Test Your Knowledge: Solute and Water Transport in Peritoneal Dialysis

Peritoneal dialysis (PD) is an effective treatment for patients with chronic kidney failure. In a recent *AJKD* Special Article, Ramesh Khanna reviews solute and water transport physiology in PD, and discusses several clinical cases to apply those principles. Test your knowledge with these questions prepared by *AJKD* Blog contributor, Sean Kalloo.

1. Which one of the following statements regarding the pores in the peritoneal membrane (PM) is correct?

    A. The PM contains predominantly large pores used for transport of albumin and water
    B. The PM contains small pores which only allow for the movement of solute-free water
    C. Aquaporin 1 channels, present in the mesothelial cells and capillaries, allow for transport of solute-free water
    D. Macromolecules such as albumin move rapidly through the PM, equilibrating in about 1 hour

2. Patient is a 55-year-old female with a past medical history of ESRD on PD for the past 2 years, CAD and HTN. She is status post cardiac catheterization with minimal contrast exposure and is being admitted for overnight monitoring. She is normally on CAPD with 4 exchanges daily. Interventional cardiology consults nephrology for PD management and requests for aggressive volume removal. The nephrology fellow changes the patient to CAPD with 2L exchanges Q1 hour with 4.25% solutions. In the morning, the patient reports feeling extremely thirsty and her serum sodium is noted to be 158. Why is the patient hypernatremic?

    A. The contrast load was likely hypertonic and resulted in elevating her serum sodium
    B. The 4.25% solution per se rather than the rate of exchanges will cause hypernatremia
    C. Due to the short duration of dwells and the use of a hypertonic dialysis solution, more water than sodium was removed from the extracellular fluid compartment

3. A 23-year-old male with a past medical history of ESRD from FSGS starts on peritoneal dialysis. He has a normal BMI and his vitals are normal. He is noted to be an average transporter. You are seeing the patient during his monthly visit and notice that his serum bicarbonate is 18. He is on CAPD with four 2L exchanges daily. You notice that his serum bicarbonate has ranged from 18-20 for the past 5 months. He reports that he is not adherent to his fluid restrictions and he frequently has to use red bags (4.25% solutions) due to edema. What is a possible contribution of his peritoneal dialysis to his chronic metabolic acidosis?

    A. As there is no bicarbonate in PD fluid, he is failing to receive any therapy for his acidosis
    B. High fluid intake is diluting his serum bicarbonate to a degree to induce acidosis
    C. Bicarbonate losses through convection are substantial given high UF rates due to use of hypertonic dialysis
    D. The 4.25% solutions have the highest lactate concentration of all the solutions, thus resulting in acidosis

4. Which of the following is true of icodextran?

    A. It allows for ultrafiltration via large pores
    B. It results in upregulation of aquaporin 1 leading to water movement
    C. It can frequently result in sodium sieving
    D. It causes ultrafiltration by colloid osmosis

5. What is the predominant way of removing potassium during peritoneal dialysis?

    A. Convection
    B. Use of low potassium dialysis solutions
    C. Diffusion

Quiz prepared by Sean Kalloo, AJKD Blog Contributor

To view the Khanna Special Article **abstract** or **full-text** (subscription required), please visit **AJKD.org**.

Solutions to *AJKD* Blog's Test Your Knowledge: Solute and Water Transport in Peritoneal Dialysis

1. **C. Aquaporin 1 channels, present in the mesothelial cells and capillaries, allow for transport of solute-free water**

   While large pores do transport albumin, water movement does not occur via these pores. In addition, the large pores are much rarer in the peritoneal membrane and equilibration of macromolecules such as albumin can take up to 24 hours. Small pores do not allow for the movement of solute-free water - only aquaporin 1 allows for this. Water does move through small pores in conjunction with electrolytes and small molecules, but movement through small pores is driven by solute transport as well.

2. **C. Due to the short duration of dwells and the use of a hypertonic dialysis solution, more water than sodium was removed from the extracellular fluid compartment**

   Most iodinated contrast agents still in use today are iso-osmolar and the volume of contrast given was noted to be minimal. Even in instances where hyper-osmolar contrast agents are used, adding the material to the plasma should not raise the serum sodium concentration, but rather would tend to reduce it by obligating water diffusion from the intracellular space. While the 4.25% dialysis solution does have a high osmolarity, it will not result in hypernatremia if the dwells are of adequate duration. This is because any elevation of sodium will be dissipated by equilibration with the dialysis solution sodium concentration. In this current scenario, the short dwells with hypertonic dialysis solutions resulted in the phenomenon of sodium sieving. In this situation, there is a dissociation between the amount of water and sodium transported over the peritoneal membrane. In the early part of a dwell with a hyperosmolar solution, the osmotic gradient is the highest, and water transport through aquaporins is maximized. Due to the short nature of dwells, this can lead to water loss in the dialysate and subsequent hypernatremia.

3. **C. Bicarbonate losses through convection are substantial given high UF rates due to use of hypertonic dialysis**

   The use of hypertonic dialysis solutions can lead to bicarbonate losses through convection due to solute drag with aggressive ultrafiltration. As water follows the osmotic gradient, it can pull other solutes (such as bicarbonate) with it, and

bicarbonate can be lost in the effluent. The normal BMI of the patient suggests that a 2L dwell volume should be adequate. Additionally, if he is an average transporter then CAPD should not lead to significant problems with clearance or ultrafiltration if the prescription is adequate. The degree of reduced bicarbonate level could not be explained by simple dilution. Despite the differences in glucose concentration in the solutions, all PD solutions contain 40 mEq/L of lactate which is converted to bicarbonate in the liver.

4. **D. It causes ultrafiltration by colloid osmosis**

   Icodextran is a macromolecule which is unable to cross the capillary walls and results in colloid osmosis. Icodextran is a unique macromolecule PD solution. Patients often will refer to them as the "purple" bags, and the concentration of icodextrin is 7.5 g/L. Compared to dextrose solutions (which are hyperosmolar), icodextrin is iso-osmolar (285 mOsm/L), and therefore, does not depend on osmosis for ultrafiltration. Due to its large size, it is unable to cross the capillary walls, and creates oncotic pressure to pull fluid into the dialysate. Large pores primarily result in loss of albumin and not free water. Icodextran does not result in aquaporin upregulation; the glucose-based PD solutions do. Lastly, because of the inconsequential free water transport with icodextran through aquaporin 1, no sodium sieving occurs.

5. **C. Diffusion**

   Potassium is cleared by diffusive clearance. It moves down its concentration gradient across the capillary membrane, similar to potassium removal with hemodialysis. Convective removal of potassium does occur, but is minimal due to low plasma concentrations; thus, minimal amounts of potassium in each liter of convective fluid is lost. PD solutions are free of potassium to allow for the maximum diffusive gradient.

Quiz prepared by Sean Kalloo, AJKD Blog Contributor

To view the Khanna Special Article **abstract** or **full-text** (subscription required), please visit **AJKD.org**.