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VENOUS INTERVENTION

Venous Thrombosis Related to Peripherally Inserted Central Catheters[1]

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Abbreviations: PICC = peripherally inserted central catheter SVC = superior vena cava

ABSTRACT

PURPOSE: To determine factors that may lead to venous thrombosis in patients with peripherally inserted central catheters (PICC).
MATERIALS AND METHODS: The medical records of 678 patients with 813 PICCs during 1997 were cross-referenced with all patients receiving venous duplex examinations (1,631) during the same time period. Multiple factors were examined in the patients with catheter-related thrombosis, including diagnosis, solution infused, catheter tip position, vein accessed, and catheter diameter.
RESULTS: Nurses placed 269 PICCs with 12 venous thromboses, for a rate of 4.5%. Radiologists placed 544 PICCs with 20 venous thromboses, for a rate of 3.7%. There was no significant difference in these rates. The overall thrombosis rate was 3.9%. After multivariate analysis, only catheter diameter remained significant. There were no thromboses in catheters 3 F or smaller. The thrombosis rate was 1% for 4-F catheters, 6.6% for 5-F catheters, and 9.8% for 6-F catheters.
CONCLUSIONS: Thrombosis rate associated with PICCs was low (3.9%). The smallest acceptable catheter diameter should be used to decrease the incidence of venous thrombosis.

INTRODUCTION

PERIPHERALLY inserted central catheters (PICCs) are a frequently used form of intravenous access. They are fairly easily and safely inserted. They are comfortable and well-tolerated by patients. They are cheaper than either a tunneled catheter or port placed in the operating room, roughly equivalent to the cost of three peripheral intravenous catheter insertions (1), and can last as long as a surgically implanted line if well-maintained. One complication of PICCs is venous thrombosis, which can lead to a painful and swollen extremity, loss of the access site, and increased risk for pulmonary embolism. The incidence of central catheter-related venous thrombosis in the literature ranges from 3% to 70% (2).

The medical records of 678 patients with 813 PICC insertions during 1997 were cross-referenced with all patients receiving venous duplex examinations (1,631) at a single hospital during the same time period. The data collected included the date of insertion, the diameter of the catheter, the vein accessed, and the position of the catheter tip. It was noted whether the PICC was inserted by an infusion nurse on the ward, or a radiologist in the fluoroscopy suite.

The nurses used a vein that was most easily palpated and cannulated, at or just above the antecubital fossa. The catheter was inserted through a peel-away sheath, without the use of a guide wire. The radiologists chose a vein that was patent, as determined by venography, in the mid-to-distal upper arm, preferably the basilic. The vein was cannulated with use of a needle, followed by a guide wire. The guide wire was used to place a dilator and peel-away sheath, though which the PICC was threaded. No postprocedure imaging of the arm was performed.

The patient data included the primary diagnosis and the intravenous solution the patient received. The duplex data included presence and location of venous thrombosis. The data were compared both by a univariate analysis using $\chi 2$, and by multivariate analysis using a stepwise logistical regression. All PICCs were maintained with routine dressing changes. They were flushed with heparin after each infusion, and weekly when not in use.

RESULTS

There were 76 upper extremity venous duplex examinations performed in 65 patients with PICC lines. The indications were swelling in 34, evaluation for a new site after PICC removal in 22 presumed, thrombosis in seven, infection in two, pain in two, and either not documented or incidental in nine. The overall venous thrombosis rate was 3.9%. Nurses inserted 269 PICCs, of which 12 led to venous thrombosis, for a rate of 4.5%. Radiologists inserted 544 PICCs with 20 venous thromboses, for a rate of 3.7%. These rates were not significantly different. Of the 544 PICCs inserted by radiologists, 479 (88%) were first evaluated in the infusion nursing department and were referred to the radiology department if the antecubital veins were sclerosed, or if the infusion nurses were unable to cannulate a vein.

The primary diagnosis of the patients receiving PICCs was cancer in 254 (31%), infection in 374 (46%), need for parenteral nutrition in 78 (10%), or a combination of these or other diagnosis in 107 (13%). The rate of thrombosis by diagnosis was 6.7% for cancer, 1.5% for infection, 5.1% for nutrition, and 4.7% for other. The thrombosis rate for cancer was significantly higher when compared to the benign diagnoses by $\chi 2$ (P = .011).

The medication infused through the PICCs was cancer chemotherapy in 120 (15%), antibiotics in 386 (47%), total parenteral nutrition in 118 (15%), and other in 189 (23%). The rate of thrombosis by medication infused was 8.3% for cancer chemotherapy, 1.6% for antibiotics, 4.2% for TPN, and 5.8% for other. The thrombosis rate for cancer chemotherapy was significantly higher than the other solutions when compared by $\chi 2$ (P = .051).

