

An exploded view of the modified breathing bag connection on the Ventimeter.

The complication was successfully treated by aspiration and underwater chest drainage. The contemplated surgical procedure was completed without further difficulty, and no sequelae were apparent during the postoperative period. In order to prevent another such accidental interchange of the corrugated tubing and the breathing bag on the Ventimeter the bag holder on the ventilator was modified as described below.

As illustrated, the modification consisted of the permanent addition of an aluminum sleeve with an attached Foregger female bag holder (#7-442-006) to the bag outlet of the Ventimeter. The diameter of the modified bag fitting is now much larger than the inside diameter of the tubing used to connect the ventilator and circle absorber. Only a rebreathing bag fitted with a Foregger male bag holder (#7-442-004) can be connected to this modified outlet, so that interchange of the rebreathing bag and tubing is now unlikely. This modification adds an important safety feature to this useful piece of equipment. A kit supplied by the manufacturer will be available soon for modifying Ventimeters now in use.

## Simplified Apparatus for IPPB/Aerosol Therapy

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Intermittent positive pressure breathing (IPPB) therapy is believed to improve ventilation and oxygenation by the following mechanisms: (1) deep lung inflations which open atelectatic areas; (2) mechanical bronchodilation; (3) improved distribution and deposition of aerosols; (4) clearing of bronchial secretions; (5) counteracting pulmonary congestion and edema; and (6) decreasing work of breathing. The availability of a simple IPPB apparatus for self-administration in the hospital and home is desirable. IPPB frequently improves exercise tolerance and general well-

being and gives the patient a feeling of security during episodes of dyspnea.

Such an apparatus for manual IPPB administration (Pitt-Puffer) (fig. 1) was designed, tested and compared with a Bird Mark VII respirator. The Pitt-Puffer consists of a 3-liter self-inflating bag (*e.g.*, extra large Ambu or Pulmonator bag), with a Ruben-type non-rebreathing valve connected to a Bird nebulizer and mouthpiece. Most commercially available self-inflating resuscitation bags deliver less than 1.5 liters and are too small for IPPB treatments, except in children. Medications or water are nebulized by a flow of 5–10 liters per minute of air (from a compressor) or oxygen. The patient assists inhalations by

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compressing the bag with both hands and, thus, he controls flow, pressure and rate of inflations. Spontaneous inhalation of aerosols without IPPB is also possible. The apparatus illustrated is one of several designs tested. Use of to-and-fro, bag-mouthpiece systems with gas flows through nebulizers and with various types of "pop-off" valves proved too difficult for the average patient to use.

EVALUATION

Repeated use of the Pitt-Puffer was supervised and studied on eight normal subjects and eight patients with chronic obstructive lung disease. Measurements of airway pressure, flow (pneumotachogram) and inspired tidal volumes (integrated pneumotachogram) were made on three of the normal subjects and three of the patients and recorded via strain gauges on a Grass Polygraph. All patients had had previous experience with IPPB therapy by an automatic apparatus. Measurements



FIG. 1. Pitt-Puffer for self-administration of IPPB: (A) 3-liter self-inflating bag (1.5 liters for children) with air inlet valve at tail; (B) non-rebreathing valve; (C) midstream nebulizer; (D) line from air compressor or oxygen source with 5-10 liters/minute flow.

