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Review of AIIMS/PGI/JIPMER Pattern May 2017

Bahram Gor
Jyotsana Priya

JAYPEE

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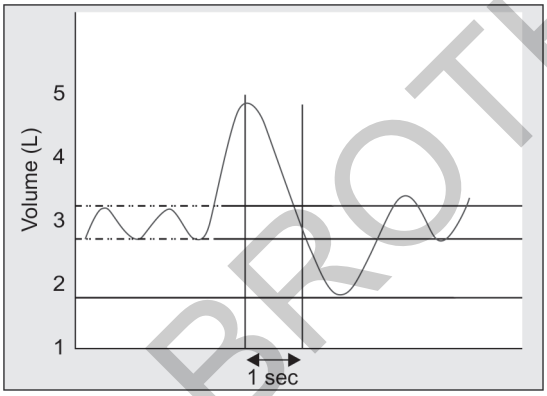
AIIMS May 2017

1. Calculate forced expiratory volume in 1 sec/forced vital capacity (FEV1/FVC) ratio from the following spirometry curve?

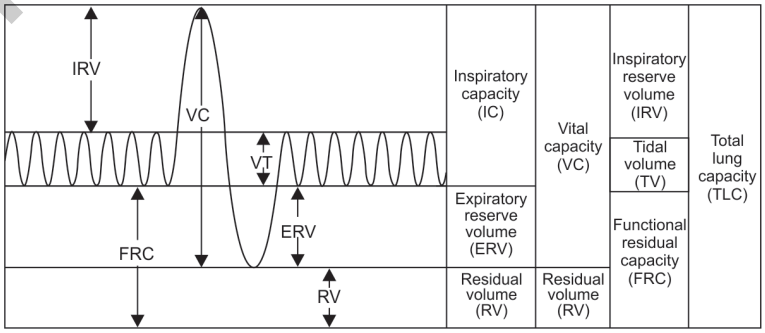


a. 90–99%
b. 80–89%
c. 70–79%
d. 60–69%

Ans. c. 70–79% *Ref: Ganong 24th/ed p629-630; Berne & Levy 6th/ed p443*

Figure given below helps in solving question:

On comparing figure given in question and figure given below
FVC: 5–1 = 4 L
FEV1: 5–2 = 3 L
So FEV1/FVC ratio = 3 L/4 L ~70–79%



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Other important points regarding FEV1 and FVC are:

- FEV1 and the ratio FEV1/FVC help in differentiating between two major patterns of abnormal ventilation — Obstructive and Restrictive (constricted) lung diseases.

Pulmonary function measurement	Obstructive pulmonary disease	Restrictive pulmonary disease
FVC (L)	Decrease	Decrease
FEV1 (L)	Decrease	Decrease
FEV1/FVC	Decrease	Normal
FEF_{25-75} (L/sec)	Decrease	Normal to increased
PEFR (L/sec)	Decrease	Normal
FEF_{50} (L/sec)	Decrease	Normal
FEF_{75} (L/sec)	Decrease	Normal
Slope of FV curve	Decrease	Normal to increased

2. ECG is recorded with phonocardiogram to identify the different heart sounds. Second heart sound will appear at which point in the following diagram?



a. Point A
b. Point B
c. Point C
d. Point D

Ans. c. Point C *Ref: Ganong 24th/ed p543; Guyton 13th/ed. p114*

Via going through the diagram we can answer this question easily.

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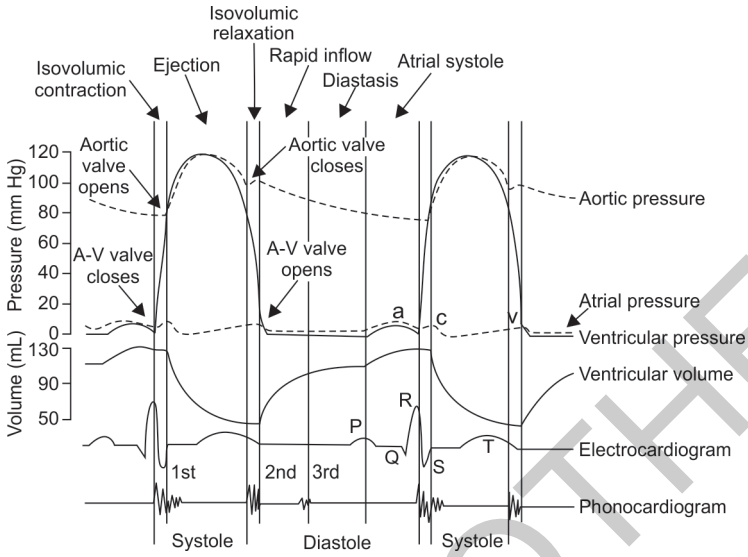

