

Clinical Applications of Inhalation Anesthesia Kinetics

Lecture
CRASH 2009

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Harvard Medical School
Med Man Simulations, Inc., a non-profit charitable organization

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Everything profitable I ever invented, is owned by Brigham and Woman's Hospital
(Edwards Vigilance CCO, Bard InfusOR Pump, Cardinal-Alaris-IVAC Signature Pump)

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James H Philip, ME(E) MD

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President, Med Man Simulations, Inc., a non-profit charitable organization

Gas Man® and Med Man Simulations Inc. are a tax-exempt nonprofit charitable organization
I am a frequent speaker for Baxter and Abbott
I have performed funded research on Isoflurane, Sevoflurane, and Desflurane

**Clinical applications of inhalation
anesthesia kinetics**
Lecture Outline

- 1) Fresh gas flow and vaporizer setting combine to provide inhalation anesthesia.
- 2) Increasing vaporizer setting is less costly and more effective than increasing fresh gas flow.
- 3) Pure inhalation anesthesia is a practical form of general anesthesia.
- 4) Low flow and closed circuit anesthesia are safe, effective, and inexpensive.
- 5) Inhalation anesthesia is inherently safe because end-expired agent tension estimates blood level and predicts brain level three minutes later.
- 6) Emergence factors and timing are easy to understand with inhalation anesthesia.
- 7) You can learn all this by downloading and using a demo version of Gas Man® from <http://www.gasmanweb.com>
- 8) You can do this with me at my workshop later in the course. Bring a portable computer if you have one.

I wrote Gas Man® because
"Uptake and distribution of
anesthetic gases
is
virtually incomprehensible"

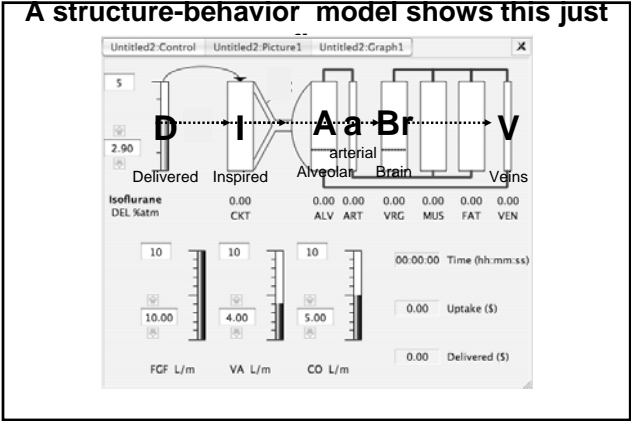
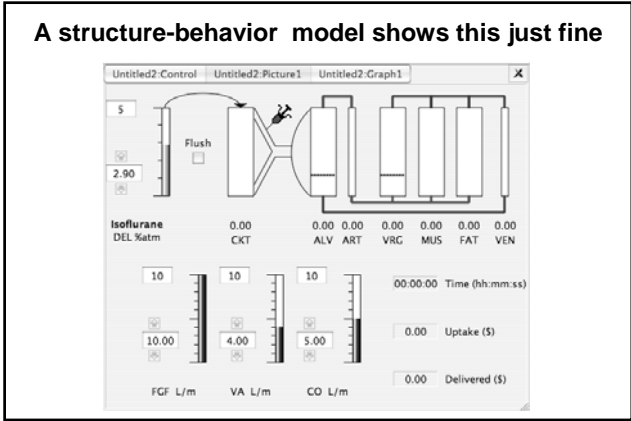
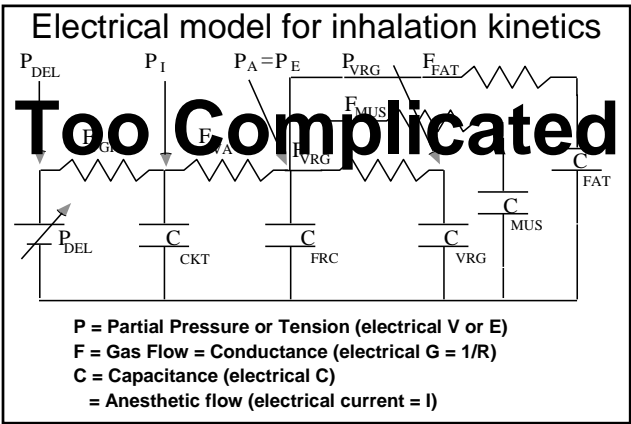
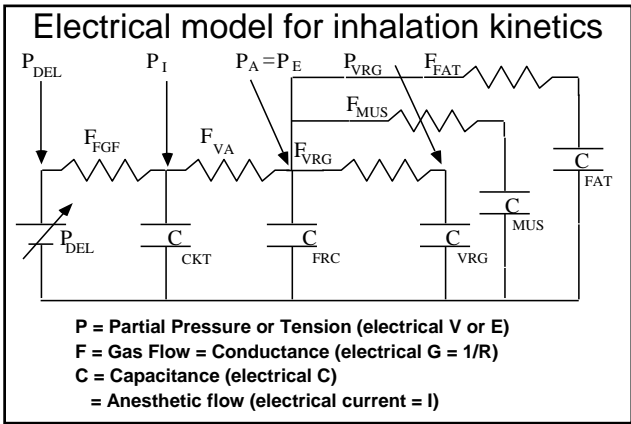
wrote
Lawson: Gas Man Review, Anesthesia and Analgesia,
August 1991

