Physiologie respiratoire

Dr Géradon Pierre

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THERE'S NO SUCH THING AS "I DON'T HAVE TIME" - YOU JUST SIMPLY NEED TO PRIORITIZE BETTER.
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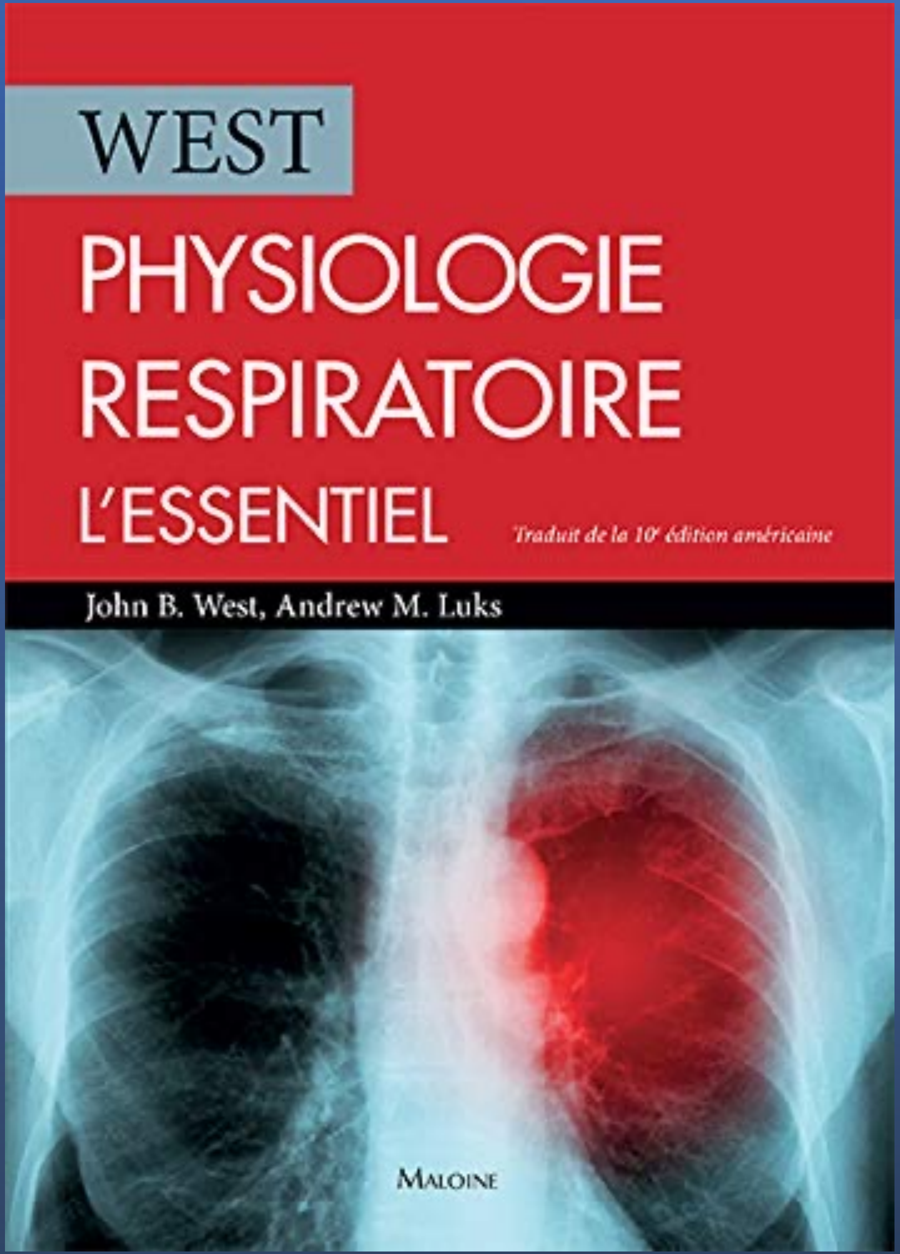
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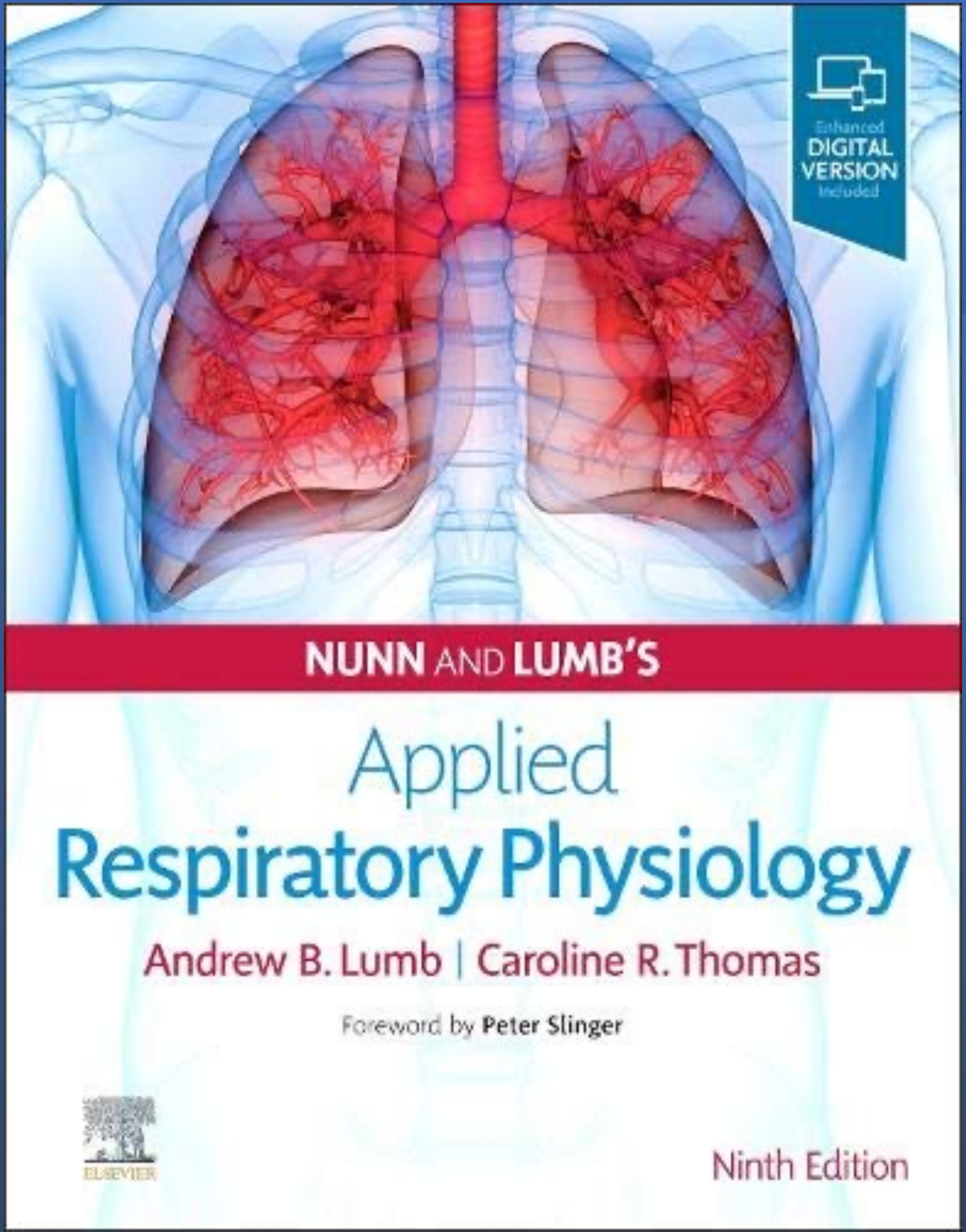
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NUNN AND LUMB'S
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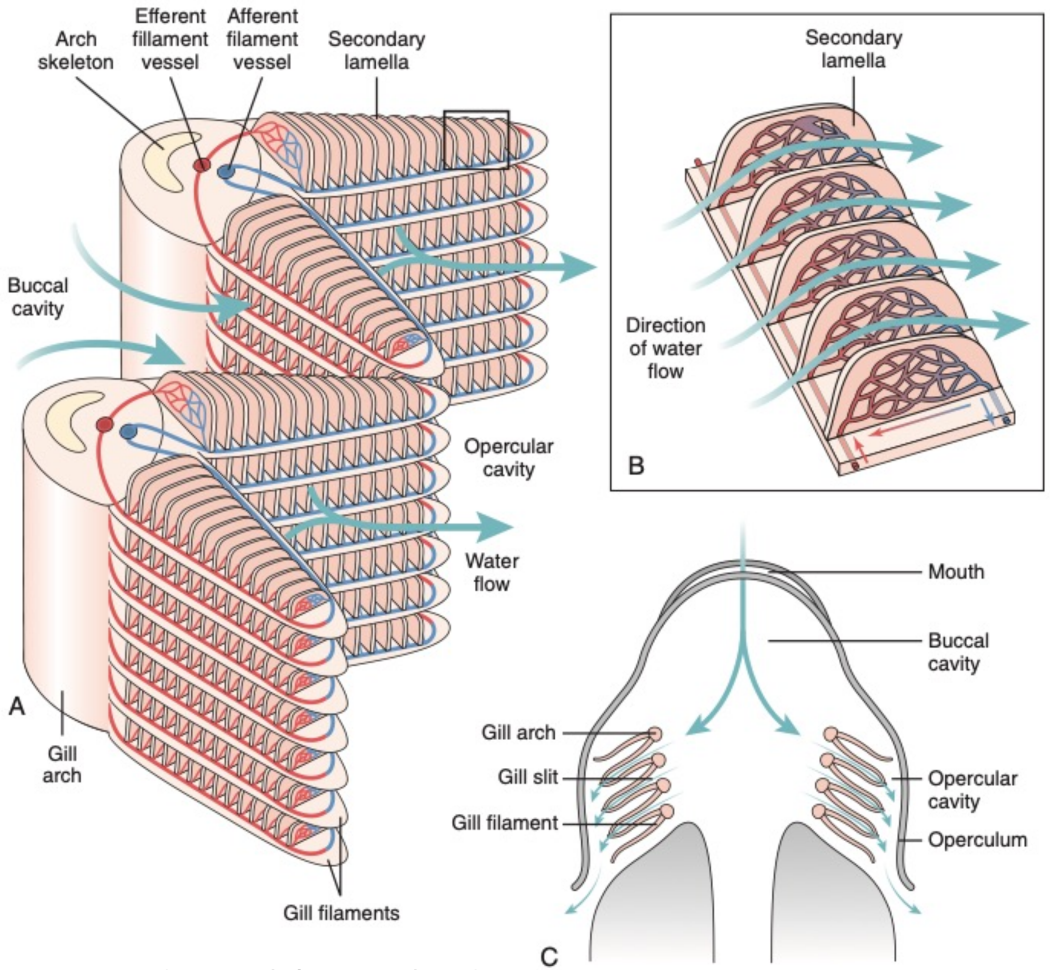
CHAPTER 25

Comparative Respiratory Physiology

Coauthor Katherine Lumb BVSc MSc MRCVS



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Distribution et relation ventilation-perfusion

Dr Géradon Pierre

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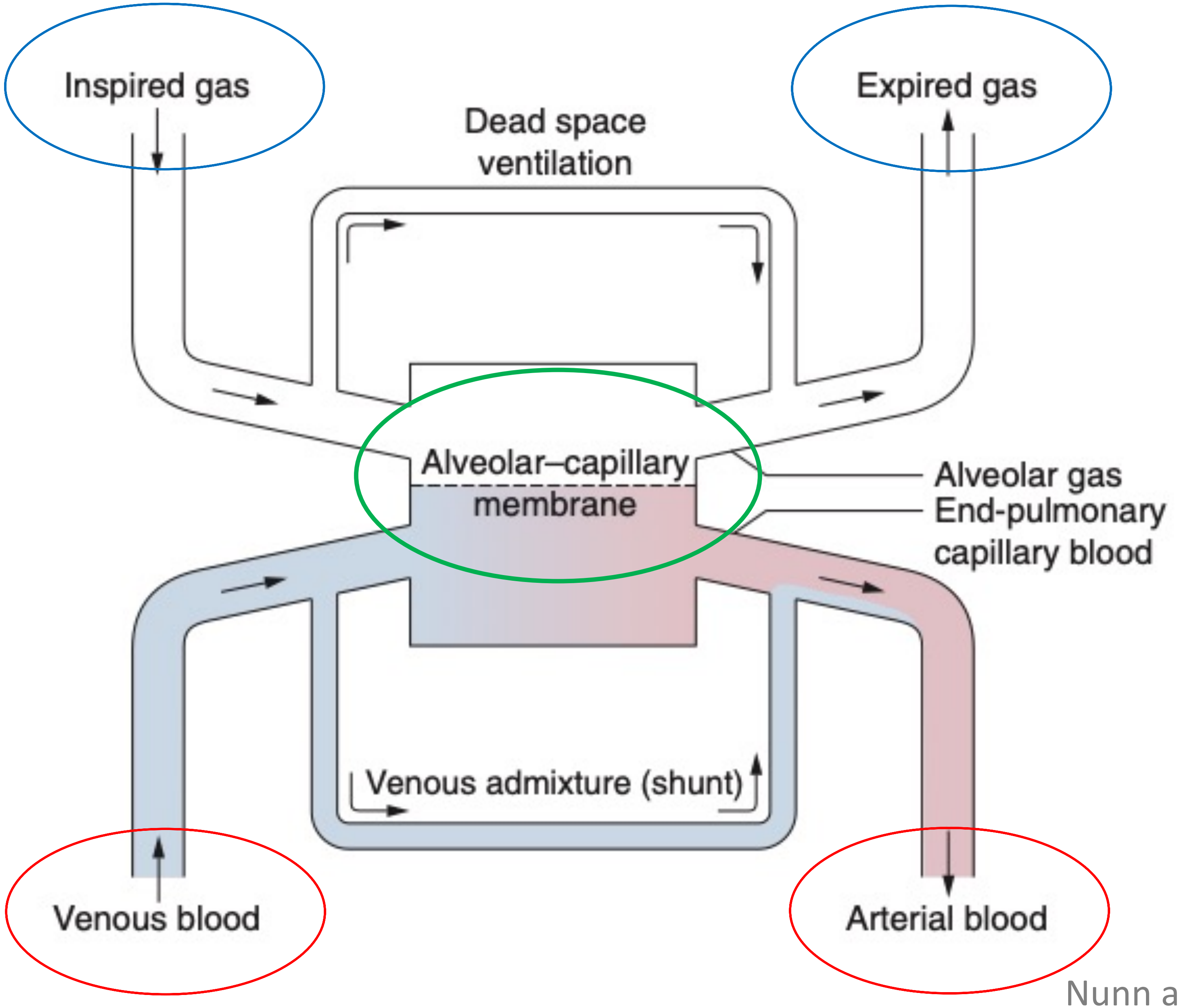
Points clés

La ventilation ainsi que la perfusion sont distribués préférentiellement dans les régions dépendantes du poumon, résultant de la gravité et variant avec la posture

Dans un poumon sain, la ventilation et la perfusion sont étroitement liés avec quelques variations du ratio ventilation/perfusion selon les différentes régions du poumon (zones de West).