Two sounds are normally heard through a stethoscope during each cardiac cycle.

- ***Option c:*** is correct because the second is a shorter, high-pitched "dup" (second sound), caused by vibrations associated with closure of the aortic and pulmonary valves just after the end of ventricular systole. In relation to ECG it comes **just before 'U' wave** and in given figure in question its **point c**.
- ***Option b:*** Point B is a low, slightly prolonged "**lub**" (first sound), caused by vibrations set up by the sudden closure of the AV valves at the start of ventricular systole. In relation to ECG it **coincides with the 'R' wave**.
- ***Option d:*** Point D correspond to a soft, low-pitched third sound is heard about one third of the way through diastole in many normal young individuals. It coincides with the period of rapid ventricular filling. In relation to ECG it comes just **after the 'U' wave**.
- ***Option A:*** Point A corresponds a fourth sound can sometimes be heard immediately before the first sound when atrial pressure is high or the ventricle is stiff in conditions such as ventricular hypertrophy. It is due to ventricular filling and is rarely heard in normal adults. In relation to ECG it **coincides with the 'P' wave.**
- **Some special feature of heart sound given in table:**

HS1	HS2	HS3	HS4
A low, slightly prolonged "lub"	Shorter, high-pitched "dup"	Soft, low-pitched	Sometimes be heard immediately before the first sound
A duration of about 0.15 s and a frequency of 25 to 45 Hz	The second sound lasts about 0.12 s, with a frequency of 50 Hz		
	It is loud and sharp when the diastolic pressure in the aorta or pulmonary artery is elevated, diseases		

Contd...

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Contd...

HS1	HS2	HS3	HS4
Caused by vibrations set up by the sudden closure of the AV valves at the start of ventricular systole	Caused by vibrations associated with closure of the aortic and pulmonary valves just after the end of ventricular systole	Heard about one third of the way through diastole in many normal young individuals	It is due to ventricular filling and is rarely heard in normal adults
		It coincides with the period of rapid ventricular filling and is probably due to vibrations set up by the inrush of blood	

3. The oxygen carrying capacity of a 18-year-old boy with hemoglobin of 14 g/dL is:

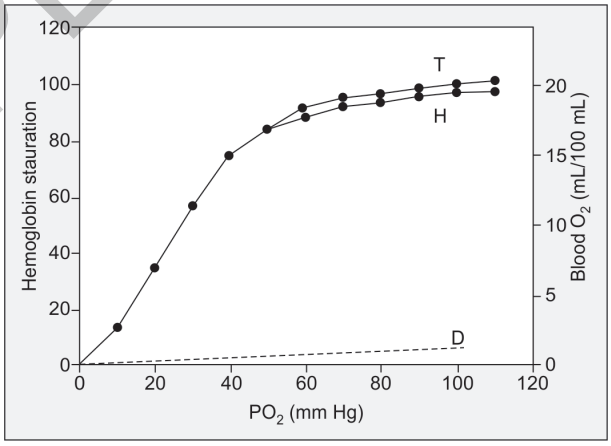
a. 14 b. 16
c. 18 d. 22

Ans. c. 18 *Ref: Textbook of Medical Physiology by RL Bijlani, 4th/ed, p227 and Ganong's Physiology, p642*

Explanation

Carrying capacity (CaO_2) = (SaO_2 × Hb × 1.34) + 0.003 (PaO_2)

