Selection of Single- Versus Double-Lumen Peripherally Inserted Central Catheters and the Influence on Alteplase Use

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ABSTRACT

The purpose of this article is to share the efforts of one institution in reducing risk of central line-associated bloodstream infections (CLABSIs). The aim is to review alteplase use as a marker for peripherally inserted central catheter (PICC) occlusions, which may increase risk of CLABSIs. The discovery that alteplase use increased with the number of PICC lumens allowed for exploration of ordering and placement practices. Following education, placement of double-lumen PICCs decreased.

Key words: alteplase, central vascular access device, central venous catheter, CLABSI, CVAD, infection, occlusion, peripherally inserted central catheter, PICC, vascular access device

BACKGROUND

Central vascular access devices (CVADs) are commonly used in oncology patients. Peripherally inserted central catheters (PICCs) may be selected for a variety of reasons: ease of placement, no need for surgery, and no treatment delays. A common risk with PICCs is catheter occlusion. Upper extremity venous thrombosis (UEVT) may develop if left untreated. Oncology patients may have coagulopathies, further elevating the risk of thrombosis.

An association exists between PICC-related thrombosis and infection.[1,2] An interprofessional central line-associated bloodstream infection (CLABSI) council formulated strategies to reduce CLABSIs. The council evaluated alteplase use as a marker for infection risk in an effort to determine if a practice change would reduce occlusion rates and lower infection risks. Alteplase use based on type of CVAD (ie, port, PICC, tunneled) and number of lumens was calculated to evaluate occlusion rates. Although other CVADs were assessed in the baseline results, the council focused efforts on PICCs and number of lumens.

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Setting

St. Luke's Mountain States Tumor Institute comprises a dedicated oncology inpatient unit in Boise, Idaho, and 5 outpatient clinics in communities in southwest Idaho. PICCs are placed in interventional radiology (IR) in this facility. The Bard PowerPICC (Bard Access Systems, Salt Lake City, UT), size 5 Fr (single and double lumen), is the most common PICC device placed in the IR department. The cost for the single-lumen PICC is $85.90; double-lumen PICCs are $95.00. The provider is responsible for determining the number of lumens desired for a given patient, and arrangement for the procedure is facilitated by the nurse.

REVIEW OF THE LITERATURE

Occlusions

Minimal research has been conducted describing occlusion rates in PICCs and lumen selection. Occlusion rates in PICCs have been reported ranging from 7% to 34%, with fibrin sheath formation as a common cause of mechanical occlusion.[3]

Barrier et al[4] examined the frequency and types of complications with PICCs placed in pediatric patients receiving antimicrobials. The most common complication was occlusion. Analysis showed that patients with double-lumen PICCs experienced higher complication rates versus those with single-lumen PICCs.

Bowe-Geddes and Nichols[5] described care and maintenance of PICCs, and identification and management of

complications. They acknowledged 3 primary causes of thrombus formation (vein wall injury, stasis/obstruction, hypercoagulability), known as Virchow's triad.[6] The authors suggested that PICC external diameter may contribute to vein wall injury if the vessel cannot accommodate the catheter.

Thrombotic occlusions may be treated with thrombolytic drugs.[7,8] Alteplase (Cathflo; Genentech, Inc, San Francisco, CA) is used for "restoration of function to central venous access devices as assessed by the ability to withdraw blood."[8(p5)] The authors' institution maintains a protocol for alteplase use when blood return from CVADs is sluggish or absent, after other causes of occlusion have been eliminated.

Upper Extremity Venous Thrombosis

Impact on the development of UEVT was not the aim of this quality initiative; however, a brief review of lumen size relative to venous thrombosis is warranted. Not all occlusions result in UEVT. Also, thrombotic occlusions may be treated with antithrombotic agents, whereas UEVT is treated symptomatically or with removal of the catheter. Anticoagulation may be initiated, preventing further complications. Number of lumens and size have been reported as thrombus formation risk factors.[7]

Zochios et al[9] searched electronic databases exploring epidemiology, pathophysiology, diagnosis, and management of PICC-related thrombosis in critically ill patients. The authors concluded that large and multilumen PICCs demonstrated increased incidence of thrombosis due to turbulence and restricted blood flow.

