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An integrative review on non–patient related factors of peripherally inserted central catheter (PICC) infections in hospitalised adult patients

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Abstract

Introduction: Peripherally inserted central catheter (PICC) has been recognised as an effective and safe vascular access device. There is a range of devices and management methods in regard to PICC, yet there is little synthesis of the evidence around non–patient related factors of PICC infections to provide an evidence-based guide for clinicians. This integrative review aimed to identify the non–patient related factors that influence PICC infections in adult patients.

Method: An integrative review was conducted across online databases.

Results: Twenty-five articles were analysed to identify non–patient related factors that influence CRBSI rates. The catheter type, insertion technique and maintenance were key factors in the infection rates in PICC.

Conclusion: This integrative review highlighted the importance of considering non–patient related factors to achieve the lowest PICC infection. There is a need for high-level studies to investigate non–patient related factors in preventing PICC infection to increase the evidence base.

Introduction

The peripherally inserted central catheter (PICC) has been recognised as an effective and safe vascular access device over the past few decades, resulting in a steady increase in its use for intermediate and long-term venous access[1]. Compared to the central venous catheter (CVC), the PICC is associated with fewer procedural and later systemic complications[2,3]. The management of PICCs can be undertaken by experienced and credentialled nurses thus benefiting the health care system, with fewer insertion delays and decreased cost compared to CVCs. In addition, the PICC can be inserted in a range of settings outside critical care units and operating theatres, again highlighting its importance[4]. However, the PICC is not free of complications which are influenced by both patient-related and non–patient related factors in relation to infection rates.

Background

The known complications of PICCs include infection, vein irritation, thrombosis, catheter occlusion and breakage[5,6]. Catheter-related blood stream infection (CRBSI) remains a major complication of PICCs, resulting in substantial increase in mortality and morbidity and associated expenses[7]. The incidence of PICC-related blood-stream infection (BSI) varies from 0.47 episodes/1000 catheter days to 4.79 episodes/1000 catheter days[8,9]. Interestingly, some studies found equal or higher incidence of PICC-related BSI than CVCs and question the use of PICCs as the single means for CRBSI prevention[2,10]. The cost of CRBSI was estimated to be between US$3,124 to US$60,536 per event due to treatment and length of hospitalisation, highlighting the need to understand the non–patient related factors involved[11,12]. This review investigates the non–patient related factors such as type of catheter, insertion technique and maintenance care to highlight differences which can influence CRBSI rates in PICCs.

The main routes of PICC contamination are intraluminal and extraluminal contamination of the PICC, which can occur during or after insertion[7,13,14]. Intraluminal contamination occurs when the PICC hub becomes contaminated with microorganisms from the skin of the patient or from the hands of health care workers. Migration of microorganisms, either from the patient's skin through the catheter tract or from inadequate decontamination of the skin prior to PICC insertion, leads to extraluminal contamination[13,15]. Sometimes the PICC can get infected haematogenously from another source of infection in the body or by contaminated infusate[7].

Patients with PICC infections can present with signs and symptoms of exit site infection, systemic infection/CRBSI or

a combination of both[16]. Clinical manifestations for systemic infection include positive central and peripheral blood cultures and a positive catheter tip culture with or without pyrexia[5]. As the exit site infection itself can lead to systemic infection by migration of the microorganism through the external catheter surface[9], it is very important to identify the exit site infection and treat as early as possible. In the current literature, the definition of CRBSI is often interchanged with catheter line-associated blood stream infection (CLABSI). In this context, articles analysing CRBSI, CLABSI, exit site or systemic infections were included for this review.

PICC-related infection remains a major concern, highlighting the importance of identifying the contributing factors to enable the development of recommendations to reduce PICC infections[17]. Previous studies have identified contributing factors to CRBSI and discussed the role of multiple interventions in preventing CRBSI[14,18-25]. The non–patient related factors that influence PICC infections among adult hospitalised patients are not well defined, leaving a gap in the literature. Most research exploring CRBSI has been with CVC and peripheral intravascular catheters and the sample patients have mainly been neonates, infants or children, leaving limited available data regarding PICC infections among adult hospitalised patients. The aim of this integrative review was to identify the non–patient related factors that contribute to PICC infections.

Objectives of this review included:

1). Conduct an extensive literature review on catheter-related infection among hospitalised adult patients with PICCs.

