

Articles

Peripherally Inserted Central Venous Catheters Low-Risk Alternatives for Ongoing Venous Access

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We prospectively evaluated the use of peripherally inserted central venous catheters to provide ongoing venous access in general medical and surgical patients in a Department of Veterans Affairs medical center. Between 1985 and 1988 trained nurses successfully inserted 393 catheters in 460 suitable patients (an 85.4% success rate). Correct catheter tip placement in the superior vena cava was documented in 359 of the 393 (91.3%) catheter insertions, but an additional 30 catheters were in a position deemed adequate for the intended use. The mean duration of catheter use was 27.6 ± 5.2 (1 standard deviation) days (median 20 days, range 1 to 370 days). A total of 65 patients left the hospital with catheters in place, with the mean length of catheter use at home being 36.2 ± 6.0 days (range 2 to 266). In all, 79% of the catheters were in use until the successful completion of therapy or patient death; catheter-related complications led to premature catheter removal in the remaining 21%. Catheter-related complications included bland phlebitis (8.2%), occlusion (8.2%), local infection (3.6%), bacteremia or fungemia (2.1%), mechanical failure or rupture (2.6%), venous thrombosis (0.7%), and other (3.3%). One patient required vein excision for the management of suppurative phlebitis, but no deaths were attributed to catheter use. This study illustrates the use and safety of peripherally inserted central venous catheters to provide reliable vascular access over prolonged periods in an elderly veteran population. At our facility, percutaneous central venous catheters and surgically implanted (Hickman or Broviac) catheters are now reserved for use in patients in whom peripherally inserted catheters cannot be placed.

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Maintaining reliable vascular access in patients hospitalized long term can be difficult for both patients and their physicians. Many techniques have been developed for this purpose, including peripheral venous cannulas, arteriovenous fistulas, percutaneous central venous catheters, subcutaneously tunneled right atrial catheters, and peripherally inserted central venous catheters. Peripheral venous cannulas must be changed frequently, and access sites may be rapidly exhausted. Arteriovenous fistulas require an operative procedure, and the rate of complications has been unacceptably high when compared with other alternatives.¹ Percutaneous central venous catheters are uncomfortable, carry substantial risks associated with insertion, and usually require that patients are kept in the hospital during their use.² Tunneled catheters carry similar risks and also require surgical insertion.^{3,4}

A useful alternative is the peripherally inserted central venous catheter (PICC), which was introduced in 1975.⁵ This silastic catheter is inserted into a peripheral arm vein and passed centrally into the superior vena cava. The use

of these catheters has gained wide acceptance for patients undergoing long-term cancer chemotherapy, total parenteral nutrition (TPN), and antibiotic therapy.⁶⁻¹⁹ Peripherally inserted central venous catheters can be inserted at a patient's bedside or in an outpatient clinic and are immediately available for use once correct placement is confirmed. These catheters appear to be less thrombogenic than Teflon and polyethylene catheters, and their pliability helps ensure patient comfort.^{20,21} Complications have generally been benign and can usually be treated without removing the catheter.

We present the results of our experience with the maintenance of 389 PICCs placed in patients in a Department of Veterans Affairs hospital from 1985 to 1988. The indications for catheter use and catheter removal, as well as associated complications in these patients, are presented.

Patients and Methods

In December 1984 we began a prospective evaluation of the applicability of PICC use in general medical and

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ABBREVIATIONS USED IN TEXT

PICC = peripherally inserted central venous catheter
TPN = total parenteral nutrition

surgical patients at the Department of Veterans Affairs Medical Center in Salt Lake City, Utah, a 301-bed teaching hospital affiliated with the University of Utah School of Medicine. Before that time various methods discussed previously had been used to provide venous access for these patients, and no specialized services were available for teaching families, patients, or medical personnel regarding catheter care and maintenance.

Since 1984, patients with special needs for vascular access due to conditions such as insufficient peripheral venous access, cancer chemotherapy, long-term antibiotic therapy, and TPN, as identified by members of the medical and surgical house staff or attending staff at this facility, have been evaluated by nursing members of an informal vascular access team. Antecubital PICC insertion was attempted at the patient's bedside by one of three nurses specifically trained to insert silicone elastomer catheters (Intrasil, Baxter Health Care, Deerfield, Ill).