Un ratio V/Q = 0 représente un shunt intrapulmonaire (sang veineux mêlé)

Un ratio V/Q = ∞ contribue à l’espace mort alvéolaire



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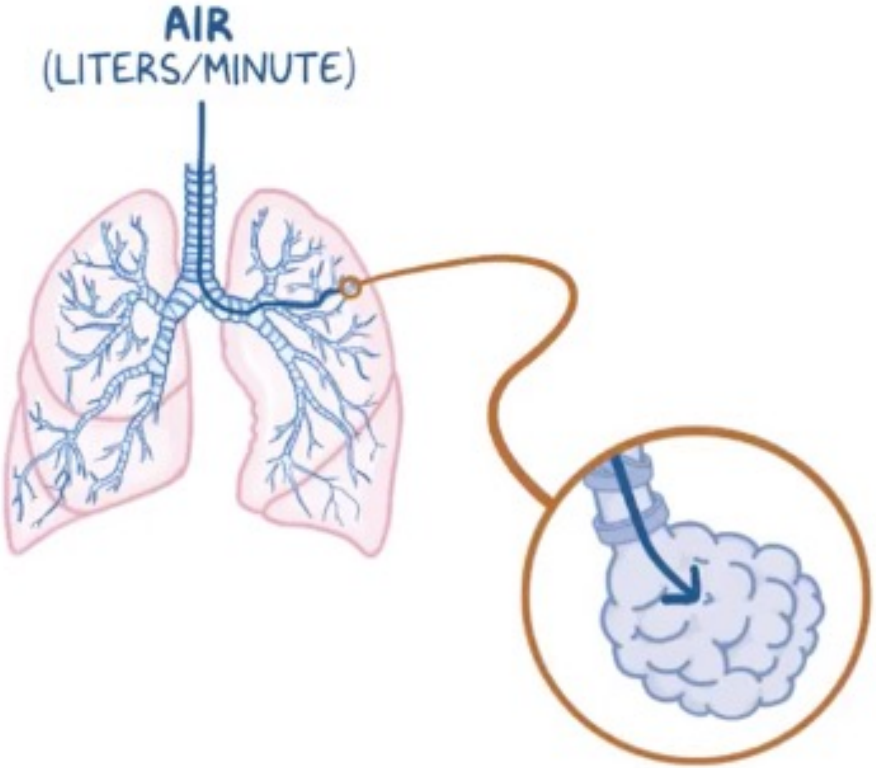
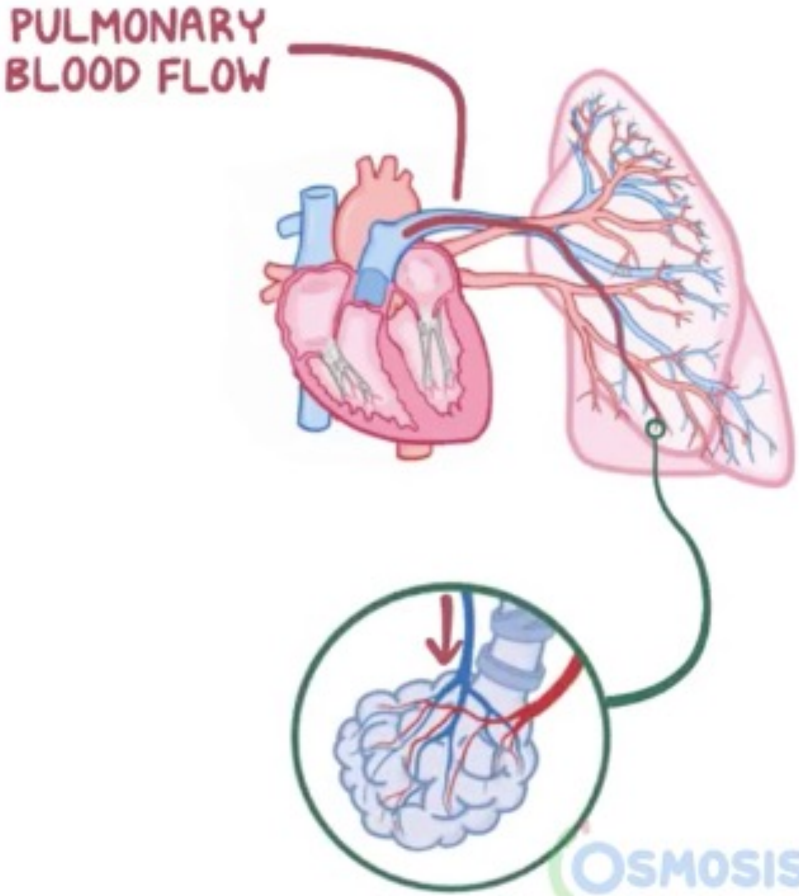
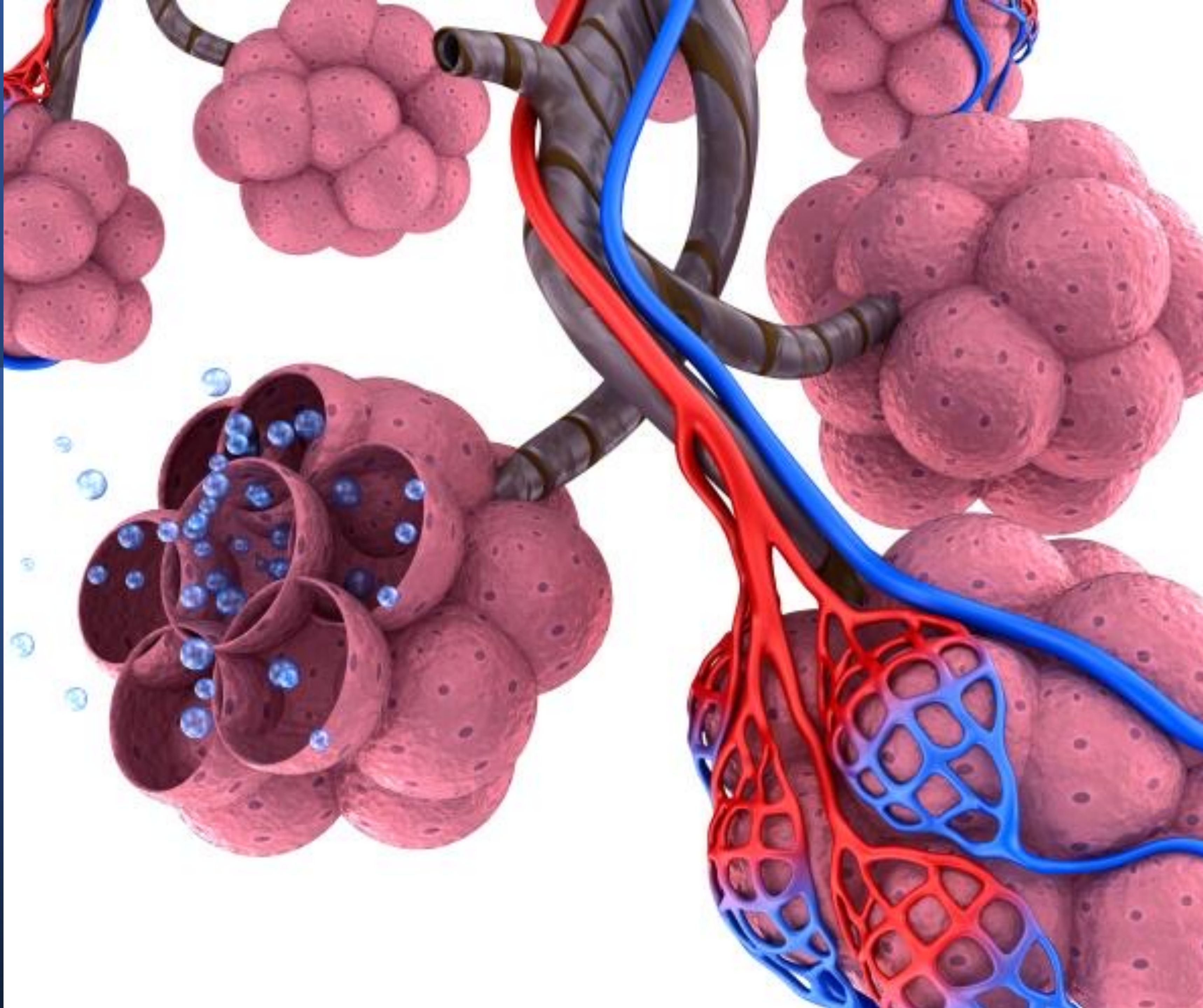
ALVEOLAR VENTILATION (V)



PERFUSION (Q)



Distribution de la ventilation



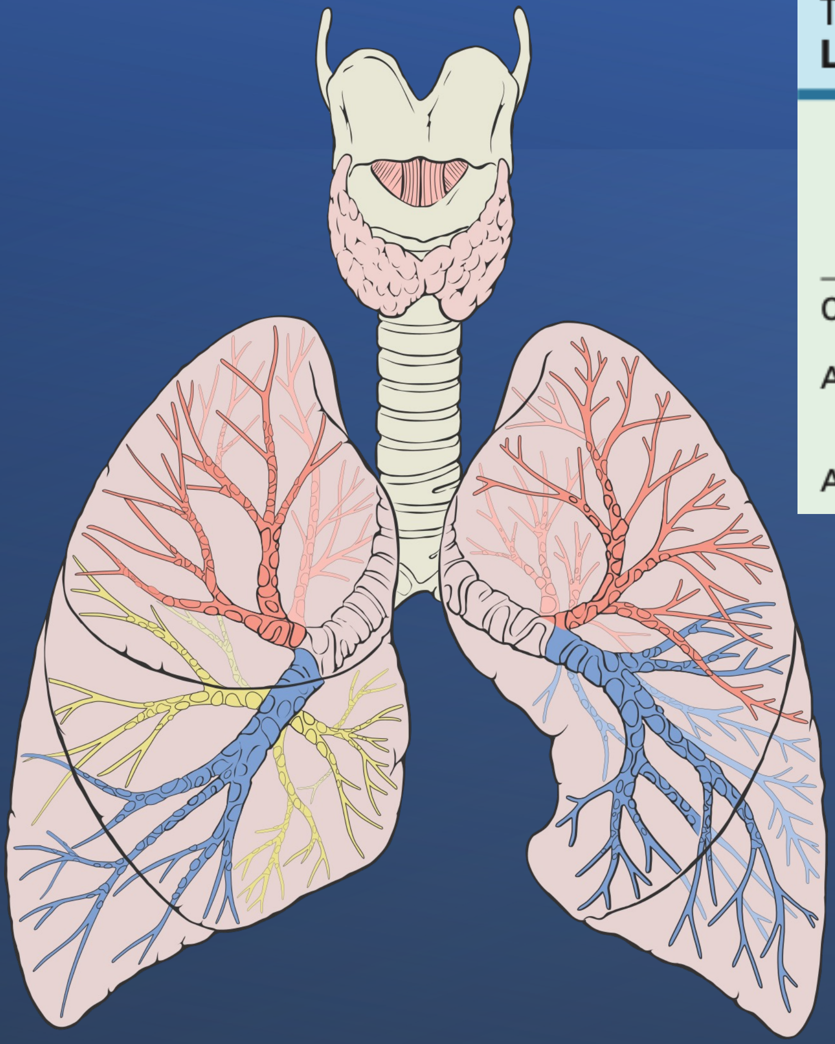


TABLE 7.1 Distribution of Resting Lung Volume (FRC) and Ventilation between the Two Lungs in Humans

	Supine		Right Lateral (Left Side Up)		Left Lateral (Right Side Up)	
	RIGHT LUNG	LEFT LUNG	RIGHT LUNG	LEFT LUNG	RIGHT LUNG	LEFT LUNG
Conscious[1]	1.69	1.39	1.68	2.07	2.19	1.38
	53%	47%	61%	39%	47%	53%
Anaesthetized artificial ventilation[3]	1.36	1.16	1.33	2.21	2.29	1.12
	52%	48%	44%	56%	60%	40%
					—	—
Anaesthetized thoracotomy[4]					83%	17%

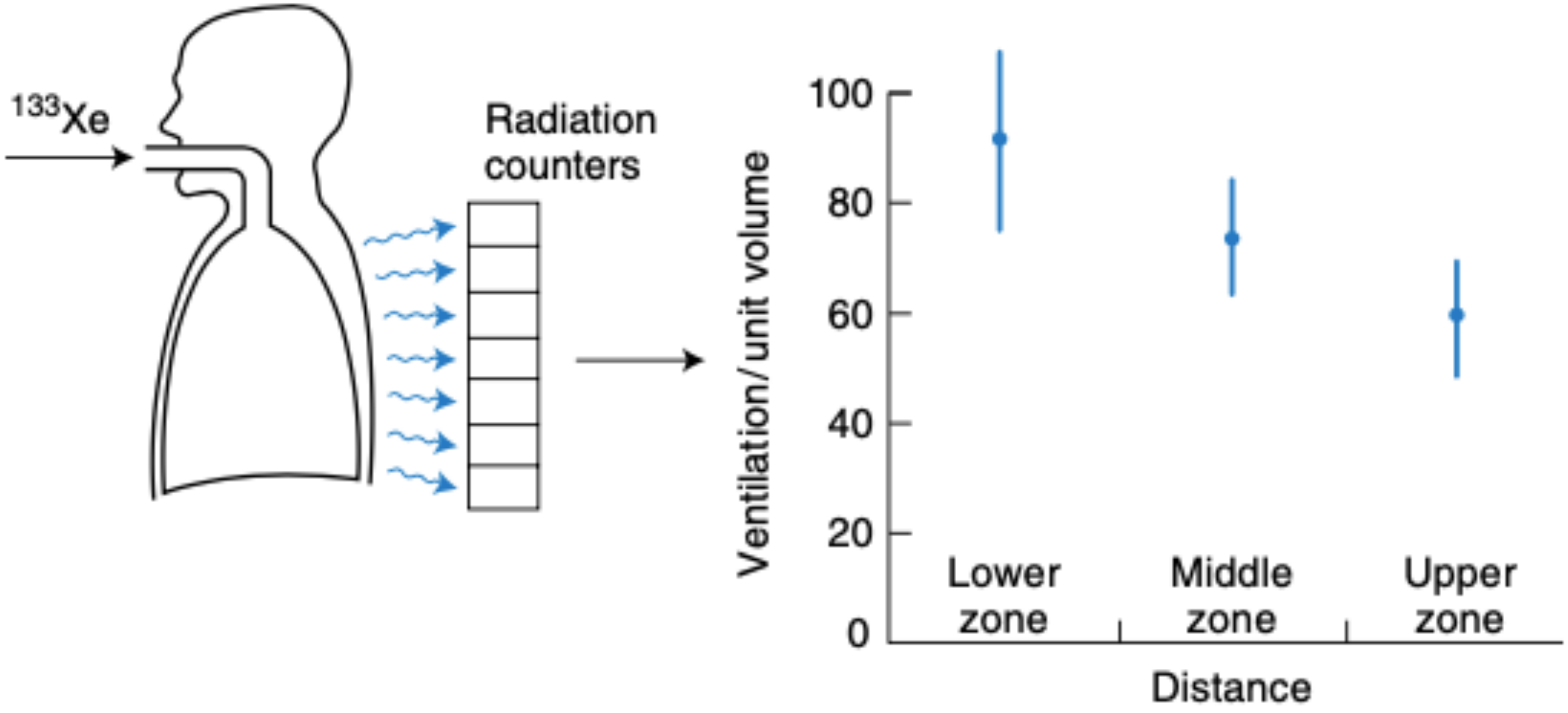


Figure 2.7. Measurement of regional differences in ventilation with radioactive xenon. When the gas is inhaled, its radiation can be detected by counters outside the chest. Note that the ventilation decreases from the lower to upper regions of the upright lung.

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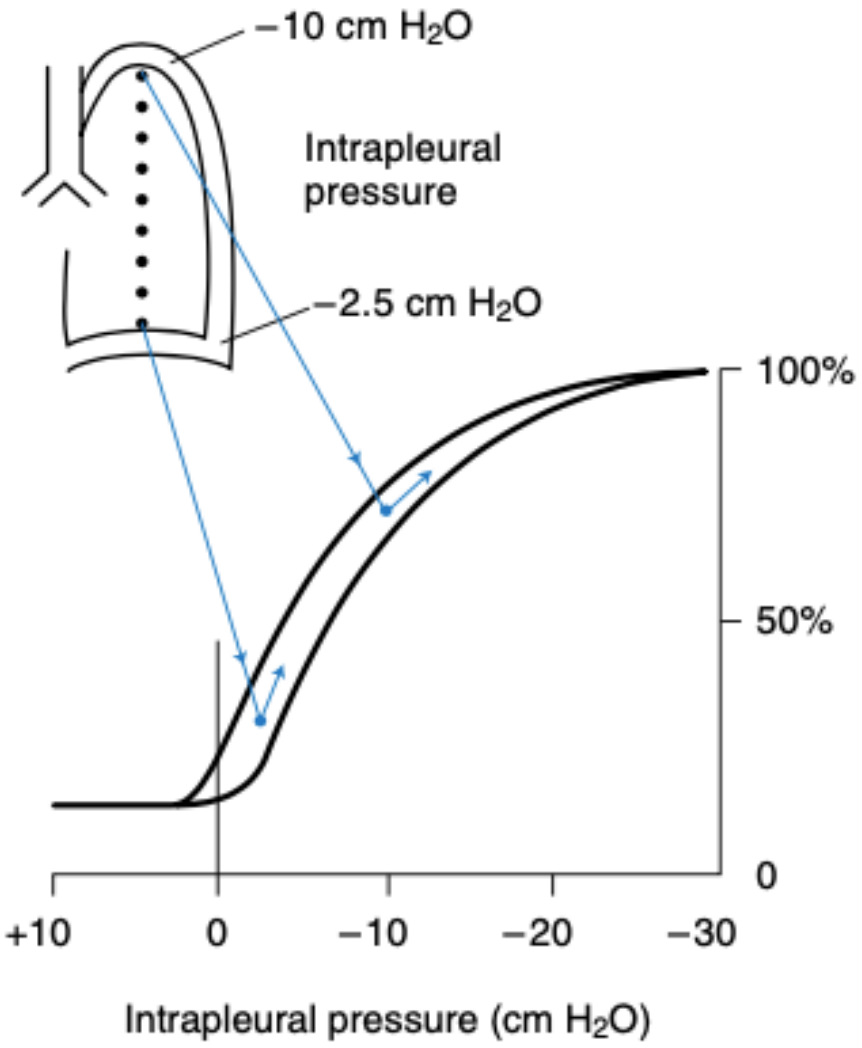

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Figure 7.8. Explanation of the regional differences of ventilation down the lung. Because of the weight of the lung, the intrapleural pressure is less negative at the base than at the apex. As a consequence, the basal lung is relatively compressed in its resting state but expands more on inspiration than does the apex.

