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Oxygen Concentrators for District Hospitals

Micheal B Dobson,
John Radcliffe Hospital, Oxford, UK

Introduction

Oxygen is one of the most basic drugs we have. In many acute illnesses such as acute respiratory infections, asthma, fetal asphyxia, and shock the availability of an oxygen supply can save a patient's life. Many small or remote hospitals have difficulty obtaining a reliable oxygen supply because of logistical and cost factors.

Oxygen supplies in cylinder form require a reliable system for supply and transportation. In many countries the cylinders themselves have to be purchased rather than rented, and losses in transit may be considerable. The cost of oxygen itself is considerable - it is relatively expensive to manufacture because of the high energy costs of the processes used to make it. An additional cost premium is usually levied on "Medical" oxygen, although it is generally indistinguishable from the industrial grade. In Tanzania, perhaps a typical developing country, a recent survey showed that 75% of the district hospitals had an oxygen supply for less than 25% of the year.

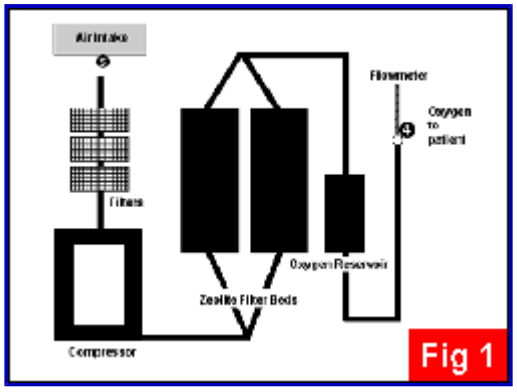
The physical separation of gases from a mixture at room temperature is the underlying principle of oxygen concentrators. This low energy method has been developed in recent years to allow separation of oxygen from air, and has been applied to all scales of size from an incubator to a complete steelworks.

The largest application of oxygen concentrators in medicine has been in the provision of portable, domiciliary machines for the provision of long term home oxygen therapy to patients with chronic lung disease. The prime reason for this development was the dramatic cost savings which could be achieved. The purchase price of a concentrator is about half the cost of a year's supply of oxygen from cylinders.

How Concentrators Work

(See Figure 1)

Room air is drawn into the machine through a series of filters, compressed to a pressure of 4 atmospheres, and passed into a column containing zeolite, a "molecular sieve" of aluminium silicate. Nitrogen binds to the zeolite, while oxygen passes through. Before the column becomes saturated with nitrogen the flow of air is switched to a second column; the first column is vented to atmosphere, discharging most of the nitrogen, and the remainder of the nitrogen is removed by back flushing the column with a small flow of oxygen from the second column. As the second column approaches saturation the process is reversed. The life of the zeolite crystals can be expected to be at least 20,000 hours which in most situations would give about 10 years' use. The gas emerging from the columns (95% oxygen) passes through a small reservoir chamber, and a flow control system to the patient. Most domiciliary sized machines can produce a flow of up to 4 litres/minute of oxygen. Higher flows result in a loss of concentration, and most machines are flow-limited to prevent this from occurring.



Are Concentrators Reliable?

In recommending technology from the western world to the developing world it is important to have an established reliability record, and oxygen concentrators certainly meet this requirement. Domiciliary concentrators have been in regular use for more than ten years and have in general proved very reliable. They do, of course, need regular servicing, usually after every 5000 hours of use. (As a comparison, after 5000 hours of driving at an average speed of 50 km/hr a car will have covered 250,000 km). Servicing is not complicated and can if necessary be carried out by the user.

There are great differences in environment between the home of a western patient with respiratory failure and a remote hospital in the tropics. For this reason a group of clinicians and engineers under the auspices of the World Health Organisation and the World Federation of Societies of Anaesthesiology has established a set of tests and performance criteria which a small concentrator has to fulfil to be of maximum value in a small hospital.

The WHO Performance Standard

An International standard (ISO) already exists for small concentrators, relating mainly to safety in use. To reach the WHO standard, the machine must first meet the ISO standard, and in addition to this it must be capable of functioning in

adverse circumstances, including:

- ambient temperature of up to 40°C
- relative humidity up to 100%
- unstable mains voltage
- excessively dusty environment

It must pass stringent tests including military standard shock, vibration, and corrosion tests and be incapable of delivering an output oxygen concentration of less than 70%.

Every machine must be supplied with a comprehensive service manual and at least 2 years supply of replacement spares.

Results in the Field

Oxygen concentrators have been field tested in a number of developing countries, including Malawi, Mongolia and Egypt (a future article will describe the results from these studies) and have proved themselves to be both reliable and effective. It is difficult to imagine more different environments than Europe, Malawi, Egypt and Mongolia - yet the concentrators have been successfully used in all of them. One of the main reasons for the success of the projects has been the training given to users and technicians - concentrators are not hard to service, but like any machine they do need to be looked after and kept clean.

Should our hospital buy one?

Experience from the field trials, and a cost study based on Papua New Guinea have shown very considerable cost savings to be possible, as well as the year-round availability of oxygen which is lacking in so many hospitals. The power consumption of a concentrator is only 350w, so even hospitals without a mains supply can use one. A portable 600w petrol generator is a sufficient power source, as is a truck battery fitted with an oscillator. The outlet pressure of a concentrator is only sufficient to ensure flow of oxygen to the patient. Small concentrators are not intended, nor are they suitable as a power source for devices such as a compressed gas anaesthesia (Boyle's) machine or a lung ventilator (although they can of course provide a supply of oxygen for use with an independently powered ventilator). Remember also that if the power fails, the oxygen reservoir inside the machine will last only 2-3 minutes.

The minimum number of concentrators should be two per hospital. Remember that no piece of apparatus will last for ever, especially if neglected. Hospitals using concentrators need to plan for regular maintenance, order a reserve of spare parts, and assign the task of looking after the machine to a named, trained individual. Make sure you buy an approved machine, (the list of approved machines is available from the Program for Health Technology, WHO, 1211 Geneva 27, Switzerland). It is wise to choose from this list a machine whose manufacturer has a reliable local agent in your country.

The use of concentrators can bring both a subtantial improvement in the availability of treatment and cost savings for the hospital. Even so it is still advisable to have the odd spare cylinder of oxygen available for emergencies. One 140 bed hospital in Nepal did just that when it installed concentrators in its operating theatres some

12 years ago; the 3 large reserve cylinders remain unopened - it would be difficult to find a better recommendation for this technology!

References

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