The Intrasil catheter is a single-lumen, 16-gauge catheter (inside diameter 0.1 cm [0.04 in], outside diameter 0.18 cm [0.07 in]) measuring approximately 51 cm (20 in) in length. Before catheter placement the desired length of the catheter was calculated to attempt to place the distal tip in the midsuperior vena cava. After placement, the catheter tip position was determined by chest x-ray study before use. A catheter tip in any location other than the superior vena cava was considered to be incorrectly positioned. In these cases, the catheter was either used at the discretion of the requesting physician or removed. If the catheter tip was in the correct position or the final site was adequate for use, the nurse secured the connector hub in the antecubital fossa using three nylon sutures. Sterile occlusive dressings were maintained over the entry site and changed twice a week. When not in use, the catheter was flushed daily with injections of heparin solution (100 units per ml) to maintain patency.

No restrictions were placed on the types of fluids that could be administered through the catheter or on its other uses, such as monitoring central venous pressure or drawing blood. Patients were observed by the vascular access nurses on a daily to weekly basis as needed during the hospital stay, with the daily catheter maintenance care provided by unit nurses. When PICCs were intended for outpatient use, catheter care instructions were given to the patient and family before discharge from the hospital or clinic. All outpatients with PICCs were monitored during subsequent clinic appointments and hospital admissions until the time of catheter removal or patient death. In general, catheter-related problems were brought to the attention of and managed by the vascular access nurses under the supervision of a physician.

Catheter occlusions were indicated by an inability to infuse fluid through or to withdraw blood from the catheter in the absence of obvious catheter kinking. Attempts

were made by the house staff or the vascular access nurses to clear the occlusion by instilling 0.8 ml of urokinase (Open Cath, 5,000 units per ml, Abbott Laboratories, Chicago, Ill), as described elsewhere.²² In accordance with the manufacturer's instructions, attempts were made to clear the catheter at times ranging from 5 to 60 minutes following urokinase instillation. Catheters that did not clear after one or two instillations of urokinase were removed and replaced if still needed. Other indications for catheter removal were completion of therapy; phlebitis, as evidenced by pain, tenderness, and erythema along the peripheral length of the catheter that did not respond to conservative measures, such as moist heat and elevation; subclavian vein thrombosis, verified by venography where possible; catheter rupture; catheter site infection that did not resolve with local treatment; and patient death.

If a fever of higher than 38.3°C developed after the catheter was inserted, a direct causal relationship between the presence of the catheter and the fever was considered, but the catheter was not empirically removed. In general, physicians were advised to obtain blood cultures through the catheter as well as from peripheral venous sites. Indications for catheter removal in these patients were the presence of septic thrombophlebitis or blood cultures positive for organisms either through the catheter or from peripheral sources. In most cases where fever persisted for 48 hours without a primary source of infection being identified, the catheter was removed at the discretion of the primary physician. In those instances, physicians were advised to culture the catheter tip upon removal. Otherwise, no attempts were made to routinely perform cultures of the catheter tip at the time of catheter removal.

Patient profile information and data regarding the attempted insertion sites, catheter tip location, and complications were stored in an IBM-PC/AT computer and analyzed with the Statistical Package for the Social Sciences (SPSS-X, SSPS Inc, Chicago, Ill). The incidence of the catheter-related complications noted above was compared with the indications for catheter use. Statistical differences between groups were determined with the Yates' χ^2 , Fisher's exact, or two-tailed Student's *t* test. The null hypothesis was rejected when the *P* value was less than .05.

Results

Between December 1984 and August 1988, attempts were made to insert PICCs in 460 general medical and surgical patients at our facility. Patient characteristics are listed in Table 1. The mean patient age was 57.8 years (range 19 to 93). Only four women are represented in this group, which reflects the predominantly male veteran population at this facility. A total of 47 patients had more than one catheter placed during the period of study, with 1 patient having catheters placed on seven separate occasions. The clinical indications for catheter placement were antibiotic administration (48.7%), venous access (26.1%), parenteral nutrition (20.0%), and cancer chemotherapy (5.2%).

