8 Advanced Laparoscopic Insertion of Peritoneal Dialysis Catheters

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Introduction

One in ten adult Americans, or an estimated 20 million people, have some form of chronic kidney disease [1]. From the years 1980 through 2009, the incidence of end-stage renal disease (ESRD) requiring renal replacement therapy (RRT) increased by 600% [1]. More interesting than these statistics is the fact that the use of peritoneal dialysis (PD) has been steadily declining in the United States [2, 3]. In 1980, the incidence of PD in patients with ESRD was 15% while current reports estimate that only 7% of patients with ESRD are utilizing this form of dialysis [2, 3].

A variety of hypotheses have been proposed to help understand the decline in the use of PD nationally. Most of these explanations center around the perceived, or even real, differences in morbidity and mortality rates between those patients who undergo hemodialysis (HD) and those patients who are started on PD [2–4]. However, it has been our experience that finding surgeons who are willing to place peritoneal dialysis (PD) catheters is even more of a contributing factor.

Prior to the publication of best-demonstrated practices of PD catheter placement, this was a procedure that was fraught with high rates of non-function. These poor results subsequently led to a decline in surgeon and patient enthusiasm for this form of dialysis. Indeed, the long-term success of PD is predicated on the proper placement of a PD catheter. In this chapter, we will discuss the indications for laparoscopic PD catheter placement, our surgical technique, and outcomes with this type of renal replacement therapy.

Indications and Patient Selection for Laparoscopic PD Catheter Placement

The transition of the patient with chronic kidney disease (CKD) to dialysis therapy is an often overwhelming and life changing event for patients and their families alike. Our role as surgeons is to make this transition as seamless as possible. The best way to ensure successful initiation of PD is early assessment of the patient with CKD [4]. In order for this evaluation to occur, surgeons must work in coordination with the PD team, including the nephrologists and the PD nurses, so that patient referral and evaluation is not delayed.

In general, patients should be evaluated by a general surgeon well in advance of the estimated time of dialysis initiation. PD catheter placement and the initiation of PD are rarely performed on an emergent basis. Without proper foresight, patients who originally planned to start with PD may unexpectedly experience a precipitous

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S. Haggerty (ed.), *Surgical Aspects of Peritoneal Dialysis*, DOI 10.1007/978-3-319-52821-2_8

decline in their renal function. In such situations, emergent HD is initiated and the transition thereafter from HD to PD is logistically challenging [4]. Therefore, it cannot be overemphasized that careful planning and communication with all members of the team are crucial.

The advantages of the laparoscopic approach to PD placement are multifold and include techniques to prevent catheter tip migration and catheter occlusion, management of intra-abdominal adhesions, and identification and possible preemptive repair of abdominal wall hernias not previously diagnosed [4]. Integrating laparoscopy into the surgical placement of PD catheters helps to minimize the risk of long-term complications which in turn provides for durable, and uninterrupted, access to the peritoneal cavity. Because of these advantages, we firmly believe that laparoscopic PD placement should be the standard of care for all ESRD patients able to tolerate general anesthesia and pneumoperitoneum.

Laparoscopic PD Catheter Placement Technique

This section will detail the operative technique for PD catheter placement at our institution. Like all surgical procedures, there is more than one safe and effective technique for PD catheter placement and our method should be adapted for surgeon comfort with the described techniques and institutional restrictions. In summary, the steps to successful PD catheter placement include:

1. Use of a double-cuff Tenkhoff type catheter
2. Careful determination of insertion incision, subcutaneous tunnel configuration, and exit site location
3. Paramedian insertion site
4. Rectus sheath tunneling of the catheter
5. Prophylactic omentopexy (as needed)
6. Prophylactic adhesiolysis (as needed)
7. Location of the deep catheter cuff within the rectus sheath
8. Location of the superficial subcutaneous catheter cuff at least two centimeters from the exit site

Patient Positioning and Induction of Anesthesia

Patients are brought to the operating room and placed supine on the operating room table. General anesthesia is induced at the discretion of the anesthesia team with the usual considerations for those patients with ESRD. Unless contraindicated by the presence of a graft or fistula, we prefer to tuck both arms. Tucking the arms is particularly helpful when laparoscopic adhesiolysis is necessary as this facilitates the ability of both the surgeon and the camera operator to be on the same side of the table. A footboard is mandatory, as the patient will eventually be placed into the steep reverse Trendelenburg position. The abdomen is then widely shaved, prepped, and draped.