- Oxygen content of the artery depends upon oxygen saturation of the blood, Hb concentration and partial pressure of the oxygen
- Saturated hemoglobin has 1.34 mL of O_2
- Hemoglobin concentration in normal blood is about 15 g/dL (14 g/dL in women and 16 g/dL in men).
- 1 dL of blood contains 20.1 mL (1.34 mL × 15) of O_2 bound to hemoglobin when the hemoglobin is 100% saturated.
- The amount of dissolved O_2 is a linear function of the PO_2 (0.003 mL/dL blood/mm Hg PO_2.
- So in given question if Hb is 14g/dL and normal saturation is 97% so
  CaO_2 = 0.97 × 14 × 1.34 + 0.003 = 18.2 (Thus the answer)



T: Total amount of oxygen carried; H: Oxygen in association with hemoglobin; D: Dissolved oxygen.

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In the figure: At the steep portion of the curve between 15 and 40 mm Hg (range of low PO_2), any small increase in PO_2 increases the oxygen carrying capacity of the blood markedly.

Thus at high altitudes, any increase in PO_2 achieved by giving 100% oxygen for breathing is highly beneficial.

4. Bezold-Jarisch reflex is mediated by:

a. Angiotensin
b. Histamine
c. Serotonin
d. Prostaglandin

Ans. c. Serotonin *Ref: Ganong 25th/ed p592 and 664, Boron p1133*

Bezold-Jarisch Reflex

- ***Option c*** is correct because in experiment on cats rabbit and rodent it is found that stimuli for Bezold-Jarisch reflex are capsaicin, ***serotonin***, phenylbiguanide and veratridine.
- Activation of chemosensitive vagal C fibers in the cardiopulmonary region causes profound bradycardia, hypotension and a brief period of apnea followed by rapid shallow breathing. This response pattern is called the Bezold-Jarisch reflex.
- Vasovagal syncope (VVS) has been attributed to activation of the Bezold-Jarisch reflex.
- ***Option a*** is incorrect because angiotensin is a peptide hormone that cause vasoconstriction and subsequently lead to hypertension.
- ***Option b*** is incorrect because histamine involved in local immune response as well as it also acts as neurotransmitter in uterus and physiological response in gut. It also plays central role in pruritis.
- ***Option d*** is incorrect because prostaglandin has role in constriction or dilation of smooth muscles, platelet aggregation, inducing labor pain, etc.
- ***Other important associated points:***

Receptor	Chemosensitive vagal C fibers in the cardiopulmonary region (e.g. juxtacapillary region of alveoli, ventricles, atria, great veins, and pulmonary artery)
Stimuli	By a variety of substances including capsaicin, serotonin, phenylbiguanide, and veratridine in cats, rabbits, and rodents
Response/effect	Profound bradycardia, hypotension, and a brief period of apnea followed by rapid shallow breathing.

- This reflex may be activated during myocardial ischemia and reperfusion as a result of increased production of oxygen radicals.
- Activation of cardiopulmonary chemosensitive receptors may also be part of a defense mechanism protecting individuals from toxic chemical hazards.
- Finally, the syndrome of cardiac slowing with hypotension **(vasovagal syncope)** has also been attributed to activation of the Bezold-Jarisch reflex.
- Similar to Bezold-Jarisch reflex: **Pulmonary chemoreflex.**
- **Pulmonary chemoreflex:** Apnea followed by rapid breathing, bradycardia, and hypotension due to stimulation of **J (juxtacapillary) receptors by** hyperinflation of the lung or by intravenous or intracardiac administration of chemicals such as capsaicin.

5. In JVP 'a' wave is due to:

a. Atrial contraction
b. Passive atrial filling
c. Ventricular contraction
d. Ventricular relaxation

Ans. a. Atrial contraction *Ref: Guyton 13th/ed p111*

- ***Option a*** is correct because in **JVP pressure** changes in the atria represented by: a, c, and v waves and the ***a wave*** is caused by ***atrial contraction***

