

Current knowledge and approaches in peripheral intravenous catheter practice

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ABSTRACT

Peripheral intravenous catheterization is one of the most common invasive nursing interventions applied to hospitalized patients. This intervention, which is of great importance for the effective implementation of treatment, is performed using a peripheral intravenous catheter. In peripheral intravenous catheter applications, local and systemic complications may occur due to application errors and care deficiencies. These complications cause patients to be exposed to unnecessary diagnostic procedures and treatment, prolonged hospitalization, and increased mortality and morbidity rates. In this context, it is very important for healthcare professionals, especially nurses, to integrate the data obtained from current research and guidelines on peripheral intravenous catheter applications into their practices. In this review, the points to be considered in peripheral intravenous catheter applications and the basic principles of catheter intervention are summarized with the current literature.

Keywords: Nursing care, peripheral intravenous catheter, complications

INTRODUCTION

Intravenous (IV) fluid therapy or IV infusion is a form of treatment applied by administering IV drugs and fluids directly into the vein (Kuş & Büyükyılmaz, 2019). Intravenous, interventions are frequently applied to hospitalized individuals for purposes such as providing fluid and electrolyte balance, regulating blood components, providing and maintaining vascular patency, ensuring patient nutrition, and administering drug treatments (Atabek & Karadağ, 2019; Potter et al., 2019). This intervention, which is of great importance for the effective administration of treatment, is performed using a peripheral intravenous catheter (PIC). Peripheral intravenous catheterization is one of the most frequently used interventions among invasive nursing interventions.

Studies have reported that the annual number of PICs used in hospitals is more than two billion worldwide and around 20 million in Türkiye, with more than 80% of inpatients undergoing PIC (National Vein Access Management Guide [NVAMG], 2019; Forsberg et al., 2018). PIC is beneficial and therapeutic when performed with the correct procedural steps. However, some complications may occur in cases of misapplication, inadequate diagnosis and care (Kuş & Büyükyılmaz, 2019; Çelik & Avşar, 2021). Common complications at this point include phlebitis, hematoma, infiltration, extravasation, venous spasm, local infection, pain, nerve injury and systemic complications (Potter et al., 2017).

In addition, various complications may develop depending on factors such as the patient's vasculature, catheter diameter, catheter material, duration of catheter stay in the vein, fluid infusion method and fluid flow rate (Denat & Erdoğan, 2016). These complications may cause patients to be exposed to unnecessary diagnostic procedures and treatment, prolonged hospitalization, increased mortality and morbidity rates, increased workload of healthcare personnel, decreased quality of care and serious economic losses (Biçer & Temiz, 2021; Aydın & Arslan, 2018; Beccaria et al., 2018). The literature shows that 90% of PIC applications are removed from the patient before the treatment is completed due to complications and 35-50% of PIC attempts result in failure (Carr et al., 2017; Nickel, 2019; Takahashi et al., 2020).

Kraiwan et al. (2024) studied 441 patients with a total of 497 PIC sites and reported that 2.41% of all sites developed level 1 and 2 phlebitis, 1.01% developed level 1 and 2 infiltration and 0.6% developed mild to moderate extravasation. In addition, use of IV crystalloids and IV analgesic drugs were shown among the factors associated with the occurrence of infiltration complications (Kraiwan, 2024). They found that more complications developed in patients who received antibiotic treatment, received parenteral nutrition solution, underwent multiple interventions in the same vein, and had a long catheter use time.

In this review, the points to be considered to reduce possible complications in PIC applications and the basic principles of catheter intervention will be explained based on the results of the current literature.

POINTS TO CONSIDER IN PIC IMPLEMENTATION

Deciding on the area where peripheral intravenous catheter (PIC) will be applied, selecting the appropriate catheter number, knowing the PIC application procedure, following the process with regular controls, performing intravenous catheter care and maintaining the intervention effectively by observing potential complications are among the responsibilities of nurses (Çelik & Avşar, 2021). To minimize PIC complications, nurses need to update their knowledge about PIC care, identify risk factors, and perform care based on scientific evidence (Beccaria et al., 2018).

PIC administration should be determined according to the patient's general condition, age, vascular characteristics, comorbidities, suitability of peripheral vascular access sites, characteristics of the infusion fluid, the purpose of the treatment and the expected duration of infusion therapy (INS, 2021). In addition, PIC should be preferred in treatments where drugs and solutions suitable for peripheral therapy (< 900 mOsm/L, not vesicant or irritant) are administered for less than 6 days (Moureau & Chopra, 2016).

