Peritoneal Dialysis Catheter Insertion

John H. Crabtree, MD,* and Kai-Ming Chow, MBChB, FRCP†

The success of peritoneal dialysis as renal-replacement therapy depends on a well-functioning peritoneal catheter. Knowledge of best practices in catheter insertion can minimize the risk of catheter complications that lead to peritoneal dialysis failure. The catheter placement procedure begins with preoperative assessment of the patient to determine the most appropriate catheter type, insertion site, and exit site location. Preoperative preparation of the patient is an instrumental step in facilitating the performance of the procedure, avoiding untoward events, and promoting the desired outcome. Catheter insertion methods include percutaneous needle-guidewire with or without image guidance, open surgical dissection, peritoneoscopic procedure, and surgical laparoscopy. The insertion technique used often depends on the geographic availability of material resources and local provider expertise in placing catheters. Independent of the catheter implantation approach, adherence to a number of universal details is required to ensure the best opportunity for creating a successful long-term peritoneal access. Finally, appropriate postoperative care and catheter break-in enables a smooth transition to dialysis therapy.
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Reliable access to the peritoneal cavity is essential to the success of peritoneal dialysis (PD) as renal-replacement therapy. Peritoneal access is attained with a catheter device that traverses the abdominal wall to provide an avenue through which dialysis solutions can be exchanged. The two most common reasons for PD failure are infectious and mechanical complications of the catheter. Knowledge of best practices in catheter placement can minimize the risk of these complications and optimize the likelihood for successful therapy.

Selection of catheter devices and insertion techniques often varies depending on the geographic availability of material resources and local provider expertise in placing catheters. The discussion herein will focus on peritoneal access for the adult chronic renal failure patient, describing the most commonly used catheter types, matching the most appropriate device to the patient, placement methods, avoidance of procedure-related complications, postoperative care, and catheter break-in procedures (Figures 1 and 2).

*Division of Nephrology and Hypertension, Harbor-University of California Los Angeles Medical Center, Torrance, CA.

†Division of Nephrology, Department of Medicine and Therapeutics, The Chinese University of Hong Kong, Prince of Wales Hospital, Hong Kong.

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Address reprint requests to John H. Crabtree, MD, Society for Education and Research in Peritoneal Access Surgery, 340 South Lemon Ave, Suite 2404, Walnut, CA 91789. E-mail: johncrabtree@sbcglobal.net

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CATHETER TYPES

The most commonly used PD catheter types are shown in Figure 1. The standard double Dacron (polyester) cuff, straight- and coiled-tip Tenckhoff catheters, and their swan neck variants with a preformed arc bend in the intercuff segment comprise the core of PD access devices around the world (Figure 1A and B). The primary difference among these catheters is that the coiled-tip configuration and the preformed arc bend increase the cost of the device. No significant difference in functionality has been shown convincingly between straight- and coiled-tip catheters with or without a preformed arc bend.[1–10] The incidence of inflow discomfort is thought to be greater with straight-tip catheters because of the jet effect of the dialysate from the end hole of the catheter. Coiled-tip catheters are said to provide for better dispersion of the dialysate during inflow. However, these claims associated with catheter tip configuration have not been studied specifically; therefore, the effect of catheter-tip design on inflow pain remains speculative. Standard abdominal catheters can be inserted by any of the implantation methodologies.

Figure 2 depicts a PD catheter showing its relationship to abdominal wall structures. Catheters equipped with two cuffs provide better immobilization of the tubing within the abdominal wall. The deep cuff is best implanted in the muscle to provide for firm tissue ingrowth and fixation of the catheter. The superficial cuff is positioned in the subcutaneous tissues 2 to 4 cm from the exit site. A properly positioned superficial cuff serves as an effective barrier to entry of cutaneous debris and bacteria into the subcutaneous track and minimizes the piston-like motion of the catheter in and out through the exit site that can propel contaminants into the track.

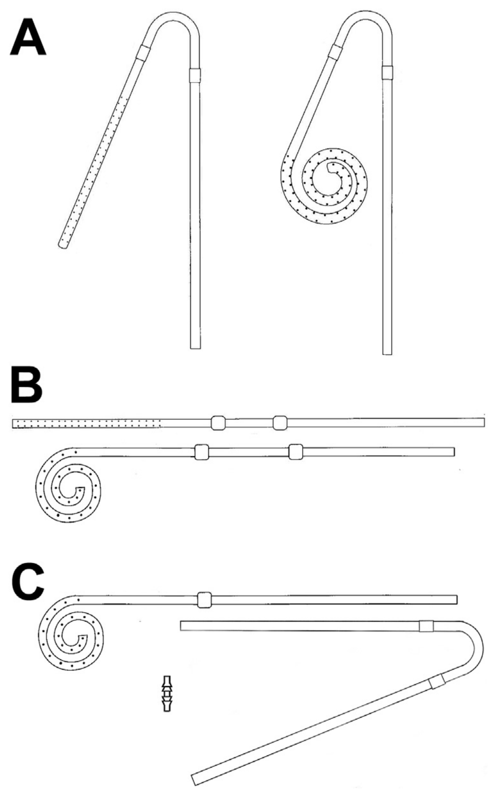

Figure 1. Commonly used peritoneal catheters are shown. (A) Tenckhoff catheters with preformed intercuff arc bend, two cuffs, and straight or coiled tips. (B) Tenckhoff catheters with straight intercuff segment, two cuffs, and straight or coiled tips. (C) Extended catheter with one-cuff, coiled-tip abdominal catheter, two-cuff extension catheter with preformed intercuff arc bend, and titanium double-barbed connector.

