

Chapter 9 Low Fresh Gas Flow Anesthesia

Theory

In a semi-closed breathing circuit, high fresh gas flow allows the inspired anesthetic tension to closely approximate that delivered from the anesthesia machine, even during induction. This relationship is important, since it is the delivered tension that the anesthetist controls. As anesthesia proceeds, expired anesthetic tension rises toward inspired tension. The fresh gas flow may now be lowered, since the only consequence is rebreathing the warm, humidified, anesthetic-containing expired gas. For this reason, *low flow anesthesia* is used by some clinicians for maintenance of anesthesia after induction is completed. Reducing flows from 8 to 2 L/min, for instance, reduces anesthesia cost by about 75%^{21,22,24,25} while simultaneously providing heat and humidity to inspired gas².

When real breathing circuits are used with low fresh gas flow, agents can be removed by flushing with oxygen. The Flush button in the Gas Man Picture allows you to simulate this action.

Gas Man also provides the user an *ideal circuit* for experimentation. Real breathing circuits behave in a manner somewhere between Gas Man's fully mixed semi-closed circuit and the unmixed, first-in first-out ideal circuit. The ideal circuit has all of the properties of the non-rebreathing or open circuit whenever FGF exceeds ventilation. When FGF is less than ventilation, fresh gas is breathed in preference to exhaled gas. Thus, inspired gas is dominated by fresh gas as long as FGF is high.

Exercise 9-1

Fresh gas flow can be reduced without changing clinical course.

SETUP

<i>Parameter</i>	<i>Selection</i>
Agent	Isoflurane
Circuit	Semi-Closed
DEL (%)	5% - See Text
FGF(L/min).....	8 - See Text
VA (L/min).....	4
CO (L/min).....	5
VIEW (min)	15
SPEED.....	20x
Special.....	n.a.

To demonstrate the effect of reducing fresh gas flow during anesthesia, adjust the Gas Man parameters as shown. Set Bookmarks at 1 minute and 4 minutes for convenience. Start with DEL set to 5%. *After 1 minute, instead of decreasing the vaporizer setting as most do clinically, decrease the fresh gas flow to 2 L/min. At 4 minutes, decrease DEL to 2%.*

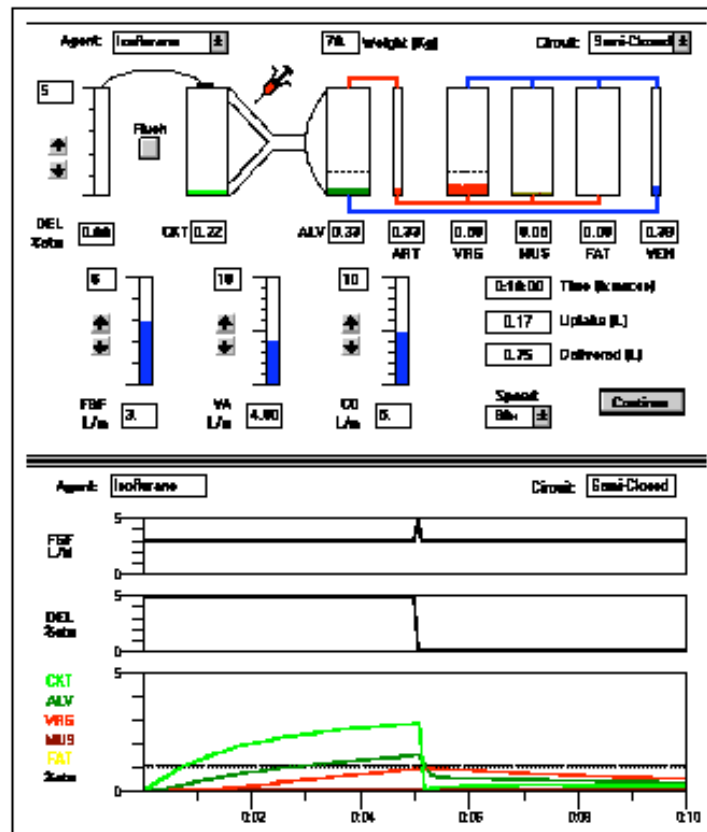


Figure 9-2b shows the second Picture and Graph of Exercise 9-2, wherein the circuit is flushed halfway through a 10 minute anesthetic.

