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Improved method for the detection of catheter colonization and catheter-related bacteremia in newborns

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ABSTRACT

Accurate diagnosis of catheter-related bloodstream infection (CRBSI) is mandatory for hospital infection control. Peripherally inserted central venous catheters (PICCs) are widely used in intensive care units, but studies about procedures for detection of colonization are scarce in neonates. We sequentially processed 372 PICCs by 2 methods, first by the standard roll-plate (RP) technique and then by rubbing catheters on a blood agar plate after being longitudinally split (LS). With both techniques, we detected 133 colonized PICCs. Ninety-four events of CRBSI were diagnosed. The sensitivity, specificity, positive predictive value, and negative predictive value for detection of CRBSI were 58.5%, 92.8%, 73.3%, and 86.9%, respectively, for RP technique and 96.8%, 88.5%, 74.0%, and 98.8%, respectively, for LS technique. The LS technique increased the proportion of detected CRBSI by 38.3%. Neonatal PICC tips should be cultured after cutting them open. This technique is simple and sensitive to detect catheter colonization and also to diagnose CRBSI.

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1. Introduction

Silastic peripherally inserted central catheters (PICCs) are widely used in neonatal units (Westergaard et al., 2013; Paulson and Miller, 2008; Tsai et al., 2012; Al Raiy et al., 2010). Catheter-related bloodstream infection (CRBSI) is one of the most common complications of PICCs (Chopra et al., 2012a; 2012b; 2013a; Dudeck et al., 2015; Rosenthal et al., 2016). Confirmation of CRBSI requires isolation of the same microorganism from blood and from the catheter tip in significant counts. Maki's roll plate (RP) technique is recommended for routine clinical microbiology analysis and is the standard procedure for large-bore catheters (Mermel et al., 2009). Catheter sonication is an alternative method for analysis (Slobbe et al., 2009).

The starting point of our study was the presence of negative RP cultures in cases with a high suspicion of CRBSI. We suspected that the small inner lumen biofilm might not have been adequately sampled using the roll plate technique. In many such cases, we detected catheter colonization by cutting the suspected catheter longitudinally and rubbing the resulting fragments on a blood agar plate. We therefore systematically performed this sequential plating procedure in all pediatric PICCs sent to the microbiology laboratory for culture. In the present study, we analyze the usefulness of the procedure in the diagnosis of catheter colonization and CRBSI in newborns.

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2. Materials and methods

We performed an observational, nonrandomized, retrospective analysis of the benefit of a sequential culture procedure for detecting colonization of PICCs.

2.1. Patients and setting

Our institution is a public university hospital with a 34-cot neonatal referral unit (1069 admissions/year) and 16-cot neonatal intensive care unit (454 admissions/year). The number of days of stay per year is 14,728. In the neonatal unit, silicone 24G (2Fr) Epicutaneo-Cava catheters (Vygon, Ecouen, France) are used as the standard of care in newborns. Patients may need more than 1 vascular catheter during admission and at any given time. The catheter insertion and maintenance protocol includes 2% chlorhexidine solution for skin cleansing before insertion and before every contact with the catheter hub, as well as the use of sterile gloves after thorough hand washing. Staff attend regular training sessions on catheter care.

When sepsis is suspected, blood cultures are obtained by peripheral venipuncture and inoculation of 0.3 to 0.5 ml of blood into BD Bactec Plus Aerobic/F and Anaerobic/F culture vials (Becton Dickinson, MD, USA). PICCs and other catheter tips are submitted for culture at the request of the attending physician. The catheter submitted for culture is removed according to a standardized protocol, which comprises

cleaning of the insertion site with chlorhexidine prior to removal and cutting 5 cm of the catheter tip for culture.

2.2. Study period

November 2011 to November 2013.

2.3. Procedures

PICC tips submitted for culture from the neonatal unit were rolled onto a blood agar plate (RP) and subsequently cut open longitudinally with a scalpel (#21 blade) over a sterile petri dish. The fragments were placed on a second blood agar plate and rubbed onto its surface (longitudinally split [LS] method). Non-PICC vascular catheters were processed using the RP method only and were not included in the event analysis. All procedures were performed following a sterile technique. Both agar plates were incubated in an aerobic atmosphere for at least 48 hours at 35 °C. Bacteria were identified and susceptibility testing performed using MicroScan panels (MicroScan WalkAway 96 Plus, Beckman Coulter, CA, USA). Fungi were identified using matrix-assisted laser desorption-ionization time of flight mass spectrometry (MALDI-TOF MS, Bruker Daltonics, Bremen, Germany), and fungal susceptibility was tested using standard procedures (CLSI, 2012). The number of each colony type detected on the culture plates was recorded.

2.4. Definitions

The catheter was considered colonized when the culture of the tip yielded ≥15 colony-forming units (CFU) of the same colony type by either method (Mermel et al., 2009).

CRBSI was defined as the presence of the same organism (identical species and antimicrobial susceptibility pattern) in a colonized PICC and in blood cultures from the same event (Mermel et al., 2009).