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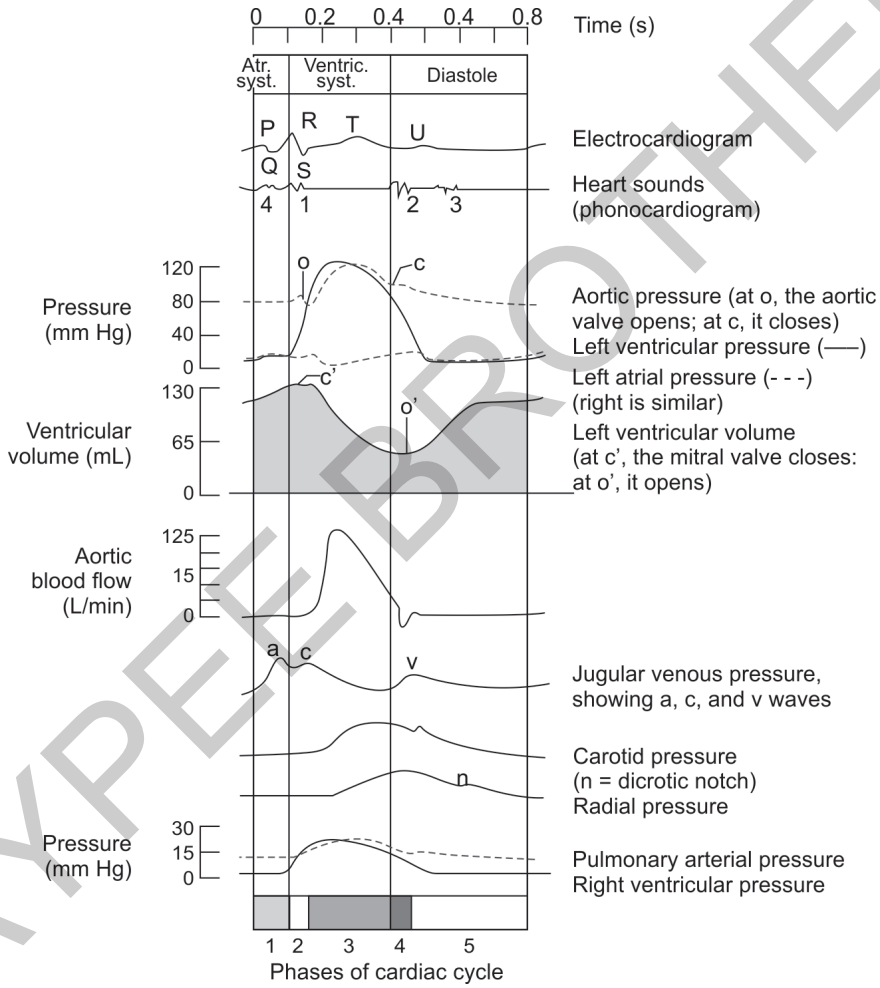
- ***Option b*** is incorrect because the **c wave** occurs when the **ventricles begin to contract**; it is caused partly by **slight backflow of blood into the atria** at the onset of ventricular contraction but mainly by bulging of the A-V valves backward toward the atria because of increasing pressure in the ventricles.
- ***Option c*** is incorrect because the **v wave** occurs toward the end of **ventricular contraction**; it results from slow flow of blood into the atria, the A-V valves open, allowing this stored atrial blood to flow rapidly into the ventricles and causing the v wave to disappear.

Answer easily by table and figure given below:

Phases of cardiac cycle:



JVP (Jugular Venous Pressure) waves	
a wave	Due to **atrial systole** some blood regurgitates into the great veins when the atria contract.
c wave	It is the transmitted manifestation of the rise in atrial pressure produced by the bulging of the tricuspid valve into the atria during **isovolumetric ventricular contraction**.
v wave	Due to **ventricular contraction**. The jugular pulse waves are superimposed on the respiratory fluctuations in venous pressure.