Catheter Building Material

While the use of metal or plastic catheters is decreasing in PIC application, the use of polyurethane catheters is increasing (Atabek & Karadağ, 2019; Kuş & Büyükyılmaz, 2019). Polyurethane catheters should be preferred in PIC selection because they are soft, cause less vein damage and are resistant to kinks (UDEYR, 2019; Berse et al., 2020).

Catheter Size (Diameter and Length)

It is recommended that the size of PICs to be applied to patients should be determined according to the patient's age, diagnosis, vein condition, activity status and the fluid/drug treatment to be administered (INS, 2021). In the literature, it is recommended to use the smallest catheters possible to prevent vein damage and to ensure that the administered drugs or fluids mix with the blood (Gabriel, 2018; Nickel, 2019). According to UDEYR (2019), it is recommended to use PICs numbered 14-16 for infusion of fluids that need to be given intensively and rapidly, numbered 20-24 for intermittent and slow drug and fluid applications, and at least numbered 20 for parenteral nutrition. The Infusion Nurses Association Practice Guideline (2021) states that PICs can be used in vulnerable patient populations such as the elderly and children, and catheters numbered 24-26 can be used for low-speed infusion treatments. In addition, it is recommended that smaller diameter catheters should be preferred in patients in whom surgical intervention is not planned, blood transfusion is not performed, vein length is short and feeding is difficult; and larger diameter catheters should be preferred in adults, patients with acute trauma, and patients with visible and palpable veins (INS, 2021). It is also stated that rapid fluid and blood infusion, transplantation treatment procedures and treatment of acute trauma conditions can be applied with large diameter catheters numbered 14-18 (Phillips & Gorski, 2014).

Duration of Catheter Use

It is known that PIC can be used safely for up to 72-96 hours as long as there is no risk of infection and phlebitis. It is stated that the catheter should not be changed routinely and the frequency of catheter intervention should be minimized unless complications are observed (INS, 2021; Gorski et al., 2021; Nickel, 2019; Cooper, 2019).

In a study by Urbanetto et al. (2018) on the duration of catheter use, it was reported that the incidence of phlebitis symptoms increased as the duration of catheter use increased (≥ 72 hours). (2012), it was found that PICs were used for a longer period of time without complications when replacement was performed in the presence of clinical indication instead of routine replacement between 72-96 hours. In another study, it was found that there was no difference in the development of complications between the experimental group in which PIC exchange was performed according to clinical findings and the control group in which routine exchange was performed (Lu et al., 2018). According to UDEYR (2019), it is recommended that short peripheral catheters should be removed when not in use for 24 hours or longer, peripheral catheters should be changed only in the presence of clinical indications in adults and children, and evaluated at least once in each shift. It is also recommended that catheters inserted under emergency and non-aseptic conditions should be recorded and replaced with a new catheter as quickly as possible within 24-48 hours. Nurses should use scales such as infiltration scale and phlebitis diagnostic scale during catheter evaluation and record their observations (Çelik & Avşar, 2021). According to Nickel's (2019) recommendation, a maximum of two catheter interventions are recommended for a patient by a healthcare professional in first-time or repeated PIC interventions. Studies indicate that the complication development rates of repeated failed attempts in catheterization are between 35% and 50% (Tosun et al., 2020; Simin et al., 2019; Carr et al., 2016).

2.4. Verilen Liquid/Drug Types

The pH values of fluids and drugs may differ from the pH values of blood (Potter et al., 2019). Acidic and basic fluids and drugs damage the tunica intima layer of the vein and cause the development of complications. Some drugs pose a higher risk for complications. (2016) reported that the use of steroids, phenytoin, dextrose, ampicillin/sulbactam combination, vancomycin and highly concentrated electrolytes increased the risk of complications. In another study, it was reported that acidic, basic compounds and vasopressors cause extravasation (David et al., 2020). In addition, it is stated in the literature that drugs should not be administered in liquid infusions and drugs should be diluted with an appropriate amount of liquid (at least 100 ml) and administered as intermittent infusion (UDEYR, 2019). In the transitions between fluid treatments, it is stated that washing should be done before and after treatment with ready injectable saline solution (Duarte-Clímets, 2021).

Osmolality of Liquid

The difference between the osmolality of intravenously administered fluids and the osmolality of blood may cause irritation of the fluids on the vein wall. Normal serum osmolality is usually in the range of 275-295 mOsm/kg. It is stated that hyperosmolar agents such as parenteral nutrition solutions, magnesium sulfate, potassium chloride, sodium

bicarbonate will cause extravasation (David et al., 2020). According to the Infusion Nurses Society (INS) (2021), fluids with an osmolarity higher than 600 mOsm/L should generally be administered centrally.

