Review Article

Nursing Studies about Central Venous Catheter Care: A Literature Review and Recommendations for Clinical Practice

Nurten Kalender, RN, PhD Student
Medical Nursing, Gulhane Military Medical Academy, School of Nursing, Ankara, Turkey

Nuran Tosun, RN, PhD
Associate Professor of Medical Nursing, Gulhane Military Medical Academy, School of Nursing, Ankara, Turkey

Correspondence: Nurten Kalender, PhD Student of Medical Nursing, Gülhane Military Medical Academy, School of Nursing, Gülhane Askeri Tıp Akademisi, Hemşirelik Yüksekokulu 06010 Etlik, Ankara, Turkey
e-mail: nkalender@gata.edu.tr

Abstract

Introduction: Evidence-based studies performed by nurses on central venous catheter care are limited in number.
Aim: The aim of this study was to systematically evaluate the literature data about nurses' responsibilities on each step of the care of central venous catheter and determining the gaps in the relevant data or issues to be re-evaluated, which could be helpful in future studies.
Methodology: A literature review was assessed. Different themes were extracted and recommended for clinical practice. A search strategy was carried out for the period 2007–2012 utilising three computerised databases: MEDLINE, PubMed and SCIENCE DIRECT.
Results: Nine studies met the inclusion criteria for review. Three prominent themes were identified in the literature related to: (1) Measures to Prevent Infection (2) Infection Control of central venous catheter, Results, and Other Findings (3) Applications to Sustain Catheter Flow**.**
Conclusions: According to the results of this study, nursing studies on the some subjects are either absent or inadequate In view of these facts, nurses are required to carry out high-quality evidence-based Randomised Controlled Trials.

Keywords: central venous catheter; central venous catheter-associated infections; evidence-based practice; nursing.

Introduction

Central venous catheters (CVC), the use of which began after the second half of 1900s, have become indispensable in the care of critically ill patients as part of the developments in intensive care units (ICU) (Ülger, 2006). These catheters are widely used for measurement of central venous pressure, medical treatment, infusion of blood and blood products, long term parenteral nutrition, and when the peripheral venous route is inappropriate (Hamilton, 2004)**.**

In 2003, The American Society of Clinical Oncology (ASCO), and in 2004, The Oncology Nursing Society published guidelines for nurses who are the primary responsibles for CVC care (Macklin, 2010). These guidelines present all the relevant evidence on issues such as catheter dressing, maintenance of catheter flow, obtaining blood samples, management of complications, and prevention of catheter occlusion (Camp-Sorrell, 2007).

On the other hand, there are still some issues such as lock solution and catheter dressing to be clarified in the care of CVC.

A systematic review reported the inadequacy of evidence on the superiority of heparin to saline solution in the prevention of catheter occlusion (Mitchell et al., 2009). Another systematic review reported that there was no adequate data on the choice of the most appropriate dressing to be used in catheter care (Gillies et al., 2003).

The literature and evidence-based studies performed by nurse on CVC care are limited The nurses who are responsible for CVC care need to pursue prospective, multi-centered and randomized studies on protocols for catheter-site cleansing, type and frequency of application of lock solutions, the importance of blood controls, and training of patients' families (Camp-Sorrell, 2007). The aim of this study was to systematically evaluate the literature data about

nurses' responsibilities on each step of the care of CVC such as skin cleansing, use of disinfections, sterile barrier precautions, hands hygiene, change of sets, obtaining blood sample, material of dressing, frequency of change of dressing, using lock solutions.

Methods

Screening and Selection of Studies

Studies published in the last five years that had used the keywords "central venous catheter" and "central venous catheter care+nurse", were screened in the databases of Medline, Pubmed and Science Direct and were included in the study (Table 1). All of the clinical environment such as oncology, haematology or ICU and patients were included in the study. Pediatric patients and patients who have port catheter were excluded. The reference lists of all studies included were also screened in order to find additional relevant researchs. The titles and abstracts of all of the electronically screened and selected articles were independently evaluated by each researcher. In the case where the abstract was short or unclear, the complete text was read for evaluation. The reasons for studies among the screened having been discarded were noted. Consequently, the results of the researchers' evaluation were compared, and the full texts of the included articles were obtained (Figure 1). There were no conflicts of opinions between the researchers.

