NHS National Services Scotland

Quality Improvement Tool (QIT) Literature Review - PVC

Insertion and Maintenance of Peripheral Venous Catheters (PVC)

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Description:	This literature review examines the available professional literature on the Insertion and Maintenance of Peripheral Venous Catheters (PVC) in the health and care setting.
Purpose:	To inform the Quality Improvement Tool on Insertion and Maintenance of Peripheral Venous Catheters (PVC) in the National Infection Prevention and Control Manual in order to facilitate the prevention and control of healthcare associated infections in NHS Scotland health and care settings.
Target Audience:	All staff involved in the prevention and control of infection in Scotland.
Update/review schedule:	Updated as new evidence emerges with changes made to recommendations as required. Review will be formally updated every 3 years with next review in 2025.
Cross reference:	National Infection Prevention and Control Manual (NIPCM)
Update level:	Practice – Change in recommendation to remove PVCs only when clinically indicated or when no longer needed. Research – Further research required in optimal dressings and securement, skin antisepsis for neonates and port/hub decontamination.

Contact

ARHAI Scotland Infection Control team:

Telephone: 0141 300 1175

Email: nss.ARHAIInfectioncontrol@nhs.scot

Version history

This literature review will be updated in real time if any significant changes are found in the professional literature or from national guidance/policy.

Version	Date	Summary of changes
1.0	October 2022	The Insertion and Maintenance of Peripheral Venous Catheters (PVC) literature reviews for Adults (V2.0 Sep 2014) and Neonates (V1.0 May 2018) were amalgamated and updated using a two-person methodology.

Approvals

Version	Date Approved	Name
1.0	July 2022	National Policy, Guidance and Evidence (NPGE) Working Group

Contents

1. Objectives

The aim is to review the extant scientific literature regarding insertion and maintenance of peripheral venous catheters (PVCs) in health and care settings to inform an evidence based peripheral venous catheter insertion and maintenance Quality Improvement Tool (QIT) and recommendations for practice. The specific objectives of the review are to determine:

1.1 Insertion of Peripheral Venous Catheters (PVC)

- What are the indications for PVC insertion?
- What administrative checks should be in place prior to insertion?
- When should hand hygiene be performed throughout the procedure?
- How should hand hygiene be performed, what should be used?
- What Personal Protective Equipment (PPE) should be worn and when?
- How should the environment be prepared prior to insertion?
- How should equipment be prepared prior to insertion?
- How should the insertion site be prepared?
- What technique should be used for insertion?
- What type of dressing should be used to cover the catheter site?

1.2 Maintenance of Peripheral Venous Catheters (PVC)

- What administrative and clinical checks should be in place for maintenance of PVCs?
- When should hand hygiene be performed when administering medication/throughout the process of maintenance?
- How should hand hygiene be performed, what should be used?
- What PPE should be worn and when?

- How should the PVC access site be maintained?
- When should removal of PVCs be considered?

2. Methodology

This targeted literature review was produced using a defined two-person systematic methodology as described in the National Infection Prevention and Control Manual: Development Process. In addition, the following were considered out of scope for this review:

- Catheter design
- Central venous catheters e.g. Peripherally Inserted Central Catheters (PICC), midline catheters
- Emergency insertion of PVCs
- Anti-microbial impregnated catheters
- Prophylactic use of antimicrobials
- Flushing technique
- Flush and lock solutions
- Administration sets including blood administration sets
- Studies focusing on procedural aspects of PVC insertion and maintenance

There are a number of factors related to healthcare delivery that were not within the remit of this review. This includes that staff are appropriately trained and competent in all aspects of the insertion and management of PVCs preferably using an approved educational package and that they complete the required competencies and accreditation according to health and care setting policy. The overall approach to the delivery of healthcare is supported by patient safety and improvement approaches and organisational readiness.

3. Discussion

3.1 Implications for practice: Insertion of Peripheral Venous Catheters (PVC)

What are the indications for PVC insertion?

This review found evidence that PVCs are most frequently used to maintain hydration, restore fluid and electrolyte balance, provide fluids for resuscitation, administer IV therapeutics containing fluids, medication, blood products and parenteral nutrition.[1-8]

It is also generally recommended that PVCs are inserted when the anticipated duration of IV therapy is short however there were inconsistencies with the identified evidence on the duration. The Royal College of Nursing (RCN) advising 3-5 days, the National Evidence-Based Guidelines for Preventing Healthcare-Associated Infections in NHS Hospitals in England (epic3) 7-10 days and although indirect, the United States Centers for Disease Control and Prevention (CDC) recommends that a midline catheter or peripherally inserted central catheter (PICC) should be used when the duration of IV therapy is likely to exceed 6 days implying PVCs may be suitable for therapies less than 6 days.[5, 7, 9] Expert opinion by the Health Service Executive Ireland (HSE, 2017) adds that as part of the clinical assessment during PVC insertion, consideration should be given to the purpose, duration and rate of the IV infusion or therapy however no specific details were provided.[4]

The National Institute for Health and Care Excellence (NICE) guideline on parenteral nutrition (NG154, 2020) recommends using a central venous catheter to give neonatal parenteral nutrition, however peripheral venous access may be considered if it would avoid delaying commencement of parenteral nutrition, if anticipated use of peripheral venous access is short-term (e.g. less than 5 days), if it would avoid interruptions in administering parenteral nutrition and, if central venous access is impractical.[6]

In order to preserve vessel health and reduce the risk of complications, expert consensus from RCN and the Infusion Nurses Society (INS) does **not** recommend PVCs for the administration of the following:[3, 7]

- Continuous infusion of medication with irritant or vesicant properties;
- Parenteral nutrition exceeding 10% dextrose and/or 5% protein;

- Solutions and/or medications with pH less than 5 or greater than 9;
- Solutions and/or medications with osmolarity greater than 900 mOsm/L.

What administrative checks should be in place prior to insertion?

Peripheral venous catheters (PVCs) are the most commonly used invasive medical devices within acute and non-acute care settings.[10] They are designed to provide vascular access for the delivery of treatments such as intravenous (IV) fluids and medication.[2] The National Prevalence Survey of Healthcare Associated Infection and Antimicrobial Prescribing 2016 reported that more than one third (36.3%, n=3924) of acute adult inpatients in Scottish hospitals had a PVC in situ at the time of the survey[11] and the prevalence was significantly higher compared to the 2011 survey (OR = 1.25, 95%CI: 1.14-1.38, p<0.001).[12] In paediatric inpatients, approximately 30.0% (n=219) had a PVC in situ at the time of survey although the prevalence was significantly lower than that of acute adult inpatients (p<0.001).[11]

Despite their ubiquity, PVCs are associated with high rates of complications and failure.[1, 2, 13-15] Additionally, studies indicate that PVCs are often inserted unnecessarily, remain unused within 24 hours from insertion, are not removed in a timely manner, and are associated with a number of patient complications including pain, infiltration, occlusion, dislodgement, phlebitis and most importantly catheter related bloodstream infections (CRBSIs), all of which are known to increase rates of patient morbidity and mortality.[1-3, 11, 16, 17] Failed PVCs may require the insertion of a new device leading to delays in treatment and increased costs.

PVCs can also cause CRBSIs as each insertion breaches the patient's skin enabling microorganisms to enter the patient's bloodstream. Infections can arise from microorganisms at the insertion site through contamination of catheters via the hands of healthcare workers if standard infection control is not followed and from the patient's own skin around the insertion site. The 2016 point prevalence survey found that a quarter of all bloodstream infections (BSIs) in acute Scottish hospitals were associated with a vascular catheter (14 of 56; 25%) with approximately 43% (n=6) microbiologically and clinically linked to PVCs; a similar proportion to that reported in hospitals in 2011 (26.2%).[11] Therefore, it is vitally important that PVCs are only inserted when they are clinically indicated for the patient.[3, 9, 16, 18]

No primary scientific studies were identified to answer this research question directly. However there was consensus among expert opinion from the Infusion Nurses Society (INS - USA 2021),[3] Spanish Society of Cardiovascular Infections (SEICAV 2016)[18] and Royal College of Nursing (RCN – United Kingdom 2016)[7] that due to complications associated with PVCs, they

should only be inserted when there is a clear clinical need. Evidence from two observational studies from Sweden and Australia indicate that unused PVCs appear to be common in the emergency department (ED) with reports of 32% to 50% of PVCs inserted routinely or "just in case" as part of patient assessment and admission rather than for a specific indication.[16, 19] The unused PVC exposes the patient to avoidable harm, provides no benefit and has additional unnecessary cost for the healthcare system and healthcare worker's time therefore reducing the number of unnecessary PVCs is important as well as regular clinical review and early removal of PVCs when no longer required. [20]

The 2011 CDC and epic3 (2014) guidelines recommend that staff should be educated on the indications for intravascular catheter use including appropriate standard infection control measures to prevent intravascular catheter-related infections.[5, 9] There is consensus in the literature that a clinical assessment should be carried out by the healthcare worker prior to the PVC insertion procedure to check for the following:[3, 4, 7, 21]

- the indication for PVC use;
- if the intravenous (IV) fluids or medication could be given by any other route e.g. oral, subcutaneous;
- purpose, duration, rate and type of IV infusion;
- patient's age (e.g. neonates) and clinical condition (acute/chronic/emergency)
- type of IV fluid or medication to be administered via the vein;
- any previous history of failed or difficult peripheral IV access.

