Baxter Sponsorship Disclosure

I am employed by Baxter Healthcare Corporation to present the material on Baxter’s behalf.
Objectives

01 Describe how to perform the Peritoneal Equilibration Test (PET)

02 Identify the four types of peritoneal membranes

03 Examine five factors that might affect the accuracy of the PET
What is a PET? Although there are many types of pets, we will be discussing the Peritoneal Equilibration Test.
Background information about the PET –
1983 – Dr. Twardowski and colleagues began measuring peritoneal transfer rates
1987 – Dr. Twardowski and colleagues published “Peritoneal Equilibration Test” in Peritoneal Dialysis Bulletin
1990 – Dr. Twardowski published “The Fast Peritoneal Equilibration Test” in Seminars in Dialysis
2000 – Dr. Mujais and colleagues published an article detailing procedure for a modified peritoneal equilibration test in Peritoneal Dialysis International

Value of the PET

- Essential component in monitoring peritoneal membrane health
- May help individualize dialysis prescription
- May help predict response to dialysis therapy
Prior to doing the PET, we have no idea of what type of membrane a patient has. We can make a supposition based on the drain volume of a 4-hour dwell of a 2.5% 2.0 L exchange, but again, this will only be a supposition.

Depending on the membrane classification, you can expect a certain drain volume. If a patient has a low membrane and they are on the right prescription but is not draining out the expected volume, this should cause you to investigate more thoroughly as to the cause of this inadequate ultrafiltration.

If a patient is on the correct prescription based on his membrane classification, but the actual 24-hour kinetics indicate that the patient is not being adequately dialyzed, this might prompt you to investigate if the patient is truly being compliant with his therapy, provided everything else is ruled out, i.e. a malfunctioning catheter.

Sometimes depending on the virulence of the invading organism, the time between the infection and treatment, and the appropriateness of the treatment, the peritoneal membrane can be damaged to the point that the solutes can not adequately diffuse across it, thus resulting in inadequacy.

In each of the described instances, doing a PET can be of great benefit.
• Remember, one of the principles of dialysis is diffusion. Diffusion causes solutes to move from an area of greater solute concentration to an area of lesser solute concentration. Since the blood compartment is saturated with urea and creatinine, and the dialysis solution in the peritoneal cavity is not, the solutes in the blood will move across the peritoneal membrane in an attempt to equilibrate. The rate at which this happens is one of the parameters the PET measures
• Secondly, based on the same principle, the peritoneal cavity is filled with high concentrations of glucose and in an attempt to equilibrate, the glucose will move in the opposite direction over into the serum. So the PET measures the rate at which the glucose is absorbed from the peritoneal cavity
• Lastly, the PET will measure the net ultrafiltration after the 4-hour dwell of a 2.5% 2 L exchange
Supplies you will need to demonstrate a PET include the following:

• Patient simulator bag
• Two **CAPD** Peritoneal Dialysis Solution bags
• Four plain red top test tubes
• One serum separator test tube
• Spring scale, used for measuring 200 mL samples
• IV pole or someway to hang **CAPD** Peritoneal Dialysis Solution bag during the demonstration
• Syringe with needle
• Betadine prep pads

It is very important to label all of the PET samples correctly and to measure volume correctly.
• Patient should be instructed to roll from side to side with each 400ml infusion to ensure dialysate comes in directed contact with all aspects of the peritoneum.
• Patient rolls from side to side as follows:
  2 mins - 400 ml
  4 mins - 800 ml
  6 mins - 1200 ml
  8 mins - 1600 ml
  10 mins - 2000 ml
• After the patient has completely filled and rolled from side to side, a sample is taken. This is known as their ZERO HOUR DWELL. The zero hour dwell gives you information about how much dialysate was left in the peritoneum after the patient was drained
Procedure for Standard PET

Key points:
- At 0 Hour Dwell Times, collect dialysate samples as follows:
  - Drain 200 mL dialysate back into the fill bag and mix sample by inverting bag 2-3 times
- Repeat at the 2 Hour Dwell, drain 200 mL as above
- Using aseptic technique, withdraw 10 mL dialysate sample and place in red top tube
- Re-infuse remaining 190 mL to patient