Although there are many different catheters available, we strictly utilize the basic Tenckhoff type double-cuffed catheters with a straight segment or swan neck arc bend between the cuffs. The decision as to which type of catheter we use is patient dependent. The straight catheter is used far more often in our practice, mainly due to patient body habitus. An important consideration for catheter type is the location of the patient's belt line. Ideally, the catheter should exit the abdominal wall either above or below the belt line for patient comfort. Similarly, the presence of incisions, ostomies, and more commonly skin folds in obese patients must be taken into consideration when determining the exit site in order to minimize the risk of catheter malfunction or infection.

Catheter Mapping

Catheter mapping, just like venous mapping for arteriovenous fistula formation, is crucial to the success of PD catheter placement [5]. Some institutions prefer to use catheter stencils for this portion of the procedure. However, we prefer to use the catheter itself as a guide. There may be an inherent variability of the catheter lengths and dimensions based on the manufacturer of the

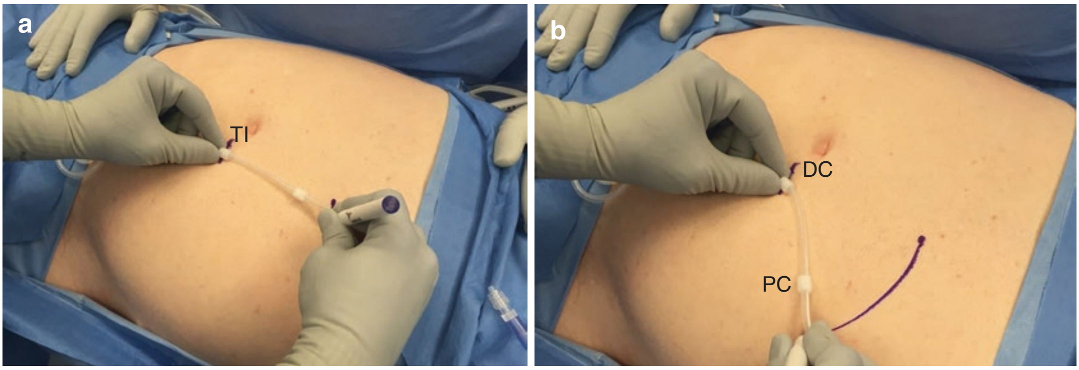

Fig. 8.1 Catheter mapping. The transverse incision (*TI*) is marked overlying the left rectus muscle (**a**). The distal cuff (*DC*) is held in place while an arc is made on the abdominal wall using the proximal cuff (*PC*) (**b**)

catheter. Therefore, only the stencil that corresponds with the particular catheter to be placed during surgery should be used to produce accurate preoperative mapping [5].

Regardless of which type of catheter is being placed, determining the location of the insertion incision for the intramuscular tunnel is the first step in PD catheter placement. Under sterile conditions, the tip of the curled portion of the catheter is placed overlying the pubis. Using gentle upwards traction, and taking care not to place undue tension on the catheter, the location of the distal cuff (that which is closest to the curled portion) is marked with a sterile marker overlying the rectus muscle. Traditionally, this incision has been placed over the left rectus muscle but this location is dependent on prior surgical wounds, the presence of a stoma, and any existing skin breakdown. Should any of these conditions be present on the left side of the abdomen, then the PD catheter may be placed on the right side to minimize the risk of catheter malfunction and infection.

Next, and while still using the catheter as our guide, the planned exit site is marked out. When a Swan neck catheter is placed, the exit site is determined by the natural curve of the catheter into the lower abdomen, again keeping in mind the location of the belt line, incisions or skin folds. Determining the exit site with a straight catheter is a bit more complex. First, the catheter is grasped two centimeters above the proximal cuff while the distal cuff is held in place at the previously marked rectus muscle incision site. Moving the proximal cuff as if it were a compass, a gentle arc is created

