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Question: 1

Water moves from one body compartment to another by:

- A. ultrafiltration.
- B. active transport.
- C. osmotic forces.
- D. all of the above.

Answer: C

Explanation:

Osmotic forces determine which way water will move from one body fluid compartment to another. In hemodialysis, water is forced through the membrane by ultrafiltration so that the solute concentration of the blood is lowered. Water is then returned to the cells and tissues from the blood by osmotic forces since the cellular osmotically active solute concentration is now higher than in the blood. This may result in a fall in blood volume and result in hypotension. Sodium may be added to the dialysate, which will then increase the osmolality of the blood, pulling water out of the cells and tissues. The sodium in the dialysate is then lowered later in the dialysis process so that the excess water can be removed from the blood. Ultrafiltration occurs within the dialyzer but not within the body compartments. Active transport may drive ion exchange across cellular membranes, but water movement is passive and determined by osmotic forces.

Question: 2

Biocompatibility is best illustrated by:

- A. synthetic membranes that do not adsorb blood proteins as well as cellulose membranes.
- B. independence from protein adsorption of the membrane.
- C. reprocessed dialyzers that have a lower biocompatibility than new ones.
- D. reprocessed dialyzers that have a better biocompatibility than new ones.

Answer: D

Explanation:

Biocompatibility refers to the interaction of the membrane with the blood contents. Touching of blood to the membrane may activate certain cellular or protein elements in the blood, causing immunologic reactions, such as allergic reactions or anaphylaxis. Release of deleterious cytokines or enhanced clotting may occur. Adsorption of blood proteins onto the fiber wall tends to improve biocompatibility since the material is no longer seen as "foreign" by immunocompetent cells. In general, synthetic membranes are more biocompatible than those of cellulose due to their ability to absorb proteins better than the latter. Reprocessed (cleaned and reused) dialyzers may be

more biocompatible than new ones since they retain some adsorbed protein (unless bleach is used to strip off the protein).

Question: 3

The amount of fluid to be taken from the patient during hemodialysis:

- A. is independent of the filtration pressure.
- B. requires the dialysate to have a higher pressure than the blood.
- C. may be calculated by subtracting the patient's estimated dry weight from the pre-dialysis weight and adding any fluid the patient receives during treatment.
- D. may be calculated by adding the patient's pre-dialysis weight and the amount of fluid the patient receives during treatment.

Answer: C

Explanation:

For ultrafiltration to force fluid through the semipermeable membrane, the hydraulic pressure in the blood compartment must be higher than in the dialysate compartment. This pressure difference is referred to as a hydraulic pressure gradient or a transmembrane pressure. The pressures in each compartment may be set by the dialysis machine. A simple method of calculating the amount of fluid to be removed is by subtracting the estimated dry weight (EDW) of the patient from his or her pre-dialysis weight (PRW). Any fluid given during the procedure may then be added to the difference. Assuming 1 L of water weighs 1 kg, the EDW is 75 kg, the PRW is 80 kg, and the patient receives 0.5 L during the treatment. Thus, the amount of fluid to be removed would be: $80 - 75 + 0.5 = 5.5$ L.

Question: 4

The ultrafiltration coefficient of a dialyzer refers to the:

- A. fluid that passes through the membrane in 1 hour.
- B. pressure in the blood compartment needed to force fluid through the membrane.
- C. pressure difference across the membrane.
- D. fluid that passes through the membrane in 1 minute.

Answer: A

Explanation:

The dialysis machine can alter the hydraulic pressures in the blood and dialysate compartments and thus control the ultrafiltration rate of the fluid transfer. Each dialyzer has an ultrafiltration coefficient (K_{uf}) determined by the manufacturer. This refers to the volume of fluid (in mL) that passes through the membrane at a given pressure difference in 1 hour. Thus, a dialyzer with a K_{uf} of 5 and a transmembrane pressure of 50 mm Hg transfers 250 mL (5 x 50) of fluid in 1 hour of dialysis. Patients with kidney failure are often edematous with excess water in the interstitial compartment so that removal by dialysis represents an efficient way of controlling fluid

volume and weight. Since the patient's kidneys are not functioning, diuretic drugs are of little benefit.