Antecubital veins were used for PICC insertion, with 44% of the catheters passed centrally through the cephalic

TABLE 1.—Characteristics of 460 Patients Who Received Peripherally Inserted Central Venous Catheters

Characteristic	Patients (n=460)	
	No.	%
Age, yr.....	57.8*	19-93†
Sex		
Male.....	456	99.1
Female.....	4	0.9
Indication		
Antibiotic therapy.....	224	48.7
Venous access.....	120	26.1
Total parenteral nutrition.....	92	20.0
Chemotherapy.....	24	5.2
Site		
Left basilic vein.....	150	32.6
Left cephalic vein.....	95	20.7
Right basilic vein.....	103	22.4
Right cephalic vein.....	112	24.4
Insertion attempts.....	460	100
Successful insertions.....	393	85.4
Correct placement‡.....	359	91.3
Successful use§.....	389	99.0

*Mean.
 †Range.
 ‡Catheter tip located in midsuperior vena cava; percentage calculated by dividing the number correctly placed by the number successfully placed.
 §Catheter used for intended purpose; percentage calculated by dividing the number successfully used by the number successfully inserted.

veins and 56% through the basilic veins. All insertion attempts and repositioning efforts were directed at placing the catheter tip in the midsuperior vena cava. Of the 460 insertion attempts, 67 (14.6%) were unsuccessful, typically because of an inability to advance the catheter into a central venous location. Proper tip placement in the superior vena cava was documented in 359 of 393 patients (91.3%), and in the remaining 34 patients the final catheter tip location was elsewhere, such as the internal jugular or axillary veins, despite repositioning attempts. In 30 of these patients, however, the final location of the catheter was deemed adequate for the intended use. Thus, incorrect catheter position was responsible for an inability to use the catheter in only 1% (4 of 393) of the catheters inserted. Overall, PICC insertion successfully fulfilled the requirement for venous access in 84.6% of the patients (389 of 460) for whom long-term venous access was necessary. The number of insertion attempts and the percentage of catheters that could not be placed correctly are shown for each year in Figure 1. As can be seen, the catheter insertion success rate was relatively stable over the four-year period despite a gradual increase in the number of catheter insertion attempts.*

To determine if anatomical considerations were important in defining the catheter insertion success rate, we compared the rates of insertion success by side of attempt (left versus right) and by basilic versus cephalic sites of insertion. Technical success rates were significantly higher when the insertion was attempted at the basilic venous

*Patricia Rushton, RN, PhD, and Sherry Brown, RN, assisted with inserting and maintaining catheters.

site compared with attempts made at the cephalic site (94.5% versus 86.4%, respectively; $P < .05$), but no differences were seen in the catheter placement success rates when compared by side of attempt.

Although most of the PICCs were inserted during a hospital stay, the catheters were intended for both inpatient and outpatient use in many of these patients. The mean duration of catheter use in the entire patient population was 27.6 ± 5.2 days (total 10,741 days, median 20 days, range 1 to 370 days). In all, 65 patients left the hospital with the PICC in place for continued outpatient use. The mean duration of catheter use in the outpatient setting was 36.2 ± 6.0 days (total 2,350 days, range 2 to 266 days). Despite the flexibility and small inside diameter of these catheters, little difficulty was encountered in the routine use of these catheters for drawing central venous blood.

Most of the catheters (64%) were removed after therapy was successfully completed (Table 2). An additional 14.9% were either removed at the time of a patient's death or were lost to follow-up when a patient was transferred to another facility. Thus, in 78.9% of these patients PICC placement allowed for successful completion of the prescribed treatment.

Catheter-related complications of a minor or serious nature were documented in 110 of 389 patients (28.3%) (Table 3). The major indication for premature catheter removal was the development of unexplained fever, which led to catheter removal in 25 patients. Although other complications, such as bland phlebitis and catheter occlusion, occurred more commonly (noted in 32 patients each), they did not necessarily lead to catheter removal. Bland phlebitis, which was characterized by local swell-

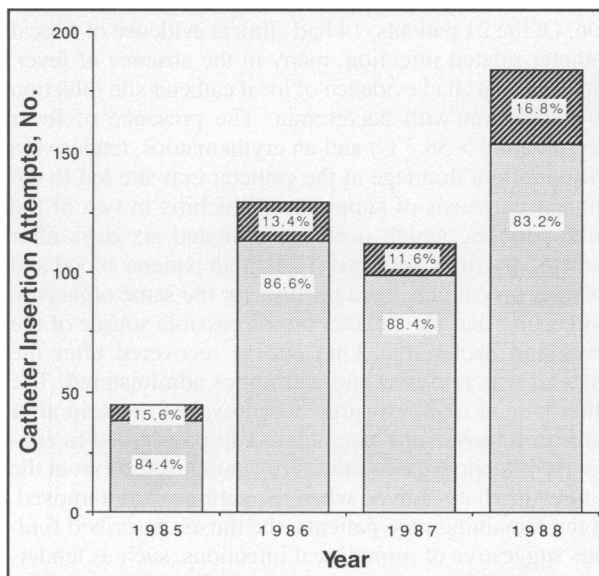


Figure 1.—The graph shows the number of peripherally inserted central venous catheter insertion attempts by year. Each bar is subdivided into the number of successful attempts (light hatch) and unsuccessful attempts (dark hatch), and within each hatched area is the percentage that that number represents of the total number of catheter insertion attempts for that year.