Inclusion and Exclusion Criteria

Papers on CVC and nursing care that were in the English language were included in the study. The Randomized Controlled Trials (RCTs) the Non-randomized Controlled Trials (non-RCTs) and the Quasi Experimental Studies (SES) comprised the systematically studied material. Six articles that were not in the English language, 26 articles with inappropriate method, and 21 articles not related to nurses were discarded (Table 2). Papers were excluded if they were not belonging to nurses, inappropriate method and English of publication language.

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This systematic study included nine papers published between years 2007 and 2012. The designs, country of origin and the time durations of the studies have been summarized in Table 3. Most of the studies were semi-experimental. In six studies, training for the prevention of CVC-associated infection was given and the results were evaluated. The studies were evaluated under three main headings.

1. Measures to Prevent Infection

In the selected studies, training for the CVC-associated infection control was given, and the results were evaluated. The training included the headings of skin cleansing, use of disinfectants, sterile barrier precautions, hand hygiene, changing sets, obtaining blood samples, dressing materials used, and frequency of changing the dressings (Table 4).

Skin Cleansing

In a SES, the method of skin cleansing was described in steps (Tsuchida et al., 2007). Other studies had not been mentioned method of skin cleansing (Charrier et al., 2008; Faruqi et al., 2012; Lobo et al., 2010; Lopez, 2011; Møller and Adamsen, 2010; Oran and Eser, 2008; Schallom et al., 2012; Wu et al., 2012)

Use of Disinfectants

The disinfectants used in SESs were tap water and soap (no property given), 10% povidone-iodine, 70% alcohol, 0.5% alcoholic chlorhexidine gluconate, 0.5% chlorhexidine, 2% chlorhexidine and 78% ethanol (Lobo et al., 2010; Lopez, 2011; Tsuchida et al., 2007; Wu et al., 2012). The name of the used disinfectant had not been mentioned in one SES (Faruqi et al., 2012). The names of the disinfectants used had not been mentioned in the RCTs and non-RCTs (Charrier et al., 2008; Møller and Adamsen, 2010; Oran and Eser, 2008; Schallom et al., 2012).

Sterile Barrier Precautions

In three SESs, the effect of maximum sterile barrier precautions (sterile gowns, sterile gloves, masks, sterile sheets) on the CVC-associated infection rate had been discussed (Lobo et al., 2010; Lopez, 2011; Wu et al., 2012). In the study performed by Tsuchida et al. (2007) compared the effects of maximum sterile barrier precautions and minimum sterile barrier precautions (sterile gloves and sheets). In the rest of the selected studies, there was no mention of sterile barrier precautions (Charrier et al., 2008; Faruqi et al., 2012; Møller and Adamsen, 2010; Oran and Eser, 2008; Schallom et al., 2012).

Hand Hygiene

In the SESs, alcohol-based gel or in case of dirty hands, soap, water and soap (no property given), and chlorhexidine gluconate were used (Lobo et al., 2010; Tsuchida et al., 2007; Wu et al., 2012).

The importance of hand hygiene was emphasized in three studies. However, the used disinfectants had not been described (Faruqi et al., 2012; Lopez, 2011; Møller and Adamsen, 2010). There was no mention of hand hygiene in the remaining studies (Charrier et al., 2008; Oran and Eser, 2008; Schallom et al., 2012).

Change of Sets

In the SES study performed by Lobo et al. (2010) reported that the sets should normally be changed every 72 hours, in case of infusion of blood, blood products and lipid solutions, the change should be made every 24 hours. There was no mention of set change in the other studies (Charrier et al., 2008; Faruqi et al., 2012; Lopez, 2011; Møller and Adamsen, 2010; Oran and Eser, 2008; Schallom et al., 2012; Tsuchida et al., 2007; Wu et al., 2012).

Obtaining Blood Samples

In one SES, obtaining the blood samples was mentioned as part of the nurse training in CVC-associated infection control measures, but the steps in blood obtaining were not described (Faruqi et al., 2012). There was no mention of obtaining blood samples in the other studies (Charrier et al., 2008; Lobo et al., 2010; Lopez, 2011; Møller and Adamsen, 2010; Oran and Eser, 2008; Schallom et al., 2012; Tsuchida et al., 2007; Wu et al., 2012).

Material of Dressings Sterile transparent dressing, gauze dressings or chlorhexidine gluconate-impregnated dressings had been used in the SESs (Faruqi et al., 2012; Lobo et al., 2010; Lopez, 2011; Tsuchida et al., 2007; Wu et al., 2012). In the study by Møller et al. (2010) had discussed CVC dressing, but the kind of dressing material used had not been discussed. There was no mention of dressings in the other studies (Charrier et al., 2008; Oran and Eser, 2008; Schallom et al., 2012).