When should hand hygiene be performed throughout the procedure?

It is recommended by the World Health Organization (WHO) that hand hygiene should be performed before, during as required and after all PVC insertion procedures (WHO Moments 1-5).[22] This is consistent with all current evidence and guidelines.[3, 7, 9, 18, 22, 23] Along with aseptic technique, hand hygiene reduces the likelihood of contamination of healthcare worker's hands after patient contact.[5, 9] The WHO Guidelines on Hand Hygiene in Health Care (2009) clearly describe the indications for hand hygiene and present these within the WHO "My 5 Moments for Hand Hygiene" approach.[22] This includes emphasising the importance of performing hand

hygiene before clean/aseptic procedures to prevent healthcare associated infections (HAI). The 5 Moments for hand hygiene are widely promoted within NHSScotland. Accessing the insertion site has been emphasised as a key factor in acquiring infection and therefore this hand hygiene moment is crucial to protect the patient.[5, 9, 24] Additionally, it is recommended by expert consensus and guidelines that gloves should not be worn as a substitute to hand hygiene.[3, 5, 7, 22]

Further guidance and recommendations on Hand Hygiene and Gloves can be found in the ARHAI Scotland systematic literature reviews Hand Hygiene: Hand washing, hand rubbing and indications for hand hygiene and Personal Protective Equipment (PPE): Gloves.

How should hand hygiene be performed, what should be used?

No primary study of sufficient quality was identified relating to this topic. Therefore, evidence for how hand hygiene should be performed during PVC insertion is largely based on guidelines and expert opinions.

WHO recommends that hand hygiene should be performed with an alcohol-based hand rub (ABHR) for at least 20 seconds for routine hand antisepsis in most clinical situations including carrying out clean/aseptic procedures such as PVC insertion and maintenance.[22] Use of ABHR is the preferred method however hands should be washed with soap and water when visibly dirty, visibly contaminated with blood or other body fluids, if patient is suspected or confirmed of having/or there is an outbreak of a spore-forming pathogen (e.g. *Clostridioides difficile)* or norovirus gastroenteritis and if alcohol-based hand rub is not available.[3, 18, 22] Further guidance and recommendations on the technique and products for hand washing and hand rubbing with ABHR can be found in ARHAI Scotland's NIPCM systematic literature reviews Hand Hygiene: Hand washing, hand rubbing and indications for hand hygiene and Hand Hygiene: Products.

What Personal Protective Equipment (PPE) should be worn and when?

This review did not find any primary scientific studies investigating individual PPE as a single intervention during insertion and maintenance of PVCs. Therefore evidence for what PPE should be worn and when are derived from 2 evidence-based guidelines from the CDC and epic3, expert guidance/consensus from The Infusion Nurses Society (INS), Royal College of Nursing (RCN), Spanish Society of Cardiovascular Infections, Australian National Health and

Medical Research Council, Association of Anaesthetists (Great Britain and Ireland), Health Service Executive (Ireland), The Association for Safe Aseptic Practice (The-ASAP) and expert opinion from Hallam et al and Rowley et al.[3-5, 7, 9, 18, 25-30] Note that the overall quality of evidence found on this topic was found to be low due to lack of support from rigorous scientific studies. There is consensus among guidelines and expert guidance from the CDC, epic3, Healthcare Infection Control Practices Advisory Committee (HICPAC), Royal College of Nursing (RCN-UK), Infusion Nurses Society (INS-USA), Australian Guidelines for the Prevention and Control of Infection in Healthcare that the decision to use or wear PPE which may include gloves, gowns, plastic aprons, masks/face-shields and eye protection should be based on an assessment of the risks associated with a specific care activity and should consider whether there is a risk of contact or exposure to blood and/or body fluids, secretions and/or excretions, non-intact skin or mucous membranes, surfaces or equipment contaminated with blood and/or body fluids or hazardous drugs or chemicals.[3, 5, 7, 23, 27] The most frequently used PPE during PVC insertion and maintenance are gloves and aprons.[3, 7, 9] Eye/face protection may be required following risk assessment of an increased exposure to blood splash.[4]

Gloves. There is consensus in the scientific literature that aseptic technique should be used during invasive procedures such as insertion of PVCs and that the decision to wear sterile or non-sterile gloves is dependent on whether aseptic technique will be maintained during the procedure.[5, 7, 28-30] It is consistently recommended in the literature that single-use non-sterile gloves should be worn when inserting PVCs if key parts (e.g. syringe tips) and key sites (e.g. insertion site) are not directly touched.[3, 4, 9, 18, 25-31] If touching key parts and key sites are unavoidable then sterile gloves should be used.[3, 4, 27, 28, 32] Additionally, the Health Service Executive (Ireland) recommends that sterile gloves should be used for PVC insertion in neonates where it is anticipated that key parts or key sites cannot be protected during difficult access.[4] It is considered good practice to wear gloves that are well fitting, provide comfort that are neither too small nor too large as to impede manual dexterity.[3, 4, 7]

Aprons/Gowns, Eye/face protection. No primary scientific studies were identified relating to use of aprons or gowns specific to insertion of PVCs however there is consensus from epic3 and Australian IPC guidelines and expert guidance from the RCN and INS that single-use aprons or gowns protect the healthcare worker's skin and clothing and they should be worn during procedures or activities in which contact with blood or body fluids is anticipated.[3, 5, 7, 27] A similar risk assessment should be carried out when considering the use of eye/face protection such as goggles or face shields. It is recommended by the literature that eye and/or face

protection should be worn when there is a risk of splash or spray of blood, body fluids or other secretions into the eyes/face.[3, 27]

For further guidance and recommendations on PPE including appropriate disposal please refer to NIPCM Systematic Literature reviews on Personal Protective Equipment (PPE): Aprons and Gowns, Gloves and Eye/Face Protection.

How should the environment be prepared prior to insertion?

Two expert opinion and two guidelines by the WHO and epic3 were identified relating to this research; no primary evidence was identified.[5, 14, 32, 33] Evidence by WHO was based on best practices in phlebotomy while general recommendations on hospital decontamination were provided by epic3 guidelines.[5, 33] The care environment is associated with transmission of healthcare associated infections (HAIs) via contact with contaminated surfaces with sites close to the patient and frequently touched surfaces identified as areas of increased contamination therefore it is recommended that the environment is clean, free from dust, dirt, non-essential items and equipment and acceptable to patients, visitors and staff.[5] Invasive vascular access devices (VADs) like PVCs provide a direct route for microorganisms to infect patients during their insertion and maintenance therefore it is important that effective infection prevention methods such as decontamination of the environment are applied to minimise the risk of HAI transmission.[5] It is recommended in the literature that PVC insertion should take place in an appropriate environment that is visibly clean, has sufficient lighting to help illuminate the insertion procedure and ensures patient comfort and privacy.[5, 14, 32, 33]

Further guidance and recommendations on cleaning the environment including blood and body fluid spillages can be found in the ARHAI Scotland NIPCM systematic literature reviews: Safe Management of the Care Environment (Environmental Decontamination) and Management of blood and body fluid spillages in health and care settings.

How should equipment be prepared prior to insertion?

This review identified eight studies of low quality evidence that relate to equipment preparation prior to PVC insertion: 1 observational study on tourniquet use,[34] 5 expert guidance/consensus[3,

[7, 14, 32, 33] and 1 UK regulation by the Medicines & Healthcare Products Regulatory Agency (MHRA).[35]

The availability of equipment required for PVC insertion depends on local policy and procurement arrangements but may include the following: alcohol-based hand rub (ABHR), clean procedure tray, sterile dressing pack (as per local guidelines), sharps container, PPE (e.g. well-fitting non-sterile or sterile gloves, plastic apron, eye/face protection if required), skin disinfectant as per local policy, IV cannula of appropriate size, 10mL syringe with sterile sodium chloride (NaCl 0.9%) for flushing, primed extension set (as per local policy), single use tourniquet, sterile transparent semipermeable dressing, sterile gauze pads and clinical waste bag.

