In Vivo Performance of a Membrane CO₂ Filter during Target-Controlled Closed-Circuit Anesthesia

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Introduction: Currently used soda lime based CO₂ absorbents are safe [1] but not ideal for reasons of ecology (production and disposal), ergonomics (need to refill or replace), economy (discarded before used to full potential), and dust accumulation in sensitive machine parts. These issues are absent with the Memorb™ (DMF Medical, Halifax, NS, Canada), a new device for gas-to-gas exchange and separation that uses technology similar to oxygenator membranes for cardiopulmonary bypass machines. A sweep gas flows through the lumen of semipermeable hollow fibers and adds or removes gases from the circle breathing system (whose gases pass in between the fibers) according to the prevailing partial pressure gradients across the fiber wall and the relative permeability of the gases. Because the permeability of CO₂ is higher than that of inhaled agents, the CO₂ transport rate and thus washout should be relatively higher than that of inhaled anesthetics. We tested the performance of the device during target-controlled closed-circuit anesthesia (TCCCA) with desflurane in O₂/air with the Zeus IE (Dräger, Lübeck, Germany).

Materials and Methods: After obtaining IRB approval and written informed consent, 8 ASA PS I-III patients undergoing robotic prostatectomy were enrolled. After induction of anesthesia and intubation of the trachea, TCCCA with the Zeus IE was used with the following settings: target inspired O₂ (FIO₂) 39% in O₂/air; target end-expired (Fₐ) desflurane 5.0%; controlled mechanical ventilation, adjusted to FₐCO₂ 4.5-6.0%; and 5 cmH₂O PEEP. An O₂/air blender (Scanatron Technics, Affltern-am-Albis, Switzerland) delivered the sweep gas (40% O₂) to the inlet of the Memorb™ canister. Sweep O₂% was set 1% above target FIO₂. The sweep flow was titrated to keep FICO₂ ≤ 0.8%. RUGloop (DEMED, Temse, Belgium) collected the following data: FIO₂, Fₐdesflurane, FCO₂, FₐCO₂, minute ventilation; O₂ and air FGF; sweep flow; and cumulative desflurane usage (Vdes). Only data of the first 2h are reported. Data are displayed as average (standard deviation) unless indicated otherwise. Vdes was compared (for Fₐdesflurane = 5.0%) with historical data of the Zeus IE used with soda lime (Dräger 800+) [2] and during conventional CCA [3].

Results: see Figure 1

Age (years), height (cm) and weight (kg) were 67(8), 173(5) and 78(10), respectively. A 14-25 L/min sweep flow maintained FICO₂ ≤ 0.8% and FₐCO₂ ≤ 6.0% combined with a minute
ventilation of 5-7.6 L/min while a CO₂ pneumoperitoneum (CO₂PP) was applied. Fₐdesflurane and F₁O₂ targets were maintained within a very narrow range. Total FGF dropped to zero within 1.5-6 min, occasionally briefly increasing upon initially applying the CO₂PP, only to remain zero thereafter most of the time. Vdes was higher than during identical conditions with a soda lime absorbent with the Zeus IE during TCCCA [2] and during conventional CCA [3].

**Discussion:** During TCCCA, Memsorb™ removes CO₂ well under conditions of high CO₂ elimination (adult patient with prolonged CO₂PP). The small increase in FₐCO₂ is inconsequential because its effect on FₐCO₂ can easily be overcome by a small increase of minute ventilation. The amount of O₂ transferred from the Memsorb™ to the circle breathing system sufficed to cover patient O₂ consumption. In order to keep FGF low during TCCCA, the target F₁O₂ and the F₁O₂ in the sweep gas should be very similar in the target F₁O₂ mode. Liquid Vdes in the Memsorb™ group was 2.05 mL/h per 1% Fₐdesflurane higher than during historical CCA data, making Vdes with Memsorb™ during TCCCA after 1h equivalent to Vdes with a FGF slightly above 1L/min when a soda lime absorber is used [4]. The exact routes of carrier gas and agent losses need to be further defined.