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# PERITONEAL CATHETERS AND EXIT-SITE PRACTICES TOWARD OPTIMUM PERITONEAL ACCESS: A REVIEW OF CURRENT DEVELOPMENTS

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♦ ***Objective:*** **This review updates the 1998 International Society for Peritoneal Dialysis (ISPD) recommendations for peritoneal dialysis catheters and exit-site practices (Gokal R, *et al*. Peritoneal catheters and exit-site practices toward optimum peritoneal access: 1998 update. *Perit Dial Int* 1998; 18:11–33.)**

♦ ***Design:*** **Data Sources: The Ovid and PubMed search engines were used to review the Medline databases of January 1980 through June 2003. Searches were restricted to human data; primary key word searches included dialysis, peritoneal dialysis, and continuous ambulatory peritoneal dialysis cross referenced with access, catheter, dialysis catheter, peritoneal dialysis catheter, and Tenckhoff catheter. Related searches were provided via the PubMed related articles link. Study Selection: Reports were selected if they provided identifiable information on catheter design, catheter placement technique, and survival or placement complications. Reports without such data were excluded from review. Each study was then categorized by its characteristics: single-center or multicenter; retrospective or prospective; controlled trial, with or without random patient assignment; or review article.**

♦ ***Main Results:*** **There are few randomized controlled evaluations testing how catheter design and/or placement influence long-term survival and function, and these are typically conducted at a single center. The majority of reports represent retrospective single-center experiences, and these are supplemented by occasional multicenter data registries.**

♦ ***Conclusions:*** **There is substantial variability in catheter outcomes between centers, and this variability is more closely correlated with operator and center characteristics than with catheter design. Some catheter designs appear to impact long-term catheter success, and, in some cases, specific patient characteristics and dialysis formats combine with specific catheter designs to influence catheter survival. Most reporters prefer two-cuff designs and placement of the deep cuff at an intramuscular location. Intramuscular cuff placement results in fewer pericatheter leaks and hernias, but makes catheter removal more difficult. High-risk patients (those with previous pelvic surgery) benefit from visual inspection of the peritoneum during catheter placement, and in randomized controlled trials, catheters with pre-shaped arcuate subcutaneous segments (“swan neck” designs) reduce the risk of early drainage failure via “migration.”**

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KEY WORDS: Peritoneal dialysis catheter; exit site.

The key to successful chronic peritoneal dialysis (PD) is permanent and safe access to the peritoneal cavity. Despite improvements in catheter survival over the past few years, catheter-related complications still occur, causing significant morbidity and often forcing the removal of the catheter. Catheter-related problems are a cause of permanent transfer to hemodialysis in up to 20% of all patients who need such therapy changes; many more require temporary periods on hemodialysis. A panel of experts, under the aegis of the International Society for Peritoneal Dialysis (ISPD), published guidelines in 1998 toward optimal peritoneal access (1). Wherever possible, the guidelines were evidence based (*e.g.*, randomized controlled trials); where scientific evidence was not available, recommendations were based on a consensus opinion. This review examines developments in peritoneal access since that publication, with the aim of enhancing and updating guidelines, based on new information published over the past 5 years. This article needs to be read in conjunction with the last set of guidelines, as many of the recommendations have not changed.

## PERITONEAL CATHETERS

The ideal catheter provides reliable, rapid dialysate flow rates without leaks or infections. Despite many newer catheter designs, the Tenckhoff catheter is still most often

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used. Variations in the peritoneal catheter include the number of cuffs (one vs two), the design of the subcutaneous pathway (permanently bent vs straight), and the intra-abdominal portion (straight vs coiled).

For the nephrologist placing and removing PD catheters, or for the nephrologist advising surgeons in this role, it is important that there is good knowledge of PD catheters and differences in function and complications, methods of insertion of PD catheters and relation to catheter outcomes, and techniques for removing PD catheters. Nephrologists should make the critical decisions regarding the choice of access devices and methods for placement, as they do for the choice to remove such access devices (2).

