INT J TUBERC LUNG DIS 5(6):524–526

Oxygen supply in rural Africa: a personal experience

G. Schneider

Worldwide Evangelisation for Christ (WEC) International, Banjul, The Gambia

SUMMARY

Oxygen is one of the essential medical supplies in any hospital setting. However, in some rural African settings without regular electricity and with logistical problems in the transport of oxygen cylinders, the delivery of oxygen can be difficult. This paper compares the costs incurred using oxygen cylinders with a solar operated oxygen concentrator in a rural Gambian setting. The paper shows that a solar operated system has a high capital investment initially, but that running costs and maintenance are minimal. The system becomes cost effective if a rural hospital needs more than 6 treatment days (1 l/min) of oxygen per month and can be considered in a setting where 6 hours of sunlight per day can be guaranteed.

KEY WORDS: oxygen supply; oxygen concentrator; Africa

RELIABLE OXYGEN SUPPLY is important and life saving in any clinical setting. Whether for the resuscitation of the new-born in a delivery room, the operating theatre or in the wards for children with severe respiratory tract infections or asthma, oxygen is essential. However, a continuous and sufficient oxygen supply can be a challenge in a rural African setting without regular power supply and with no reliable source of oxygen cylinders on hand.

The World Health Organization (WHO) suggests two ways for the delivery of oxygen in developing countries: the oxygen cylinder or an oxygen concentrator.[1] The former is dependent on a good transport system for oxygen cylinders, while the latter needs 24 hours of reliable electricity supply.

The Gambia is a small West African country, where rural areas, except for a number of larger towns, are without regular power supply. Oxygen is available in the capital and can be purchased in cylinders containing 7 cubic meters of oxygen at a cost of US $63.00.

For over 10 years I worked in a rural mission hospital in The Gambia. Electricity was only available for 2–3 hours at night. Initially there was no source of oxygen at all at the hospital, and all cases that needed oxygen therapy had to be referred to the main hospital in the capital, 85 km away. Seeing the need for improved services, we solved the supply of oxygen with the provision of oxygen cylinders. This allowed us to manage children with severe respiratory tract infections and assist more effectively in the resuscitation of asphyctic new-borns. Although the costs were high and logistical problems with the transport of large cylinders occurred, an oxygen concentrator was no alternative due to the limited electricity supply.

Costs for the use of oxygen cylinders

The initial capital investment for an oxygen cylinder in The Gambia amounts to 750.00 Dalasi (US $63.00). Available cylinders in The Gambia provide approximately 6000 litres of oxygen, the equivalent of 1.4 adult treatment days at 3 l/min, 4.2 treatment days for children at 1 l/min or 8.3 treatment days for infants at 0.5 l/min.

Recurrent costs for the refill of an oxygen cylinder are D350.00 ($29.40) for the oxygen supply and then the transport of D2.50/km, amounting to D425.00 ($35.70) per trip. As oxygen refills are usually combined with other transports for practical reasons, we calculate 20% of the transport costs as part of the recurrent costs for oxygen refills. Therefore the total recurrent cost per cylinder is D435.00 ($36.60). For a patient using 1 l/min oxygen, the daily running costs for oxygen using a cylinder amounts to US $8.70. Other studies that looked at costs of oxygen (using cylinders) in developing countries showed the following figures: US $6.00 for 1 l/min/day in New Guinea, or US $14 for 1 l/min/day in Malawi.[1–3]

Alternative oxygen supplies

Oxygen concentrators have been recommended as a practical and economic method of oxygen supply, especially in rural settings where there may be logistic problems in accessing oxygen cylinders.[1,2]

The oxygen concentrator uses an electrical power compressor to force compressed air through synthetic aluminium silicate which reversibly binds nitrogen.[1] The oxygen delivery contains over 90% of oxygen, but with a lesser concentration at higher flow rates.[1] Such a system is an option where there is a regular 24-

Correspondence to: Gisela Schneider, WEC International, Box 86, Banjul, The Gambia. Tel: (+220) 483 235. Fax: (+220) 373 104. e-mail: gschneider@gamtel.gm or 114224.2716@compuserve.com

Article submitted 3 July 2000. Final version accepted 5 January 2001.

hour electricity supply, which cannot be guaranteed in rural Africa.

