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The Effect of Extending the Time Interval between Routine Replacement of Intravenous Administration Sets on Central Line Associated Bloodstream Infection, Nursing Workload and Costs

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Abstract

Introduction: Routine replacement of the intravenous (IV) administration set is a hygiene measure to prevent central line associated bloodstream infection (CLABSI). This intervention adds to the nursing workload and is costly. The optimal time interval between IV administration set replacements is unknown.

Methods: A retrospective before-after study in a single-center Intensive Care Unit (ICU) was performed between February 1st 2015 and July 1st 2017. Central venous catheters (CVCs) of adult patients with a time interval of 72 hours (pre-intervention group) between routine replacement of the IV administration sets were compared with CVCs of patients with a time interval of 96 hours (post-intervention group). Primary endpoint was the incidence of CLABSI. Secondary endpoints were CVC colonization, nursing workload and costs. Two tailed Fisher's exact test was used to compare the incidence of CLABSI between both groups.

Results: 2,127 patients with 11,027 catheter days were analysed. 1,106 patients with a CVC in the pre-intervention group were compared with 1,021 patients in the post-intervention group. The incidence of CLABSI was not different between both groups (15 cases in the pre-intervention group vs. 14 cases in the post-intervention group; rate difference 0.28/1,000 CVC days (95% CI = -1.64 – 2.20, P= 0.920). Less IV administration sets were replaced in the post-intervention group, reducing nursing workload with approximately 175 hours and material costs by 11,529 Euros per year.

Conclusion: Extension of the time interval between routine replacement of IV administration sets in patients with a CVC does not increase CLABSI and reduces nursing workload and costs.

Keywords: CLABSI, Central Venous Catheter, Administration sets, Costs, Nursing Workload.

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Introduction

Central line associated bloodstream infection (CLABSI) is an unintentional injury resulting from the adherence of bacteria on a catheter inserted in a central venous blood vessel. Therefore, only patients who depend on a central venous catheter (CVC) for hemodynamic measurements, dialysis, parenteral nutrition or specific medications, should have one. Critically ill patients often need a CVC and are at risk of catheter-related complications, such as infection, which are associated with increased morbidity and costs.1,2 In the Netherlands, PREZIES, the national nosocomial infection surveillance network commenced surveillance of CLABSI in 2000.3 Data from at least 24 participating Dutch hospitals were collected and showed a CLABSI incidence of 1.8/1,000 CVC-days (95% CI: 1.7 – 2.0) over the last five years.4 The most frequent group of pathogens of CLABSI was Coagulase Negative Staphylococci (CNS).

In 2008, a four-year patient safety agency programme was launched in the Netherlands to reduce unintentional harm in the health care sector, which included prevention of CLABSI.3 As a result, a bundle of multiple interventions was implemented in several hospitals in the Netherlands. The majority of the interventions were directed towards raising awareness and increasing the application of hygiene precautions regarding CVCs. One of the improved hygiene measures

to avoid microbial growth in the system, was the routine replacement of the intravenous (IV) administration sets every 72 - 96 hours in patients not receiving lipids or blood products.5 An administration set (or tubing) consists of infusion lines, needleless connectors, a four-way infusion connector, fluid containers, syringe infusion pumps for medication administered and a pressure measurement system. In practice, to prevent the 96 hours being exceeded and since the administration sets were only replaced during the dayshift, a time interval of 72 hours was agreed upon in our hospital.

Routine replacement of IV administration sets is assumed to reduce CLABSI. However, there are some data that call this assumption into question and suggest that the increased number of CVC manipulations due to replacement may actually increase the risk of CLABSI.6,7 A systematic review of the Cochrane library (2013), showed no effect of the frequency of IV administration set replacements on CLABSI in adults (RR 1.06, 95% CI 0.67 to 1.69), however within the neonatal population increased mortality was seen when sets were replaced infrequently (24 hours vs. 48 hours, 24 hours vs. 72 hours)(RR 1.84, 95% CI 1.00 to 3.36).5 This negative effect in the subgroup analysis of this systematic review was based on two studies, and parenteral nutrition may have contributed to these results.5,8,9

In addition to the possible manipulation risk, two considerable disadvantages of the routine replacement of the IV administration sets have been reported; increased nursing workload and costs.5,7

This study aims to analyse the effect of an extension of the time interval between routine replacement of IV administration sets on CLABSI incidence, nursing workload and costs.

