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Reducing Pediatric Morbidity Through Development of a Clinical Practice Guideline

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Abstract
Peripheral intravenous therapy is a commonly utilized treatment modality for the care of acutely ill pediatric patients. Two risk factors include infiltration and extravasation injuries. These injuries, peripheral intravenous infiltration or extravasation injuries (PIVIEs), can vary in their clinical manifestations from minor discomfort to harm as severe as loss of limb or disfigurement. Clinicians caring for patients at risk of developing PIVIEs need to be able to act quickly to reduce potential morbidity. The purpose of this project was to create a clinical practice guideline (CPG) that would guide staff intervention if a PIVIE occurs, with the ultimate goal of reducing PIVIE-related patient morbidity. An online literature review was conducted utilizing four primary databases including PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), MEDLINE (EBSCO), and the Cochrane Library. The initial search yielded 3412 results, with 16 studies ultimately meeting inclusion criteria. The literature was appraised and translated into the CPG. The AGREE II instrument was used to guide formatting and final appraisal of the CPG. A team of stakeholders onsite were assembled including two chairs of the existing PIVIE committee and the Wound Care RN. Stakeholders were consulted during the writing process and ultimately approved and appraised the final completed CPG. The CPG was presented and submitted for final approval to the entire multidisciplinary PIVIE committee. It is recommended to pilot the CPG on a single patient unit to monitor for barriers to implementation, tailor staff education,
and evaluate the effect of implementation on patient outcomes.

*Keywords:* infiltration, extravasation, peripheral intravenous therapy, hyaluronidase, neonates, infants

**Reducing Pediatric Morbidity through Development of a Clinical Practice Guideline**

Intravenous (IV) therapy involves the insertion of a catheter into the peripheral vasculature; it is a mainstay of acute management of critically ill neonates and children (Desarno et al., 2018). IV therapy is a common route of delivery for fluid resuscitation, nutrition, medications, blood products, and chemotherapies (Desarno et al., 2018). As many as 74 percent of hospitalized pediatric patients require either peripheral or central vascular access during their course of treatment (Cincinnati Children’s Solution for Patient Safety, 2021). While this method is largely considered to be safe, it is not without risk. Many medications administered via IV are defined as vesicant solutions which can inflict severe damage to the vessel and surrounding tissue (Alexander, 2020; Odom et al., 2019; Ong & Van Gerpen, 2020). It is important to note that infusions can be classified as non-vesicant and still result in significant trauma (Odom et al., 2019).

Two potential consequences of intravenous therapy are infiltration and extravasation injuries. Infiltration is defined as the unintended migration of a non-vesicant solution from the intended vessel into the surrounding soft tissue (Desarno et al., 2018; Odom et al., 2019; Ong & Van Gerpen, 2020). Extravasation is defined as an unintended migration of a vesicant solution from the intended vessel into the surrounding soft tissue (Desarno et al., 2018; Odom et al., 2019; Ong & Van Gerpen, 2020). Peripheral
intravenous infiltration and extravasations (PIVIE) are a common iatrogenic consequence of intravenous therapy in the pediatric population.

The estimated incidence of PIVIEs in children ranges from 10% to 58% (Alexander, 2020; Odom et al., 2017). The incidence is highly variable depending upon age, weight, acuity, and the medications or fluids prescribed. A defined barrier to capturing an accurate incidence of these events is a lack of reliable reporting methods and outcome follow up (Crowther et al., 2011). Neonates and small children have many factors that contribute to their increased risk of developing PIVIEs.

Neonatal risk factors include fragile vessels with reduced diameter, anatomically immature skin, reduced cohesion between the epidermis and dermis, inability to verbally communicate pain, and a lack of subcutaneous tissue (Desarno et al., 2018; Kostogloudis et al., 2015; Odom et al., 2018). Incidence in extremely low birthweight (ELBW) infants is high, estimated at 11 percent in neonates less than 27 weeks’ gestation (Desarno et al., 2018). An additional pediatric-specific challenge is a lack of developmental capacity to comply with medical treatments. Maintaining securement of an IV on a child that has no physical restrictions requires diligent attention however, this is not always possible in an acute care setting. Older children can also experience harm from PIVIEs as a result of pressure exerted on the blood vessels; this can result in a deformity of the vessel, causing reduced blood flow and ischemia (Odom et al., 2018). An especially high-risk subpopulation are children in the intensive care setting. These patients are critically ill and often require multiple sites of IV access. The severity of injuries can be related to the components of the fluid or medication being infused such as the osmolality, pH, chemical components and
additives, length of exposure, and mechanical pressure from the delivery method of the medication (Odom et al., 2018).

The consequences of PIVIEs can vary from minor discomfort to severe injury and can include: pain at the insertion site, swelling, redness, local irritation of the vein, infection, vascular occlusion, tissue necrosis, compartment syndrome, surgical intervention, disfigurement, and loss of limb (Alexander, 2020; Corbett et al., 2018; Desarno et al., 2018; Kuensting, 2010; Odom et al., 2019; Ong & Van Gerpen, 2020; Reynolds et al., 2014). Institutional sequelae include increased cost of care, increased length of stay, and potential litigation for serious injuries (Alexander, 2020; Reynolds et al., 2014).

In a Magnet designated pediatric acute care setting there is an opportunity to improve the staff registered nurse (RN) response when a PIVIE occurs. A large focus for these injuries has been prevention-focused utilizing a bundle-element approach provided by the SPS cohort. An identified gap in patient care is the lack of an organized process for staff to implement when a PIVIE occurs. With PIVIEs, timely intervention upon discovery is vital to reducing potential morbidity (Alexander, 2020; Ong & Van Gerpen, 2020; Reynolds et al., 2014). The purpose of this project is to create a clinical practice guideline (CPG) that will guide staff intervention if a PIVIE occurs, with the ultimate goal of reducing PIVIE-related patient morbidity. The Stetler model for research utilization served as the guiding framework. The aim of this clinical scholarship project is to provide an evidence-based CPG. Outcomes measures are the completed PIVIE CPG that can be adopted by the facility with a future goal of a reduction in moderate and serious harm injuries. The study question guiding this
REDCUCING PEDIATRIC MORBIDITY

project is what evidence-based literature is required to develop a clinical practice
guideline for staff RNs in the hospital setting in order to improve the care of children
experiencing PIVIE’s?

