Journal of Critical Care xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Journal of Critical Care

journal homepage: www.jccjournal.org

Complication rates among peripherally inserted central venous catheters and centrally inserted central catheters in the medical intensive care unit☆

Matthew E. Nolan, MD [a], Hemang Yadav, MBBS [a], Kelly A. Cawcutt, MD [b], Rodrigo Cartin-Ceba, MD [a,*]

[a] Division of Pulmonary and Critical Care, Mayo Clinic, 200 First St SW, Rochester, MN, 55905
[b] Division of Infectious Diseases, Mayo Clinic, 200 First St SW, Rochester, MN, 55905

ARTICLE INFO

Available online xxxx
Keywords:
Central venous catheterization
Peripherally inserted central catheter
Central venous catheter thrombosis
Deep vein thrombosis
Catheter-associated infection
Adverse event

ABSTRACT

Purpose: There are limited contemporary data describing the rates of catheter-related deep vein thrombosis (CRDVT) and central line–associated bloodstream infection for peripherally inserted central venous catheters (PICCs) and centrally inserted central venous catheters (CICCs) in the medical intensive care unit (ICU).
Methods: We performed a retrospective cohort study of 200 PICCs (dual/triple lumen) and 200 CICCs (triple/quadruple lumen) placed in medical ICU adults at Mayo Rochester between 2012 and 2013. Central lines were followed from insertion time until hospital dismissal (primary analysis) or ICU discharge (secondary analysis). Symptomatic CRDVT was determined by Doppler ultrasound. Central line–associated bloodstream infection was defined according to federal reporting criteria.
Results: During 1730 PICC days and 637 CICC days, the incidence of CRDVT when followed until hospital dismissal was 4% and 1% (4.6 and 3.1 per 1000 catheter-days), respectively, $P = .055$. When censored at the time of ICU dismissal, the rates were 2% and 1% (5.3 and 3.7 per 1000 catheter-days), $P = .685$. Only 1 central line–associated bloodstream infection occurred in a PICC following ICU dismissal, $P > .999$.
Conclusions: Thrombotic and infectious complications were uncommon following PICC and CICC insertion, with no significant difference in complication rates observed. Half of PICC DVTs occurred on the general floor, and like all central catheters placed in the ICU, PICCs should be aggressively discontinued when no longer absolutely needed.

1. Introduction

Central venous access is commonly required in the critical care setting for hemodynamic monitoring and medication administration. Although initially used in the outpatient setting [1], peripherally inserted central venous catheters (PICCs) have emerged as viable alternatives to short-term, nontunneled centrally inserted central venous catheters (CICCs) in the intensive care unit (ICU) [2]. Although PICC use in the ICU has become increasingly prevalent, limited contemporary data exist regarding complications from PICC insertion. Prior ICU-based studies evaluating PICC and CICC complications show widely varying rates for central line–associated bloodstream infection (CLABSI) and catheter-related deep vein thrombosis (CRDVT) [2–26]. Importantly, modern practice innovations including the introduction of smaller-gauge PICC catheters, specialized insertion teams [27], and improved central line stewardship [28] may make prior findings outdated. Given the paucity of contemporary data on central line complications specific to the medical ICU (MICU), we performed a retrospective cohort review to define the complication rates associated with PICCs and CICCs in a tertiary, academic medical ICU.

2. Materials and methods

2.1. Study population and catheter type

Our retrospective cohort study included consecutive adult patients (age ≥18) admitted to our 24-bed tertiary care medical ICU in Rochester, MN, who had a new central venous catheter (CVC) placed during their MICU admission on or before June 30, 2013. We had a prespecified target accrual of 200 central line insertions for each type of line. To identify the most recent catheter data, we reviewed records starting at our end date and moving backward until we achieved our target. We included nontunneled, peripherally inserted central catheters and nontunneled, centrally inserted CVCs in our study. Temporary dialysis catheters and "introducer" catheters were excluded because of the

☆ Conflicts of interest and source of funding: The authors have no financial or nonfinancial disclosures to report for this study, and no potential conflicts of interest. The authors received no specific funding for this research and manuscript.
* Corresponding author. Tel.: +1 507 284 2494; fax: +1 507 266 4372.
E-mail addresses: nolan.matthew@mayo.edu (M.E. Nolan), yadav.hemag@mayo.edu (H. Yadav), cawcutt.kelly@mayo.edu (K.A. Cawcutt), cartinceba.rodrigo@mayo.edu (R. Cartin-Ceba).

http://dx.doi.org/10.1016/j.jcrc.2015.09.024
0883-9441/

unique indication for this type of intravenous access. The specific indication for each central line could not be systematically assessed in a retrospective manner. For patients with more than 1 qualifying central line placed during the study period, we included only the most recent line placed for each line type. Our institution uses 5F or 6F, 2- or 3-lumen PowerPICC SOLO*2 peripherally inserted central catheters (Bard Access Systems, Inc, Salt Lake City, UT). Triple-lumen catheters were 7F, with two 18-gauge lumens and one 16-gauge lumen, made by Arrow International (Teleflex Medical, Research Triangle Park, NC). Quadruple-lumen catheters were 8.5F, with two 18-gauge lumens, one 16-gauge lumen, and one 14-gauge lumen made by Arrow International.