Extended two-piece catheters originally were designed to create a presternal exit site (Figure 1C). The extended catheter consists of a one-cuff abdominal catheter segment that attaches to a two-cuff subcutaneous extension segment using a double-barbed titanium connector to permit remote location of the exit site to the upper chest.[11] Extended catheters also are used to provide remote exit site locations to the upper

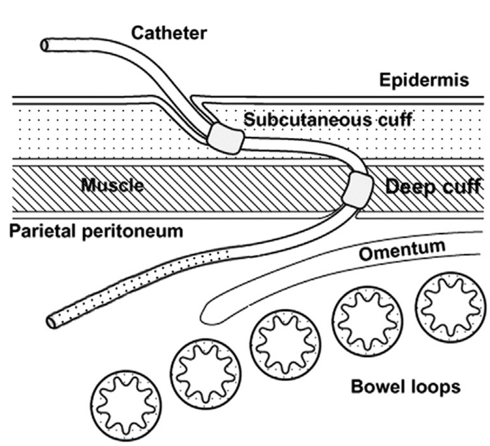

Figure 2. Schematic of a straight-tip Tenckhoff peritoneal catheter showing its proper relationship to adjacent anatomic structures.

abdominal and back regions.[12,13] The abdominal catheter can be placed by any insertion method. The subcutaneous extension catheter is implanted using a vascular tunneling rod or similar device supplied by the catheter manufacturer.

Most currently manufactured chronic catheters possess a white radiopaque stripe along the longitudinal axis of the tubing that enables radiographic visualization. The stripe also can serve as a guide during catheter implantation to avoid accidental twisting or kinking of the catheter tubing.

Various modifications of the basic Tenckhoff catheter designs have been made to address the common mechanical problems of tissue attachment, tip migration, and pericatheter leaks.[14] However, none of these alternative configurations have been shown to outperform the standard Tenckhoff catheter design, but do increase the cost and difficulty of device insertion. Concerns for these common mechanical problems are addressed more reliably by proper insertion technique than by a catheter design.

CHOOSING A PD CATHETER

Choice of catheter type should take into consideration the patient's belt line, obesity, skin creases and folds, presence of scars, chronic skin conditions, incontinence, physical limitations, bathing habits, and occupation. The provider's familiarity with a basic inventory of catheter types is indispensable in enabling a customized peritoneal access that addresses the specific needs of the patient and affords maximum flexibility in exit site location. An exit site that is located in an environmentally hostile zone or in a position that the patient cannot easily see or take care of predisposes the exit site and tunnel to infection.

Figure 3 shows how a basic catheter inventory might be used. Patients with belt lines below the umbilicus generally are best matched with a catheter with a straight intercuff segment that is bent to produce a laterally directed exit site emerging above the belt line (Figure 3A). Patients with belt lines above the umbilicus often are best suited to a catheter with a preformed swan neck bend that allows the exit site to emerge below the belt line (Figure 3B). Individuals with large rotund abdomens, severe obesity, intestinal stomas, feeding tubes, suprapubic catheters, urinary or fecal incontinence, or a desire to take deep tub baths are candidates for extended two-piece catheters to produce upper abdominal or presternal exit sites (Figure 3C and D).

The correct catheter choice is the one that produces the best balance of pelvic location of the catheter tip, an exit site easily visible to the patient, and can be inserted through the abdominal wall with the least amount of tubing stress. The catheter insertion site is