Frequency of Change of Dressings

In one SES, it was reported that the dressings for dialysis catheters were changed three times a week, and for other catheters two times a week (Tsuchida et al., 2007). In another SES it was reported that gauze dressings should be changed every day (when there is no leakage, dirt or loosening) and transparent dressings every seven days (when there is no leakage, dirt or loosening) (Lobo et al., 2010). Wu et al. (2012) discussed the use of transparent dressings, but did not make mention of the frequency of change.

In two of nine studies, it was emphasized the importance of dressings, but they did not report the frequency of changing dressings (Faruqi et al., 2012; Lopez, 2011; Møller and Adamsen, 2010). There was no mention of dressing materials and frequency of dressing change in the other studies (Charrier et al., 2008; Oran and Eser, 2008; Schallom et al., 2012).

2. Infection Control of CVC, Results, and Other Findings

According to the selected studies, the CVC-associated infections were evaluated under the following headings: Method for evaluating infection, duration of infection control, rate of infection and other findings (Table 5).

Method for Evaluating Infection

Out of six studies evaluating CVC-associated infection, the According to the Centers for Disease Control and Prevention (CDC) criteria (Lobo et al., 2010; Wu et al., 2012) were used in two, and the criteria set by Garner et al. were used in the SCS by Tsuchida et al. (2007). Faruqi et al. (2012) used their own criteria in their SES. In the rest of the selected studies, there was no mention of evaluaton criteria for CVC-associated infection (Charrier et al., 2008; Lopez, 2011; Møller and Adamsen, 2010; Oran and Eser, 2008; Schallom et al., 2012).

Duration of Infection Control

Having trained the nurses following application of CVCs, the duration of infection control changed between 1.5 months and 24 months. In a SES, the rates of infection before and after the nurses' trainings were evaluated after a period of four months (Faruqi et al. 2012). In the other studies, there was no mention of the durations of training, nor of CVC care (Charrier et al., 2008; Lobo et al., 2010; Lopez, 2011; Møller and Adamsen, 2010; Oran and Eser, 2008; Schallom et al., 2012; Tsuchida et al., 2007; Wu et al., 2012).