Review of the Literature

An online literature review was conducted utilizing four primary databases
including PubMed, Cumulative Index to Nursing and Allied Health Literature
(CINAHL), MEDLINE (EBSCO), and the Cochrane Library. Search terms and phrases
included “extravasation of diagnostic or therapeutic materials”, children, pediatrics,
infiltration, extravasation, hyaluronoglucosaminidase, hyaluronidase, and hylenex.
Boolean operators AND and OR were utilized with the search terms. The initial search
yielded 3412 results. Abstracts were manually selected before seeking out full text.
Repeated publications were removed. A total of 56 full-text publications were sought.
Inclusion criteria included a publication limit of 10 years, English language, and an age
filter from birth to 18 years old. Exclusion criteria included study population outside of
the 0–18-year-old age range, animal studies, studies only assessing extravasation of
chemotherapeutic agents or contrast, and publications that were not in English. Sixteen
studies were ultimately selected for review based on inclusion and exclusion criteria. The
literature search yielded publications with retrospective, prospective, or observational
designs with small sample sizes and uncontrolled variables. Numerous case series, and
literature reviews were also identified.

Treatment

To begin drafting the clinical practice guideline, the literature was reviewed to
determine which interventions were studied and recommended. Treatment for PIVIEs
can vary, depending on the medication or fluid infusing at the time of the event. Treatment is dictated by a number of factors based on the known mechanisms of tissue injury including pH, osmolarity, cytotoxicity, and vasoconstriction (Ong & Van Gerpen, 2020). Initial treatment is often conservative and may consist of removal of the catheter, elevation of the extremity, application of a warm or cold compress to alleviate discomfort, frequent monitoring, and various topical wound care products (Alexander et al., 2020; Odom et al., 2018; Ong & Van Gerpen, 2020; Reynolds et al., 2014). Additional interventions may be indicated based on the grade of the injury, the potential for tissue irritation based on the medication infusing, and the amount of medication in the soft tissue.

There are multiple tools available to stage or classify the degree of an infiltration or extravasation and they often include assessment of pain, edema, blanching, sensation, skin integrity, and circulation (Alexander, 2020; Corbett et al, 2018; Ong & Van Gerpen, 2020; Reynolds et al., 2014). For acute purposes, the response initiated by the staff should be based on whether the medication infusing was a vesicant or an irritant or the grade assigned to the injury (Alexander, 2020; Ong & Van Gerpen, 2020). The review identified a lack in high quality comparative studies defining superiority or efficacy of one intervention versus another which was consistent with published literature reviews (Chan et al., 2020; Hackenberg et al., 2021; Ong Van Gerben, 2020; Santos et al., 2021).

**Saline Flush-Out Technique**

Saline flush-out or local irrigation via multiple stab incisions with various volumes of saline with or without the addition of hyaluronidase following a PIVIE is a
commonly seen intervention in the literature (Alexander, 2020; Ching et al., 2014; Gault, 1993; Ghanem et al., 2015; Gopalakrishnan et al., 2017; Kostoglou-dis et al., 2015; Murphy et al., 2019; Weber et al., 2019). The original technique is described in a study by Gault (1993) and involves the injection of hyaluronidase followed by irrigation of a minimum volume of 500 mL of saline into the subcutaneous space via four stab incisions. While this intervention is commonly mentioned in the literature, it is worth mentioning that there are no published studies that compare this technique with other potentially less-invasive methods which may provide the same outcome. In a single-patient case series by Alexander (2020), a modified flush-out technique with multiple stab incisions in a grin-pattern was utilized for a 6-month-old infant with an extravasation to the dorsal surface of the right foot. Complete resolution of the injury was achieved by one week (Alexander, 2020). The findings are limited by the single-patient sample and the lack of alternative intervention (Alexander, 2020). The author recommends identifying patients at high risk of injury, grading extravasations, tailoring responses to extravasations based on the assigned grade, and swift intervention for severe injury with saline washout and liposuction or surgical intervention (Alexander, 2020). In a similar study by Ching et al. (2014) written as a letter to the editor, a retrospective case series of 69 pediatric patients were followed with 62% of the sample receiving Gault’s saline washout technique following confirmed extravasation. Again, this study design lacked comparison of interventions to determine efficacy and is subject to potential selection bias (Ching et al., 2014). Recommendations made included early plastic surgery team referral for all extravasation events, utilization of Gault’s technique, serial photography of injuries, and further research to determine best
Gopalakrishnan et al. (2017) completed a systematic review including studies from 1966-2017 to determine the efficacy of saline irrigation for treatment of extravasation in the neonatal population. The researchers were unable to identify any high-quality studies that met their criteria for eligibility, instead identifying 10 case reports (Gopalakrishnan et al., 2017). The review was limited by the lack of eligible studies; the authors recommended future studies utilize a multi-center randomized trial design comparing saline irrigation with standard care (Gopalakrishnan et al., 2017).

Kostogloudis et al. (2015) sought to expand on Gault’s technique with a retrospective review case series with a sample of 34 hospitalized neonates over a 24-month period in Greece (incidence of 2.4%). An immediate intervention was utilized and consisted of catheter removal after attempted aspiration and instillation of saline via multiple full-thickness skin incisions. The average amount of instilled saline was 60 mL, but the range was anywhere from 10-160 mL based on surgeon discretion (Kostogloudis et al., 2015). Fischer exact tests were completed to determine that there was not a statistically significant relation between gestational age and incidence of extravasation (p= 0.07), but there was a significant association to birthweight and rate of tissue necrosis (P <0.001) (Kostogloudis et al., 2015). Recommendations included early surgical consultation with rapid intervention utilizing the saline wash-out technique (Kostogloudis et al., 2015). Limitations of this study included single facility, small sample size, and no randomization or alternative intervention to compare findings (Kostogloudis et al., 2015).