2). Identify non-patient factors that promote the reduction or elimination of PICC-related infections in hospitalised adult patients.

3). Identify gaps in current practice.

Non–patient related factors, including sterile techniques, PICC insertion methods, type of PICC and number of PICC lumens, that can be controlled or modified by interventions, were the focus of this study. Patient-related factors such as age, gender, diagnosis and associated comorbidities were not the subject of this study as they are not controllable or modifiable by interventions.

Method

An integrative review was used to explore the non–patient related factors of PICC infection. Integrative review is well known for promoting a comprehensive understanding of a problem by allowing inclusion of qualitative, quantitative and mixed methods of research designs[26]. The Whittemore and Knafl framework was adapted for this review, which includes problem identification, literature search, data evaluation, data analysis and presentation[26]. The inclusion and exclusion criteria used for the article selections are listed in Table 1

Table 1: Inclusion and exclusion criteria

Inclusion criteria	• English language: 2000–2016 [since late 1990s witnessed emergence of evidence-based CRBSI prevention practices] • Includes factors influencing the PICC-related infection. • Studies CRBSI among central venous access device (CVAD), provided it clearly states the number of PICC line insertions among total CVC, CRBSI associated with PICC lines and factors related to PICC BSI/CRBSI • Published in a peer-reviewed journal
Exclusion criteria	• Studies/articles solely including neonates or children • Articles/studies only addressing CRBSI associated with CVC.

Search strategy and outcome

A search was completed using PubMed, CINAHL, Cochrane Library, PROQUEST, Trip, National Library of Science and Medline. The keywords and combinations used to perform the search were 'PICC infections or BSI', 'CRBSI', and 'non patient factors'. See Table 2 for definition of research terms.

Table 2: Definition of research terms used in this review

Research term	Definition
PICC-related infection	Any infection that results from insertion of or as a result of existing PICC. May include: PICC infection, PICC BSI, PICC exit site infection.
CRBSI	CRBSI is the presence of bacteraemia resulting from an intravascular device. May include: catheter-related sepsis, catheter-associated BSI, central line-associated blood stream infection (CLABSI)
Non-patient factors	Any factor that is not related to patient characteristics such as age, sex, diagnosis or underlying morbidity. May include: PICC material, number of lumens, presence of valve, PICC insertion methods, dwell time and PICC care practices.

The initial search revealed 3498 articles. The articles were initially selected based on their title and abstract. Articles meeting inclusion criteria were obtained and further assessed. In order to maintain the validity of the review, possible broad search terms were used to search the articles. Twenty articles

were selected from the electronic data base that met the inclusion criteria. Ancestry method was used to identify the potential research articles that were not listed in the initial database search. This was performed by reviewing the reference list of the articles that met the inclusion criteria. This resulted in addition of five articles. A total of 25 articles were selected for this review. See Table 3 for summary of articles including Mixed Methods Appraisal Tool (MMAT) scores.

Data evaluation/quality appraisal

The MMAT version 2011 was used to appraise the quality of eligible studies[27]. The reliability and efficiency of MMAT is supported by previous studies and is considered a critical appraisal tool for assessing qualitative, quantitative and mixed-methods studies scoring in relation to the methodological quality to address the research question[27]. The five-point scoring zero, 25, 50, 75 or 100% identify how the research meets the criteria, with 100% being all criteria met. The selected studies were assessed and scored by two reviewers with an independent reviewer for consensus when needed. All eligible studies were included irrespective of their MMAT score.

Data analysis and presentation

As classifying the selected articles based on its evidence-based strength helps towards critically analysing the research[26,27], the selected studies were rated and presented in Table 3. To provide clarity for analysis, the data was presented using different characteristics, including author, year, aims, design, sample method, size, variables or interventions, outcomes, limitations and MMAT score. The identified factors were categorised into three groups based on its relation with PICC selection, insertion and maintenance.

Results

Study characteristics

The selected articles were published between 2000 and 2016, with the majority of them published since 2006 (16%) and 2011 (76%). The selected studies were conducted and published in different countries. Among them, 10 of the studies were published from the United States of America (USA), with three each from Italy and the Republic of China. The other studies were completed in Canada, Japan, Spain, Taiwan, United Kingdom and one international study. The research method and quality of the selected studies was also different. Among the 25 studies, only five of them were randomised controlled studies. The majority of the studies (n=20) employed a quantitative non-randomisation method. Of the selected studies, 20 had 100% score according to the MMAT scoring scale.

