SHORT REPORT

How many oxygen cylinders do you need to take on transport? A nomogram for cylinder size and duration

D Lutman, A J Petros

Emerg Med J 2006;23:703–704. doi: 10.1136/emj.2005.026724

When undertaking patient retrieval, it is important to take adequate supplies of oxygen to ensure patient safety. Oxygen can be delivered via a flowmeter into a facemask or used to drive pneumatic ventilators. Given the lack of space in the back of an ambulance or helicopter, the numbers of cylinders that can be taken is limited, hence the number needed to complete the journey must be carefully calculated prior to embarking. We have produced nomograms to predict how many oxygen cylinders will be consumed during a given journey when using either a flowmeter or a commonly used transport ventilator.

All gas cylinders in the UK have a collar indicating the pressure within them when full and their content in litres at 15°C. Cylinders are made in different sizes and are given alphabetical labels. The most frequently used cylinders on transports are sizes D, CD, and F (British Oxygen Company, Worsley, Manchester, UK). The D size is a small cylinder often strapped to the side of an ambulance stretcher and holds 340 litres of oxygen at 13 700 kPa. The CD size is a newer version of the D with an integral valve, and holds 460 litres at 23 000 kPa. Two F size cylinders are often found in "front line" ambulances, and each holds 1360 litres at 13 700 kPa. The volume of gas in the cylinder is directly proportional to the pressure; at sea level a flowmeter set at 5 l/min will deliver oxygen at that rate. However, ventilators often consume oxygen at a rate higher than the selected minute volume. We present a graphical solution to assist oxygen management and reduce the risk of running out of oxygen during a patient transport.

METHODS

As explained above, there are different sizes of cylinder. There are also many different transport ventilators. The simplest retrieval involves oxygen delivery via a flowmeter either into a facemask, nasal cannula, or breathing circuit.

We calculated oxygen consumption using a flowmeter at standard temperature and pressure, and also calculated oxygen usage for a number of transport ventilators including the Oxylog 2000 (100% oxygen and air mix), Oxylog 3000 (100% oxygen), Draeger 5400 incubator, and Babylog 2000 in ventilation and continuous positive airway pressure modes. We then developed nomograms to estimate the duration of a full cylinder of oxygen with these different ventilators. We also performed bench tests on our two most commonly used ventilators to assess the accuracy of the nomograms. Two full CD cylinders were connected to a BabyPac and Oxylog 1000 ventilator. Ventilation was simulated using a test lung, and the time from start of ventilation to ventilation failure was noted.

RESULTS

Nomograms are presented for the time period different sizes of oxygen cylinders last when used with a flowmeter or when used to drive a variety of transport ventilators (fig 1 (and supplementary figures 2–8; available online at <http://www.emjonline.com/supplemental>)). The table (available online at <http://www.emjonline.com/supplemental>) lists the size of each cylinder commercially available and the pressure within that full cylinder at 15°C.¹

Oxygen consumption was calculated at different rates (fig 1) and plotted against duration of usage (for example, line $y = 660x$ represents 11 l/min flow $\times$ 60 min $\times$ hours used, while line $y = 300x$ represents 5 l/min flow $\times$ 60 min $\times$ hours used). The x axis represents the estimated total journey time (hours); the left hand y axis represents oxygen requirements (litres) and the right hand y axis the anticipated rate of consumption of oxygen. Each vertical unit represents 340 litres, which is equivalent to one standard size cylinder. Therefore, for the D axis, one small grid square represents a D size cylinder, two grid squares represents an E size cylinder, and four grid squares an F size cylinder.

Bench tests were performed on the BabyPac, at inflation pressures of 28/8 H₂O, with 100% oxygen and a rate of 30 breaths/min, and the Oxylog 1000, set at "no air mix" at inflation pressures of 30/5 H₂O with a minute volume of 15 l/min and a rate of 30 breaths/min. The respective nomograms were accurate to 8% and 9% of predicted duration.

DISCUSSION

When called upon to undertake retrieval, time can be wasted trying to calculate how much oxygen to take. A number of reports have described the morbidity associated with having an inadequate number of cylinders during transport.^{2–3}

Figure 1 Oxygen cylinder duration plotted against number of oxygen cylinders required. Diagonal lines represent oxygen consumption at different flowmeter rates. Cylinder sizes: C, CD, E, F, HX.

The nomograms presented here provide estimates of cylinder duration and have a number of limitations. During air flights, pressure differentials can cause a reduction in ventilator consumption for a set minute volume. Local variations in temperature can also affect consumption. Furthermore, precise setting of these ventilators is not possible, owing to the absence of a graduated scale for respiratory rate or minute volume. Thus large errors in oxygen consumption can be introduced by when setting up or taking readings from these transport ventilators.

However, despite these limitations, it is possible using our nomograms to quickly estimate the duration of most of commonly available cylinders when used under normal circumstances. Selecting a rate of oxygen consumption close to that used by the ventilator or flowmeter allows the user to estimate the quantity of oxygen required. The grid is arranged in whole cylinder sizes so that the number and type of each cylinder that will be needed can be chosen. Any change in consumption rate on cylinder duration can be readjusted by referring back to the graph during a retrieval allowing the team to plan accordingly.

Supplemental data can be found online at <http://www.emjonline.com/supplemental>.

Authors' affiliations

D Lutman, A J Petros, Children's Acute Transport Service, London, UK

Competing interests: there are no competing interests

Correspondence to: Dr D Lutman, Consultant, Children's Acute Transport Service (CATS), 44B Bedford Row, London WC1N, UK; lutmaa@cats.nhs.uk

Accepted for publication 12 May 2006

REFERENCES

- 1 **British Oxygen Company**. *Medical Cylinder Datasheet*, <http://www.bocmedical.co.uk>.
- 2 **Edge WE**, Kanter RK, Weigle CG, *et al*. Reduction of morbidity in interhospital transport by specialized pediatric staff. *Crit Care Med* 1994;**22**:1186–91.
- 3 **Wallen E**, Venkataraman ST, Grosso MJ, *et al*. Intrahospital transport of critically ill pediatric patients. *Crit Care Med* 1995;**23**:1588–95.