Other Techniques
A small collection of studies selected for this review assessed interventions beyond invasive techniques. Chan et al. (2020) completed a pre-and-post intervention analysis study to evaluate the effect of implementing a clinical practice guideline (CPG) for the prevention and treatment of neonatal extravasation injuries. The setting was a neonatal intensive care unit in Hong Kong with a sample of 104 intervention neonates and 109 post-intervention neonates (Chan et al., 2020). Outcome measures included the number of extravasations that occurred pre-and-post implementation of the CPG (Chan et al., 2020). Independent t-tests and Pearson’s chi-square tests were utilized to compare the mean differences in the outcomes between the two groups of neonates (Chan et al., 2020). The findings demonstrated a reduction of injury in the post-intervention group by 80% ($p = 0.02$) which was statistically significant (Chan et al., 2020). Limitations to this study included RN knowledge of observation, which could potentially have impacted the validity of the results and lack of available research-based evidence to inform the adopted guideline (Chan et al., 2020). Recommendations from this study include delivery of a multidimensional education program for nurses for care and implementation of an evidence-based clinical practice guideline (Chan et al., 2018).

Chin et al. (2018) conducted a single-center prospective randomized control trial to determine if extravasation rates were reduced with elective replacement of peripheral IV catheters in neonates. The sample included 113 neonates, 55 in the standard group and 58 in the intervention group (Chin et al., 2018). Primary outcome measures were the rate of extravasation between both groups. Cox proportional model was the statistical analysis utilized to compare outcomes between both groups which
revealed similar rates of extravasation between both the standard and intervention group (Chin et al., 2018). This study had multiple strengths including the design which is the first randomized trial completed in this specific population observing extravasation as a primary outcome measure (Chin et al., 2018). Limitations of this study included the single center setting and occasional deviations from their protocol which may impact generalizability of the findings (Chin et al., 2018). The findings of this study indicated that elective replacement of PIVs did not reduce the rate of PIVIEs (Chin et al., 2018).

Yan et al. (2014) completed a retrospective case series in a neonatal acute care unit in China with a sample of 13 neonates. Researchers sought to evaluate the efficacy of hyaluronidase and hirudoid topical for the treatment of extravasation injuries. No adverse effects were experienced. Limitations to this study include a small sample size in a single facility and a retrospective design with no randomization (Yan et al., 2014). Recommendations moving included using hyaluronidase and topical hirudoid ointment application for management of extravasations and future studies to determine best methods of extravasation management in the neonatal population (Yan et al., 2014).

**Systematic Reviews**

Evidence-based interventions for PIVIEs are limited with similar conclusions from multiple reviews. Four systematic reviews that met inclusion criteria were identified. Corbett et al. (2018) sought to complete a scoping review but found limited high-quality data to support any one intervention in the pediatric population. To assess frequently used methods of treatment the authors’ sent survey questionnaires to staff working in pediatric and neonatal units, producing 63 responses (Corbett et al., 2018).
Common interventions identified were conservative management, saline washout and irrigation with or without hyaluronidase, subcutaneous injection with hyaluronidase, and surgical intervention (Corbett et al., 2018). Little et al. (2020) completed a review to determine the strength of the evidence supporting surgical intervention for PIVIEs and found no comparative studies to support any singular intervention. To determine which interventions are the strongest in future observational studies, the authors recommended to establish a registry for tracking and outcome evaluation (Little et al., 2020). Ong and Van Gerpen (2020) conducted a review of both medical and pharmaceutical literature sources to determine best practice for management of noncytotoxic extravasations. This review was important as it made it clear that interventions should be guided based on the medication infusing at the time of the PIVIE instead of the grade assigned (Ong & Van Gerpen, 2020). The authors provided pharmaceutical antidotes based on the medication extravasated or infiltrated (Ong & Van Gerpen, 2020). Limitations of this study included the lack of high-quality literature to base recommendations (Ong & Van Gerpen, 2020). Reynolds et al., (2014) also conducted a review to assess evidence for various interventions aimed to reduce morbidity from extravasations. The authors were unable to identify quality evidence but offered pharmaceutical recommendations based on the medication(s) extravasated (Reynolds et al., 2014). All of the systematic reviews identified gaps in the literature surrounding evidence-based interventions for treatment and management of PIVIEs and recommended conducting studies with large test groups with randomization.

**Early Surgical Consultation**

Two studies recommended a multidisciplinary approach with early consultation
to surgical services. Ghanem et al. (2015) conducted a retrospective case series and chart audit to evaluate the implementation of a hospital guideline with early plastic surgery involvement in the management of extravasation injuries. The sample included 82 pediatric extravasation injuries in 78 patients over a twelve-month period in a pediatric acute care setting in the UK. The audit demonstrated improved outcomes following extravasation injuries. Limitations to this study include retrospective analysis of a single intervention and small sample size. It was not possible to determine if the outcomes were directly related to the intervention (Ghanem et al., 2015).

Murphy et al. (2019) conducted a prospective cohort study of patients referred to the plastic surgery department with the aim to identify processes and opportunities for improving care for patients with PIVIEs. In the 18-month audit timeframe, a sample of 43 extravasation injuries were recorded. Plastic surgery was consulted and subsequently completed saline flush out procedures if the injury was deemed to be at risk of tissue necrosis. Both studies completed retrospective electronic medical record reviews of patients referred to plastic surgery for PIVIE related injuries (Ghanem et al., 2015; Murphy et al., 2019). Limitations to both studies included retrospective designs with small sample sizes and no randomization. Without randomization, it cannot be reliably determined which intervention, if any, significantly affected the patient outcomes. It is also worth noting that at smaller pediatric facilities, there are not always pediatric-specific plastic surgery teams, consultation to pediatric general surgery may be more generalizable.

**Problem Scope**

To grasp the scope of the problem, some studies sought to define the incidence
and risk of PIVIEs and determine interventions being used. Yan et al. (2017) conducted a retrospective analysis of the electronic health record to estimate the incidence of PIVIEs in a pediatric acute care setting in China. In a sample of 1004 pediatric patients an incidence of 1.79 percent or 18 out of 1004 patients were reported. Multivariate logistic regression was used to identify risk factors for PIVIEs including high volume infusion, surgical patient status, and high osmolality infusion (Yan et al., 2017). Limitations of this study include its retrospective design and single center setting. The authors recommend future study to determine the role of these risk factors in pediatric patients and implementation of protocols targeted at extravasation management.

