Richard Swartz, Joseph Messana, Leslie Rocher, Janice Reynolds, Barbara Starmann, and Patricia Lees

Division of Nephrology, Department of Internal Medicine, University of Michigan
Medical Center, Ann Arbor, Michigan

The Curled Catheter: Dependable Device for
Percutaneous Peritoneal Access

Richard Swartz

The curled peritoneal dialysis catheter is theoretically less prone to catheter migration and drainage failure. It also allows percutaneous placement, rather than surgical placement exclusively, whenever desired or necessary. Review of 213 curled-catheter placements, 134 (63%) percutaneous and 79 (37%) surgical, over the last 4 years, shows that the probability of continuing catheter function by life-table analysis was 88% at one year, 71% at 2 years, and 61% at three years, with no difference comparing percutaneous to surgical placement. Among the 213 total cases, nearly 50% of all catheters were still functioning at last follow up, and 38 catheters (17.8%) have been lost in total, attributed to infectious complications in 24 cases (tunnel-exit infection alone in 5, peritonitis alone in 11, combined infection in 8), refractory drain failure in 9 cases (early drain failure in 4, late drain failure in 5), recurrent late subcutaneous dialysate leaking in 3 cases, and peri-catheter hernia in 2 cases.

Among other complications, the incidence of early drain failure (7.0%), and late drain failure (4.2%), compare favorably to reports describing other devices or other placement methods having comparable size of reported experience. Analyzing our own percutaneous and surgical placements separately, there were no differences in the respective frequencies of early drain failure, late drain failure, late subcutaneous dialysate leaking, outer cuff extrusion, required hernia repair, peritonitis or tunnel-exit infection. Only early external dialysate leaking was more frequent using percutaneous placement methods (21.6% vs. 10.1%; p < 0.05), although no catheters were lost due to early external leaking.

In conclusion, the present experience suggests that the curved catheter is both amenable to safe and convenient percutaneous placement methods in the majority of cases, as well as dependable for long-term peritoneal dialysis in a large university program.

KEY WORDS: Catheters; catheter placement; catheter complications; catheter failure; dialysate leaking; peritonitis; tunnel-exit infection; curled catheter.

Success in attaining peritoneal access is a major factor in the smooth initiation and maintenance of chronic peritoneal dialysis. Intractable drainage failure interrupts the course of chronic peritoneal dialysis in 5% to 30% of cases (1-11), more frequently in the early period after access placement than later (9), and other types of catheter complications do not appear to be characteristic of any specific access device. Although several different access devices have been described, clear cut differences in success rates have been difficult to demonstrate.

The standard straight catheter (12, 13) has usually offered the greatest flexibility because this access device can be placed initially by either percutaneous or surgical methods, and catheter complications can often be handled by percutaneous methods on an outpatient basis. However, drainage failure using the straight catheter, whether placed by surgical or percutaneous methods, has been consistently reported in 10-20% of cases in the early period after placement, and in 5-10% of cases later in the course of chronic peritoneal dialysis (4,5,8-11).

Among the alternative devices is the "column-disc" access, a flat device placed anteriorly in the peritoneal cavity and not subject to displacement, theoretically reducing the tendency toward drainage failure due to omental or mesenteric obstruction. The "column-disc" device requires surgical placement exclusively, and is subject to 8-14% early drainage failure, although late failure may be less frequent (14-16). The Toronto-Western catheter, a modification of the straight catheter designed to reduce intraperitoneal migration but also requiring surgical placement exclusively, is also subject to 15% or more early failure and a smaller incidence later (1-3, 10), with some reports describing more difficulty eradicating peritonitis without completely removing the device (2, 10). Several other modified devices (17, 18) and surgical procedures for intraperitoneal fixation of the straight catheter (19, 20) have been described, but all require some degree of surgery, none eradicate drainage failure completely, and few have been widely accepted or reported in large series.

