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Nursing Strategies for Preventing Peripheral Intravenous Infiltration and Extravasation in Hospitalized Patients

Hussam Hussain Mahrous[1], Raghad Musharraf Kassar Alanazi[2], Jamilah Dahl O Alruwaili[3], Wedyan Yousef Nassar Alharbi[4], Anwar Rashed A Alanazi[5], Ibtisam Mohammed Muqbil Alhazmi[6], Intisar Madallah M Alanazi[7], Alsharari, Fahdah Sulaiman M[8], Badrah Ibrahim Kredim Alzubidi[9], Maryam Hindi Alshammari[10]

[1] Nursing – King Fahad Hospital – Madinah Health Cluster – Ministry of Health – Madinah – Madinah Region – Saudi Arabia
Email: HMAHROUS@MOH.GOV.SA
[2] Specialist Cardiovascular Nursing – Prince Abdullah bin Abdulaziz bin Musaed Cardiac Center – Northern Borders Health Cluster – Ministry of Health – Arar – Northern Borders Region – Saudi Arabia
Email: Ralanazii20@gmail.com
[3] Nursing Specialist – Dumat Al-Jandal General Hospital – Al Jouf Health Cluster – Ministry of Health – Dumat Al-Jandal – Al Jouf Region – Saudi Arabia
Email: Jdalruwaili@moh.gov.sa
[4] Nurse – Madinah Health Cluster – Ministry of Health – Madinah – Madinah Region – Saudi Arabia
Email: wedy1407@gmail.com
[5] Nursing Technician – Beneficiary Experience Department, Branch of the Ministry of Health in the Northern Borders Region – Ministry of Health – Arar – Northern Borders Region – Saudi Arabia
Email: Aralanze@moh.gov.sa
[6] Nursing – Burj Al-Shamal Medical Hospital – Northern Borders Health Cluster – Ministry of Health – Arar – Northern Borders Region – Saudi Arabia
Email: IbMAlhazmi@moh.gov.sa
[7] Nursing Specialist – Branch of the Ministry of Health in the Northern Borders Region – Ministry of Health – Arar – Northern Borders Region – Saudi Arabia
Email: inalanazi@moh.gov.sa
[8] Nursing Technician – Eradah and Mental Health Complex, Al Qurayyat – Al Jouf Health Cluster – Ministry of Health – Al Qurayyat – Al Jouf Region – Saudi Arabia
Email: Fahdaha@moh.gov.sa
[9] Staff Nurse – Dogah Al-Awla Primary Health Care Center – Al-Qunfudhah – Makkah Region – Saudi Arabia
Email: bedo1426.hm@gmail.com
[10] Nursing Specialist – Northern Borders Health Cluster – Ministry of Health – Arar – Northern Borders Region – Saudi Arabia
Email: Mahialshammari@moh.gov.sa

ABSTRACT: Infiltration and extravasation are significant complications associated with peripheral intravenous (IV) therapy, often leading to pain, swelling, and potential long-term

tissue damage. To prevent these occurrences, nurses should employ a combination of strategic assessment, patient education, and vigilant monitoring. Initial strategies include selecting appropriate IV sites by avoiding areas with compromised circulation, using the smallest catheter size necessary, and utilizing ultrasound guidance when indicated. Regular assessment of the IV site for signs of swelling, redness, or discomfort is crucial. If infiltration is suspected, the IV should be promptly removed, and the site should be elevated and monitored. Additionally, education plays a vital role in preventing complications associated with peripheral IV therapies. Healthcare providers should inform patients about the signs and symptoms of infiltration and extravasation, empowering them to communicate any discomfort or changes promptly. Implementing standardized protocols for IV fluid administration, including appropriate rates and concentrations, can minimize the risk of complications. Ongoing training and simulation exercises for nursing staff in recognizing early signs of infiltration and extravasation are also essential.

