Incidence of Nonelective Removal of Single-Lumen Silicone and Dual-Lumen Polyurethane Percutaneously Inserted Central Catheters in Neonates

Priscila Costa, MSc, RN
Department of Maternal-Child and Psychiatric Nursing, School of Nursing, University of São Paulo, São Paulo, Brazil
Eny Paiva Dorea, PhD, RN
Department of Maternal-Child Nursing, School of Nursing, Federal Fluminense University, Rio de Janeiro, Brazil
Amélia Fumiko Kimura, PhD, RN
Department of Maternal-Child and Psychiatric Nursing, School of Nursing, University of São Paulo, São Paulo, Brazil
Larissa Yumi Yamamoto
School of Nursing, University of São Paulo, São Paulo, Brazil
Lucas Petri Damiani, MSc
Statistics and Mathematics Institute, University of São Paulo, São Paulo, Brazil

Abstract

Objective: *To compare the incidence of nonelective removal of single-lumen silicone and dual-lumen polyurethane percutaneously inserted central catheters (PICCs).*

Study Design: *A prospective cohort study was conducted with neonates in whom 247 PICC lines had been successfully inserted. Patients were assigned to either the single-lumen silicone group or the dual-lumen polyurethane group and nonelective removal incidence was compared using a logistic regression model.*

Results: *Incidence of nonelective removal in dual-lumen polyurethane PICCs ($n = 91$) was 48.3% versus 34% in single-lumen silicone PICCs ($n = 156$). Thus, dual-lumen polyurethane catheters had a significantly increased chance of nonelective removal compared with single-lumen silicone PICCs ($P = .004$). The most usual complication in dual-lumen polyurethane PICCs was suspected catheter-related bloodstream infection; in single-lumen silicone PICCs it was external rupture.*

Conclusions: *Dual-lumen polyurethane PICCs are associated with higher rates of nonelective removal and complications such as suspected catheter-related bloodstream infection. Cautious nursing care is necessary to prevent complications.*

Keywords: *central venous catheterization, critical care, newborn, nursing*

Introduction

A peripherally inserted central catheter (PICC) is a device inserted into a peripheral vein and threaded into the central venous circulation.[1] PICCs can vary in gauge size, material, and number of lumens. The PICCs used in neonatal intensive care units (NICUs) are usually 2F (24 gauge) and 3F (20 gauge), silicone or polyurethane catheters, with single or dual lumens. PICCs made of silicone have a slower gravity flow rate and thicker catheter walls. Using polyurethane provides PICCs with greater wall strength thereby allowing the production of a small-sized, high-flow catheter with greater luminal capacity.[2] Single-lumen catheters are generally preferred, unless multiple lumens are essential for patient management because they appear to be less likely to induce complications.[3]

The incidence of major complications associated with PICC lines is low.[1] However, mechanical and infectious

Correspondence concerning this article should be addressed to priscila2.costa@usp.br
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complications occur in 13%-63.6% of inserted catheters. These complications include occlusion, phlebitis, thrombosis, catheter site inflammation, leakage, rupture, extravasation, pericardial effusion, and catheter-related sepsis.[4,5] Catheter material and number of lumens are associated with the incidence of complication such as phlebitis, occlusion, and catheter-related bloodstream infection.[2] A study[6] that evaluated and compared the relative durability and complications of proximal valve polyurethane and distal valve silicone PICCs in 326 adult patients demonstrated that polyurethane PICCs were more durable. In addition, a study[3] that identified the frequency and types of complications associated with PICCs used in pediatric patients for parenteral antimicrobial therapy showed that the use of dual-lumen catheters was associated with a higher incidence of complications.

Some risk factors, such as the material and number of lumens of PICCs, have been studied independently.[3,6] However, the relationship between different types of PICCs made from different materials and having a different number of lumens and the incidence of nonelective removal in the neonatal population remains unclear. The advent of PICC technology requires evidence to inform clinical practice. The aim of our study was to compare the incidence of nonelective removal of single-lumen silicone and dual-lumen polyurethane PICCs in neonates.