## CATHETER MATERIAL

Most catheters are manufactured of either silicone elastomer or polyurethane. Silastic tears easily and has limited tensile strength; urethanes are soluble in organic solvents and can be physically degraded by aldehydes, alcohols, and ethers. There are reports that some polyurethanes are not durable in a clinical environment (3). Barium is often extruded into Silastic and urethane polymers to provide a radiopaque marker. This renders the catheter sensitive to oxidative degradation, accelerated by halide exposure. Silastic remains the predominant material for PD catheters, which should incorporate a radiopaque marker for ease of identification on plain radiography during use.

## CATHETER CONFIGURATION

Intraperitoneal and transcutaneous catheter modifications continue to appear, indicating that no single design is perfect. Most of these modifications are intended to eliminate early drainage failure (4). The likelihood of incomplete catheter drainage (5) falls when the internal tip is directed toward the left lower quadrant (6) and if the subcutaneous catheter segment does not transmit torque to the intraperitoneal segment (7). Currently, four of five reports comparing swan neck catheters to straight catheters report less frequent catheter drainage failure using the swan neck design (8–11). The exception occurs when the straight catheter is not tunneled through an arcuate pathway with a downward directed exit site (12). This creates a cephalad-directed exit site and may result in an increased risk of exit-site infection. Unless a single-cuff catheter is used, the swan neck design demands greater planning and technical skill for tunnel construction than is required for a standard Tenckhoff catheter. Fortunately, there is strong evidence that single-cuff catheters are as durable as two-cuff designs when the single cuff is placed deep in the preperitoneal rather than in a superficial subcutaneous position (13,14).

The role of peritoneal catheter configuration in preventing catheter tip migration has been assessed. In a comparative study over 6 years, two catheter types, both with curled ends, were assessed: a straight catheter with two cuffs versus a swan neck permanent-bend design. All catheters were inserted using the laparoscopic technique. There was significantly more catheter tip migration in the straight catheter. These authors recommended the double-cuff, curled swan neck catheter as being superior (8).

The Ash Advantage t-fluted catheter (Medigroup, Inc., Naperville, Illinois, USA) uses long, inverted T-shaped channels to replace the distal drainage holes of the Tenckhoff catheter, and is designed to drain the anterior peritoneal space and avoid omental attachment. Initial experiences reported 1-year catheter survivals as high as 90% but recorded a high incidence of undesired events in "high risk" patients. No prospective comparisons are available. The catheter may become a useful alternative to conventional Tenckhoff catheters in patients at high risk of catheter failure or in standard PD patients (15).

The tungsten loaded or "self locating" catheter has a small titanium weight incorporated in the catheter tip (16–18); a similar modification placing a stainless steel weight on the outside of the intraperitoneal catheter tip has been used to repair poorly draining catheters exhibiting migration (19). Limited early reporting suggests that these designs reduce catheter migration and early outflow failure, but the safety of intraperitoneal modification is yet undetermined.

## OUTCOME IN RELATION TO NUMBER OF CUFFS

Earlier studies reported in the previous review in 1998 showed that the single-cuff catheter is associated with a shorter time to the first peritonitis episode and has more exit-site complications and shorter survival times than the double-cuff catheter (1). However, the positioning of the single cuff is important. In a prospective random study, a single-cuff catheter with the cuff placed in the deep rather than superficial position is equivalent to the two-cuff catheter design in outcome (13). This appears to indicate that the one-cuff catheter is not noticeably inferior to the two-cuff design, and if it simplifies placing arcuate designs and the inevitable catheter removal/exchange, then the single-cuff catheter with a deep extraperitoneal cuff, either in the rectus muscle or abutting the preperitoneal fascia, may become the preferred design.

## CATHETER INSERTION

Ideally, catheter insertion should be undertaken by an experienced operator, under operating-room sterile conditions. This cannot be emphasized enough. This can be done on either an inpatient or an outpatient basis (20,21).

