Chemical oxygen release: an evaluation of utility

Oxygen is a primary first aid tool to manage decompression sickness following compressed gas diving[1]. Securing adequate supplies in remote locations can be problematic given the prohibition against transport of pressurized cylinders on commercial aircraft and the inconvenience and expense of ground transport. Alternatives to pressurized gas sources include oxygen concentrators and chemical oxygen releasing devices. Oxygen concentrators rely on electrical power – plug in or battery. Chemical oxygen release requires no external power. We previously reported on a chemical oxygen releasing system that had an inadequate supply volume for field utility[2]. This article summarizes the evaluation of a newer chemical oxygen releasing device. Full details can be found in the published report[3].

System Description and Basic Operation

The emergency oxygen device (emOx) is a portable non-pressurized oxygen delivery system developed by Green Dot Systems, Inc. (South Africa). The unit is marketed as being useful for first aid use until professional medical assistance is available. Advertising focuses on the absence of a pressurized storage container, high purity of delivered oxygen, total flow duration, and long shelf life of the reactants. We evaluated the performance of the emOx system under controlled laboratory conditions.

The emOx device is similar in appearance to a 15 inch high, five inch diameter thermos bottle (Figure 1). A flexible supply line connects the top of the assembly to a simple patient mask. Single dose packs of two chemicals are mixed with water in the large chamber and the components are assembled. Oxygen and heat are released through chemical reaction. Oxygen is flowing as long as bubbles are seen through the transparent cap. Multiple reactant packs are available for repeat use.

Methods

We conducted seven unmanned trials under stable, standard, indoor laboratory conditions. The device was operated in compliance with manufacturer instructions. The simple face mask was replaced with monitoring equipment to measure the output.

All components were measured and activation carried out in a standardized manner for each trial. Trial data were captured through a computerized data acquisition system. Gas flow was measured continuously and averaged over sequential 60 second periods until the flow decreased to zero. Total volume was computed from the minute average flow readings. Temperatures were measured on the outside wall of the reaction chamber. Samples for delivered gas temperature and humidity were drawn from the gas stream at the approximate position of a patient mask. Values were reported as mean ± standard deviation with ranges in brackets.

Results

The total weight of the system was 5.8 lbs (2.65 kg) with one set of reactants (including water). Each additional set of reactants added approximately 2.0 lbs (0.9 kg).

The mean flow rate (measured to the last non-zero minute average) was 1.75±1.58 (0.05-6.75) $L \bullet min^{-1}$ (ambient temperature and pressure, saturated with water vapor; ATPS) (Figure 2). Oxygen was released for 23±6 (18-35) minutes. The time it took for the flow rate to exceed 2.0 $L \bullet min^{-1}$ was 15.7±6.4 (11-29) minutes. The flow rate remained above 2.0 $L \bullet min^{-1}$ ATPS for only 6.4±1.0 (5-8) minutes (transiently

peaking at 5.93±0.56 (5.23- 6.75) L•min^{-1} ATPS before quickly falling to zero). The total oxygen yield was 40.4±2.6 (37.7-44.4) L.

Reaction canister outside wall temperatures reached 54.7±7.4 (46.4-64.9)ºC. Gas temperature measured at the approximate position of a delivery mask varied little from ambient temperature at any point in the reaction cycle.

Oxygen delivery systems appropriate for first aid use must be reliable, easy to use, easy to transport and able to provide sufficient volume and flow rates for the conditions of treatment. Nominal flow rates recommended for treatment with continuous flow systems are often in the 10-15 L•min^{-1} range.

Rapidly deployable but limited oxygen supplies could be appropriate for some urban or suburban settings with readily available emergency medical services support. Remote settings or situations in which rapid EMS response could not be relied upon demand greater oxygen resources.

Reliance on traditional pressurized sources of oxygen can create transport difficulties. The concept of chemical oxygen release is compelling since it avoids both pressurized vessels and power supply challenges. High purity oxygen can be released by stable and safe reactants. The problems, however, remain limited oxygen flow rate and total yield.

The emOx portable non-pressurized oxygen delivery system is compact, robust and easy to use as long as all three reactants are available. Unfortunately, the total oxygen yield for a set of reactants is extremely limited – approximately 10% of that provided by a single 'D' size oxygen cylinder. Practically, this extremely limited supply would likely be ineffective in treating most medical conditions. Additionally, the slow and variable time required for the oxygen production rate to climb, despite careful standardization of activation steps, brings into question any benefit of rapid deployment in advance of EMS arrival. Ultimately, the time spent dealing with the device and not spent paying attention to other needs of the patient does not seem justified for the limited benefits delivered.

The final issue is that delivered gas was not warmed substantially above ambient temperatures as promised. Despite very high reaction chamber temperatures, heat transfer along the length of the standard delivery line provided a nearly complete equilibration with ambient temperature. Thus, any treatment benefit of warmed inspired gas to a patient would not be realized.

Conclusions

Increasing the number of alternatives to pressurized oxygen sources for the effective delivery of first aid oxygen is desirable. Unfortunately, our testing of the emOx system indicates an extremely limited mean oxygen flow rate, an extremely limited total oxygen yield and a problematically inconsistent timeline of oxygen release. Based on these results, we concluded that the emOx device does not provide an adequate source of emergency oxygen. Our experience led us to conclude that the practical benefits of powdered chemical oxygen releasing systems for first aid or emergency medical use may remain marginal at best. We speculated that future efforts to replace compressed gas sources would be more productively directed at improving oxygen concentrator technology.

Fig. 1	Fig. 2

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