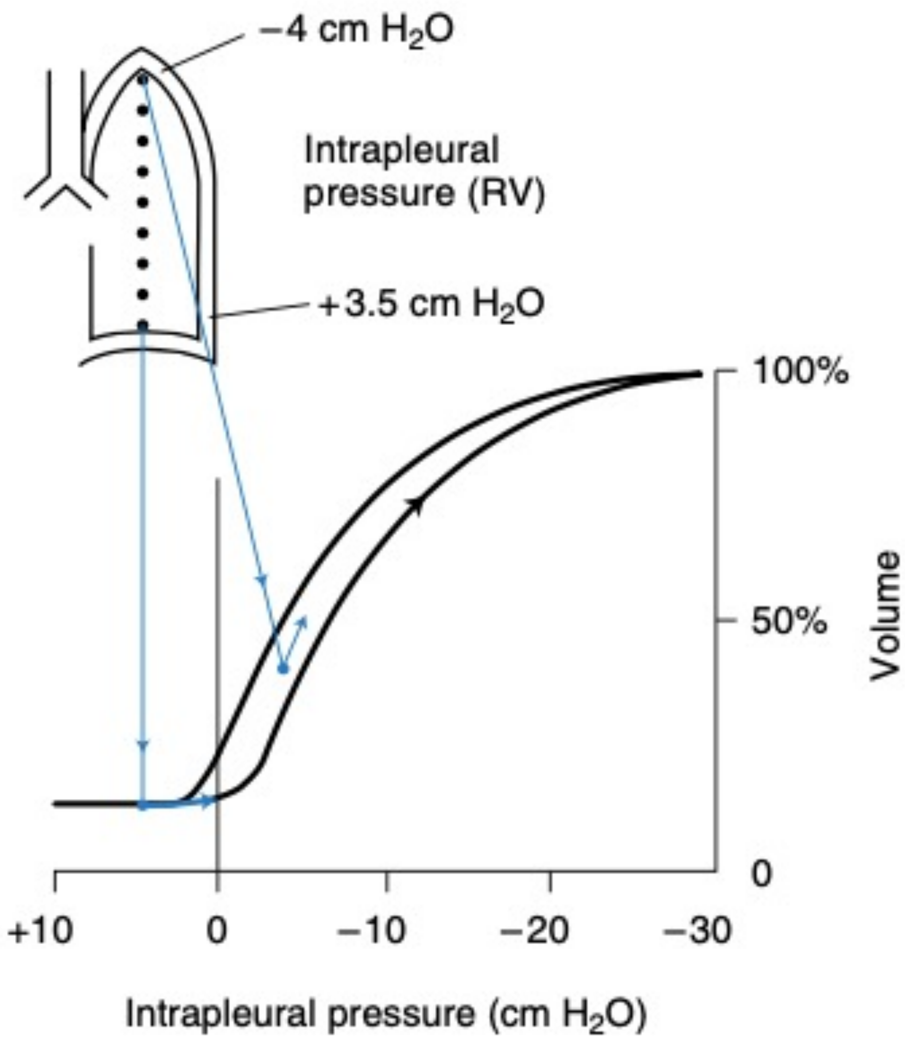

Figure 7.9. Situation at very low lung volumes. Now intrapleural pressures are less negative, and the pressure at the base actually exceeds airway (atmospheric) pressure. As a consequence, airway closure occurs in this region, and no gas enters with small inspirations.

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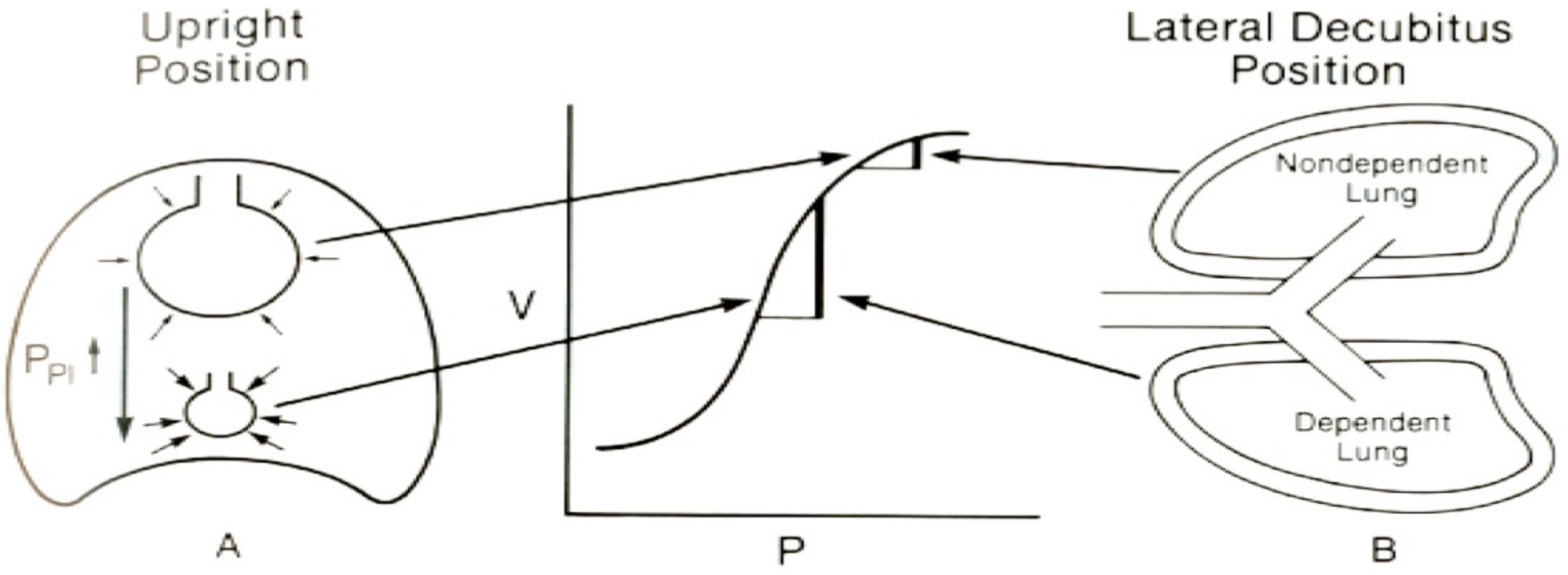

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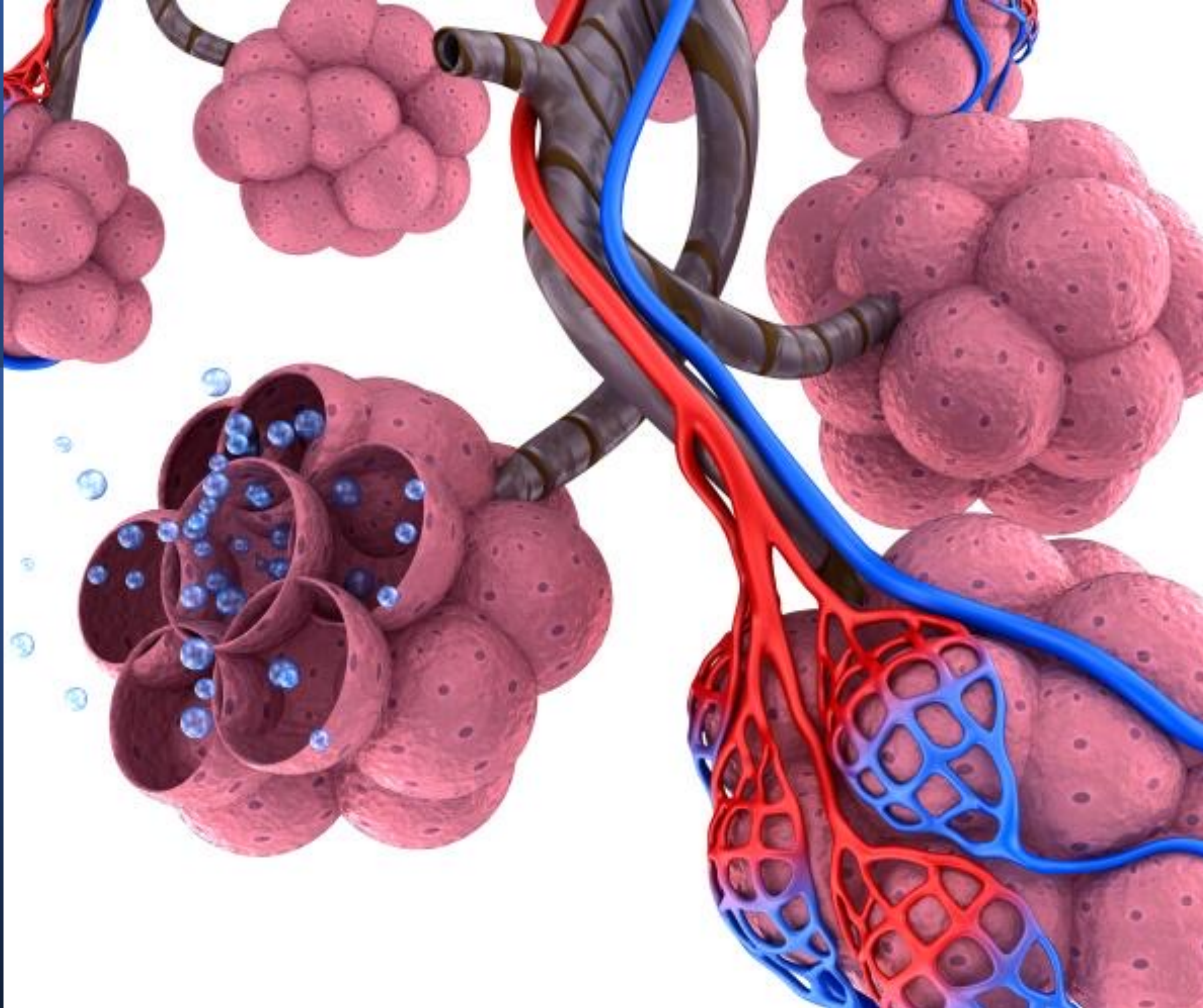
Distribution de la perfusion



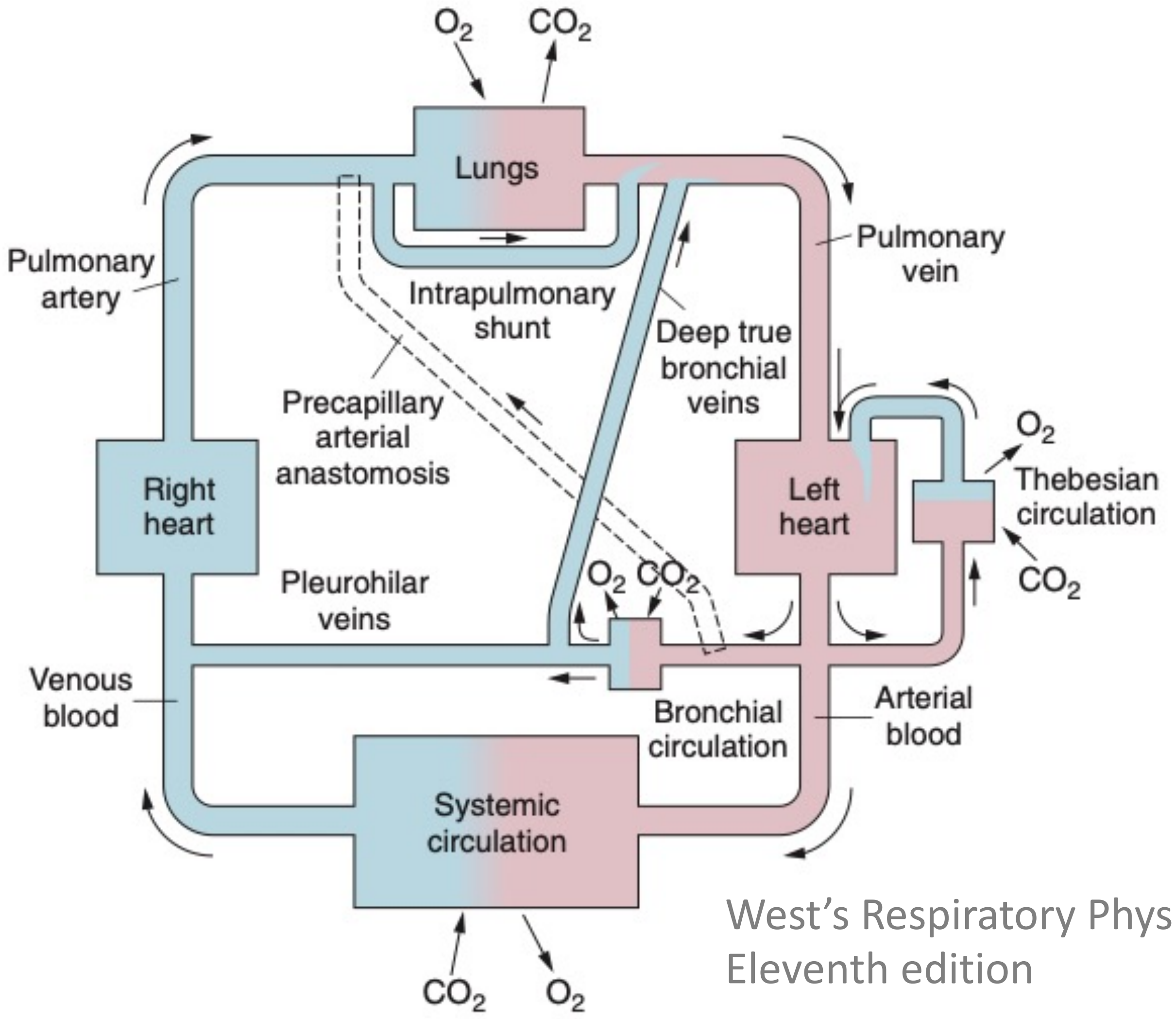


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FIG. 6.1 ■ Schema of bronchopulmonary anastomoses and other forms of venous admixture in a normal subject. Part of the bronchial circulation returns venous blood to the systemic venous system while another part returns venous blood to the pulmonary veins constituting venous admixture. Other forms of venous admixture are the Thebesian circulation of the left heart and flow through atelectatic parts of the lungs. It is clear from this diagram why the output of the left heart must be slightly greater than that of the right heart.

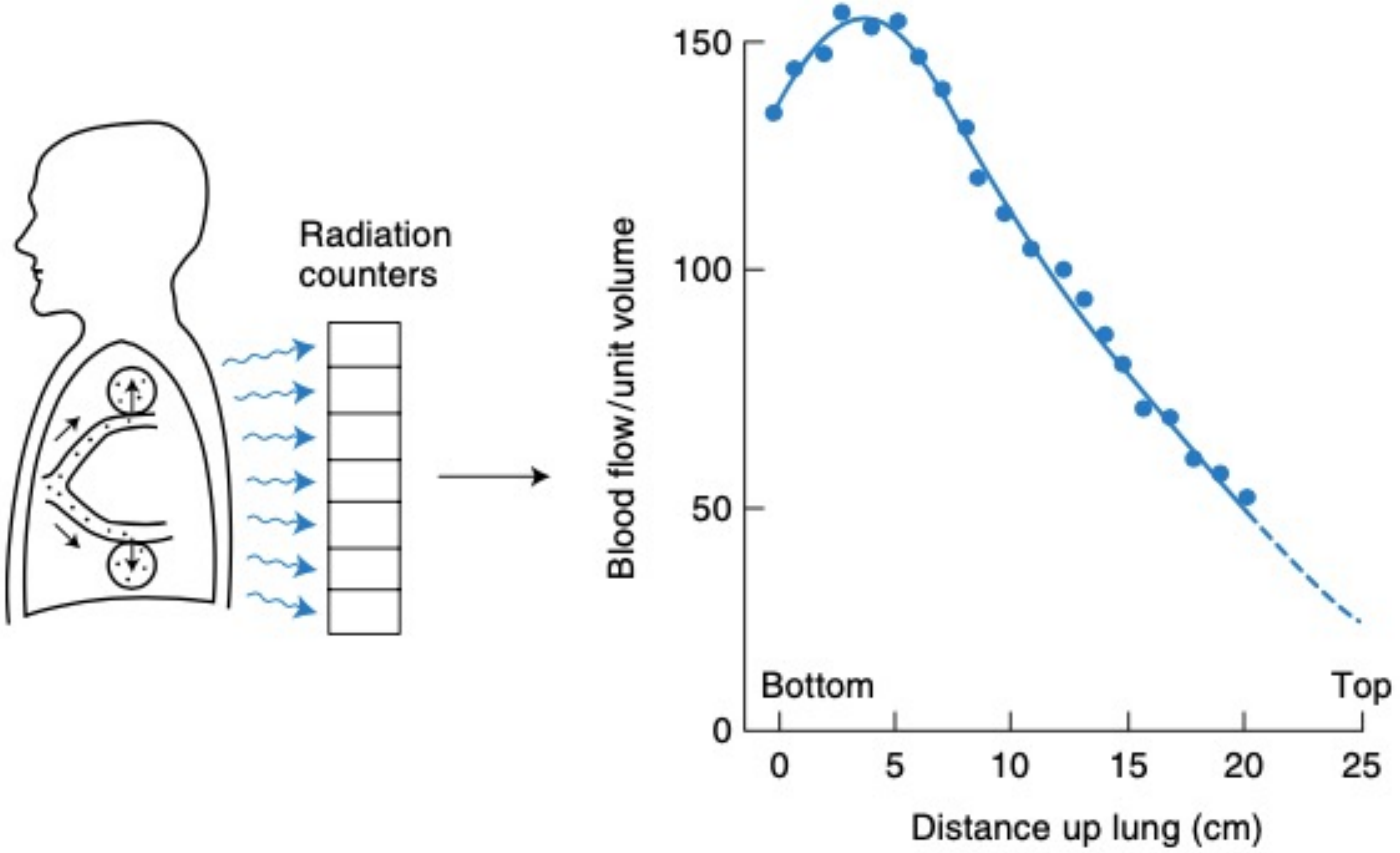

Figure 4.7. Measurement of the distribution of blood flow in the upright human lung, using radioactive xenon. The dissolved xenon is evolved into alveolar gas from the pulmonary capillaries. The units of blood flow are such that if flow were uniform, all values would be 100. Note the small flow at the apex.