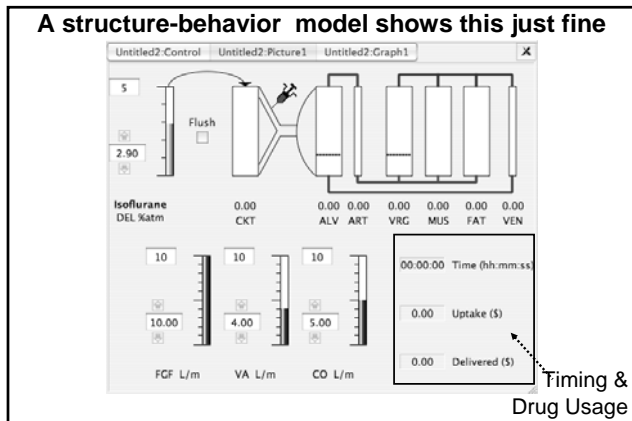
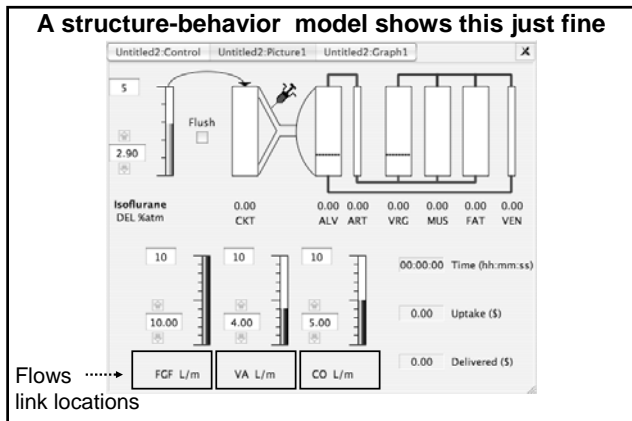
Pharmacokinetics is important !

Pharmacokinetics is important !