Yi et al[10] examined predictive risk factors for thrombus formation in patients with PICCs by conducting ultrasounds, after insertion. Other risk factors of statistical significance were observed, but the authors concluded that the number of lumens was not a factor in thrombosis development.

Other investigators determined that increased catheter external diameter raises the risk for venous thrombosis. Grove and Pevec[11] reviewed records for 678 patients with PICCs, evaluating venous duplex test results and data collected on PICC diameters. Thrombosis rates were statistically higher in larger-diameter catheters ($P = .001$).

Evans et al[12] described risk-reducing methods for UEVT, noting that larger-gauge catheters elevated risk for deep vein thrombosis in hospitalized patients. Later, the authors also observed that patients with small-gauge triple-lumen PICCs required significantly more alteplase compared to patients with single- and double-lumen PICCs because of decreased external lumen size.[13]

REVIEW OF DATA

Data were collected using a custom report created in the electronic health record (EHR) to reflect individual patient encounters, CVAD type, and whether the alteplase protocol was initiated. Much of the data from the first year (2013) required manual extraction as it was discovered that the EHR nursing documentation for PICCs included selections for only "PICC Catheter" and "PICC Catheter DL," with DL identifying a double-lumen PICC. The selection for "PICC Catheter" did not clearly identify it as the appropriate selection if a patient had a single-lumen PICC. IR and surgical reports were used to confirm the presence of a single-lumen or double-lumen PICC.

A total of 183 adult patients had PICCs managed at the outpatient cancer center in 2013. Nineteen PICCs were single-lumen (10%). Double-lumen PICCs accounted for 164 of the total number (90%). Of the 164 double-lumen PICCs, 45 required alteplase (27%). Two of the 19 single-lumen PICCs required alteplase (11%). These initial data indicated that double-lumen PICCs may require alteplase at a higher rate than single-lumen PICCs. However, these findings may not be significant given the small number of patients with single-lumen PICCs.

The data for 2013 were reported to the CLABSI council in early 2014 for discussion. These data were then presented to 2 additional groups, the nursing practice group focused on intravenous catheter care and the oncology pharmacy and therapeutics committee. Both groups discussed PICC selection and ordering practices as well as the historical practice perception that more CVAD lumens were favorable. It was discovered that the EHR did not have a specific order option for a single-lumen PICC. A checkbox was available to identify the order for a double-lumen PICC, but a note was necessary to identify the order for a single-lumen PICC. Additionally, if the IR department called to clarify which type of catheter was desired, the default by nursing and providers was usually to advise a double-lumen PICC. Education was provided to both groups on the potential benefits to placing single-lumen PICCs in patients who needed short-term treatment and didn't require a multilumen CVAD. A checkbox option for ordering a single-lumen PICC was added to the EHR in June 2013.

The same data collected in 2013 were then collected for 2014 and 2015. The data for all 3 years are shown in Table 1. The number of single-lumen PICCs placed demonstrated a 3-fold increase to 30% in 2014. Alteplase was required in 11% of the single-lumen PICCs. This was the same rate of alteplase use in single-lumen PICCs as represented in 2013, but with a larger denominator. The number of double-lumen PICCs requiring alteplase (26%) was also similar to the data from 2013. In 2015, 33% of PICCs placed were single lumen. This demonstrated a sustained practice change from the previous year. The rates of alteplase use continued to show that single-lumen PICCs required alteplase at a lower rate (8%) than double-lumen PICCs (32%).