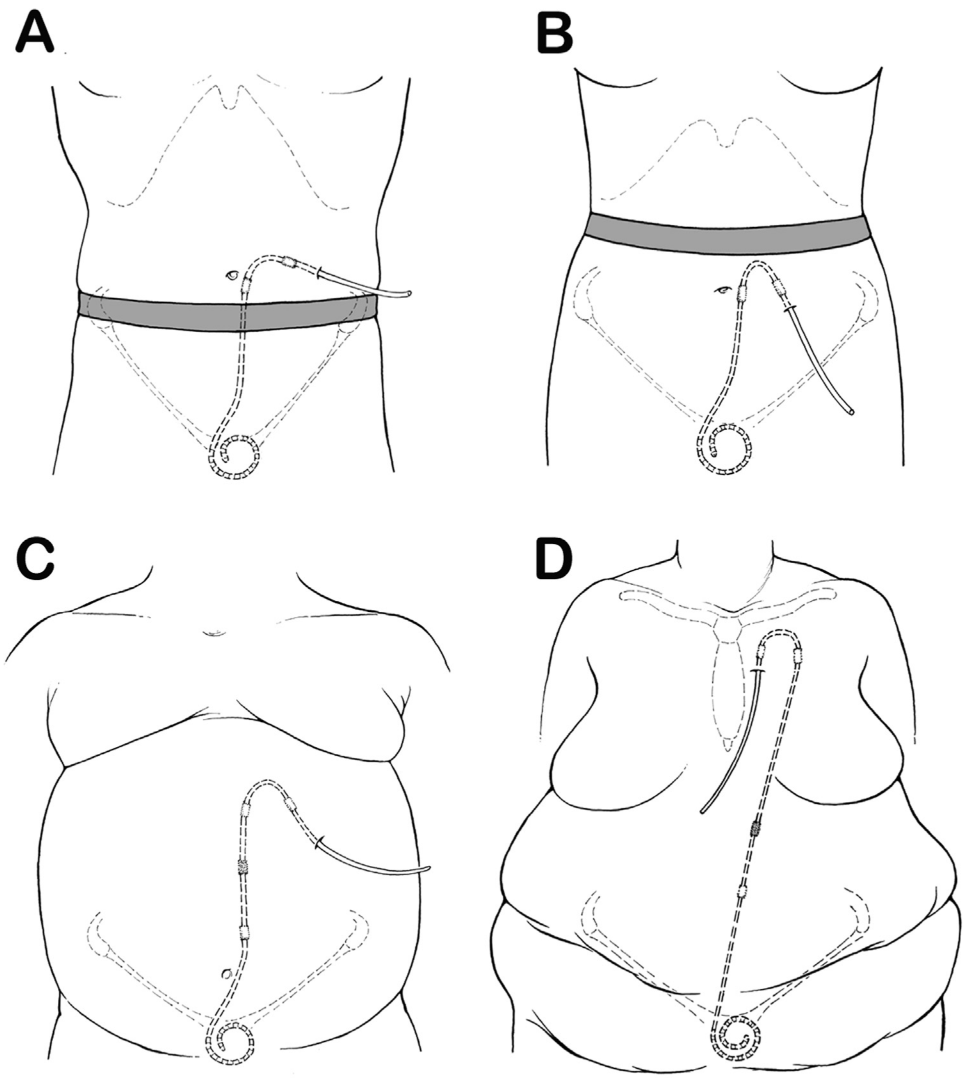

Figure 3. Practical applications of a basic catheter inventory. (A) Straight intercuff segment catheter with a laterally directed exit site emerging above a low-lying belt line. (B) Preformed swan neck intercuff arc bend catheter with a downwardly directed exit site emerging below a high-lying belt line. (C) Extended catheter with an upper abdominal exit site for an obese rotund abdomen, lower abdominal skin folds, or incontinence. (D) Extended catheter with a presternal exit site for severe obesity, multiple abdominal skin folds, intestinal stomas, or incontinence.

the fulcrum of this best balance and will determine the pelvic position of the catheter tip and the range of reachable exit sites. Therefore, catheter selection begins with determination of the insertion site.

Determination of Catheter Insertion Site

Identifying the most appropriate insertion site is more crucial for coiled-tip catheters than straight-tip devices because all of the side drainage holes are limited within an approximate 5-cm diameter, disc-like space. The coiled-tip configuration with its confined area of side holes may be more vulnerable to compression-obstruction by adjacent pelvic structures than the extended area spanned by the side holes of a straight-tip design. With the patient in the supine position, the insertion site for a coiled-tip catheter is determined by marking the upper border of the deep cuff in the paramedian plane when the upper border of the coil is aligned with the upper border of the pubic symphysis (Figure 4). During the catheter placement procedure, the deep cuff is implanted in the rectus sheath, within the muscle tissue or just below, at the level of the insertion incision. Use of this convention to determine the insertion site will prevent the catheter tip from being implanted too low in the pelvis, leaving it susceptible to pressure discomfort, early termination of dialysate outflow from compression-obstruction, and severe end-of-drain pain.

Straight-tip catheters have more flexibility in the location of the insertion site. The most commonly used

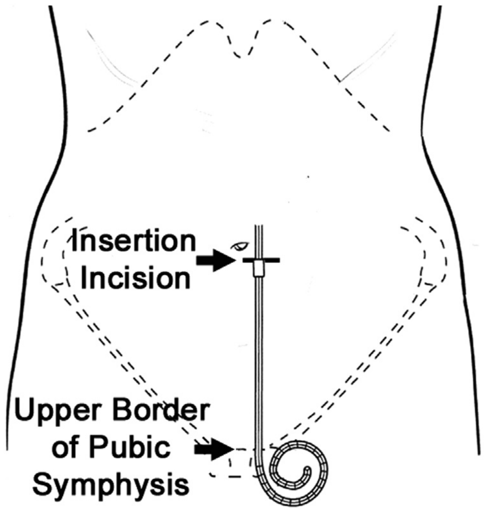

Figure 4. Schematic of a supine patient showing the method in which the coiled-tip catheter insertion site and deep cuff location are determined to achieve proper pelvic position of the catheter tip. The upper border of the catheter coil is aligned with the upper border of the pubic symphysis. With the catheter so aligned, the upper border of the deep cuff indicates the location of the insertion incision.

two-cuff, 42- and 47-cm length, straight-tip catheters possess side holes extending 7 to 15 cm from the end of the tubing. Periumbilical insertion sites typically will result in catheter-tip side holes spanning from the deep pelvis to the lower abdominal region. Caution should be exercised in avoiding catheter insertion sites so low on the abdominal wall that excess tubing in the pelvis causes pressure discomfort or buckles out of the pelvis into the upper abdomen. Importantly, the insertion site should take into account whether or not the amount of available tubing external of the deep cuff can reach a favorable skin exit site location satisfactorily with acceptable subcutaneous tunnel configuration and superficial cuff position.

Tunnel Configuration and Exit Site Location

After determining the catheter insertion site, the subcutaneous tunnel path and exit site location for catheters with a swan neck bend simply follows the configuration of the tubing, marking the skin exit site 2 to 3 cm beyond the superficial cuff. Catheters with a straight intercuff segment should assume a gentle arc in the subcutaneous tissues to produce more of a laterally directed exit site. When the straight intercuff segment is bent no more than what is needed to form a laterally directed tunnel and exit site, the creation of excessive tubing stress and shape-memory resiliency forces that can lead to catheter-tip migration and superficial cuff extrusion is minimized. If the catheter needs to be bent more than what is needed for a laterally directed exit site, a swan neck catheter should be used instead to eliminate these excessive forces. Upwardly directed exit sites should be avoided to prevent pooling of cutaneous bacteria and debris, perspiration, and shower water in the exit sinus, predisposing the patient to exit site and tunnel infections.

After mapping the prospective exit site location as described in the preceding paragraph, the patient assumes a sitting or standing position and the marked exit site is checked to see if it can be visualized by the patient and does not conflict with the belt line, skin creases, or apices of bulging skin folds. If the marked exit site for a standard abdominal catheter is unsatisfactory, the patient is considered for an extended catheter to produce an upper abdominal or presternal exit site location.