Pharmacokinetics explains what goes on from vaporizer to brain

Crucial to clinical practice





Alveolar Tension is important

Tension = Partial Pressure
 Tension equalizes when Concentration equilibrates
 Concentration does not drive molecular motion
 Tension drives molecular motion

Inspired Tension drives Alveolar Tension
 Alveolar Tension drives Arterial Tension
 Arterial Tension drives Tissue Tensions
 Brain it the important Tissue for Anesthesia
 Brain Tension drives depth of anesthesia

Alveolar Tension is important

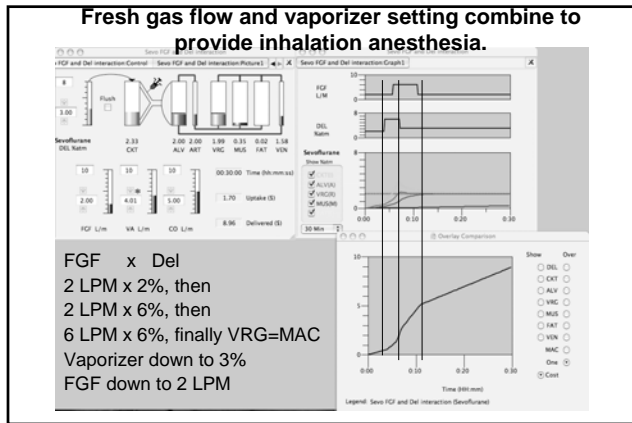
Tension = Partial Pressure
 Tension equalizes when Concentration equilibrates
 Concentration does not drive molecular motion
 Tension drives molecular motion

Inspired Tension drives Alveolar Tension w loss + delay
 Alveolar Tension drives Arterial Tension =, approx
 Arterial Tension drives Tissue Tensions w delay
 Brain it the important Tissue for Anesthesia
 Brain Tension drives depth of anesthesia

If we know Alveolar Tension, we know the hard part

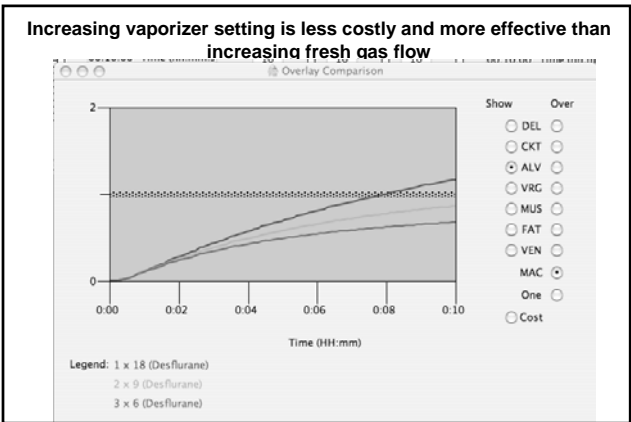
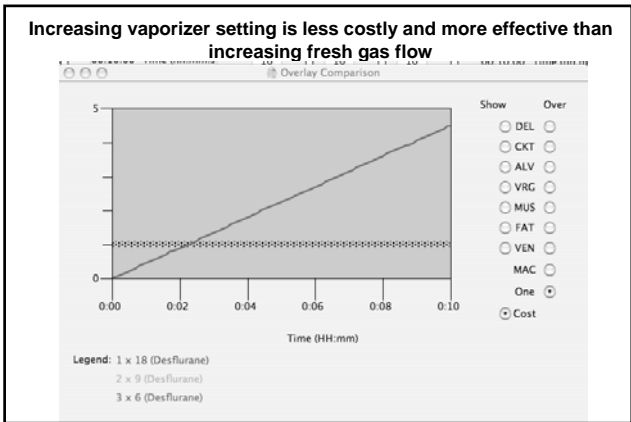
Fresh gas flow and vaporizer setting combine to provide inhalation anesthesia.