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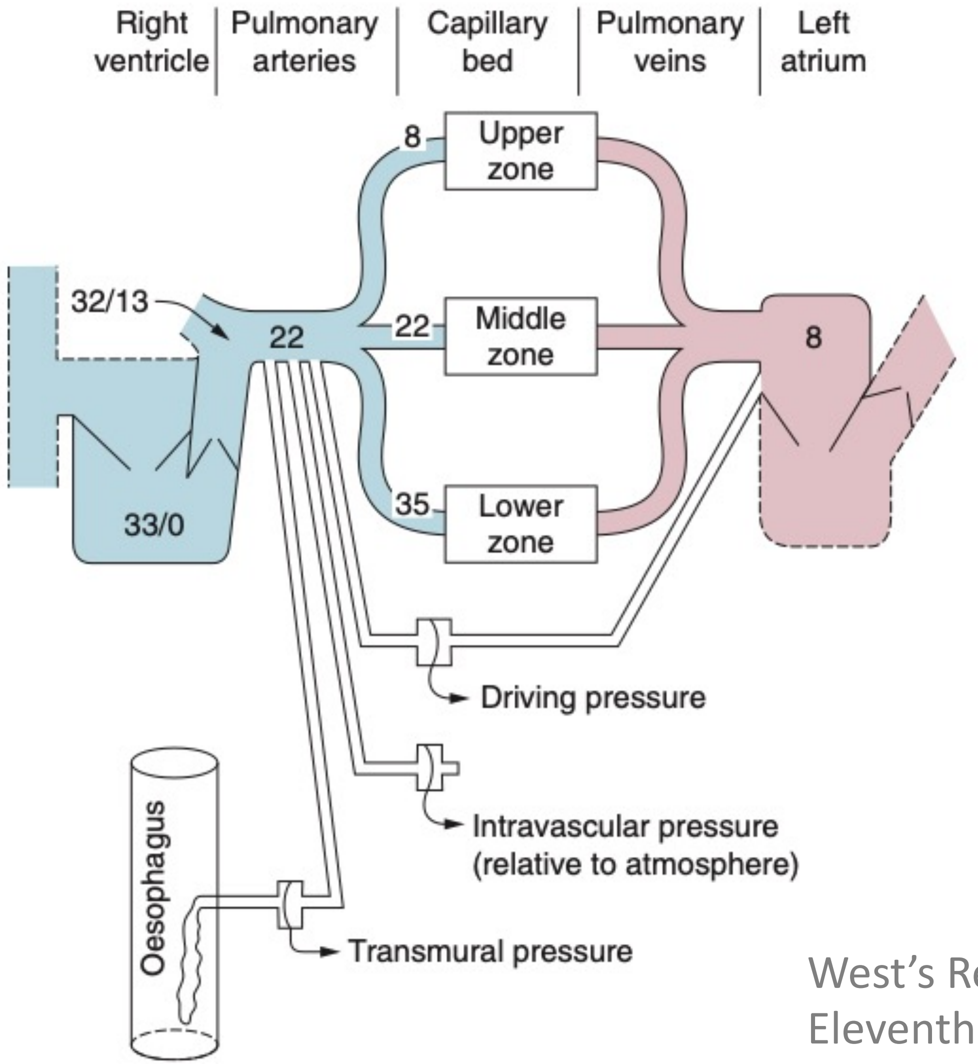

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FIG. 6.3 Normal values for pressures in the pulmonary circulation relative to atmospheric pressure (cmH_2O). Systolic and diastolic pressures are shown for the right ventricle and pulmonary trunk and mean pressures elsewhere. Note the effect of gravity on pressures at different levels in the lung fields. Three different manometers are shown connected to indicate driving pressure, intravascular pressure and transmural pressure.

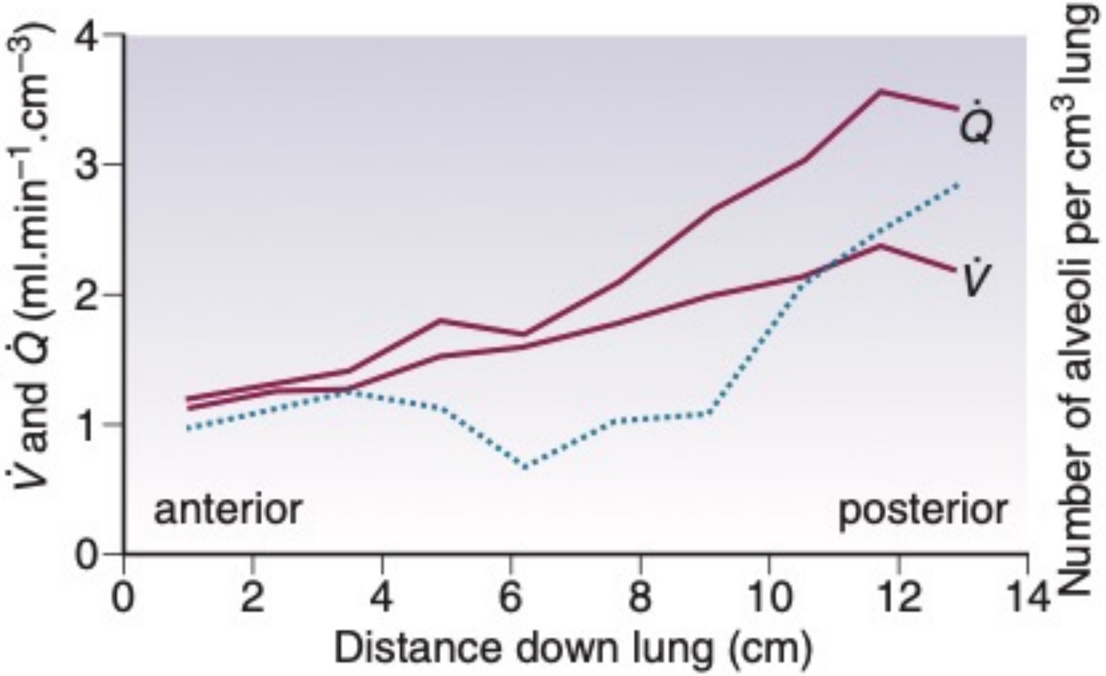

FIG. 7.4 Vertical gradients in ventilation and perfusion in the supine position. Data are mean results from PET scans of eight subjects during normal breathing, and for each vertical level represent the average value for a horizontal slice of lung. The solid lines relate to the left ordinate and are ventilation (*$\dot{V}$*) and perfusion (*$\dot{Q}$*) per cubic centimetre of lung tissue. Ventilation and perfusion both increase on descending through the lung. The dotted line relates to the right ordinate and represents the number of alveoli per unit lung volume, which increases in dependent areas such that the blood flow *per alveolus* remains fairly constant. (After references 9 and 10.)

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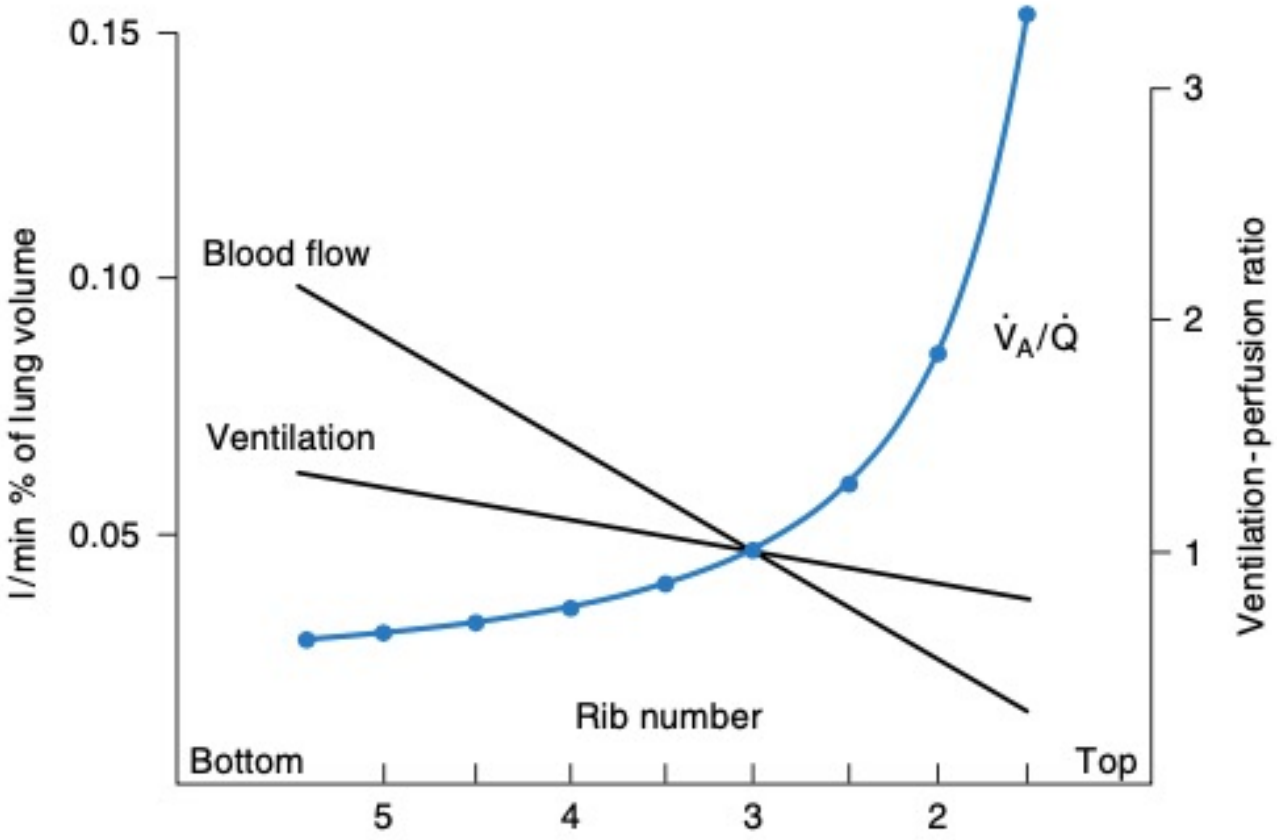

Figure 5.9. Distribution of ventilation and blood flow down the upright lung (compare Figures 2.7 and 4.7). Note that the ventilation-perfusion ratio decreases down the lung.

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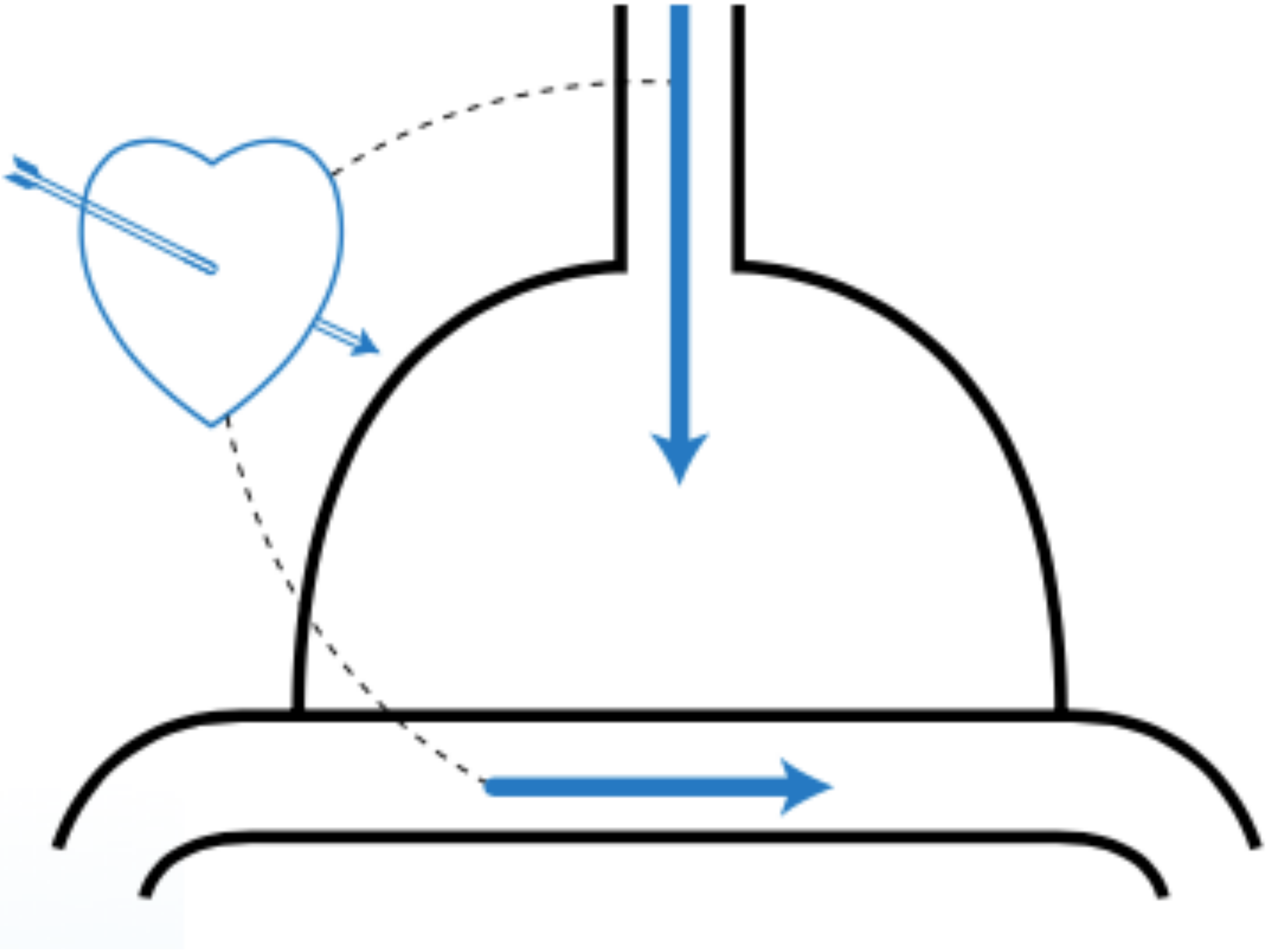
Relation ventilation-perfusion



Zones de west

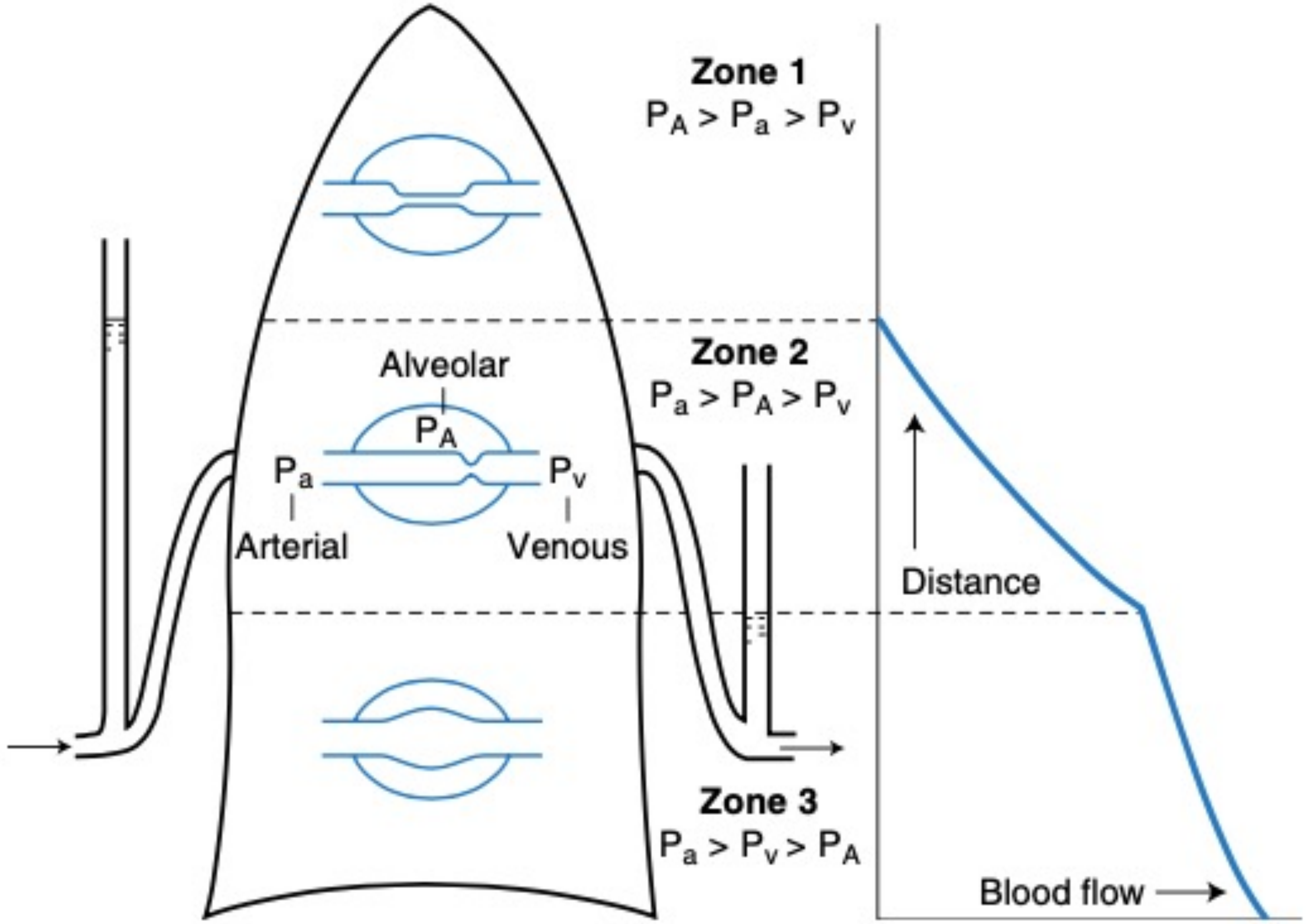


Figure 4.8. Explanation of the uneven distribution of blood flow in the lung, based on the pressures affecting the capillaries. See text for details.