The curved catheter is designed with a flexible coil which can be straightened with an obturator prior to placement. The coil was originally intended to reduce pain on dialysate infusion by slowing the velocity of fluid at the catheter tip (12,21). This coiled configuration, when placed in the anterior peritoneal cavity,
may also have the same advantage as the column-disc device—namely to reduce the likelihood of drainage failure due to catheter migration and external omental or mesenteric obstruction (21). Equally important, this device can be placed by percutaneous methods without operating room support when necessary or desirable. Limited experience with the curled catheter compares equally or favorably to that using other devices (21-23). This report summarizes our experience since 1985 with the curled catheter.

METHODS

This report covers the period from January 1985 through December 1988, during which virtually all of the 213 devices placed in 180 patients were curled catheters. In more than 98% of these cases, two-cuff devices were utilized. Percutaneous placement of the catheter was undertaken by the nephrology staff whenever possible (134/213 instances, 63%), using a guide wire and peel-away sheath technique in a paramedian location, performed on an inpatient or outpatient basis depending on the status of the patient. Visceral injury, or hemorrhage necessitating operative intervention, occurred in 2/134 percutaneous cases (1.5%). Surgical placement of the curled catheter was undertaken by surgical staff in the operating room in 79 instances (37%), including 12 patients (6%) with extensive prior abdominal surgery, 32 young children (15%), and 35 patients (16%) desiring general anesthesia or having catheter placement incidental to another surgery, usually removal of a failed transplant or failed hemodialysis access. Surgical placement technique varied with the attending and house staff involved, but ordinarily included a caudally directed tunnel through the abdominal wall (19), fixation and purse-string closure of the internal cuff within or interior to the rectus muscle, and occasional intraperitoneal fixation of the catheter to prevent migration. Patient selection for percutaneous or surgical placement was not randomized, prospective, or controlled.

After catheter placement, peritoneal dialysis was initiated as required by the clinical setting, including the need for acute treatment, the feasibility of acute hemodialysis, and the presence of other illness or complications. In general, a "break-in" period of 7-14 days without dialysis was allowed, facilitating fibrous incorporation of the subcutaneous cuffs of the catheter without the increased pressure from intraperitoneal fluid or leaking of dialysate around the catheter. However, when peritoneal dialysis was required in the immediate period after catheter placement, low volumes and short intra-peritoneal dwell time were employed. In the event of early, external dialysate leaking, peritoneal dialysis was discontinued for 10-14 days, if possible. In patients already performing outpatient peritoneal dialysis for several months or more, late subcutaneous leaking with swelling in the abdominal wall and/or genitalia was treated initially by reducing the volume and peritoneal dwell time, and subsequently by discontinuation of peritoneal dialysis and interval hemodialysis for 10-14 days when such leaking persisted. When late subcutaneous leaking persisted, or worsened, catheter replacement was undertaken by either percutaneous or surgical techniques.

Early (first 4 weeks) and later drainage failure were defined as the inability to drain effluent reliably, even after conservative maneuvers to restore catheter function, such as abdominal massage, ambulation, enema, or cathartic. Such failures required intervention. Occasionally, replacement or repositioning by nephrology staff was possible, but more often, laparotomy, with or without omentectomy, was required with replacement of the catheter if deemed necessary by the nephrology and surgery staff. An effort was ordinarily made to restore peritoneal dialysis whenever feasible, if desired by the patient or deemed advisable by the nephrology staff.

Peritonitis was defined as the occurrence of cloudy effluent, with or without fever and abdominal pain, usually with effluent white blood count (WBC) more than 100/mm3 and more than 50% neutrophils, but confirmed by positive bacterial culture whenever possible. Treatment of peritonitis was accomplished using loading and maintenance doses of appropriate intraperitoneal antibiotic for 10-14 days, on an inpatient or outpatient basis, as dictated by clinical circumstances. Tunnel or exit-site infection was defined clinically as an inflammation, with or without discharge, confirmed by culture when deemed necessary to better define treatment. Treatment of tunnel and exit-site infections included local catheter care and oral or intraperitoneal antibiotic as deemed necessary by nephrology staff. When external cuff extrusion was inflammatory, and associated with active tunnel or exit site, local release of the external cuff and shaving of the exposed cuff material, without catheter removal or interruption of peritoneal dialysis, was undertaken electively on an outpatient basis by the nephrology staff.