### PRE-IMPLANTATION PREPARATION

Presurgical assessment of the patient is essential, searching for herniation, eventration, and weakness of the abdominal wall. If present, it may be possible to correct these at the time of catheter insertion. Prior to insertion, the exit site should be identified and marked on the skin. It is advisable to avoid locations where there may be pressure during daily activities.

*Skin Preparation:* On the morning of the operation, the patient should bathe or have a shower with soap or detergent. If necessary, abdominal hair should be clipped. Patient's nares may be swabbed to determine nasal carriage of *Staphylococcus aureus*. Eradication of nasal carriage has shown significant improvement in exit-site infections but has cost implications (22).

*Bowel Preparation:* Bowel preparation and avoiding constipation are of paramount importance; similarly, emptying the bladder before the procedure is mandatory. Enema preparation is not necessary although an evening laxative is useful; similarly, a Foley catheter should be considered if voiding is abnormal (diabetic neuropathy).

### PROPHYLACTIC ANTIBIOTICS AT CATHETER INSERTION

There is evidence of reduced catheter exit-site colonization, wound infection, and exit-site infections following perioperative antibiotics. There are four randomized controlled trials that allude to this (23–26). This topic has been reviewed recently (27).

*Recommendation:* A single dose of first- or second-generation cephalosporin given intravenously is recommended. To avoid development of vancomycin-resistant enterococcus, vancomycin should not be used routinely.

### CATHETER PLACEMENT TECHNIQUES

Several placement techniques are described and practiced: surgical placement by dissection, blind placement using the Tenckhoff trocar, blind placement using a guidewire (Seldinger technique), mini-trocar peritoneoscopy placement, laparoscopy, other modifications (Moncrief and Popovich, presternal).

*Laparoscopy:* Physicians continue to search for the optimal catheter configuration and insertion technique, and recent interests have centered on peritoneoscopy and laparoscopy, or "minimally invasive surgery." Several of these reports represent single-center, prospective randomized trials. Successful early outcomes remain more closely related to operator experience than to specific operative techniques or catheter design (28). In uncomplicated patients, no uniform advantage of any operative technique over the classic "bedside" or ambulatory percutaneous catheter placement is evident (29–32). Further, by using specially designed trocars, tunneling tools, peritoneoscopes, and stylets, minimally invasive techniques reduce tissue trauma and perioperative complications in comparison to open surgical techniques (14,33–38).

The least invasive of the "minimally invasive" procedures is the mini-trocar or peritoneoscopic approach (2). In this procedure, a plastic-sheathed 13-g needle and stylet percutaneously puncture the peritoneum, air insufflation separates the peritoneum from the omentum, and a rigid 2.2-mm peritoneoscope is advanced through the needle to inspect the peritoneum and direct the peritoneoscope toward the pelvis. The needle and peritoneoscope are removed and the "quill" plastic sheath left in place so that the puncture hole can be dilated sequentially. A dialysis catheter on a stylet is then advanced through the plastic sheath and directed toward the pelvis, without direct visualization. This procedure results in a single peritoneal puncture and yields exceptional early and long-term catheter survival at the development center. Other experienced centers have also published experiences, reporting 1-year catheter failure rates of 10% – 20%.

A substantial number of centers are now reporting experiences with laparoscopic catheter insertion. These are extensions of earlier laparoscopic rescue procedures for dysfunctional catheters. Generally, two to four access ports are surgically placed, allowing peritoneal access to a videolaparoscope, specially designed surgical instruments, and the dialysis catheter. Catheter position is visually confirmed during placement, and additional procedures, such as hernia repair, pelvic catheter fixation, omentopexy, omentectomy, and adhesiolysis, are conducted as necessary during the placement procedure. While laparoscopic placements are generally described as safe, effective, and successful, one single-center retrospective analysis of 148 procedures in 123 patients, where the technique also involved catheter tip suture into the pelvis (39), reported that 5% of subjects experienced hemorrhage, 31% required catheter revision/ removal, and 14% had catheter blockage. While videolaparoscopy is a safe procedure, this report confirms that patient selection and technical processes, some of which may be related to the surgical procedure selected, can result in a high complication/failure rate. The laparoscopic technique can also be used for omental fixation to prevent the obstruction caused by omental wrapping and compares favorably with open PD catheter insertion with respect to postoperative discomfort, complication rates, and catheter survival (40).