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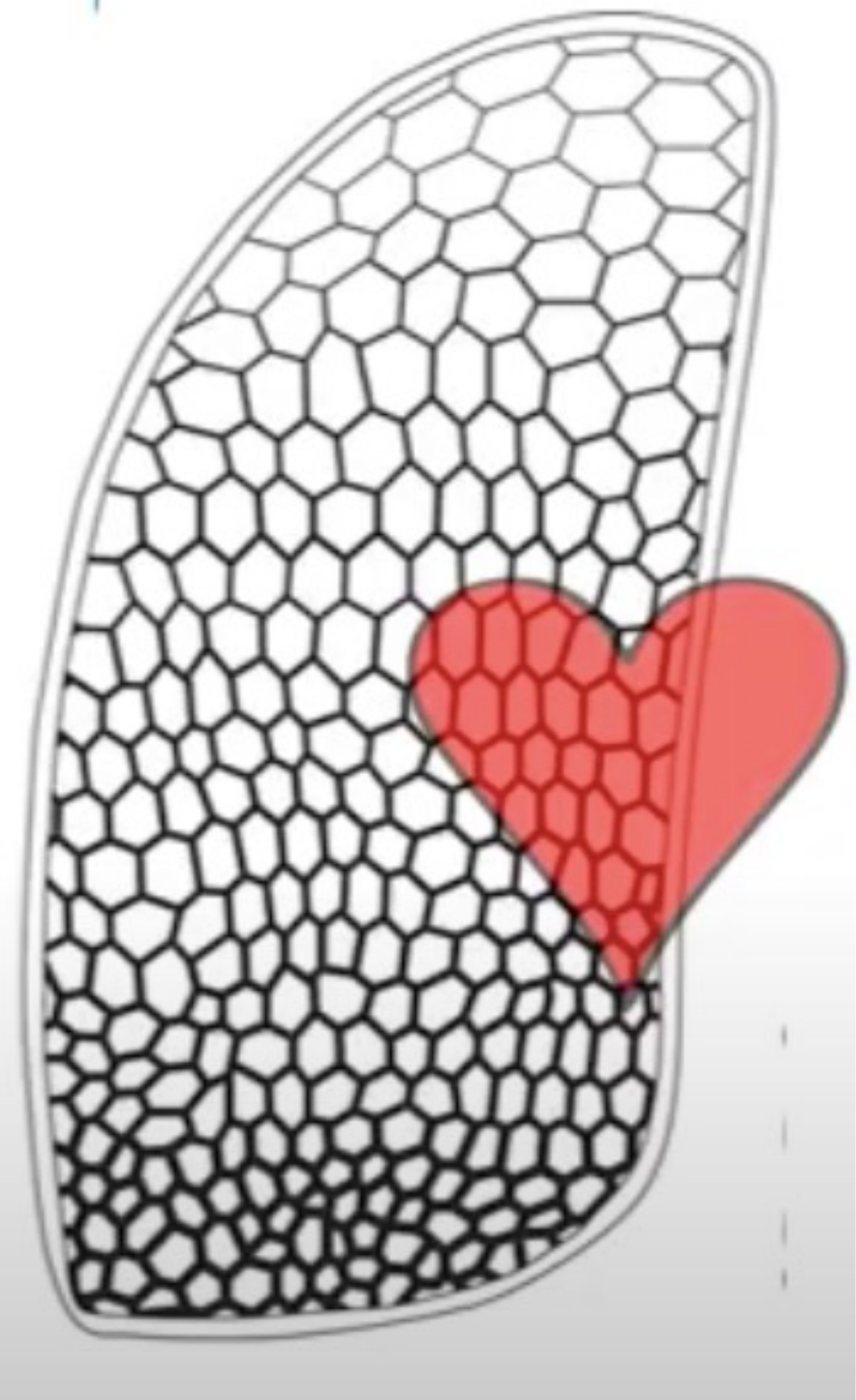

	Ventilation	Perfusion
Zone 1	Ventilation pauvre Ppl plus négative Alvéoles plus larges Compliance moindre	Faible débit (espace mort)
Zone 2	Ventilation normale	Débit normal
Zone 3	Ventilation haute Alvéoles plus petites Meilleure compliance	Haut débit

Ratio V/Q

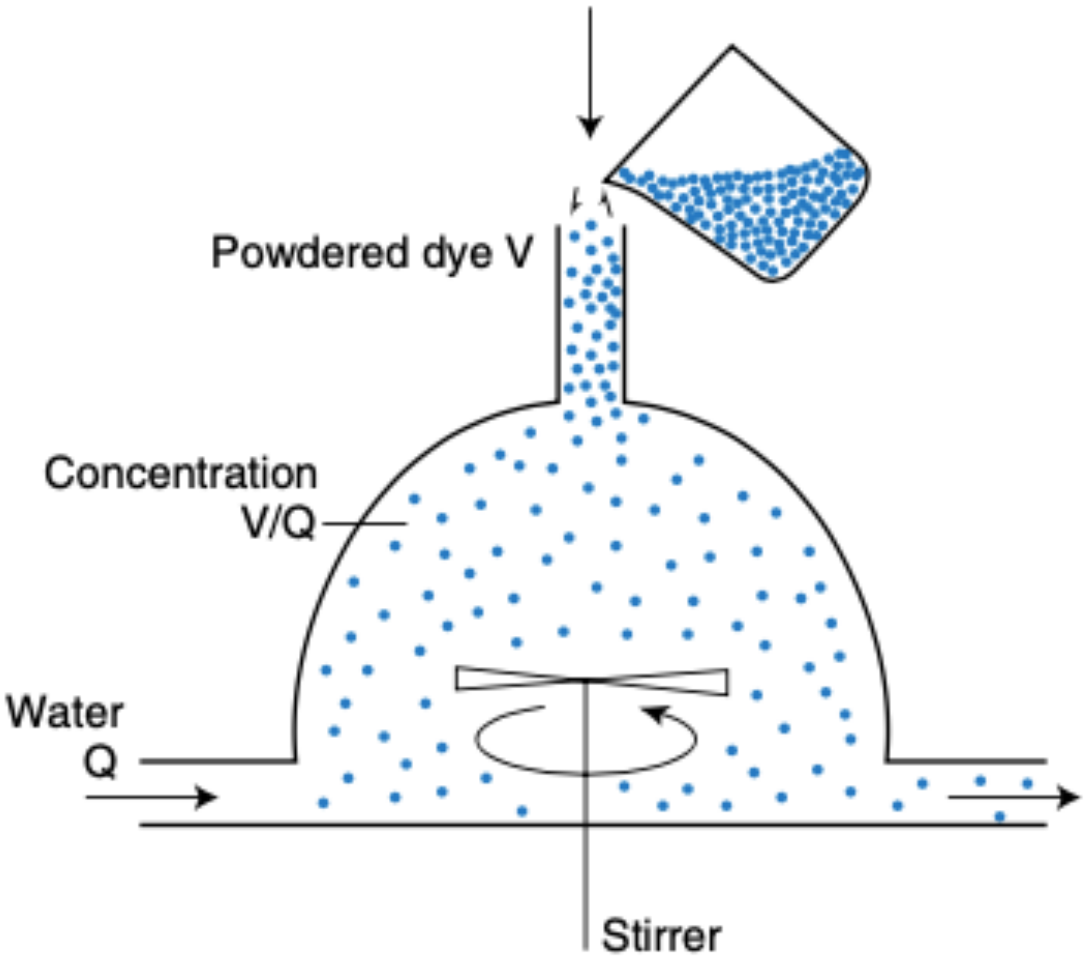

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Figure 5.6. Model to illustrate how the ventilation-perfusion ratio determines the PO_2 in a lung unit. Powdered dye is added by ventilation at the rate V and removed by blood flow Q to represent the factors controlling alveolar PO_2. The concentration of dye is given by V/Q.

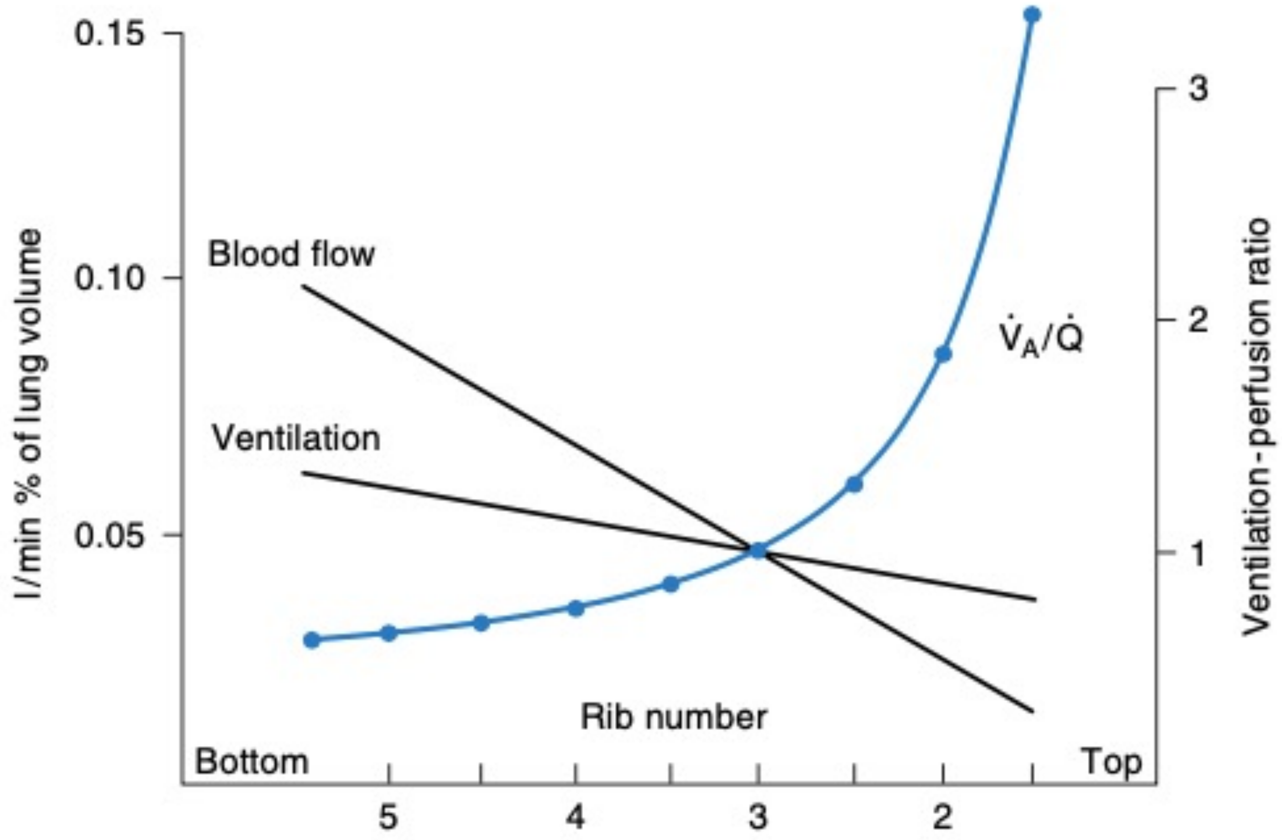

Figure 5.9. Distribution of ventilation and blood flow down the upright lung (compare Figures 2.7 and 4.7). Note that the ventilation-perfusion ratio decreases down the lung.

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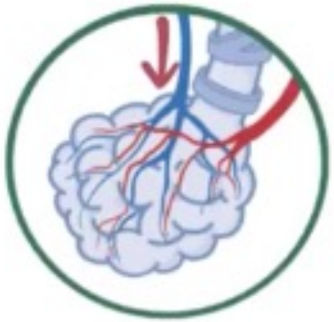
ALVEOLAR VENTILATION (V)

PERFUSION (Q)



when the LUNGS are UPRIGHT & at REST:

$$\frac{V = 4\ L/min}{Q = 5\ L/min} = 0.8\ ratio$$

Vol (%)	$\dot{V}_A$ (l/min)	$\dot{Q}$ (l/min)	$\dot{V}_A/\dot{Q}$	P_{O_2} (mm Hg)	P_{CO_2} (mm Hg)	P_{N_2} (mm Hg)	O_2 conc. (ml/100 ml)	CO_2 conc. (ml/100 ml)	pH	O_2 in (ml/min)	CO_2 out (ml/min)
7	.24	.07	3.3	132	28	553	20.0	42	7.51	4	8
13	.82	1.29	0.63	89	42	582	19.2	49	7.39	60	39

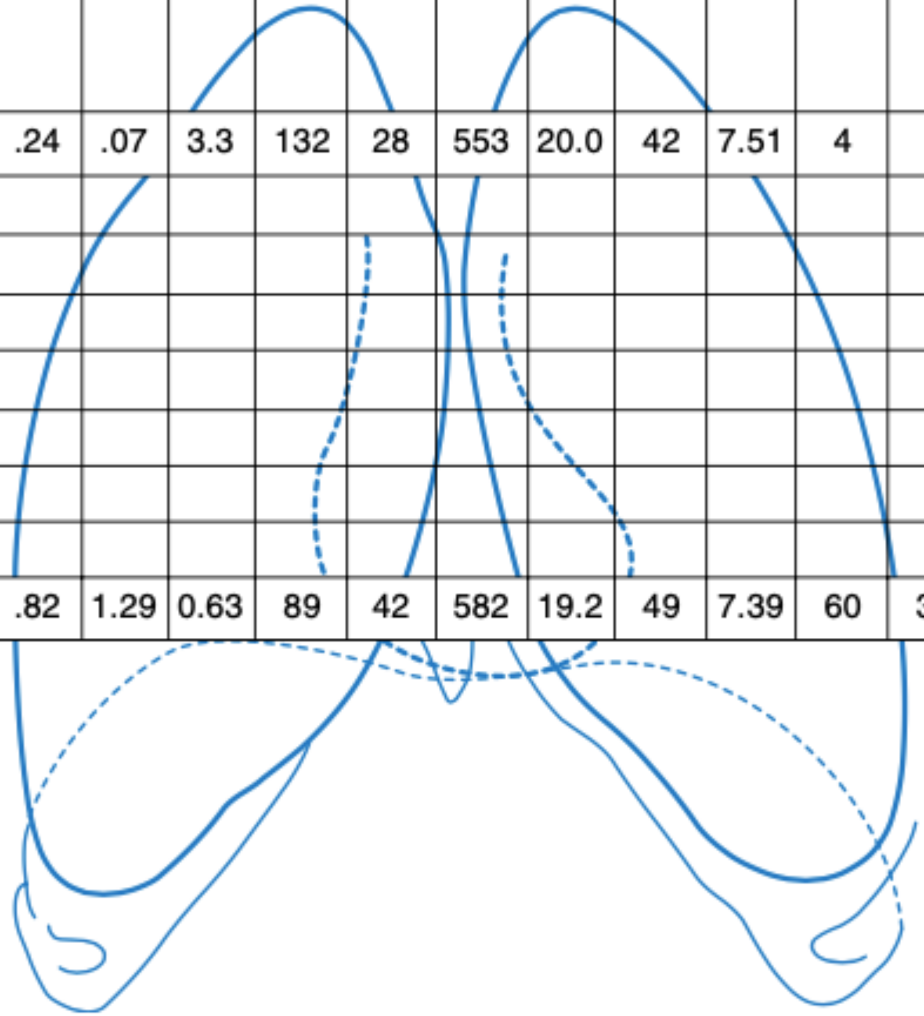


Figure 5.11. Regional differences in gas exchange down the normal lung. Only the apical and basal values are shown for clarity.