Odom et al. (2018) sought to identify incidence of severe injury and common treatment modalities in a single pediatric acute care facility. Using a retrospective medical record review design, a sample of 147 cases were included. Inclusion criteria included patients aged 0-18 with a stage 3 or 4 peripheral infiltration injury (Odom et al., 2018). The results demonstrated 65 percent of the sample were successfully managed with nurse-driven conservative management and the remaining 35 percent qualified for administration of a pharmaceutical reversal agent of either hyaluronidase (N = 25) or phentolamine (N = 1) (Odom et al., 2018). No patients required surgical intervention (Odom et al., 2018). Limitations to this study include a relatively small sample size in a single facility, a lack of a standardized protocol, lack of randomization, and potential for selection bias (Odom et al., 2018).

Identified gaps in the literature include no published randomized control trials to determine the safety and efficacy of these commonly utilized invasive techniques. In
light of a transitioning focus to patient and family-centered care, studies could explore an approach that begins with less invasive measures and escalates over a period of time or based on assessment findings.

The Stetler model for research utilization guided this clinical scholarship project (Stetler, 2001). The Stetler model involves five phases including preparation, validation, evaluation/decision making, translation/application, and evaluation (Stetler, 2001). This model is appropriate for an individual practitioner-lead approach to research utilization to facilitate evidence-based practice (Stetler, 2001).

To summarize, pediatric patients are at increased risk of complications related to peripheral intravenous therapy. Extravasation is a significant issue. Up to 25 percent of injuries resulting from extravasation cause an acute burden that is more significant than the initial cause of hospitalization (Reynolds et al., 2014). At present, the literature does not support any single intervention or evidence-based guideline to improve outcomes for pediatric patients that experience PIVIEs. This review has identified a considerable gap in the literature, a majority of the interventions identified are based on case series or reports that are greater than 5 years old. Creating a clinical practice guideline will have to rely on poor-quality evidence in addition to stakeholder consensus.

**Methods**

**Design**

For this quality improvement (QI) project, a descriptive design for the development of a clinical practice guideline (CPG) was utilized.

**Setting**
This project took place in a pediatric not-for-profit academic medical center with a level one trauma center and level IV neonatal intensive care unit.

Sample

The targeted population for the CPG included pediatric acute care patients who experienced a PIVIE event. This does not include PIVIEs of chemotherapeutics.

Approval Process

Institutional Review Board (IRB) approval was given for both the site and the University of Missouri St Louis (UMSL). The goal was to produce a CPG based on evidence synthesized from a review of the literature along with stakeholder consensus. Identified stakeholders included the chairs of the pre-existing multidisciplinary PIVIE committee and the pediatric wound care RN. Stakeholders evaluated the CPG and offered feedback during the writing process. Finally, the completed CPG was presented at the monthly multidisciplinary PIVIE meeting and sent out to all members prior to receiving approval. Approval was received and the CPG was appraised by the stakeholders using the AGREE II instrument (AGREE Next Steps Consortium, 2017).

Data Collection/Analysis

No patient data collection was required for creation of the CPG.

Procedure

The DNP student assembled a team of stakeholders onsite. The DNP student completed a systematic review of the literature and selected studies based on inclusion and exclusion criteria. The literature was appraised. The development of the CPG was guided by the standardized Appraisal of Guidelines for Research and Evaluation (AGREE) II instrument and feedback from stakeholders (AGREE Next Steps
Consortium, 2017). Onsite meetings with stakeholders as well as digital correspondence occurred to establish current PIVIE management, mutual goals for the guideline, as well as goals for future adoption. Drafts of the proposed CPG were submitted to stakeholders for approval and revision feedback. The finished guideline was presented at the monthly PIVIE meeting where the multidisciplinary team reviewed and accepted it. The team of stakeholders completed a final appraisal of the CPG utilizing the AGREE II instrument (AGREE Next Steps Consortium, 2017).

**Results**

The CPG *Management of Pediatric Intravenous Infiltration or Extravasation Injuries* was created using the Appraisal of Guidelines Research and Evaluation (AGREE) II Instrument for the target audience of staff RNs working in pediatric acute care (AGREE Next Steps Consortium, 2017). The AGREE II instrument is a tool with established validity and reliability for evaluation of clinical practice guidelines which made it an ideal guide for formatting and final appraisal of this CPG (AGREE Next Steps Consortium, 2017). The guideline contains the scope of the problem, population specific risk factors, definitions of terms, assessment parameters and guidance, management strategies including a clinical algorithm, and ongoing management. The finished guideline was presented at the monthly multidisciplinary PIVIE committee meeting where it was approved. Finally, the CPG was submitted to the chairs of the committee and wound care RN for final appraisal using the AGREE II instrument (AGREE Next Steps Consortium, 2017) (See appendix B). Appraisal scores were 93.4% and 95.6% respectively with all appraisers recommending adoption of the completed CPG.
Discussion

The study question guiding this project was, what evidence-based literature is required to develop a clinical practice guideline for staff RNs in the hospital setting in order to improve the care of children experiencing PIVIE’s? After a thorough review of the pediatric extravasation literature, it can be concluded that there remains a significant gap. While studies were identified as meeting the inclusion and exclusion criteria, the studies were weak in their designs. A majority of the studies are retrospective, descriptive, or case series that lacked comparison or controlled variables. The samples were prone to selection bias. Recommendations made within the studies are weak, no study could identify which intervention(s) were most effective. Guidelines drafted on the currently available evidence will undoubtedly require anecdotal or consensus-based recommendations until further research can be conducted. One recommendation that was consistently seen was the recommendation to initiate therapy quickly and favor over-treatment to reduce the risk of patient harm (Alexander, 2020; Chan et al., 2020; Corbett et al, 2018; Hackenberg et al., 2021; Ong & Van Gerpen, 2020; Reynolds et al., 2014). However, it is difficult for institutions to provide consistent interventions when there is no literature to support which interventions are the most appropriate.