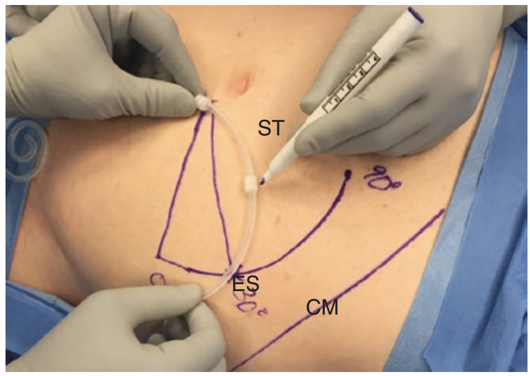

Fig. 8.2 Exit site marking. The exit site (*ES*) is at a 30° angle to the distal cuff /transverse incision. In order to determine the trajectory of the subcutaneous tract (*ST*), the catheter is grasped four centimeters from the proximal cuff and aligned with the previously identified ES. Care is taken to ensure that the ES is far enough away from the costal margin (*CM*)

in the upper abdomen using a sterile marker from 90° to 0° with respect to the distal cuff. A point 30° from the distal cuff is then marked on the arc, which serves as the planned exit site (Fig. 8.1).

In order to minimize the potential for cuff extrusion, it is imperative to keep the subcutaneous cuff at least two centimeters from the exit site. To this end, the catheter is grasped four centimeters from the proximal cuff, a gentle bend is created with the catheter, and this point is aligned with the previously determined exit site (Fig. 8.2). This line defines the planned path for subcutaneous tunneling of the portion of the PD catheter between the proximal and distal cuffs, while

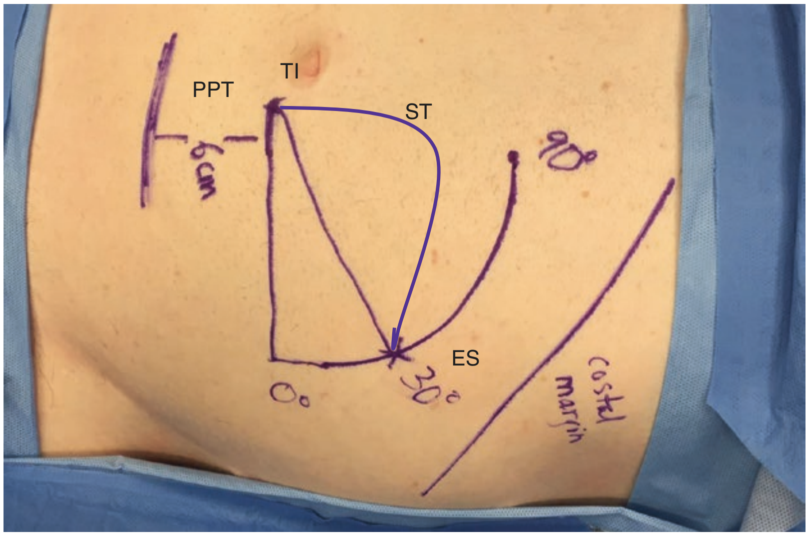

Fig. 8.3 Preoperative mapping. The landmark for preoperative mapping is the transverse incision (*TI*). Distal to the TI is the site of the preperitoneal tract (*PPT*) while proximal to the TI is the catheter exit site (*ES*) and subcutaneous tract (*ST*) for the proximal portion of the catheter

keeping the proximal cuff well away from the skin. In planning the location of the catheter exit site, it is imperative to always be cognizant as to the location of the costal margin so that this position is not too close to the rib.

Finally, the length of the rectus sheath tunnel must be marked. A six-centimeter rectus sheath tunnel is normally developed, although a shorter four-centimeter tunnel may be required for obese patients. The proximal extent of the intramuscular tunnel is the planned location of the deep PD catheter cuff. A ruler is used to mark 4–6 cm distal to this site (towards the pubis) based on the patient's body habitus (Fig. 8.3).

Entrance into the Abdominal Cavity

Unless otherwise contraindicated due to previous surgery or skin issues, we prefer to place a five-millimeter trocar in the right upper quadrant. It is important to avoid periumbilical incisions, as this location does not provide for adequate visualization of the tunnel, and may lead to future hernia. Entrance into the abdomen is performed using a 5 mm, 0-degree scope as well as an optical viewing trocar. Once the abdomen has been accessed, CO_2 insufflation is begun and the 0-degree scope is switched out for a 30-degree scope. A careful diagnostic laparoscopy is performed.

