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# Enhancing Equilibrium Time of Anesthesia Gases Using a Circulator

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## Introduction

An uncommon approach to delivering anesthesia to patients is the use of a gas circulator. This work explores potentially unique characteristics of a gas circulator in the breathing circuit. The intention of this study is to demonstrate the potential for the circulator to improve speed of induction and provide other advantages for breathing circuit function. Previous studies investigated a Neff circulator, a device which is inserted into the inspiratory limb of a circle breathing system that can eliminate apparatus dead space to ensure rapid mixing of the anesthetic atmosphere, and compensate for apparatus breathing resistance (1). The Neff circulator is built around a Venturi injector system, while the circulator here is a simple fan (1).

## Materials & Methods

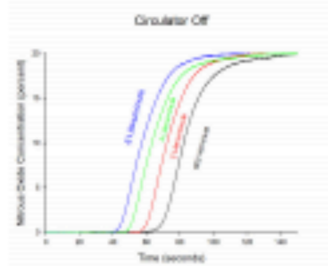
The time for fresh gas inflows of medical air and 20% nitrous oxide were observed at four different fresh gas flow rates and three different circulator flow rates. Data were initially collected from a gas analyzer (GE 8850) and a flow measuring system (BC Biomedical PFC-3000 Flow Analyzer). Both, the gas analyzer and the flow measuring system were hooked up to the breathing circuits inspiratory and expiratory limbs. The circulator was a six inch direct current tubeaxial fan (Ebm-papst, Inc.,Farmington, CT) that was mounted inside of one of the two carbon dioxide absorber canisters. No soda lime was used. The fan was powered from a Tektronix variable power supply permitting the voltage applied to the fan to control the flow of gas circulating in the breathing circuit of the Aestiva anesthesia machine. The circulator was set to deliver three fan speeds; no circulatory flow, 0.42 L/minute and 1.25 L/minute. The gas analyzer sampled oxygen and nitrous oxide at a rate of ten data points per second. Each gas was tested at each of the four different total flow rates: 800 mL/min, 2 L/min, 4 L/min, and 6L/min. The nitrous oxide and oxygen concentration data were collected using a gas analyzer that transmitted data to a laptop computer running Tracer Daq software (Measurement Computing). During data collection the bag switch was placed on manual and the APL valve was all the way open. Circulator flow was collected along with circuit pressure every 15 seconds and entered into an Excel spreadsheet to be graphed and analyzed along with the gas concentration data

Aestiva Anesthesia Machine
Gas Analyzer (GE 8850)
Flow Measuring System (BC Biomedical PFC-3000)
Circulator (Ebm-papst, Inc.,Farmington, CT)
Tektronix Power Supply
Breathing Circuit
Laptop With Tracer Daq Software (... with Measurement Computing)
Anesthetic Gasses (Medical Air and Nitrous Oxide)

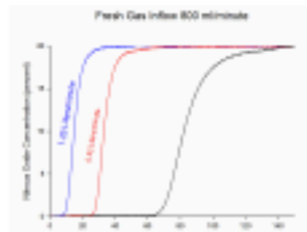
This is the circulator used in this experiment. It is a six inch direct current tubeaxial fan (Ebm-papst, Inc.,Farmington, CT) that is mounted inside of a carbon dioxide absorber with no soda lime. This circulator was powered by a Tektronix power supply.

## Results

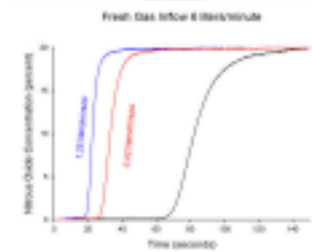
From what was shown in the data, the use of a gas circulator allows the gas to reach the patient more quickly potentially aiding the speed of induction and emergence. All trials without the gas circulator and just an increased total flow rate proved it took longer to reach maximum concentration throughout the entire system. All trials with the circulator powered at 13 Volts shows that maximum concentration was reached quicker. When the circulator was powered to 16 Volts it showed the quickest concentration equilibrium.




This graph depicts the use of only medical air and nitrous oxide fresh gas inflows rather than using a circulator to help reach a concentration equilibrium. As we can see it takes lower flows, 800mL/min, a significantly longer time to reach equilibrium in the system, roughly 145 seconds. Just as we expected a flow rate 6L/min is the shortest time to reach concentration equilibrium in the system, only taking about 90 seconds.



This figure shows all three circulator speeds and how they vary at a total of 800mL/min fresh gas flow. Just as predicted, when the circulator is in the off position it takes nearly 140 seconds for the gas concentrations to reach an equilibrium in the system. When the circulator was set at 0.42L/min, equilibrium was reached in roughly 80 seconds. At the max setting of 1.25L/min it is displayed that the maximum concentration was reached in 25 seconds.



This graph shows our maximum fresh gas inflow rate of 6L/min. We see that with the circulator in the off position it takes nearly 140 seconds for the gas to reach an equilibrium concentration in the circuit. When the circulatory was turned on and set to 0.42L/min we see that the time to reach equilibrium was reduced by a large amount and it only took about a minute. Increasing the circulator speed even more, up to 1.25L/min, the time was reduced yet again. It only took roughly 25 seconds for equilibrium to be reached.

## Discussion/Conclusion

Now that we know a gas circulator provides a faster time to reach a concentration equilibrium we can explore some of the disadvantages of using the circulator in its current configuration. If a circulator were to be to added to all anesthesia machines we would need to determine how soda lime would affect the flow rates if it does at all. Soda lime may also produce dust that could be toxic for the patient or damage the anesthesia machine. To prevent this, an option could be to add filters to the inspiratory and expiratory limbs. We would also want to see if different size circulators would show the same effect as the data presented here. This would require more studies with different size and style circulators.

## References

1. Peter L. Jones, F.F.A.R.C.S, John Prosser, F.F.A.R.C.S, "An Assessment Of The Neff Circulator" *Canadian Anesthesiology Society Journal*, vol. 20, no. 5, September 1973, 659-674.