Evaluation of a new system of oxygen administration: the Wenoll system®

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Introduction

O_2 administration is essential for patient survival in clinical situation as: reanimation or anesthesia of a polytrauma, CO poisoning, decompression sickness...

When the oxygen stock is limited (critical situations as war zones, disasters…) , the delivery of high FiO_2 for an extended period may become insufficient.

To limit the O_2 volume required in spontaneously breathing patients, we can use the Wenoll system®(rebreather with closed circuit to recapture the exhaled O_2).

This closed circuit provides a 100% FiO_2 for a low flow rate for patients at rest : O_2 flow rate covers O_2 consumption (VO_2) and a soda-lime cartridge absorb the CO_2 produced by the patient's metabolism (VCO_2).

Since we know that an O_2 flow rate of 1 to 2 l / min with an usual O_2 cylinder (O_2C) is generally sufficient to ensure the VO_2 of a patient ventilating at rest, our goal was to determine whether the use of a portable oxygen concentrator (POC) could effectively replace the use of a O_2C and thus ensure proper FiO_2.

Methods

The study was conducted on bench with the Wenoll system® connected to an a two compartment adult lung model (Dual Test Lung ®) controlled by a Maquet Servo I® ventilator (Vt: 0,5 L; I/E: ½; Peep: 0 cm H_2O: Rf 10 to 40 cpm). Different minute ventilation (MV: 5 to 20 l / min) were investigated. An oxygen flow rate of 2 l / min was ensured using either a O_2C (B2: Air Liquide ™) or an POC (Sequal Saros ®). Two mode of O_2 delivery systems were tested: Continuous O_2 (O_2C and POC) and bolus O_2 : 74 ml at each breath (with POC). The FiO_2 and minute ventilation measurements were made using a iWorx® acquisition system (GA207 gas analyzer and analog / digital IX / 228s) and LabScribe II ® software.

Statistical test used: ANOVA test followed by a post hoc test (Tukey test).

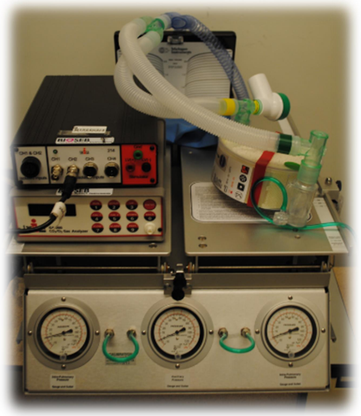
Saros® military version for battlefield

Portable oxygen cylinder

Results

After a period of 5 minutes necessary for the denitrogenation of the Wenoll system® dead volume (Oxygen flow rate: 2 l/min), the FiO_2 reached a value of 100% with O_2C and 92% with POC at continuous flow ($p < 0.05$). With POC, there was no significant difference between continuous and bolus mode (pulsed volume of 74 ml at each respiration).

Wenoll system®



Bench test

Discussion

If we assume that the oxygen extraction ratio (E) of air in the lung:

$$E = FiO_2 - FEO_2$$

was stable and equal to 5%. In this case, if VI is equal to VE, then VO_2 is:

$$VO_2 = (VI * FiO_2) - (VE * FeO_2)$$

VO_2: oxygen consumption ($l.min^{-1}$)

VI: volume of air inspired per minute

VE: volume of air expired per minute

FiO_2: fraction inspired of O_2

FeO_2: fraction expired of O_2

Consequently, for minute-ventilation from 5 to 20 l / min, with the use of an POC coupled to Wenoll system®, we can administer for a long period, FiO_2 near 92% with a very low O_2 flow rate (2 l / min) to ensure the patient VO_2. Note that the duration of effectiveness of the decarboxylation by soda lime cartridge of Wenoll system is estimated (by the manufactory) to be 5 hours for a patient ventilating at rest.

Bibliography

Jurgen Graf. In-Flight Medical Emergencies. Dtsch Arztebl Int. 2012 Sep; 109(37): 591–602.