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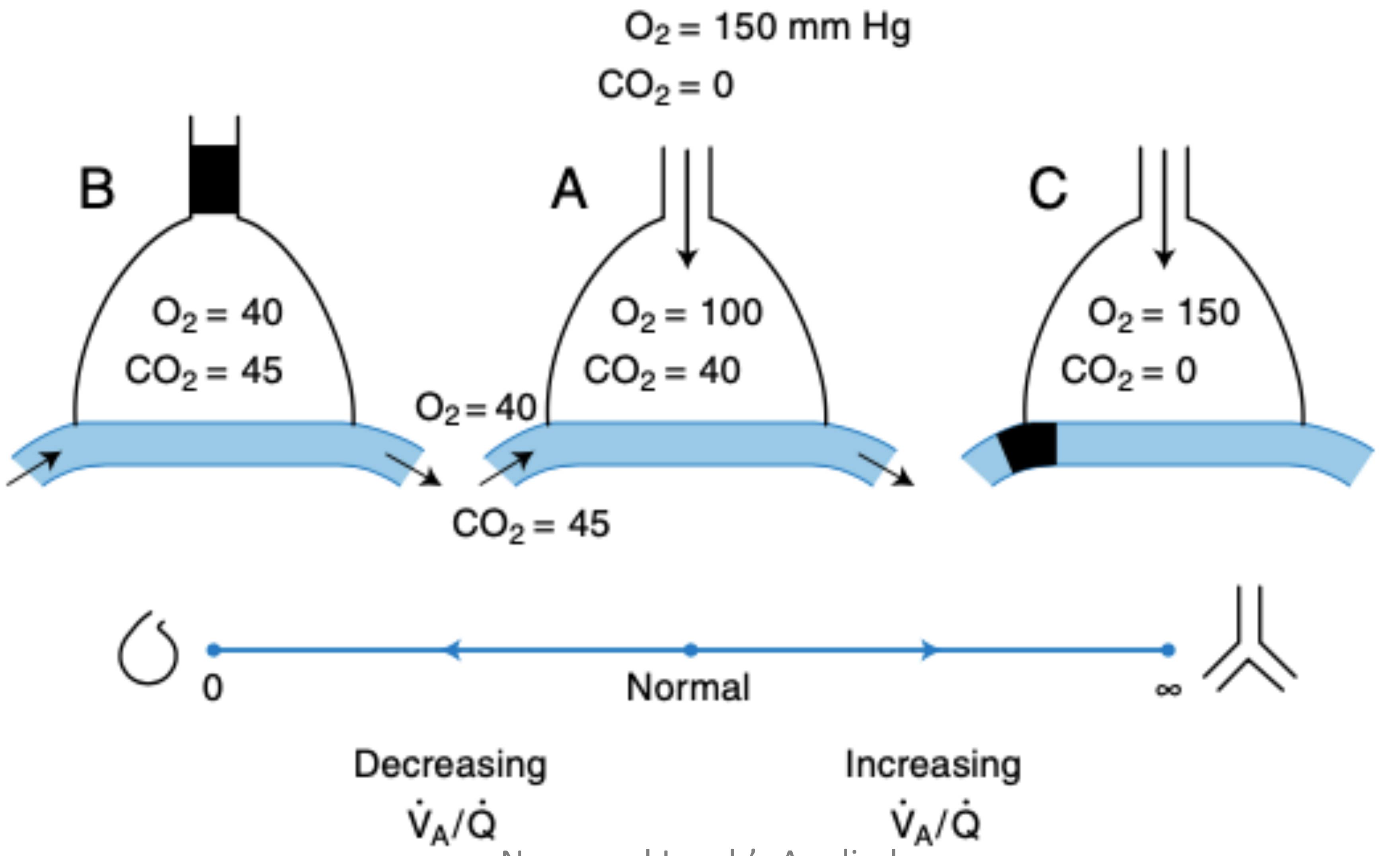

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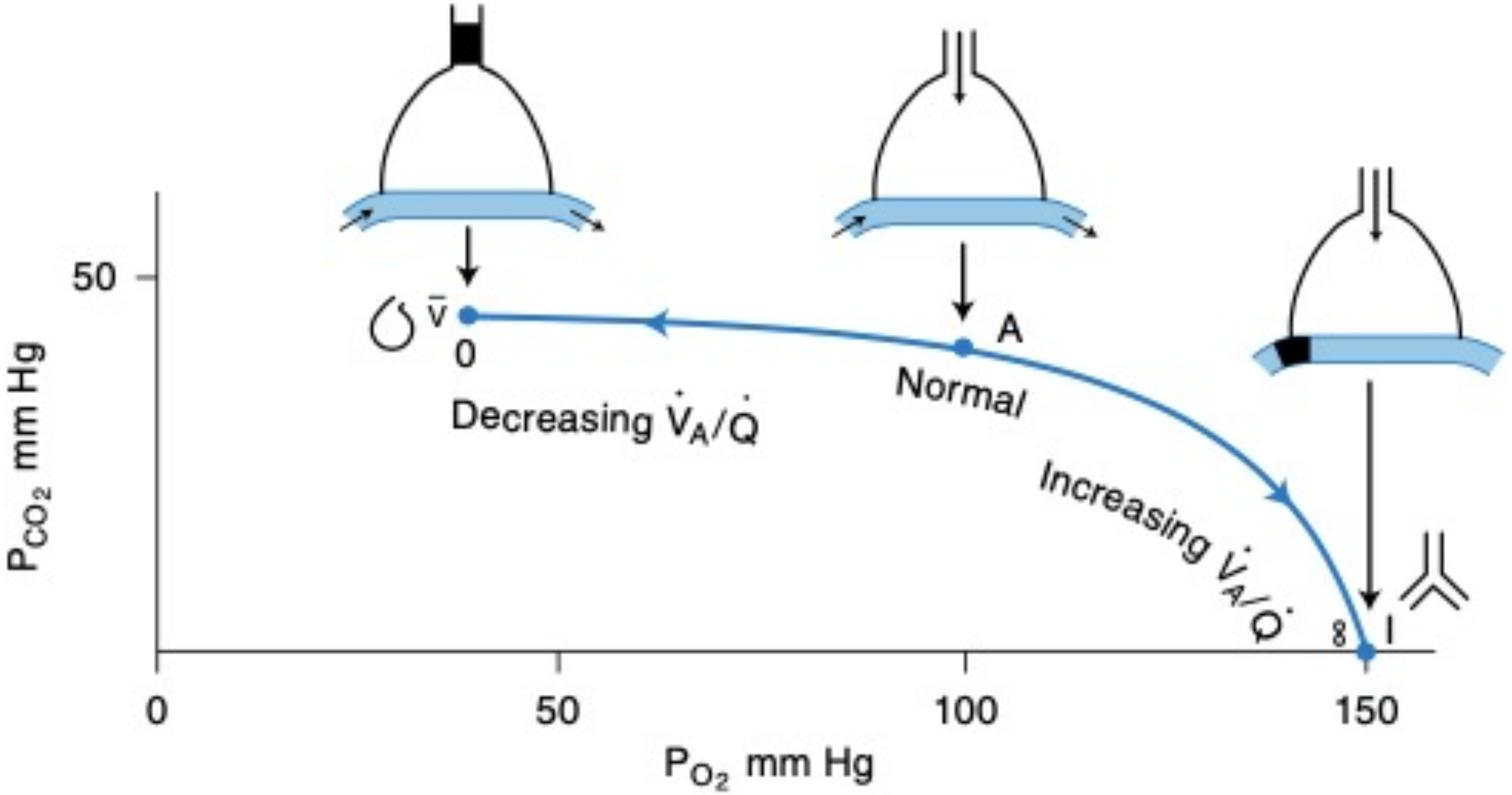

Figure 5.8. O_2-CO_2 diagram showing a ventilation-perfusion ratio line. The P_{O_2} and P_{CO_2} of a lung unit move along this line from the mixed venous point to the inspired gas point I as the ventilation-perfusion ratio is increased (compare Figure 5.7).

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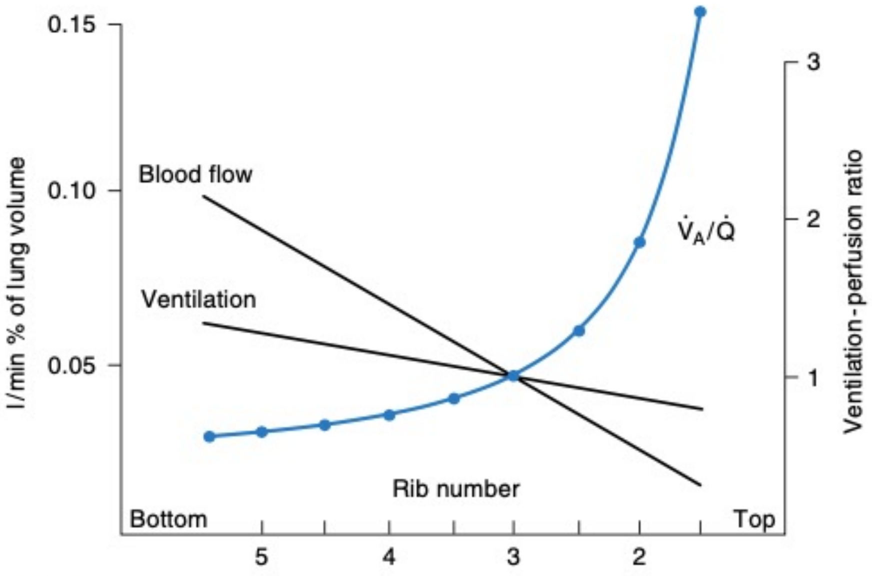

Figure 5.9. Distribution of ventilation and blood flow down the upright lung (compare Figures 2.7 and 4.7). Note that the ventilation-perfusion ratio decreases down the lung.

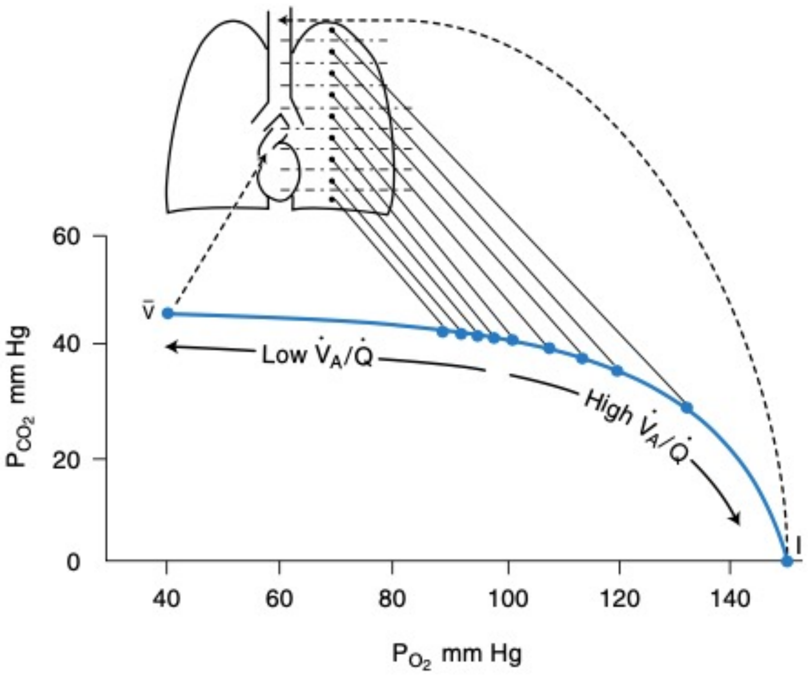

Figure 5.10. Result of combining the pattern of ventilation-perfusion ratio inequality shown in Figure 5.9 with the effects of this on gas exchange as shown in Figure 5.8. Note that the high ventilation-perfusion ratio at the apex results in a high P_{O_2} and low P_{CO_2} there. The opposite is seen at the base.

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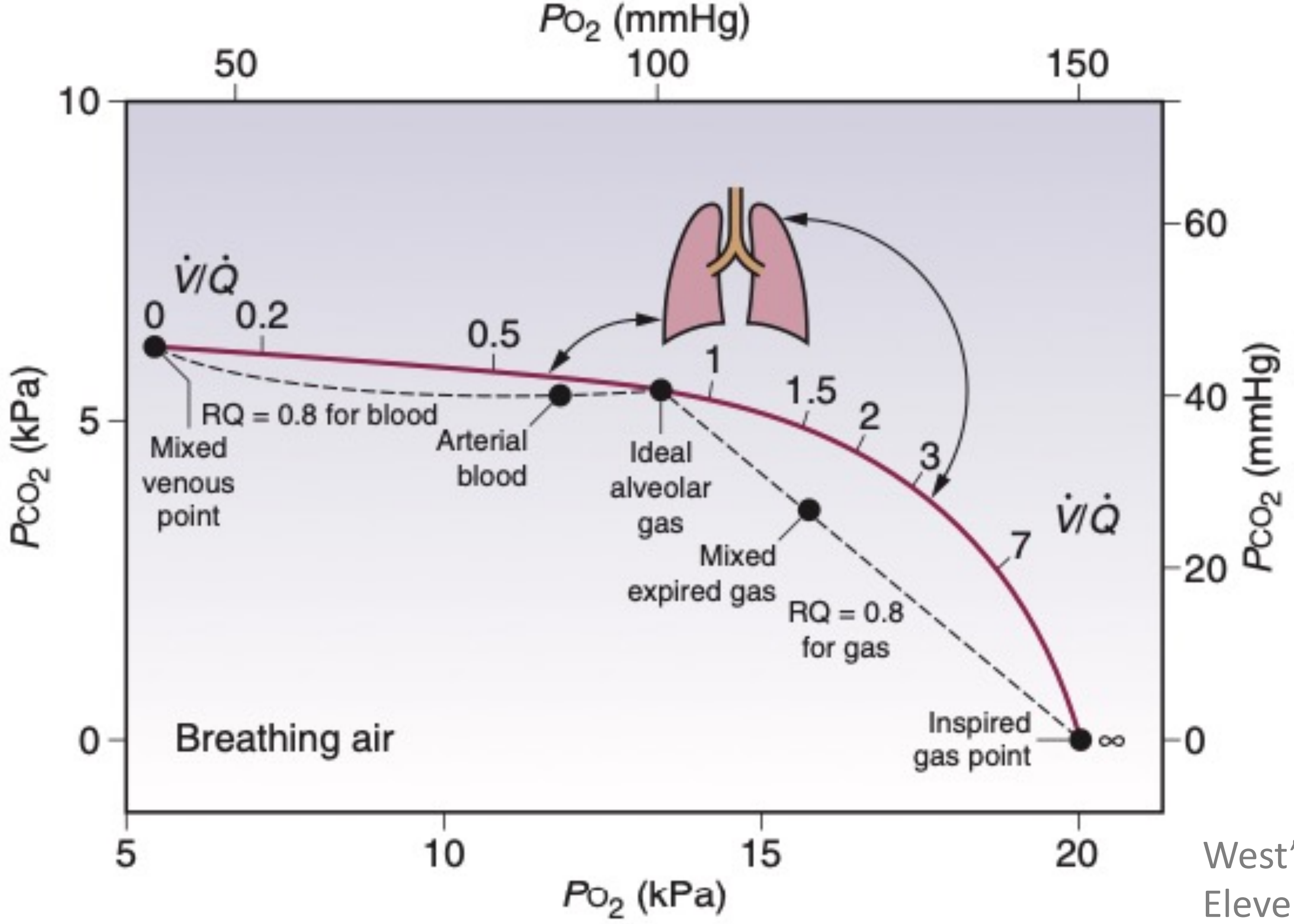

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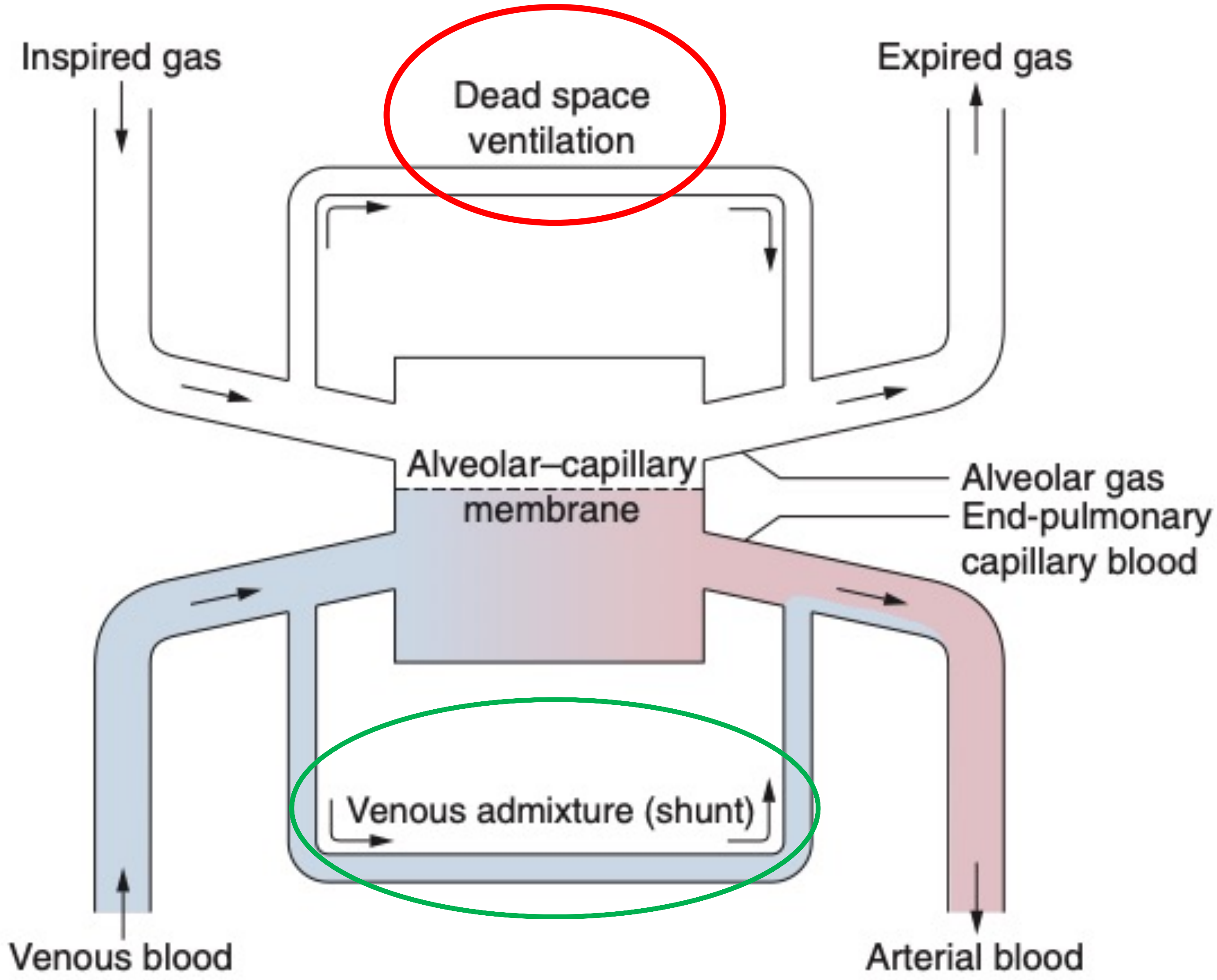
FIG. 7.6 The heavy line indicates all possible values for P_{O_2} and P_{CO_2} of alveoli with ventilation/perfusion ($\dot{V}/\dot{Q}$) ratios ranging from zero to infinity (subject breathing air). Values for normal alveoli are distributed as shown in accord with their vertical distance up the lung field. Mixed expired gas may be considered as a mixture of ideal alveolar and inspired gas (dead space). Arterial blood may be considered as a mixture of blood with the same gas partial pressures as ideal alveolar gas and mixed venous blood (shunt).