A microlaparoscopic technique has recently been described but experience is limited. Visualization is achieved using a 2.7-mm microlaparoscope; intra-abdominal manipulation, as well as catheter placement using the Seldinger technique, is accomplished through a second 5-mm port. The advantages of this method include visual confirmation of catheter placement, minimal patient morbidity, and immediate availability of the catheter for PD (41,42).

Unfortunately, laparoscopy is expensive and routine use appears justified only if the anticipated early catheter failure rate exceeds approximately 15%, or when surgical placement is routinely accompanied by hospitalization, or in cases of catheter salvage (43,44). There are reports that post-insufflation pain and general anesthesia can be mitigated by using nonirritating insufflation gasses and local anesthesia (45,46).

*Buried Catheter Technique:* The "buried" catheter technique is a novel concept first introduced in the literature in 1993. Rather than immediately exposing the external catheter segment through an exit site, the entire extraperitoneal catheter is placed in a subcutaneous pocket for 4 – 6 weeks while the Dacron cuff heals firmly in place. The exit site is created later, when the external segment is located and extricated from its "buried" position (47). Without an external segment or exit site, early dialysis is impossible, but pericatheter dialysate leaks and immediate exit-site infections are rare. It was hoped that "burying" the entire catheter would reduce early bacterial colonization and lead to fewer subsequent infections (48,49). However, prospective trials have not uniformly confirmed improved long-term catheter outcomes (7,50,51). Additionally, because catheter "burying" incorporates significant technical challenges and can lead to perioperative complications, it has not been widely incorporated in clinical practices (52).

## PRESTERNAL CATHETERS

The swan neck, presternal PD catheter provides an alternative location from which a catheter can exit the skin when an abdominal site is not suitable. The exit site is in the upper anterior chest. The presternal catheter was designed for patients who would not ordinarily be considered for PD because of body habitus, intestinal stomas, or urinary–fecal incontinence. The swan neck presternal catheter is composed of two flexible (silicon rubber) tubes joined by a titanium connector at the time of implantation. The exit site is located in the parasternal area. The catheter located on the chest was designed to reduce the incidence of exit-site infections compared to PD catheters with abdominal exits. The largest experience has been reported by Twardowski (53). From August 1991 to 30 September 2001, 974 swan neck presternal catheters were implanted worldwide. At the University of Missouri, 150 of these catheters were implanted and followed for over 130 patient-years. Presternal catheters tended to perform better than swan neck abdominal catheters regarding exit and tunnel infections, even though they were implanted in several patients in whom regular catheters with the exit on the abdomen would be difficult or impossible to implant. In this veteran program with superb surgical support, the 2-year survival probability of presternal catheters was 0.95 and recurrent/refractory peritonitis was the only reason for catheter failure.

The presternal catheter is reportedly particularly useful in obese patients (body mass index >35), patients with ostomies, children with diapers and fecal incontinence, and patients who want to take baths without the risk of exit contamination. Additionally, the University of Missouri program believes that patients prefer the presternal catheter because of the better body image.

Disadvantages of the presternal catheter are minimal. Compared with abdominal catheters, dialysis solution flow is slightly slower because of the increased catheter length; however, slower flow is insignificant clinically. There is a possibility of catheter disconnection in the tunnel, but this complication is extremely rare in adults and easily corrected. Finally, the implantation technique is more challenging compared with that of single-piece abdominal catheters.

## RECOMMENDATIONS FOR CATHETER CHOICE AND CATHETER INSERTION TECHNIQUE

1. Catheter survival of >80% at 1 year is a reasonable goal.
2. Convincing data exist to indicate that the double-cuff catheter is preferable to the single-cuff catheter, with the cuff placed in the superficial location proposed for temporary access. Peritoneal catheters intended for chronic use should be inserted with a cuff deep either within the rectus muscle or abutting the preperitoneal fascia.