There is expert consensus that all the required equipment requiring aseptic non touch technique should be prepared, assembled and be fit for purpose prior to PVC insertion.[4, 14, 32] The equipment and packaging should be checked to ensure that equipment is in date and not damaged or contaminated.[3, 14] Single-use devices (e.g. PVCs) are intended for single use only and must not be reused.[35] The same PVC should not be repeatedly used after a failed insertion attempt. When undertaking a PVC insertion, it is important that only the required equipment is brought to the bedside or workspace to prevent cross-contamination from occurring.[4] Expert guidance from the Infusion Nurses Society (INS) states that when applying aseptic technique using e.g. Aseptic Non Touch Technique (ANTT®) framework, staff should establish a "General Aseptic Field" to provide a controlled workspace or barrier from the environment in order to protect and maintain sterility of a sterile equipment's 'key part(s)'.[3] Examples of general aseptic field include a procedure tray, single-use procedure kit, dressing trolley/cart; they should be cleaned using a detergent and disinfectant before and after patient use as per local decontamination policy.[3, 32]

Findings from an observational study by Elhassan et al showed that 36% (18 of 50) of non-disposable tourniquets sampled from junior doctors and nursing staff tested positive for *Staphylococcus aureus* and of these 12% (6/50) were contaminated with methicillin-resistant *Staphylococcus aureus* (MRSA).[34] Moreover, 60% (30/50) were visibly soiled and of these 13 were blood stained and only 40% (20/50) tourniquets appeared 'clean'. Although this study has a small sample size, it provides evidence that reusable tourniquets may present a risk of HAI transmission. Expert guidance from the Royal College of Nursing (RCN) and WHO recommended that tourniquets should be either single patient use or be made of cleanable

material where possible.[7, 33] The tourniquet should be cleaned and disinfected between each patient use as per manufacturer instructions however no other details were provided.

Expert guidance from the Health Service Executive of Ireland stated that tourniquets should not be used in neonates for venepuncture or insertion of PVCs[4] however there was no rationale nor evidence provided to support this recommendation. This review did not find any evidence in the literature to support or refute this practice.

Further guidance and recommendations on cleaning care equipment can be found in the ARHAI Systematic Literature Review: Management of Care Equipment.

How should the insertion site be prepared?

Most catheter-related blood stream infections (CRBSIs) are caused by microorganisms that colonise catheter hubs and skin next to the catheter insertion site. Coagulase-negative staphylococci and particularly coagulase-positive *Staphylococcus aureus* are most frequently implicated and their density at the insertion site is a major factor for CRBSIs.[5, 36, 37] Therefore, skin cleansing/antisepsis plays an important role in preventing CRBSIs and is recommended by PVC-specific scientific studies and in several guidelines.[5, 9]

One randomised control trial (RCT) by Guenezan et al (2021, CLEAN 3 study) was identified that compared the effectiveness of different antiseptic solutions for the insertion of PVCs in adults however no primary studies on paediatrics and neonates were identified.[37] Additional evidence was sourced from Epic3, CDC and National Institute for Health and Care Excellence (NICE) guidelines and two expert consensus from the Infusion Nurses Society (INS) and Spanish Society of Cardiovascular Infections (SEICAV).[3, 5, 9, 18, 24]

The CLEAN 3 study by Guenezan et al was a well designed open-label RCT that compared the effect of 2% chlorhexidine in 70% isopropyl alcohol versus 5% povidone iodine in 69% ethanol on the incidence of infectious complications (local infection, catheter colonisation or bloodstream infections) in 1000 adult patients admitted to medical wards in a single university hospital in France.[37] Findings showed that patients in the chlorhexidine plus alcohol group had fewer local infections (0 [0%] of 496 vs six [1·2%] of 493 patients) and a lower incidence of colonisation (four [1%] of 431 patients vs 70 [17%] of 415 patients) compared with the povidone iodine plus alcohol group (adjusted sub distribution HR 0·08 [95% CI 0·02–0·18]). The CLEAN 3 study confirms the superiority of chlorhexidine plus alcohol over povidone iodine in alcohol in

reducing local infection and catheter colonisation and supports its use for skin antisepsis for short-term PVC insertion and care[37], similar findings were previously reported for central venous catheters.[38] However, it should be noted that the primary outcome was weighed heavily towards a proxy outcome of colonisation and local infection; no CRBSI was found during the study period.[37] Maintenance practices were not taken into account by the study, blinding was not possible and generalisability to other health and care settings outside medical wards might be limited.

Epic3 guidelines and expert opinion from the Spanish Society of Cardiovascular Infections also recommend to decontaminate skin with 2% chlorhexidine gluconate in 70% isopropyl alcohol (or povidone iodine in alcohol for patients with sensitivity to chlorhexidine) and allow to dry prior to PVC insertion[5] whereas the CDC guidelines state 'prepare clean skin with an antiseptic (70% alcohol, tincture of iodine, or an iodophor or chlorhexidine gluconate) before PVC insertion'.[9] Additionally, the 2017 update to National Institute for Health and Care Excellence (NICE) guideline on healthcare-associated infection: prevention and control in primary and community care includes a new recommendation to decontaminate the skin with chlorhexidine in 70% alcohol before inserting a peripheral vascular access device, though the concentration of chlorhexidine is not given due to the low quality of evidence available.[24] In contrast the recommendation to 'prepare clean skin with an antiseptic (70% alcohol, tincture of iodine, or an iodophor or chlorhexidine gluconate)' within the CDC guideline (published in 2011) is classified as Category 1B, which is defined as a strong recommendation even where the underpinning evidence may be considered relatively low quality.[9] Expert consensus from the Infusion Nurses Society (2021) also recommend that skin antisepsis should be performed with alcohol-based chlorhexidine solution or if chlorhexidine is contraindicated then an iodophor e.g. povidone-iodine or 70% alcohol may be used as alternatives.[3]

No primary scientific evidence on skin antisepsis specific to PVC insertion in neonates and paediatrics was identified. The Infusion Nurses Society (2021) stated that povidone-iodine, alcohol-based or aqueous chlorhexidine solution may be used for preterm neonates, low-birth-weight infants and within the first 14 days of life, however no antiseptic solution has been established in studies as superior for safety or efficacy in neonates.[3] Moreover, chlorhexidine products have been associated with skin irritation such as dermatitis and chemical burns as well as a risk for systemic absorption due to skin immaturity.[3] CDC guidelines have added that no recommendation can be made for the safety and efficacy of chlorhexidine in infants aged less than 2 months.[9] There is consensus in the literature that tincture of iodine must be avoided at the umbilical site due to potential deleterious effects on the neonatal thyroid gland.[3, 9]

The requirement that the skin antiseptic is allowed to dry is included as a recommendation within evidence based guidelines.[3, 5, 9] There is no specific evidence within the literature with regards to the method of application or the time the antiseptic is allowed to dry before insertion. However, it is recommended that manufacturer's instructions should be followed.[3, 9]

Based on the evidence found on this topic, it is therefore recommended that a single-use skin antiseptic containing 2% chlorhexidine gluconate in 70% isopropyl alcohol should be used to cleanse the skin and allow to dry before PVC insertion. If chlorhexidine is contraindicated e.g. due to sensitivity or allergy, then povidone-iodine in alcohol or 70% alcohol may be used.

Note: All medical and nursing staff involved in the use of all medical devices and medicinal products containing chlorhexidine should be aware of the risk of an anaphylactic reaction due to chlorhexidine allergy. The full details of the alert are available from the following web link http://www.mhra.gov.uk/Publications/Safetywarnings/MedicalDeviceAlerts/CON197918.

What technique should be used for insertion?

Three evidence based guidelines from the CDC (USA), epic3 (UK), NICE (CG139, UK), guidance from the Australian National Health and Medical Research Council and five expert consensus were identified in relation to this question.[3, 5, 9, 18, 24, 27-30]

There is consensus in the literature recommending that 'aseptic technique' is maintained throughout the insertion procedure i.e. critical/key parts are not touched.[3, 5, 9, 18, 24, 27-30] The CDC and epic3 guidelines recommend that aseptic technique should be used for the insertion and care of intravascular catheters however the CDC's recommendation is based on outdated evidence and no specific details were provided from either guideline as to how 'aseptic technique' should be performed to ensure patient safety.[5, 9] Aseptic technique is a broad term for a number of actions which prevent cross transmission of microorganisms. Despite its importance, there are variations in terminology used in the literature with little agreement concerning definitions and practice.[14, 29, 39]

The specific theory and clinical practice framework Aseptic Non-Touch Technique (ANTT®), originated by Rowley,[28-30] has been advocated for use in many parts of the UK including Scotland based on the concept of protecting key parts and key sites through the integration of Standard Precautions such as hand hygiene and PPE with appropriate aseptic field management, using non-touch technique and sterilised equipment.[28, 29, 40] ANTT® is promoted

for use by the Health Service Executive Ireland (HSE) in its guiding framework for the education, training and competence validation in venepuncture and peripheral cannulation for nurses and midwives.[4] Public Health Wales and the Welsh Government have facilitated the national implementation of ANTT® in order to standardise the approach and training/education of aseptic technique.[41] The Infusion Nurses Society (INS-USA)[3] have added ANTT® to their Infusion Therapy Standards while both the Australian Government and NICE recognise ANTT® as best practice example of a clinical practice framework for aseptic technique.[24, 27]

The CDC, epic3 and NICE CG139 guidelines recommend that an aseptic technique is maintained for the insertion and care of all intravascular catheters.[5, 9, 24] The requirement not to touch critical parts is included within the term 'aseptic technique'; however there are a number of other activities which should also be considered. These include: preparation of a suitable surface area which prevents touch contamination of equipment; use of sterile equipment; use of PPE; and not touching critical parts that must remain sterile.