Indication	Patients	
	No.	%
Treatment completed.....	249	64.0
Death.....	54	13.9
Fever.....	25	6.4
Occlusion.....	14	3.6
Phlebitis.....	12	3.1
Ruptured catheter.....	10	2.6
Bacteremia or fungemia.....	8	2.1
Local infection.....	6	1.5
Transfer to other facility.....	4	1.0
Patient pulled out.....	3	0.8
Thrombosis.....	2	0.5
Unknown.....	2	0.5
Total.....	389	100.0

ling, erythema, and tenderness along the tract of the catheter, typically appeared during the first 24 to 72 hours after catheter insertion and in most cases resolved with moist heat. In 12 patients persistent phlebitis that did not resolve with local measures led to catheter removal. Urokinase instillation led to the restoration of patency in 18 of the 22 (81.8%) occluded catheters, whereas 4 catheters remained unusable despite urokinase administration and were subsequently removed. Ten catheters were removed because of catheter occlusion without an attempt being made to restore patency.

Fever led to catheter removal in 25 patients, but many of those patients had neither blood nor catheter tip cultures obtained. In all, 24 catheter-related infections were recorded in 21 patients. The onset of infection was documented at a mean of 32.5 ± 5.8 days after catheter insertion. Of the 21 patients, 14 had clinical evidence of a local catheter-related infection, many in the absence of fever. Three patients had evidence of local catheter site infection in association with bacteremia. The presence of fever (temperature $> 38.3^\circ\text{C}$) and an erythematous, tender vein with purulent drainage at the catheter exit site led to the clinical diagnosis of suppurative phlebitis in two of the three patients, which occurred four and six days after catheter insertion, respectively. In both patients blood and catheter tip cultures were positive for the same organism, suggesting that the catheter was a possible source of the fever and bacteremia. One patient recovered after the catheter was removed and antibiotics administered. The other patient required surgical removal of the vein after catheter removal and parenteral antibiotics failed to control the infection. Two patients had minor infections at the suture site that resolved when the sutures were removed. In the remaining nine patients, the nurses described findings suggestive of minor local infections, such as tenderness and erythema, that were not confirmed by cultures. The signs and symptoms of infection cleared rapidly with aggressive local management in most of these patients, but the infection led to removal of the catheter in 6 of the 14 patients with local infection, including the 2 patients with suppurative phlebitis.

Bacterial or fungal cultures of peripheral blood specimens, catheter tips, or blood drawn through the catheter were positive in 10 of the 21 patients thought to have catheter-related infections. Bacteremia (6 patients) or fungemia (2 patients) was documented in eight patients in whom a PICC was present at the time of suspected systemic infection, with all eight growing the same organism from simultaneous blood and catheter tip cultures. Five of these patients had evidence of inflammation (erythema, tenderness, or both) at the catheter insertion site at the time that the bacteremia or fungemia was discovered, with two of the five displaying evidence of suppurative phlebitis as described earlier. The other three patients had no evidence of infection at the catheter insertion site. Four of the eight patients had documented infections at other sites involving lungs, bone, or urinary tract, which may have also served as sources for the bacteremia or fungemia. Two additional patients had positive cultures obtained at the time fever developed. One patient had bacterial growth in blood drawn through the catheter while simultaneous peripheral blood and catheter tip cultures were bacteriologically negative. In the other patient catheter tip cultures were bacteriologically positive at the time fever developed, but blood cultures were not obtained.

The bacterial species identified in the blood and catheter tip cultures were *Staphylococcus aureus* in four patients, *Klebsiella* species in three patients, and *Staphylococcus epidermidis* in one patient. Blood and catheter tip cultures from one patient grew the yeast form, *Torulopsis globrata*, whereas *Candida albicans* was cultured from both sources in another patient. Six of the nine patients with positive blood cultures, including both patients whose cultures grew yeast species, were receiving TPN at the time fever developed, whereas the remaining three patients were receiving antibiotics for previously established infections. Documentation of positive blood or catheter cultures in the setting of presumed systemic infection led to catheter removal and appropriate antibiotic therapy in ten patients. None died as a result of the presumed catheter-related infection.