We therefore looked into the possibility of running an oxygen concentrator using solar energy. Over 10 years we had established an extensive solar system for lighting and support for other electrical equipment such as laboratory equipment, an ultrasound machine and computers. We investigated the possibility of extending the solar powered system to be able to run an oxygen concentrator.

An oxygen concentrator uses 30 amps/hour, or 720 amps per day. This can be supplied by 24 solar panels each producing 30 amps/day, provided there are at least 6 hours of sunlight. The electricity needs to be stored in six 150 amp batteries, which in practice allow the use of 80% of their capacity.

To strengthen the system, we added a direct battery charge for during the times when electricity is available; in addition, the oxygen concentrator can run off the main electricity supply during generator times.

The capital investment for a solar operated system amounts to a total of US $13 140.80, including the oxygen concentrator, solar panels, batteries and an inverter (see Table 1).

In this specific case, we already had the inverter and part of the solar panels in place, and only needed to upgrade the batteries and panels. However, this still amounted to an initial investment of US $8154.00.

Recurrent costs for the solar operated system

Although the initial investment for any solar power system is high, the recurrent costs are extremely low, although its effectiveness is highly dependent on the commitment of staff.

The recurrent costs are as follows (Table 2): upkeep of the batteries: weekly check of battery acid levels; replacement of acid losses with distilled water, which is locally produced at a negligible cost; and cleaning of battery poles, which is important and can be done monthly. Cleaning of solar panels: this is a very important task and needs to be done daily, especially in the dry season.

Neither of these tasks are labour intensive, but they need commitment on the part of the staff, as dust on the solar panel will reduce electricity supply significantly, as do partly functional batteries. The cost for labour for these tasks can be calculated at $10.00/month.

Table 1 Capital investment

Item	Cost per unit (US $)	No. of units	Total
Oxygen concentrator	1 700.00	1	1 700.00
Battery	126.00	6	756.00
Solar panel	420.20	24	10 084.80
Inverter	600.00	1	600.00
Total cost			13 140.80

Table 2 Recurrent costs for the solar operated system in the Gambia

Tasks	Monthly costs (US $)
1 Upkeep of the batteries	
Weekly check of battery acid levels	
Replacement of acid losses with distilled water	
Monthly cleaning of battery poles	$10.00
2 Cleaning of solar panels	
3 Maintenance of the oxygen concentrator*	$10.00
Daily washing of the external filter	
Cleaning of the humidifier	
Replacement of two other filters (every 3–6 months)	
Skilled maintenance once yearly (US $100.00/year)	$8.30
4 Possible electrical repairs	$10.00
5 Replacement of batteries (every 5 years)	$12.60
Total running costs	$50.90

* According to WHO guidelines.[1]

Training needs for staff to conduct these duties are minimal, and can be achieved in a one-day workshop for maintenance staff. However, supervision is needed in order to check that the tasks are done satisfactorily on a daily and weekly basis.

Maintenance of the oxygen concentrator: according to WHO guidelines the maintenance for an oxygen concentrator includes daily washing of the external filter; cleaning of the humidifier; replacement of two other filters every 3–6 months. The costs for these tasks amount to US $10.00/month. Skilled maintenance once yearly comes to US $100.00/year (i.e., $8.30/month).

Possible electrical repairs would total $10.00/month, and replacement of batteries, which need replacing every 5 years, can be calculated at a cost of $12.60/month. Therefore the total running costs of such a system amount to US $50.90/month.

These costs are independent of the amount of oxygen used, as long as the concentrator is not used 24 hours/day for 365 days/year, in which case higher repair costs are likely.

If oxygen is delivered by a cylinder the cost is dependent on the amount of oxygen needed; we showed a cost of US $8.7 for 1 l/min per day. Therefore a solar operated system in the Gambian context will become cost effective if there is a need for more than six treatment days at 1 l/min per month.