Stencil-Based Preoperative Mapping

Some dialysis catheter manufacturers produce marking stencils for the most commonly used coiled-tip catheter designs. Stencils facilitate the preoperative evaluation process by obviating the need to carry around an inventory of sample catheters. In addition, a protocol of stencil-based preoperative mapping is implemented easily wherein PD unit staff participate in determining the patient's most appropriate catheter type and exit site location. The PD staff readily can fabricate marking stencils for use with catheter brands that do not provide these invaluable assessment aids.[15]

Properly constructed stencils embody essential catheter design information including the distance between the deep cuff and the coil, suggested subcutaneous tunnel configurations, and recommended exit site locations relative to the position of the superficial cuff.[15] Additional features of a well-designed stencil permit its precise orientation on the trunk region according to fixed anatomic landmarks, such as the cranial border of the pubic symphysis, representing the anterior upper boundary of the true pelvis, and the anatomic midline of the torso. Stencils permit accurate and reproducible association of the catheter design elements to these anatomic landmarks to help determine the best catheter style and insertion site that will produce the optimal pelvic position of the catheter tip and ideal exit-site location. In addition to the preoperative evaluation, the marking stencil is used again at the time of the catheter placement procedure to retrace the previously determined insertion incision, tunnel configuration, and exit site location.

PD CATHETER INSERTION PROCEDURES

The choice of catheter insertion methodology depends on a number of factors including operator expertise and availability, ease of timely access to a procedure room, condition of the patient, material and equipment

Table 1. Best Practices in Patient Preparation for Peritoneal Catheter Implantation

Preoperative assessment to select the most appropriate catheter type, insertion site, and exit site location
Bowel preparation the day before the procedure: 2 L of polyethylene glycol solution, enema, or stimulant suppository
Shower on the day of the procedure with chlorhexidine soap wash of the planned surgical site
Removal of body hair in the preoperative holding area, preferably with electric clippers
Empty the bladder before procedure, otherwise a Foley catheter should be inserted
Single preoperative dose of prophylactic antibiotic to provide antistaphylococcal coverage

Reprinted with permission from Crabtree.[18]

Table 2. Best Practices in Performance of Peritoneal Catheter Implantation

Surgical personnel are attired in cap, mask, sterile gown, and gloves
Surgical site is prepared with chlorhexidine-gluconate scrub, povidone-iodine (gel or scrub), or other suitable antiseptic agent and sterile drapes are applied around the surgical field
Peritoneal catheter is rinsed and flushed with saline and air is squeezed out of the Dacron cuffs by rolling the submerged cuffs between fingers
Paramedian insertion of the catheter through the body of the rectus muscle
Deep catheter cuff positioned within or below the rectus muscle
Pelvic location of the catheter tip
Catheter flow test performed to confirm acceptable function
Skin exit site directed lateral or downward (not upward)
Subcutaneous tunneling instrument should not exceed the diameter of the catheter
Exit site should be the smallest skin hole possible that allows passage of the catheter
Position subcutaneous cuff 2 to 4 cm from the exit site
No catheter anchoring sutures at the exit site
Attach transfer (extension) set at the time of procedure
Exit site is protected and the catheter is immobilized by nonocclusive dressing

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supply, and cost. Independent of the catheter implantation approach, adherence to a number of universal details is required to ensure the best opportunity for creating a successful long-term peritoneal access.[16,17] Best practices for preoperative preparation and peritoneal catheter placement are listed in Tables 1 and 2, respectively.[18] Omission of any one of these practices can lead to loss of the PD catheter. Some implantation techniques do not incorporate all of the best practices, such as percutaneous needle-guidewire approaches performed through the midline or positioning the deep cuff above the level of the fascia. It is essential that the practitioner be aware of deviations from recommended practices and be observant for the potential complications that may arise from such departures.

Percutaneous Needle-Guidewire Technique

Placement of catheters by percutaneous puncture with or without image guidance is performed using a modification of the Seldinger technique, usually under local anesthesia and often at the bedside.[19–21]

With the patient in supine position, the abdomen is prefilled with 1.5 to 2 L of dialysis solution instilled with an 18-gauge introducer needle inserted through a 1.5- to 2-cm infraumbilical or paramedian incision. Alternatively, a Veress needle may be used to perform the prefill. A guidewire is placed, the needle is withdrawn, and the tissue track is dilated serially. A caudal direction of dilatation is recommended toward the pelvic cavity, in the same direction of the original needle. This is to avoid the wire and dilator being pushed into subcutaneous tissue superficial to the rectus abdominis muscle, instead of entering the peritoneal cavity through the muscle.[22] Serial dilatation sometimes is omitted to create a tighter seal and hence minimize the risk of leakage. Next, a dilator with an overlying peel-away sheath is advanced through the fascia over the guidewire. The guidewire and dilator are removed. Optionally, to facilitate insertion, the catheter can be straightened and stiffened by insertion of an internal stylet. The dialysis catheter is directed through the sheath toward the pelvis. As the deep catheter cuff advances, the sheath is peeled away. The deep cuff is advanced to the level of the fascia. With the aid of a tunneling tool, a subcutaneous tunnel to the designated skin exit site is fashioned. To confirm the pelvic positioning of the catheter, plain radiography or fluoroscopic screening can be used. A small amount of contrast can be injected through the PD catheter under fluoroscopy to exclude any kinks in the catheter and to confirm correct location of its tip in the peritoneal cavity. If patients have ascites, the position sometimes is confirmed by aspirating a small amount of ascitic fluid besides injecting the nonionic contrast.