Before the placement of additional trocars, the location of adhesions and/or previously undiagnosed hernias is appreciated. Additional 5 mm trocars are placed as necessary for adhesiolysis or herniorrhaphy. If no adhesions are present, then a second 5 mm port is routinely placed in the right lower quadrant. Further details regarding lysis of adhesions and concurrent hernia repair are described in further detail below.

Lysis of Adhesions

Adhesions lead to abdominal and pelvic compartmentalization that can cause incomplete dialysate drainage during PD. Similarly, such scarring can prevent visualization of the posterior abdominal wall where the intramuscular tunnel is to be created. For these reasons, adhesions in the pelvis and lower abdominal wall should be addressed at the time of PD catheter placement. Please keep in mind that excessive adhesiolysis is oftentimes not beneficial for PD catheter function and therefore more superior adhesions can be left alone [4]. Indeed, upper abdominal adhesions between the omentum and the abdominal wall may sometimes serve as a natural omentopexy, keeping the omentum out of the retrovesical space.

If indicated, our practice is to perform adhesiolysis using sharp dissection without the use of an energy device, if possible. Although this method is a bit more tedious, we feel that it minimizes the risk of thermal injury to other intra-abdominal structures. Previous abdominal or pelvic surgery should not be a deterrent to attempting laparoscopic PD catheter placement. However, it is important to realize that intra-peritoneal adhesions are sometimes so severe that the PD catheter cannot be safely placed. Therefore, the possibility that catheter placement may not be feasible should be discussed in detail prior to surgical intervention with any patient who has a history of previous major abdominal and/or pelvic surgery. Nevertheless, we do not feel that prior abdominal surgery is a contraindication to catheter placement as it is impossible to predict the extent of adhesive disease preoperatively [6, 7].

Omentopexy and Resection of Epiploic Appendages

Catheter obstruction or dislodgement is most often caused by the omentum falling into the retrovesicular space and less frequently by the epiploic appendages occluding the PD catheter. Because catheter obstruction is the most common reason for abandonment of PD for HD, it is imperative to preemptively address these causes at the time of PD catheter placement.

In order to determine if the patient requires an omentopexy, the patient is placed into the steep reverse Trendelenburg position. If the omentum falls into the retrovesicular space, then the omentum will have to be retracted out of the deep pelvis. It should be noted that omentopexy is at least equivalent to omentectomy for the management of the omentum in these cases. As omentopexy has decreased associated morbidity, it is the preferred option for the management of the omentum [4].

In order to perform an omentopexy, the patient is placed back into the supine position and a small stab incision is made in the left upper quadrant with an 11-blade scalpel. This incision is usually above the planned PD catheter exit site. The omentum is then retracted into the upper abdomen using a laparoscopic soft bowel grasper. A suture passer with a nonabsorbable suture is used to take several bites of the omentum. The suture is then grasped with a Maryland forceps and the suture passer is withdrawn. Through the same skin incision, but with a different trajectory through the fascia, the suture is handed back to the suture passer and brought out through the skin. The stitch is then used to secure the omentum to the abdominal wall and out of the pelvis (Fig. 8.4). Great care must be maintained in order to remain well away from the transverse colon during this portion of the procedure. The efficacy of the omentopexy is confirmed by placing the patient back into the steep reverse Trendelenburg position to ensure that the omentum no longer falls into the retrovesicular space. If the omentum still falls into the pelvis, then the omentopexy should be redone, either at a point superior to the original incision or with a larger bite of omentum secured to the abdominal wall.

Epiploic appendages are fat-filled projections most commonly found in the region of the sigmoid colon [4]. When small, these appendages do not interfere with PD catheter function. However, these attachments can be up to 15 centimeters in length. The longer the epiploic appendage, the more mobile it is, and the more likely it is to lead to PD catheter occlusion. When these structures are noted to interfere with PD catheter function, there are two options for their management. Firstly, the epiploics can be removed with the use of an energy device. A bowel grasper holds the appendage in place while the energy device is used to amputate it from the colon. Care must be taken to ensure that the site of resection is far enough away from the colon so that the colon does not sustain inadvertent thermal injury. These appendages should be removed either through a 10-mm port or with the assistance of a specimen collection bag if more than one appendage is removed. Far easier in our opinion is to simply secure one or two of the epiploics to the lateral abdominal wall in a manner, which is very similar to an omentopexy (Fig. 8.5). Again, through a two-millimeter stab incision, the suture passer and a permanent suture can be used to 'lasso' the distal epiploics and secure them to the upper and lateral abdominal wall. Again, great care has to be maintained when performing this procedure in order to prevent injury to the colon.