2.2. Catheter insertion technique and maintenance

Peripherally inserted CVCs are placed under ultrasound guidance by a specially trained nurse-led "PICC-team" using a microintroducer and Seldinger technique, or by Interventional Radiology. The PICC insertion team chooses the optimal vessel based on a goal vessel-to-catheter ratio of at least of 3:1, which is determined by visual estimate using an onscreen guide included in the Bard Site-Rite 6 vascular ultrasound. Triple- and quadruple-lumen CICCs are placed under ultrasound guidance by the MICU team at the bedside. A chest radiograph confirms central line location. All trainees and attending physicians at our institution undergo structured central line insertion training and competency-based evaluation [29,30]. During central line insertion, a mandatory "central line bundle" is used. These policies require preprocedural hand hygiene; use of maximum sterile technique including mask, cap, full gown, and gloves; head-to-toe patient draping; and allowing the skin antiseptic (typically 2% chlorhexidine solution) to dry before needle insertion. There is at least 1 assistant present, among whose tasks it is to observe for breaks in sterile technique. Use of sterile technique is required postprocedural documentation. Site selection is left to the discretion of the physician, with femoral access discouraged unless necessary. Following insertion, an antimicrobial patch is placed at the site of skin entry. All central line sites undergo daily visual assessments by nursing staff, and catheter dressings are changed approximately every 2 (gauze-covered) to 7 (transparent) days using clean or sterile gloves. The entire medical team performs daily assessment of ongoing need for the CVC, and nursing staff documents the indication. Placement and maintenance of PICCs and CICCs described in this article were part of routine clinical practice and were not protocolized for this study.

2.3. Data collection

Our institution's critical care research group maintains a prospective database that tracks demographic and outcome data for all intensive care admissions, which has been described and validated elsewhere [31]. A separate local data warehouse [32] was queried to identify patients who had new central intravenous access charted during their admission to the MICU. All potential cases were manually reviewed to ensure that they met inclusion/exclusion criteria and to verify the date and time of insertion and removal to ensure accuracy of line-duration data. Patients were followed for line-related complications until the central line was removed or the patient was dismissed from the hospital. Patients were excluded if they declined consent for general retrospective research at our institution. This study was approved by the Mayo Clinic institutional review board, which waived the requirement for written informed consent.

2.4. Outcomes

The primary end points were the overall rate-per-line (incidence) and rate-per-1000-catheter-days of symptomatic catheter-related deep vein thrombosis (CRDVT) and central line–associated bloodstream infection (CLABSI) for PICCs and CICCs placed in the MICU and followed until hospital discharge. For our secondary end points, we repeated this analysis but followed central lines only until the time of ICU discharge. The CICC cases were additionally screened for insertion-related pneumothorax or hemothorax.

2.5. Definitions

Symptomatic CRDVT was defined as a new acute thrombus in a deep vein where a catheter was present or removed within the previous 5 days for which a venous Doppler ultrasound was obtained for the work-up of a new unexplained symptom (eg, swelling, fever [33]). We excluded cases of asymptomatic, incidentally detected catheter-related thrombus if the ultrasound was obtained for alternative reasons. Superficial vein thromboses were excluded. The CRDVT events were identified by manual chart review of ultrasonography reports by the primary author (MN) and confirmed by 2 other reviewers (HY and RCC). *Central line–associated bloodstream infection* was defined using the standard Centers for Disease Control/National Healthcare Safety Network reporting definitions [34]. Although catheter-related bloodstream infection is an alternative criterion for infection event outcomes, we chose to use the CLABSI definition because it is more inclusive and is the standard national reporting definition, which has both patient-safety and administrative relevance. The CLABSI events were detected by manual chart review of the microbiology data by the primary author (MN), confirmed by a second author (KC), and cross-referenced with our hospital's CLABSI reporting database to ensure that no CLABSI events were overlooked.

2.6. Statistics

For comparison of normally distributed, continuous data, we used a 2-sided Student *t* test assuming either equal or unequal variances according to the associated F test. For continuous data that failed tests for normal distribution, we reported the median and used a nonparametric Wilcoxon rank sums test. For comparison of nominal data, we used a Pearson χ^2 test, or Fisher exact test if the expected event rate was fewer than 5. A P value of .05 was considered statistically significant. All data analyses were performed using JMP statistical software (Version 9.0.3; SAS Institute, Cary, NC).

3. Results

We manually reviewed 612 patient charts to identify 400 consecutively placed central lines that met our inclusion/exclusion criteria, consisting of 200 PICCs and 200 CICCs placed in 371 unique patients between July 20, 2012, and June 30, 2013 (Fig. 1). No patients were lost to follow-up. We found significantly higher baseline severity of disease in the CICC group as reflected in the 24-hour Sequential Organ Failure Assessment (SOFA) and Acute Physiology and Chronic Health Evaluation (APACHE) III scores, invasive ventilator use, and length of hospital stay, but no significant difference with respect to overall in-hospital mortality (Table 1). The laterality of the central lines is specified in Table 2, and the indwelling time distribution is provided in Fig. 2. Overall complications following line placement are outlined in Table 3. In total, we accrued more than 2300 hospital catheter-days of data, with 1730 days of PICC data and 637 days of CICC data. The groups differed with respect to indwelling duration, with PICCs remaining in place for a median of 3.5 days longer. Overall, 8 (4%) of 200 PICC lines and 2 (1%) of 200 CICCs developed symptomatic CRDVT, $P = .055$. We identified only 1 CLABSI out of the 400 central lines, occurring 34 days after placement of a PICC in a neutropenic patient following discharge from the MICU to a step-down care unit. There were no cases of insertion-related pneumothorax or hemothorax in any of the CICCs.

Table 4 provides ICU-specific rates of central line complications, with event data duration censored at the time of ICU discharge. Total indwelling-catheter duration was 750 PICC days and 535 CICC days. Two (100%) of the 2 CICC DVTs occurred in the ICU, whereas only 4

Please cite this article as: Nolan ME, et al, Complication rates among peripherally inserted central venous catheters and centrally inserted central catheters in the medical in..., J Crit Care (2015), http://dx.doi.org/10.1016/j.jcrc.2015.09.024