Modifications of this technique include dissection to the anterior rectus sheath instead of blind puncture, peritoneal entry guided by real-time ultrasound, and use of a hollow blunt introducer without a peel-away sheath.[22,23] Grayscale ultrasonography can be helpful in determining the site on the abdominal wall without underlying bowel loops or, at least, the area with the maximum separation between the anterior abdominal wall and the bowel loops. Some interventional radiologists prefer to use color Doppler ultrasonography to confirm the absence of major vessels (primarily the

Table 3. Best Practices Specific for Laparoscopic Peritoneal Catheter Implantation*

- No midline abdominal entry points for laparoscopic ports
- Immobilize catheter toward pelvis by rectus sheath tunneling or lower abdominal suture sling (no pelvic anchoring stitches)
- Omentopexy performed for redundant omentum
- Adhesiolysis performed to enable catheter placement and/or to eliminate recognized intraperitoneal compartmentalization that can impede dialysate drainage
- Laparoscopic port wound is not used as a catheter skin exit site
- Irrigation test completed before removal of laparoscopic ports in case additional interventions required
- Suture closure of all laparoscopic port sites regardless of port size if acute or urgent dialysis is anticipated

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inferior epigastric artery and its branches) coursing through or deep to the anterior abdominal wall.[22]

Open Surgical Dissection

An open surgical method can be performed under local or general anesthesia. Under direct vision, a transverse or vertical paramedian incision is made through the skin, subcutaneous tissues, and anterior rectus sheath. The underlying muscle fibers are split to expose the posterior rectus sheath. The posterior sheath then is lifted and incised. This is followed by dissecting open the peritoneum and entering the peritoneal cavity. Peritoneal dialysis catheter insertion is performed with or without an internal stiffening stylet. The peritoneum and posterior rectus sheath are closed with the internal cuff secured within the rectus muscle. An absorbable purse-string suture completes the closure at the level of the posterior rectus sheath to prevent leakage. After showing satisfactory catheter flow function, the anterior rectus sheath is repaired with a continuous suture. The catheter then is directed through a subcutaneous tunnel to the desired skin exit site.[18,19,24–26]

Peritoneoscopic Procedure

The peritoneoscopic approach also is known as the *Y-TEC procedure*, a proprietary laparoscopic-assisted technique of peritoneal catheter placement (Y-TEC; Merit Medical, South Jordan, UT). Peritoneoscopy and laparoscopy are synonymous; however, the term *peritoneoscopic* has been retained by interventional nephrologists to indicate the Y-TEC approach. The procedure typically is performed in a treatment room under local anesthesia. A 2.5-mm trocar with an overlying plastic sleeve is inserted percutaneously into the peritoneal cavity through a paramedian incision. The obturator of the trocar is removed, permitting insertion of a 2.2-mm peritoneoscope to confirm peritoneal entry. The scope is withdrawn and 0.6 to 1.5 L of room air is pumped into the abdomen with a syringe or hand bulb. The scope is re-inserted and the overlying cannula and plastic sleeve are visually directed into an identified clear area within the peritoneal cavity. The scope and cannula are withdrawn, leaving the expandable plastic sleeve to serve as a conduit for blind insertion of the catheter over a stylet toward the previously identified clear area. The plastic sleeve is withdrawn and the deep cuff is pushed into the rectus sheath. After testing flow function, the catheter is tunneled subcutaneously to the selected exit site.[27,28]

Surgical Laparoscopy

Laparoscopy provides a minimally invasive approach with complete visualization of the peritoneal cavity during the catheter implantation procedure.[29] The advantage of laparoscopic catheter placement over other approaches is the ability to proactively use adjunctive procedures that significantly improve catheter outcomes. Laparoscopically guided rectus sheath tunneling places the catheter in a long musculofascial tunnel directed toward the pelvis and effectively prevents catheter-tip migration, eliminates pericatheter hernias, and reduces the risk of pericatheter leaks. Observed redundant omentum that lies in juxtaposition of the catheter tip can be displaced from the pelvis into the upper abdomen and fixed to the abdominal wall or shortened by folding and suturing it upon itself (omentopexy).[30,31] Compartmentalizing adhesions that may affect completeness of dialysate drainage can be divided. Intraperitoneal structures that siphon up to the catheter tip during the intraoperative irrigation test can be resected laparoscopically, including epiploic appendices of the sigmoid colon and uterine tubes. Previously unsuspected abdominal wall hernias can be identified and repaired at the time of the catheter implantation procedure.

Through a lateral abdominal wall puncture site remote from the point of intended catheter insertion, the abdomen is insufflated with gas through a Veress needle to create an intraperitoneal working space. A laparoscopic port and laparoscope are inserted. Under laparoscopic guidance, the catheter is introduced at a second puncture site and placed in a musculofascial tunnel oriented toward the pelvis, usually through the use of a port device that creates the rectus sheath tunnel. Some variations of the technique use a third laparoscopic port site to introduce laparoscopic forceps to assist in the catheter tunneling process. The catheter tip is directed into the true pelvis under visual control. The deep cuff of the catheter is positioned in the rectus muscle just below the anterior fascial sheath. A purse-string fascial suture is placed around the catheter at the level of the anterior sheath to minimize the risk of pericatheter leak. The pneumoperitoneum is released but laparoscopic ports are left in place until a test irrigation of the catheter shows successful flow function. After any indicated adjunctive procedures are completed, the catheter is tunneled subcutaneously to the selected exit site. Best practices specific for laparoscopic catheter implantation are summarized in Table 3.[18]

Special Peritoneal Access Techniques

Extended two-piece catheters

The abdominal segment of two-piece extended catheters can be inserted by any of the earlier-mentioned placement methods. A secondary incision is made in the vicinity of the planned upper abdominal, presternal, or back exit site.[11–13] A marking stencil is invaluable in devising the location of the secondary incision and exit site. The measured distance between the abdominal insertion incision and the secondary incision is used to calculate how much tubing length will be trimmed from one or both of the catheter segments to span the distance correctly. The trimmed catheters are joined with a double-barbed titanium connector and the linked catheter segments are tunneled on the surface of the fascia from the abdominal insertion site to the remote secondary incision with a tunneling rod. The extension catheter then is passed from the secondary incision through the exit site using a stylet to complete the procedure.