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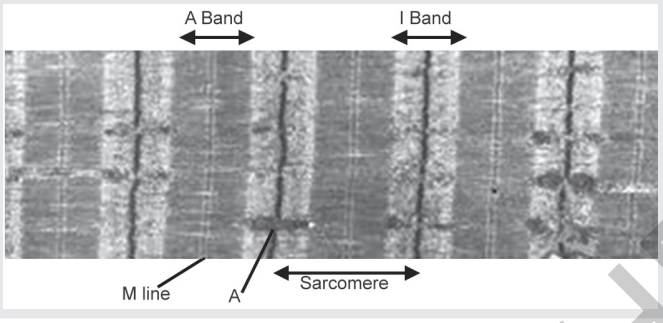
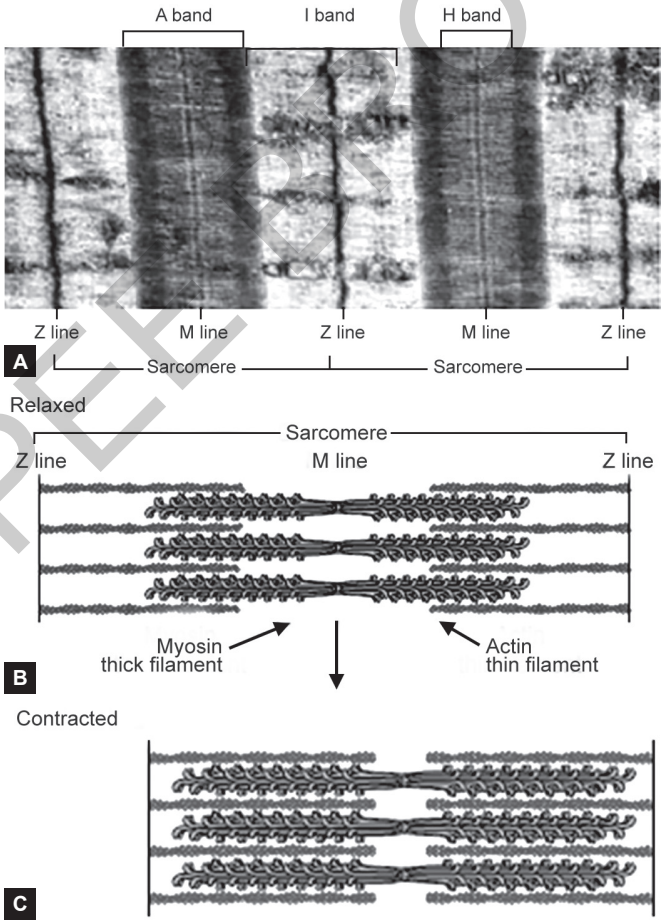
6. Which of the following is the constituent of the marked area in the electron microscopic picture of muscle?



a. Alpha actinin
b. Titin
c. Nebulin
d. Calmodulin

Ans. a. Alpha actinin *Ref: Ganong 25th/ed p101*

Answer can be given easily by seeing figure given below:



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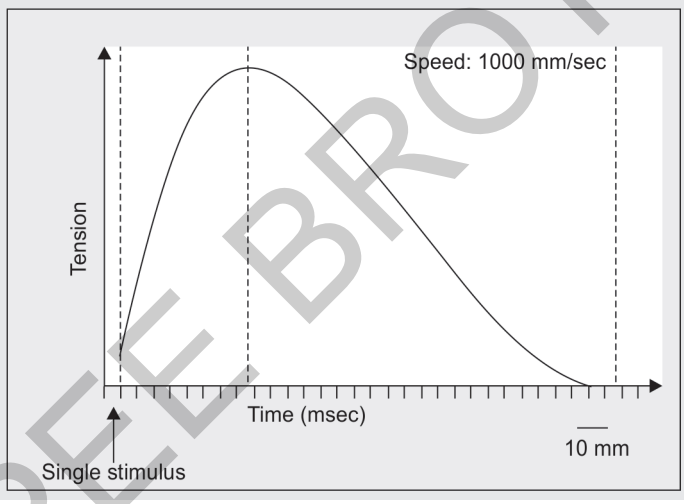
- Each muscle fiber is a single cell that is multinucleated, long, cylindrical, and surrounded by a cell membrane, the sarcolemma.
- The contractile mechanism in skeletal muscle largely depends on the proteins myosin-II, actin, tropomyosin, and troponin.
- The form of myosin found in muscle is myosin-II, with two globular heads and a long tail.
- The myosin molecules are arranged symmetrically on either side of the center of the sarcomere, and it is this arrangement that creates the light areas in the pseudo-H zone.
- Each of the three troponin subunits has a unique function.
- Troponin T binds the troponin components to tropomyosin
- Troponin I inhibits the interaction of myosin with actin.
- Troponin C contains the binding sites for the Ca^{2+} that helps initiate contraction.
- **Actinin** binds actin to the Z lines
- Titin connects the Z lines to the M lines and provides scaffolding for the sarcomere.
- Desmin adds structure to the Z lines in part by binding the Z lines to the plasma membrane.