Question: 5

The molecular weight cutoff of a dialyzer is 12,000 daltons. Which of the following molecules would not pass through the membrane into the dialysate?

- A. Phosphate
- B. Urea
- C. Albumin
- D. Sodium

Answer: C

Explanation:

Molecular weights of a chemical compound represent the sum of the atomic weights of the atoms that make up the molecule. Each dialyzer membrane has a molecular weight cutoff (in daltons) that determines the size of the molecules that can pass through it. These may range from 3000 to 15,000 daltons. Small molecules (e.g., sodium, potassium, phosphate, urea, water) pass through the filter easily, while large molecules, such as proteins (e.g., albumin with a molecular weight of 66,000 daltons) cannot. Choosing the appropriate molecular cutoff for a membrane helps to determine what size molecule may be removed from the blood. This is particularly important for drug overdoses and toxins.

Question: 6

Clearance of low-molecular-weight molecules by dialysis is accomplished mostly by:

- A. convection.
- B. diffusion.
- C. adsorption.
- D. solvent drag.

Answer: B

Explanation:

The volume of blood that can be cleared of a given solute per unit time is referred to as clearance (K). The clearance for a given solute is given by the manufacturer based on blood and dialysis flow rates; membrane characteristics; and the molecular weight, size, and charge of the solute. Most low-molecular weight solutes are removed during dialysis by diffusion from the high-concentration to the low-concentration side of the membrane with the rate also dependent on temperature. Large molecules tend to cross the membrane by convection (solvent drag). The sieving coefficient (SC) indicates the amount of solute passing through the membrane with the rest rejected or adsorbed. Thus, an SC of 0.4 predicts that 40% of a given solute will pass through the membrane. Mostly small proteins are removed from the blood by adsorption to the membrane,

although cellulose membranes tend to absorb more than synthetic hydrophobic ones. Membranes with adsorbed material are more biocompatible but may diminish diffusion and convection.

Question: 7

A hollow fiber dialyzer has which of the following properties?

- A. Very fine fiber tubes held in place by polyurethane material
- B. Fibers about 1 cm in width
- C. A high-membrane compliance
- D. A high resistance in the fibers, enhancing ultrafiltration pressure

Answer: A

Explanation:

A hollow fiber dialyzer holds thousands of fiber tubes through which the blood flows. They are surrounded by dialysate, separated by the membrane. The blood and dialysate flow in opposite directions, a so-called countercurrent mechanism, which enhances molecular exchange. This is because the concentration gradients are little changed from one end of the fiber to the other. The hollow fibers are very thin but rigid so that the membrane compliance (deformability or volume change) is low. Ultrafiltration rates are predictable so that precise amounts of fluid removal may be accomplished. The hollow filters have a low resistance to blood flow so that there is not much volume difference at low and high pressure.

Question: 8

Synthetic membranes have which of the following properties?

- A. They are cellulose membranes in which hydroxyl groups are replaced with acetate
- B. They have thick fiber walls
- C. They have poor adsorption
- D. They remove solute by diffusion only

Answer: B

Explanation:

Dialysis membranes may be of three types: cellulose, modified cellulose, and synthetic. Cellulose membranes have thin fiber walls, and solutes pass through them mostly by diffusion. The molecular cutoff is low, about 3000 daltons, so that intermediate-size molecular passage (e.g., beta₂-microglobulin at 11,800 daltons) is limited. They are also the least biocompatible of the three types since adsorption is limited. Modified-cellulose membranes have the hydroxyl groups of the molecule replaced by acetate, amino acids, or other synthetic molecules. Their adsorption is improved, and diffusion, convection, and adsorption of solute are better than cellulose. The most effective membranes are purely synthetic made of polymers (e.g., polysulfone, polymethacrylate) formed into hollow fibers with thick walls. These membranes can remove solute up to 15,000 daltons in size, and their adsorption is quite good, leading to an improved biocompatibility.