What type of dressing should be used to cover the catheter site?

Six primary studies were identified in relation to this question.[42-47] The remaining evidence base consists of three guidelines (CDC, epic3 and NICE) and two expert consensus/opinions.[3, 5, 9, 18, 24] All six primary studies (4 RCTs, 1 non-randomised controlled trial, 1 systematic review) were published in Australia, two guidelines were from the UK and the 2 remaining studies were from the USA. Of the six primary evidence identified, three studies were carried out in adults aged 18 years or older,[42, 45, 47] two involved paediatrics,[43, 44] and a systematic review included trials with adults and paediatric participants.[46] No studies specific to neonates were found.

The 2015 Cochrane systematic review by Marsh et al evaluated the impact of different dressings and securement products on the incidence of PVC failure.[46] Included were 6 RCTs (total 1539 adults and children on medical and surgical wards) from USA (n=2), Spain (n=2) , Italy (n=1) and England (n=1) comparing 4 different ways to secure PVCs: transparent dressings versus gauze; bordered transparent dressing versus a securement device; bordered transparent dressing versus tape and transparent dressing versus sticking plaster. Findings from two low quality evidence studies suggest that compared to gauze, transparent dressing was associated with fewer catheter dislodgements or accidental removals (278 participants, RR 0.40; 95% CI: 0.17 to 0.92, P = 0.03) but overall effect on phlebitis and infiltration was unclear. Studies that favoured one dressing over another were based on very low quality single studies.

All included trials were small with either high or unclear risk of bias requiring larger high quality RCTs to confirm results. Three trials were published in 1993, 1997 and 2002 therefore evidence and practice may be outdated. Overall, the authors found no strong evidence to suggest that any one PVC dressing or securement product is more effective than any other dressing citing lack of high quality evidence and uncertainty regarding the best methods of securing PVCs.

Adults: Three RCTs (total 2252 participants) assessed the effect of dressings and securement methods on PVC failure in adults.[42, 45, 47] Bugden et al (2016) investigated in 360 patients in the emergency department (ED) whether the addition of cyanoacrylate skin glue to the insertion site plus standard bordered polyurethane (BPU) dressing would improve failure rates at 48 hours due to any cause compared with standard BPU alone.[42] 17% of PVC catheters failed in the skin glue group compared to 27% with standard BPU, a difference of 10% (95%CI: -18% to -2%; p=0.02). PVC failure by phlebitis (3% glue vs 5% standard) and occlusion (8% glue vs 11% standard) were similar in both groups however dislodgement was lower in skin glue group versus standard (7% versus 14% respectively, p=0.04). Findings support the use of skin glue in addition to standard BPU dressings to reduce PVC failure rates in adult patients in the ED however evidence is limited due to the following important limitations: short follow-up time of 48 hours, outcome assessment for 209 discharged patients following PVC removal occurred retrospectively by telephone presenting a high risk of recall bias, underpowered study to detect significant differences in outcomes due to higher than expected PVC failure rates and no detailed analysis relating to consumables cost and staff time.

Both the small pilot RCT by Marsh et al (2015) [45] (n=85 participants) and the larger high quality RCT by Rickard et al (2018, SAVE trial, n=1807 participants)[47] investigated the efficacy of four securement methods: tissue adhesive with standard polyurethane (TA + SPU) versus bordered polyurethane (BPU) versus securement device with standard polyurethane (SD + SPU) versus standard polyurethane (SPU) on the incidence of all-cause PVC failure defined as a composite of dislodgement, occlusion, phlebitis and infection (bloodstream infection or local infection). The overall findings from both trials indicated that compared to standard polyurethane dressing, none of the other 3 interventions (TA+PU, BPU, SD+PU) significantly reduced PVC failure.[47] There was less than 10% difference in absolute risk between the 3 intervention groups compared to control group suggesting that none of the 3 interventions were superior. Skin adverse events were significantly higher in the TA+SPU group compared with the standard/control group (17 [4%] versus 7 [2%] respectively, p=0.0412). It would also appear that standard polyurethane dressings provide lower costs however a full cost-benefit analysis would

be beneficial to confirm this. Evidence from both RCTs is limited to adult patients admitted to medical and surgical wards.

Paediatrics: Two primary studies on paediatrics were included relating to this question. The high quality pilot RCT by Kleidon et al (2020, SMILE study) set in Australia compared three dressing plus securement products/methods: (i) integrated securement device plus sterile foam (ISD + SF), (ii) tissue adhesive plus non-sterile foam (TA + NSF) and (iii) standard bordered polyurethane plus non-sterile foam (BPU + NSF) on PVC failure and complications (n=319).[43] Overall, 35% (112/319) of PVCs failed prior to treatment completion. A significant reduction in PVC failure was observed in the ISD group (31/107, 29%, Incidence rate (IR) 4.4 per 1000 catheter hours; 95%CI: 3.09-6.25, p=0.017;) followed by TA group (34/107, 32%, IR = 5.15 [3.68–7.21, p = 0.052] and BPU group (47/105, 45%; IR = 6.65 [4.99–8.85]). No statistically significant differences in IRs were found between groups and no securement intervention significantly reduced PVC failure in the multi-variate analysis. This pilot study failed to demonstrate that ISD or TA were associated with lower PVC failure compared to the standard BPU dressing. A larger RCT is required to confirm findings.

The second paediatric study was a non-randomised controlled trial by Laundenbach et al (2014) that compared complication rates in standard sterile transparent dressing (n=44) versus transparent dressing plus stabilisation/anchoring device (intervention; n=36) in 80 hospitalised children (aged 2-17 years) in the USA.[44] Eighteen out of 80 participants (22.5%) experienced some PVC complication with occlusion being most frequent, followed by infiltration, leaking and dislodgement however no statistically significant differences in complication rates were found between the standard and intervention group (10/44; 22.7% versus 8/36, 22% respectively, p=0.957). Evidence is limited by a small convenience sample at one hospital.

Findings from the two paediatric studies provide inconclusive evidence on what type of dressing should be used to cover the catheter site in paediatrics. PVC failure and complication rates were broadly similar across all the dressing types demonstrating non-superiority when compared to standard transparent film dressings and securement/taping methods however visibility of insertion site should be considered to monitor for signs of complications. All results should be viewed with caution due to the high risk of bias associated with small sample sizes and variability observed across studies in age, settings, dressing and securement type.

Elsewhere in the literature, it is consistently recommended by guidelines from the CDC,[9] epic3,[5] NICE (CG139)[24] and expert consensus[18] that a sterile, transparent, semipermeable dressing should be used to cover the PVC site. Altogether, no evidence was found from primary studies

suggesting one type of dressing is any better to the standard transparent dressing in reducing reported catheter negative outcomes.[42-48] It is recommended that if a patient has profuse perspiration or if the insertion site is bleeding or oozing, a sterile gauze dressing should be used[5, 9, 24] for its absorbency however this prevents easy visual inspection of the insertion site[48] and may not be as effective in preventing dislodgement.[46] Gauze dressings should be changed at least every 24 hours or sooner if soiled [5, 9, 18, 24] and should be replaced with a sterile transparent semipermeable dressing as soon as possible once the perspiration and/or site oozing/bleeding are resolved.[5, 24]

3.2 Implications for practice: Maintenance of Peripheral Venous Catheters (PVC)

What administrative and clinical checks should be in place for maintenance of PVCs?