7. Calculate tetanizing frequency of frog gastrocnemius muscle from the graph shown below:



a. 25–30 Hz
b. 30–35 Hz
c. 35–40 Hz
d. 40–50 Hz

Ans. a. 25–30 Hz

Ref: Cl GHAI Experimental Physiology (Amphibian and Mammalian Experiments) 20th/ed p330

Explanation

In order to produce tetany a muscle must get another stimulus just before it starts relaxing. So if the muscle starts relaxation after T seconds then the frequency of the stimulus must be: one stimulus per T seconds = 1/T sec^{-1} i.e., 1/T Hz

In the figure in question, see the following points:

- Tetanising frequency is 1/T (where T= time point just before the time of relaxation)
- Calculate T from the figure in question:
  - Speed is 1000 mm/sec
  - 10 mm = 2 units on the X axis

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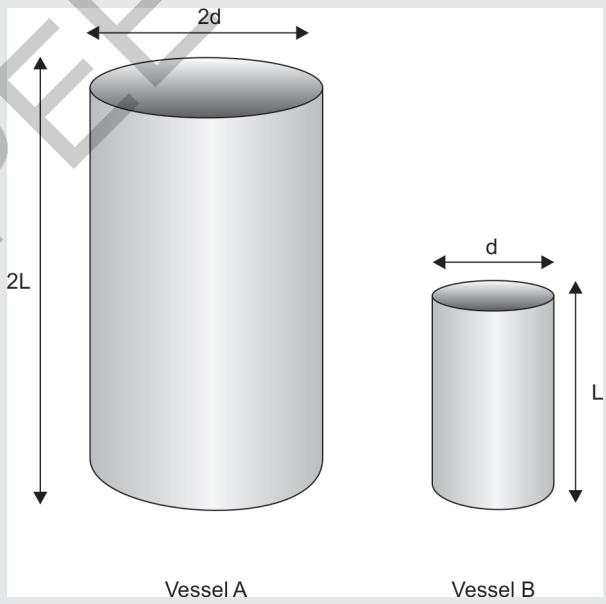
- Relaxation starts at 8 units, that is at 40 mm
- Convert this 40 mm to seconds, it will be 40/1000 seconds

❑ Now, tetanising frequency = 1/T = 1000/40 = 25 per sec or 25 Hz, ***thus the answer***

Important terminologies in relation to the above question:

❑ On applying many successive stimuli, the response of the muscle depends on the frequency of stimulation.
❑ At low rates of stimulations, the muscle gives jerky or tremulous contractions called subtetanus.
❑ At high frequencies, the muscle remains in a state of smooth, sustained, and forceful contraction called tetanus.
❑ The "tetanizing" or "fusion" frequency is that rate of stimulation at which there is complete fusion of individual contractions to produce tetanus.
❑ In amphibian muscle and in "slow" muscle fibers, the tetanizing frequency is about 30/sec, while in mammalian muscle and in "fast" fibers, it is 60 or more stimuli per second.
❑ The term tetanus should not be confused with a disease called tetanus (widespread convulsions in the body due to tetanus toxin released by the infecting bacteria).
❑ How much tension is developed by a muscle depends on the active state of the contractile components; and how much tension is transmitted to the recording system (or to the bone) depends on the amount of stretch (laxity or tautness) exerted on the series elastic components (SEC) of the muscle.
❑ During one twitch contraction, enough Ca^{2+} is released to engage all the myosin heads to the actin sites, but it is removed quickly from the cytoplasm and relaxation occurs.
❑ With repeated stimuli, Ca^{2+} remains longer in the cytoplasm, increasing the duration of the active state (due to continuous recycling of myosin heads).
❑ This increases the amount of stretch on the SEC and the tension developed rises.