The sample sizes of the studies varied, ranging from 26 to 2193 PICC insertions. Based on its relation to the time of PICC placement (that is to say, before, during or post-PICC insertion), the identified studies have been categorised into three groups: studies acknowledging factors related to PICC selection; PICC insertion; and PICC care or maintenance. Figure 1 illustrates the summary of the factors identified in this study.

Summary of information

a) Factors related to PICC selection

There were 17 studies that examined the factors related to PICC selection that influenced PICC infection. A majority of

Figure 1: Non–patient related factors influencing PICC infection

Factors related to PICC selection	Factors related to PICC insertion	Factors related to PICC care and maintenance
• Antibiotic-impregnated PICC • Number of lumen • PICC material • Presence of valve • Type of PICC	• Catheter tip in the lower third of superior vena cava • Care bundles — hand scrub for minimum of 2 minutes, maximal barrier precautions, strict sterile technique for PICC insertion • Compliance of PICC operator with care bundles • Modified Seldinger technique • Nurse-led PICC insertion • PICC insertion in ICU • Prior PICC insertion • Right-sided insertion • Upper arm placement • USS-guided insertion	• Dedicated central vascular access device team • Delay in PICC care • Education and training of staff • Long dwell time of PICC • Multidisciplinary team and nursing leadership • PICC assessment and care • Strict aseptic technique during dressing change • Sutureless securement devices • Use of chlorhexidine preparation and use of strict aseptic technique during dressing change

the studies (n=15) had an MMAT score of 100%. The remaining two studies scored 75% and 50% respectively. The identified non–patient related factors associated with PICC selection included the type and material of the PICC[5,28-30], the number of PICC lumens[17,29-31], the presence of a valve[32-34] and whether the PICC was antibiotic-impregnated/coated[9,35,36]. Though the presence of a valve and the type and material of the PICC showed mixed results with regard to PICC infection rates, the antibiotic-impregnated PICC and fewer lumen demonstrated a strong relation with reduced CRBSI incidence[17,29-31,33,35].

b) Factors related to PICC insertion

Factors influencing PICC infection rates during insertion were explored by 10 studies. Seven of the selected studies had an MMAT score of 100%, with the remaining three studies scoring 75. The influencing factors for PICC infection included ultrasound-guided PICC insertion and use of the Modified Seldinger technique (insertion using sheath and guidewire) for PICC insertion[37,38]. The position of the PICC tip in the lower third of the superior vena cava[39,40], anatomical position of the PICC insertion site (such as upper arm PICC placement)[38] and right-sided PICC insertion[39,41] influenced infection rates. Factors such as prior PICC insertion[41] and PICC insertion in ICU[8,17,30] increased the risk of infection. Though right-sided PICC insertion, prior PICC insertion and insertion in ICU were associated with increased CRBSI, the remaining factors, especially compliance of the operator with care bundles and ultrasound-guided Modified Seldinger technique, were the main factors promoting reduction in CRBSI[37,38,42,43].

c) Factors related to PICC maintenance

Ten of the studies identified non–patient factors related to PICC maintenance that influence PICC infection rate. All of the studies had an MMAT score of 100%. The factors related to PICC maintenance include delay in catheter care and longer dwell time[17,30,33], use of a sutureless securement device[40,44], education and training of the staff[36,45,46], a multidisciplinary team (including medical staff)[43], and nurse-led team[8,47,48]. Other than delay in catheter care and longer dwell time, all other factors showed a positive influence in reducing CRBSI.

Discussion

This integrative review investigated the role of non–patient related factors in prevention of PICC infections. The selected studies have shown that either adaptation or elimination of such factors can reduce CRBSI and local infection associated with PICCs. The identified factors have been summarised in Figure 1. Use of a maximal sterile barrier including 2% chlorhexidine, prior insertion and post-insertion aseptic technique still remains the basis for infection prevention[29,46]. Though it was not the variable, most studies included in this review used strict sterile field techniques.

