PhysioEx Exercise 7: Respiratory System Mechanics – KEY

GRADING: 20 points total: 15 for completeness and 5 points for a reasonable summary of Activity 3.

Activity 1: Measuring Respiratory Volumes and Calculating Capacities

- **Experiment:** The basic setup is similar to the usual balloon model of respiration. Simulated lungs are suspended in a glass jar, and a rubber diaphragm at the bottom of the jar is used to adjust the volume and pressure of the cavity surrounding the lungs. In this experiment, we investigated the effect of airway radius on respiratory parameters such as tidal volume (TV) and Forced Expiratory Volume in 1 second (FEV_1). A decrease in airway radius can be used to simulate obstructive pulmonary disease.
- **Prediction:** Answers will vary.
- **Results:** Data are shown in the table below. As expected, FEV_1 goes way down as airway radius decreases (though the ratio FEV_1/VC does not decline as much as would be expected). In addition, minute ventilation is lower at smaller airway radii because of smaller tidal volumes.
- **Conclusion:** The problems caused by obstructive pulmonary disease include slowed flow through the airways and thus reduced FEV_1. (The data may not be a realistic simulation of obstructive disease in that the breath rate would normally increase to compensate for the reduced tidal volume.)

Radius	Flow (ml/min)	TV	ERV	IRV	RV	VC	FEV_1	TLC	Breath Rate
5.00	7500	500	1200	3091	1200	4791	3541	5991	15
4.50	4920	328	787	2028	1613	3143	2303	4756	15
4.00	3075	205	492	1266	1908	1962	1422	3871	15
3.50	1800	120	288	742	2112	1150	822	3262	15

Activity 2: Comparative Spirometry

- **Experiment:** Spirometry (respiratory volume and flow measurements) were performed on several subjects under different conditions: normal, emphysema, asthma, inhaler-treated asthma, and moderate and heavy exercise.
- **Prediction:** Answers will vary.
- **Results:** Data are below. Both emphysema and asthma show several altered volumes, including reduced FEV_1. Exercise causes increases in both tidal volume and breath rate (not shown) increase, resulting in a greatly increased minute ventilation.
- **Conclusion:** Both emphysema and asthma show some characteristics of restrictive disease, such as low FEV_1. Minute ventilation during exercise increases greatly due to increases in both tidal volume and breath rate.

Patient Type	TV	ERV	IRV	RV	FVC	TLC	FEV_1	FEV_1 (%)
Heavy Exercise	3650	750	600	1000	no data	6000	no data	no data
Moderate Exercise	1875	1125	2000	1000	no data	6000	no data	no data
Asthma Attack Plus Inhaler	500	1500	2800	1200	4800	6000	3840	80%
Acute Asthma Attack	300	750	2700	2250	3750	6000	1500	40%
Emphysema	500	750	2000	2750	3250	6000	1625	50%
Normal	500	1500	3000	1000	5000	6000	4000	80%

Activity 3: Effect of Surfactant and Intrapleural Pressure on Respiration

- **Experiment:** This experiment was similar to that of Activity 1, except that the amount of surfactant coating the lungs was varied, and also the left cavity was opened up to the outside at one point.
- **Prediction:** Answers will vary.
- **Results:** Adding surfactant to the lungs increased tidal volume and total flow rates, as shown in the data below. (Flows are less for a surfactant level of 0 than for a surfactant level of 2. Flows are even higher at a surfactant level of 4.) Opening the left cavity to the outside changed the left-side pressure to 0 atms and collapsed the left lung so that no ventilation could occur on the left side (flow = 0 for that side).
- **Conclusion:** Surfactant reduces surface tension and thus helps the lungs inflate. A lack of surfactant is one cause of restrictive lung disease. Prematurely born infants sometimes have this problem. The equilibration of one pleural cavity with the atmosphere was a simulation of what happens when there is, for example, a knife or gunshot wound that penetrates the thoracic cavity. The lung collapses, a condition called pneumothorax.

Airway Radius	Breath Rate (breath/min)	Surfactant	Pressure Left (atms)	Pressure Right (atms)	Flow Left (ml/min)	Flow Right (ml/min)	Total Flow (ml/min)
5	15	2	-4.00	-4.00	69.56	69.56	139.13
5	15	4	-4.00	-4.00	89.44	89.44	178.88
5	15	0	-4.00	-4.00	49.69	49.69	99.38
5	15	0	0.00	-4.00	0.00	49.69	49.69