8. Below are two vessels shown. Assuming the pressure along both the vessels is the same and both of them follow linear flow pattern. What will the amount of blood flow in vessel A compared to vessel B?



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a. 4 times
b. 8 times
c. 16 times
d. 32 times

Ans. b. 8 times *Ref: Ganong 24th/ed p575*

Explanation

- Question asks about blood flow in vessel A compared to vessel B. This can be answered by understanding Poiseuille's law:
- Poiseuille's Law states that the flow of fluid is related to a number of factors:
  - The viscosity (n) of the fluid
  - The pressure gradient across the vessel (P)
  - Length (L) and diameter(r) of the vessel
- The relationship is given by Poiseuille–Hagen formula:

$$F = (P_A - P_B) \times \left(\frac{\pi}{8}\right) \times \left(\frac{1}{\eta}\right) \times \left(\frac{r^4}{L}\right)$$

- Where

  F = Flow
  $P_A - P_B$ = Pressure difference between two ends of the tube
  η = Viscosity
  r = Radius of tube
  L = Length of tube
- Now see the question again,
  - Diameter is doubled, means radius is doubled (consider 2r)
  - Length is doubled (2L)
  - On substituting the values in formula;
    $(2r)^4/(2L)$ = 8 times increase in flow **(Thus the answer is b.)**

9. In a diseased person intrapleural pressure measured –4 mm Hg and –9 mm Hg at the start and end of inspiration having tidal volume 500 mL. Calculate pulmonary compliance in Lit/mm Hg:

a. 0.1 b. 0.2
c. 0.5 d. 0.7

Ans. a. 0.1 *Ref: Respiratory Physiology by John B West, 9th/ed p99*

- The slope of the pressure-volume curve, or the **volume change per unit pressure change**, is known as the *compliance* ***(delta V/ delta P)***
- Tidal volume is change in volume per respiration. So its *delta V = 500 mL*
- So in litre = 0.5 L *and* Delta P given 9–4 = 5 mm Hg
- So compliance = 0.5/5 = **0.1 Lit/mm Hg**
- Compliance of the normal human lung = 200 mL·cm water-1.
- At high expanding pressures lung is stiffer, and its compliance smaller (flatter slope of the curve)
- ***Reduced*** **compliance**
  - Increase of fibrous tissue in the lung (pulmonary fibrosis)
  - Alveolar edema (prevents the inflation of alveoli)
  - Lung unventilated for a long period
  - If the pulmonary venous pressure is increased and the lung becomes engorged with blood.

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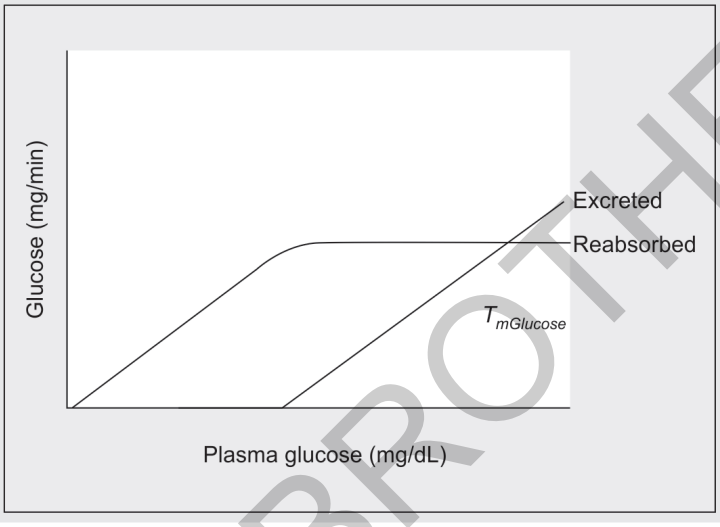
- **An *increased* compliance**
  - Pulmonary emphysema
  - Normal aging lung
  - During an asthma attack

10. A diabetic patient having blood glucose of 200 mg/dL and GFR of 90 mL/min. Transport maximum of glucose = 150 mg/min. What is the amount of glucose excreted in urine?