BASIC PRINCIPLES IN PIC APPLICATIONS

In PIC applications, there are basic principles to be considered in hand hygiene, glove use, skin asepsis, anatomical region used, frequency of use, tools placed in the catheter entry, fixation and maintenance of the catheter site.

Hand Hygiene and Glove Use

To prevent catheter-associated infections; hand hygiene should be practiced meticulously before and during catheter insertion and aseptic technique should be followed during catheter interventions. Effective hand hygiene can be achieved by rubbing hands with alcohol-based hand antiseptic until dry or by hand washing with soap and water. Clean gloves should be worn while wearing the PIC. Wearing gloves does not eliminate the need for hand hygiene; hand hygiene must be ensured before and after gloves are put on (UDEYR, 2019).

Skin Antisepsis

Preparation of the catheter insertion site and skin cleansing before PIC is very important in preventing catheter-associated infections. Before skin evaluation, the patient should be questioned about any history of allergy or sensitivity. If the area is visibly dirty, it should first be cleaned with soap and water. Then, the area to be treated with PIC should be wiped with alcohol containing >0.5% chlorhexidine or 70% alcohol containing 2% chlorhexidine in a single motion by gently pressing from top to bottom and the area should be allowed to dry spontaneously for at least 15 seconds or two minutes. It is also stated that in individuals with contraindications to the use of alcohol-containing chlorhexidine, povidone iodine or only 70% alcohol solution should be preferred (Gorski, 2021; Nickel, 2019).

Anatomical Region Used and Frequency of Use

The recommended PIC insertion site in the literature is the forearm, but the appropriate catheter and vein should be selected considering the infusion fluid to be administered, the patient's age, weight and duration of treatment (Erdoğan & Denat 2016; Gorski et al., 2016; Potter et al., 2019). When determining the area for PIC, the choice should be made from distal to proximal extremity. Cephalic, basilic or metacarpal veins should be preferred (Nickel, 2019). Application to veins that are difficult to palpate, red or painful should be avoided. In a study, it was found that nurses mostly preferred upper extremities in PIC applications (Berse et al., 2020). Lower extremity veins and flexion areas should not be preferred unless it is mandatory due to the risks such as infiltration, phlebitis and dislocation of PIC (Gorski et al., 2016; Potter et al., 2019). In cases requiring application to these areas, the area should be immobilized (Erdoğan & Denat, 2016). In addition, lower extremities should not be used in patients with diabetes due to the risk of tissue damage and tissue necrosis. PIC should not be preferred on bony prominences, hand and joint areas, and areas where the vein bifurcates unless absolutely necessary (Phillips & Gorski, 2014; Potter et al., 2019). PIC should not be placed in the relevant extremity in patients who have undergone mastectomy and have a fistula (Potter et al., 2019). When vein selection is difficult in

PIC applications, various imaging devices such as ultrasound can be used (Simin et al., 2018).

Tools Placed at the Catheter Entrance

The need for tools such as a drip setting set that ensures that the fluids and drugs given to the patient via PIC are delivered in a certain amount per hour, a three-way tap that allows multiple drugs and fluids to be given to the patient from the same PIC, and an infusion pump that is attached to the Y-port of a primary infusion fluid and has a short set should be evaluated (Uzun, 2012). In PIC applications, catheter connections with screw-locking (luer-lock) system should be preferred and needle-free intervention apparatus should be used to reduce the risk of catheter-associated infection. The needle-free apparatus should be cleaned with 70% alcohol before each use and intervention should be performed after complete drying (INS, 2021). In a study, it was determined that there was a 50% decrease in PIC-induced infections and annual care costs in patients using needle-free apparatus compared to the 3.5.

Catheter Site Fixation and Care

It is recommended to fix the catheter as catheter movement may increase the risk of complications. The nurse should fix the PIC in the vein by assessing the patient's age, skin turgor, skin integrity and skin damage caused by the previous fixation material. It is recommended to use transparent and semi-permeable polyurethane dressings for fixation of the catheter site to ensure visibility of the infusion site and facilitate assessment (Gabriel, 2018; Simin et al., 2019). Skin microflora at the catheter site is known to play an important role in catheter-associated infections. Therefore, catheters should be covered with a sterile catheter dressing material so as not to interfere with vascular circulation and treatment (Loveday et al., 2020). The catheter insertion site should be monitored for redness, edema, increased temperature and signs of infiltration as long as it is inserted. The catheter dressing must be changed when its integrity is compromised or visibly soiled. The skin antiseptic should be allowed to dry completely before the dressing is placed, at least 30 seconds for alcoholic chlorhexidine and 1.5-2 minutes for povidone-iodine. The application of cream containing antibiotics to the catheter entry site is not recommended except for hemodialysis catheters due to the increasing effects of fungal infections and antimicrobial resistance (UDEYR, 2019).