The basilic vein was accessed in 533 (65%) PICC placements; the cephalic vein in 128 (16%). One hundred fifty-two (19%) catheters were either placed in other veins, or the site of insertion was not documented. The rate of venous thrombosis by vein accessed was 3.8% for basilic, 2.3% for cephalic, and 5.9% for not documented/other. There was no significant difference between these rates. The infusion nursing department placed PICCs in 91 basilic veins, 92 cephalic veins, seven antecubital veins, and 79 undocumented veins. The interventional radiology department placed PICCs in 442 basilic veins, 36 cephalic veins, 17 brachial veins, five antecubital veins, and 44 undocumented veins.

The tip location, as determined by chest x-ray at the time of insertion, was the superior vena cava (SVC) and/or right atrium (RA) in 770 (95%) PICCs, and either not documented or some other location in 43 (5%). The rate of thrombosis for the PICCs in the SVC/right atrium was 3.6%; the rate for the lines in other locations was 9.3%. There was no significant difference between these values (P = .15).

The number of venous thromboses by catheter diameter and the service inserting the catheter is shown in Table. There were no venous thromboses with catheters 3 F or smaller. The venous thrombosis rates for 5-F catheters (6.6%) and 6-F catheters (9.8%) were significantly higher when compared to the rate for catheters ≤4 F (1%) (P = .0001 and P = .0006, respectively).

Table 1. Number of Thromboses by Diameter and Service

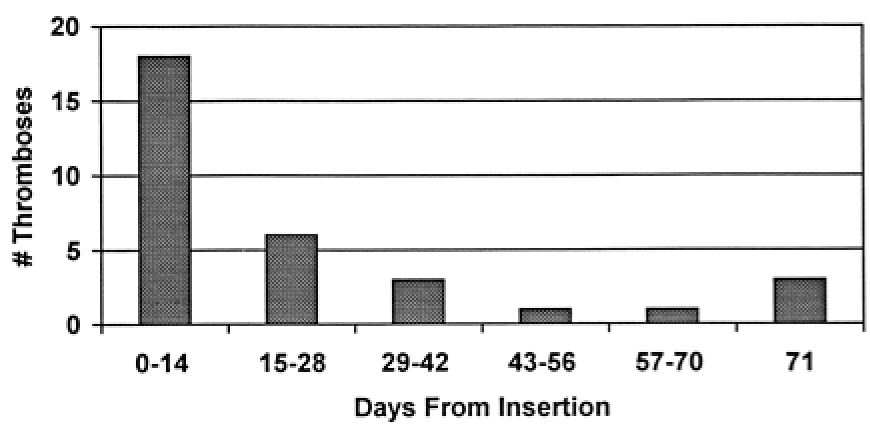
Size (F)	Nursing (%)	Radiology (%)	Total (%)
≤3	0/14 (0)	0/15 (0)	0/29 (0)
4	3/166 (1.8)	1/215 (0.5)	4/381 (1.0)
5	9/88 (10)	15/274 (5.5)	24/362 (6.6)
6	0/1 (0)	4/40 (10)	4/41 (9.8)
Total	12/269 (4.5)	20/544 (3.7)	32/813 (3.9)

All PICCs 4 F or smaller were single lumen. Six of the 362 5-F catheters were single lumen, the rest were dual lumen. Four of the 41 6-F catheters were single lumen, the rest were dual lumen. There was one thrombosis associated with each of the 5-F and 6-F single-lumen catheters, however, because of the small number in these subgroups, no significant difference in thrombosis rates can be claimed. The overwhelming majority of the catheters used were silicone. There were no thromboses in the small number of silastic catheters used, but once again no statistical conclusion can be drawn.

The location of the venous thromboses based on the duplex information was recorded. There were six internal jugular vein thromboses, 20 subclavian vein thromboses, 22 axillary vein thromboses, 24 basilic vein thromboses, 10 cephalic vein thromboses, and eight brachial vein thromboses. Twenty-six of the patients were symptomatic and they were more likely to have multiple deep segments thrombosed. Five of the six asymptomatic patients had only one vein segment thrombosed. The sixth asymptomatic patient had both a deep vein as well as multiple superficial segments thrombosed. The side of thrombosis correlated with the side of PICC insertion in all cases. There were no documented pulmonary emboli in the study group.

A stepwise logistic regression determined that the single most significant factor affecting venous thrombosis was catheter diameter (P = .001). Secondary factors affecting venous thrombosis rate were diagnosis (P = .009) and solution infused (P = 0.006). The tip location (P = .1) was insignificant, as was the service inserting the catheter (P = .6). After adjusting for the significance of catheter diameter, none of the previously significant secondary predictors remained significant (diagnosis, P = .5; solution infused, P = .4; tip position, P = .1). After adjusting for catheter diameter, the service inserting the catheter approached significance (F statistic 3.32 and P = .07), with an adjusted odds ratio of approximately 2 for the infusion nursing department relative to the radiology service.

The number of days from PICC insertion to diagnosis of thrombosis is shown in the Figure. The highest number of thromboses was in the first 2 weeks. Data on when the PICCs were removed were not available so no estimate of the rate of thrombosis per unit time can be made. However, one would expect events to cluster in the first weeks because the catheters were left in place for variable periods of time. Seventeen of the 18 patients diagnosed with venous thrombosis during the first 2 weeks were symptomatic. Nine of the 18 patients diagnosed with venous thrombosis during the first 2 weeks were receiving antibiotics alone, and an additional three were receiving antibiotics in combination with some other medication. Fourteen of these 18 PICCs were placed by the radiology service. Five of the 32 PICCs with thrombosis had concomitant infection (16%). No patient had two separate thromboses documented during the study period.