Nine studies were included in relation to this question consisting of two guidelines (CDC and epic3) and seven expert guidance/opinion; no primary evidence was identified.[3, 5, 7, 9, 14, 18, 21, 26, 27]

There is consensus from guidelines and expert opinion that the clinical need for PVCs should be assessed daily to reduce the risk of infection[3, 18, 21, 26] and catheters that are no longer required for IV therapy should be removed.[3, 5, 18] Epic3, CDC and INS state that the PVC insertion site and dressing should be inspected at least daily during each shift or when the device is used.[3, 5, 9] A number of expert opinion pieces further added that assessment should be through visual inspection and palpation through the dressing and that the frequency of assessment may be increased depending on patient factors such as age (e.g. neonates), clinical condition, type of IV therapy (e.g. infusions of vesicant medication) and healthcare setting.[3, 9, 26] Expert guidance from the Infusion Nurses Society (2021) states that PVCs in inpatient and nursing facilities should be assessed at least every four hours, every 1-2 hours in critically ill or sedated patients or those with cognitive deficits and hourly for neonatal and paediatric patients.[3] In outpatient or community care settings, the PVC should be assessed at every visit and patients should be educated to report signs/symptoms of complications at the insertion site immediately to their home care or healthcare staff.[3, 27]

It is consistently recommended that the insertion site and surrounding area should be assessed for signs and symptoms of complications such as infection, phlebitis, pain/tenderness, dislodgement, infiltration, extravasation and leakage. The CDC stated that gauze and opaque

dressings should not be removed if there are no clinical signs of infection however if the patient reports local tenderness or other signs associated with CRBSI then such dressings should be removed and the site inspected visually.[9] When monitoring for signs of phlebitis, it is recommended to use a standardised phlebitis scale e.g. Visual Infusion Phlebitis Scale (VIP) to measure and document the degree or severity of infection.[3, 5, 7, 14]

When should hand hygiene be performed when administering medication/throughout the process of maintenance?

The evidence base and recommendation for this question is similar to the hand hygiene recommendation prior to PVC insertion.

There is consensus in the literature that hand hygiene is performed immediately before accessing the catheter line/site and throughout the care and maintenance of PVCs including dressing changes and removal of PVCs. Hands should also be decontaminated before and after direct contact with the patient, before donning and after removal of gloves, before and after infusion/medicine administration and after any exposure to blood and/or body fluids.[3, 5, 9, 22, 24]

Further guidance and recommendations on Hand Hygiene and Gloves can be found in the ARHAI Scotland NIPCM systematic literature reviews Hand Hygiene: Hand washing, hand rubbing and indications for hand hygiene and Personal Protective Equipment (PPE): Gloves.

How should hand hygiene be performed, what should be used?

The evidence base on how hand hygiene should be performed is similar for PVC insertion and maintenance. WHO recommends that hand hygiene should be performed with an alcohol-based hand rub (ABHR) for at least 20 seconds during clean/aseptic procedures including care and maintenance of PVCs.[22] Use of ABHR is the preferred method however hands should be washed with soap and water when visibly dirty, visibly contaminated with blood or other body fluids, if patient is suspected or confirmed of having/or there is an outbreak of a spore-forming pathogen (e.g. *Clostridioides difficile)* or norovirus gastroenteritis and if alcohol-based hand rub is not available.[3, 18, 22]

What Personal Protective Equipment (PPE) should be worn and when?

The evidence base for this question is similar to the research question What Personal Protective Equipment (PPE) should be worn and when? for PVC insertion.

There is consensus in the literature that the decision to use or wear PPE (which may include gloves, gowns, plastic aprons, masks/face-shields and eye protection) should be based on an assessment of the risks associated with a specific care activity and should consider whether there is a risk of contact or exposure to blood and/or body fluids, secretions and/or excretions, non-intact skin or mucous membranes, surfaces or equipment contaminated with blood and/or body fluids or hazardous drugs or chemicals.[3, 5, 7, 23, 26, 27]

Gloves. It is recommended in the literature that single use well-fitting gloves should be used during the care and maintenance of PVCs including during dressing changes and removal of PVCs.[3, 9, 27]

Aprons/Gowns, Eye/face protection. It is recommended in the literature that aprons/gowns and eye/face protection should be worn during procedures or activities in which contact with blood or body fluids is anticipated or there is a risk of splash or spray of blood, body fluids or other secretions into the eyes/face.[3, 5, 7, 27]

How should the PVC access site be maintained?

Ten studies were identified relating to this question comprising of three guidelines from NICE, CDC and epic3, one RCT and six expert guidance/opinion pieces.[3-5, 9, 14, 18, 24, 27, 49, 50]

Aseptic technique. Similar to the evidence for PVC insertion, it is consistently recommended that aseptic technique combined with hand hygiene and appropriate PPE should be used for the care and maintenance of PVCs. This includes during catheter dressing changes and whenever the insertion site is exposed.[4, 5, 9, 14, 27]

Dressing changes. There is consensus from the CDC, epic3 and Australian guidelines that dressings should be intact otherwise they should be changed if damp, loosened or visibly soiled.[5, 9, 27] However it is unclear if routine change of transparent semipermeable dressings is required in the care and maintenance of PVCs. NICE guidelines stated to leave transparent dressing in situ for the life of the cannula if they remain intact however this was based on expert opinion in the absence of clinical evidence for frequency of dressing changes for PVCs.[24] In

contrast, epic3 guidelines and the Infusion Nurses Society recommended that transparent, semipermeable dressings should be changed immediately if dressing integrity is disrupted (e.g. lifted or detached edges, visibly soiled or damp) or at least every 7 days if PVC is still in situ (except at-risk skin e.g. neonatal patients).[3, 5] Neonatal skin, particularly in preterm infants, may be easily damaged or torn by removing adherent dressings. The potential risk for skin injury during dressing/adhesive changes should also be considered for the elderly, malnourished patients, and those with malignancies, clinical conditions or undergoing therapies and medication that can compromise skin integrity. Less frequent dressing changes may be more appropriate for these patients. The INS advised that in neonatal patients, dressing change should be performed as needed per patient or when clinically indicated due to risk of catheter dislodgement, patient discomfort or skin injury.[3]

Skin antisepsis. Similar to the evidence for PVC insertion, the literature supports decontamination of the catheter insertion site and surrounding skin during dressing changes using 2% chlorhexidine gluconate in 70% alcohol and allow to air dry.[5, 7, 14, 24]

Needleless connectors/catheter hubs. It has been previously reported that hubs and connection points may be contaminated and must be disinfected before being accessed by healthcare workers (HCWs).[5, 9] Needleless connectors (NC) were originally introduced to reduce the risk to staff from needlestick injuries[51] however an unintended consequence was an increase in blood stream infections (BSI).[50] Likely causes were attributed to various NC design which may influence decontamination of the injectable surfaces and HCW non-compliance with appropriate NC decontamination policies.[50] The most commonly recommended disinfectants for NC/hubs decontamination are 70% isopropyl alcohol (IPA) and chlorhexidine gluconate (CHG) in 70% IPA;[3, 9, 50] 10% povidone iodine is rarely used in clinical practice due to its long drying time.[3] It is unclear if 70% IPA alone or CHG with 70% IPA is the most effective disinfectant.[52] Spanish and Australian guidance recommend scrubbing the hub with 70% alcohol wipes before each access to minimise the risk of microbial contamination,[18, 27] while guidelines by NICE, epic3, Health Service Executive Ireland and the Royal College of Nursing favour the use of 2% chlorhexidine gluconate in 70% IPA[4, 5, 7, 24] To add to the uncertainty, the CDC and expert opinion from the Infusion Nurses Society and Moreau et al (2015) recommend scrubbing the access port with an appropriate antiseptic which includes chlorhexidine, povidone iodine, an iodophor, or 70% alcohol and allowing to dry prior to access.[3, 9, 50] Only one primary study was identified by this review that investigated decontamination of PVC needleless connectors and duration of scrub in a clinical environment. The recent RCT by Slater et al (2020) compared the effectiveness of 70% IPA versus 2% CHG in 70% IPA with decontamination (scrub) times of 5,

10, or 15 seconds for 300 NCs attached to PVCs of adult patients in an Australian hospital.[49] There was no significant difference in decontamination rates between the two disinfectants tested (RR=2.16 (95% CI: 0.20-22.9, P=0.62) or decontamination time between the 3 tested periods (RR=1.29 [0.88-1.89], P=0.21). Both 70% IPA and 2% CHG in 70% IPA were equally effective in disinfecting NCs and the study also demonstrated little difference in decontamination efficacy whether scrub times were performed for 5, 10 or 15 seconds however the authors cautioned changing the guidelines from a 15-second scrub to a 5-second scrub stating that all visibly unclean NCs should be changed immediately.[49] In summary, the evidence identified supports disinfection of the access hub/NC with 70% IPA or 2% CHG in 70% IPA and allowing to dry before access – and rubbing the access hub for at least 15 seconds ('scrub the hub').

