the gluteus minimus muscle, well away from the sciatic and other large nerves. To define the surface anatomy of this safe area, place an index finger on the anterior superior iliac spine, the middle finger on the tubercle of the iliac crest and the palm on the greater trochanter. The injection can be made safely anywhere between the spread index and middle fingers. (Bay, E.: Technique and Dangers of Intramuscular Injection, Germ. Med. Mth. 13: 159 (April) 1968.)