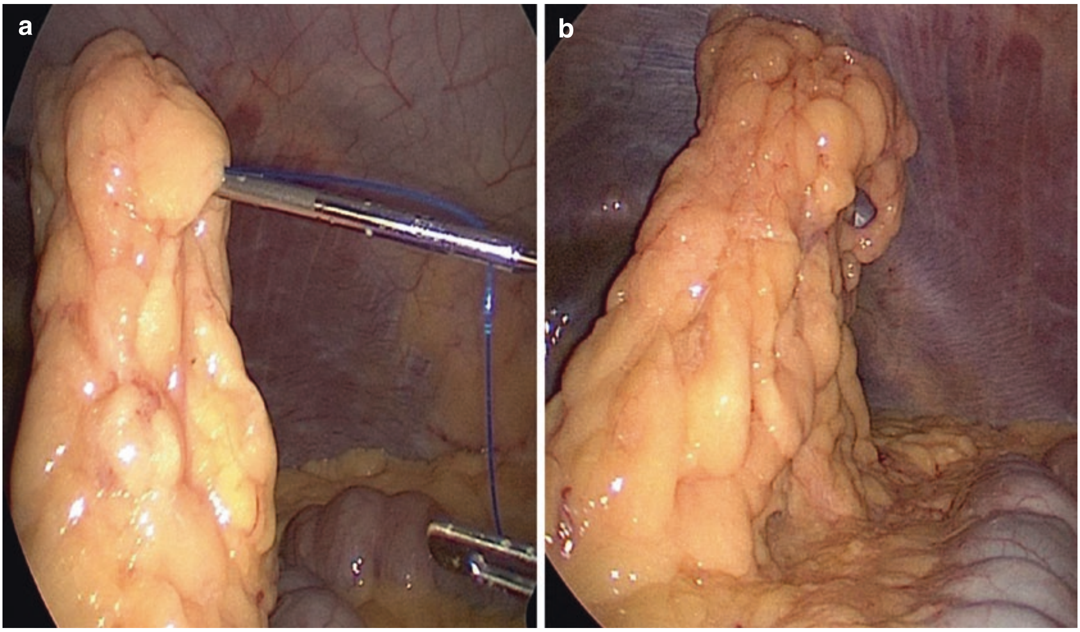

Fig. 8.4 Omentopexy. Omentum is grasped with a small bowel grasper into the left upper quadrant. A suture passer is passed through the omentum (**a**) which is then secured to the abdominal wall (**b**)

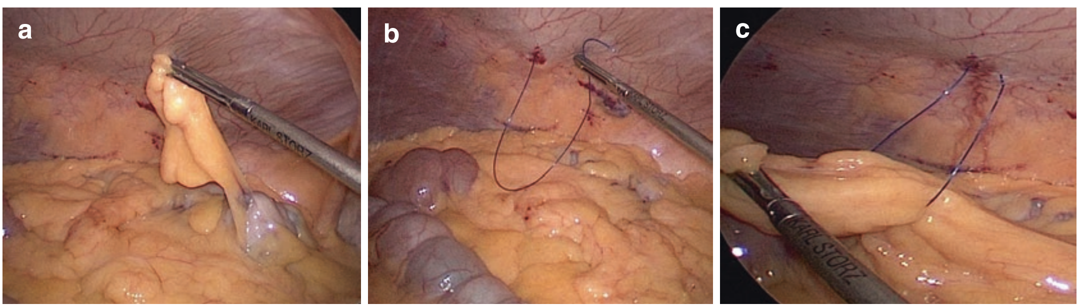

Fig. 8.5 Management of epiploic appendages. Large epiploics (**a**) are pulled up to the abdominal wall using a small bowel grasper. The suture passer is not passed through the epiploic itself. Rather, the epiploic is passed through a loop of suture (**b**) and secured to the abdominal wall (**c**). Care should be taken to ensure that the colon is identified and excluded from any epiploic lasso