Rupture of the catheter led to premature catheter re-

Complication	Patients	
	No.	%
Bland phlebitis.....	32	8.2
Occlusion.....	32	8.2
Infection.....	24	6.2
Local.....	(14)	(3.6)
Bacteremia or fungemia.....	(8)	(2.1)
Other*.....	(2)	(0.5)
Catheter rupture.....	10	2.6
Venous thrombosis.....	2	0.5
Other (pain, bleeding).....	10	2.6
Total.....	110	28.3

*Included 1 patient with a positive catheter tip culture only and 1 patient with a positive blood culture through the catheter but negative catheter tip and peripheral blood cultures.

removal in ten patients. In several instances the catheter was inadvertently penetrated during needle introduction through the cap, and in others the rupture was caused by the use of excessive force during attempts to clear catheter occlusion. In some cases no obvious explanation for the rupture was found. No cases of catheter embolization occurred.

Catheters were removed from two patients because arm swelling led physicians to suspect venous thrombosis. The presence of axillary vein thrombosis was confirmed by venography in one patient and was suspected in the second patient but not documented radiographically. Both patients had complete resolution of the arm swelling following catheter removal; only the patient with the abnormal venogram received heparin therapy.

To determine if any features of our patient population might identify patients at high risk of having a catheter-related complication we compared the incidence of complications by treatment indication subgroup—for example, chemotherapy versus TPN—and by patient age (60 years or older versus younger than 60), year of catheter insertion (1985-1986 versus 1987-1988), and site of insertion (left versus right, basilic versus cephalic). The incidence of bacteremia in patients with PICCs inserted specifically for TPN administration was significantly higher than in those patients in whom the catheters were used for other purposes (6.1% versus 1.0%, respectively; $P < .01$). Further analysis of the various patient subpopulations revealed no other factors that were associated with a significantly higher risk of having catheter-related complications.

Discussion

Providing long-term venous access through central venous catheters is accepted as standard practice in both surgical and medical patients. These catheters provide a route for the administration of fluids, chemotherapeutic agents, blood products, antibiotics, and total parenteral nutrition. In the past few years, the availability of several catheter types that vary in diameter, composition, lumen number, and mode of insertion has made the complication rates resulting from their use difficult to compare. The complication rates for percutaneously inserted central venous catheters of the tunneled variety have been reviewed recently,^{1,23-25} but despite several years of experience with the peripherally inserted central venous catheters, no detailed descriptions of the complications resulting from the insertion of these catheters are available.

In this study, we have demonstrated that one particular PICC, the Intrasil catheter, is a safe and convenient alternative to other catheter types for providing long-term venous access for patients in a general medical or surgical service. Most of these catheters (75%) were inserted for use either in long-term antibiotic administration or to provide venous access; intravenous hyperalimentation was the indication for insertion in about 20% of the patients. In other reported series, the use of the PICC was limited to a particular population, such as patients receiving cancer chemotherapy^{6,9,10} or TPN.^{5,8,11} Thus, the variability in the complication rates noted in these reports may most accurately reflect differences in the study populations.

In our patients, the two most frequent complications associated with PICC use were phlebitis and catheter occlusion, both of which tended to be relatively minor and usually did not lead to catheter removal. Bland phlebitis, which typically occurred within two to three days of catheter insertion, usually resolved rapidly with local measures. The 8.2% incidence of phlebitis observed in this study is lower than the 23% incidence reported in early studies by Bottino and colleagues⁶ but falls within the 1% to 10% range noted in more recent reports.^{7,8,10-19} Suppurative phlebitis was noted in only two (0.5%) of our patients, and only one patient required vein excision. The incidence of suppurative phlebitis in the other reported series has been exceptionally low,¹⁰⁻¹⁹ leading us to conclude that this is an unusual complication with these catheters.

Occlusion was noted in 8.2% of the catheters and was usually related to intravenous lines running dry. Catheter patency was rapidly reestablished in 82% of the catheters in which a fibrinolytic agent was used. Catheter occlusion rates in other descriptions of PICC use have ranged from 1.5% to 15%,⁷⁻¹⁹ with many of the catheters being removed without an attempt to reestablish patency. A fibrinolytic agent routinely instilled into occluded PICCs, using methods described by Hurtubise and associates,²² would make catheter occlusion an infrequent reason for premature catheter removal.

