Prevention of peripherally inserted central catheter-related infections in very low-birth-weight infants by using a central line bundle guideline with a standard checklist

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Objective: To investigate the effectiveness and feasibility of using a central line bundle (CLB) guideline with a standard checklist in the prevention of peripherally inserted central catheter (PICC)-related infections (CRIs) in very low-birth-weight infants (VLBWIs).

Methods: Fifty-seven VLBWIs who underwent PICC insertion at a hospital in Qingdao, China, between November 2012 and June 2013, were monitored with the CLB guideline and a standard checklist. Fifty-three VLBWIs who underwent PICC insertion were monitored by standard hospital procedures. The incidence of CRIs was compared between the two groups.

Results: The incidence of infection significantly decreased from 10.0% catheter days in the control group to 2.2% catheter days in the study group (p < 0.05). The indwelling catheter time significantly increased in the study group compared to the control group (31.9 ± 15.0 days vs. 24.8 ± 7.4 days, respectively, p < 0.05). Colonization infections also decreased from 6.9% catheter days in the control group to 2.2% catheter days in the study group (p < 0.05). The incidence of catheter-related bloodstream infections decreased from 3.1% catheter days in the control group to 0% catheter days in the study group.

Conclusion: The use of a CLB guideline with a standard checklist could be an effective and feasible protocol for preventing CRIs and prolonging indwelling catheter time in VLBWIs.

1. Introduction

The use of the peripherally inserted central catheter (PICC) technology is widespread because of its simplicity, osmotolerance, and longevity [1]. However, 16.4%–28.8% of the PICCs are susceptible to catheter-related infections (CRIs), a severe complication of PICC placement [2–4]. If treatment of the CRI is not timely, the incidence of further infection and mortality rates are high [5]. Therefore,
identifying methods to reduce or eliminate CRIs is important. A central line bundle (CLB) guideline was first proposed by the Institute for Healthcare Improvement, and included five key measures—hand hygiene, maximum sterility, chlorhexidine disinfection, choosing the best puncture site, and daily assessment of whether to remove the catheter [6]. These measures effectively reduce the occurrence of catheter-related bloodstream infections (CRBSIs) [7,8].

Very low-birth-weight infants (VLBWIs) have a low immune response and indistinct symptoms after an infection compared to other populations [9]. It is unknown whether a CLB in VLBWIs is effective and safe, and whether it could prevent bacterial colonization and infection [10]. We investigated the effectiveness of the CLB guideline in preventing PICC CRIs in VLBWIs. We hypothesized that using the CLB guideline with a standard checklist could prevent CRIs in very low-birth-weight infants.

2. Materials and methods

2.1. Clinical data

In this study, 110 VLBWIs who received PICCs were enrolled. All patients met the standards of PICC insertion. Fifty-seven VLBWIs were included in the study group. The CLB guideline and a standard checklist were implemented between November 2012 and June 2013. Fifty-three patients were included in the control group. This group had catheters inserted, but the CLB guideline and a standard checklist were not implemented. This study was conducted in accordance with the Declaration of Helsinki. This study was conducted with approval from the Ethics Committee of Qingdao Center Medical Group. Written informed consent was obtained from the parents of all enrolled VLBWIs.

2.2. Bundle insertion

A senior nurse, who was qualified to perform catheter insertions, inserted PICCs in all the participants. The following conditions were established for the study group: 1) creation of a PICC treatment center, 2) hand hygiene, 3) maximum sterility, 4) skin preparation, and 5) selection of the best puncture site. The PICC supplies (single-lumen 1.9-Fr catheter and No. 26 catheter sheath, BD Inc., Illinois, USA) were kept in a fixed location. Regular inspections were undertaken to ensure the presence of adequate supplies and backups within the study period. The VLBWIs underwent PICC line insertion only in the treatment center. The nurse and assistants were required to wash their hands in strict accordance with the seven-step hand-washing method. For maximum sterility, the nurse and assistants wore sterile surgical gowns, gloves, hats, and masks. Masks were completely and tightly wrapped around the nose and mouth. The hats completely covered all hair. The patients were completely covered with sterile towels with only the puncture site exposed. The pre-puncture upper arm (from the fingertips to the fossa cubitalis) was washed with warm soapy water followed by cleaning with a 75% alcohol solution. This procedure was repeated two or three times according to the condition of the patient’s skin. Thereafter, Anerdian (Disinfection Technologies Ltd., Haili Kang, ShangHai) was used to disinfect the skin from the armpits down to the fingertips three times. Anerdian is a skin disinfectant widely used in clinics. It contains iodine (0.2% ± 0.02%), chlorhexidine acetate (0.45% ± 0.045%), and ethanol (65% ± 5%). Anerdian kills intestinal bacteria, pyogenic bacteria, yeast and pathogenic bacteria. The skin was allowed to dry naturally before the best puncture site was selected. The first choice was the basilica vein, followed by the cubital and axillary veins. Puncture of the lower limbs was avoided. In the control group, strict hand hygiene, skin preparation, and aseptic manipulation practices were followed; however, the measures of using the PICC treatment center, ensuring maximum sterility, and selecting the best puncture site were not enforced or implemented.

2.3. Bundle maintenance

The following conditions were established for the study group: 1) hand hygiene, 2) dressing management, 3) filling and sealing the catheter tube, and 4) daily assessments by duty nurses. Hands were washed in strict accordance with the seven-step hand-washing method, or a hand disinfectant was used before and after touching the catheters and dressings. The dressing was replaced exactly every week after catheter insertion. Daily assessment guidelines were as follows: observed whether the puncture site exhibited redness, swelling, tenderness, or inflammation; avoided removing the catheter because of simplex fever; and comprehensively evaluated the need to remove the catheter according to clinical manifestations and laboratory findings. In addition, the catheter was removed when no longer necessary.