Procedure for Standard PET

Key points:

• At 4 hours – with the patient in upright position – completely drain exchange for no less than 20 minutes

• Mix sample: invert bag 2-3 times

• Withdraw a 10 ml dialysate sample and place into a red top tube

• Weigh drain bag and record volume drained

This is a timed study which requires you to get a dialysate sample at 0, 2 and 4 hours. The solutes in each sample are then compared to the 2 hour serum sample to determine the equilibration ratio.
So, with the information contained in a PET and the understanding of peritoneal membrane transport (vascular surface area), clinicians have information that may assist in the development of an appropriate PD modality such as APD or CAPD, and the dwell times of an APD modality. This chart is a high-level graph of the relationship between the underlying PET category and membrane function.

Higher transporters will have more rapid diffusion of toxins into the dialysate and, therefore, higher rates of toxin clearance- but also higher rates of absorption of the osmotic agent which challenges the ultrafiltration result of the exchange- these higher transport patients may be better suited for shorter dwell time exchanges provided by cycler therapy.

On the other hand, the lower transporter have less vascular surface area to diffuse toxins into the dialysate so less rapid clearance of toxins but a more sustained UF. These patients may require longer dwell times.

This demonstrates the usefulness of the PET- to provide clinicians with an additional understanding of the underlying peritoneal membrane physiology in which PD therapy is based.
The PET graph on the left shows the various diffusion curves— from a rapid transporter to slower transporter. It is important to remember that these transport categories correlate to the peritoneal membrane vascular surface area amenable to diffusion. So the higher transporters have larger vascular surface area, the lower transporters have lower vascular surface area.

So, it is important to realize that the PET is a test that helps us understand the internal peritoneal membrane’s anatomy in terms of its vascular surface area. This understanding of the vascular surface area and rate of diffusion can assist clinicians in the development of PD prescriptions.
The membrane classification is determined by the 4-hour D/P of creatinine. The 0-hour data gives information about the amount of dialysate left in the peritoneum after you had drained the patient. The 2-hour data gives information about how transport happens over a short dwell and is of particular importance for an APD patient. The 4-hour data is what the membrane is classified by glucose absorption is also measured by the PET. The 2-hour and 4-hour dialysate glucose is divided by the 0-hour glucose. If you know how much glucose you started with and how much you have left in the dialysate at 2-hour and 4-hour this tells you how much has been absorbed.
This slide is showing you the actual calculation of the 4-hour D/P. If the dialysate creatinine was 6.1 and the plasma creatinine was 6.1, this would indicate that the patient is 100% equilibrated, in other words, all the dialysis that can take place at this point has taken place. This particular 4-hour D/P shows that the creatinine is 68% equilibrated. Another way of saying this is that 68% of the serum creatinine in now in the dialysate after the 4-hour dwell.

If you know how much glucose you had initially, which is your 0-hour dialysate glucose or D₀, then dividing you 2-hour and 4-hour dialysate glucose by the 0-hour glucose tells you how much was still in the peritoneal cavity at that time. Simply do the math and you can tell how much had been reabsorbed into the blood.
### Peritoneal Membrane Characteristics

<table>
<thead>
<tr>
<th>Membrane Type</th>
<th>4-Hr D/P Creatinine</th>
<th>Solute Transport</th>
<th>UF in 4 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>0.82 – 1.03</td>
<td>Fast+</td>
<td>Poor</td>
</tr>
<tr>
<td>High-Average</td>
<td>0.65 – 0.81</td>
<td>Moderately fast</td>
<td>Fair</td>
</tr>
<tr>
<td>Low-Average</td>
<td>0.50 – 0.64</td>
<td>Moderately slow</td>
<td>Good to very good</td>
</tr>
<tr>
<td>Low</td>
<td>0.34 – 0.49</td>
<td>Slow</td>
<td>Very good</td>
</tr>
</tbody>
</table>

*At 4 hours, shortened dwell times enhance solute removal in patients with high transport/equilibration ratios.*

