Respiratory Physiology - Part B
Experimental Determination of Anatomical Dead Space Value

(Human 9 - Version Sept. 10, 2013)

[This version has been modified to also serve as a tutorial in how to run HUMAN's artificial organs]

Part of the respiratory physiology computer simulation work for this week allows you to obtain a hand-on feeling for the effects of anatomical **dead space** on alveolar ventilation. The functional importance of **dead space** can explored via employing HUMAN's artificial respirator to vary the respiration rate and tidal volume.

DEAD SPACE DETERMINATION

Introduction

The lack of unidirectional respiratory medium flow in non-avian air ventilators creates the existence of an anatomical dead space. The anatomical dead space of an air ventilator is a fixed volume not normally under physiological control. However, the relative *importance* of dead space is adjustable by appropriate respiratory maneuvers. For example, recall the use by panting animals of their dead space to reduce a potentially harmful respiratory alkalosis while hyperventilating.

In general, for any given level of *lung ventilation*, the fraction of the *tidal volume* attributed to dead space will affect the resulting level of *alveolar ventilation*, and therefore the efficiency (in terms of gas exchange) of that ventilation. [You should, of course, refresh your knowledge of total lung ventilation, tidal volume alveolar ventilation.]

Your <u>objective</u> here is to observe the effects of a constant "unknown" dead space on resulting alveolar ventilation by respiring the model at a variety of tidal volume-frequency combinations. You are then asked to <u>calculate</u> the functional <u>dead space</u> based on the data you collect. [Note that you could 'look up' the value for the HUMAN dead space variable but should not! Instead you should determine it experimentally by this procedure.]

Procedure

The HUMAN model allows you to control respiratory tidal volume (TIDVOL) and frequency (RESPRT) by putting the subject on an <u>artificial respirator</u>.

A] <u>Set Up</u> (initial)- You must first run a new subject i.e. <Start Over> and select the following variables (in **View Output:**) for your tables:

Ventilation, total	(**VENT**)	
Tidal volume	(**TIDVOL**)	<-These are the actual *resulting* tidal volume and resp.
Respiration rate	(**RESPRT**)	<-rate regardless of whether under control or 'natural'
Arterial pCO_2	(**PCO2A**)	
Arterial pO_2	(**PO2A**)	
Alveolar ventilation	(**AVENT**)	

View Output:

VENT ⬍	TIDVOL ⬍	RESPRT ⬍	PCO2A ⬍	PO2A ⬍	AVENT ⬍

B] <u>Set Up</u> (artificial respirator)

<u>Controlling respiration</u> with the <u>artificial ventilator</u> - HUMAN contains the ability to simulate the function of various organs/systems artificially (an artificial ventilator, heart, kidney, etc.).

In each case there are *two logical steps* to such organ control

1) Your 'throw' a switch (set from 0 to 1) to tell HUMAN *you* are taking over the job of running that organ.

2) *You* then have the responsibility to set the level of those (parameters) properly (or the model will usually die … no heart, no respiration, etc.).

In the case of the artificial ventilator today you need to 1) set the respirator switch to ON & 2) control VENT (rate & frequency) on our own. [Note that you can teach yourself the basics of respirator manipulation by simply mousing <Tips: Artificial Respirator> in the **Help** section].

a) Turn the artificial respirator switch on [**ARTRES**=1 turns it on, **ARTRES**=0 turns it off, its' default is 0]

b) Run the experiment for 0 min. at 0 min. intervals to verify having successfully turned on the respirator and

c) Set the respirator rate (**ARRT**) and respirator volume (**ARVOL**) at levels (approximately) equal to the subject's normal levels (what were RESPRT & TIDVOL before you turned the respirator on?).

View Output:

VENT	TIDVOL	RESPRT	PCO2A	PO2A	AVENT
as: text	text	text	text	text	text

Experiment Controls

Change Variable	Enter New Value	Info on Variable
ARTRES	1	1=On, 0=Off
Choose		

Run Experiment:
for 0 minutes at 0 minute intervals.

Logout   Prefs.   Go   Start Over   Expt: Save Get

Help

Help info on: ARTRES
Tips: Artificial Respirator

View
Variable Value: Choose
Patient Charts or Lab tests:
Choose One

Graph Style   Size: 600
Normalized, one graph

d) Run the simulation <**Go**> for one min. with one min. between printouts and record values at that time.

Note that the resulting physiological variables (RESPRT, TIDVOL) should now be completely under the control of the values you set on the ventilator (ARVOL, ARRT). [Be aware that it is a very common error to set the respirator rate and volume but forget to turn the respiration on (**ARTRES**=1). Also ware running the model for long time periods as some of your ventilator setting are potentially fatal.]

C] Run the experiment -

a) Repeat the procedure with a new subject three times, each time *raising* **respirator tidal volume** and lowering the rate to achieve a total lung ventilation (VENT= rate x volume) equal to your control run above. For example, if your VENT started at 6.00 L/M (i.e. 12*500) then raising the tidal volume to 1000 & dropping the rate to 6 will achieve the same VENT (6.0 L/M).

Time saving tip- You can retrieve the above View Output: tables settings by simply using the *back button* on your browser to restore the screen at which your ventilator is already turned on but volumes and frequencies have not yet been set.

Next repeat the procedure with three *lowered* **tidal volumes** and appropriate calculated respiratory rates. Record all your values.

The objective is to achieve 6 runs in addition to the control run, all with the same level of lung ventilation (VENT) but differing resulting alveolar ventilation.

The assignment [short write-ups are worth 1/3 of full papers)
Please turn in your work in before leaving the computer lab room.

[required] <u>Dead space determination</u>* - The objective is to determine *graphically* the functional dead space from the data you have collected. The simplest way is to plot a graph of AVENT vs. TIDVOL. From the graph, <u>very briefly</u> answer the following two questions: a) what is the value of the functional dead space? b) What was your reasoning?

[optional] A more elegant way to attack the analysis is to ask at what tidal volume does the dead space *ventilation* become equal to the total ventilation? To do this you will need to calculate & add to a data table you construct the dead space ventilation for each volume-frequency pair. Then proceed to answer the two questions above (a & b).

* Note that while it may be possible to look up the value of dead space in the model, the objective here is to determine it graphically.

Reminders: Please type all text sections. All labs due before you leave lab today.