REVIEW

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Bloodstream Infection, Venous Thrombosis, and Peripherally Inserted Central Catheters: Reappraising the Evidence

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ABSTRACT:

The widespread use of peripherally inserted central catheters (PICCs) has transformed the care of medical and surgical patients. Whereas intravenous antibiotics, parenteral nutrition, and administration of chemotherapy once necessitated prolonged hospitalization, PICCs have eliminated the need for such practice. However, PICCs may not be as innocuous as once thought; a growing body of evidence suggests that these devices also have important risks. This review discusses the origin of PICCs and highlights reasons behind their rapid adoption in medical practice. We evaluate the evidence behind 2 important PICC-related complications—venous thrombosis and bloodstream infections—and describe how initial studies may have led to a false sense of security with respect to these outcomes. In this context, we introduce a conceptual model to understand the risk of PICC-related complications and guide the use of these devices. Through this model, we outline recommendations that clinicians may use to prevent PICC-related adverse events. We conclude by highlighting important knowledge gaps and identifying avenues for future research in this area.

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KEYWORDS: Central line-associated bloodstream infections; Peripherally inserted central catheters; Venous thrombosis

Whereas intravenous antibiotics, parenteral nutrition, and administration of chemotherapy once required prolonged hospitalizations, the growing availability of peripherally inserted central catheters (PICCs) has virtually eliminated the need for this practice.[1-4] This review provides a historical overview of PICCs and describes factors promoting PICC use. We summarize the literature regarding complications associated with PICCs and introduce a domain-based, conceptual framework through which clinicians may better understand these risks. By using this model, we present evidence-based strategies to prevent adverse outcomes.

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MATERIALS AND METHODS

We performed a literature search of multiple databases, including MEDLINE via Ovid (1946 to the present), EMBASE (1946 to the present), BIOSIS (1926 to the present), EBM Reviews via Ovid including Cochrane CENTRAL (1960 to the present), and Conference Papers Index via ProQuest (1982 to the present) for key terms, including *peripherally inserted central catheter, PICC, venous thrombosis, bloodstream infection,* and *central line–associated bloodstream infection.* All human studies published in full text, abstract, or poster form were included. A total of 475 articles were retrieved by this search (last updated February 13, 2012). For this narrative review, we concentrated on studies that reported on the complications of bloodstream infection and venous thromboembolism associated with PICCs in adults.

Historical Origins of the Peripherally Inserted Central Catheter

Although the concept of a long-term venous access device had been considered previously,[5] the successful use of a

peripherally inserted, centrally located catheter was first reported in 1975.[6] In a case series, Hoshal[6] placed a 61-cm silicone catheter into the superior vena cava through the basilic or cephalic veins for total parenteral nutrition. Although 6 catheters were discontinued prematurely for "venous and nonvenous reactions," 30 lasted the entire duration of parenteral necessity (range 4-56 days).

Although technologic progress has led to novel polyurethane compounds and an array of configurations, little of Hoshal's original approach to PICC placement has changed. However, the clinical indications for PICCs have expanded to include tasks as diverse as long-term antibiotic delivery, parenteral nutrition, delivery of irritant/vesicant medications (eg, chemotherapy), establishment of vascular access in patients with difficult venous anatomies, and even central venous pressure monitoring.[7]

CLINICAL SIGNIFICANCE

- The use of PICCs has grown in hospitalized, critically ill, and ambulatory patients.
- Despite widespread use, scant data regarding the prevalence, patterns and appropriateness of PICC use exists.
- PICCs are associated with venous thromboembolism and bloodstream infections, complications that may offset any perceived benefit(s) from these devices.
- A research agenda examining patterns of use, complications, and comparative risks and benefits of PICCs in well-defined populations is needed.

Factors Promoting Widespread Peripherally Inserted Central Catheter Use

Although today's physician is presented with a selection of venous catheter choices with inherent advantages and disadvantages (**Table 1**), PICC use has specifically grown in hospitals across the United States.[1,8,9] Several factors may explain this development. First, owing to its peripheral site of entry, PICC insertion is easier and safer than that of conventional venous catheters.[10] Second, PICCs eliminate the pain associated with phlebotomies or routine replacement of peripheral intravenous catheters. In one of the few randomized controlled trials involving these devices, PICCs effectively reduced needle punctures, improved patient satisfaction, and were cost-effective in a cohort of surgical patients.[11] In an era of patient satisfaction, it is not inconceivable that providers may preferentially turn to a device that minimizes patient discomfort. Third, a unique prevailing practice paradigm involves the use of "vascular access teams" to insert PICCs. These teams are typically composed of registered nurses who (with specific training) occupy niche roles dedicated to venous access.[10,12] The development of these teams may have created the perfect prescribing privilege for physicians, who have been demonstrated to rely on nursing-led PICC placement when peripheral intravenous access is not routinely available.[13] Finally, PICCs are perceived as being safer than central venous catheters. Because the initial evidence supported this viewpoint, this perspective likely played a salient role in expanding PICC use.[14-18]

Evidence Regarding Peripherally Inserted Central Catheter–Related Complications

Despite the widespread adoption of PICCs, accumulating evidence suggests that they are associated with important complications, including bloodstream infection and venous thrombosis (**Table 2**).[19-21] The literature regarding these adverse events emanates from 2 distinct patient populations: those with and without cancer. Because important differences exist between these patients with respect to PICC-related bloodstream infections and thrombosis, these subsets are examined separately.

Adult Patients Without Malignancies

Central Line-Associated Bloodstream Infection. A central line-associated bloodstream infection occurs when a patient with an indwelling central venous catheter develops bacteremia in the absence of another identifiable source. Central line-associated bloodstream infections are significant because they prolong hospitalization, increase mortality, and increase healthcare costs.[22,23] Many clinicians believe that PICCs are associated with a lower-risk of central line-associated bloodstream infection than other venous catheters. Various quasi-scientific explanations were proffered to support this viewpoint, including the fact that lower temperatures and lesser bacterial colonization over the skin of the upper arm (vs that of the neck, groin, or chest) decreased the risk of bacterial entry into the bloodstream during line insertion.[24,25] Initial studies supported this hypothesis, finding PICC-related bloodstream infection rates of 0.4 to 0.8 per 1000 catheter days, an incidence significantly lower than the 2.0 to 5.0 central line-associated bloodstream infections per 1000 catheter days reported for other catheter types.[8,14-16,18]

However, a number of investigators have challenged this belief. In a prospective cohort study, Safdar and Maki[26] found that PICCs placed in hospitalized patients were associated with 2.1 bloodstream infections per 1000 catheter days. In an accompanying systematic review of the literature, subgroup analysis showed that inpatient PICC insertion was associated with twice the rate of bloodstream infection than outpatient placement (2.1 [95% confidence interval {CI}, 1.0-3.2] vs 1.0 [95% CI, 0.8-1.2] per 1000 catheter days). The authors theorized that inadvertent selection of healthier patients in ambulatory settings might have confounded the low-rate of PICC-related bloodstream infections in the literature.[26] Supportively, Shuman et al[27] found that PICCs were the most common device associated