$V/Q = \infty$



$V/Q = \infty$

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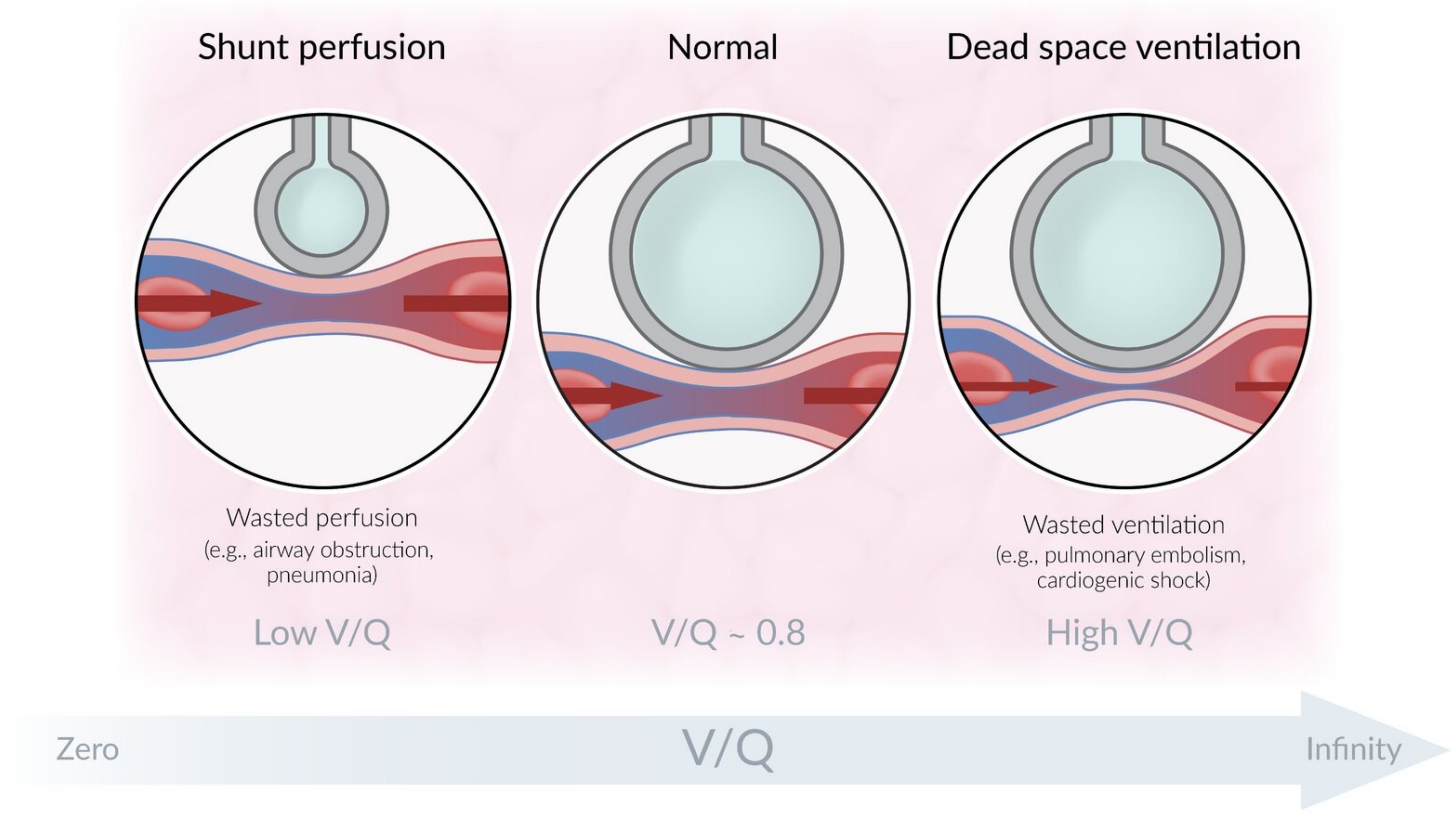
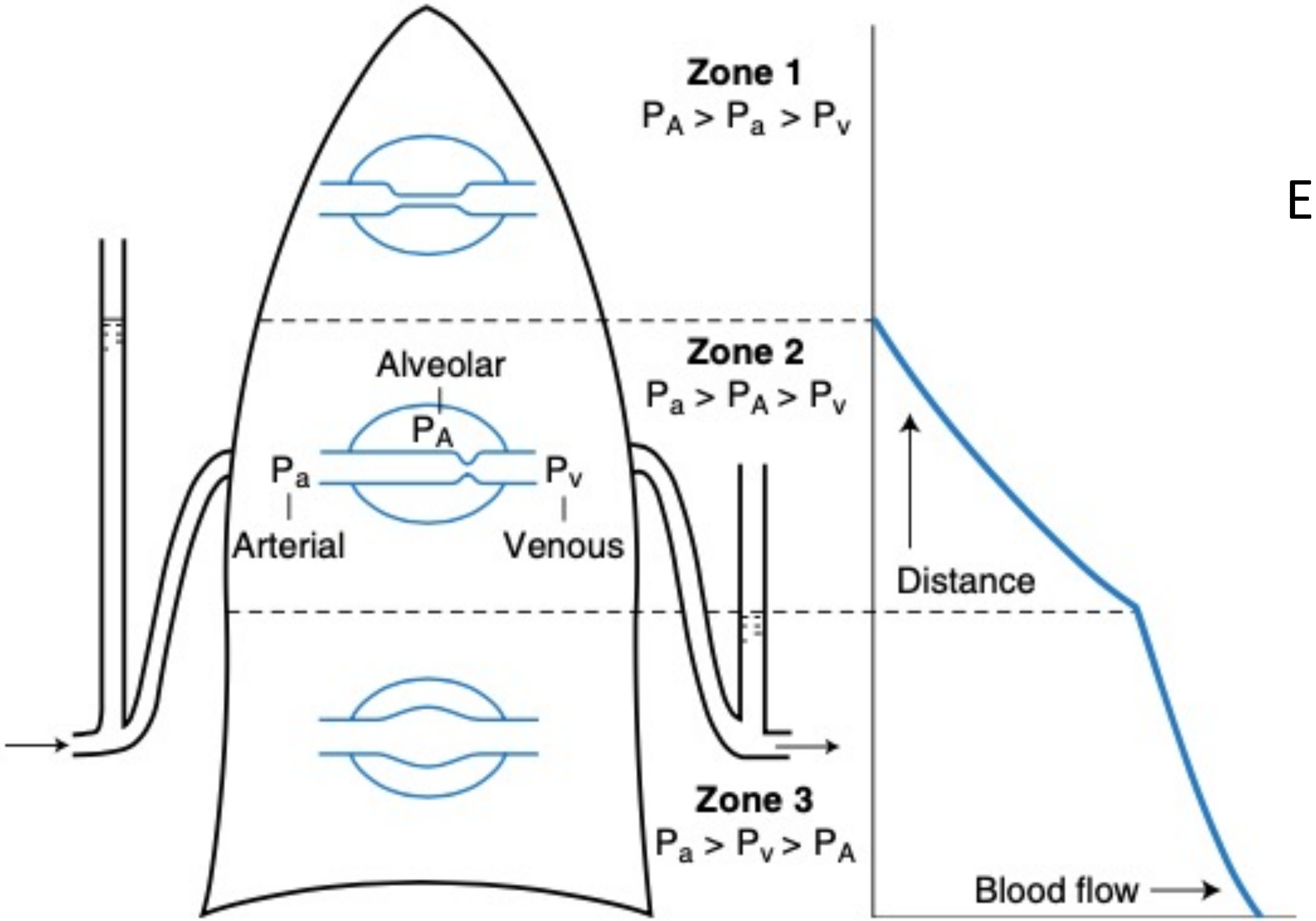

Shunt perfusion
Normal
Dead space ventilation
Wasted perfusion
(e.g., airway obstruction, pneumonia)
Wasted ventilation
(e.g., pulmonary embolism, cardiogenic shock)
Low V/Q
V/Q ~ 0.8
High V/Q
Zero
V/Q
Infinity



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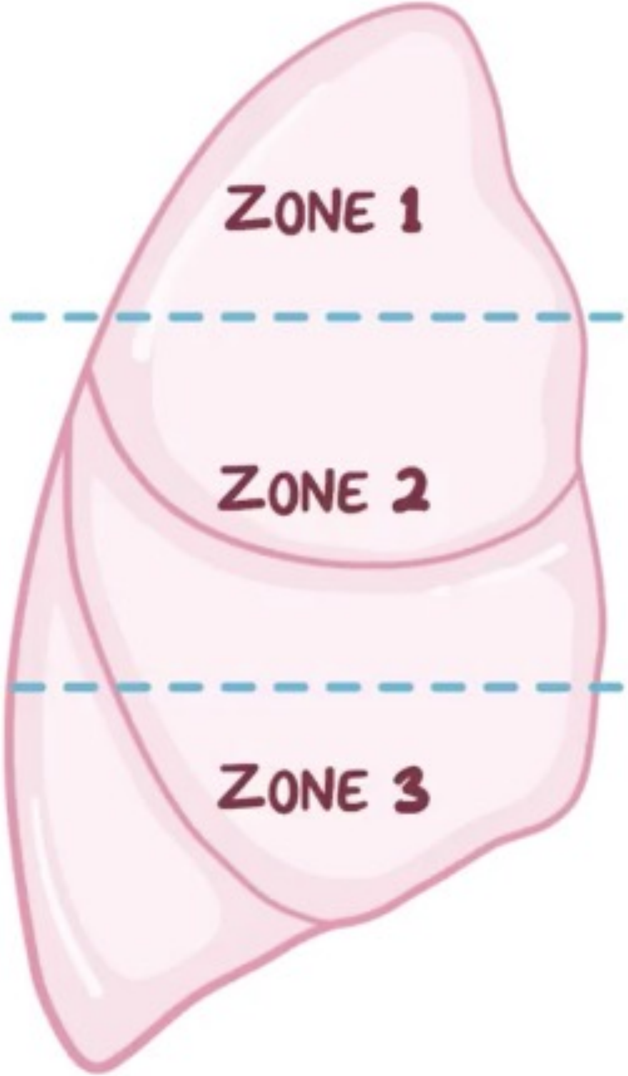
V/Q ∞
Espace mort alvéolaire

V/Q = 1
Diffusion maximale

V/Q =0
Shunt



V/Q	ALVEOLAR VENTILATION	BLOOD FLOW
HIGHEST (3.6)	LOWEST (0.25 L/min)	LOWEST (0.07 L/min)
(1)	V = Q	Q = V
LOWEST (0.6)	HIGHEST (0.8 L/min)	HIGHEST (1.3 L/min)

AVERAGE = 0.8

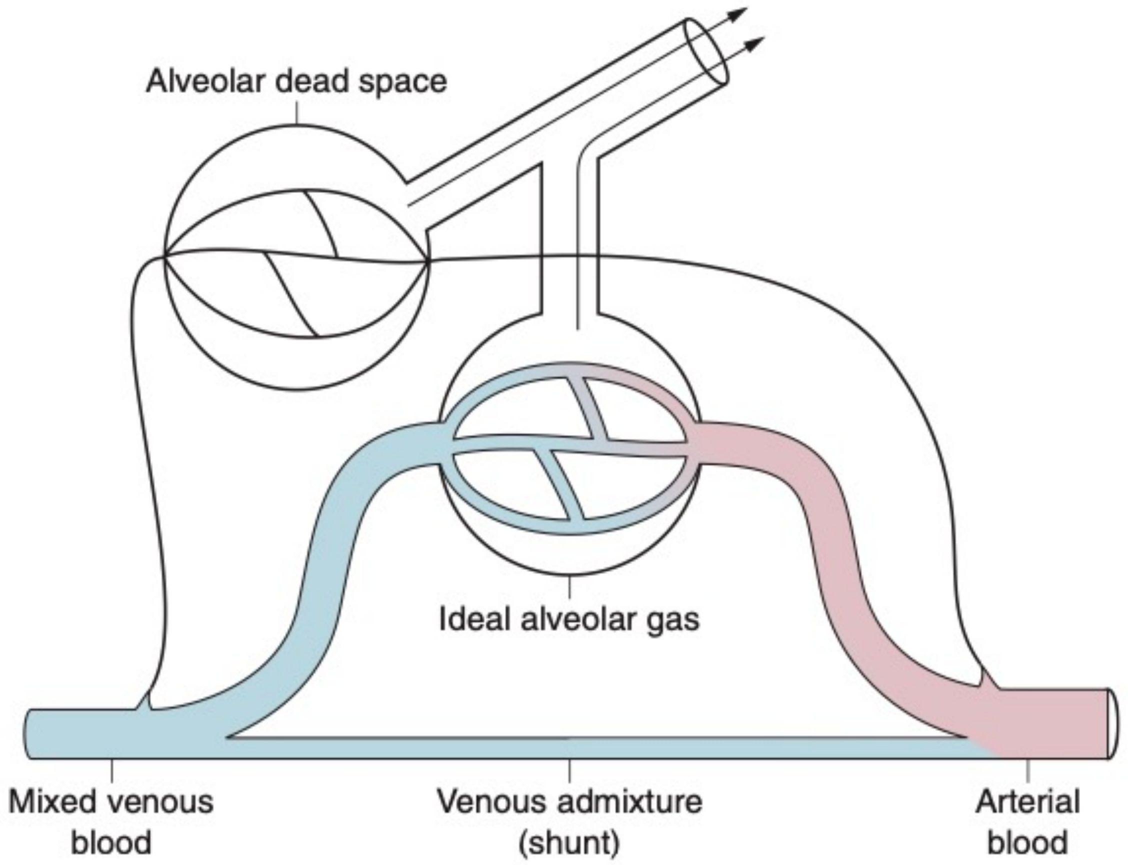


FIG. 7.10 ■ Three-compartment (Riley) model of gas exchange. The lung is imagined to consist of three functional units comprising alveolar dead space, ideal alveoli and venous admixture (shunt). Gas exchange occurs only in the ideal alveoli. The measured alveolar dead space consists of true alveolar dead space together with a component caused by $\dot{V}/\dot{Q}$ scatter. The measured venous admixture consists of true venous admixture (shunt) together with a component caused by $\dot{V}/\dot{Q}$ scatter. Note that ideal alveolar gas is exhaled contaminated with alveolar dead space gas, so it is not possible to sample ideal alveolar gas.

