**Children's Health Orange County (CHOC)**
***Best Evidence and Recommendations (BEaR)***

# Best Practices for Peripheral IV Infiltration and Extravasation (PIVIE) Prevention in Pediatric Patients

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## Abstract

Peripheral intravenous therapy (PIV) is a fundamental nursing practice and one of the most frequently performed invasive procedures in pediatric healthcare. This healthcare intervention plays a vital role in delivering life-saving fluids, medications, nutrition, and blood; however, intravenous therapy (IV) carries a significant risk of infiltration and extravasation, which can result in patient injury, prolonged hospital stays and increased healthcare costs. Compared to adults, children are particularly vulnerable to PIV complications due to their small and fragile veins, the location of the IV, and the aggravating characteristics of the medication or fluid being administered.

This project aimed to address the question: What are the best practices for preventing peripheral IV infiltrations and extravasations (PIVIE) in pediatric patients? A comprehensive review of evidence was performed to identify the most effective recommendations for PIVIE prevention. The project led to four key practice change recommendations: risk assessment, advanced monitoring techniques using technology, PIV care bundles, and buddy checks. The outcomes of this project will be measured using the institution's PIVIE data, with the goal of minimizing harm and identifying optimal interventions to improve patient care.

## Keywords

Infiltration, extravasation, PIVIE, nursing, prevention, pediatrics, children, infusion therapy, bundle

## PICO(T)

What are the best practices for preventing peripheral IV infiltrations and extravasations (PIVIE) in pediatric patients?

## Background and Significance

Peripheral intravenous therapy (PIV) is one of the most frequently performed invasive procedures in pediatric healthcare settings. This healthcare intervention is essential for

delivering medications, fluids, nutrition, and blood products. However, pediatric patients are particularly vulnerable to complications due to their small, fragile veins and increased mobility (Park, Jeong, Kim et al., 2016). Additionally, children's limited ability to understand, communicate, and report discomfort also makes them more susceptible to pain, anxiety, and fear during vascular access attempts (Dufficy et al., 2022; Hartman et al., 2020).

Among the complications associated with PIV therapy, infiltration and extravasation are of significant concern. Infiltration occurs when a non-vesicant solution or medication unintentionally leaks out of the vein into the surrounding tissue, while extravasation involves the leakage of vesicant solutions. Extravasation injuries can lead to severe complications, such as tissue necrosis, compartment syndrome, nerve damage, or even amputation (Doellman & Rineair, 2019). As many as 11% of pediatric patients and up to 70% of neonates may experience an extravasation from intravenous therapy (Dufficy et al., 2022). The incidence of PIV complications is higher in pediatric patients than adults, with rates ranging between 34 to 56% compared to 20% to 32% in adults (Indarwati et al., 2020). These complications can prolong hospital stays, increase healthcare costs, and cause unnecessary pain and discomfort (Watterson et al., 2018). Catheter-related blood stream infections can cost up to $47,600 per event, and replacing a PIV can cost approximately $85 per catheter (Dufficy et al., 2022; Indarwati et al., 2020).

While our institution has implemented internal resources to reduce PIVIEs within our institution, there remains considerable room for improvement. The current policy requires nurses to assess IV sites hourly for infusing IVs and every two hours for heparin or saline-locked IVs. As part of documentation changes in March 2024, Touch, Look, Compare (TLC) assessments and family education were introduced. Nurses were trained through online modules to use TLC for IV assessments and to educate families on this process. Nurses are instructed to touch the skin to determine any changes in temperature, swelling, or pain; look for any blanched, translucent, or red skin at the insertion site; and compare the extremity with the opposite limb for signs of swelling. Additional measures for determining IV patency include flushing, checking for blood return, and assessing pain. TLC flyers were printed and distributed for patient and family education upon admission.

In August 2024, nurses from selected units were asked, "What is the primary barrier that prevents you from hourly assessing your patients' infusing IVs?" Responses revealed that 50% cited high workloads – such as being "stuck" in a patient room, especially for new admissions or high-acuity patients – as a barrier to consistent IV assessments. Additionally, 31% mentioned concerns about patient comfort, particularly when parents did not want to disturb their child. Thirteen percent mentioned oversight or forgetting, and 6% cited technical challenges, such as IVs being wrapped and difficult to assess.