The scope of this clinical scholarship project (CSP) was to create a CPG that specifically addressed management of pediatric PIVIE events. Throughout the process of creating the CPG it became clear that the intervention should be guided based on the qualities of the medication infusing, not only the assigned grade of the injury. This brought to light potential barriers in practice. It is not easily determined by staff if the
medication infusing is a vesicant or an irritant, which is vital in determining next steps for management. Future implications for practice include developing a vesicant label or alert for nursing staff to know which medications have the highest risk for harm if they extravasate. In addition, this guideline offers a standard work for staff to reference when a PIVIE occurs. Without a standard work or process for staff to follow there is a large margin for error and potential for unintended patient morbidity. If this guideline is adopted by the site, it is also recommended that the PIVIE committee assesses the literature annually to determine if any new recommendations are available.

Recommendations for further study related to this CSP include a quality improvement project that measures the effect, if any, of implementation of the CPG. It is recommended to implement the guideline on a single patient care unit, such as the pediatric intensive care unit (PICU) where patients are at high risk of PIVIEs and closely monitored. Single unit implementation will assist in determining barriers to adoption, tailoring of staff education based on feedback, and close monitoring of outcomes. If adoption is determined to be successful on a single unit, it could then be expanded throughout the facility.

**Role of the DNP**

The doctorate in nursing practice (DNP) encompasses a wide array of science-based knowledge that can be applied and translated directly into practice (AACN, 2006). The DNP graduate has the foundation of nursing knowledge which is necessary in navigating the complex needs of patients in addition to the skills to develop new practice approaches. The DNP education emphasizes care for not only individual patients but improving care for an entire target population (AACN, 2006). Broadening
the scope of care ultimately prepares the DNP role to improve patient outcomes through a quality improvement lens. Development of a CPG requires clinical knowledge to reflectively identify a weakness in practice and clinical scholarship to execute a systematic literature review and translate relevant findings into practice recommendations (AACN, 2006). This project highlighted key objectives in the DNP education, with the ultimate goal of improving patient outcomes.

**Conclusion**

Peripheral intravenous therapy is a mainstay of acute care that up to 74% of admitted pediatric patients ultimately receive (Cincinnati Children’s Solution for Patient Safety, 2021). With how common this route of therapy is, it is easy to take for granted the potential harm that could occur. As healthcare providers it is important to have a plan in place in the event that unavoidable patient events occur. For this CSP the clinical practice guideline, *Management of Pediatric Intravenous Infiltration or Extravasation Injuries*, was developed based on a literature review and stakeholder consensus. The guideline is intended to serve as a reference that addresses the scope of the problem, population specific risk factors, assessment, management, and recommendations for adoption. The target goal is to provide an evidence-based approach for staff, with the long-term goal of reducing pediatric PIVIE-related morbidity in the future.
Appendix A

Management of Pediatric Intravenous Infiltration or Extravasation Injuries

Clinical Practice Guideline

Management of Pediatric Intravenous Infiltration or Extravasation Injuries

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Disclosures

This author has no financial or non-financial conflicts of interest to disclose.

Introduction

As many as 74 percent of hospitalized pediatric patients require either peripheral or central vascular access during their course of treatment (Cincinnati Children’s Solution for Patient Safety, 2021). Peripheral intravenous infiltration and extravasations (PIVIEs) are a common iatrogenic effect of intravenous therapy in the pediatric population that cannot always be prevented. Consequences of these injuries can vary from minor discomfort to severe injury that can result in permanent disfigurement. Staff recognition and prompt management are vital to minimizing patient harm. This guideline is drafted based on available evidence and stakeholder consensus. It is important to note that a key limitation to this guideline is the lack of published comparative studies within the existing literature.

Guideline Development Process

An online literature review was conducted utilizing four primary databases PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), MEDLINE (EBSCO), and Cochrane Library. The initial search yielded 3412 results. Articles were selected based on predetermined inclusion criteria. A total of 56 full-text publications were sought and further appraised. 16 publications were selected based on inclusion criteria. The literature identified consists of observational or retrospective study designs, case studies, and literature reviews (See Appendix A Evidence Table).

- Inclusion criteria: Publication limit of ten years (2012), English language, subject age
limited from 1 day to 18 years of age.

- Exclusion criteria: Studies including patients greater than 18, animal studies, chemotherapeutic extravasation injuries, and central-line related extravasation injuries.
- Search terms: “extravasation of diagnostic or therapeutic materials”, extravasation, infiltration, children, pediatric, infant, neonate, hyaluronoglicosaminidase, hyaluronidase, hylenex.

**Aim**

- To define assessment parameters and corresponding management recommendations for pediatric and neonatal acute care patients that experience a PIVIE event.
- Reducing patient harm related to PIVIE events.
- This guideline is limited to peripheral lines. If an extravasation is suspected for a patient with a central line, it is vital to escalate per institutional policy.
- This guideline does not include management of chemotherapeutic related extravasations.

**Target Audience**

- This guideline serves as a reference for those participating in direct patient care. Including, but not limited to, registered nurses and physicians.

**Definition of Terms**

- Infiltration: the unintended migration of a non-vesicant solution from the intended vessel into the surrounding soft tissue (Desarno et al., 2018; Odom et al., 2019).
- Extravasation: an unintended migration of a vesicant solution from the intended vessel into the surrounding soft tissue (Desarno et al., 2018; Odom et al., 2019).
- Irritant: substances or medications with potential for tissue irritation (Hackenberg et al., 2021).
- Vesicant: substances or medications with potential for tissue necrotizing (Hackenberg et al., 2021).
- Hyaluronidase: enzyme that works to dissolve hyaluronic acid in connective tissue, allowing fluid and medications to move more freely throughout the tissue layers (Ong & Van Gerpen, 2020). Increased tissue permeability benefits PIVIE management by allowing fluid and medications to diffuse and thus broken down more quickly. A 150-unit dose can effectively disperse up to 1 Liter of subcutaneous fluid (Ong & Van Gerpen, 2020).
- Phentolamine: a non-selective alpha-adrenoceptor blocker, acts to reduce tissue ischemia via vasodilation and increasing perfusion. Ischemia to the tissues is a serious risk for PIVIEs related to vasoconstrictive agents (dopamine, epinephrine) (Ong & Van Gerpen, 2020).