Sevoflurane example

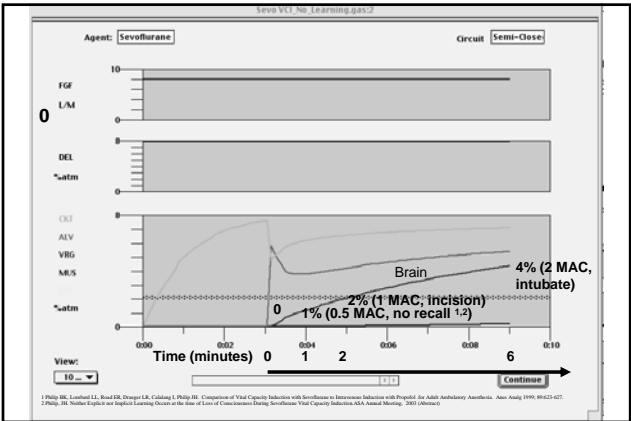


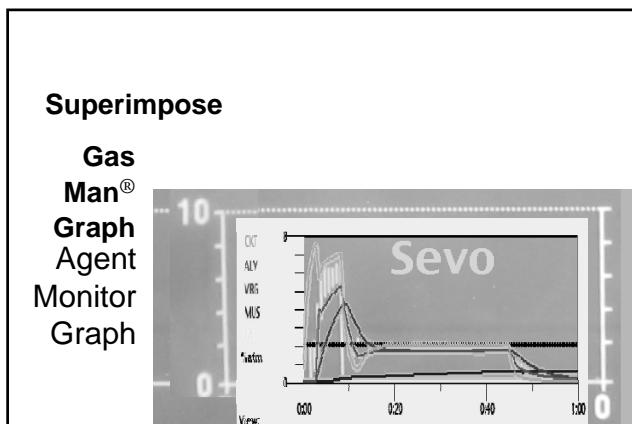
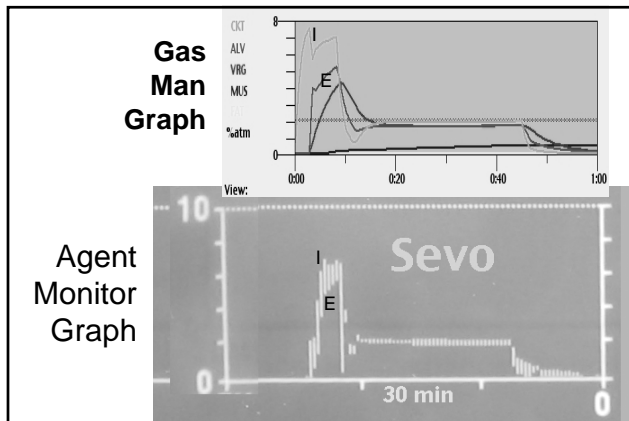
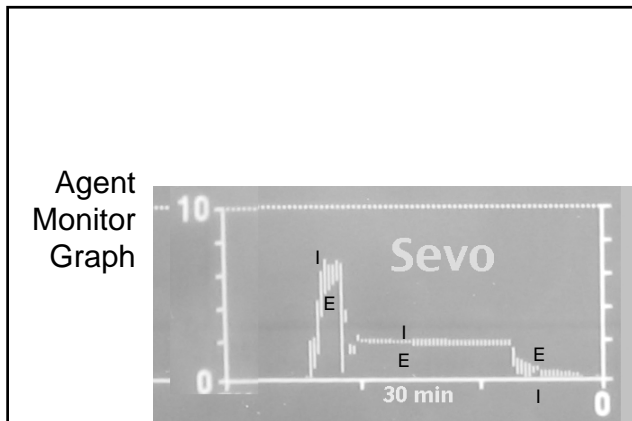
Right time to turn down FGF
 When VRG = desired level.
 Venous return of anesthetic has now stabilized

Increasing vaporizer setting is less costly and more effective than increasing fresh gas flow.



