IMPROVED EQUIPMENT FOR OXYGEN THERAPY

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The wider testing and use of oxygen in various therapeutic applications was much delayed by lack of simple and efficient apparatus. With the introduction of the B.L.B. mask (Boothby, Lovelace, and Bulbulian, 1938) the difficulties were for the most part overcome, and the subsequent adoption of the mask for general use enabled the anticipated value of oxygen therapy to be confirmed.

The new equipment supplied to us for trial, and here reported on, was similar to that described by Barach and Eckman (1941), and has certain advantages over the B.L.B.

Bunsen burner, oxygen is diluted with air to a determined extent, and the resultant mixture flows continuously into a reservoir bag, whence it is drawn as required through an inspiratory valve into a face-mask. The mask is provided with a second non-return valve, which directs the expired mixture into the room. Apparatus on the injector principle can be used for making mixtures of other components besides oxygen and air. In fact, apparatus which gives nitrous oxide-air mixtures for analgesia and nitrous oxide-oxygen mixtures for anaesthesia is on trial in this department. It is of interest to note that nitrous oxide-air apparatus of this type was described by Marston (1899) and patented by him.

Description of Oxygen-therapy Apparatus

For a more detailed account it is convenient to describe the main parts separately.

The Injector Unit.—A photograph of the unit is shown in Fig. 1, and a section of it in Fig. 2. Oxygen is supplied from a cylinder which has a reducing valve adjusted to 30 lb. per square inch; alternatively, the supply can be taken direct from

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 1.—Photograph of the injector unit. V, Fine-adjustment valve. F, Control disk. D, To humidifier.
FIG. 2.—The injector unit shown in section.
FIG. 3.—The mask and reservoir bag.

mask. The percentage composition of the oxygen-air mixture inspired by the patient can be adjusted instantaneously to any one of a number of fixed figures. Partial rebreathing, which allows only a negligible economy of oxygen at the cost of a significant rise in the amount of carbon dioxide inspired, is eliminated, with the result that the resistance offered to respiration is much reduced.

The principles of the apparatus are that by means of an air-injector, such as is used in the common laboratory

a low-pressure pipe-line system. The rate of flow is controlled by a fine-adjustment valve (Fig. 1, V). From this the oxygen passes via tube A (Fig. 2), through jet B, and, expanding into tube D, creates a partial vacuum in chamber C, surrounding the jet. Air is drawn into the chamber through aperture E, and becomes mixed with the oxygen expanding into the Venturi tube. The proportion of air in the mixture depends upon the size of aperture E. Therefore, in order that mixtures containing 40, 50, 60, 70, 80, 90, or a nominal 100% (see later) of oxygen may be obtained, provision is made to adjust aperture E

to a series of fixed sizes. This is done by mounting a metal disk, bearing a series of holes of the required sizes, in such a way that any of the holes may be slid over the main aperture as required (see F, Figs. 1 and 2). Opposite each hole in the disk is marked the percentage of oxygen in the mixture delivered when that hole is over the main aperture. After leaving the Venturi tube the oxygen-air mixture is passed through a humidifier and subsequently to the reservoir bag D (Fig. 3) through a rubber tube attached to inlet C (Fig. 3). It must be remembered that the nominal 100% position will include water vapour in a concentration up to 3%, depending on the rate of flow and temperature.

The Mask and Reservoir Bag.—The nasal mask (Fig. 3) is made of moulded rubber, and is held in position by a light rubber strap round the head. The capacity of reservoir bag D is 4½ litres. A light rubber flap-valve (B) between the nasal piece and the bag prevents rebreathing, the expired air passing out through another similar valve (A) attached to the nose-piece. It is by this arrangement of valves that the rise of carbon dioxide which is found in the B.L.B. mask is prevented and mechanical resistance to respiration is greatly reduced.

Tests performed with the Apparatus

1. The composition of the mixture supplied by the injector was examined at different settings of the control, using various rates of oxygen flow. At the different settings, changing the flow of oxygen from 3 litres a minute to 12 litres a minute did not alter the composition of the mixture by more than 3%.

