CLINICAL STUDY

Patterns and Predictors of Peripherally Inserted Central Catheter Occlusion: The 3P-O Study

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ABSTRACT

Purpose: To evaluate patterns and predictors of peripherally inserted central catheter (PICC)–related occlusion.

Materials and Methods: Data from a multihospital study were used to examine factors associated with PICC occlusion. Occlusion was defined if documented in the medical record or when tissue plasminogen activator was administered for occlusion-related concerns. Mixed-effects logistic regression was used to predict occlusion, controlling for patient-, provider-, device-, and hospital-level characteristics.

Results: A total of 14,278 PICCs placed in 13,408 patients were included. Of these, occlusion developed in 1,716 PICCs (12%) in 1,684 patients. The most common indications for PICC insertion were intravenous antibiotic therapy (32.7%), difficult intravenous access (21.5%), and central access (13.7%). PICCs placed in the right arm had decreased odds of occlusion compared with those in the left arm (odds ratio [OR] = 0.82; 95% confidence interval [CI] = 0.72–0.94). Verification of catheter tip position following insertion was associated with reduction in occlusion (OR = 0.75; 95% CI = 0.61–0.92). Although normal saline solution or heparin flushes did not reduce occlusion, PICCs flushed with normal saline solution and "locked" with heparin were less likely to become occluded (OR = 0.54; 95% CI = 0.33–0.88). Compared with single-lumen devices, double- and triple-lumen PICCs were associated with greater incidences of occlusion (double, OR = 3.07; 95% CI = 2.56–3.67; triple, OR = 3.72; 95% CI = 2.92–4.74). Catheter tip malposition was also associated with occlusion (OR = 1.46; 95% CI = 1.14–1.87).

Conclusions: Several patient, provider, and device characteristics appear associated with PICC occlusion. Interventions targeting these factors may prove valuable in reducing this complication.

ABBREVIATIONS

CI = confidence interval, ICU = intensive care unit, OR = odds ratio, PICC = peripherally inserted central catheter, SASH = saline, administer medicine, saline, heparin [infusion technique], TPA = tissue plasminogen activator

Increasing use of peripherally inserted central catheters (PICCs) has led to new insights regarding benefits and risks. Compared with central venous catheters (CVCs), PICCs offer several benefits, including lower risk of insertion complications and reliable access for medium- to long-term treatment. Conversely, PICCs are also associated with complications, including infection and venous thrombosis (1–3). Although these adverse events have garnered much interest, minor complications from PICC use such as occlusion have received comparatively less attention.

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This asymmetry is unfortunate, as minor complications are not only more frequent than major complications, but also interrupt treatment and may necessitate device removal (4,5).

One of the most common minor complications associated with PICC use is occlusion, defined as a temporary or permanent inability to aspirate blood or infuse therapeutic agents through a lumen (6). Occlusion of a PICC and damage to its corresponding vein has important sequelae, including potential failure of future arteriovenous grafts or fistulae in patients with chronic kidney disease, ultimately requiring dialysis (7,8). Despite these important aspects, which patient-, provider-, and device-associated factors influence the probability of PICC occlusion remains unknown (9). Given these knowledge gaps, data from a multihospital collaborative quality initiative was used to conduct a retrospective cohort study (the 3P-O study) to understand (*i*) patterns of PICC occlusion and (*ii*) which patient-, provider-, and device-related factors were associated with this event.

MATERIALS AND METHODS

Study Setting and Participants

The present study used data from a collaborative clinical quality initiative supported by Blue Cross Blue Shield and Blue Care Network that is focused on preventing adverse events in hospitalized patients. The design and setting of this consortium have been previously described (10,11). Since December 2013, 51 hospitals have engaged in a prospective cohort study to examine PICC use and outcomes. Adult patients admitted to a general medicine ward or intensive care unit (ICU) who received a PICC for any reason during clinical care were eligible for inclusion. Patients who were (*i*) younger than 18 years of age, (*ii*) pregnant, (*iii*) admitted to a nonmedical service (eg, general surgery), or (*iv*) admitted under observation status were excluded.

At each hospital, dedicated medical record abstractors used a standardized protocol and template to collect data. Patients with PICCs were sampled on a 14-day cycle with the use of a convenience sampling method. Abstractors selected the first eligible PICC inserted each cycle day from 1 to 14, then the second, and so on, for as many as 17 cases. As available, we asked abstractors to select seven PICCs that were inserted in an ICU setting. All patients were followed until death, PICC removal, or 70 days from insertion, whichever occurred first. Follow-up was restricted to the medical record if patients remained hospitalized or underwent PICC removal before hospital discharge; patients discharged with a PICC underwent medical record review and telephone follow-up. Sample size, 14-day sample cycle, and 70-day censoring were all selected to fit abstractor workload and the fact that 90% of PICCs were removed by this time point. Sampling for this project is ongoing. To ensure data accuracy, random audits are performed annually at each site.

Covariates and Outcomes of Interest

Catheter occlusion was identified when either of the following two criteria were met: (*i*) catheter occlusion was documented in the medical record by a medical provider or (*ii*) tissue plasminogen activator (TPA) was administered to treat problems suggestive of occlusion (eg, poor blood return, sluggish flow). Occlusion was further categorized as irreversible (defined as catheter removal or exchange within 24 h of occlusion with documentation that the reason for removal was occlusion) or transient (ie, catheter remained in place and no device exchange occurred).

Patient-, provider-, and device-related predictors of catheter occlusion were selected a priori based on a conceptual model of PICC complications (12). Patient factors including age, sex, tobacco use (current, former, never), body mass index, uncomplicated or complicated diabetes, severe liver disease, renal failure, coagulopathy, hyperlipidemia, hypertension, and indication for PICC use were included. Because statins, aspirin, and antiplatelet agents are associated with thrombosis (13), these were included if administered while the PICC was in situ. Baseline values for creatinine, hemoglobin, and white blood cell count at the time of PICC insertion were also included. Because the risk of PICC complications is greater in critically ill patients, ICU status was included as an indicator variable if (*i*) the patient underwent PICC placement in an ICU or (*ii*) received care in an ICU setting before device occlusion. Although PICC dwell time was included, data were censored at 70 days due to follow-up terminating at this time.

Provider factors including vein selected for insertion (basilic, brachial, cephalic, other), arm of insertion, and type of operator inserting the PICC (vascular access nurse vs. other) were recorded. Additionally, ascertainment of appropriate PICC tip position (by radiography or electrocardiography) and occurrence of catheter malposition (defined as radiographic evidence of PICC tip localization at any site other than the cavoatrial junction) before PICC occlusion were recorded. As some infusates are associated with increased incidence of occlusion, delivery of chemotherapeutic agents and specific antibiotic agents (vancomycin, cefepime, or piperacillin/tazobactam) through the PICC was also examined.

Device-related factors included total PICC length, number of lumens, and type of PICC (power-injectable vs not). Additionally, the effect of catheter coating or impregnation (antimicrobial, antithrombotic, or both) and valve presence were evaluated as risk factors for occlusion. To understand the effect of flushing and catheter care, protocols for PICC flushing from each hospital were incorporated. Flushing frequency was coded as daily, twice daily, or three times daily. Flush type was coded as normal saline solution, heparin, or normal saline solution followed by drug administration, 10 mL normal saline solution flush, and 3-mL heparin "lock" (known as the SASH technique). The 2016 Infusion Nursing Standards (14) provide more details regarding this technique.