Hernia Repair

Careful consideration must be given to repairing previously undiagnosed abdominal wall or inguinal hernias that are detected at the time of laparoscopy, due to the risk of hernia enlargement or symptom progression with the initiation of PD. The decision to proceed with hernia repair must be considered in the context of the specific risks and benefits of hernia repair in this patient population. Specifically, hernia repair with mesh increases the potential for catheter non-function from omental and bowel adhesions as well as mesh infection should the patient experience PD catheter-associated peritonitis [8, 9]. On the other hand, hernia repair utilizing primary suture repair has led to an unacceptably high rate of recurrence in our experience, except when the hernia defects are quite small. Surgeons must be mindful of these very real risks when deciding how best to manage previously undiagnosed abdominal wall and inguinal hernias at the time of laparoscopy.

After taking all risks and benefits of concomitant hernia repair at the time of PD catheter placement into account, the laparoscopic approach has been the preferred approach when an unexpected defect is identified. Traditionally, abdominal wall hernias are sutured closed and reinforced with synthetic mesh placed into the peritoneal cavity, if indicated by the size of the hernia. Inguinal hernias are repaired using a standard transabdominal preperitoneal (TAPP) approach with synthetic mesh reinforcement. TAPP is preferred to total extra-peritoneal repair (TEP) as the preperitoneal dissection required with TEP repair often interferes with the intramuscular catheter tunnel.

Over time however, it has become our practice to simply avoid repairing hernias when they are discovered at the time of PD catheter placement. Rather, the presence of a ventral or inguinal hernia is documented in the operative report at the time of PD catheter placement. Should the hernia enlarge or become symptomatic, it may be repaired at a later date. This approach allows for mesh to be placed in the preperitoneal space during ventral hernia repair, which absolves the risk of catheter malfunction from adhesive disease to the mesh previously discussed. Furthermore, symptomatic inguinal hernias can be repaired using an open technique, which prevents the risk of pelvic adhesion formation that may occur following a TAPP repair.

Tunneling and PD Catheter Placement

As previously stated, we prefer to place PD catheters to the left of the umbilicus, although there is no literature to support one side over the other. Using the tunneling site that was marked at the beginning of the operation, a two-centimeter paramedian incision is made overlying the left rectus muscle. Dissection is carried down through the subcutaneous tissues until the anterior fascia is exposed. Starting at the most cranial aspect of the incision, a five-millimeter incision is created in the fascia to expose the underlying rectus muscle. A 7/8 mm cannula and dilator trocar access needle is advanced through the rectus abdominus muscle in a perpendicular fashion until it is just superior to the posterior sheath (Fig. 8.6). This portion of the procedure is performed under direct visualization with the laparoscope. The trocar is then tunneled on the surface of the posterior rectus sheath toward the pelvis for a distance of four to six centimeters, depending on the size of the patient. The extent of the tunnel is identified by injecting 0.25% Marcaine through the abdominal wall at the point which had been marked out at the beginning of the procedure. Once the trocar has reached the end of the dissected tunnel, downward pressure is maintained in order to gain entry through the peritoneum and into the pelvis.

As previously mentioned, we use a Tenckhoff-type double-cuffed catheter. Several studies have found no statistically significant difference in rates of technical failure between straight versus curled catheters. In our practice, we have used coiled-tip catheters exclusively [10–12]. The PD catheter is placed over a lubricated stylet and guided through the tunneled intramuscular tract into the peritoneal cavity under direct visualization. The catheter is advanced into the pelvis and the retrovesicular space until the distal cuff is visualized. This cuff is then pulled back until it is within the intramuscular portion of the tunnel.

A Maryland grasper or similar device is used to grasp the catheter within the peritoneal cavity while the stylet and trocar are removed. A 2-0 absorbable suture is used to reapproximate the fascia of our proximal tunnel. This stitch should be placed with great care to ensure that the fascial closure does not incorporate the PD catheter or put undue pressure on the catheter lumen causing partial occlusion. Using a Faller stylet, our proximal catheter is then tunneled through the abdominal wall just above the fascia and brought out through the planned exit site. During this aspect of the procedure, it is again best to grasp the distal catheter with a laparoscopic instrument in order to make sure that the catheter is taut through our subcutaneous tunnel and is not pulled out of the pelvis. The proximal cuff should then be at least several centimeters away from our exit site to prevent eventual irritation of the skin by extrusion of the cuff itself. The catheter is then secured to a titanium adaptor.