Methods

Study design and population

We conducted a single-centre retrospective cohort study with a before after design to analyse the effect of an extension of the time interval between routine replacement of IV administration sets on CLABSI incidence. The study was performed in the Intensive Care Unit (ICU) and the Medium Care Unit (MCU) patients at the St. Antonius Hospital, Nieuwegein, in the Netherlands between February 2015 and July 2017. In April 2016, the time interval between routine placement of IV administration sets was extended from 72 - 96 hours to 96 - 120 hours to reduce workload, save on materials and eventually reduce costs. The pre-intervention and post-intervention periods each lasted 14 months (Figure 1).

The St. Antonius hospital has a 24 bed ICU and 10 bed MCU that handle approximately 2,400 admissions annually. Care for patients above 18 years of age for all medical specialties is offered, with the exception of neurosurgery. All adult patients admitted to the ICU/MCU with a CVC for at least 48 hours were eligible for inclusion. CVCs used for renal replacement therapy (RRT), transvenous pacemaker treatment and Swan-Ganz (SG) measurements were excluded, since no administration set is used with these catheters. CVCs that were previously inserted at another hospital were also excluded. CVCs were monitored until removal.

The review board of the local ethical committee (Medical research Ethics committee United, number W18.099) waived the need for informed consent as patients were not subjected to investigational actions. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Routine nursing care for IV administration sets

In each patient with a CVC, routine hygiene measures were applied to prevent CLABSI, including: optimal insertion site and catheter selection, hand hygiene prior to insertion, maximal sterile barrier precautions at the CVC insertion site (sterile gloves, cap, mask, sterile gown and a sterile full body drape), skin antisepsis, sterile transparent semi-permeable dressing to cover the catheter site and the use of closed infusion lines with needle-free connectors (Swann lock®).2 In addition, IV administration sets were routinely replaced every 72 - 96 hours.2 Patients receiving lipids or blood products had their IV administration sets replaced immediately after use or every 24 hours to avoid microbial growth, following CDC guidelines.2 These CVCs were included in the analyses.

During an IV administration set replacement, pressure measurement systems, syringe infusion pumps for medication administration, infusion lines, infusion connectors and infusion dressings are replaced. This also applies to the measurement system of the arterial line and the syringe infusion pumps for medication administered, infusion lines and patch of the peripheral infusion needle. On average, a routine IV administration set replacement takes approximately 45 minutes and costs approximately 50 Euros (Figure 2).

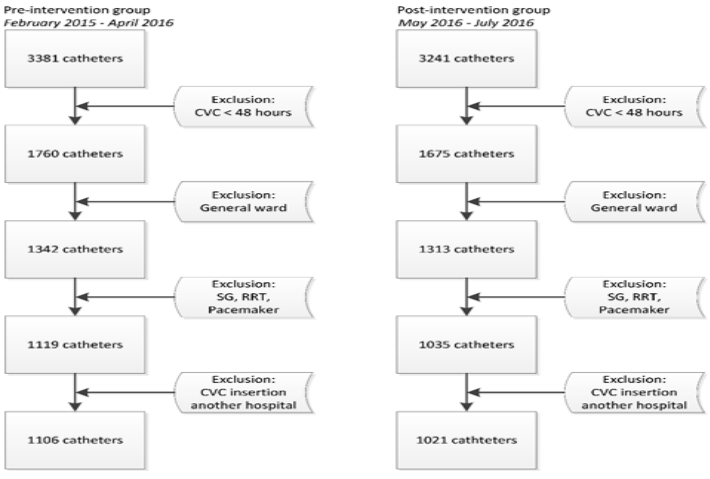

Figure 1. Flowchart patient inclusions

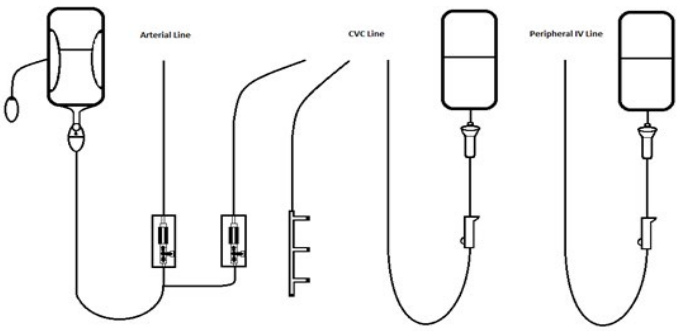

Figure 2. An administration set; Arterial and CVC pressure measurement system, a four-way infusion connector and two peripheral infusion lines with fluid containers