Pure inhalation anesthesia is a practical form of general anesthesia





Most likely reason for VCI to fail

Poor inspired agent control

Even if the patient fails to exhale to RV

Even if the patient fails to take a Vital Capacity breath

Any breathing pattern will deliver agent to lungs, to blood, and to brain

Most anesthesia machines need to be primed

Some anesthesia machines control inspired without priming

Low flow and closed circuit anesthesia are safe, effective, and inexpensive

Low flow and closed circuit anesthesia are safe, effective, and inexpensive

Compare Desflurane used as follows

High flow = 5 LPM, Vaporizer = 3, 4, 5, 6, 7, 8 %

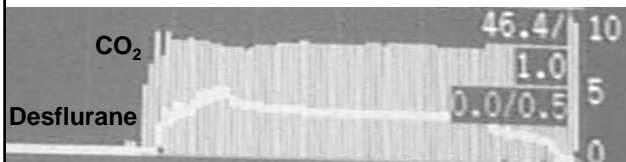
Low flow = 1 LPM, Vaporizer = 18%, 10%

Closed Circuit = 0.2 LPM after VRG = 1 MAC

Same pattern of inspired and expired rise

Very different pattern of agent cost

Gas Monitor shows the same curve
(DEL = 18%; FGF = 1 LPM)



Fresh gas flow for cost reduction

Below 1 Liter per minute there is not much saving

Below 1LPM vaporizer setting must be increased to match

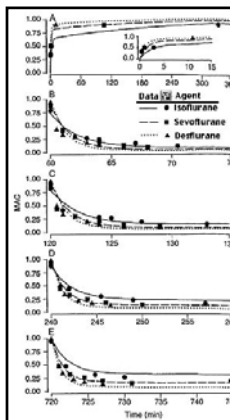
Inhalation Anesthesia inherent safety

End-expired anesthetic tension (%) estimates blood level

With this, clinician controls brain level 3 minutes later

Patient uptake, compartment models, size don't matter

Even low flow and closed circuit anesthesia work perfectly



(A) Wash-in
360 minutes = 6 hr
15 minutes

(B) Wash-out
after breathing
1 MAC for 1 hr.

(C) Wash-out
after breathing
1 MAC for 2 hr.