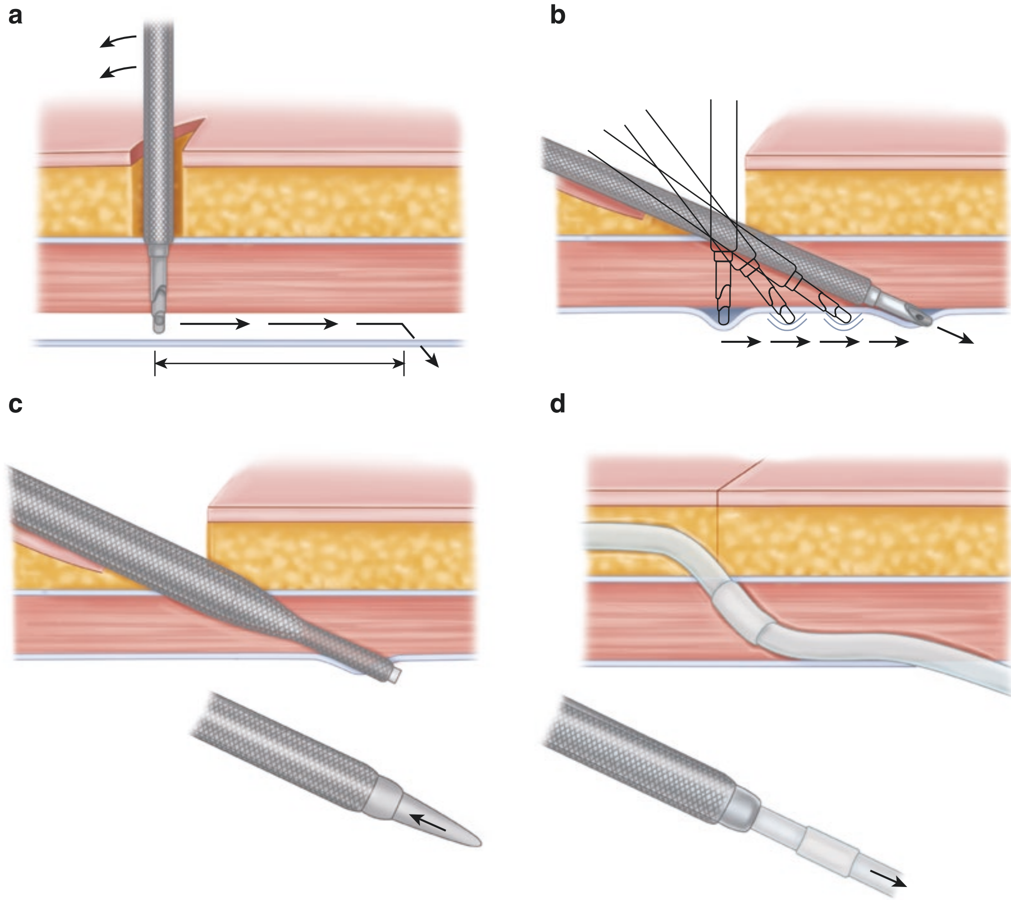

Fig. 8.6 Preperitoneal, rectus sheath tunneling. A cannula and dilator system is inserted perpendicular to the rectus muscle at the site of the transverse incision (**a**). This system is advanced towards the pelvis through the space between the rectus muscle and the peritoneum (**b**). The needle dilator is withdrawn (**c**) and the peritoneal dialysis catheter is advanced through the cannula into the peritoneal cavity (**d**) (This image was published in Kidney International Supplemental, John Crabtree, MD, "Selected Best Demonstrated Practices in Peritoneal Dialysis Access" pages 527-37. Copyright Elsevier 2006).