This integrative review identified antibiotic-impregnated PICCs as a factor that reduces PICC infection[9,35,36]. However, despite no reported evidence of bacterial resistance, the emergence of resistant pathogens remains a major concern for the use of antibiotic-impregnated PICCs[35]. The Centers for Disease Control and Prevention recommends the use of antibiotic-impregnated PICCs only if the risk of CRBSI remains high after successful implementation of a comprehensive strategy for infection prevention[7]; including skin preparation using alcohol-based antisepsis with more than 0.5% chlorhexidine, maximal sterile barrier precautions and education of staff who insert or care for the catheter[7]. If the patient remains at high risk for CRBSI because of their underlying comorbidity status, even a single episode of CRBSI could be fatal. Further high-level evidence studies are needed to identify the role of antibiotic-impregnated PICCs in the prevention of CRBSI among high-risk patients and to exclude the risk of resistant pathogens.

This integrative review found conflicting results regarding the role of different PICC types such as silicone versus polyurethane PICCs, valved versus non-valved PICCs or standard cap PICC in preventing PICC infection[34,39,49]. Catheter material like silicone is known to promote adherence of microorganism to the PICC surface, leading to microbial colonisation and infection[7]. A study published in 2009[33] failed to identify any statistical difference in PICC infections rated between PICCs with a positive pressure valve (PPV) versus those with a standard cap. In the following year, another study[39] showed an increased CRBSI rate with silicone PICCs compared to polyurethane PICCs. However, the PICCs were different in structure; the silicone PICCs had a distal valve, whereas the polyurethane PICCs had a proximal valve. A randomised control trial (RCT) published in 2012[49] also compared infection rates between silicone and polyurethane PICCs and found no relation between catheter material and infection rate. The RCT published in 2014[34] also concluded that there was no relation between presence of a valve and CRBSI. The heterogeneity among these study samples emphasises the need for further investigation to understand the multiple factors related to catheter type.

The delay in dressing change was identified as a risk factor for PICC-related infection. Choosing semipermeable transparent dressing and changing it at least every seven days is considered as ideal for PICC dressing changes unless the site is oozing/bleeding or the patient is diaphoretic, when using a sterile gauze dressing and changing it every second day[7]. Daily insertion site assessment and recording the findings helps in the early identification of signs of infection[13].

These integrative review findings support the theory that the dwell time is a risk factor for CRBSI. Research has demonstrated that the longer the PICC is in situ, the higher the incidence of CRBSI[17,30]. Practices such as not removing the PICC until patient discharge from hospital or forgetting the patient has a PICC can significantly increase the risk of CRBSI[50]. Health care workers need to be vigilant about assessing ongoing need for the PICC and removing it if it is no longer needed[2,51]. Research has demonstrated that the dwell time and number of lumens are directly associated with increase in CRBSI[17,30]. Though it was not the primary outcome, the quasi-experimental study by Khalidi *et al.*[33] showed an increased incidence of CRBSI in double lumen PICCs with longer dwell times.

The density of skin flora at the insertion site is a major CRBSI risk factor[7]. Among adult populations, PICCs are usually inserted in the cephalic, basilic or brachial veins of the arm[7]. Compared with the cubital fossa, the upper arm is considered to be less colonised with bacteria as it has fewer sweat glands[41]. In addition, PICCs placed in the upper arm are associated with minimal in and out movement, thus reducing the transfer of skin flora to the deeper layers[38]. A study published in 2010 compared the relation of CRBSI with the arm or vein used for PICC insertion, but failed to find any difference in the CRBSI rates in regard to the arm or vein used[39]. However, another study published in 2011[41] showed an increased risk in the incidence of CRBSI associated with right-sided PICC insertions. Though this study did not specify the dominant hand of the patients, this could possibility support the increased risk of infection associated with right-sided placement, where right-handed people use their dominant hand more, resulting in an increased chance of PICC movement. The person who inserts the PICC should consider dominant arm and arm position as influencing factors while selecting the site.

As the use of ultrasound sonography facilitates identification of the right-sized vein, it reduces the risk of failed insertions and inserting a large bore line into a small vein[16,52], which is associated with increased risk of thrombosis, and in turn increases the risk of CRBSI[16]. Adoption of ultrasound-guided PICC insertion and the provision of training for personnel may result in better patient outcomes. Future high-level research on the effect of ultrasound-guided PICC insertion on CRBSI is warranted.