**Population-Specific Risk Factors**

It is important to reiterate that these injuries are not always preventable. The pediatric and neonatal population are at higher risk of PIVIEs for multiple reasons and prompt recognition and response is vital to reduce risk of harm.

- Developmental or cognitive inability to comply with medical treatment (Odom et al., 2019).
- Inability to verbally communicate pain (Odom et al., 2019).
- Increased duration of peripheral intravenous fluid or medication delivery (Corbett et al., 2018; Odom et al., 2019).
- Physiological factors including anatomically immature skin, reduced cohesion between skin layers, fragile vessels, reduced subcutaneous tissue (Corbett et al., 2018; Odom et al., 2019).
Assessment
A physical assessment should be conducted once a PIVIE has been identified and documented accordingly.

- See Appendix B *Pediatric Patient Post-PIVIE Assessment Checklist* for the initial post-acute assessment.
- Components of the initial assessment should include the following: pain assessment, insertion site assessment, skin integrity assessment, localized circulator assessment, and neurovascular assessment (Corbett et al., 2018; Hackenberg et al. 2021; Odom et al., 2018; Ong & Van Gerpen, 2020).

Management
Management of PIVIEs is dependent on:

- The medication(s) infusing when the PIVIE is discovered (See Appendix D *Treatment Algorithm for Management of Pediatric Infiltrations and Extravasations*).
- The assigned Grade of the PIVIE based on the assessment (see Appendix C *PIVIE Grading*).
- It is general consensus to initiate therapy without delay and to favor over-treatment to undertreatment to prevent potentially avoidable patient harm (Corbett et al., 2018; Hackenberg et al., 2021; Ong & Van Gerpen, 2020).
  - Cost analysis supports implementation of pharmaceutical antidotes when comparing cost of treatment versus potential time and cost of wound care or surgical service consultation (Hanraha, 2013).

Ongoing Management
Once a PIVIE has been identified continued frequent monitoring is indicated (Hackenberg et al., 2021; Ong & Van Gerpen, 2020).

- Continued hourly monitoring is recommended since these injuries can evolve quickly (Hackenberg et al., 2021; Ong & Van Gerpen, 2020).
- Local monitoring should include level of pain, peripheral sensation, range of motion, circulatory assessment, and evaluation of the effect of the intervention (Hackenberg et al., 2021).
  - If desired result is not achieved, Hyaluronidase treatment can be repeated (Ong & Van Gerpen, 2020).
- Completion of an Event Report is recommended for patient outcome monitoring and follow up (Crowther et al., 2011).
  - Event reporting is also a tool in determining facility-specific incidence for PIVIE events.

Recommendations for Guideline Adoption and Updating
Adoption of this Guideline should be piloted on a single patient care unit prior to facility-wide implementation.

- Allows for tailoring of staff education with live feedback.
- Patient outcomes can be closely monitored.
- The effect of implementation can be measured.

If this guideline is adopted, it is recommended to reassess the literature every 3-5 years to ensure practices are evidence-based.

References


<table>
<thead>
<tr>
<th>Citation</th>
<th>Purpose of the Study</th>
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<th>Statistical Analysis</th>
<th>Findings</th>
<th>Strengths/Limitations/Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chan, K. M., Chau, J., Choi, K. C., Fung, G., Lui, W. W., Chan, M., &amp; Lo, S. (2020). Clinical practice guideline on the prevention and management of neonatal extravasation injury: a before-and-after study design. <em>BMC pediatrics</em>, 20(1), 445. <a href="https://doi.org/10.1186/s12887-020-02346-9">https://doi.org/10.1186/s12887-020-02346-9</a></td>
<td>Evaluate the effect of implementation of a Clinical Practice Guideline (CPG) on prevention and management of neonatal extravasation injuries. Examine the impact on RN knowledge regarding management.</td>
<td>Controlled pre-and-post intervention analysis, Level IV</td>
<td>Sample: 104 pre-intervention neonates 109 post-intervention neonates</td>
<td>Independent Variable: CPG implementation and RN education</td>
<td>Number of extravasations pre- and post-intervention</td>
<td>Independent t-tests and Pearson’s chi-square tests to compare the mean and differences in neonate outcomes between the pre- and post-intervention. Logistic regression to estimate the odds ratio of EI in the post-intervention period.</td>
<td>Reduction of post-intervention injury by 80% (p = 0.02) Statistically significant change in Nurse knowledge post intervention (p &lt;0.001).</td>
<td>Strengths: Study demonstrated improvement in clinical outcomes with multifaceted education and adoption of CPG. Limitations: Due to study design in a single unit, randomization was not possible. CPG development limited by lack of high-quality studies to base practice recommendations on. Hawthorne effect possible as nursing staff knew they were being monitored. Recommendations: Implementation of an evidence-based clinical practice guideline along with a multifaceted education program to reduce morbidity secondary to extravasation injuries in neonates.</td>
</tr>
<tr>
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<td>Chin, L. Y., Walsh, T. A., Van Haltren, K., Hayden, L., Davies-Tuck, M., &amp; Malhotra, A. (2018). Elective replacement of intravenous cannula in neonates—a randomized trial. European journal of pediatrics, 177(1), 1719–1726. <a href="https://doi.org/10.1016/j.ejped.2014.08.355">https://doi.org/10.1016/j.ejped.2014.08.355</a></td>
<td>To determine if the rate of extravasation is reduced with elective replacement of peripheral IV catheters in neonates.</td>
<td>Single center prospective randomized control trial (non-blinded)</td>
<td>Sample: 113 neonates; 55 to the standard group and 58 to the elective replacement group</td>
<td>Independent Variable: elective peripheral IV replacement every 72-96 hours or earlier as clinically indicated</td>
<td>Primary outcome measure: Rate of extravasation between both groups. Secondary outcome measures: Secondary complications from PIVC use (phlebitis, leaking, etc.).</td>
<td>Cox-proportional model; Kaplan-Meier failure estimates</td>
<td>Time to first extravasation was similar between both groups. There was an increase in leaking rates in the elective replacement group. Dislodgement and phlebitis rates were similar in both groups.</td>
<td>Strengths: First RCT performed in neonatal population for this subject. The data from this study mirrors outcomes performed in adult studies. Extravasation was the primary outcome measured, which is specific to this population. Limitations: Small single-center study. Findings may not be generalizable due to deviations from protocol. Recommendations: Elective replacement of PIV catheters in neonatal population (32 weeks and above) is not recommended.</td>
</tr>
<tr>
<td>Citation</td>
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<tr>
<td>Corbett, M., Marshall, D., Harden, M., Oddie, S., Phillips, R., &amp; McGuire, W. (2018).</td>
<td>To review and compare various treatment modalities for pediatric (0-18) extravasation injuries.</td>
<td>Scoping Systematic Review; Survey to pediatric/neonatal wards</td>
<td>Level V</td>
<td>Treatments for extravasation injuries, reported injuries from outside facilities</td>
<td>Outcomes of interest in literature review: wound healing time, scarring, infection, pain, contractures, functional impairment, disfigurement, requirement for surgery, mortality and anaphylactic reactions to extravasation treatments.</td>
<td>N/A</td>
<td>There continues to be uncertainty around best practice for management of extravasation; saline irrigation and conservative management continue to be commonly used.</td>
<td>Strengths: Outlines gaps in the literature to highlight recommendations for future studies. Limitations: No high-quality studies identified. Recommendations: Randomized registry trial, RCT may be difficult.</td>
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<tr>
<td>plastic, reconstructive &amp; aesthetic surgery : JPRAS, 68(4), 505-518. doi:10.1016/j.bjps.2014.12.029</td>
<td>To examine available evidence to determine the safety and efficacy of saline irrigation for treatment of neonatal extravasation.</td>
<td>Systematic literature review</td>
<td>Level I</td>
<td>Independent variable: delivery of saline irrigation with or without hyaluronidase versus no intervention or normal wound care only.</td>
<td>Complete tissue healing with or without scar tissue formation.</td>
<td>Descriptive Statistics utilized</td>
<td>No high-quality evidence in the form of RCTs comparing saline irrigation and standard care were identified.</td>
<td>Consider early plastic surgery referral to reduce harm related to extravasations.</td>
</tr>
<tr>
<td>Hackenberg, R. K., Kahir, K., Muller, A., Heydweiller, A., Burger, C., &amp; Welle, K. (2021). Extravasation Injuries of the Limbs in Neonates and Children. Dtsch Arztebl International, 118(33–34), 547–554.</td>
<td>To examine available evidence to construct a treatment algorithm for management of pediatric extravasation events.</td>
<td>Selective review of the literature from 1979 to June 2020.</td>
<td>N/A</td>
<td>N/A</td>
<td>Treatment algorithm development</td>
<td>N/A</td>
<td>45 studies were included in the review, no RCTs were identified. Due to lack of comparative studies it is not possible to rate therapies or establish standard procedures.</td>
<td>Demonstrates gap in the literature for comparative studies. Treatment algorithm developed that could be adopted with outcomes measured.</td>
</tr>
</tbody>
</table>