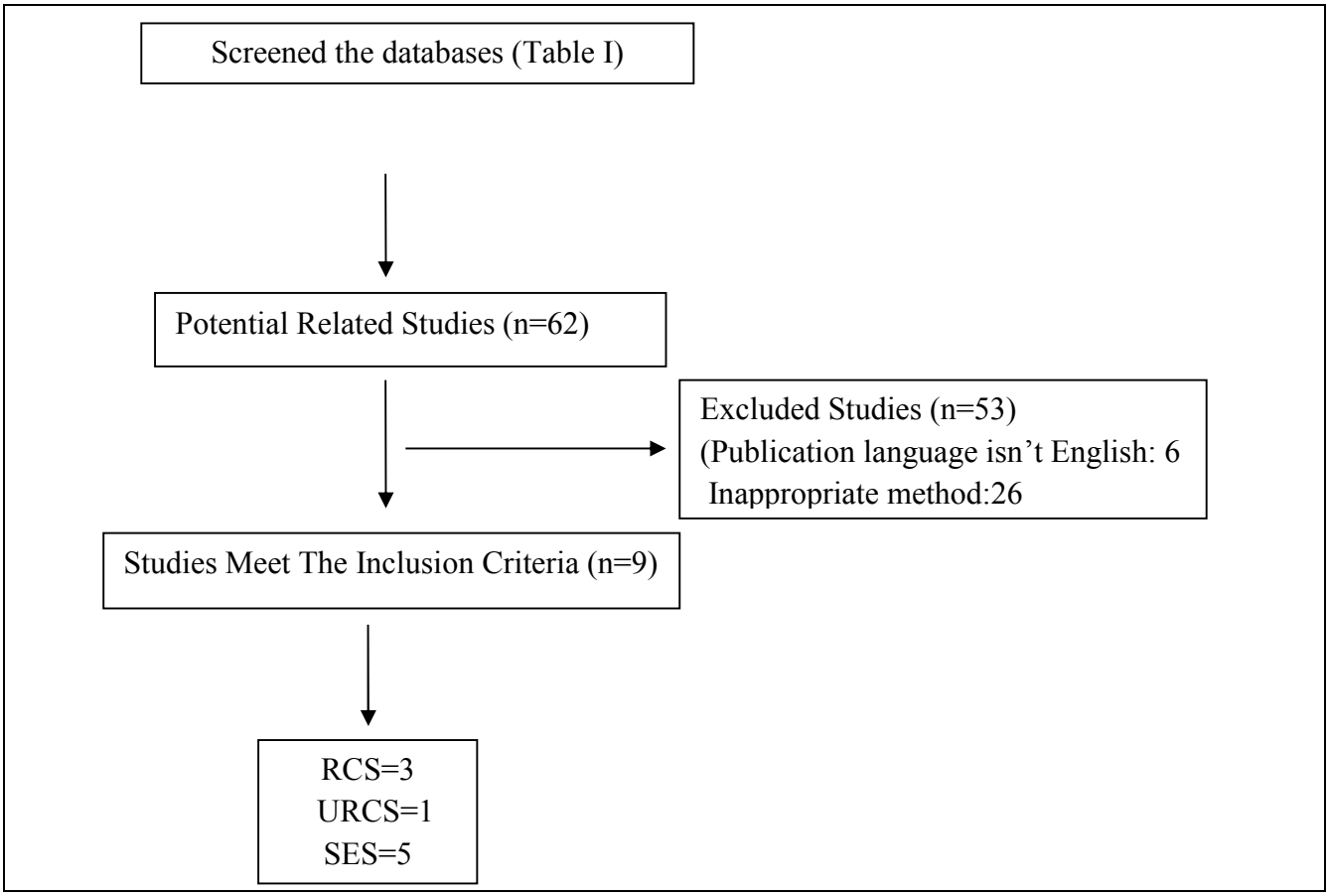

Figure 1. Included/Excluded Studies in Flow Diagram

Table 1. Databases searched, literature studies and search strategies

MEDLINE

Search	Keyword	Results
1	Central venous catheter	1733
2	Central venous catheter care+nurse	983
3	Pediatric patients+port catheter (excluded)	62
4	Title and abstracts obtained by examining the number of studies again	18
5	The number of studies that meet the inclusion criteria after full text review	**1**

PUBMED

Search	Keyword	Results
1	Central venous catheter	2.569
2	Central venous catheter care+nurse	79
3	Pediatric patients+port catheter (excluded)	61
4	Title and abstracts obtained by examining the number of studies again	25
5	The number of studies that meet the inclusion criteria after full text review	**5**

SCIENCE DIRECT

Search	Keyword	Results
1	Central venous catheter	17.152
2	Central venous catheter care+nurse	1.870
3	Pediatric patients+port catheter (excluded)	88
4	Title and abstracts obtained by examining the number of studies again	19
5	The number of studies that meet the inclusion criteria after full text review	**3**

Table 2. Excluded studies

Reason for Excluded Studies	N
Publication Language isn't English	6
Inappropiate Method	26
Not Belonging to Nurses	21

Table 3. According to the characteristics of the included studies

Author (s)	Year	Design of Study	Country of Origin	Time Duration of The Study
Tsuchida et al.	2007	Quasi Experimental Studies	Japan	Prospective
Charrier et al.	2008	Randomized Controlled Trials	Italy	Prospective
Oran and Eser	2008	Non-randomized Controlled Trials	Turkey	Prospective
Lobo et al.	2010	Quasi Experimental Studies	Brazil	Prospective
Møller and Adamsen	2010	Randomized Controlled Trials	Denmark	Prospective
Lopez	2011	Quasi Experimental Studies	Athens	Prospective
Faruqi et al.	2012	Quasi Experimental Studies	USA	Prospective
Schallom et al.	2012	Randomized Controlled Trials	USA	Prospective
Wu et al.	2012	Quasi Experimental Studies	Taiwan	Prospective

Rate of Infection

In a SES, the CVC-associated infection rates were determined as 3% before and 2% after the training (Faruqi et al., 2012). In some of the studies, the infection rate was calculated over 1.000 CVC-days. Such calculated rates ranged between 1.2 and 16.2 before the training, and between 0 and 13.7 after the training (Lobo et al., 2010; Lopez, 2011; Tsuchida et al., 2007; Wu et al., 2012). In a RCT, it was reported the infection rate as 0 in the group where heparin had been used as lock solution, and as 3.1 in the group where 0.9% saline had been used as the lock solution (Schallom et al., 2012). There were no mention on the CVC-associated infection rate in the other studies (Charrier et al., 2008; Møller and Adamsen, 2010; Oran and Eser, 2008).