**Note: All medical and nursing staff involved in the use of all medical devices and medicinal products containing chlorhexidine should be aware of the risk of an anaphylactic reaction due to chlorhexidine allergy. The full details of the alert are available from the following web link http://www.mhra.gov.uk/Publications/Safetywarnings/MedicalDeviceAlerts/CON197918

When should removal of PVCs be considered?

A moderate volume of primary evidence was identified to answer this research question. In adults, nine RCTs (Vendramim 2020,[8] Webster 2007[53], Webster 2008,[54] Barker 2004,[55] Nishanth 2009,[56] Rickard 2010,[57] Rickard 2012,[58] Van Donk 2009[59] and Xu 2017[60]) and two high quality Cochrane systematic reviews and meta-analysis (Webster 2015[61] and updated in Webster 2019[62]) were identified. All nine adult RCTs were included in the 2019 Cochrane systematic review however each RCT and both systematic reviews were appraised individually.

Two further RCTs on neonates were found (Liew 2021[63], Chin 2018[64]) and the rest were comprised of one observational study (Buetti 2021)[65], two guidelines (CDC[9] and epic3[5]) and seven low quality evidence expert guidance.[3, 4, 7, 18, 25, 27, 66]

The 2019 Cochrane systematic review and meta-analysis (SR+MA) by Webster et al investigated the effects of removing PVCs when clinically indicated (CI) compared with routine replacement.[62] This was an update to the 2015 review also by Webster et al[61] and included two new trials taking the total to nine RCTs involving a total of 7412 participants from studies which ranged in size between 42 and 3283 participants. Five RCTs were carried out in Australia and the remainder in Brazil, China, England and India. Seven trials were conducted in hospital

settings (5 single-centre acute inpatient and 2 multicentre tertiary hospitals) and one trial was conducted in a community setting. To avoid duplication of results, only the 2019 Cochrane SR+MA and not the 2015 version will be referred to in this section.

Seven trials (Rickard 2010, Rickard 2012, Van Donk 2009, Vendramin 2018, Webster 2007, Webster 2008 and Xu 2017)[8, 53, 54, 57-60] compared outcomes between routine/elective replacement of PVCs at 72-96 hours versus clinically indicated (CI) changes while two studies (Barker 2004 and Nishant 2009)[55, 56] compared 48-hour routine changes with removal of PVCs on clinical indications such as pain, catheter dislodgement or phlebitis. Due to the nature of the intervention, it was not possible to blind either the participants or healthcare staff in any of the trials therefore outcome assessment is classified as having a high risk of bias particularly Barker 2004 and Nishant 2009 due to the direct involvement of the chief investigator in assessing outcomes.

Findings from seven trials (n=7323 participants) that assessed catheter-related blood stream infection (Rickard 2010; Rickard 2012; Van Donk 2009; Vendramim 2018; Webster 2007; Webster 2008, Xu 2017)[8, 53, 54, 57-60] showed no clear difference in the incidence of catheter-related blood stream infections (CRBSI) between routine replacement of PVCs at 72-96 hours versus replacement when clinically indicated. The 2019 Cochrane SR+MA reported 1/3590 vs 2/3733 in clinically indicated group (CI) and routine change respectively, risk ratio RR 0.61, 95%CI: 0.08-4.68, P=0.64.[62]

All nine trials reported incidence of phlebitis (n=7412 participants).[8, 53-60] There was consistent evidence from 7 trials (n=7323 participants) showing no significant differences in the incidence of phlebitis between the CI group and 72h replacement group (Rickard 2010; Rickard 2012; Van Donk 2009; Vendramim 2018; Webster 2007; Webster 2008, Xu 2017).[8, 53, 54, 57-60] However, opposite findings were reported by Barker 2004 and Nishant 2009 both of which used a 48h replacement schedule, had very small sample sizes (n=89 combined total) and reported extreme results (42 to 100% in clinically indicated group developed phlebitis versus 5% in 48h replacement group). Heterogeneity was eliminated (I^2=0) when the 2019 Cochrane SR+MA removed the two trials allowing for analysis of the combined data from the remaining seven studies.[62] Their findings show no clear difference in incidence of phlebitis whether PVCs were replaced when clinically indicated or routinely at 72h (317/3590, 8.8% vs 307/3733, 8.2% in CI and 72-hour change respectively, RR 1.07 [0.93-1.25, P=0.34], result was unaffected by whether infusion was continuous or intermittent.[62]

Six studies reported rates of phlebitis by number of device days (Rickard 2010; Rickard 2012; Van Donk 2009; Vendramim 2018; Webster 2007; Webster 2008)[8, 53, 54, 57-59] and their combined data showed no clear difference between the two groups for this outcome (248/17,251 vs 236/15,458 in CI and 72-hour change respectively, RR 0.90 [0.76-1.08, P=0.25]).[62]

One RCT by Rickard 2012 (n=3283) assessed all-cause bloodstream infection and findings showed no clear difference in this outcome between the two groups (RR 0.47, 95%CI:0.15-1.53; clinically indicated: 4/1593 (0.02%); routine change 9/1690 (0.05%; P=0.19)).[58]

Six trials with 7123 participants (Rickard 2010; Rickard 2012; Vendramim 2018; Webster 2007; Webster 2008; Xu 2017)[8, 53, 54, 57, 58, 60] reported lower rates of infiltration in routine replacement group (747/3638; 20.5%) compared with clinically indicated group (combined data: 834/3485; 23.9%, RR 1.16 [1.06-1.26, P=0).[62] While seven trials (n=7323 participants, Rickard 2010; Rickard 2012; Van Donk 2009; Vendramim 2018; Webster 2007; Webster 2008; Xu 2017)[8, 53, 54, 57-60] found lower rates of catheter failure due to occlusion/blockage in the routine replacement group compared to the CI group (combined data: RR 1.14, 95%[1.02-1.27]; routine-replacement group 519/3733 (13.9%); clinically indicated group 560/3590 (15.6%), P=0.02).[62]

In four trials that reported on local infection (Rickard 2010; Rickard 2012; Webster 2007; Webster 2008),[53, 54, 57, 58] the evidence is uncertain (due to very wide confidence interval) if there are differences in local infection rates between the 2 groups (combined data: RR4.96, 95% CI: 0.24 to 102.98; clinically indicated 2/2260 (0.09%); routine replacement 0/2346 (0.0%); P=0.3).[62]

In one trial (n=3283, Rickard 2012) that reported incidence of mortality, 4/1593 (0.25%) died in the clinically indicated group compared with 4/1690 (0.24%) in the routine replacement group (RR 1.06, 95% CI 0.27 to 4.23).[58] A smaller trial (n=198, Vendramin 2018) found no clear difference in device-related pain between CI and routine replacement groups (MD −0.60, 95% CI −1.44 to 0.24).[8] In three trials that performed cost analysis, findings suggested reduced device-related costs by approximately 7.00 Australian dollars when PVCs were removed on clinical indications compared with routine removal (mean difference [MD] -6.96, 95%CI: −9.05 to −4.86, P<0.0001), providing significant cost savings.[62]

Two RCTs assessed PVC replacement in neonates. The small non-blinded RCT by Liew et al (2021) assessed in 113 neonates the influence of elective PVC replacement every 72 to 96 hours versus clinically indicated (CI) on combined adverse events per patient and per 1000 IV hours.[63] The combined adverse outcomes included all reasons for PVC failure (including

extravasation, phlebitis, leaking, dislodgement of cannula, bleeding). There was no significant difference in combined adverse outcomes per infant in the CI group (48, 87.27%) versus elective replacement group (44, 75.86%) (RR 0.87; 95% CI 0.71–1.04, p=0.15). More neonates in the CI group experienced adverse outcomes per 1000 IV hours compared to elective group (87.27% versus 70.69 respectively, RR 0.81 (95% CI 0.65–0.98, p=0.04). Similar results were observed in the per-protocol analysis showing an insignificant risk ratio of 0.92 (95% CI 0.75–1.09, p=0.41) for any combined adverse outcome per patient (87.27% standard/CI group vs 80% elective group) but contrary to the intention-to-treat analysis, there was no significant difference in risk of any combined adverse outcome per 1000 IV hours between the two groups (RR 0.84; 95% CI 0.67–1.02, p=0.12).The authors concluded that elective replacement of PVCs every 72 to 96 hours failed to significantly reduce the risks of any combined adverse events in neonates however evidence is limited due to small sample size and study carried out in a single neonatal unit in Australia.