The goal of this evidence-based practice (EBP) project was to evaluate sources of evidence for best practices in preventing PIVIEs in pediatric patients. By striving to minimize harm and

identify optimal interventions for enhancing patient care, this project aligns with the institution's mission to nurture, advance, and protect the health and well-being of patients.

**Framework**

This EBP project utilized the "Translating Evidence into Practice: CHOC's Approach to EBP" model, adapted from the EBPI Model © 2007 Brown & Ecoff (Ecoff, Stichler & Davidson, 2020).

**Search for the Evidence**

Databases searched for this review included CINAHL, PubMed, Google Scholar, and Cochrane. Key search words: infiltration, extravasation, PIVIE, nursing, prevention, pediatrics, children, infusion therapy, bundle. This search yielded 40 articles, including quasi-experimental studies, quality improvement projects, systematic reviews, cohort studies, scoping reviews, and pilot studies. Of these articles, 14 were found to have applicable information. In addition, approaches to preventing PIVIE's were examined from Children's Health: Children's Medical Center Plano, Cincinnati Children's Hospital, and Johns Hopkins All Children's Hospital.

**Critical Appraisal and Synthesis of the Evidence**

Four areas for institutional improvement in PIVIE practices arose from the literature and evidence review: Risk Assessment, Advanced Monitoring Using Technology, PIV Care Bundles, and Buddy Checks.

***Risk Assessment***

- Given the numerous negative effects that can result from PIVIEs, prevention and risk assessment are crucial.
- Park et al. (2016) emphasized that nurses working in children's hospitals should consider the risk of IV infiltration in high-risk patients early to prevent potential damage.
- The highest risk factors for PIVIEs include younger age, IV placement in the lower limbs, being underweight, extended catheter dwell time, and the use of certain medications. These medications include those that are highly acidic or basic (phenytoin, ampicillin/sulbactam, vancomycin), have high osmotic pressure (10% dextrose), high concentration electrolytes (potassium), steroids, crystalloids, and analgesics (Jeong et al., 2016; Kaphan et al., 2024; Park et al., 2016).

***Advanced Monitoring Using Technology - The ivWatch***

- The ivWatch, developed in 2010, is a near-infrared sensor technology designed to assist with the early detection of PIVIEs through non-invasive continuous monitoring. It detects changes in the optical properties of a patient's tissue and triggers an alarm (yellow or red) when infiltration or extravasation is suspected. The ivWatch is particularly useful for

patients with high-risk factors or those receiving high-risk medications (van Rens et al., 2019).

- Literature gaps exist regarding the ivWatch, as studies have been conducted with smaller sample sizes and in single centers. Larger multicenter studies are needed to generalize the findings.
- Van Rens et al. (2019) conducted a pilot study of the device in the neonatal population and found the device had a 93.3% sensitivity. Notably, all infiltration alerts were issued before clinicians identified the PIVIE.
- In another pilot study by Doellman & Rineair (2019), conducted on patients aged between 2 weeks and 17 years, the device demonstrated 80% sensitivity in detecting infiltration events, with notifications occurring before clinician detection.
    - It is recommended that the ivWatch be used in conjunction with the bedside nurse's hourly site assessments (Doellman & Rineair, 2019).
    - Benefits of using the device include reducing costs by potentially avoiding serious harm and litigation. Barriers to implementation include the additional costs of purchasing the device and adjustments to nursing workflow (Doellman & Rineair, 2019).
- This technology is already in use at hospitals such as Cincinnati Children's Hospital and Johns Hopkins All Children's Hospital (E. Wendell, personal communication, October 3, 2024).

***PIV Care Bundles***

- A review of literature identified five distinct care bundles implemented at various children's hospitals, each resulting in a reduction in PIVIEs (Park, Jeong, Kim et al., 2016; Tasdelen & Caglar, 2021; Tofani et al., 2012; Trinidad, 2023; Watterson et al., 2018). Each bundle included a variety of interventions customized to address unique challenges.
- A systematic review by Ray-Barruel et al. (2019) concluded that implementing an evidence-based PIVIE prevention bundle has the potential to enhance patient outcomes. However, further research is needed to determine the exact components that should be included, as there is significant variation among bundles reported in literature.
- Notably, the S.T.I.C.K. bundle by Watterson et al. (2018) is a straightforward and effective approach, resulting in a reduction in IV infiltrations five to six months post-implementation (See Chart 1).
- Kaphan et al. (2024) emphasized that PIVs should be removed promptly when no longer needed.

