An Interchangeable Mapleson A-E Circuit is Practical And Cost-Effective

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Introduction: In third world and remote locations where oxygen and anesthesia gas supplies are limited and where circle systems are not available, means to reduce fresh gas flow during maintenance of inhalational anesthesia are of potential value. We developed and tested a breathing circuit allowing the interchange between Mapleson D (Map-D) and Mapleson A (Map A) configurations. With such, we hoped to find an apparatus that readily adapts to the needs of a case depending on the need for: (1) control of ventilation, or (2) low fresh gas flows with spontaneous respiration during maintenance of anesthesia. This project sought to validate one such design on patients undergoing knee arthroscopy in the operating room.

Methods and Materials: A Vital Signs transport circuit served as a prototype Map-D circuit. The Map-A configuration was achieved by switching positions of the exhaust valve and the elbow connector containing the fresh gas inflow port. A small straight connector bearing a gas sampling line was interposed between the endotracheal tube and circuits for continuous monitoring of respiratory gasses. Ten healthy men (ASA physical status I and II) undergoing knee arthroscopy were consented and then studied with general endotracheal anesthesia administered with a standard circle system on an Ohmeda 7900 anesthesia machine. With surgery underway and with a stable respiratory pattern and stable hemodynamics, the following sequence was followed: 1) Baseline minute ventilation, tidal volume, inspired and expired CO_2, oxygen, and expired anesthetic concentration were quantitated on the Ohmeda machine. 2) A switch to the Mapleson D system was then made with the circuit connected to the common gas outlet. Anesthetic gas vaporizers were adjusted to maintain the same expired concentration read in step one. Fresh gas flows were increased as needed to prevent rebreathing of CO_2. If inspired CO_2 was less than 2mm Hg, gas flows were decreased until this value was reached, then increased until the reading was zero. The rate of fresh gas flow corresponding to zero inspired CO_2 was held for five minutes, after which the patient was reconnected to the circle system for measurement of minute ventilation and tidal volume. 3) The final experimental period had the patient breathing through the Map-A modification of the transport circuit. Fresh gas flows were turned down in the manner described above until stable readings were achieved. Inspired and expired gas concentrations were measured as above, with minute ventilation recorded after reconnecting the patient to the standard anesthesia machine.

Results/Discussion: Fresh gas flows for both Map D and Map A circuits were titrated down to find the lowest inflow rate where there was no evidence of rebreathing CO_2. When comparing the two designs in individual patients, a mean decrease in FGF of 2.8 liters per minute was seen ($P=0.003$ with paired two tailed t-test). There was no significant difference in minute ventilation throughout the experimental period for individual patients, however the FGF/ VE was significantly lower with the Mapleson A configuration than with the Mapleson D circuit design (1.1 vs. 1.8 ; $p=0.007$ by 2-tailed t test).

Conclusion: As guided by end tidal CO_2 monitoring, fresh gas flow rates can be safely and substantially reduced with the circuit modification described. Calculations extrapolating these findings to reductions in oxygen use, pollution, and anesthetic vapor consumption with the Mapleson A circuit can be made, and will show substantial savings in key resources that may limit care in underdeveloped or impoverished locations.