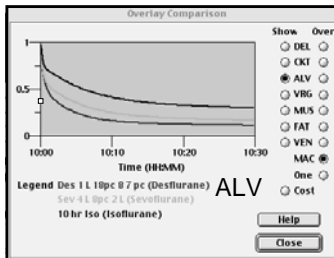
(D) Wash-out
after breathing

Gas Man
Model and
Math
appear to be
correct

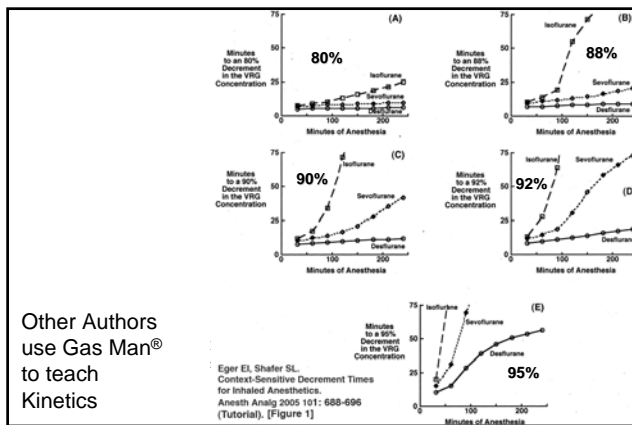
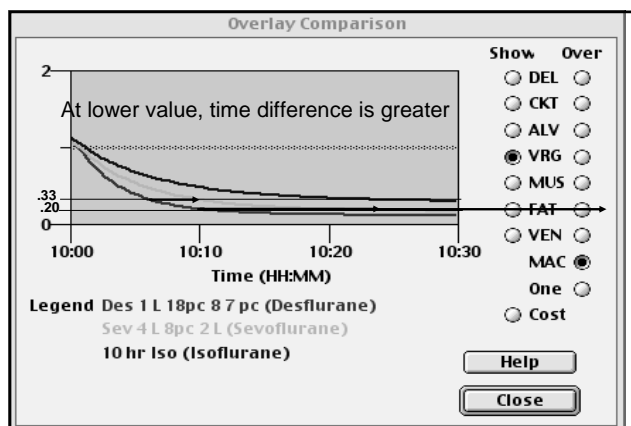
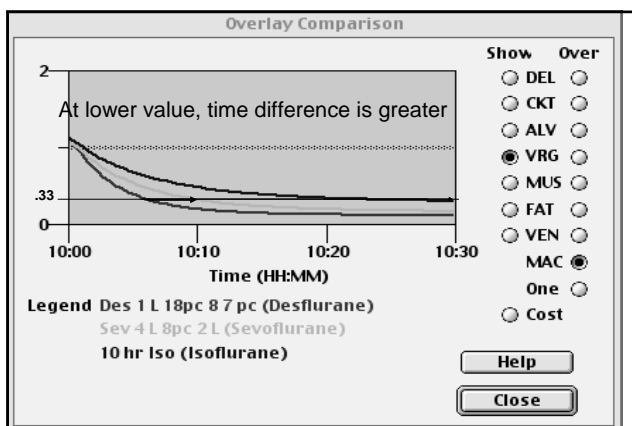
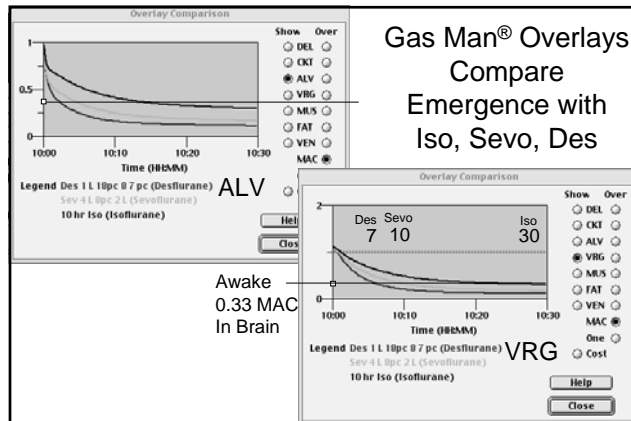
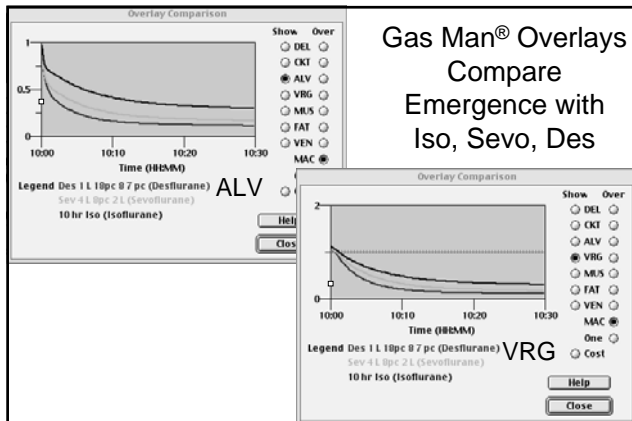
*Bouillon T, Shafer S.
Editorial – Hot air or
full steam ahead?
An empirical
pharmacokinetic
model of potent
inhaled agents.
Brit J. Anaes.
84:429-431 2000.*

Enough of going to sleep
It's now time to

Wake
Up
!



Gas Man®
Overlays
Compare
Emergence with
Iso, Sevo, Des



Other Authors use Gas Man® to teach Kinetics

You can learn this by downloading and using a demo version of Gas Man from <http://www.gasmanweb.com>

You can do this with me at my workshop later in the course.

Bring a portable computer if you have one.

Computer simulation can teach the theory and then explain what we observe during clinical anesthesia

**Thank
you**

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Gasman@gasmanweb.com

Download
Gas Man® Version 4 demo
www.gasmanweb.com