Catheter embedding

Commonly referred to as the *Moncrief-Popovich technique*, catheter embedding consists of inserting a peritoneal dialysis catheter far in advance of anticipated need.[32] Instead of bringing the external limb of the catheter out to the surface, it is embedded under the skin in the subcutaneous space. When renal function decreases to the point of needing to initiate dialysis, the external limb is brought to the outside through a small skin incision.

Because the catheter has been allowed extended healing time within the abdominal wall, the patient is able to proceed directly to full-volume peritoneal dialysis without the necessity of a break-in period that ordinarily accompanies a newly placed catheter. Firm tissue ingrowth of the cuffs and absence of biofilm formation have been speculated to reduce catheter infection–related peritonitis. Another important attribute of catheter embedding is greater patient acceptance for earlier commitment to peritoneal dialysis by catheter placement ahead of time. The patient is not burdened with catheter maintenance until dialysis is needed. The need for insertion of vascular catheters and temporary hemodialysis can be avoided in patients previously implanted with an embedded catheter. The embedding technique permits more efficient surgical scheduling of catheter implantation as an elective nonurgent procedure and helps to reduce stress on operating room access. Disadvantages of the catheter embedding strategy include the need for two procedures (implantation and externalization) as opposed to one, and the possibility of futile placement in the event of an adverse change in the patient's condition during the time period that the catheter is embedded.

Catheter embedding can be incorporated into any of the insertion approaches using any catheter device. The catheter temporarily is externalized through the future skin exit site before embedment. The exit site scar serves as a landmark to know where to come back to for externalization. After acceptable flow function of the catheter is confirmed, the tubing is flushed with heparin, plugged, and buried in the subcutaneous tissue. To minimize the risk of hematoma or seroma and to facilitate subsequent externalization, the catheter should be embedded in a linear or curvilinear subcutaneous track using a tunneling stylet as opposed to curling the tubing into a subcutaneous pocket. Embedding should not be performed if the anticipated need for dialysis is sooner than 4 weeks. Externalization of embedded catheters is an office procedure. Catheters have been embedded for months to years with an 85% to 93% immediate function rate upon externalization.[33–36] Catheter dysfunction usually is owing to adhesions or intraluminal fibrin clots. Overall, 94% to 99% are used successfully for dialysis after radiologic or laparoscopic revision of nonfunctioning catheters.[33,35,36]

Insertion Procedure–Related Complications

Peritoneal dialysis catheter insertion can be associated with several important procedural complications, in addition to anesthesia-related complications. Serious complications include leakage, hemorrhage, visceral injury, and mechanical flow dysfunction. The overall success of peritoneal dialysis as renal-replacement therapy hinges on avoiding these problems. To this end, a consensus on the best practice guidelines recommends that catheter-related complications be monitored with regular audit to recognize deficiencies and provide opportunities to improve practice.[17]

Leakage

Leakage is the most common complication, with a reported frequency as high as 12.8%.[27] Dialysate leakage usually occurs in the first weeks or months after catheter insertion, and is more apparent after patients become ambulatory. By convention, early leak refers to those occurring within 30 days of catheter insertion, and late leak occurs after 30 days. The frequency of dialysate leak varies according to the definition, but is usually higher in infants.[37]

Overt leakage usually is detected when there is bulging underneath the catheter entry site or near the exit site. Pericatheter drainage may be evident. In addition to loss of fluid at the catheter insertion site, other peritoneal boundary defects that result in leakage include abdominal wall hernias, especially inguinoscrotal, and the pleural cavity. Less obvious manifestations of fluid loss are subcutaneous edema, weight gain, and diminished dialysate return.[37–39]

Hemorrhage

Bleeding is a relatively common complication after PD catheter insertion, although severe bleeding is encountered in only 1% to 5% of procedures.[17,40,41]

There are different degrees of hemorrhagic complications after catheter insertion surgery. The relatively mild but frequently encountered bleeding is intra-abdominal with blood-stained effluent postoperatively. Bleeding is self-limiting in most cases and conservative management using regular flushing and intraperitoneal heparin administration ordinarily suffices. Transfusion support or even surgical re-exploration might be needed after a complicated procedure involving omentectomy or adhesiolysis.[40]

Another relatively common bleeding source is pericannular bleeding close to the exit site.[19] Bleeding at the exit site often requires frequent dressing changes. Risk factors include trauma induced by prolonged and difficult manipulation during subcutaneous tunneling and systemic anticoagulation therapy.[40–42] On the other hand, it is considered safe to continue aspirin for open or laparoscopic catheter insertion based on observational study data comparing procedures with and without stopping aspirin.[43] Given the dearth of safety data in patients with newer-generation or dual antiplatelet medication, the decision to withhold drugs such as clopidogrel before PD catheter insertion must be made on a case-by-case basis after careful consideration of the potential risks and benefits.

Management of bleeding at the exit site postoperatively should include manual pressure, additional suturing, and administration of epinephrine (local injection around the external cuff) or desmopressin acetate (0.3-0.4 μg/kg intravenously or subcutaneously as a single injection).[19,41,42] Desmopressin (also referred to as 1-deamino-8-D-arginine vasopressin) is a synthetic derivative of the antidiuretic hormone vasopressin, which has a hemostatic effect via an increase in von Willebrand factor and factor VIII levels.[44] Pressure application has been proposed to be performed by gauze covering the exit site together with an elastic bandage encircling the trunk.[42]

Rectus sheath hematoma also has been observed after PD catheter insertion. This complication can be caused by direct injury of the inferior epigastric arteries or their branches. Another mechanism is direct damage to the rectus muscle during surgery, sometimes precipitated by minor injury, even apparently innocuous trauma or exertional abdominal wall straining from protracted coughing during the postoperative period.[45,46] In the absence of major vessel injury, the most common presenting symptoms and signs are abdominal pain followed by a palpable abdominal wall mass. Severe bleeding can occur after inferior epigastric artery injury, resulting in shock or significant anemia symptoms. If identified during surgery, it should be managed by ligation. Postoperatively, hemodynamically significant hemorrhage warrants invasive interventions such as exploratory surgery or angiographic embolization, in addition to transfusion support.