Membrane transport characteristics are fundamental to appropriate prescription. Note that low transporters have high D/D₀ glucose and low D/P₇ which means they UF well, but may not clear solutes as well. High transporters are just the opposite as they have low D/D₀ glucose and high D/P₇ meaning they clear solutes well, but may not UF as well.
The reason why you want to wait for at least a month before you do the PET is due to the inflammatory response that occurs with the membrane once this hypertonic glucose is added to the peritoneal cavity. The membrane becomes more porous and thus more solutes diffuse across the membrane, resulting in a false high clearance. It takes about a month for the peritoneal membrane to settle down after being exposed to this hypertonic glucose. Therefore, it is recommended that you wait until the patient has been on the therapy for one month and is stable before you do the PET. It will take approximately five hours of the patient’s time, not to mention your time, so why would you want to do a preliminary PET only to have to repeat it again?
Careful assessment of patient parameters during the training period is essential. Volume of urea distribution and residual kidney function can be easily determined; however, accurate assessment of peritoneal transport type is more difficult due to inflammatory changes that may occur during the first month. Therefore, during training, careful assessment of drain volumes following a 4-hour dwell using 2.5% dextrose, 2.0 liter fill volume can help in estimating transport properties.
With peritonitis, the membrane is inflamed and the pores are more porous resulting in greater solute clearance. This will yield a false positive high transport rate. The PET should not be performed for four weeks after an episode of peritonitis. (KDOQI Clinical Practice Recommendations 3.5 – All measurements of peritoneal transport characteristics should be obtained when the patient is clinically stable and at least one month after resolution of an episode of peritonitis.)
Interpreting PET Results

- Make sure the data makes sense
- Dialysate creatinine should be increasing with dwell time
- 0 hour dialysate glucose should be greater than 2000 mg/dl and then decrease with dwell time
- PET classification based on 4-hour D/P
- 4-hour D/P’s and D/D0 should be identical or within one standard deviation
Key metrics to review in your PET data. The BUN and creatinine should increase over time. Glucose should start at >2000 mg/dl and then decrease over time. The 4 hour dialysate BUN and creatinine should be less than the 2 hour serum value.
Now we are going to discuss interpreting the results of the PET, and we will do some problem solving.

What is wrong with this PET?

- The 0-hour glucose is too low if a 2.5% PD solution was used
- Was this patient drained completely prior to initiating the PET? This also is revealed in the results of the 0-hour creatinine (elevated)

Before beginning to interpret PET results, make sure that the data makes sense.

- The dialysate creatinine should be increasing with dwell times and the glucose should be decreasing with the dwell times. The PET classification is based on the 4-hour D/P creatinine
- In these results, the 4-hour creatinine and glucose classifications are different, but they are within one standard deviation of each other, so this would be classified as a high-average transporter
What's wrong with this PET?

Look at the data, it doesn't make sense. These results are physiologically impossible. It looks as if the 2-hour and 4-hour samples were switched and were labeled incorrectly. This PET will have to be repeated.
This is an example of a good PET.
A 2 L fill volume is the standard fill volume for a PET. In order to do the PET according to Dr. Twardowski’s procedure, they will have to use a 2 L fill volume. If using modeling software, you can calculate results based on a simulated PET. To ensure that patients do not arrive late, tell them up front how long the PET takes and that it will probably have to be repeated if they are not back on time. You may also have the patient scheduled to come back approximately twenty to thirty minutes before the sample needs to be drawn.

Caution with the use of PET in patients with serum glucose concentration > 300 mg/dL, as this can lead to unreliable results. Hyperglycemia decreases the dialysate to plasma glucose (osmotic) gradient, thereby reducing transcapillary ultrafiltration rate as well as the diffusion of glucose. Korbet S, Rodby R. Causes, Diagnosis, and Treatment of Peritoneal Membrane Failure. In: Heinrich Wm. Ed. Principles and Practice of Dialysis. 2nd ed. New York, NY; Lippincott Williams & Wilkins: 1998:185-206.
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Thank You

Annual Dialysis Conference 2018

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