Implications for nursing practice

Nurses play an integral role in identifying and preventing PICC-related infection, from the pre-insertion period to removal of the PICC[13]. Use of maximal barrier precautions, antisepsis and adhering to aseptic technique post-insertion remains the basis for infection prevention[7,9,29,46]. Research has shown that the education of nurses on PICC management plays an integral role in reducing PICC infections[31,45]. Ensuring adherence to best-practice guidelines and providing aggressive educational programs are considered effective means for the prevention of CRBSI[53]. In addition, standardised practices for PICC care and maintenance are also important in preventing PICC infection[31,47]. In this context, the role of nursing leadership and education is very important to promote staff compliance with the guidelines and ensuring that the best practices are implemented[9,54].

Limitations

Limitations of this review include heterogeneity of the studies and incomplete reporting. Two of the studies included in this integrative review were supported by industry funding[8,17], which might potentially affect the validity of its outcome. Differences in PICC techniques and comparison of PICC types influenced the ability to compare research findings and draw conclusions. In addition, exclusion of studies that included the neonates/children, studies published in non-English languages and studies that exclusively addressed CRBSI in CVC might have also contributed to incomplete reporting.

Future research

Future research to build evidence regarding the influence of different non–patient related factors for minimising PICC infections would increase the understanding in this area. There is a gap in the literature regarding the factors contributing to local/exit site PICC infections and the measures to prevent or minimise it. There is also the need for further studies to identify the role of multiple non-patient factors in preventing infections associated with PICCs.

Conclusion

This integrative review identified the role of non–patient related factors such as PICC selection, PICC insertion and PICC maintenance in preventing or minimising PICC infections among adult hospitalised patients. The findings from this integrative review highlight the importance of considering these factors towards achieving the target of zero infection among patients with PICCs. This integrative review also emphasised the role of nurses and nursing practices in preventing PICC infections in hospitalised patients. Health care workers should be aware of the factors that favour prevention of PICC infections. Health care managers should make sure that the staff is aware of the preventive strategies and that adequate resources for CRBSI prevention are readily available. This integrative review identified the need for high-level evidence to identify the influence of non–patient related factors in PICC infection prevention.

Table 3: Summary of selected articles

Author/year Country	Design	Aim	Setting/ Sample	Variables	Findings	Limitations	Industry funding/ Conflict of interest	MMAT
Ajenjo *et al.* 2011[8] USA	Retrospective cohort study	Assess the incidence of PICC BSI and effect of discontinuation of intravenous therapy service on PICC use and PICC BSI rates	495 PICC insertions	Patient and treatment factors	Higher PICC BSI in ICU	PICC inserted by Nurse led team, thus institutional PICC practice may differ	Financial assistance — yes Nil conflict of interest	100
Alexandrou *et al.* 2012[48] Australia	Case study	Review the characteristics and outcomes of nurse-led CVC insertion	4212 CVC, including 1635 PICC insertions	CVC-related complications associated with nurse-led insertions.	Synergy between medical and nursing staff or developing new roles focusing on skills rather than profession can deliver better patient outcome.	Institutional PICC practice may differ	Nil	75
Armstrong *et al.* 2013[35] USA	Quasi experimental study	Assess the impact of antibiotic impregnated PICC lines on bacteremia in burns patients	49 PICC insertions	Antibiotic impregnated PICC	Antibiotic impregnated PICC lines decreases bacteremia in burns patients	Institutional PICC practice changed over time	Nil	50
Baxi *et al.* 2013[29] USA	Retrospective cohort study	Identify the effect of post insertion adjustment on CRBSI	2,193 PICC insertions	Post placement adjustment, CRBSI rates	No relationship between post insertion PICC adjustments and CRBSI. Increased risk of infection with higher number of PICC lumens Increased risk of CRBSI with Power injectable PICC	Incomplete reporting of influencing factors including comorbidities	Nil	100
Burrell *et al.* 2011[42] Australia	Case study	Reduce CRBSI	10507 CVC insertions including 1467 PICC insertions	CRBSI, compliance with aseptic CVC insertion	Lower CRBSI with aseptic care bundles Five times increased CRBSI rate among PICC group inserted by clinician non-compliant with care bundles	Reporting error from self-reporting Problem with identification of CRBSI Minimal number of PICC insertions compared to the total insertions	Nil	
Chopra *et al.* 2014[30] USA	Retrospective cohort	Examine the pattern, incidence, timing and predictors of PICC BSI	966 PICC insertions	Patient, provider and device characteristics, CRBSI	Patient comorbidities, dwell time, health professional factors influenced CRBSI rate Higher number of PICC lumens associated with earlier onset of CRSBI	High number of male patients in cohort Patient treatment and comorbidities influenced BSI rates not clearly reported.	Nil	100
Curto-Garcia *et al.* 2016[43] Spain	Prospective case study	Investigate implementation of multidisciplinary approach to PICC care and PICC-related complications	44 PICC insertions	Change of insertion and maintenance guidelines	Decreased CRBSI and other complications Multidisciplinary approach for PICC care may reduce CRBSI	Institutional PICC practice may differ Patient treatment and comorbidities influenced BSI rates not clearly reported	Nil	100