Total alteplase doses for each year were also reported. One dose of alteplase is 2 mg/2 mL. Both lumens of a double-lumen PICC are not routinely treated in this setting if only 1 lumen is assessed as occluded. Both lumens of a double-lumen PICC are assessed and treated as appropriate. Some patients required multiple doses; total doses are represented in Figure 1. Although an in-depth analysis of the total alteplase doses was not performed, the fact that

TABLE 1

Lumen Selection and Rates of Alteplase Use Associated with Single- and Double-Lumen Peripherally Inserted Central Catheters

Year	2013		2014		2015	
Total PICCs	183		211		256	
	Single Lumen	Double Lumen	Single Lumen	Double Lumen	Single Lumen	Double Lumen
Number	19 (10%)	164 (90%)	64 (30%)	147 (70%)	85 (33%)	171 (67%)
Treated with alteplase	2	45	7	38	7	55
Percentage	11%	27%	11%	26%	8%	32%

Abbreviation: PICC, peripherally inserted central catheter.

there was relatively no change in total doses over the 3-year period is notable. The total number of patients with PICCs increased in 2015, as did the total number of catheters that required alteplase, but total alteplase doses did not increase (Figure 1). Many variables would need to be evaluated to fully understand this finding. Some PICCs require more than 1 alteplase dose to regain patency. Some require alteplase on more than 1 clinic encounter.

CONCLUSION

Eastman et al[14] reviewed records of 160 patients receiving continuous infusion treatment through central venous devices. Thirteen percent of the patients developed central venous device-related bloodstream infections, which were associated with the type of therapy and thrombosis (odds ratio, 4.1; 95% confidence interval, 1.5-11.4; $P = .008$). Actual infection rates were not evaluated within this project. The team assessed PICC lumen selection and alteplase use in this facility for more than 3 years. The findings identified potential strategies to reduce the risk of CLABSI using an interprofessional approach. Interventions included education for oncology providers and nurses on lumen selection. Revisions to the EHR simplified single-lumen PICC ordering. Post implementation, the data reflected an increase in single-lumen PICC placement, a practice change that was maintained during the subsequent year. A collateral benefit to this project might be decreased expense since single-lumen PICCs are less costly. The savings would be $9.10 when a single-lumen PICC is placed instead of a double-lumen device.

A limitation for this project was not collecting more in-depth data on alteplase doses. The authors were unable to accurately determine doses per lumen, patients that required alteplase doses on multiple occasions, and whether both lumens of a double-lumen PICC were treated. This information would provide increased understanding of the relationship between occlusion and the number of PICC lumens.

This project demonstrated that the selection of the number of PICC lumens influenced alteplase use in our institution. Single-lumen PICCs required alteplase at a lower rate than those with double lumens. It also illustrated the importance of collaborative patient safety initiatives. Emphasizing thoughtful PICC lumen selection is one approach that may decrease serious central line-associated complications such as occlusion and infection.

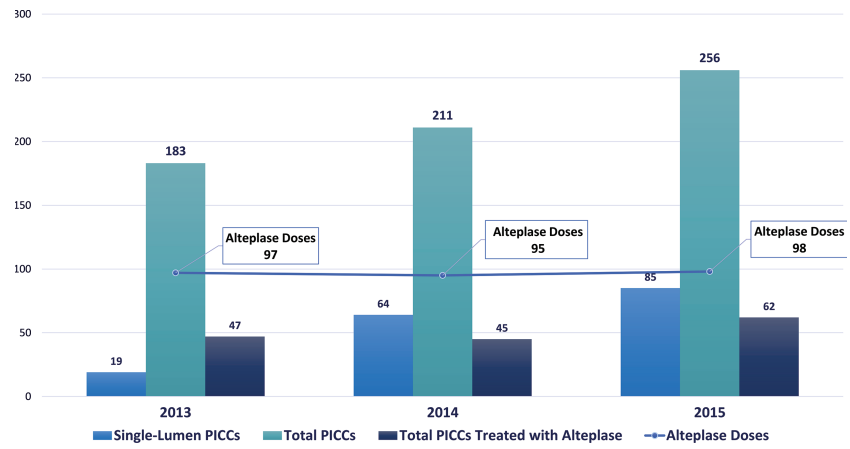

Figure 1 Alteplase doses. *Abbreviation: PICCs peripherally inserted central catheters.*

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