Question: 9

If a dialyzer has a urea clearance rate (K) of 200 mL/min and a blood flow rate (Qb) of 300 mL/min, what volume of the blood will be cleared of urea in 1 minute?

- A. 100 mL
- B. 200 mL
- C. 300 mL
- D. 500 mL

Answer: B

Explanation:

A dialyzer's clearance rate for a particular solute indicates the volume of blood from which the solute will be removed per unit time. It is usually expressed as a K value in mL/min. Thus, with a K of 200 mL/min for urea, 200 mL of the 300 mL blood flowing through in 1 minute will be cleared of urea in 1 minute. Of course, blood is continually recirculated through the dialyzer so a considerable amount of urea may be removed. Blood flow rate (Qb) may be increased to lessen the time of dialysis, but there is a rate limit due to the amount of blood that can flow through the needle in the patient's vascular access. Dialysis flow rate (Qd) may also increase clearance but to a lesser degree.

Question: 10

To determine the most accurate clearance rate of a particular solute, one should:

- A. use water instead of blood.
- B. use a large-molecular-weight molecule.
- C. reduce the manufacturer's stated rate by 10%.
- D. measure the solute concentrations of blood going into and out of the dialyzer.

Answer: D

Explanation:

The manufacturer's stated clearance for a particular solute is based on laboratory analysis of watery fluids that only approximate the rheological properties of blood. The actual value may differ by $\pm 10\%$ – 30% . Urea is the solute most frequently employed. The true clearance may be calculated by measuring the concentration of the solute going in and coming out of the dialyzer. The formula for dialyzer solute clearance is: $K = (C_{b_i} - C_{b_o}) / C_{b_i} \times Q_b$, where K is the clearance, C_{b_i} is the inlet solute concentration (arterial), C_{b_o} is the outlet solute concentration (venous), and Q_b is the blood flow in mL/min. Increasing the dialysate flow rate (Qd) may slightly improve the solute clearance, but this is not a part of the formula.

Question: 11

All of the following substances are added to the dialysate EXCEPT:

- A. bicarbonate.
- B. chloride.
- C. sodium.
- D. phosphate.

Answer: D

Explanation:

The dialysate composition contains ions and glucose in concentrations similar to those of the blood. Usually two concentrates are prepared: acid (contains sodium, potassium, magnesium, calcium, chloride, and glucose) and bicarbonate buffer. Acetic acid is added to the acid solution to adjust the PH. The two concentrates are then mixed and diluted with treated water. The concentrates come in three different formulations so it is important to mix the compatible ones. The final concentrations of the ions are adjusted, depending on whether one wishes to raise or lower their blood concentration. Thus, for a hyperkalemic (high potassium) patient, one might not add any potassium or keep it lower than the blood concentration. Phosphate is not routinely added to the dialysate.

Question: 12

Sodium modeling refers to:

- A. changing the concentration of the dialysate sodium during the course of dialysis.
- B. injecting sodium chloride directly into the patient's vein.
- C. adjusting the sodium concentrate of the dialysate with normal saline.
- D. none of the above.

Answer: A

Explanation:

Usually sodium concentration in the dialysate is kept the same or similar to that of the blood: 135-145 mEq/L However, higher concentrates are sometimes used at the outset to drive sodium into the blood and raise its concentration. This then enhances an osmotic fluid shift from the interstitial space into the blood and accelerates fluid withdrawal. Then the sodium concentration is slowly reduced during the course of the dialysis, a process called sodium modeling. Caution must be used when performing this procedure since increased thirst and hypertension may result. The physician usually prescribes the concentration of sodium and the speed with which it is reduced.

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