CVC registration and follow up

An electronic CVC registration system is used to record CLABSI incidence in our hospital. Every patient with a CVC is registered in this system and is visited daily by an ICU nurse, who is responsible for monitoring of symptoms of CLABSI and repeated evaluation of the indication for each CVC. During this visit the insertion opening, clinical parameters and the current need for a CVC are checked. In case of signs of inflammation or lack of indication, the ICU nurse consults the ward doctor for possible follow-up actions. These follow-up actions could be: taking two peripheral blood cultures or taking cultures to check infection at any other body site (for example: urine or bronchial secretion cultures) when CLABSI suspicion is not very high, or removing the CVC when CLABSI suspicion is high or when there is no further need for a CVC. All observations and consequential actions are recorded in the electronic CVC registration system, which is incorporated in the electronic medical file of the patient. If the CVC is removed in case of suspicion of CLABSI, the catheter tip is cultured for the presence of microorganisms and the ICU nurse visits the patient for several days to monitor recovery.

A group consisting of an ICU doctor, two ICU nurses and an infectious diseases specialist analysed all collected data individually and categorised patients as no CLABSI versus (possible) CLABSI. In case of doubt, individual cases were discussed within this team before a definite conclusion was drawn. The definition of CLABSI and possible CLABSI are adopted from the Dutch PREZIES surveillance system.3

Data aggregation and analysis

Data were collected from electronic medical patient records and included patient characteristics (gender and age) and CVC specifications (CVC duration, (no) elective insertion, indication, location, number of lumens, CVC tip colonization and (no) CLABSI). Data retraction was performed using the software program Pentaho (Hitachi Vantara, release 4.8.3 GA, California).

Outcome parameters

The primary outcome was the incidence of CLABSI per 1,000 catheter days. CLABSI was defined as a clinical symptom of a bloodstream infection (i.e. fever (>38°), shivers, hypotension (systolic pressure <100 mmHg)) not secondary to an infection at any other body site and in which the peripheral blood culture contained the same microorganism as the catheter tip culture (Semi quantitative method in which the growth of >15 colony forming units (CFU) were cultured after rolling of the catheter tip on an agar plate was considered positive10).3 Possible CLABSI was defined as clinical symptoms of a bloodstream infection not secondary to an infection at any other body site with either a positive peripheral blood culture (or a missing blood culture) or a positive catheter tip culture (or a missing catheter tip culture). For the diagnosis of possible CLABSI the clinical symptoms of a bloodstream infection had to disappear within 24 hours after removing the CVC.3 To prevent underreporting patients with a possible CLABSI were classified as CLABSI.

Secondary outcomes were CVC colonization per se, nursing workload in hours and costs in Euros per year. CVC colonization was defined as growth of >15 CFU from distal segment of CVC tip on removal, using the semi quantitative culture method, with or without clinical signs of CLABSI in the patient.6

Statistical analysis

Numerical data were described using means and standard deviation (SD) or medians and interquartile ranges (IQR), when appropriate. Continuous data were analysed using the T-test or, when distribution was abnormal, the two-sample Wilcoxon test. Categorical data were described using proportions and percentages and were analysed using Chi-square or Fisher's exact test. The number of CLABSI cases per 1,000 CVC days were compared with the two tailed Fisher's exact test and summarised with a rate difference and 95% CI. Adjustment for differences in baseline characteristics were carried out by logistic regression analysis. Statistical uncertainty was expressed by the 95% confidence interval (95% CI). P-values less than 0.05 were considered significant. All the analyses were performed using R version 3.1.2.

Results

Population

During the entire study period 2,127 patients with 11,027 catheter days were analysed. 1,106 patients with a CVC in the pre-intervention group were compared with 1,021 patients in the post-intervention group. Most patients were male (62%) and median age was 69 years (IQR 61 – 75 years). The median CVC duration was four days (IQR 2 – 7 days). The most common indication for a CVC was hemodynamic monitoring (90%). The majority of CVCs were electively inserted (64%) in the internal jugular vene (89%). Mostly triple lumens CVCs were used (65%). Baseline characteristics of both groups are presented in Table 1.