DISCUSSION

According to Goodwin et al, the risk factors for venous thrombosis include "altered coagulation, poor catheter management, malposition of the catheter, catheter tip location in the subclavian vein rather than the SVC, intrathoracic tumor, and engorgement of the upper trunk vessels resulting from compression of the SVC by an extrinsic mass" (3). The number of catheters inserted, distribution of medications infused, and distribution of catheter diameters in the current series are comparable to the series presented by Goodwin, in which there were three episodes of venous thromboses with 858 PICCs (0.3%). The patients with thromboses had PICCs that migrated into the subclavian vein. James et al found only one venous thrombosis with 158 PICCs, and the tip was in the SVC (4). The data from the current study are not as clear cut, with only four of the 32 PICCs with venous thrombosis in noncentral positions. Loughran et al described one deep venous thrombosis with 322 PICCs (5), and Abi-Nader had one venous thrombosis with 92 PICCs (6). Paz-Fumagalli et al had no venous thromboses with 38 PICCs (2). Duerksen et al noted an incidence of 0.5 thromboses per 1,000 catheter days, which was not significantly different than the rate for non-PICC catheters in the same series (7). Goodwin also described 40 instances of phlebitis (4.6%), usually occurring during the first week after insertion and unresponsive to heat. This was similar to the incidence and onset of thrombosis in the current study and may represent overlap in these diagnoses. James had 19 episodes of phlebitis with 158 PICCs (12%), usually occurring within 4 days of insertion and resolving within 3 days of treatment. Loughran describes a bimodal distribution with 17 patients (5.9%) developing phlebitis at 3.7 days after insertion and 11 patients (3.8%) at 18 days after insertion. Abi-Nader had five patients (5%) with phlebitis, all within 10 days of insertion, and most often at day 5 or 6. In the current study, phlebitis was defined as an area of localized irritation of the vein, characterized by induration, warmth, and tenderness. There were 17 episodes (2.1%) of phlebitis that were unrelated to the cases with thrombosis.

Although there was no significant difference in the venous thrombosis rate between nurse-inserted PICCs and radiologist-inserted PICCS by univariate analysis, this approached significance after adjusting for catheter diameter by stepwise logistical regression. This may be due to the diameter of the vein accessed, or the manner of insertion. The nurses are limited to the palpable segment of the vein in the antecubital fossa, and insert the catheter directly through a peel-away sheath. The radiologists can access the vein more proximally on the arm and are able to direct the placement of the peel-away sheath with use of a guide wire. This difference was discussed by Cardella et al (1), but no significant difference in thrombosis rates was found between the two sites in that series.

Diameter, as it relates to venous thrombosis, has been described for central lines (8) but no comparable data exist for PICCs. PICCs are inserted in areas where the vein is relatively small, and travel long distances, usually crossing at least one joint. This leads to intimal trauma and thrombogenesis. The present study demonstrates a linear increase in the incidence of thrombosis with increasing catheter diameter. One would expect the highest rates of thrombosis in hypercoagulable patients receiving sclerosing intravenous solutions. The highest rates of thrombosis were in cancer patients, and those receiving chemotherapy and total parenteral nutrition. Usually, these solutions are given through large single-lumen or multi-lumen PICCs. After taking this into consideration, diameter is the most important factor in predicting thrombosis due to PICCs.

There are disadvantages to using smaller diameter catheters. They are more fragile, more prone to kink, and more likely to occlude. Larger dual-lumen catheters must be used if incompatible substances are to be infused simultaneously. The smallest diameter catheter capable of performing the desired function should be selected to decrease the incidence of venous thrombosis.

The true incidence of venous thrombosis in this population is probably higher than that reported. Venous thrombosis was only recorded if the patient was evaluated in the hospital vascular laboratory. It is possible that some patients had venous thrombosis documented in another facility, and very likely that some venous thromboses went undetected. Determination of the true incidence of venous thrombosis would require prospective, per protocol, sequential venous duplex of all patients with PICCs. Furthermore, the retrospective nature of this report means that bias in patient selection and underreporting of the endpoint can lead to erroneous conclusions.

In summary, PICCs can be inserted with relative safety at relatively low cost. They are well-tolerated by patients and can frequently be maintained for long periods of time. However, PICCs can cause venous thrombosis, with potential for upper extremity swelling and pain, pulmonary embolism, and loss of access site. Venous thrombosis occurs more frequently in patients with cancer, in patients receiving cancer chemotherapy or total parenteral nutrition, and with larger diameter catheters. Of these, the only independently significant factor is catheter diameter. This also is the only factor controllable by the person inserting the catheter. Therefore, to decrease the incidence of venous thrombosis, PICCs with the smallest acceptable diameter should always be chosen.

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