a. 10 mg/min
b. 20 mg/min
c. 30 mg/min
d. 40 mg/min

Ans. c. 30 mg/min *Ref: Guyton, 13th/ed p350*

Explanation

Solution of question:

- Given GFR = 90 mL/min
- Plasma concentration = 200 mg/dL or we can say that 200 mg/100 mL = 2 mg/mL
- So Filtration load = 90 × 2 = 180 mg/min
- But in question they asked excretion rate
- Excretion rate = filtration rate–reabsorption
- And reabsorption is equal to threshold maximum which is given 150 mg/min
- So excretion rate in given question = 180–150 = 30 mg/min
- So correct answer of this question is ***option c***
- Transport maximum is the maximum rate at which glucose can be reabsorbed from the tubules. The threshold for glucose refers to the filtered load of glucose at which glucose first begins to be excreted in the urine
- Transport maximum for substances that are actively reabsorbed
  - There is a limit to the rate at which the solute can be transported, which is often referred to as the transport maximum
  - Limit is due to saturation of the specific transport systems involved when the amount of solute delivered to the tubule (referred to as tubular load) exceeds the capacity of the carrier proteins and specific enzymes involved in the transport process.

  e.g. glucose transport system in the proximal tubule

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- Normally, measurable glucose does not appear in the urine because essentially all the filtered glucose is reabsorbed in the proximal tubule.
- However, when the filtered load exceeds the capability of the tubules to reabsorb glucose, urinary excretion of glucose does occur.
- Adult - transport maximum for glucose = 375 mg/min
  - Filtered load of glucose = 125 mg/min

  (GFR × plasma glucose = 125 mL/min × 1 mg/mL).

  With large increases in GFR and/or plasma glucose concentration that increase the filtered load of glucose above 375 mg/min, the excess glucose filtered is not reabsorbed and passes into the urine.

Figure below shows the relation between plasma concentration of glucose, fltered load of glucose, tubular transport maximum for glucose, and rate of glucose loss in the urine.

- Note that when the plasma glucose concentration is 100 mg/100 mL and the filtered load is at its normal level (125 mg/min) there is no loss of glucose in the urine.
- However, when the plasma concentration of glucose rises above about 200 mg/100 mL, increasing the filtered load to about 250 mg/min, a small amount of glucose begins to appear in the urine. This point is termed the threshold for glucose.
- Note that this appearance of glucose in the urine (at the threshold) occurs before the transport maximum is reached.

  One reason for the difference between threshold and transport maximum
  - **Not all nephrons have the same transport maximum** for glucose some of the nephrons therefore begin to excrete glucose before others have reached their transport maximum.
- However, in uncontrolled diabetes mellitus, plasma glucose may rise to high levels, causing the filtered load of glucose to exceed the transport maximum and resulting in urinary glucose excretion.

Substances that are Actively Transported but Do Not Exhibit a Transport Maximum.

- The reason that actively transported solutes often exhibit a transport maximum is that the transport carrier system becomes saturated as the tubular load increases.
- Some substances that are passively reabsorbed do not demonstrate a transport maximum because their rate of transport is determined by:

1. The electrochemical gradient for diffusion of the substance across the membrane
2. The permeability of the membrane for the substance
3. The time that the fluid containing the substance remains within the tubule.

   (Referred to as gradient-time transport because the rate of transport depends on the electro-chemical gradient and the time that the substance is in the tubule, which in turn depends on the tubular flow rate).

   e.g. sodium reabsorption in the proximal tubule, where the maximum transport capacity of the basolateral sodium-potassium ATPase pump is usually far greater than the actual rate of net sodium reabsorption since a significant amount of sodium transported out of the cell leaks back into the tubular lumen through junctions of the epithelial cells. Therefore, **sodium transport in the proximal tubules obeys mainly gradient-time transport principles rather than tubular maximum transport characteristics**.

- In the more **distal parts of the nephron**, the epithelial cells have much tighter junctions and transport much smaller amounts of sodium, thus **sodium reabsorption exhibits a transport maximum similar to that for other actively transported substances**.
- Transport maximum can be increased by aldosterone.

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Pattern May 2017

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