Author/year Country	Design	Aim	Setting/ Sample	Variables	Findings	Limitations	Industry funding/ Conflict of interest	MMAT
Gao *et al.* 2015[40] Republic of China	3-year prospective cohort study	Identify the patterns, prevalence and risk factors for CRBSI associated with PICC	912 PICC insertions	Multiple variables (17)	StatLock fixing and PICC tip position in lower one-third of superior vena cava were associated with lower CRBSI PICC insertion in summer and catheter care delay were associated with increased CRBSI	Only single lumen PICC were used	Nil	100
Hoffer *et al.* 2001[32] USA	RCT	Evaluate benefit of PICC with proximal valve against PICC with distal valve in regard to the incidence of occlusion, infection or malfunction	100 PICC insertions	PICC with distal and proximal valve, PICC complications	Lower incidence of infection with proximal valve	Small sample number	Nil	100
Khalidi *et al.* 2009[33] USA	Quasi-experimental study	Compare the infection rate between PPV and standard PICC caps	160 PICC insertions	PPV versus a standard cap without PPV	No statistical difference in the occlusion, dwell time and CRBSI rate. Double lumen catheters had significantly longer dwell times.	Small number of participants might have affected the study outcome Institutional PICC practice may differ	Nil	100
Leung *et al.* 2011[45] Taiwan	Retrospective case study	Evaluate the factors causing failure of PICC	276 PICC insertions	Education on PICC maintenance	Decreased complication rates including CRBSI with adherence to educational guidelines	Patient treatment and comorbidities influenced BSI rates not clearly reported	Nil	100
Miyagaki *et al.* 2011[49] Japan	Prospective randomised trial	Compare PICC with two different material and tip design	26 PICC insertions	Polyurethane PICC with proximal valve and silicone PICC with distal valve	No difference in complication and durability between two groups	Small number of participants/PICCs RCT stopped due to Groshong Catheter withdrawal	Nil	75
Mollee *et al.* 2011[41] Australia	Prospective cohort study	Identify the risk factors for CRBSI among cancer patients	1127 CVAD including 807 PICC insertions	Risk factors for CRBSI	Increased CRBSI is associated with right-sided insertion, prior line insertions and CVC	Institutional PICC practice may differ Patient treatment and comorbidities influenced BSI rates not clearly reported	Nil	100