Data analysis included life-table construction using the method of Kaplan and Meier (24), in which catheter failure was defined as removal or death due to mechanical or infectious complication. Specific outcomes between patient groups were compared using the chi-square test. Infection rates for peritonitis and tunnel-exit site infection were calculated in 2 ways, both expressed in episodes/patient-year: first, the descriptive cumulated rate for each group of patients (total cumulated infections/total cumulated patientyears); and second, the unweighted average of infection rates for tunnel-exit site infection. However, statistics were applied to only the latter values, using both the Student t test and the Mann-Whitney ranking test.

RESULTS

Four years of experience with 213 catheter placements includes a total of 2613 patient-months, 1660 patient-months for catheters placed percutaneously, and 953 patient-months for surgical placements. Figure 1 shows the life-table analysis of overall catheter survival, with the probability of continuing catheter
function at 88%, 71%, and 61% at 1, 2, and 3 years, respectively, with no difference comparing percutaneous to surgical catheters. In 38 of 213 instances (17.8%), catheters failed, and the details of these cases are described in Table 1. At the time of this report, in 101 of 213 instances (47.4%) patients were still being actively followed with a functioning catheter for up to 48 months, and in 74 of 213 instances (34.7%) follow up ended without catheter failure for as long as 30 months. These latter 74 cases included 34 unrelated deaths, 29 transplants, 8 transfers to another center or recovery of renal function, and 3 elective terminations of peritoneal dialysis.

Among the complications shown in Table 1, early drain failure occurred in 15 instances (7%), 11 resolving without catheter replacement after percutaneous revision or laparotomy with omentectomy, and only 4 resulting in catheter loss (3 of the latter receiving another catheter, by percutaneous replacement in 2 instances, and by surgical replacement in one). Late drain failure occurred in only 9 instances (4%), 5 resulting in catheter loss, with all 5 patients returning to peritoneal dialysis after percutaneous catheter replacement in 2 instances and surgical replacement in 3. In the other 4 cases of persisting late drainage failure, the catheter was not removed and the problem resolved after omentectomy or conservative management.

Table 1 also shows that early external leaking of dialysate occurred in 37 cases (17.3%). This early external leaking appeared to be more frequent following percutaneous placement (29 cases, 21.6%) than in surgical placement (8 cases, 10.1%), despite the paramedian placement of percutaneous catheters, and attributable most likely to the technique of abdominal wall closure utilized during surgical placement or to better enforcement of the "break in" protocol when patients were hospitalized for surgical catheter placement. Even with this difference in the frequency of early leaking, no catheters were lost because of early leaking. On the other hand, late subcutaneous leaking accounted for 3 catheter losses, all percutaneously placed and all returning to peritoneal dialysis with percutaneous catheter replacement in one instance and surgical replacement in two.

Among other complications, Table 1 shows that outer-cuff extrusion occurred in 19 cases (8.9%), not different between percutaneous and surgical placements. The incidence of herniae requiring surgical repair was 5.6% (12 cases equally divided between percutaneous and surgical cases), 2 cases resulting in catheter loss but both patients returning to peritoneal dialysis after hernia repair and surgical catheter replacement. Finally, among the 38 cases of catheter loss, infectious complications led directly to catheter loss in 24 instances.

Table 2 summarizes the infectious complications during the survey period. The overall rates of peritonitis and tunnel-exit infection approximate the long-term cumulated rates of 0.9-1.0 peritonitis/patient-yr, and 0.6-0.7 tunnel-exit infections/patient-yr reported for our center through the National Continuous Ambulatory Peritoneal Dialysis (CAPD) Registry (25). Placement technique did not appear to influence infectious complications, although the fre

![Figure 1 — Life-table analysis of overall catheter survival for the entire 4-year follow up. For definitions see methods and results. Values appearing along the curve with an asterisk represent the number of catheters “at risk” at the end of each yearly interval.](chart.png)
quency of tunnel-exit infection was somewhat higher in the surgical group, which included a disproportionate complement of pediatric cases. Table 3 characterizes each of the 24 cases in which catheter loss was directly associated with infectious complication.