Confirmation of PD Catheter Function

The catheter should be tested to ensure that it is working properly prior to completion of the case. The patient is placed back into the reverse steep Trendelenburg position and CO_2 insufflation is released. Using sterile IV tubing, a 500 mL bag of sterile saline is placed to gravity and infused through the PD catheter and into the peritoneal cavity. Flushing through the catheter should be easy due to gravity. If the flow is weak, this usually indicates that there is kinking of the catheter within either the intramuscular, or more commonly, the subcutaneous tunnel. After verification of excellent flow into the peritoneal cavity, the saline is then drained from the abdomen, using simple gravity drainage into a sterile basin. Again the flow should be brisk and without resistance.

If there are concerns regarding either flow into or drainage out of the peritoneal cavity, then the catheter should be carefully re-evaluated as poor flow in the operating room is indicative of catheter malfunction and non-function postoperatively. The patient is returned to the supine position, insufflation is resumed, and trouble shooting of potential causes of PD catheter malfunction is performed. As previously discussed in this chapter, the potential sources of catheter malfunction include insufficient omentopexy, catheter tip migration out of the pelvis, large epiploic appendages not previously addressed, or kinking or leakage of the catheter within the intramuscular tunnel. The source of PD catheter malfunction should be identified and addressed followed by repeat testing of PD catheter function until there is free return of the injected sterile saline.

Securing the PD Catheter in Place

Upon completion of the operation, the patient is flattened out and the CO_2 insufflation is begun once again. The abdomen should be carefully inspected to ensure that there is adequate hemostasis. Appropriate positioning of the catheter is verified. The insufflation is once again released and all trocars removed. The subcutaneous incisions should be closed according to surgeon preference for skin closure. The catheter should be connected to a transfer set, injected with approximately 50 mL of heparinized saline (5000 units of Heparin in 50 mL) to prevent fibrin clot formation, followed by a Betadine cap. The catheter exit site is secured with a sterile non-occlusive dressing. A catheter anchoring stitch predisposes the patient to early exit site and tunnel infection and should never be used. The catheter can be adequately immobilized on the abdominal wall with sterile adhesive strips and protected by an appropriately applied dressing.

If the patient is not anticipated to begin PD for several months, the catheter may be embedded into the subcutaneous tissue with interval externalization when dialysis access is required. The embedding technique has been proposed to help decrease the risk of PD-related peritonitis events by allowing the PD catheter to heal in a sterile environment [4, 13–16].

Patients Outcomes Following Laparoscopic PD Placement

PD has been shown to be an effective mode of dialysis over both the short- and long-term [4, 17–21]. In fact, PD is preferred to HD for the preservation of residual kidney function which has been shown to lead to a short-term survival advantage [5, 22, 23]. Patients who undergo PD are also offered self-autonomy through a home renal replacement modality with an improved quality of life compared to patients who undergo HD [2, 4]. Furthermore, the most common reasons for PD catheter malfunction, mainly catheter tip migration and omental occlusion, have been successfully addressed by proactive laparoscopic techniques of rectus sheath tunneling and selective omentopexy [2]. In a study published by our institution in 2010 that details the adoption of lysis of adhesions, selective omentopexy, and rectus sheath tunneling proposed by Dr. Crabtree, no patient experienced catheter outflow occlusion due to omental blockage or catheter tip migration out of the pelvis. Furthermore, the rate of PD catheter malfunction decreased from 36.7% to 4.6% [22]. Subsequently, reasons for transfer from PD to HD, including catheter related peritonitis and inadequate filtration, have received great attention in the recent years, leading to improvement in PD techniques [2].

Nevertheless, PD is not for every patient. The advantages offered with an independent mode of renal replacement therapy also come with increased patient responsibility for treating their disease. Although previously we preferred to place PD catheters mainly in younger, healthier patients as a bridge to renal transplantation at our institution, we have found that this modality can be just as successful and satisfying for those patients who are not or never will be on the transplant list. Indeed, we do not consider previous operations, size and age as contraindications to peritoneal dialysis.

Conclusion

Peritoneal dialysis is an underutilized option for renal replacement therapy. Proactive techniques enabled by a laparoscopic approach, such as adhesiolysis, omentopexy and rectus sheath tunnel leads to a decreased incidence of catheter malfunction with subsequent improvement in the long-term durability of this dialysis option. The success of peritoneal dialysis relies on the adoption of these techniques along with the collaboration and early referral of patients with chronic kidney disease to the general surgeon.

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