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Techniques in Vascular and Interventional Radiology

Image-Guided Approach to Peritoneal Dialysis Catheter Placement

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Peritoneal dialysis (PD) is a vastly underused form of renal replacement therapy that offers great flexibility to the patient, breaks the cycle of tri-weekly visits to a hemodialysis center, and is associated with fewer interventions to maintain functional dialysis access. PD catheter placement allows for urgent initiation of dialysis and minimizes the unnecessary use of temporary vascular access catheters. Image-guided placement of a PD catheter by interventional radiologists that combines ultrasound and fluoroscopy is an elegant, cost saving, safe, less invasive, and at least as effective an option when compared with traditional surgical placement.

KEYWORDS Peritoneal dialysis, Fluoroscopy, Ultrasound, Interventional radiology

Introduction

Peritoneal dialysis (PD) is a form of renal replacement therapy (RRT) used to treat patients with end-stage renal disease (ESRD), manage patients with acute kidney injury in need of renal support, or aid in ultrafiltration in patients with heart failure resistant to diuresis. The first accounts of PD to treat uremia in humans date to the early 20th century when George Ganter used it to acutely treat a uremic woman in 1923.[1] Currently, PD is a vastly underused modality with only a 6.85 % prevalence rate in all patients with ESRD as of 2013.[2]

Although traditionally performed by surgeons, percutaneous image-guided PD catheter placement by interventional radiologists is becoming more commonplace. Comparison studies between the image-guided percutaneous approach and laparoscopic approach has shown a similar or slightly lower complication rate, faster patient recovery, and decreased cost with the former approach.[3,4] PD uses the peritoneal membrane to maintain adequate clearance and ultrafiltration. In a normal patient, fluid in the peritoneal space that is filtered from capillaries and absorbed through lymphatics at a rate of 1 L/day.[5] When the peritoneum is used for dialysis, peritoneal pores allow for solute transfer through diffusion and convection, and ultrafiltration. The movement of solutes and water is dependent on an intact peritoneum (eg, a peritoneum that is heavily scarred from any prior intrabdominal trauma may be ineffective), access to the peritoneum through the insertion of a dialysis catheter, and the infusion of electrolyte and polysaccharide containing solutions that will establish solute and osmotic gradients.[6]

There are several types of PD that can applied to a patients unique needs, making it a very versatile and attractive form of RRT (Table 1).[6] PD can occur as continuous or intermittent forms. Continuous ambulatory PD uses multiple manual daytime exchanges with an overnight dwell to provide continuous clearance. Automated PD (APD) requires a peritoneal cycler that performs exchanges, usually during the nighttime. Patients on APD can either have a daytime dry abdomen or a long daytime dwell. In addition to these modalities, there are other forms of intermittent PD that create alternating periods of dry vs wet abdomens. The specific type of PD that a patient uses depends on many factors, including a patient's membrane characteristics (how fast solute exchange and ultrafiltration occur), dialysis adequacy, and patient comfort and preference. The volume of dialysate depends on patient size. Average fill volume is 2 liters and the daily total volume ranges from 10 L for continuous ambulatory PD to 14 L for APD.

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Table 1 Peritoneal Dialysis Modalities.

Modality	Comments
CAPD	Uses manual exchanges to maintain continuous volume in the peritoneum
APD	Cycler-assisted dialysis that is usually conducted overnight
CCPD	Dialysate remains in the abdomen throughout the day
IPD	Daytime dry abdomen
TPD	Incomplete draining with residual fluid left over often to help with abdominal pain on drain

CAPD, continuous ambulatory peritoneal dialysis; CCPD, continuous cycler peritoneal dialysis; IPD, intermittent peritoneal dialysis; TPD, tidal peritoneal dialysis.

Approaches

PD catheters are inserted by interventional radiologists, surgeons, and nephrologists. Approaches vary by specialty and operator preference and include: image-guided (fluoroscopic ± ultrasound), blind, open surgical, and laparoscopic.[7] The following overview will discuss image-guided placement by interventional radiologists.