Visceral Injury

Inadvertent injury to the small or large bowel and urinary bladder may occur during the catheter insertion procedure. Injury usually occurs during the entry into the abdominal cavity or advancing the PD catheter with the stylet into the lower abdomen.

Bowel injury can be recognized intraoperatively by visualization of bowel lumen, return of bowel contents from the dialysate effluent, a hissing sound from gas release, or emanation of foul-smelling gas (positive sniff test). If perforation occurs during fluoroscopically guided procedures, contrast injection characteristically outlines the mucosal folds of the small intestine or the haustral folds of the large bowel. However, perforation may go undetected during catheter insertion. Postoperative manifestations include severe watery diarrhea (secondary to malpositioning of the catheter in the bowel lumen), abdominal pain with hypotension, rigid abdomen, and peritonitis.[24,47,48] Some of these manifestations may be masked temporarily in the event of a through-and-through bowel wall perforation.[48] Reported risk factors include blind insertion methodology, use of trocars, adhesions from previous abdominal surgery, and procedures that include adhesiolysis.[47,48]

Urinary bladder perforation usually is recognized by an increase in urine volume, hematuria, and bladder distension immediately after instillation of dialysis fluid, and urinary peritonitis (local inflammation) causing ileus.[49,50] Urinalysis frequently is strongly positive for glucose. In practice, however, because the peritoneal dialysis catheter might have some side holes outside the urinary bladder, it is not uncommon to have a silent period of good catheter function, resulting in a delay in diagnosis. Urinary bladder perforation by the PD catheter can be confirmed by cystoscopy, cystogram, and other imaging techniques. In addition to the shared risk factors with bowel injury, neurogenic bladder with incomplete emptying may predispose to inadvertent urinary bladder perforation.[24,49–51]

Mechanical Flow Dysfunction

Mechanical factors are a major cause of PD catheter malfunction, manifesting as insufficient inflow and/or outflow of dialysate. Intuitively, reasons for mechanical failure can be traced along the path of dialysate flow.[18,52]

At the subcutaneous level, kinking of the tubing can lead to slow dialysate flow (including the inflow and outflow rate). Inside the peritoneum, bowel trapping (mostly owing to constipation), omental wrapping, and ensnaring by adhesions, epiploic appendices, or uterine tubes can result in outflow failure (drainage volume being significantly less than the inflow volume). Within the catheter lumen, blood clots or fibrin can lead to slow inflow and outflow rates.

Another common cause of flow dysfunction is migration of the catheter, largely of subdiaphragmatic location. Migration of the catheter tip into a position of poor drainage function is caused most commonly by shape-memory resiliency forces of a straight catheter bent into a configuration that imposes excessive stress on the tubing. Over time, the tubing will resume its straight configuration, resulting in migration of the catheter tip. Excessive bending of the catheter in the subcutaneous track to produce a lateral or downward exit site direction combined with poor immobilization and fixation of the transmural segment is a set-up for migration. Inserting the catheter through the thin midline fascia, perpendicular passage through the abdominal wall, or leaving the deep cuff above the level of the fascia are causes of inadequate immobilization and fixation.[18]

Catheter displacement can be recognized by a plain abdominal radiograph. Ideally, the peritoneal dialysis catheter tip should be located in the deep pelvic area to minimize the risk of omental entrapment and maximize the hydraulic function. A high peritoneal dialysis catheter, defined as higher than the pelvic brim on a lateral abdominal radiograph, is associated with significantly higher rates of clinically important drainage problems.[53]

Catheter Placement Approaches and Best Outcomes

It often has been stated that no single implantation approach has been shown to produce superior outcomes. Operator performance aside, when catheter placement by percutaneous needle-guidewire with or without fluoroscopic imaging, open surgical dissection, and surgical laparoscopy are compared side to side on identical study populations with equivalent adherence to best practices, the results are basically equal.[54–57] If laparoscopy is used only to observe the position of the catheter tip, the outcomes are no different than any other catheter insertion method. However, the advantages of laparoscopy over every other technique are the adjunctive procedures enabled by this method, principally, rectus sheath tunneling, omentopexy, and adhesiolysis.[29,58,59] When these techniques are applied effectively, the laparoscopic approach can both prevent and resolve most of the common mechanical problems that complicate insertion of PD catheters.

As previously noted, the choice of catheter insertion methodology depends on a number of factors, the most important of these being operator expertise and the ability to provide peritoneal access in a timely fashion. These two factors are key in determining the penetration of peritoneal dialysis. The ultimate goal is to achieve timely and effective catheter insertion without unduly long waiting times, during which potential candidates for peritoneal dialysis may lose interest in this modality.[20,60]

When timely access to the operating room for laparoscopic catheter implantation is a rate-limiting step for initiating peritoneal dialysis, catheter insertion by interventional nephrologists or radiologists represents a reasonable option. Potential advantages of interventional nephrologists as operators include better continuity of care, reduced waiting times, and the creation of a committed nephrology team with a keen interest in peritoneal catheter placement. In fact, a national survey in the United States showed that overall peritoneal dialysis catheter training is inadequate under current surgery residency programs, with most surgeons placing only two to five catheters during their residency.[61] In a population-based cohort study involving nearly 4,000 incident peritoneal dialysis catheter insertions, catheter insertion by nephrologists resulted in the highest rates of peritoneal dialysis utilization in Canada.[62] Similar conclusions were shown in previous smaller studies.[63–65] In addition, multiple case series describing peritoneal dialysis catheters inserted solely by nephrologists have shown primary successful insertion rates ranging from 92.9% to 100%.[20,26,66,67]

The important principle is that practice makes perfect. This is exemplified by a multicenter study showing similar catheter outcomes between catheters inserted by surgeons and interventional nephrologists. The procedure volume performed per center was the only significant variable associated with the rates of mechanical and infectious complications.[68] Operator availability, expertise, and experience should be the determining factors of who will place PD catheters. Even more important is to develop an institutional culture in which interventionalists and surgeons work collaboratively to develop common pathways and techniques to provide timely peritoneal access and to resolve PD complications.