Chart 1 The S.T.I.C.K. Bundle

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| **S** = Securement – A standardized method for IV securement was developed, which outlined specific tape types and application techniques. |
| **T** = TLC or Touch, Look, Compare – This component has already been implemented at this institution through house-wide education introduced in March 2024. Watterson |

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| et al. (2018) takes the education further by placing a visual aid of TLC in each patient room to create family awareness in surveillance of the IV. |
| **I** = Irritants – Watterson et al. (2018) collaborated with pharmacy on common irritants and sought guidance to standardize dilution practices. This information was placed in a policy and reviewed by all staff nurses. |
| **C** = Catheter – An algorithm was introduced to aid nurses in choosing the appropriate gauge and type of access, including the consideration for a midline. |
| **K** = Keep It? – Staff were encouraged to assess whether the patient still required their IV, and if oral medications could be used as an alternative to the IV form. |

***Buddy Checks***

- Children's Health: Children's Medical Center Plano (Burris-Alcala & Washington, 2024) piloted a buddy check system for IV assessments with the aim to catch PIVIEs early to prevent moderate to serious harm.
  - Literature highlights that cognitive bias can prevent nurses from noticing subtle changes in their patient's PIVs over time.
  - The process involves selecting an RN buddy to independently assess and document their patient's PIV status once per shift.
  - The pilot concluded that the buddy checks helped identify PIVIEs at an early stage preventing more serious harm. The system was well accepted among nursing staff and did not disrupt workflow.

**Practice Recommendations**

***Risk Assessment***

- Improve risk assessment of patients identified as high-risk for complications based on PIVIE risk factors and provide more frequent assessments and higher levels of monitoring for these patients.
  - Expand the risk assessment categories to encompass not only medication-related factors, but also physiologic factors, device related issues, and previous patient experiences.
- Configure the electronic medical record to indicate if the patient required a vascular access consult during previous admissions.
- Enhance MAR alerts so that medications classified as "red drugs" in the institution's PIV management policy are clearly indicated on the MAR to increase nurse awareness during medication administration.
  - Features of the electronic medical record, such as Cerner's "Smart Zone" upgrade can be used to flag high-risk drugs or patients.

***Advanced Monitoring Using Technology - The ivWatch***

- Recommend evaluation of the ivWatch at the institution. A piloted evaluation using a specific population where frequent IV site checks are more challenging due to operational constraints (e.g., the Operating Room), would be optimal.

***PIV Care Bundles***

- Implement the S.T.I.C.K. bundle by Watterson et al. (2018). The bundle is succinct, effective, and its usage demonstrated a notable reduction in IV infiltrations shortly after implementation. This bundle could be easily integrated at the institution due to the recent education and implementation of the TLC assessments.
- Implement a standardized method for IV securement and application techniques to be shared with all nursing staff.
- Provide visual aids of the TLC process, displayed in patient rooms or common areas to facilitate family awareness about proper IV monitoring.
- Collaborate with pharmacy to develop a list of common irritants and standardize dilution practices for medications with a high risk of infiltration. Once developed, provide nursing education on these irritants and their impact on IV maintenance.
- Develop algorithms to guide nurses in selecting the appropriate gauge for IV placement and determining whether the patient is a candidate for a midline catheter.

***Buddy Checks***

- Implement independent buddy checks hospital-wide, where nurses assess and document IVs at least once per shift for every patient with an IV.
- Analyze the institution's patient data to identify when PIVIEs occur most frequently and plan buddy checks during this time.

**Outcome Measures**

Patient outcome measures will be assessed using the PIVIE data already tracked by the institution's PIVIE workgroup. Additionally, these interventions may impact patient and family satisfaction, measured through patient experience scores, as PIVIEs can increase stress for both patients and families.

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