CLABSI and CVC colonization

During the entire study period 29 cases of CLABSI were diagnosed (2.6/1,000 CVC days). During the pre-intervention period 15 cases of CLABSI (2.8/1,000 CVC days) were diagnosed compared to 14 cases (2.5/1,000 CVC days) during the post-intervention period; rate difference 0.28/1000 CVC days (95% CI = -1.64 – 2.20, P = 0.920). In both groups the most frequent group of pathogens found in CLABSI belonged to the Coagulase Negative Staphylococci (CNS) (73% vs. 71%). In the post-intervention group one CLABSI case was caused by a Staphylococcus aureus. The pathogens cultured from the CVC tip were not significantly different in both groups (Table 2).

CVC colonization rate was higher in the post-intervention group compared with the pre-intervention group (16% vs 12%; P<0.05). After adjustment for baseline characteristics (age, gender) and CVC specifications (CVC duration, elective insertion, indication, number of lumens, insertion location), CVC colonization ratio was equal in both groups (OR 1.24, CI = 0.95 – 1.61, P= 0.11). CVC tip colonization was most commonly caused by CNS (11%) followed by Gram- negative bacilli (2%) and Candida species (2%) (Table 2).

	Pre-intervention	Post-intervention	P value
Total catheters, n	1,106	1,021	
Total catheter duration, days	5,411	5,616	
Age, years (IQR)	69; 60 - 75	69; 61 - 74	0.91
Male, n (%)	676 (61.1%)	634 (62.1%)	0.64
Catheter duration, hrs (IQR)	93.5; 55 - 149	98; 57 - 167	<0.05
Elective insertion, n (%)	733 (66,3%)	629 (61,6%)	<0.05
Indication, n (%) • Hemodynamic monitoring • Antibiotic administration • Parenteral Nutrition •Other	 1,013 (91.6%) 28 (2.5%) 30 (2.7%) 25 (3.2%)	 907 (88.8%) 38 (3.7%) 30 (2.9%) 46 (4.5%)	0.14
Number of lumens, n (%) • One • Two • Three • Four	 28 (2.5%) 611 (55.2%) 437 (39.5%) 30 (2.7%)	 17 (1.7%) 12 (1.2%) 955 (93.5%) 37 (3.6%)	<0.05
Location CVC, n (%) • Jugular • Subclavian • Femoral	 988 (89.3%) 65 (5.9%) 53 (4.8%)	 912 (89.3%) 69 (6.8%) 40 (3.9%)	0.45

Table 1. Characteristics of the groups. Age, gender, catheter duration are displayed as median and interquartile range (IQR) and other parameters as number and percentage (%).

	Pre-intervention n (%)	Post-intervention n (%)	P value
Pathogens CLABSI • CNS • Enterococci • Gram- negative bacilli • Staphylococcus aureus • Candida species • Others	 12 (80%) 1 (7%) 1 (7%) 0 (0%) 0 (0%) 1 (7%)	 10 (71%) 1 (7%) 1 (7%) 1 (7%) 1 (7%) 0 (0%)	0.89
Pathogens Colonization •CNS •Enterococci •Gram- negative bacilli •Staphylococcus aureus •Candida species •Others	 103 (65%) 8 (5%) 24 (15%) 1 (1%) 19 (12%) 3 (2%)	 125 (64%) 13 (7%) 25 (13%) 4 (2%) 21 (11%) 6 (3%)	0.81

Table 2. Pathogens of CLABSI and CVC tip colonization

**17 patients >1 pathogen, **24 patients >1 pathogen*

CVC colonization rate was higher in the post-intervention group compared with the pre-intervention group (16% vs 12%; P<0.05). After adjustment for baseline characteristics (age, gender) and CVC specifications (CVC duration, elective insertion, indication, number of lumens, insertion location), CVC colonization ratio was equal in both groups (OR 1.24, CI = 0.95 – 1.61, P= 0.11). CVC tip colonization was most commonly caused by CNS (11%) followed by Gram- negative bacilli (2%) and Candida species (2%) (Table 2).

Nursing workload and costs

A total of 1,803 IV administration sets were replaced during the study period. After extending the time interval between routine IV replacements, significantly less IV administration sets were used in the post-intervention group compared to the pre-intervention (1,036 vs. 767; P <0.05). Saving 269 IV administration sets replacements reduced nursing workload significantly (777 vs. 575 hours; P< 0.05) with 172 working hours per year.