Open a New simulation and run it using the same parameters, but this time, at 5 minutes, reduce DEL to 0% and press the Flush button, located between the DEL control bar and the CKT compartment. Press **Continue**. The results are shown in Figure 9-2. Once the circuit is flushed, CKT tension immediately falls to zero. Then, anesthetic again returns to the circuit in exhaled gas and circuit tension rises slightly. With this technique, you see 10-minute values of 0.22% for CKT, 0.33% for ALV, and 0.50% for VRG.

Exercise 9-3

In an Ideal circuit, fresh gas fills the circuit first and then mixes with exhaled gas.

The ideal circuit represents what would happen if there were no gas mixing in the semi-closed circuit. In that case, inspired tension would approach delivered tension more closely. At very low fresh gas flows, both circuits would behave similarly. As fresh gas flow approaches minute ventilation, the ideal circuit behaves more and more like an ideal circuit. The behavior of clinical circuits lies somewhere in between that of the semi-closed and ideal circuit.

SETUP

<i>Parameter</i>	<i>Selection</i>
Agent.....	Isoflurane
Circuit.....	Semi-Closed; Ideal
DEL (%).....	3%
FGF (L/min).....	3
VA (L/min).....	4
CO (L/min).....	5
VIEW (min).....	10
SPEED.....	60x
Special.....	n.a.

For this Exercise, you will run two simulations according to the parameters shown at left – first using a semi-closed circuit and then using an ideal circuit.

□ OBSERVATION

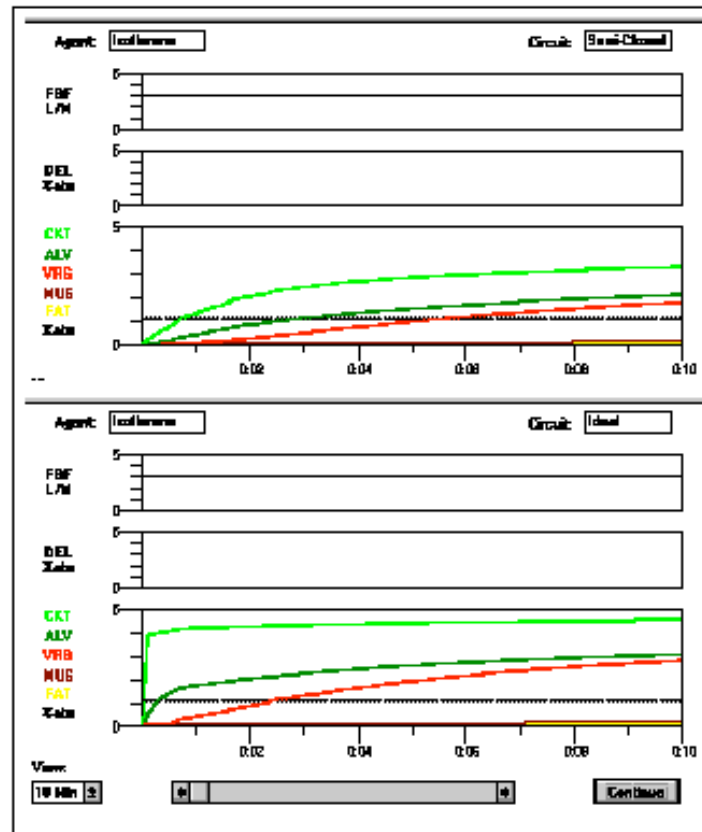


Figure 9-3 shows the Graphs of Exercise 9-3, simulating low flow administration of isoflurane in a semi-closed (top) and ideal (bottom) circuit.

The Graphs from these two simulations (Figure 9-3) show that with a semi-closed circuit, inspired rises exponentially toward the 5% set on the vaporizer. In an ideal circuit, inspired rises to near 4% very quickly and then begins to level off. This is expected, because in an ideal circuit, inspired gas is comprised preferentially of fresh gas, augmented by the requisite exhaled gas to provide minute ventilation. This augments circuit concentration.

 Summary

In low flow anesthesia, fresh gas flow can be decreased after the initial period of rapid anesthesia uptake without sacrificing control of inspired tension. Cost savings can be achieved while maintaining the same inspired anesthetic tension, and hence the same clinical anesthesia course, as with high flow technique.

To allow rapid lightening of anesthetic depth, pushing the oxygen flush button clears the breathing circuit of anesthetic agent, at least transiently.

If actual breathing circuits were not well mixed, they could perform more like the Ideal circuit, in which the patient breathes fresh gas in preference to exhaled gas.