2. Dr. H. G. Epstein compared the pressure changes taking place in the nasal piece of the new apparatus with

at a flow (total) of 7 litres a minute, with a subject who had a small tidal volume. With a subject having a larger tidal volume greater pressure fluctuations occurred. The variations in pressure in the mask under trial were found to be the same at all rates of flow, and less in all instances than in the B.L.B. mask (Fig. 4). The rise of pressure against expiration is undesirable, as mouth-breathing, which requires less effort, is the usual result and the therapy is wasted.

The Mask in Use

The bag is first partly filled with oxygen and the mask placed in position on the nose, where it is fixed by adjusting the strap round the head. It is important to ensure an air-tight fit, and this can be obtained without discomfort by suitably bending the metal tabs strengthening the rubber. The composition of the mixture to be given is then set by turning the graduated disk to the required figure, and the rate of flow is adjusted so that the bag is just filled before inspiration. There is no necessity to know the rate of flow of oxygen, so a flowmeter is not incorporated. This allows simplicity and robustness of design. The oxygen concentration should be varied according to the patient's symptoms or set at 100% when intensive therapy is required.

The bag is of sufficient capacity to allow a full inspiration to be taken without it being emptied. This, combined with the low resistance offered, facilitates nasal breathing and renders the therapy effective while causing little discomfort to the patient.

Summary

The design and use of improved equipment for oxygen therapy are described. The injector principle allows simple control of the percentage of oxygen delivered to the patient; the disadvantages of partial rebreathing and mechanical resistance found in the B.L.B. mask are eliminated.

The figures given in Fig. 4 for alveolar oxygen and for carbon dioxide in the rebreathing bag of the B.L.B. mask are taken from M.R.C. War Memorandum No. 1, 1940.

The injector apparatus was supplied by Medical and Industrial Equipment Ltd.

REFERENCES

- Barach, A. L., and Eckman, Morris (1941). *Anaesthesiology*, 2, 421.
Boothby, W. M., Lovelace, W. R., and Bulbulian, A. H. (1938). *Proc. Mayo Clin.*, 13, 641.
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FIG. 4.—Pressure changes in the nasal piece of the new apparatus compared with those in the nasal piece of the B.L.B. mask. (Summary of Dr. Epstein's figures.)

those taking place in the nasal piece of a standard B.L.B. mask. In both, the changes were recorded while using several different rates of oxygen flow. The nasal piece was connected to a membrane manometer of high periodicity, and the pressure changes were observed as deflections of a beam of light. In this way he obtained figures of greater accuracy than those of Barach and Eckman, although their main conclusion, that the pressure changes during respiration are considerably smaller with the injector apparatus than with the B.L.B. mask, was confirmed.

From Epstein's results, summarized in Fig. 4, it is seen that, with the B.L.B. mask, as higher concentrations of oxygen were given there was an increasing rise of pressure against expiration. This pressure rose to 45 mm. of water

In the annual report for 1940 of the Retreat, York, it is claimed that this institution, founded by members of the Society of Friends in 1796 as a "retired habitation" for persons afflicted in mind, was the first establishment in England to treat the insane in accordance with modern humane methods. During the year under review the work of the hospital was carried on normally despite the absence of a number of the staff engaged in national service. One hundred and twenty-one new cases were admitted, and in only two of these, both victims of Nazi oppression, could mental breakdown be directly attributed to the war. The physician-superintendent maintains that during the continuance of hostilities, when personal problems tend to be merged in the difficulties facing the country as a whole, no increase in nervous disease is to be expected. On the other hand, he predicts a sharp rise should the post-war period bring about those conditions of economic and financial insecurity which occurred twenty years ago. The report states that during the last two years 6% of the total cases were admitted as a direct result of excessive alcoholic indulgence. Attacks of delirium tremens were successfully treated by the intramuscular injection of adequate doses of vitamin B accompanied by immediate withdrawal of alcohol. In some cases a replacement mixture composed of paraldehyde and compound tincture of rhubarb was also administered, the latter ingredient giving a resemblance in colour to whisky or brandy. It is claimed that this mixture removes the craving and acts as an effective soporific.