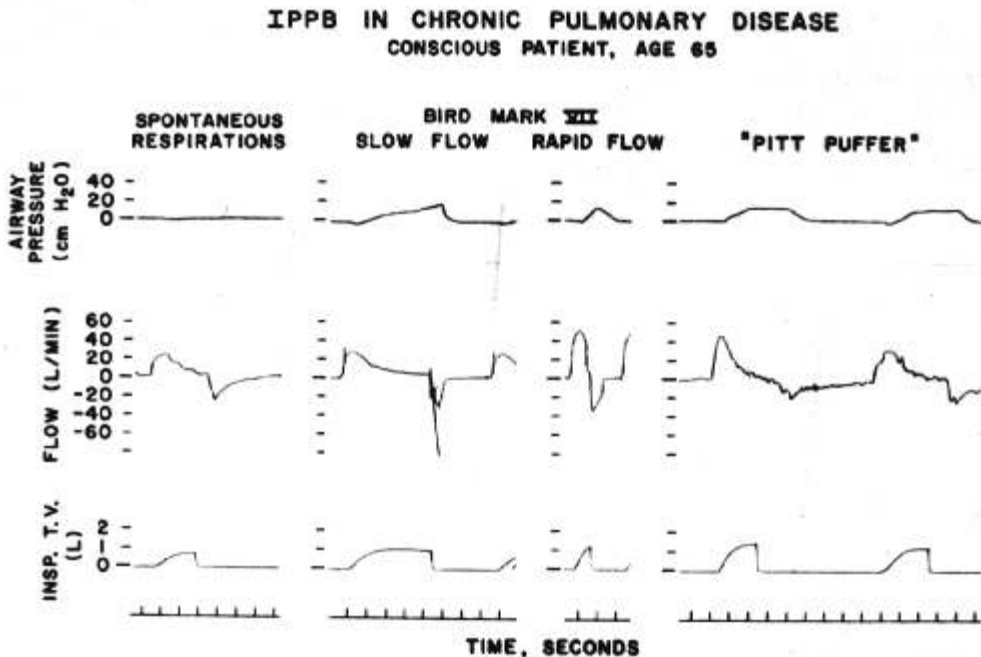


FIG. 2. Measurements of airway pressure, flow and inspired tidal volume during various respiratory patterns.

were obtained on each subject during four respiratory patterns (fig. 2): (1) spontaneous, maximal deep breaths; (2) Bird apparatus,† flow setting 10; (3) Bird apparatus,† flow setting 40; (4) Pitt-Puffer with patient instructed to produce the same sensation of inflation and rate as had been produced by the Bird respirator. With use of the Bird apparatus the retardation exhalation valve was adjusted to abolish or markedly diminish expiratory wheezes as ascertained by auscultation.

#### RESULTS

All patients adapted quickly to the use of the Pitt-Puffer and were able to adjust inflation pressures, flows and volumes according to their demands. The exception was one patient who was too weak to squeeze the bag herself during an acute asthmatic attack. With the Pitt-Puffer, pressures, flows and inspiratory volumes were as satisfactory as with the use of the Bird Mark VII. In all subjects with similar peak airway pressures, inflation volumes were increased with both methods. In most subjects, volumes were greater with the use of the "Pitt-Puffer." This may have been related to better adaptation of flow and pressure to spontaneous inhalations when the patient controlled these parameters. The same volume was delivered more rapidly with the "Pitt-Puffer," because of the higher flow rate at the beginning of inhalation. Thus, the

† Bird Mark VII respirator, air dilution, peak line pressure 20 cm. of water.

"educated hand" produced inflation patterns more like those of the Engstrom than those of the Bird respirator. Exhalation could be retarded by slow bag release, which resulted in delayed re-seating of the valve. Although this caused some rebreathing (undesirable during anesthesia or prolonged ventilation), inspired CO<sub>2</sub> tensions were found essentially to be zero with IPPB treatment sessions of five minutes' duration. When a valve without back-leak was used (*e.g.*, Sierra, Frumin), a controllable orifice for retardation was added to the expiratory port. With forced vigorous hyperinflation dizziness occurred, probably due to decreased venous return (Valsalva maneuver). Dizziness and possible lung rupture are avoided by correct training, the volume limitation of the bag and the patient's sensation of depth of inflation.

Patients with respiratory disease are sometimes referred to an inhalation therapy clinic where various treatments are evaluated. Such evaluation includes tests of peak flow rate, forced expiratory capacity and subjective improvement. Those treatments found most effective are taught to the patient for self-administration at home. IPPB sessions of about three minutes' duration with Isuprel 1:400 were found most suitable in patients with chronic asthma or obstructive emphysema. The Pitt-Puffer is valuable in these patients when more expensive apparatus is unobtainable.

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