Methods

Study Design and Setting

This was a prospective cohort study of infants admitted to a tertiary-level NICU of a private hospital in the city of São Paulo, Brazil, between August 2010 and August 2012. The indications for PICC insertion were determined by an attending neonatologist and included the need for parenteral nutrition with dextrose concentration $> 12.5\%$, continuous infusion of vesicant medications, therapies with variations in osmolarity or pH, and prolonged antibiotic therapy.[7] Two types of catheters were included in this study: 1.9F (26 gauge) single-lumen silicone PICC (BD First PICC; Beckton, Dickinson and Company, Franklin Lakes, NJ) and 2.0F (24 gauge) dual-lumen polyurethane PICC (Nutriline Twinflo; Vygon, Aachen, Germany). A single-lumen silicone PICC was inserted for single-agent therapy, such as antibiotics only or intravenous fluid only. A dual-lumen polyurethane PICC was inserted for the delivery of multiple intravenous infusates such as parenteral nutrition and antibiotics. No blood products were administered through PICCs because it is not recommended to administer these through PICC lines smaller than 3F.

PICCs were inserted by a team of 2 nurses under sterile conditions. Nurses were encouraged to participate in a training program that consisted of didactic and practical development of clinical skills for PICC insertion, maintenance, and removal. The procedure of insertion was considered successful when the position of the catheter tip was confirmed and approved for use after assessment of a supine-position radiograph by the attending neonatologist and the nurses.[7] The catheter tip could be located in veins such as the brachiocephalic, jugular, subclavian, axillary, iliac, saphenous, superior or inferior vena cava, and cavoatrial junction. Details of catheter insertion, maintenance care, and removal were documented in patients' charts. The catheter hub was disinfected before access using an alcohol swab and new clean gloves. Transparent semipermeable membrane dressings, sterile tapes, and surgical strips were changed every 7 days or earlier in the case of loss of adhesion. Dwell time and PICC removal were determined by an attending neonatologist according to a patient's clinical condition, type of intravenous therapy, and functionality of the device.[7]

Participants and Data Collection

The study sample comprised neonates who were born at the hospital and underwent successful insertion of PICC lines (single-lumen silicone or dual-lumen polyurethane PICC), had no other central venous catheter inserted, and no congenital anomalies. The exclusion criteria were death of the infant, transfer to another hospital during follow-up, and no record of the type of the catheter or reason for removal in the medical chart.[7] A statistical power analysis was used to calculate the required sample size. Based on the study by Ong et al,[6] assumptions were made as follows: $\alpha = 0.05$, power $= 0.80$, nonelective removal incidence in polyurethane PICCs of 26.8% and in silicone PICCs of 47.9%, and ratio of sample sizes was 1:1. The sample size necessary for a 2-tailed test was estimated as 182 catheters, 91 in the single-lumen silicone group and 91 in the dual-lumen polyurethane group. Medical records of neonates were examined, and patients were assigned to either the single-lumen silicone group or the dual-lumen polyurethane group. Data were collected until the number of dual-lumen polyurethane catheters was reached, resulting in a sample of 247 catheters. All neonates were monitored daily from PICC placement until removal, which was the main outcome variable.

Definitions

The following variables were collected: date of PICC insertion, main medical diagnosis, weight at the time of PICC insertion, postnatal and corrected gestational age at the time of PICC insertion, sex, catheter type (single-lumen silicone or dual-lumen polyurethane PICC), intravenous therapy indicating the need for PICC (eg, parenteral nutrition, antibiotic, or general intravenous access), initial tip position, date of removal, reason for removal, and dwell time of the catheter (ie, time interval between insertion and removal of the catheter in days). The following definitions were used: elective removal of the catheter occurred when it was no longer required (eg, end of therapy) and nonelective removal occurred when there were complications.[7] Suspected catheter-related bloodstream infection was bacteremia or fungemia in a neonate who had an intravascular device if the neonate had ≥ 1 positive blood culture results (from samples drawn from the peripheral vein or central access) or clinical manifestations of infection (fever or hypotension) with no other apparent sources of bloodstream infection.[1,8] Catheter occlusion was the inability to flush the catheter with 1 mL saline solution using a 10-mL syringe.[1] External catheter rupture was a rupture of an external segment of the device due to high pressure generated by using a small-