Other Findings

In the included studies, the effects of training of nurses and doctors, or the application of formed protocols in the clinics on the control of CVC-associated infection were evaluated. Protocols were formed in one RCT (Charrier et al., 2008) and in one SES (Lopez, 2011); training was given in four SESs (Faruqi et al., 2012; Lobo et al., 2010; Tsuchida et al., 2007; Wu et al., 2012) and one RCT (Møller and Adamsen, 2010). These studies demonstrated that the training given caused a decrease in the rate of CVC-associated infection. Only in one SES, after the training, there was initially a decrease in the rate of CVC-associated infection, but an increase ensued nine months after the training (Lobo et al., 2010). There were no mention on other findings in the other studies (Oran and Eser, 2008; Schallom et al., 2012).

3. Applications to Sustain Catheter Flow

According to the selected studies, sustaining the catheter flow was evaluated under the following headings: The lock solution used, the frequency of lock solution and obtaining the appropriate blood samples (Table 6).

Lock Solution Used

In one RCT, heparin was used as lock solution according to the nursing care protocol (Charrier et al., 2008). In another RCT, it was used heparin for dialysis catheters (Oran and Eser, 2008). In two studies, the lock solution was mentioned, but no name was given (Faruqi et al., 2012; Møller and Adamsen, 2010). In one RCT, heparin solution was compared with 0.9% saline (Schallom et al., 2012). There were no mention on lock solution in other studies (Lobo et al., 2010; Lopez, 2011; Tsuchida et al., 2007; Wu et al., 2012).

Frequency of Using the Lock Solution

In one RCT, it was compared the use of 5.000 IU/ml heparin six times a week with that of heparin use of three times a week (Oran and Eser, 2008). In another RCT, it wasn't emphasized the frequency with which they used heparin (Charrier et al., 2008). In a RCT performed by Schallom et al. (2012) 0.9% saline was used to flush the active and inactive lumens intermittently or every eight hours, respectively; when heparin was used, they flushed the active lumens intermittently, and the inactive lumens every eight hours.

In two studies, there was mention of lock solution, but the frequency of its use was not reported (Faruqi et al., 2012; Møller and Adamsen, 2010). There were no data on the frequency of lock solution use in other studies (Lobo et al., 2010; Lopez, 2011; Tsuchida et al., 2007; Wu et al., 2012).

Obtaining the Blood Samples

The process of obtaining the blood sample was described stepwise in one RCT (Schallom et al., 2012). In two RCTs, there was training on how to obtain blood samples, but there was no data of the method (Faruqi et al., 2012; Møller and Adamsen, 2010). There were no mention on obtaining the blood samples in other studies (Charrier et al., 2008; Lobo et al., 2010; Lopez, 2011; Oran and Eser, 2008; Tsuchida et al., 2007; Wu et al., 2012).

Discussion

Evidence-based medicine is the cautious, explicit and logical use of the current best evidence in making decisions about the care of individual patients (Akan, 2005). RCTs provide scientific evidences that directly affect the clinical decisions, as well as the most correct method for the comparison of interventions made (Partlak-Güneşen and Üstün, 2009). Semi-experimental and non-experimental studies are accepted as weak trials (Keller, 1994). When the literature was screened for this study, it was seen that most of the papers on the subject were semi-experimental.

The colonization and infection risk can be decreased with the use of appropriate disinfectants. Chlorhexidine is the preferred antiseptic in skin cleansing, because of longer duration of its antimicrobial activity (The Joint Commission, 2009).

CDC recommendes chlorhexidine should be the first preference in skin cleansing, and povidone-iodine and 70% alcohol should be used only when there is a contraindication or absence of chlorhexidine (O'Grady et al., 2011). There is evidence that chlorhexidine+alcohol produce a synergistic effect on bacteria and, decrease the risk of CVC-associated infection. In one of the included studies, 0.5% alcoholic chlorhexidine was used and found to be effective in preventing infection (Tsuchida et al., 2007). No study was found comparing alcoholic chlorhexidine with alcoholic povidone-iodine (The Joint Commission, 2009). Such a study is needed.