An event was defined as a PICC submitted for culture and the corresponding blood cultures from the same patient within ±7 days of catheter removal.

2.5. Statistical analysis

Quantitative variables were expressed as median and interquartile range (IQR), and categorical variables were expressed as proportions. LS and RP were compared using the McNemar test for paired samples. Differences were considered statistically significant if $P < 0.05$. Differences between proportions were calculated with a 95% confidence interval (CI) using a 2-tailed Fisher exact test. We also evaluated the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for each technique for diagnosis of CRBSI. Data were analyzed using Stata/IC version-13.1 (StataCorp, Texas, USA).

3. Results

During the study period, the laboratory processed 372 PICCs from 277 newborns. Median birth weight was 1485 g (range, 430–4740 g; IQR, 1700 g), 141 (50.4%) weighed under 1500 g, and 69 (24.6%) weighed under 1000 g. Median gestational age was 30.6 weeks (range, 23.6–42 weeks; IQR, 9.8 weeks). The male/female ratio was 120:157. Median age at the time of withdrawal was 15 days (range, 3–194 days; IQR, 18 days). Median indwelling time was 8.65 days (range, 1.41–157.45 days; IQR, 6.97 days).

3.1. Colonization of PICCs

A total of 133 (35.8%) of 372 PICCs from 113 neonatal patients were positive by either method. Fifty-eight samples (43.6% of all positive cultures) were positive only by LS. Comparative results for both procedures are summarized in Table 1. Colonized PICCs yielded 146 different organisms in significant counts. Colonization was monomicrobial in 108 PICCS and by 2 or more genera in 9 PICCS. Significant growth of more than 1 strain of *Staphylococcus* spp. was detected in 16 additional PICCs. LS enabled us to detect 2 PICCs colonized by *Malassezia furfur* yeasts that grew in regular blood agar enriched with traces of the lipids remaining in the PICC lumen. The organisms detected are shown in Table 2.

3.2. CRBSI

Blood cultures were positive in 152 events. Positive blood cultures met the definition of CRBSI in 94 events, all of which occurred within −6 to +1 days of removal. The LS technique increased the proportion of CRBSI diagnosed by 38.3% (95%CI, 26.5–48.3%). In 58 events, positive blood cultures did not indicate PICC-related bloodstream infections (PICCs were not colonized in 51 events and PICCs were colonized by a different organism in 7 events). Blood cultures were sterile in 131 events. In 89 events, no blood cultures were drawn within the defined event period. In 62 of these events, blood cultures were drawn more than 7 days before catheter withdrawal. The results of both procedures for diagnosis of CRBSI are summarized in Table 3. The sensitivity, specificity, PPV, and NPV were 96.8%, 88.5%, 74.0%, and 98.8%, respectively, for LS technique, and 58.5%, 92.8%, 73.3%, and 86.9%, respectively, for RP technique (Table 4).

4. Discussion

We demonstrated that the RP technique does not detect colonization of a substantial number of PICCs used in neonatal units. Colonization of PICCs can be detected easily by sectioning the catheter tip longitudinally before plating.

A cause of concern when implementing the recommended procedure can be the potential risk of handling a sharp blade over a slim sample. In our experience, the complete procedure took about 1 minute to perform, and no potentially hazardous events were reported.

Most vascular catheter colonization studies have been performed in adults and large-bore central lines compared with PICCs and extrapolated to neonates (Al Raiy et al., 2010; Johansson et al., 2013; Chopra et al., 2013b; Tariq and Huang, 2006). PICCs differ from other central vascular catheters. They are made of silicone instead of the more commonly used hard plastic polymers. In addition, they have only 1 small lumen with no lateral openings. Consequently, rolling the tip of a PICC on an agar plate does not sample the inner surface biofilm. The direct methods of demonstrating catheter colonization recommended by Infectious Disease Society of America Guidelines are RP and catheter tip sonication (Mermel et al., 2009). Comparative studies on RP and sonication in which the processing order was randomized revealed that the results of the method performed first were better, although the method performed second may still be able to reveal a small additional number of colonized catheters (Slobbe et al., 2009; Bouza et al., 2005). The results of a recent study by our group comparing sonication, LS, and RP in neonatal PICCs confirm the low performance of RP (58.6%) in the detection of colonization of PICCs (Guembe et al., 2016a).

We tested RP and LS sequentially to evaluate the potential added value of LS. We do not believe that the sequential plating procedure should be the method of choice. The process of taking RP samples

Table 1
Number of colonized and noncolonized PICCs detected by each method.

Number of colonized PICCs detected by each method		Longitudinally sectioned (LS)		
		Positive (n, %)	Negative (n, %)	Total (n, %)
Roll plate (RP)	Positive (n, %)	65 (17.5)	10 (2.7)	75 (20.2)
	Negative (n, %)	58 (15.6)	239 (64.2)	297 (79.8)
	Total (n, %)	123 (33.1)	249 (66.9)	372 (100)

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