Chin et al (2018) also carried out a non-blinded RCT in 113 neonates admitted to a neonatal unit in Australia to compare rates of extravasation between elective replacement of PVC every 72-96 hours versus standard practice of replacing when clinically indicated.[64] Secondary outcomes were also investigated including rates of phlebitis, leakage or spontaneous dislodgement of PVC. More participants (60%, 33/55) in the standard CI group had PVC extravasation compared to the elective replacement group (48%, 28/58) representing a non-significant 20% reduction in extravasation risk per patient in the elective group (RR 0.8, 95%CI: 0.57 – 1.13; p=0.21). An increase in leaking rates (HR 1.98 CI 1.03–3.81, p=0.04) was observed in the elective replacement group while phlebitis and spontaneous dislodgement rates were similar to standard CI group. These findings suggest no significant benefit with elective replacement compared to standard replacement when clinically indicated. Evidence is limited as this was a single-centre study with a small sample size and results may not be generalisable to the Scottish neonatal population and setting.

In both the 2015 and 2019 version of the Cochrane SR+MA, the authors found moderate-certainty evidence of no clear differences in rates of CRBSI, thrombophlebitis, all-cause BSI, mortality and pain between clinically indicated or routine replacement of PVCs.[61, 62] The addition of the two new trials found no further evidence to support changing PVC every 72 to 96 h.[61, 62] Evidence from both SR+MA is at risk of bias due to non-blinding of participants, researchers, clinicians/nurses/medical staff due to the nature of intervention therefore the overall certainty of evidence was moderate for most outcomes. Moreover, five of the nine trials were conducted in

Australia but the addition of two studies in the 2019 version, one from China and one from Brazil, broadens the evidence and increases generalisability.

It is consistently recommended by epic3 guidelines, Infusion Nurses Society, Health Service Executive Ireland, Spanish Society of Cardiovascular Infections, Association of Anaesthetists of Great Britain and Ireland and the Royal College of Nursing to remove PVCs only when clinically indicated and not routinely[3-5, 7, 18, 25] based on findings from the recent Cochrane systematic reviews by Webster et al (2015, 2019)[61, 62] This aligns with recommendations from the CDC, Health Service Executive Ireland and Australian guidelines to remove PVCs in children and neonates when clinically indicated[4, 9, 27] to reduce the risk of complications such as extravasation and to spare unnecessary pain and discomfort from routine re-siting in the absence of clinical indications.[5, 62-64]

In contrast, the CDC (2011) stated there was no need to replace PVCs more frequently than every 72 to 96 hours in adults and made no recommendation regarding replacement of PVCs when clinically indicated as this was an unresolved issue at that time.[9] However the CDC guidance predates the publication of the 2012 RCT by Rickard et al (3283 participants)[58] and the Cochrane systematic reviews published in 2015[61] and 2019[62] which address this issue. Meanwhile Australian guidelines state both options can be followed, i.e. replace a PVC every 72 hours or replace based on clinical indication, as long as surveillance of PVC related BSI is performed at the facility.[27]

Conflicting findings were reported by Buetti et al (2021) in their observational study using surveillance data of 412, 631 PVCs at a tertiary hospital in Geneva which showed that clinically indicated replacement of PVCs during the intervention period (130,779 PVCs, 46 PVC-BSIs) was associated with a significant increase in the risk of PVC-BSIs compared with routine replacement at every 96 hours during baseline (241,432 PVCs, 11 PVC-BSIs; IRR 7.20; 95%CI: 3.65-14.22; P<0.001).[65] This prompted a change back to routine replacement policy whereby the incidence of PVC-BSIs returned to baseline values (40,420 PVCs, 4 PVC-BSIs; IRR 1.35 (0.30-6.17; P=0.69). Study results favoured routine replacement of PVCs every 96 hours for hospitalised patients however data also suggested it would require approximately ~13,000 catheter-days to observe 1 additional BSI many of which were skin commensals. Additionally, routine replacement was associated with higher costs in terms of used catheters per hospital stay, patient discomfort, staff needle-stick injuries and staff time. Further limitations of the study included the diagnostic definition of PVC-BSI being a composite of catheter-related BSI (microbiologic confirmation) and catheter-associated BSI (more subjective surveillance-based),

no information on how policy change was implemented, non-randomised study design resulting in imbalanced number of PVCs and unequal number of days analysed in the 3 study periods (baseline, intervention and reversion), non-blinding of assessors, significant difference in the distribution of insertion site between baseline and intervention period (elbow and wrist instead of forearm) and unknown distribution and effects of potential confounders between study periods. Caution is advised when considering observational studies to inform practice given the limitations highlighted above. Buetti et al[65] found low rates of PVC-BSI with less than 1 case per 10,000 PVCs regardless of removal policy which is consistent with findings in the RCTs and systematic reviews.[58, 61, 62] It is calculated that a study would require a sample size of greater than 25,000 participants to show clear differences between groups for CRBSI and phlebitis[62] however it is unlikely that such a study is warranted given the low rate for CRBSI, the very high number to treat for one patient to avoid phlebitis (almost 1700) and the very high number needed to harm (3,500 PVCs) to prevent 1 case of PVC-BSI.[62, 67]

The majority of evidence identified in the literature consistently show no statistically significant differences in the rates of CRBSI, all-cause bloodstream infection, phlebitis, mortality and pain between clinically indicated or routine replacement of PVCs suggesting that patients are not adversely affected if the catheter is replaced based on clinical indications (e.g. signs of infection, blockage or infiltration). Extending the catheter dwelling time and replacing when clinically indicated did not increase the risk of important clinical outcomes of CRBSI, all BSI and phlebitis and although higher rates of catheter failure due to blockage and infiltration was observed in the clinically indicated group, this could be expected due to longer dwell times. Replacing PVCs when clinically indicated would provide significant cost savings and spare patients the unnecessary pain associated with the routine re-siting of PVCs in the absence of clinical indications. To further minimise the risk of complications, healthcare workers should assess the insertion site routinely as per local policy and remove the PVC if no longer needed for therapy or if signs of complications and infections are present.

4. Implications for research

The majority of evidence for PVC insertion and maintenance is based on adult studies and there is a general lack of primary evidence to inform recommendations specific to paediatrics and neonates. There is a need for high quality studies investigating the prevalence and impact of unused PVCs. As stated previously, the unused PVC exposes the patient to preventable harm from complications such as phlebitis and infection, provides no clinical benefit and incurs increased cost to healthcare systems and healthcare worker's time. Further research is required to establish clear indications when placing PVCs.

More high quality research is also needed to determine the optimum antiseptic agent and concentration for skin antisepsis for paediatrics and neonates particularly preterm infants both before insertion and during dressing changes. Neonates are vulnerable to harmful effects of antiseptics due to skin immaturity therefore it is important to establish the safest method for skin antisepsis in this population.

Dressings and securement methods – there is a need for suitably powered, high quality RCTs to evaluate newer but expensive dressings and securement methods such as surgical grade glue. Cost-benefit analysis would help inform decision making.

5. Recommendations

This review makes the following recommendations based on an assessment of the extant scientific literature on the insertion and maintenance of Peripheral Venous Catheters (PVCs) in the health and care setting.

5.1 Recommendations for Insertion of Peripheral Venous Catheters (PVC)

What are the indications for PVC insertion?

PVCs are frequently inserted for the administration of intravenous therapy (IV) such as fluids, medication (e.g. antibiotics, analgesics) and blood products.

(No recommendation)

To preserve vessel health and reduce the risk of complications, PVCs are **not recommended** for the administration of the following:

- Continuous infusion of medication with irritant or vesicant properties;
- Parenteral nutrition exceeding 10% dextrose and/or 5% protein;
- Solutions and/or medications with pH less than 5 or greater than 9;
- Solutions and/or medications with osmolarity greater than 900 mOsm/L.

(Category C Recommendation)

Central venous catheter (CVC) is the preferred route for the administration of neonatal parenteral nutrition but peripheral venous access may be considered if:

- It would avoid a delay in starting parenteral nutrition;
- short-term use of peripheral venous access is anticipated e.g. less than 5 days;
- it would avoid interruptions in giving parenteral nutrition;
- central venous access is impractical.

(Category C Recommendation)

What administrative checks should be in place prior to insertion?

PVCs should only be inserted when there is a clear clinical indication for their use.

(Category C recommendation)

PVCs should be inserted when the anticipated duration of IV therapies is short.

(Category C Recommendation)

When should hand hygiene be performed throughout the procedure?

Hand hygiene should be performed before all PVC insertion procedures.

(Category C Recommendation)

Hand hygiene should be performed before and after palpating the PVC insertion site. The catheter insertion site should not be touched after the application of skin antisepsis unless aseptic technique is maintained.

(Category C Recommendation)

Hand hygiene should be performed before donning gloves and after removing gloves.

(Category C Recommendation)

How should hand hygiene be performed, what should be used?

