Development of an Anesthetic Reflection System

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Introduction: The World Health Organization declared climate change the defining issue for health systems in the modern century. Ironically, the health care industry itself is a leading emitter and accounts for 8% of the total carbon dioxide emissions alone [1]. In anesthesia, publications have brought growing concern about the global warming potential of emitted inhalational anesthetics. Previously we have demonstrated that activated charcoal has suitable sorption isotherm characteristics to absorb and desorb isoflurane, suggesting feasibility to reflect exhaled anesthetic gases back to a patient during sedation [2]. Building off this research, we have developed an anesthesia machine add-on that allows for traditional anesthesia delivery in tandem with a charcoal filter for gas reflection.

Methods: An initial proof-of-concept prototype was created to be fitted within the rebreathing circuit of a current anesthesia machine. This system consisted of a housing of two chambers printed with biocompatible acrylic (MED610, Stratasys, Eden Prairie, MN). One chamber was fitted with a charcoal cartridge (Oxpure 1220C-75, Oxbow Activated Carbon, West Palm Beach, FL), and the other remained open. A gear with a semicircular opening was actuated externally to direct gas flow between chambers. In addition, differential pressure sensors were attached at both chamber ends to determine direction of gas flow (simulated inhalation and exhalation). Anesthetic gas concentration measurements from a standard infrared gas bench (Datex-Ohmeda, Helsinki, Finland) was used for basic feedback control. A microcontroller controlled the gear valve to titrate a user give anesthetic concentration based on flow detection and anesthetic gas concentration using a rudimentary hysteresis controller. This device was tested between the breathing circuit of an anesthesia machine and a test lung.

Results and Discussion: Our proof-of-concept device was successful in meeting the basic criteria. During a mock induction, the device oscillated between the open chamber (inhalation) and the charcoal filter (exhalation) to initially saturate the activated charcoal (Figure 1). During this time, it took approximately 6 minutes for the charcoal filter to saturate. Fresh gas flow then primarily flowed bidirectionally through the charcoal filter, with the controller able to maintain average isoflurane concentrations within 0.2% by volume of the user set point (1 MAC). Given a cartridge with 40 grams of activated charcoal, the Anesthetic Reflection System would can reflect 1 MAC/hour of anesthetic gas at a fresh gas flow rating of 1 liter/minute.

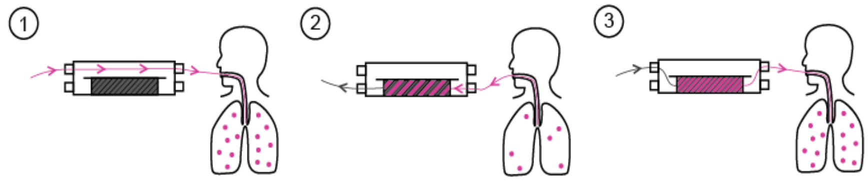

Figure 1 – (1) Patient inhales anesthetic gas directly from anesthesia machine during induction. (2) Patient exhales anesthetic gas into activated charcoal filter. (3) Anesthetic gas is supplied from filter to the patient during anesthetic maintenance.

References:

[1] J. W. Chung and D. O. Meltzer, "Research letter," *J. Am. Medial Assoc.*, vol. 302, no. December 2010, pp. 1970–1972, 2009.

[2] P. Kolbay, J. Orr, and K. Kück, "Reducing Volatile Anesthetic Waste Using Activated Charcoal," in *Proceedings of the 2017 Society for Technology in Anesthesia Annual Meeting*, 2017.