Author/year Country	Design	Aim	Setting/ Sample	Variables	Findings	Limitations	Industry funding/ Conflict of interest	MMAT
Morano *et al.* 2015[47] Italy	Retrospective cohort study	Assess the feasibility and safety of the use of PICC in patients with malignancies	612 PICC insertions.	Risk factors for CRBSI and catheter-related thrombotic complications	PICC is a safe and feasible alternative to other CVC in haematology patients Decreased CRBSI related to management of PICC by a dedicated CVAD team of doctors and nurses with standardised procedures for overall management of PICC	The study design might have resulted in reporting errors The experienced staff in the insertion and care of PICC line might have contributed to the lower infection rate	Nil	100
O'Brien, Paquet, Lindsay & Valenti 2013[31] Canada	Retrospective cohort study	Identify differences in lumen type and CRBSI rates	1,525 PICC insertions	PICC with single lumen and double lumen	Decreased rate of CRBSI with single lumen PICC	Incomplete reporting of influencing factors including comorbidities Institutional PICC practice may differ	Nil	100
Ong *et al.* 2010[39] International study	Prospective randomised trial	Compare proximal valve polyurethane PICC to a distal valve silicone Groshong in terms of infection, occlusion, thrombosis or malfunction	392 PICC insertions	Polyurethane PICC with proximal valve and silicone PICC with distal valve	Proximal valve polyurethane PICCs more durable. Distal valve silicone PICC groups more infections.	Unable to eliminate the operator-induced bias due to large number of patients	Nil	100
Pittiruti *et al.* 2014[34] Italy	RCT	Compare valved and non-valved PICC in terms of infection, occlusion, thrombosis or malfunction	180 PICC insertions	Valved and non-valved power injectable PICC	No clinical advantages of valved PICCs against non-valved PICC in terms of infection or occlusion	Study ceased due to PICC complications	Nil	100
Pittiruti *et al.* 2012[28] Italy	Retrospective case study	Evaluate the performance of power injectable PICCs	89 PICC insertions	Power injectable PICC	With a proper protocol CRBSI associated with power injectable PICC is similar to or lower than CVC	Limitation from study design	Nil	75
Pongruangporn *et al.* 2013[17] USA	Nested case-control study	Investigate device and patient-specific risk factors related BSI	647 PICC insertions	Patient and device-specific risk factors, PICC-related BSI	Dwell time, number of lumens and comorbidities influenced BSI	Institutional PICC practice may differ Patient treatment and comorbidities influenced BSI rates not clearly reported.	Financial assistance — yes Nil conflict of interest	100

Author/year Country	Design	Aim	Setting/ Sample	Variables	Findings	Limitations	Industry funding/ Conflict of interest	MMAT
Rutkoff 2014[9] USA	Quasi-experimental	Evaluate the effect of antimicrobial PICC, impregnated with chlorhexidine, on the CRBSI incidence	517 PICC insertions	Antimicrobial PICC, Unprotected PICC	Use of antimicrobial PICC with current infection prevention practices results in statistically significant reduction in CRBSI	Retrospective data for the non-interventional group used. Institutional PICC practice may differ	Nil	100
Simcock 2008[38] UK	Retrospective case study	Evaluate the effect of upper arm PICC placement and ultrasound guidance on PICC complication rates, success rate and longevity	944 PICC insertions	Upper arm placement, modified Seldinger technique and ultrasound guidance.	Ultrasound-guided upper arm PICC placement is associated with reduced exit site infection, thrombosis, catheter migration, increased success rate and longevity	Patient treatment and comorbidities not consistently reported. Institutional PICC practice may differ	Nil	75
Tavianini *et al.* 2014[36] USA	Case study	Evaluate the influence of a chlorhexidine-impregnated PICC in reducing CRBSI	100 PICC insertions	Chlorhexidine-impregnated PICC, staff education,	No incidence of CRBSI after the introduction of the chlorhexidine-impregnated PICC	Need for further study	Nil	100
Tian *et al.* 2010[46] Republic of China	Comparative case study	Evaluate the effect of multifaceted implementation of interventions in decreasing PICC-related complication	242 PICC insertions	Nurse education, PICC insertion technique and maintenance	Significant reduction in infective and non-infective complication of PICC with the multifaceted implementation strategies	Institutional PICC practice may differ Patient treatment and comorbidities influenced BSI rates not clearly reported	Nil	100
Yamamoto *et al.* 2002[44] USA	RCT	Assess the performance of sutureless securement adhesive device for securement of PICC	170 PICC insertions	Suter and StatLock	Significant reduction of CRBSI in StatLock group	Small sample numbers and incomplete follow up	Nil	100
Yuan *et al.* 2013[37] Republic of China	Prospective cohort study	Identify the appropriate PICC insertion technique by comparing complication and success rates with three different PICC insertion methods	597 PICC insertions	Standard insertion technique, non–ultrasound guided MST insertion, ultrasound-guided MST insertion	Lower incidence of PICC infections and thrombosis with ultrasound-guided MST insertion group.	Limitation from study design	Nil	100

Keys: BSI — Blood Stream Infection; CRBS — Catheter-Related Blood Stream Infection; CVC — Central Venous Catheter; MST — Modified Seldinger Technique; ICU — Intensive Care unit; PICC — Peripherally Inserted Central Catheter; PPV — Positive Pressure Valve; RCT — Randomised Control Trial.

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