In a review of intravenous catheter-related infections, Hampton and Sheretz reported that the rate of catheter-related septicemia leading to systemic sepsis is low, occurring in less than 1% of patients.²⁶ Comparisons of the infection rates reported with various types of catheters are made difficult by differences in the definitions of "catheter-related infection," as well as by differences in the routine screening methods used to detect catheter colonization or infection. Peters and colleagues reported that bacterial colonization within or around any catheter probably begins almost immediately following catheter insertion.²⁷ Thus, the incidence of catheter-related infections reported in any series of patients will depend on the indications and techniques used for catheter tip culture and on whether blood specimens for culture were obtained through the catheter as well as from peripheral sites. In this series we noted local or systemic infections, or both, in 21 of 389 (5.4%) patients. A total of 14 patients had evidence of local infections, of which 8 responded to local care without catheter removal. In 10 patients (2.6%) bacteremia, fungemia, or positive catheter cultures led to catheter removal. Four of these patients had other sites of infection that may have been the source of bacteremia. Three patients had evidence of local catheter infection. The precise catheter-related sepsis rate cannot be determined in this study because of a failure to consistently obtain cultures of the catheter tip and blood before catheter removal or in all patients with unexplained fever.

A comparison of the catheter infection rate reported here with those from previous PICC studies is made difficult by the differences in definitions. Bottino and co-workers reported a 1% catheter-related sepsis rate in patients receiving long-term cancer chemotherapy.⁶ Mills

and associates reported a single episode of staphylococcal sepsis in 61 patients in whom 67 PICCs (1.5%) had been placed for TPN administration,¹³ whereas Roundtree reported only 2 catheter-related infections (positive tip cultures) during the use of 410 PICCs (infection rate < 0.5%) in patients in a general hospital setting.¹⁵ In terms of infection rates per 100 days of catheter use, the patients in our series had a rate of 0.022 infections per 100 catheter days—24 infections during 10,741 days. This rate compares favorably with the rates of 0.1 to 1.9 infections per 100 days noted in other reported percutaneous catheter series and 0.00 to 0.18 infection per 100 days noted in patients with implantable catheter devices.²⁸ Thus, the incidence of local and systemic infections associated with the use of PICCs appears to be low and compares favorably with that seen during the use of other traditional catheter types.²⁸

Special mention should be made of the ten catheters in this series that perforated or ruptured. The composition of these catheters makes needle penetration of the catheter wall easy during the process of gaining access through the rubber cap. Extra care must be taken to avoid catheter penetration during needle access and to avoid the use of excessive force during the process of clot dissolution. In the event that catheter rupture is confirmed, however, an alternative to removing the catheter would be to attempt to replace the catheter over a guidewire, as described by Lum and Soski.²⁹ The routine use of that technique in our patients might have obviated the need for reinserting the catheters in all ten patients.

Tunneled catheters of the Hickman or Broviac variety appear to be the gold standard in longevity for providing long-term central venous access. In a review of the complications associated with the use of Hickman catheters in patients with malignancy, Press and colleagues reported that the average duration of catheter use in 17 reported series was 92.4 days (range 15 to 120 days).²⁵ The average reported duration of PICC use has been in the 20- to 50-day range,⁷⁻¹⁹ which is in keeping with the mean duration of 27.6 days noted in this series. The differences in average catheter dwell time between the two types are probably related to differences in the patient populations for which the catheters are targeted. Catheters of the tunneled variety are seldom inserted in patients in whom the projected need is for less than three to four months, whereas PICCs are chosen in those cases where either shorter durations of access are needed or double- or triple-lumen catheters are not required. Evidence that PICCs can be used for longer periods, if necessary, is provided by Legha and associates, who reported a median duration of catheter function of 238 days (range 2 to 521 days).¹⁰

In this series, PICCs were successfully placed and used in 85% of the patients who were identified as needing long-term venous access. Catheters remained in place for more than 70 days in 21 patients, with the longest period of use being 370 days. In 79% of the patients in whom a PICC was placed, the catheter successfully fulfilled the requirements for venous access for the duration

of the identified need. Moreover, 16% of our patients were discharged with the PICC in place and were managed successfully as outpatients for an average of 36.2 days. This feature of PICCs offers a clear advantage over percutaneous central venous catheters and peripheral cannulas, which typically are less durable.

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