INTRODUCTION

Peripheral intravenous (PIV) therapy is one of the most frequently performed invasive procedures in hospitalized patients, and nursing interventions play a central role in determining whether PIV therapy remains safe and effective [1]. PIV catheters are used for fluids, medications, blood products, and nutritional support, but they are associated with preventable complications that can affect patient comfort, treatment continuity, and clinical outcomes [2]. The burden of PIV-related complications is particularly evident in hospitalized populations, where infiltration, extravasation, phlebitis, and catheter failure remain common despite advances in vascular access practice [3]. Pediatric and neonatal patients are especially vulnerable because of small vessel caliber, fragile skin, limited communication, and greater dependency on continuous infusion therapy [4].

Prevention of infiltration and extravasation is therefore a core nursing responsibility. Nurses are present at insertion, during infusion, and at every reassessment point, and they are best positioned to detect early changes before tissue injury becomes severe [1]. Evidence-based bundles such as the PIVC-SAFE care bundle have demonstrated that structured nursing practices can reduce infiltration and improve first-attempt insertion success in pediatric emergency settings [5]. Best-practice implementation projects have also shown that gaps in hourly assessment, documentation, and post-event management can be reduced through education, standardized tools, and practice audit [6]. These findings confirm that infiltration and extravasation are not inevitable complications of PIV therapy but are largely preventable through consistent, nurse-led prevention strategies.

Definitions and Classification: Infiltration versus Extravasation

A clear understanding of the difference between infiltration and extravasation is essential for prevention, early recognition, and appropriate management. Infiltration refers to the leakage of non-vesicant intravenous fluid or medication into surrounding subcutaneous tissue, whereas extravasation refers to the leakage of a vesicant or irritant substance that can cause tissue damage [7]. This distinction matters because non-vesicant infiltration may resolve with conservative care, while extravasation of a vesicant can progress to blistering, necrosis, compartment syndrome, and permanent disability [7]. The clinical approach to non-chemotherapy infiltration and extravasation therefore requires prompt recognition, cessation of infusion, elevation, and severity-based management [7].

Intravenous medications are commonly classified as non-vesicants, irritants, or vesicants. Non-vesicants generally have little soft-tissue toxicity, irritants may cause pain and mild local injury, and vesicants can cause extensive tissue necrosis and ulceration [7]. This classification guides risk stratification, monitoring intensity, and decisions about whether peripheral access is appropriate. Table 1 summarizes the classification of infusates and the associated clinical significance for leakage events.

Table 1. Classification of Infusates and Clinical Significance for Leakage Events

Category	Definition	Examples	Potential for Tissue Injury	Nursing Priority
Non-vesicant	No significant soft-tissue toxicity	0.9% sodium chloride, lactated Ringer's, most antibiotics	Low	Monitor, remove catheter if infiltration occurs, provide supportive care

Irritant	Causes pain along the vein or at the site, with limited tissue damage	Some antibiotics, dilute potassium chloride, radiographic contrast	Moderate	Prompt recognition, stop infusion, symptomatic management
Vesicant	Causes extensive necrosis, ulceration, and blistering	Anthracyclines, vinca alkaloids, vasopressors, concentrated electrolytes	High	Immediate cessation, antidote consideration, surgical consultation, close monitoring

Incidence and Clinical Burden of Infiltration and Extravasation

The reported incidence of PIV infiltration and extravasation varies across settings and populations, but the available evidence indicates that these events are frequent and clinically important. In a study of 11,006 pediatric surgery inpatients with 19,771 PIV catheters in China, the incidence of PIV infiltration and extravasation was 16.93% [8]. In neonatal and pediatric populations, extravasation identification and management practices vary widely, and the reported incidence of neonatal extravasation and related complications has ranged from 1.0% to 78.0% depending on definitions and monitoring intensity [9]. These figures highlight both the vulnerability of certain populations and the inconsistency of surveillance practices.