During the pre-intervention period, 1,036 IV administration set replacements were used with a total cost of approximately 51,800 Euros, compared with 38,350 Euros for 767 IV administration set replacements during the post-intervention period (P< 0.05). Approximately, 11,527 Euros in material costs per year were saved by the intervention.

Discussion

This study shows that an increased time interval between routine replacements of IV administration sets did not alter the risk of developing CLABSI. Prolongation of the time interval from 72 to 96 hours can be considered safe and reduces nursing workload and material costs.

These findings are in agreement with previous studies, such as published by Richard et al. (2004).7 In this study a RCT took place in a 18-bed ICU in a tertiary referral hospital and included 251 ICU patients with 404 CVCs. CVCs that were inserted in the ICU and were in situ on day four were randomised to have their IV administration set changed on day four or not at all. They showed that infrequent routine replacements of IV administration sets did not affect colonization rate or CLABSI risk. The results of their study suggest that routine replacement of IV administration sets are unnecessary within seven days after placement.

In addition, a systematic review and meta-analysis in the Cochrane database of 16 RCTs on the frequency of venous or arterial catheter administration set replacement in 5,001 hospitalized participants (neonates and adults), showed no effect of the frequency (24 hours vs. ≥ 48 hours, 48 hours vs. ≥ 72 hours, 72 hours vs. ≥96 hours) of routine IV administration set replacements on CLABSI (RR 1.06, 95% CI 0.67 to 1.69).5 However, the quality of the included trials was considered low to moderate because of a high or unclear risk of bias. In this systematic review, costs were also described as an intended outcome parameter but the authors were unable to perform an economic analyses due to the lack of data.

The Center for Disease Control and Prevention (CDC) recommends that sets used to administer fluids (other than lipid or blood products) should be routinely replaced every 96 hours.2 Our hospital protocol demanded routine replacement of IV administration sets every 72 - 96 hours, a shorter interval than recommended by the CDC. This hospital agreement is based on daily practice; sets were only routinely changed during the dayshift. This means a minimum interval time of 72 hours with a maximum up to 96 hours. However, based on the results from this study, it appears as if the requirements in this protocol may have been chosen too conservatively.

Extending the time interval of routine replacements of IV administration sets directly reduces the quantitative workload. Quantitative workload is one of the seven dimensions of workload, described by Carayon et al. (2007) and defined as the amount of work directly related to working hours.11 Since high nursing workload may have negative consequences for nurses wellbeing and patient safety in ICUs11, it is important to work as efficiently as possible. By reducing the workload, the extension of the time interval of routine replacements of IV administration sets indirectly contributes to the patient safety at ICUs. The review of Penoyer (2010) about nurse staffing and patient outcomes, described four studies which examined the effect of nurse staffing on CLABSI.12 In all four studies, during time periods of reduced nursing staffing, patients had more CLABSI and vice versa, indicating a direct relationship between nursing staffing, workload and CLABSI. We showed in our study that reduction of workload can be achieved without harming the patients when it is done in a planned manner.

Material costs were significantly reduced after decreasing the frequency of IV administration set replacements. The cost of an IV administration set change vary greatly between patients and were not available at the individual level. In addition medication costs and use of medication infusion pumps were left out of this calculation. For simplicity, minimum costs were assumed and therefore, the average calculated reduction in costs is likely higher per patient.

Our study has some limitations. The study has a retrospective design, resulting in related methodological issues 1) The two groups were not equal in some important baseline characteristics, which may influence colonization rate. After correcting for baseline characteristics and CVC specifications, CVC colonization rate was equal in both groups. However, it is not possible to do the same for CLABSI rate, because incidences of CLABSI are too low to correct for. The difference could also be explained by some unmeasured confounders that were not collected, because the dataset was an administrative dataset and not specifically designed for research purposes. 2) Although the data on all the patients that entered the CVC registration database is complete, it cannot be completely ruled out that there were patients in the hospital with CVCs that were not registered in the system. However, this is very unlikely because in the ICU and MCU, daily CVC check and registration in the electronic system is a daily routine.

Our current study showed that reduction in workload can be safely achieved by increasing the interval between routine replacement of IV administration sets from 72 to 96 hours. In the future we will examine a longer (168 hours) routine time interval between IV administration set changes and the risk of CLABSI to study whether this can be done safely as well.

We have demonstrated that extending the time interval from 72 to 96 hours of routine replacement of IV administration sets does not increase the incidence of CLABSI. This extended time interval reduces nursing workload and costs.

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