Intravenous washing/locking: In the literature, it is recommended to evaluate catheter function by flushing and aspiration before intermittent use of catheters and when clinically indicated for continuous infusions. The type and size of the catheter, the age of the patient and the type of infusion therapy being given should be taken into consideration when selecting the flushing volume. At a minimum, approximately 5 ml of preservative-free saline in a volume equal to twice the internal volume of the catheter system should be used to flush peripheral catheters. If preservative-containing saline is used, no more than 30 ml should be used within a 24-hour period to reduce the potential toxic effects of benzyl alcohol (Adams et al., 2016; Frank, 2016).

Change of sets: Sets should be routinely replaced at the recommended intervals according to factors such as type of solution, frequency of infusion (intermittent or continuous). If the integrity of the product or system is compromised

or contamination is suspected, the set should be replaced immediately. In addition to routine changes, the set should also be changed when the PIC site is changed or a new catheter is inserted. The packaging should be checked for latex content and latex-containing sets should be avoided for patients with latex allergy (Ranum & Hagle, 2014; O'Grady, 2011; Adams et al., 2016).

Primary and secondary continuous infusion sets do not need to be routinely changed before 72-96 hours (except for sets administering lipids, blood or blood products, etc.). Secondary infusion sets added to the primary continuous set should be changed every 24 hours. Intermittent infusion sets should be changed every 24 hours. After each intermittent use, a new, sterile and compatible cap should be aseptically attached to the catheter insertion end of the administration set (Guanche-Sicilia, 2021). The transfusion administration set should be replaced after the completion of each unit or every 4 hours. Sets used for propofol infusions should be replaced every 6 or 12 hours according to the manufacturer's instructions. Sets of IV lipid emulsion infused alone should be changed every 12 hours. Parenteral nutrition solutions and sets should be changed every 24 hours at the latest.

Use of safe products for patient/staff: An estimated 35 million healthcare workers are injured with sharps annually worldwide. Needlestick injuries are a common occupational risk for healthcare workers. The most commonly transmitted infections are human immunodeficiency virus (HIV), hepatitis B virus (HBV) and hepatitis C virus (HCV). Safety injectors and PICs should be preferred for safe injection practices. Thus, a 95% reduction in needle sticks and injuries can be achieved. An integrated closed system with a safety strip should be preferred to reduce blood leakage from the PIC body and blood exposure risks (UDEYR, 2019).

Needle sticks and injuries can be prevented by using a needle-free intervention apparatus. A blunt needle tip that protects healthcare workers from needle sticks and injuries that may occur during drug preparation, cleans glass and fungal particles that may be mixed into the solution during drug preparation thanks to its filter, and thus protects patient health and safety should be used.

PATIENT/RELATIVE AND STAFF TRAINING

Patient education is important for early diagnosis of complications. The Turkish Society for Hospital Infections and Control (2019) emphasized the need to inform the patient and obtain consent before invasive procedures. The nurse should educate the patient/relative about the intended and expected outcomes, infusion therapy, potential complications or treatment-related side effects, risks and benefits. Patients and relatives should also be informed about aseptic technique, prevention of infection and other complications, including hand hygiene. They should support the patient to avoid touching the catheter insertion site or drape, to keep the site dry and avoid sudden movements, and to report any pain, swelling or redness at the catheter site to healthcare personnel. They should also be informed about where to report complications and symptoms that may occur after the catheter is removed or the patient is discharged, and about the safe storage, maintenance and disposal of solutions, consumables and equipment (UDEYR, 2019).

Prevention and control of catheter-associated bloodstream infections should be part of the basic education of nursing students at both undergraduate and graduate levels. Healthcare workers should be educated on indications for PIC use, rules for insertion and care, and infection control measures. The knowledge and compliance of all personnel involved in PIC insertion and care with current guidelines should be regularly evaluated (UDEYR, 2019).

CONCLUSION

PIC applications are one of the invasive interventions that nurses are responsible for and frequently apply. In this context, it is important for nurses to perform their practices by taking into account the current literature and guidelines regarding this practice in order to improve the quality of care, prevent complications, increase patient comfort, and reduce costs and workload. In addition, determining current approaches to reduce and prevent complications in safe PIC practices and increasing research in this field will contribute to improving the quality of patient care and achieving effective results by integrating it into clinical practice.

ETHICAL DECLARATIONS

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper and that they have approved the final version.

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