The clinical burden of infiltration and extravasation extends beyond local swelling and discomfort. Extravasation can cause pain, erythema, blistering, skin necrosis, nerve damage, compartment syndrome, and in severe cases amputation [10]. When infiltration occurs, patients may not receive the prescribed dose of medication, which can delay therapeutic effects and prolong hospitalization [10]. The preventable nature of many events makes surveillance, early recognition, and standardized nursing response essential components of hospital safety [8]. Table 2 summarizes the principal risk factors that contribute to these events.

Risk Factors for PIV Infiltration and Extravasation

The development of infiltration and extravasation is multifactorial and reflects patient characteristics, catheter-related factors, infusate properties, and care delivery practices. Extremes of age are important, with neonates and older adults demonstrating elevated vulnerability because of fragile veins and reduced subcutaneous integrity [4]. In pediatric patients, smaller catheter gauges, catheter dislodgement, and hospitalization in surgical wards have been associated with increased risk of infiltration and phlebitis [4]. The number of insertion attempts and the quality of catheter securement are also important modifiable factors because repeated puncture and poor stabilization increase endothelial trauma and catheter migration [3].

Infusate-related factors include osmolality, pH, duration of infusion, and the intrinsic irritant or vesicant potential of the medication [3]. Continuous infusion has been identified as an independent risk factor for infiltration in children because it exposes the vessel wall to prolonged mechanical and chemical irritation [4]. Care delivery factors include inconsistent hourly assessment, inadequate documentation, and failure to elevate the affected extremity after an event; these gaps have been documented in best-practice implementation projects [6]. Table 2 organizes these risk factors into discrete domains to support risk stratification at the bedside.

Table 2. Multifactorial Risk Factors for PIV Infiltration and Extravasation

Domain	Risk Factors	Clinical Implications
Patient-related	Neonatal and infant age; older adult age; fragile skin; small vessels; surgical ward hospitalization	Elevated baseline vulnerability; requires heightened surveillance
Catheter-related	Small-gauge catheters in children; catheter dislodgement; inadequate securement; multiple insertion attempts	Modifiable through device selection, site selection, and stabilization
Infusate-related	Continuous infusion; high osmolality; extreme pH; irritant or vesicant medications	Requires risk-stratified monitoring and consideration of central access
Care delivery-related	Inconsistent hourly assessment; poor documentation; knowledge gaps; delayed response	Addressed through bundles, education, audit, and feedback

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Site Assessment and Monitoring: The Cornerstone of Early Recognition

Early recognition depends on systematic, frequent, and structured nursing assessment of the PIV site. Validated tools are essential because they standardize language, severity grading, and clinical action thresholds. The Pediatric Peripheral IV Infiltration Scale provides a pediatric-specific framework for grading infiltration severity and has been used to improve consistency in pediatric practice [11]. The INS Infiltration Scale grades infiltration from 0 to 4 using edema size, skin color, temperature, and circulatory status, allowing nurses to quantify severity and guide escalation [12]. The Millam grading system provides an additional framework for extravasation and infiltration events, particularly in neonatal and pediatric populations where skin and vessel fragility require adapted assessment [13].

The Visual Infusion Phlebitis (VIP) score is a validated 0–5 scale that links observable signs of phlebitis to defined clinical actions at every stage [14]. A score of 0 indicates a healthy site and continued monitoring; a score of 1 indicates possible first signs and increased vigilance; a score of 2, defined by the presence of any two of pain, erythema, or swelling, is the validated threshold for catheter removal and re-siting [14]. Higher scores indicate progressively severe phlebitis and require catheter removal with treatment and escalation [14]. The Touch, Look, Compare method complements these scales by prompting palpation, visual inspection, and contralateral comparison, which are particularly useful in neonates and infants who cannot report pain [6]. Table 3 compares commonly used assessment and grading tools.