Patient Evaluation

Relevant medical and surgical history should be reviewed before scheduling a patient for PD catheter placement. This includes obtaining a complete blood count, chemistry profile, and checking the patient's coagulation status. If there are any concerns about abdominal anatomy or history of complex surgical intervention that would hinder catheter placement, a computed tomography may be obtained beforehand. Presence of underlying adhesions, surgical mesh, hernias, cesarean section scars, organopexy, etc. may alter the procedural approach.

Patient preference regarding the skin exit site of the catheter is also taken into account. Although placement of a left-sided catheter may be preferred for most right-handed persons, the determination of the skin exit site is useful to maximize patient comfort and prevent external compression of the catheter. This is, especially important to avoid placing the catheter close to or below the belt line in patients with a significant abdominal pannus. The preferred catheter exit site is thus marked on the skin with the patient sitting or standing before the patient is brought into the room.

Anesthesia and Antibiotics

In most cases, the procedure can be performed under moderate sedation using a combination of fentanyl and midazolam. At our institution, most physicians prefer general anesthesia, particularly in patients where peritoneal entry may be challenging or uncomfortable (owing to habitus).

Administration of antibiotic prophylaxis is left to the discretion of the operator, as the current data are mixed. However, 4 studies have shown a decrease in peritonitis in patients receiving preoperative intravenous prophylaxis.[8] If the operator chooses to pursue prophylaxis, the most commonly used agent is cefazolin. The prophylactic dose is weight based: 1 g for patients under 80 kg, 2g for patients 81-120 kg, and 3g for patients over 121 kg.

Patient Preparation and Peritoneal Entry

A wide prep with antiseptic solution is made from the costal margin to the iliac crest and across the midline. Most operators proceed with catheter placement based on predetermined landmarks and choose the peritoneal entry site usually 4-5 cm superolateral from the umbilicus.[9] However, ultrasound-guided needle placement using a high-frequency linear transducer can be helpful to identify the thickest aspect of the rectus abdominis through which to pass the catheter (Fig. 1). This can minimize dialysate leakage, migration, and the likelihood of infection. One of the concerns with fluoroscopy only peritoneal entry is bowel injury. Ultrasound-guided needle placement usually provides clear visualization of the needle tip after it traverses the parietal peritoneum, visualized as an echogenic line deep to the hypoechoic body of the rectus muscle. Ultrasound guidance can also minimize the risk of inadvertent inferior epigastric artery injury (Fig. 2).

There are many needle choices to gain initial access to the peritoneum. A 22-gauge Chiba needle or 21-gauge micropuncture needle is commonly used. A 21-gauge 15 cm long echogenic Chiba needle (Cook Medical) can provide added support in patients with a large body habitus to make a relatively long pass through the rectus muscle, thus achieving a tunneling effect. An alternative to

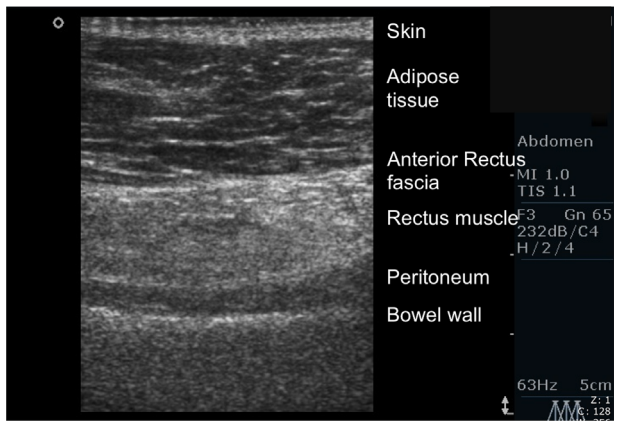

Figure 1 Grayscale ultrasound image obtained with 10 MHz probe illustrates layers of the abdominal wall.