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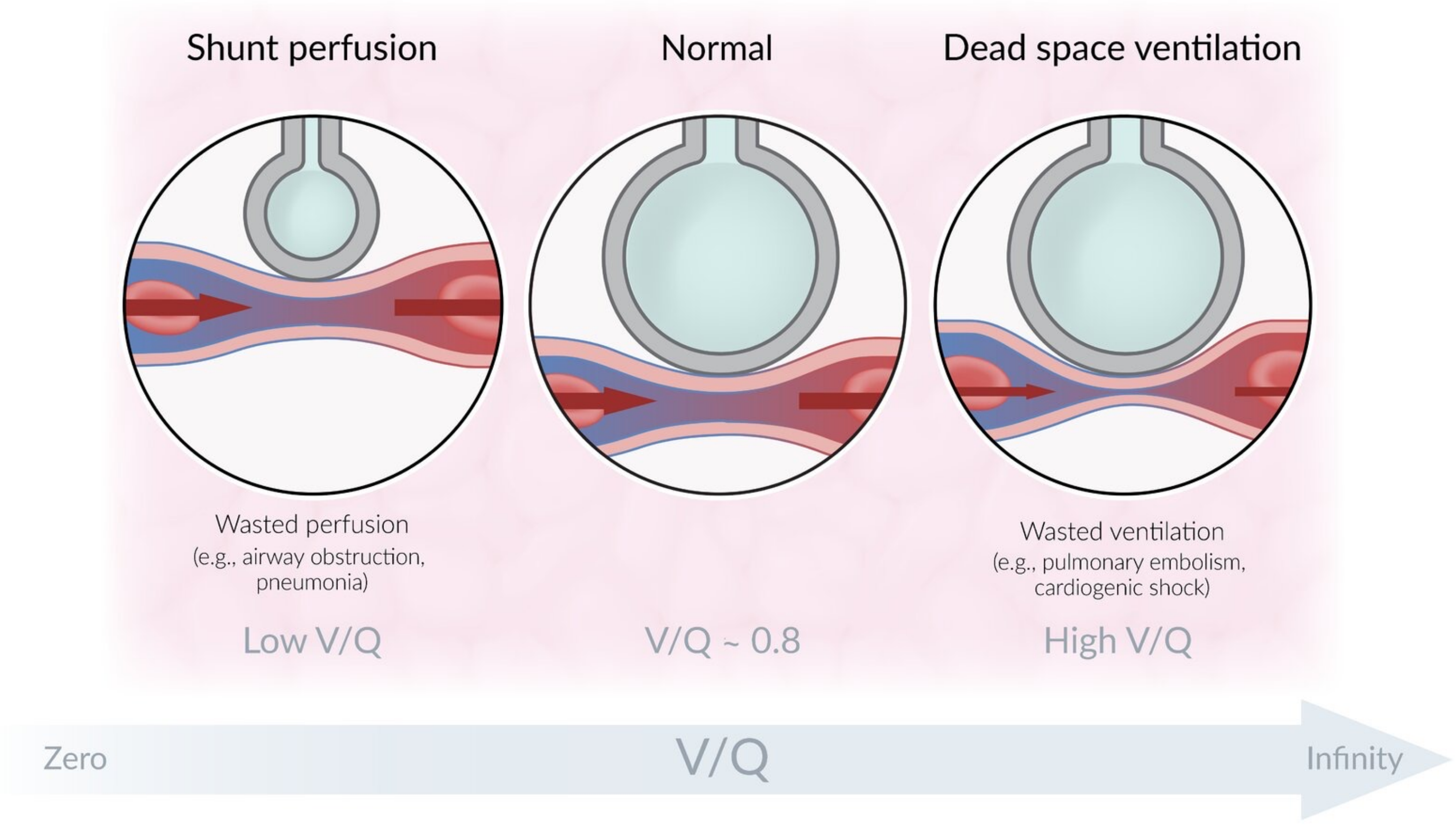
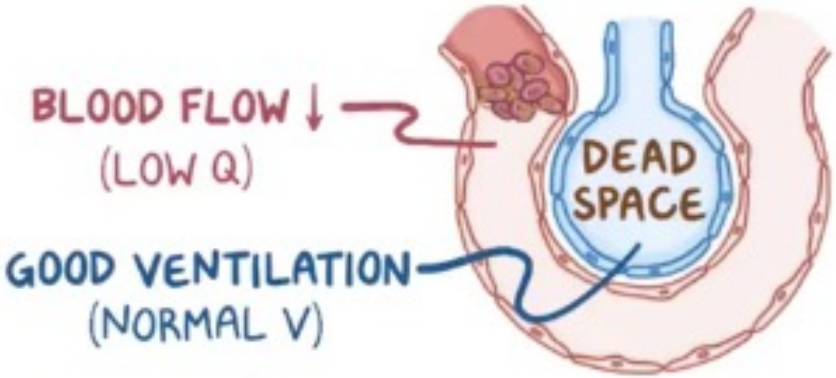
Mismatch ventilation-perfusion

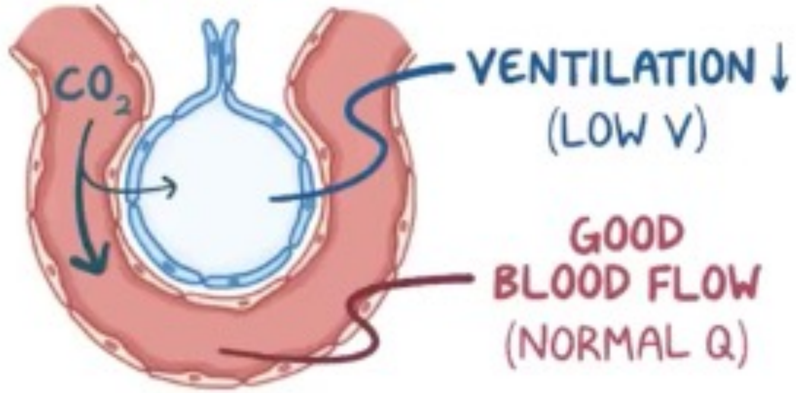


PULMONARY EMBOLISM



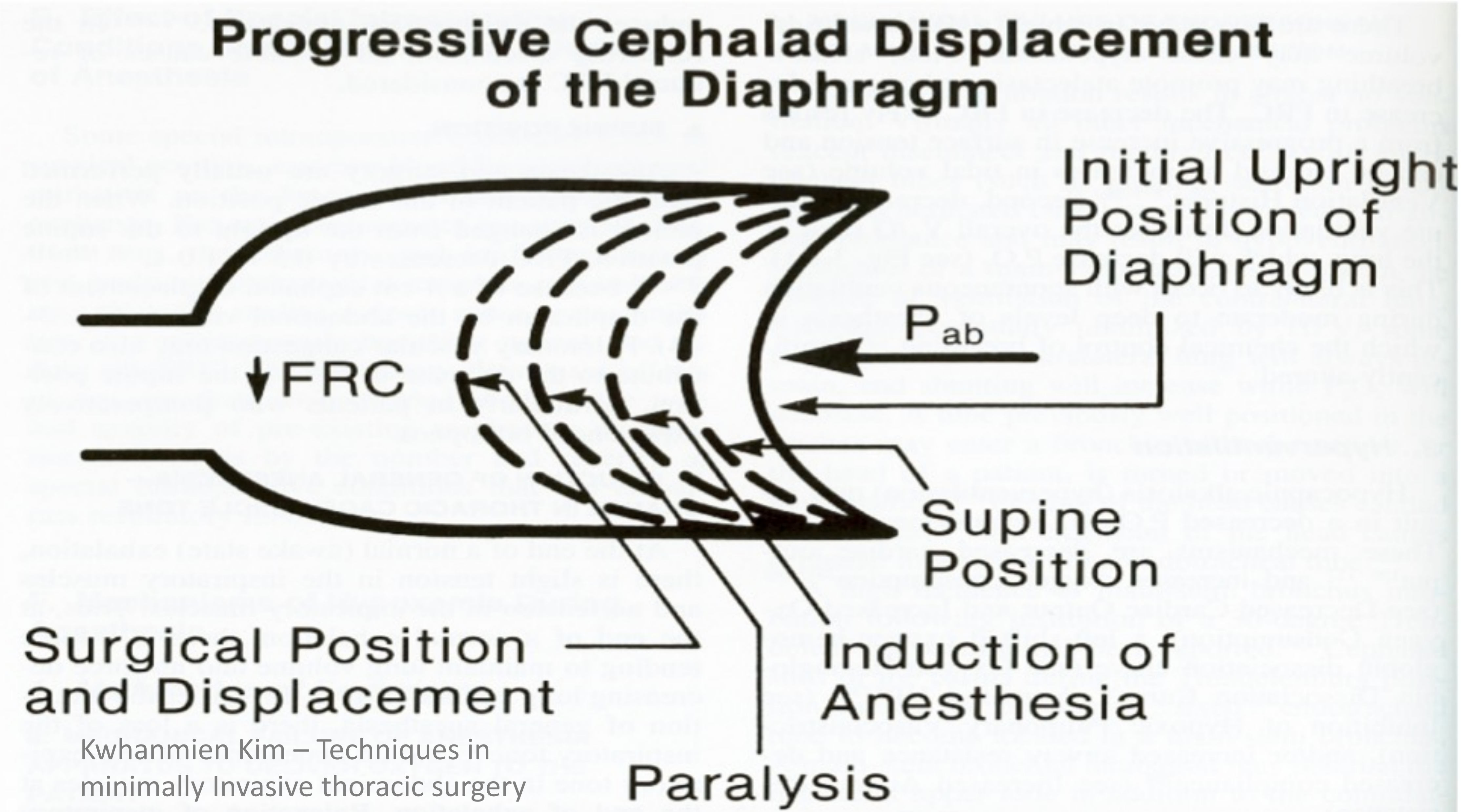
V/Q	HIGH (can equal ∞)
Pa_{O_2}	N/A
Pa_{CO_2}	N/A
PA_{O_2}	150 mmHg
PA_{CO_2}	0 mmHg

AIRWAY OBSTRUCTION



V/Q	LOW (can equal zero)
Pa_{O_2}	ECREASES to 40 mmHg
Pa_{CO_2}	NCREASES to 46 mmHg
PA_{O_2}	N/A
PA_{CO_2}	N/A

Ventilation-perfusion et anesthésie générale



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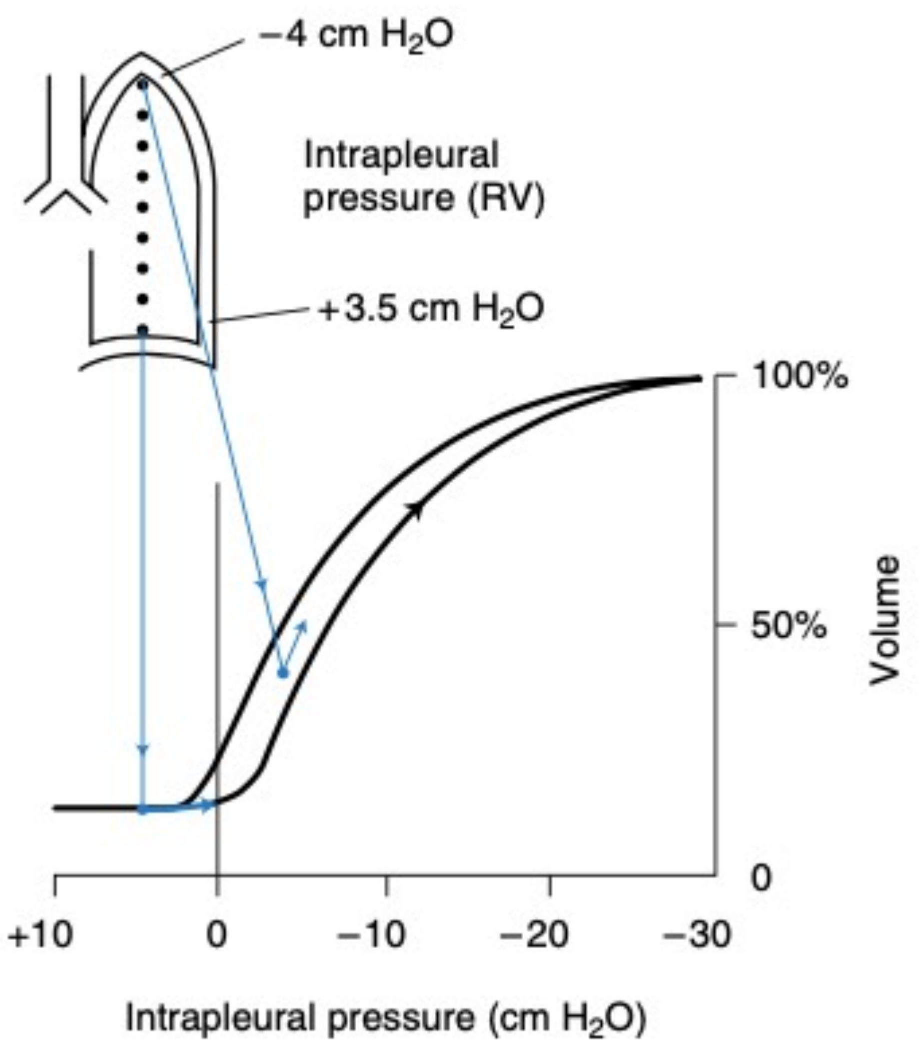

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Covid-19 : ce geste simple qui permettrait de sauver les patients en détresse respiratoire

Placer les patients atteints de Covid-19 et présentant un syndrome de détresse respiratoire aiguë (SDRA) sur le ventre leur permettrait de bénéficier d'une meilleure ventilation des poumons et d'une meilleure oxygénation.

Écrit par Anaïs Chabalier

Publié le 16/04/2020 à 14h35, mis à jour le 14/03/2022 à 14h27

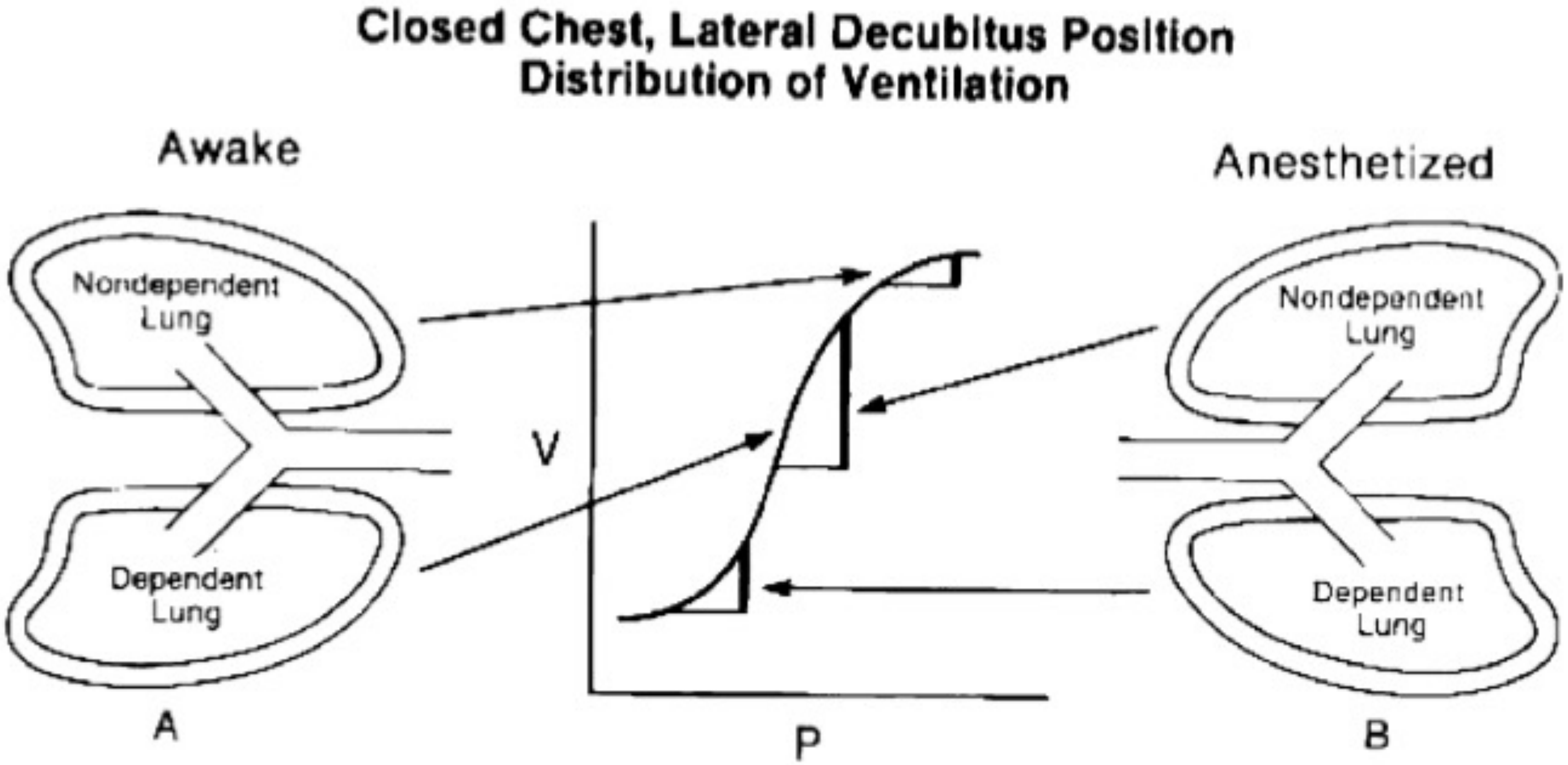

FIG. 5.9. Schematic diagram of a patient in the lateral decubitus position. The change in the distribution of ventilation with the transition from the awake state to the anesthetized state is illustrated (modified from Benumof [2]. © Elsevier 1995).

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Points clés

La ventilation ainsi que la perfusion sont distribués préférentiellement dans les régions dépendantes du poumon, résultant de la gravité et variant avec la posture

Dans un poumon sain, la ventilation et la perfusion sont étroitement liés avec quelques variations du ratio ventilation/perfusion selon les différentes régions du poumon (zones de West).

Un ratio V/Q = 0 représente un shunt intrapulmonaire (sang veineux mêlé)

Un ratio V/Q = ∞ contribue à l'espace mort alvéolaire