**DISCUSSION**

The present report suggests that the curled catheter is a dependable peritoneal access device when placed by percutaneous methods, comparing favorably with other devices and placement methods for early and late drainage failure and for required surgical intervention. Furthermore, the curled catheter can be inserted using a bedside percutaneous technique, making this access applicable to the outpatient, chronic-renal-failure setting where elective placement can obviate surgical intervention in more than 90% of cases, as well as the inpatient, acute-renal-failure setting where placement in unstable patients is often emergent and initial catheter function is often critical.

The standard straight catheter consistently manifests drainage failure approximately twice as often as the curled catheter in our own uncontrolled experience (9) and in the experience of others (5,10,21,22). Although the column-disc device has the theoretical advantage for more predictable drainage function, the early failure rate of the column-disc device ranges from 8-14% (14-16). Furthermore, even though reported late drainage failure is infrequent with the column-disc device, cumulated experience is very limited and surgical placement is required. Similar drawbacks limit the universal applicability of the Toronto Western (1-3,10) and other modifications (17,18) of the standard catheter, since placement of these devices usually requires surgical methods, early failure still occurs in 10-20% or more of cases, and removal for refractory peritonitis may require another surgical procedure (2,10,22).

In the search for other methods to improve the success of peritoneal access placement, several procedures to prevent migration and drainage failure with straight catheters have also been devised. As examples, creation of a small "peritoneal tunnel" (19), downward angling of the catheter track through the abdominal wall (20), and the swan-neck permanent bend in the subcutaneous tunnel to avoid torque on the catheter (26), may all obviate some complications, but surgical placement is required for the first 2 methods and overall experience is insufficient to warrant comparison with other large series. Peritoneoscopy has also been advocated in order to prevent subsequent complications (27); however, drainage failure is not eliminated (27), and the method has no specific modifications which avoid complications such as dialysate leaking. Interestingly, peritoneoscopy has been successfully used on occasion to reposition a failing catheter and restore drainage function (28). Catheter salvage has also been described using a stiff wire or trochar inserted into the catheter lumen and twisted (29). However, overall results using these latter methods have been disappointing (29, 30), and we have found that such methods are painful and pose the risk of internal organ injury.

In conclusion, it is important to note that the present results with the curled catheter, along with our own previously reported experience using the standard straight catheter (9), strongly suggest that percutaneous catheter placement can be effective in establishing peritoneal dialysis access for the majority of patients, with long-term success and almost equal complication rates when compared to surgical placement techniques. In the ongoing treatment of patients with end-stage renal failure, availability of an easily

**TABLE 2**

Infectious Complications

<table>
<thead>
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<th></th>
<th>All</th>
<th>Percutaneous</th>
<th>Surgical</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Peritonitis (per patient-yr)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cumulated rate</td>
<td>1.03</td>
<td>0.98</td>
<td>1.15</td>
</tr>
<tr>
<td>Individual average (±SEM)</td>
<td>0.96 ± .11</td>
<td>0.91 ± .13</td>
<td>1.05 ± .19</td>
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<tr>
<td><strong>Tunnel-exit (per patient-yr)</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>cumulated rate</td>
<td>0.79</td>
<td>0.75</td>
<td>0.88</td>
</tr>
<tr>
<td>Individual average (±SEM)</td>
<td>0.90 ± .13</td>
<td>0.72 ± .14</td>
<td>1.20 ± .24</td>
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</table>

**TABLE 3**

Catheter Loss Due To Infection

<table>
<thead>
<tr>
<th></th>
<th>Gram Pos*</th>
<th>Pseudomon</th>
<th>Fungal</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tunnel-Exit Only</strong></td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Peritonitis Only</strong></td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>Both</strong></td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

* All *S. aureus* except one case of recurrent *S. epidermidis* peritonitis and one case of Streptococcal peritonitis.
† Enteric (diverticulitis) one case; recurrent negative cultures one case; *Acinetobacter* one case.
‡ *Serratia* one case; *Proteus* one case.
placed, easily revised, and predictable peritoneal access device allows considerably more flexibility in day-to-day management and may improve the retention of patients on chronic peritoneal dialysis.

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REFERENCES