The control group received routine nursing care, including the use of aseptic technique, timely sealing of the catheter, and film replacement.

2.4. Use of a standard checklist

In the study group, a standard checklist was used to monitor for any infections. Any violation of the operating rules was stopped in a timely manner and corrected. In the control group, the standard checklist was not used.

CRI diagnosis and classification criteria [11] were used to determine the following conditions: 1) local infection: defined as skin with redness, tenderness, or any secretion around the intubation; 2) phlebitis: defined as painful and diffuse erythema occurring at the subcutaneous site along the catheter that was not related to physical or chemical factors; 3) catheter colonization: defined when the insertion site had no signs of infection and the distal part of the catheter had pathogens amounting to ≥15 colony-forming units (CFU/tablet, with semiquantitative cultures or pathogens amounting to ≥1000 CFU on the quantitative culture; and 4) CRBSI: defined when the same pathogen was isolated on quantitative or semiquantitative catheter cultures and other blood cultures.

2.5. Data collection

Patients without clinical CRI symptoms [12] underwent routine alcohol and Anerdian disinfection around the catheter
three times when the catheter was removed. The nurse wore gloves and used sterile towels to form a sterile area. The catheter tip was placed 5 cm into the sterile blood dish. The sample was taken to the microbiological laboratory for semi-quantitative catheter culture. Patient samples that were suspected of being infected were divided into reserved and non-reserved catheters.

Catheter blood and peripheral blood from the reserved catheter were further subjected to pathogen and antimicrobial susceptibility tests within five minutes of blood sampling. If the culture results confirmed or could not rule out infection, the catheter was removed immediately. A catheter tip culture and a sensitivity test were performed. Two peripheral blood samples were extracted from the non-reserved catheter for pathogen and catheter tip cultures. An antimicrobial susceptibility test was performed.

2.6. Outcome measures

The outcome measures for both groups were as follows: 1) Nurses observed and recorded each patient’s temperature, any blood oozing, exudation, redness, swelling and indurations, and punctured limb swelling. Nonspecific clinical manifestations associated with infections, such as listlessness, jaundice, and persistent and recurrent apnea, were also noted; and 2) Laboratory test results including catheter tip and blood cultures. The following formula was used to determine the presence of PICC-related infection [13]: cases of infection/PICC catheter days over the same period × 1000%.

2.7. Statistical analysis

Statistical analysis was performed using the SPSS software. The measured data were presented as mean ± standard deviation. The Student’s t test was used to compare data between the groups. Qualitative data were analyzed by using the χ² test. A p < 0.05 denoted a significant statistical difference.

3. Results

No significant differences were observed in gestational age, sex, and birth weight between the study and control groups (p > 0.05, Table 1).

We observed significant differences between the study and control groups. The incidence of CRIs decreased from 10.0% catheter days in the control group to 2.2% catheter days in the study group (p < 0.05) (Table 2). The indwelling catheter time also increased after implementation of the CLB guideline with the standard checklist. Very few studies have reported catheter colonization infections because symptoms could not be observed after the onset of infection [17]. Furthermore, if a catheter tip bacteria culture is not performed when the catheter was removed, then obviously the detection rate will be low. In this study, all the removed catheters were subjected to catheter tip culture. Interestingly we observed a high colonization infection rate. By proactively monitoring for the colonization infection rate, we dramatically reduced this risk factor of CRBSI [18].

4. Discussion

This study provided evidence that the CLB guideline with the standard checklist effectively reduced the incidence of CRIs, colonization infections and CRBSIs in the VLBWIs. The indwelling catheter time also increased after implementation of the CLB guideline with the standard checklist. Very few studies have reported catheter colonization infections because symptoms could not be observed after the onset of infection [17]. Furthermore, if a catheter tip bacteria culture is not performed when the catheter was removed, then obviously the detection rate will be low. In this study, all the removed catheters were subjected to catheter tip culture. Interestingly we observed a high colonization infection rate. By proactively monitoring for the colonization infection rate, we dramatically reduced this risk factor of CRBSI [18].

This study not only adopted the five measures put forward by the Institute for Healthcare Improvement but also added measures to further decrease the risk of infection. After searching the literature and consulting with experts, we also established a PICC treatment center, a strict dresscode, and a protocol for correctly filling and sealing tubes. Furthermore, other studies [19,20] indicated that operator compliance monitoring could prevent nosocomial infection a large extent. Consequently, we employed quality control nurses to monitor the entire process of PICC insertion, and to assess whether the measures were being implemented according to the checklist. The quality control nurses also ensured compliance with the rules of the operation in a timely manner.

The limitations of this study were that all patients of this study were collected over a short period (one year), and underlying diseases were not considered and classified.
Comparison of CRBSI and colonization infection rates between the control and study groups

<table>
<thead>
<tr>
<th>Group</th>
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<th>CRBSI</th>
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<td>Cases</td>
<td>Infection rate</td>
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* There was a cell-expectation count of less than 5. The minimum expectation count was 1.67 using Fisher’s exact test to correct.

5. Conclusions

In summary, a CLB guideline can effectively, simply, and feasibly reduce the incidence of CRIs, colonization infections, and CRBSIs in VLBWIs. In addition, it is critical to ensure that each measure is completed. We found that each measure was implemented effectively by following a standard checklist. Therefore, the CLB guideline could have a greater impact in preventing infection. This study provides evidence that new protocols should be implemented to decrease the risk of infection associated with PICCs.

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Conflict of interest

The authors have no conflicts of interest.

REFERENCES