During the insertion of CVC, taking the maximum sterile barrier precautions results in a decrease in the risk of infection. CDC recommends maximum sterile barrier precautions in the insertion and care of CVC (O'Grady et al., 2011). In four of the included studies, it was found that taking maximum sterile barrier precautions was effective in reducing the CVC-associated infection risk (Lobo et al., 2010; Lopez, 2011; Tsuchida et al., 2007; Wu et al., 2012). Nurses should observe if precautions are taken or not and warn when necessary during the insertion of CVC (Berentholtz et al., 2004). High-evidenced nursing studies are required on maximum sterile barrier precautions to be taken by nurses and other health care providers.

For prevention and control of CVC-associated infection, hand hygiene should be carried out with an appropriate product. One of the five evidence-based methods (maximum sterile barrier precautions, use of chlorhexidine in skin cleansing, selection of appropriate catheter site, daily control of catheter site) to prevent the risk of infection was washing the hands (Pronovost et al., 2006). CDC recommends the use of water and soap or alcohol-based hand solutions (O'Grady et al., 2011). There was no mention of the used solution in most of the studies. More nursing studies on hand hygiene carried out about appropriate product which should be used

One of the most important responsibilities of nurses is to regularly change the infusion sets for prevention CVC-associated infection. The purpose of changing infusion systems is to prevent sepsis that may be caused by the contaminated fluid (Zengin and Üstündağ, 2004). In a study, it has been stated that there is no need to change the sets in intervals shorter than 72 hours if there is no suspect of infection (O'Grady et al., 2002). CDC recommends the change of sets every 24 hours if blood, blood products and lipid solutions are infused; when other substances are infused, there is no need to change the sets in intervals shorter than 96 hours (O'Grady et al., 2011). In this review, data on changing the sets were found only in one study (Lobo et al., 2010). As already seen, the trends in changing the sets are diverse, and RCTs are required to set standards on the subject.

Keeping the catheter site dry and clean is an important point in minimizing CVC-associated infection risk. Generally, there are two types of dressing material used: 1) sterile gauze dressing and 2) sterile, semipermeable, transparent, polyurethane dressings (The Joint Commission, 2009). The dressing materials can cause an increase in the microorganisms around catheter site. In some studies, transparent dressings were found to increase the infection risk (Powell et al., 1982; Rello et al., 2000). CDC recommends transparent and gauze dressing (O'Grady et al., 2011). A multi-center study reported that chlorhexidine-impregnated dressing decreased the infection (Timsit et al., 2009). In two of the studies in this review, it was observed that the rate of infection decreased with the use of chlorhexidine-impregnated dressings (Faruqi et al., 2012; Lopez, 2011). The effects of transparent dressings (Lobo et al., 2010; Tsuchida et al., 2007; Wu et al., 2012) and gauze dressing (Lobo et al., 2010) in catheter care have not been compared in other studies. In view of the inadequate evidence on the type of dressing and chlorhexidine-impregnated dressing, further nursing studies are required on the subject.

Following the insertion of CVC, a fibrin sheath develops around the catheter, which can lead to various thrombotic events. One of these events' reason is inadequate flushing of the catheter (Baranowski, 1993). The catheter should be flushed with lock solution to prevent this condition. In the guideline published by Bishop et al. (2007), it is stated that heparin and saline solution, demonstrated the same effect and there was no adequate evidence that heparin prevented thrombosis. Schallom et al. (2012) reported that heparin and saline solution had similar effects and saline solution should be used in view of the probable side effects of heparin. CDC states that there is no definite evidence regarding the use of heparin and saline solution. CDC recommends use of antibiotic lock solution in patients with a history of infection and with long term catheters (O'Grady et al., 2011). Antibiotic lock solution was used in any of the studies included in this review. The lock solutions (heparin, saline solution) were mentioned in only three RCTs (Charrier et al., 2008;

Oran and Eser, 2008; Schallom et al., 2012). Providing catheter flow is an important responsibility of the nurse, and further studies are required.

Unnecessary opening of the catheter line increases the risk of contamination. For this reason, the blood sample should be obtained in the shortest time possible. According to the literature, the volume of aspirated blood can be 3-10 ml or 5-10 ml, but there is no adequate evidence (Camp-Sorrell, 2007). Relevant training was seen to have been given in only one RCT and one SES of the papers included in this review, but no method was mentioned (Faruqi et al., 2012; Møller and Adamsen, 2010). Nursing studies on the consecutive steps in taking blood samples, as well as on the content and methods of relevant training that would be of guidance in practice are required.