3. A downward directed exit may decrease the risk of catheter-related peritonitis. Properly implanted preshaped arcuate catheters will always have a downward directed exit and are, therefore, advantageous in this respect. The preformed bend eliminates the resilience force or "shape memory" of straight catheters. It must be implanted in a tunnel that accurately reflects this shape. Preformed arcuate catheters are associated with fewer episodes of early outflow obstruction and catheter migration than are straight catheters traversing an arcuate tunnel, and may well reduce the incidence of catheter infections.
4. In uncomplicated patients, no uniform advantage of any operative technique over the classic "bedside" or ambulatory percutaneous catheter placement is evident. In complex cases, there may well be advantages of laparoscopic insertion. Operator experience is more likely to dictate outcomes.

## CATHETER REMOVAL AND CATHETER TIP MIGRATION

Catheters need to be removed safely and completely. While PD catheters currently exhibit better primary survival than hemodialysis accesses (54,55), they are not permanent, and catheter removal is not a trivial undertaking. The "explant" physician should be aware of the device type and implant procedure, completely expropriate all catheter segments, including cuffs (56,57), and avoid bleeding, tissue injury, incisional hernias, omental herniation, and pain (58–60). In general, complex intraperitoneal designs (which induce intraperitoneal irritation) that contain large intraperitoneal segments and increased numbers of subcutaneous cuffs, or involve pelvic suturing or intratissue cuff placement, increase the difficulty of catheter removal.

While Tenckhoff catheters were designed for implant and explant using local anesthesia, most posttransplant catheter removals are undertaken surgically using monitored anesthesia care. A technique for Tenckhoff catheter removal by a "pull" technique intending to avoid discomfort, risk, and surgical costs has been reported. In this pull technique, steady non-jerky traction is applied to the catheter, which is successfully removed without local anesthetic (61). The authors' attempts at traction catheter removal have not uniformly realized atraumatic intact catheter and cuff extraction.

### CATHETER MANIPULATION FOR CATHETER MALPOSITION AND OBSTRUCTION

Several observational studies and reports allude to the usefulness of catheter manipulation under fluoroscopic control (62–65). There is up to 60% success for at least 6 months reported.

There are no new recommendations for these sections and the reader is referred to the 1998 guidelines (1): immediate postoperative care, early exit-site care, chronic care of the healed exit site, diagnosis and treatment of exit-site and tunnel infections, prevention of catheter infections, noninfectious (mechanical) catheter complications, and posttransplant care of the catheter.

## RECOMMENDATION FOR CATHETER OUTCOME EVALUATION

All centers should maintain data that, on subsequent analysis, provide information on catheter survival, exit infection, and peritonitis. Outcome data are important and should denote whether a catheter is still functioning when removed and the reasons for removal. Removal rates expressed as catheters lost per 100 catheter-years at risk, and categorizing the losses into mechanical problems, exit-site complications, and peritonitis should be assessed annually. A second report of early losses (those occurring before or within the first 2 months of dialysis use) needs to be maintained. This indicator should report the percent of catheters placed each year that are lost due to infectious or mechanical problems and needs to be associated with the surgical team/institution responsible for catheter placement.

## SUMMARY

The peritoneal catheter is the PD patient's lifeline. Advances in catheter knowledge have made it possible to obtain access to the peritoneal cavity safely and to maintain access over an extended period of time. Catheter-related infections remain a major problem, solutions for which are being actively researched. Nevertheless, the successful outcome of a catheter is very much dependent on meticulous care and attention to detail. Adherence to the principles of catheter insertion and subsequent management and care remain the cornerstone of successful PD access. The guidelines provided in this publication represent a consensus view based on studies from the literature and opinions of experts in this field. It is hoped that implementation of these guidelines will improve catheter-related outcomes and, therefore, enhance patient care.

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