Table 3. Comparison of PIV Site Assessment and Grading Tools

Tool	Purpose	Grading	Key Features
Pediatric PIV Infiltration Scale	Pediatric infiltration grading	0–4	Percentage-based limb involvement; validated in pediatric populations [11]
INS Infiltration Scale	Infiltration severity grading	0–4	Edema measurement; skin color and temperature; circulatory assessment [12]
Millam Grading System	Extravasation and infiltration grading	I–IV	Adapted for fragile skin and small vessels [13]
VIP Score	Phlebitis assessment and action threshold	0–5	Score 2 is removal threshold; links each score to clinical action [14]

Prevention Care Bundles: Integrating Multiple Strategies

Individual prevention measures are most effective when integrated into a coordinated care bundle. A scoping review of bundles for preventing infiltration in short peripheral intravenous catheters in children found that bundle components ranged from four to seven interventions, with PIV catheter stabilization and dressing being the most frequently reported component [15]. Another study demonstrated that peripheral intravenous catheter care bundle instructions reduced phlebitis and infiltration grades and improved catheter dwell time among patients undergoing chemotherapy [16]. These findings support the use of bundles as a practical method for translating evidence into bedside practice.

The PIVIE Prevention Bundle operationalizes prevention through three integrated components: hourly TLC assessment with real-time documentation, confirmation of dressing and securement integrity with site visibility, and patient and family education on the TLC method [17]. For patients who experience a PIVIE event, the bundle specifies a structured response: stop the infusion, leave the catheter in place, elevate the extremity, refer to the infiltration/extravasation management standard operating procedure, notify the vascular access team and provider, and reassess and document every hour for two hours and then every four hours until resolution [17]. This structured approach reduces variation and ensures that early recognition is linked to immediate action [17]. Table 4 summarizes evidence-based bundle components and outcomes.

Table 4. Evidence-Based PIV Prevention Bundle Components and Outcomes

Bundle Component	Specific Practices	Reported Outcomes
Insertion and aseptic technique	Chlorhexidine-alcohol antisepsis; limited attempts; hand hygiene	Reduced infiltration; improved first-attempt success [5]
Securement and stabilization	Transparent dressing; integrated securement; tissue adhesive adjunct	Reduced catheter failure and dislodgement [18,19]

Hourly assessment	TLC/ACT method every 60 minutes; real-time documentation	Earlier recognition and reduced injury severity [6,17]
Education and competency	Structured training; simulation; protocol education	Improved nurse knowledge and vigilance [23,24]
Structured response	Stop infusion; leave catheter; elevate limb; notify; reassess	Reduced progression to severe injury [17]

Insertion, Securement, and Dressing Practices

Prevention begins at insertion. Site selection should prioritize straight, palpable veins of adequate caliber while avoiding joints, areas of flexion, and sites with compromised skin integrity [2]. The smallest catheter gauge appropriate for the prescribed therapy should be used to minimize endothelial trauma, although small-gauge catheters in pediatric patients may still carry elevated risk because of vessel fragility [4]. For vesicant medications and other high-risk infusates, central vascular access should be considered whenever clinically feasible [7]. Limiting insertion attempts and escalating to an experienced clinician after repeated failures can reduce endothelial trauma and subsequent catheter failure [5].

Securement and dressing are among the most consistently emphasized prevention measures. A systematic review and meta-analysis of dressing and securement methods for peripheral intravenous catheters found that securement practices influence catheter failure and complication rates [18]. In children, novel peripheral intravenous catheter securement strategies have been associated with reduced catheter failure compared with standard care [19]. Transparent semipermeable membrane dressings maintain site visibility, while tissue adhesive and integrated securement dressings provide additional stabilization in high-risk patients [18,19]. Joint stabilization boards may be used when the catheter is near a joint to reduce movement-related dislodgement [2]. Table 5 summarizes evidence-based insertion and securement practices.