Our study has some limitations. There was limitation of language in the search strategy. There may be scientific journals in other countries and in other languages of which we have no knowledge. Another limitation of this study was the exclusion of non-full paper studies which may have influenced the findings of this study.

Conclusions

According to the results of this systematic study, nursing studies on the following subjects are either absent or inadequate: Substances used for skin preparation in CVC-care, sterile barrier precautions, substances used for hand hygiene, the type of dressings used in catheter-dressing and the frequency of dressing change, the type of lock solution used, appropriate method of obtaining the blood sample, the criteria for the diagnosis of infection, and the effect of patient- and family-training. In the view of these facts, nurses are required to carry out high-quality evidence-based RCTs.

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Table 4. Measures to prevent infection

Author(s) and year	Skin Ceansing	Use of Disinfectants	Sterile Barrier Precautions	Hand Hygiene	Change of Sets	Obtaining Blood Samples	Material of Dressings	Frequency of Change of Dressings
Tsuchida et al. (2007)	• Place a pad under the body beneath the insertion site in order to absorb the water used for cleansing. • Use a piece of non-sterile gauze to generate soap foam and use it to thoroughly cleanse the insertion site over an area of diameter 15–20 cm. Rinse the skin with warm water (100–300 ml). • Wipe the insertion site with non-sterile gauze and wipe insertion site with a cotton pad soaked in 70% ethanol and check the pad to confirm thorough cleansing and absence of any dirt.	Water and soap, 10% povidone-iodine, 0.5% chlorhexidine gluconate, 78% ethanol were used and compared	Compared the effects of maximum sterile barrier precautions and minimum sterile barrier precautions	Soap and water and alchol-based hand solution were used	No mention	No mention	Sterile transparent polyurethane dressings was used	Dressings for dialysis catheters were changed three times a week, and for other catheters two times a week
		0.5% chlorhexidine gluconate was more effective than others	Maximum sterile barrier precautions was more effective	No comparison				

Table 4. Continued

Author(s) and year	Skin Ceansing	Use of Disinfectants	Sterile Barrier Precautions	Hand Hygiene	Change of Sets	Obtaining Blood Samples	Material of Dressings	Frequency of Change of Dressings
Lobo et al. (2010)	No mention	0.5% chlorhexidine gluconate	Maximum sterile barrier precautions was used	Alcohol-based gel and chlorhexidine gluconate were compared	Sets should normally be changed every 72 hours, but in case of infusion of blood, blood products and lipid solutions, the change should be made every 24 hours	No mention	Gauze dressings and transparent dressings were used	Gauze dressings should be changed every day (when there is no leakage, dirt or loosening) and transparent dressings every seven days (when there is no leakage, dirt or loosening)
		Effective	Effective	Chlorhexidine gluconate was more effective than others	No comparison		No comparison	
Møller and Adamsen (2010)	No data	No mention	No mention	No data	No mention	No mention	No data	No data

Table 4. Continued

Author(s) and year	Skin Ceansing	Use of Disinfectants	Sterile Barrier Precautions	Hand Hygiene	Change of Sets	Obtaining Blood Samples	Material of Dressings	Frequency of Change of Dressings
Lopez (2010)	No data	2% chlorhexidine gluconate	Maximum sterile barrier precautions are discussed	No data	No mention	No mention	Chlorhexidine gluconate-impregnated dressings was used	No data
			Effective				Effective	
Faruqi et al. (2012)	No data	No data	No mention	No data	No mention	The steps in blood obtaining were not described	Chlorhexidine gluconate-impregnated dressings was used	No data
							Effective	
Wu et al. (2012)	No mention	10% povidone-iodine, 70% alchol	Maximum sterile barrier precautions are discussed	Chlorhexidine gluconate	No mention	No mention	Transparent dressings was used	No data
		No comparison	Effective	Effective				

There was no mention of Skin Cleansing, Use of Disinfectants, Sterile Barrier Precautions, Hand Hygiene, Change of Sets, Obtaining Blood Samples, Material of Dressings and Frequency of Change of Dressings in Charrier et al. (2008), Oran and Eser (2008), Schallom et al. (2012) studies.