Hand hygiene should be performed with an alcohol-based hand rub (ABHR) unless hands are visibly dirty, contaminated with blood or other body fluids, if patient is suspected or confirmed of having/or there is an outbreak of a spore-forming pathogen (e.g. *Clostridioides difficile*) or norovirus gastroenteritis in which case hands should be washed with soap and water.

(Category C Recommendation)

What Personal Protective Equipment PPE should be worn and when?

Personal protective equipment (PPE) should be sufficient and accessible at the point of care. Appropriate PPE should be selected and used based on the assessment of:

- The risk of exposure and transmission of microorganisms to the patient or healthcare worker;
- Potential for exposure and/or contact with blood, body fluids, secretions and/or excretions, non-intact skin, mucous membranes, hazardous drugs and chemicals;
- Suitability of the equipment for proposed use.

(Category C Recommendation)

Single use, well-fitting gloves should be used for the insertion of a peripheral venous catheter.

(Category C Recommendation)

If key parts (e.g. syringe tip) and/or key sites (e.g. insertion site) are likely to be directly touched or is unavoidable during PVC insertion (e.g. during difficult access), then sterile gloves should be used.

(Category C Recommendation)

Single-use aprons should be worn during procedures or activities where there is a risk of exposure to blood and/ or body fluids.

(Category C Recommendation)

All used PPE must be disposed of into the appropriate waste stream in accordance with local policies for waste management.

(Mandatory)

How should the environment be prepared prior to insertion?

The environment should be visibly clean, free from non-essential items and equipment, and have adequate lighting and privacy.

(Category C Recommendation)

If using a dressing trolley or non-disposable procedure tray (e.g. plastic kidney dish), the surfaces should be decontaminated appropriately in accordance with NIPCM or local policy prior to PVC insertion.

(Category C Recommendation)

How should the equipment be prepared prior to insertion?

All the required equipment for cannulation should be prepared and assembled prior to insertion of a PVC.

(Category C Recommendation)

Tourniquet should be single use or suitable for decontamination between uses.

(Category C Recommendation)

How should the insertion site be prepared?

A single-use skin antiseptic containing 2% chlorhexidine gluconate in 70% isopropyl alcohol should be used to cleanse the skin and allowed to dry before insertion. If chlorhexidine is contraindicated** (caution, see below), e.g. due to sensitivity or allergy, then povidone-iodine in alcohol or 70% alcohol may be used.

(Category A Recommendation)

For paediatrics: There is insufficient evidence to inform a recommendation regarding this research question. Local policies should be followed.

For neonates: Ensure that a single-use application of an appropriate antiseptic is used to cleanse the skin and left to dry before insertion. Tincture of iodine should not be used on neonates due to harmful effect on neonatal thyroid gland.

(Category C Recommendation)

The insertion site should not be touched or palpated after the application of skin antiseptic.

(Category C Recommendation)

** Note: All medical and nursing staff involved in the use of all medical devices and medicinal products containing chlorhexidine should be aware of the risk of an anaphylactic reaction due to chlorhexidine allergy. The full details of the alert are available from the following web link http://www.mhra.gov.uk/Publications/Safetywarnings/MedicalDeviceAlerts/CON197918

What technique should be used for insertion?

Aseptic technique should be maintained throughout the insertion procedure i.e. key-parts and key-sites are not touched.

(Category B Recommendation)

What type of dressing should be used to cover the catheter site?

A sterile, transparent, semipermeable dressing should be used to cover the catheter site.

The insertion site should remain visible through the dressing (except if using gauze dressing).

(Category A Recommendation)

A sterile gauze dressing may be used if the patient has profuse perspiration or if the catheter insertion site is bleeding or oozing.

Gauze dressings should be changed at least every 24 hours or sooner if soiled.

Gauze dressings prevent visual observation of the insertion site and should be replaced with a sterile, transparent semipermeable dressing as soon as possible e.g. when bleeding/oozing has resolved.

(Category C Recommendation)

5.2 Recommendations for Maintenance of Peripheral Venous Catheters (PVC)

What administrative and clinical checks should be in place for maintenance of PVCs?

The clinical need for the PVC should be reviewed and recorded at least daily.

(Category C Recommendation)

Assess the need for intravenous (IV) therapy including antibiotics daily – switch to other routes if possible e.g. oral

The PVC insertion site and dressing should be routinely assessed through visual inspection at least daily and prior to use.

The frequency of assessment may be increased depending on patient factors such as age (neonates), clinical condition, type of IV therapy and healthcare setting.

(Category C Recommendation)

The insertion site and surrounding area should be assessed for signs and symptoms of complications such as phlebitis, pain/tenderness, dislodgement, infiltration, extravasation and exudate.

The catheter insertion site should be monitored for signs of phlebitis using a standardised phlebitis scale such as the Visual Infusion Phlebitis (VIP) tool.

(Category C Recommendation)

When should hand hygiene be performed when administering medication/throughout the process of maintenance?

Hand hygiene should be performed immediately before accessing the catheter line/site and throughout the care and maintenance of PVCs including dressing changes and removal of PVCs.

(Category C Recommendation)

Hand hygiene should be performed before and after infusion administration and after any exposure to blood and/or body fluids.

(Category C Recommendation)

Hand hygiene should be performed before donning gloves and after removing gloves.

(Category C Recommendation)

How should hand hygiene be performed, what should be used?

Hand hygiene should be performed with an alcohol-based hand rub (ABHR) unless hands are visibly dirty, contaminated with blood or other body fluids, if patient is suspected or confirmed of having/or there is an outbreak of a spore-forming pathogen (e.g. *Clostridioides difficile*) or norovirus gastroenteritis in which case hands should be washed with soap and water.

(Category C Recommendation)

What Personal Protective Equipment (PPE) should be worn and when?

Single-use, well-fitting gloves should be used for the ongoing care and maintenance of PVCs.

(Category C Recommendation)

Single-use aprons should be worn during procedures or activities where there is a risk of exposure to blood and/ or body fluids.

(Category C Recommendation)

All used PPE should be disposed of into the appropriate waste stream in accordance with local policies for waste management.

(Mandatory)

How should the PVC access site be maintained?

Aseptic technique should be used for the care and maintenance of PVCs. This includes during catheter dressing changes and whenever the insertion site is exposed.

(Category C Recommendation)

PVC dressings should be intact. The dressing should be changed if it is loosened, visibly soiled, damp and if skin integrity is compromised under the dressing.

(Category C Recommendation)

There is insufficient evidence to recommend changing the dressing routinely if intact and in the absence of clinical indications.

(No recommendation)

Dressing changes in those at risk of skin injury (e.g. neonates, elderly patients) should be performed as needed per patient or when clinically indicated e.g. risk of catheter dislodgement, patient discomfort, skin injury or as per local policy.

(Category C Recommendation)

A single-use skin antiseptic containing 2% chlorhexidine gluconate** (caution, see below) in 70% isopropyl alcohol should be used to clean and decontaminate the catheter insertion site and left to dry during catheter dressing changes. If chlorhexidine is contraindicated, e.g. due to sensitivity or allergy, then povidone-iodine in alcohol or 70% alcohol may be used.

(Category A Recommendation)

A single-use antiseptic containing 70% isopropyl alcohol or 2% chlorhexidine gluconate in 70% isopropyl alcohol should be used to clean the access hub before accessing – rub the access hub for at least 15 seconds ('scrub the hub') and allow to air dry. If chlorhexidine is contraindicated, e.g. due to sensitivity or allergy, then povidone-iodine in 70% alcohol or 70% alcohol may be used.

(Category B Recommendation)

** Note: All medical and nursing staff involved in the use of all medical devices and medicinal products containing chlorhexidine should be aware of the risk of an anaphylactic reaction due to

chlorhexidine allergy. The full details of the alert are available from the following web link http://www.mhra.gov.uk/Publications/Safetywarnings/MedicalDeviceAlerts/CON197918.

When should removal of PVCs be considered?

The PVC should be removed when clinically indicated or when no longer needed and not at routine intervals. The PVC should be removed if the patient develops signs and symptoms of complication such as inflammation and/or infection.

(Category A Recommendation)

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Appendices

Appendix 1: Grades of recommendation

Grade	Descriptor	Levels of evidence
Mandatory	'Recommendations' that are directives from government policy, regulations or legislation	N/A
Category A	Based on high to moderate quality evidence	SIGN level 1++, 1+, 2++, 2+, AGREE strongly recommend
Category B	Based on low to moderate quality of evidence which suggest net clinical benefits over harm	SIGN level 2+, 3, 4, AGREE recommend
Category C	Expert opinion, these may be formed by the NIPC groups when there is no robust professional or scientific literature available to inform guidance.	SIGN level 4, or opinion of NIPC group
No recommendation	Insufficient evidence to recommend one way or another	N/A

Appendix 2: PRISMA Flow Diagram[68]