CARE OF THE CHRONIC PERITONEAL CATHETER

Postoperative Catheter Immobilization and Dressings

Because no catheter anchoring stitches should ever be used, it is important to immobilize the catheter on the abdominal wall with medical adhesive tincture and sterile adhesive strips. A nonocclusive barrier dressing of sufficient size to protect the exit site and surgical wounds and to further immobilize the catheter should be applied at the time of the placement procedure. In addition, the transfer set should be secured to the abdominal wall to prevent tugging on the catheter at the exit site. It is helpful to secure the transfer set to the abdominal wall separately from the main dressing so that the peritoneal dialysis nurses have access to the tubing for catheter irrigation without having to disturb the dressing over the exit site. As long as the dressings are clean and intact and the exit site appears stable, dressings are changed on a weekly basis until such time that the patient is instructed in the protocol for chronic exit site care.[17,69] If at any time the exit site appears unstable, the frequency of exit site care is modified according to the findings.

Catheter Irrigation

Catheters that are not used immediately should undergo irrigation with 1 L of solution (saline or dialysate) within 72 hours after insertion to wash out blood and fibrinous debris. If the effluent is particularly bloody, irrigation is repeated until signs of clearing are evident. To ensure patency, it is a good idea to repeat the irrigation weekly until such time that dialysis is instituted. Heparin added to the irrigation fluid (1,000 U/L) is helpful in preventing fibrin plugging of the catheter during the early postoperative period. Few data, however, are available to suggest the optimal frequency of irrigation.

Catheter Break-In Procedures

There is a belief among many nephrologists and experts that peritoneal dialysis catheter insertion should be performed at least 2 weeks before starting dialysis exchange.[17,69,70]

During this 2-week break-in period, according to various international guidelines, small dialysate volume in the supine position can be used if dialysis is required.[17,27,70] The recommendations are largely on the basis of expert opinion. Concerns have been raised about mechanical complication (mostly leakage) caused by an early or urgent start. In the absence of randomized controlled trials, most of the data have been drawn from observational studies. A relatively large case series of 657 consecutive incident peritoneal dialysis patients showed that patients with a break-in period of 7 days or fewer experienced a slightly higher risk of catheter dysfunction (8.4% versus 1.7% for those with a break-in period of >2 wk), but there was no major effect on technique survival.[71] Another group compared the results for 310 peritoneal dialysis patients with break-in periods of shorter than 2 weeks and longer than 2 weeks. Catheters were implanted surgically with a purse-string suture at the posterior rectus sheath. Dialysis was initiated incrementally by stepping-up dwell volumes. No differences in catheter-related complications (14.6% versus 13.1%) or leakage (2.2% versus 2.4%) were reported.[72] Potential limitations of these two studies were their inclusion of Chinese subjects (thus relatively small body builds) with mean body mass indices of 21.9 and 23.6, respectively.[71,72] Because the existing data for shorter break-in periods among Caucasians were of smaller sample size,[73,74] the possible downside of short break-in periods in obese subjects needs to be addressed.

On the whole, the early start of peritoneal dialysis, with break-in periods of shorter than 2 weeks, increasingly has been accepted as an option for patients in need of urgent dialysis. Based on recent studies with a very low incidence of leakage, an early start is acceptable for catheters inserted with technique modifications to ensure a watertight seal around the catheter.[74,75]

Long-Term Catheter and Exit Site Care

Patients should limit themselves to nonstrenuous activities for 4 to 6 weeks after catheter placement to permit good wound healing. If exit site healing is uneventful, most patients are able to resume showering in 3 to 4 weeks. This usually coincides with implementation of the chronic exit site care routine. Most exit site care protocols involve daily cleansing with nonirritating, nontoxic, antiseptic agents, and application of a prophylactic antibiotic ointment or cream such as mupirocin or gentamicin. Sterile dressings over the exit site are encouraged. Tub bathing and swimming with immersion of the exit site are discouraged. Centers that permit swimming usually restrict the activity to properly chlorinated private pools or ocean water. It is recommended that an ostomy appliance or similar device cover the exit site and catheter during swimming and to perform routine exit site care after the activity. Patients should be reminded that the catheter is a lifeline and are advised to consider the consequences of risking exposure of their peritoneal access to potential contamination during swimming.[76]

Embedded Catheter Care and Externalization

Patients who undergo catheter embedment may resume showering after 48 hours. Nonstrenuous activities are required for 4 to 6 weeks after catheter placement to permit good wound healing. Externalization of embedded catheters is a clinic procedure performed using a sterile technique in a suitable treatment room under local anesthesia. If an appropriate embedding technique was performed, the catheter tubing should be easily palpable at the incision scar created during the procedure while the catheter was externalized temporarily at the future exit site. In equivocal cases, ultrasound examination has been used to identify the catheter tubing at the correct distance from the superficial cuff. Care is exercised in anesthetizing the skin and making the incision to avoid damage to the catheter. Hemostat dissection is used to identify and deliver the catheter from the embedment track. The plugged end of the tubing is amputated, the catheter adapter is inserted, the transfer set is attached, and flow function is tested. The catheter may require brisk irrigation with a 60-mL syringe and saline to dislodge fibrin clots. Unsatisfactory flow function should be managed as described under the section on mechanical complications and management. Exit site care after externalization of embedded catheters is the same as described for primarily externalized catheters.[76]

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