Practical experience

This system of oxygen supply has now been effectively in place in the hospital for 18 months. Overall, the solar operated system works very well, although during the rainy season months and during the high season of Hamartan there may be days where a back-up is necessary. However, this has never exceeded a period of 2–3 days at a time, and never for more than 1–2 weeks/year.

As a consequence of the very positive experience with solar energy over the years, the hospital's solar power system was recently substantially extended, so that it now also supplies all electrical appliances, and the entire hospital is run on solar energy. Generator power is used only once per week for 2–4 hours as a back-up system. An oxygen cylinder is also in place as a back-up for the oxygen concentrator.

DISCUSSION

Oxygen supply is essential in any secondary referral facility that looks after sick children, performs surgery or runs a maternity unit. In a rural African setting this can be difficult due to the logistical problems of transport of oxygen cylinders and the lack of continuous electricity supply.

Oxygen concentrators have been recommended by the WHO as an appropriate means of oxygen supply,[1] but this is still dependent on regular electricity supply, which may be difficult in rural settings.

Solar operated systems are dependent on a minimum of 6 sun hours/day, which is readily available in many parts of Africa. However, for rainy days a back-up is needed. This can be provided in form of a back-up oxygen cylinder, additional battery storage or a generator back-up for the oxygen concentrator.

This paper compares the costs incurred by the use of oxygen cylinders with the use of a solar operated electricity supply for an oxygen concentrator. In the Gambia setting it was shown that if the demand for oxygen is low (fewer than six children treatment-days/month at 1 l/min) the oxygen cylinder is an appropriate and cost effective way of providing oxygen to the patient. However, where the demand exceeds 6 patient days or more, a solar operated system may be worth considering as it may be a more cost effective way of supplying oxygen, despite the fact that the initial investment is relatively high.

The data presented are based on personal experience and local market costs and cannot be generalised. However, they do show that in certain situations where there is sufficient demand for oxygen, solar energy can be a cost effective alternative of supplying electricity even for high energy users such as an oxygen concentrator.

References

1 World Health Organization ARI Programme. Oxygen therapy for acute respiratory tract infections in young children in developing countries. Geneva: WHO, 1993: (http://www.who.int/chd/publications/ari/oxygen.htm).

2 Dobson M. Oxygen concentrators offer cost savings for developing countries: a study based on New Guinea. Anaesthesia 1991; 146: 217–219.

3 Pederson J, Nyrop M. Anaesthetic equipment for a developing country. Br J Anaesthesia 1991; 66: 264–270.

RÉSUMÉ

L'oxygène fait partie des produits médicaux essentiels dans tout cadre hospitalier. Toutefois, dans certaines situations d'Afrique rurale, où l'électricité est irrégulière et les problèmes logistiques de transport des bouteilles d'oxygène sont importants, il peut être difficile d'administrer l'oxygène. Ce travail compare les coûts encourus par l'utilisation de bouteilles d'oxygène avec ceux d'un concentrateur d'oxygène à énergie solaire dans un cadre rural de Gambie. Cet article montre qu'un système à base solaire comporte un investissement de capital élevé mais que les coûts de fonctionnement et d'entretien sont minimes. Le système bénéficie d'un bon rapport coût-efficacité si plus de 6 jours de traitement (à raison d'un litre d'oxygène/minute) par mois sont nécessaires dans un hôpital rural ; on peut l'envisager dans les situations où 6 heures de lumière solaire par jour peuvent être garanties.

RESUMEN

El oxígeno forma parte del suministro esencial en el marco hospitalario. Sin embargo, en algunos ámbitos rurales de África sin suministro regular de electricidad y problemas logísticos en el transporte de los cilindros de oxígeno, el suministro del mismo puede ser difícil. Este trabajo compara los costos originados por la utilización de cilindros de oxígeno con un concentrador que funciona con energía solar en un área rural de Gambia. El trabajo muestra que un sistema que funciona con energía solar tiene una gran inversión de capital al inicio, pero los costos de funcionamiento y mantenimiento son mínimos. El sistema se torna beneficioso si un hospital rural requiere más de seis días de tratamiento (1 litro de oxígeno/minuto) por mes y debe ser considerado en un ambiente donde pueden garantizarse seis horas de luz solar diarias.