Table 5. Evidence-Based Insertion and Securement Practices for PIV Prevention

Practice Domain	**Recommendation**	**Rationale**
Site selection	Choose straight, palpable veins; avoid joints and flexion areas	Reduces mechanical irritation and dislodgement [2]
Catheter gauge	Use the smallest gauge appropriate for therapy	Minimizes endothelial trauma [4]
Securement	Transparent dressing; tissue adhesive adjunct; integrated securement in children	Maintains visibility and prevents migration [18,19]
Stabilization	Joint stabilization board if indicated; minimize manipulation	Reduces mechanical phlebitis and catheter migration [2]
Insertion attempts	Limit attempts and escalate after repeated failure	Reduces endothelial trauma and failure risk [5]

Early Recognition and Immediate Nursing Response

When infiltration or extravasation is suspected, the nurse must immediately stop the infusion [7]. The catheter should generally be left in place initially to allow aspiration of residual drug and to facilitate antidote administration if indicated, although institutional protocols vary [20]. The affected extremity should be elevated to promote venous return and reduce edema, and this simple measure is frequently omitted in practice despite its recognized benefit [6]. The severity of the event should be graded using a standardized scale, and the provider and vascular access team should be notified promptly [17]. Warm or cold compresses may be applied depending on the infusate and institutional protocol, and antidote administration should be considered for severe events or vesicant extravasation [20].

Neurovascular status must be assessed and documented, including capillary refill, pulse, sensation, and motor function [21]. Any signs of neurovascular compromise or suspected compartment syndrome constitute a surgical emergency requiring immediate escalation [21]. The Royal Children's Hospital Melbourne guideline emphasizes initial management and washout

procedures for peripheral extravasation injuries, reinforcing the need for structured escalation when tissue injury is suspected [21]. NHS Scotland guidance similarly stresses prompt recognition, cessation of infusion, elevation, and referral for severe extravasation injuries [20]. These guidelines support a consistent nursing response that prioritizes patient safety and limits progression of tissue damage [20,21].

Management of Extravasation: Antidotes and Supportive Care

The management of extravasation extends beyond immediate cessation and elevation to include specific antidote therapy for certain infusates and supportive measures to limit tissue injury [7]. Hyaluronidase is commonly used for non-vesicant extravasation because it facilitates dilution and diffusion of the extravasated drug, reducing local concentration and tissue contact time [7]. Phentolamine is used primarily for extravasation of vasopressors and other sympathomimetic agents, producing local vasodilation and improving blood flow to the affected area [7]. Sodium thiosulfate is used for selected vesicant extravasations and neutralizes reactive species that contribute to tissue injury [7]. The choice of antidote depends on the specific medication that has leaked, and rapid identification of the offending agent is essential [7].

Supportive care includes elevation, compression or cold/warm compresses as appropriate, analgesia, and close monitoring for progression [20]. For severe extravasation with large volume or suspected compartment syndrome, surgical consultation is mandatory, and surgical intervention including fasciotomy or washout may be required [21]. Following the acute event, the affected area should be reassessed at regular intervals—hourly for the first several hours and then every four hours until resolution—with documentation of size, color, temperature, tenderness, and neurovascular status [17]. Patients and families should receive education about delayed complications, including infection and necrosis, and follow-up arrangements should be made when appropriate [21].

Special Populations: Pediatric and Neonatal Considerations

Pediatric and neonatal patients require dedicated prevention strategies because their risk profile and clinical presentation differ from those of adults. Pediatric patients are at greater risk for infiltration and extravasation because of sensitive skin, small blood vessels, limited communication, and mobility [4]. Neonates are particularly vulnerable because of flexible subcutaneous tissue, small blood vessels, and poor venous integrity, all of which increase the risk of complications from venipuncture and infusion therapy [9]. The incidence of PIV infiltration and extravasation in pediatric populations has been reported to range from 16% to 20% in some reviews and to be as high as 78% in certain neonatal studies, reflecting both vulnerability and variation in monitoring practices [8,9].