Table 5. Infection control of CVC, results, and other findings

Author(s) and year	Method for Evaluating Infection	Duration of Infection Control	Rate of Infection	Others Findings
Tsuchida et al. (2007)	Criteria set by Garner et al. was used	Sixteen months	*Before Training:* 4.0/1.000 central venous catheter-days *After Training:* 1.1/1.000 central venous catheter -days Significant	Training was given /Effective
Charrier et al. (2008)	No mention	Fifteen months	No mention	Protocol was formed /Effective
Lobo et al. (2010)	The Centers for Disease Control and Prevention criteria was used	Nine months	**Intensive Care Unit A** *Before Training:* 12.0/1.000 central venous catheter -days *After Training:* 0 Significant **Intensive Care Unit B** *Before Training:* 16.2/1.000 central venous catheter -days *After Training:* 0, but then increased to 13.7/1000 central venous catheter-days Non-significant	Training was given/Training wasn't effective in intensive care unit B
Møller and Adamsen (2010)	No mention	One and a half months	No mention	Training was given about central venous catheter to patients/Effective
Lopez (2010)	No mention	Nine months	*Before Training:* 5.7/1.000 central venous catheter -days *After Training:* 0.2/1.000 central venous catheter -days Significant	Protocol was formed /Effective

Table 5. Continued

Author(s) and year	Method for Evaluating Infection	Duration of Infection Control	Rate of Infection	Others Findings
Faruqi et al. (2012)	Used their own criteria	Four months	*Before Training:* %3 *After Training:* %2 Significant	Training was given Effective
Schallom et al. (2012)	No mention	One month	The infection rate as 0 in the group where heparin had been used as lock solution, and as 3.1 in the group where 0.9% saline had been used as the lock solution	No mention
Wu et al. (2012)	The Centers for Disease Control and Prevention criteria was used	Twenty four months	**Intensive Care Unit 1** *Before Training:* 2.14/1.000 central venous catheter -days *After Training:* 2.02/1.000 central venous catheter -days No significant **Intensive Care Unit 2** *Before Training:* 0 *After Training:* 0 Significant	Training was given Effective

There was no mention of method for evaluating ınfection, duration of infection control, rate of ınfection and others findings in Oran and Eser (2008) study.

Table 6. Applications to sustain catheter flow

Author(s) and year	Lock Solution Used	Frequency of Using the Lock Solution	Obtaining the Blood Samples
Charrier et al. (2008)	Heparin was used	No data	No mention
Oran and Eser (2008)	5.000 IU/ml heparin 6 times a week (Dialysis catheters) 5.000 IU/ml heparin 3 times a week (Dialysis catheters)	5.000 IU/ml heparin 6 times a week and 5.000 IU/ml heparin 3 times a week	No mention
	5.000 IU/ml heparin 6 times a week is more effective		
	Heparin solution should be used for hospitalized patients who have greater risk for thrombus formation And Patients who are visited at home by a nurse.		

Table 6. Continued

Author(s) and year	Lock Solution Used	Frequency of Using the Lock Solution	Obtaining the Blood Samples
Schallom et al. (2012)	**Active lumen:** 10 mL 0.9% NaCl, followed by intermittent infusion, followed by 10 mL 0.9% NaCl, followed by 3 mL heparin lock flush solution (10 units/mL) **Inactive lumen:** 10 mL 0.9% NaCl, followed by 3 mL heparin lock flush solution (10 units/mL) Heparin and saline solution had similar effects and that saline solution should be used as lock solution, in view of the probable side effects of heparin	0.9% saline was used to flush the active and inactive lumens intermittently or every 8 hours, respectively; when heparin was used, they flushed the active lumens intermittently, and the inactive lumens every 8 hours	When an order for alteplase was obtained, it was administered with a pulsatile technique and the volume instilled was based on dwell volume of the specific catheter lumen. After 30 mins, blood withdrawal was attempted. If unable to withdraw blood, the alteplase was allowed to dwell another 120 mins. If the lumen remained occluded, a second dose of alteplase was administered and the same process was followed. If blood return was obtained, 4–5 mL of blood was removed and wasted. The lumen was then irrigated with 10 mL of 0.9% NaCl followed by a heparin flush if the patient was in the heparin group.

There was no mention of lock solution used, frequency of using the lock solution and obtaining the blood samples in Tsuchida et al. (2007), Lobo et al. (2010), Lopez (2010), Wu et al. (2012) studies. There was no data of lock solution used, frequency of using the lock solution and obtaining the blood samples in Møller and Adamsen (2010) and Faruqi et al. (2012) studies.