Prevention in these populations requires adaptations to general strategies. Hourly site assessment is considered best practice for patients receiving continuous infusions, and in neonates and infants the site should be monitored hourly because these patients cannot express pain or discomfort [9]. The TLC method is particularly valuable because it does not rely on patient self-report [17]. Safe site selection should avoid active limbs, and cannula dwell time should be minimized [4]. Care bundles specifically designed for pediatric populations, such as the PIVC-SAFE bundle, have demonstrated reductions in infiltration rates from 46% to 25% and improvements in first-attempt insertion success from 41% to 70% [5]. Parental involvement in observation can extend surveillance beyond nursing rounds and has been incorporated into pediatric prevention bundles [17].

Nurse Education and Competency Development

The effectiveness of any prevention strategy ultimately depends on the knowledge, skills, and vigilance of the bedside nurse. Simulation-based education has emerged as an effective approach for improving infiltration recognition and clinical decision-making. A randomized controlled trial evaluating standardized patient and in situ simulation for IV infiltration recognition is designed to test whether simulation improves nursing students' ability to recognize PIV catheter-related infiltration and enhance clinical decision-making [23]. Scenario-supported training combining theoretical lectures with case-based simulation activities has also been shown to improve pediatric nurses' competencies in extravasation and infiltration management, with the strongest effect observed in clinical skills [24]. These educational approaches provide a safe environment for practicing assessment, escalation, and response before real patient harm occurs [23,24].

Education should be ongoing rather than a one-time event, and competency should be verified through direct observation and documentation audit [6]. Best-practice implementation projects that include education on hourly PIV assessment using the ACT method, a 60-minute rounding tool, and a management algorithm have demonstrated improvements in practice and are recommended for standardizing care and strengthening staff skills [6]. Structured education should include definitions of

infiltration and extravasation, risk factors, severity grading, immediate response, antidote awareness, and documentation requirements [7,17]. This comprehensive approach ensures that nurses can recognize subtle early signs and act promptly [23,24].

Documentation and Quality Improvement

Accurate and contemporaneous documentation is both a professional and a safety imperative in the prevention and management of PIV complications. Documentation should include the date and time of each site assessment, the VIP score or infiltration grade, the presence or absence of pain, erythema, swelling, and leakage, the integrity of the dressing and securement, and any interventions performed [14,17]. When an event occurs, documentation should capture the time of recognition, the infusate involved, the volume infused, the severity grade, the immediate response, notifications made, and the plan for ongoing reassessment [17]. Underreporting of infiltration and extravasation is a recognized problem, and standardized grading scales should be used to ensure that all events, including mild ones, are recorded and available for surveillance and quality improvement [25].

Quality improvement initiatives that combine education, standardized assessment tools, audit and feedback, and protocol implementation have demonstrated measurable reductions in PIV injury rates [6]. One quality improvement project that introduced the TLC method for hourly PIV site assessment, mandatory staff education and demonstration, and performance monitoring observed a significant reduction in injury rates [6]. A best-practice implementation project using the JBI Evidence Implementation Framework identified gaps in hourly assessment and management protocols and implemented targeted strategies that improved practice [6]. System-level strategies such as adverse event reporting, staff training, quality improvement, and multidisciplinary collaboration are emphasized as essential components of a comprehensive framework for preventing and managing infusion complications [25]. Grading PIVIE events and reviewing data regularly allows organizations to identify patterns, target education, and evaluate the effectiveness of prevention bundles [25].

CONCLUSION

Peripheral intravenous (PIV) infiltration and extravasation are common complications in hospital care that can be prevented through a nurse-driven, multifaceted approach. Key prevention strategies include careful selection of sites and catheters, adherence to securement and dressing protocols, regular site assessments, integration of care bundles, and focused education and competency training. Risk management requires awareness of the differences between infiltration and extravasation and categorization of infusions. Special attention is needed for pediatric and neonatal patients due to their vulnerability. In case of incidents, immediate actions such as stopping the infusion, elevating the limb, and monitoring for complications are crucial. The bedside nurse plays a vital role in PIV safety, and organizational support in education and standardized practices can significantly reduce preventable harm. Future directions should aim for standardized outcome definitions and pediatric-specific studies while enhancing monitoring technologies.

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