Strengths: Complete review of the literature found no high-quality studies, able to make recommendations and highlight implications for future research. 
Limitations: No eligible studies identified. 
Recommendations: multi-center randomized trial to determine efficacy and safety of irrigation with saline for the care of extravasations.
<table>
<thead>
<tr>
<th>Citation</th>
<th>Purpose of the Study</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Hanrahan K. (2013).</td>
<td>Describe implementation and evaluation of an evidence-based guideline for Treatment of Intravenous Extravasations in a pediatric population.</td>
<td>Guideline development utilizing a systematic literature review, pre- and post-survey analysis, retrospective EHR review.</td>
<td>Setting: Pediatric acute care, US. Sample: Acute Care Staff utilizing CPG.</td>
<td>Adoption of Evidence-based CPG, staff education.</td>
<td>Knowledge pre-and-post guideline implementation, number of incident reports, hyaluronidase usage.</td>
<td>Independent t-tests</td>
<td>Guideline implementation increased knowledge, subsequent reporting of events, initiation of treatment, and reduced to treatment administration.</td>
<td>Strengths: Identified statistically significant changes in the average time to initiate intervention post-adoption of CPG, effect sustained one year later. Demonstrates potential return on investment for early intervention in extravasation events. Limitations: No available studies to provide a standard intervention for extravasation injuries, guideline/standard practice made from published studies older than 10 years. Single institution. Recommendations: Adoption of CPG can increase staff knowledge, incident reporting, and reduce time to initiation of intervention.</td>
</tr>
<tr>
<td>Kostogloulias, N., Demiri, E., Tsimponis, A., Dionysissiou, D., Ioannidis, S., Chatzioannidis, I., &amp; Nikolaidis, N. (2015).</td>
<td>To determine the efficacy of adapted saline irrigation with immediate intervention.</td>
<td>Case series; Not identified whether prospective or retrospective.</td>
<td>Sample: 34 infants with stage III-IV injury Setting: Acute Neonatal Unit, Greece.</td>
<td>Independent variable: Intervention provided (adapted saline flush technique via multiple incisions); Time of intervention; Gestational age; infusate.</td>
<td>After treatment seven children experienced superficial injuries with blistering and tissue loss, six developed tissue necrosis. A single case of ischemia to the foot resolved after treatment. All wounds included healed.</td>
<td>Fischer Exact Tests</td>
<td>Gestational age was not significantly associated with incidence of injury, but was associated with incidence of tissue necrosis. Wound healing occurred in 1-25 days.</td>
<td>Strengths: Contributes to minimal available literature assessing extravasations injuries in this high-risk population. Limitations: Single facility, small sample size, no randomization, no comparison of interventions, potential for selection bias. Recommendations: Immediate irrigation with saline to reduce potential toxic effects.</td>
</tr>
<tr>
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<td>Little, M., Dupré, S., Gardiner, M., Gale, C., &amp; Jain, A. (2020). Surgical intervention for paediatric infusion-related extravasation injury: a systematic review. <em>BMJ open</em>, 10(8), e034950. <a href="https://doi.org/10.1136/bmjopen-2019-034950">https://doi.org/10.1136/bmjopen-2019-034950</a></td>
<td>Assess the quality of literature that supports surgical intervention for the care of pediatric extravasation injuries.</td>
<td>Systematic literature review</td>
<td>Systematic search of studies from 1966-2017 using PubMed, Cochrane Database of Systematic Reviews and and Central Register of Controlled Trials, MEDLINE, Embase, AMED, CINAHL, clinicaltrials.gov</td>
<td>Techniques utilized to care for extravasation injuries.</td>
<td>NA</td>
<td>Descriptive statistics utilized</td>
<td>Surgical management is common in injuries that result in significant soft tissue damage. The evidence lacks comparative studies, further observational studies are required to determine whether surgical intervention is optimal.</td>
<td>Strengths: This scoping review demonstrates that a majority of extravasation injuries achieve resolution independently. This also demonstrates gaps in the literature and implications for future research. Limitations: Low quality studies, with inconsistent outcome reporting to support any interventions. Recommendations: Utilization of a universal extravasation grading scale, registry for tracking extravasations, outcome and evaluation monitoring required to provide sufficient evidence.</td>
</tr>
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<tr>
<td>Ong, J., &amp; Van Gerpen, R. (2020).</td>
<td>Literature review to assist clinicians in noncytotoxic extravasation management by creating evidence and consensus-based recommendations</td>
<td>Systematic literature review</td>
<td>Level I</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>The body of extravasation literature is subject to multiple biases, it is not possible to create recommendations without supporting consensus recommendations at this time. Further higher quality studies are required to create a truly evidence-based guide.</td>
<td>Strengths: Authors provide concise and easy to navigate recommendations which could be adopted in the acute setting. Defines medications currently labelled as vesicants. Limitations: Majority of studies have multiple biases, lack of high-quality comparative studies. Recommendations: Initiation of prompt management strategies in favor of overtreatment versus undertreatment.</td>
</tr>
<tr>
<td>Santos, L. M. D., Nunes, K. de J., Silva, C. S. G. E., Kusahara, D. M., Rodrigues,</td>
<td>Elaboration and validation of treatment algorithm used to Bibliographic review to elaborate on available</td>
<td>State University of Feira de</td>
<td>N/A</td>
<td>Content Validity of 0.99 of</td>
<td>Descriptive statistics, Content Validity</td>
<td>Algorithm reached content validity in the third evaluation, CVI of 0.99.</td>
<td>Strengths: Study offers first validated algorithm specific to pediatric infiltrations and extravasations.</td>
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<tr>
<td>Yan Y.M., Gong M., Chen J.L., Li D., Xu T.T., Zou H., Li</td>
<td>To explore incidence, risk factors, and Retrospective analysis of extravasation incidence.</td>
<td>Sample: 1004 Pediatric</td>
<td>Patient demographic s.</td>
<td>Extravasation incidence, T Tests, Mann-Whitney U</td>
<td>Incidence of extravasation was 1.79% (18/1004). 1 case required surgical</td>
<td>Strengths: Provided important information on incidence of extravasation.</td>
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Pediatric Patient Post-PIVIE Assessment Checklist:

Pain Assessment:
- Determine appropriate pain scale based on patient development and assess pain level.

Peripheral IV Insertion Site Assessment:
- Assess catheter hub to determine if securement or connection are at fault.
- Assess for leaking or fluid around the insertion site?

Skin Assessment:
- Assess temperature of the skin.
- Assess color of skin: presence of erythema, pallor or persistent blanching, deep blue/purple/or black could be necrosis.
- Assess general skin integrity: skin intact, blistering, sloughing.
- Assess edema:
  - Where does it start/end?
  - Assess severity of edema based on percent of extremity involvement:
    - Mild (10-25%)
    - Moderate (25-50%)
    - Severe (>50%)

Circulatory Assessment:
- Assess presence and strength of pulses distal to insertion site, utilize doppler if necessary.
- Assess capillary refill on upper extremities.

Neurovascular Assessment:
- Assess for sensation in effected extremity.

[Corbett et al., 2018; Hackenberg et al. 2021; Odom et al., 2018; Ong & Van Gerpen, 2020]
<table>
<thead>
<tr>
<th>Grade I</th>
<th>Grade II</th>
<th>Grade III</th>
<th>Grade IV</th>
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<tbody>
<tr>
<td>- Localized swelling (1-10%). &lt;br&gt; - Difficulty Flushing. &lt;br&gt; - Pain at site. &lt;br&gt; - No erythema present.</td>
<td>- Mild swelling (10-25%) of extremity involved above or below site. &lt;br&gt; - Erythema present. &lt;br&gt; - Pain at site.</td>
<td>- Moderate swelling (25-50%) of extremity involved above or below insertion site. &lt;br&gt; - Pain at site. &lt;br&gt; - Skin cool to touch. &lt;br&gt; - Blanching present. &lt;br&gt; - Pulse below site is diminished.</td>
<td>(PIVIEs involving blood products, tissue irritants, vasoactive medications, or vesicants should be considered Grade IV regardless of appearance) &lt;br&gt; - Severe swelling (&gt;50%) of extremity involved above or below insertion site. &lt;br&gt; - Erythema present, may extend beyond borders of swelling. &lt;br&gt; - Pain at site. &lt;br&gt; - Blanching present. &lt;br&gt; - Skin cool to touch. &lt;br&gt; - Decreased or absent pulse below insertion site. &lt;br&gt; - Increased capillary refill (&gt;4 seconds). &lt;br&gt; - Skin breakdown, blistering, persistent blanching, or necrosis present.</td>
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Recommended Initial Interventions based on Grade:

<table>
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<tr>
<th>Grade I</th>
<th>Grade II</th>
<th>Grade III</th>
<th>Grade IV</th>
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<tbody>
<tr>
<td>- Remove cannula &lt;br&gt; - Elevation of affected extremity.</td>
<td>- Remove cannula &lt;br&gt; - Elevation of affected extremity. &lt;br&gt; - Consider pharmaceutical antidote. &lt;br&gt; - Regular clinical monitoring.</td>
<td>- Leave cannula in place and use a 3-5 mL syringe to aspirate as much infusate as possible. &lt;br&gt; - Remove cannula unless it will be used for antidote administration. &lt;br&gt; - Elevation of affected extremity. &lt;br&gt; - Consider pharmaceutical antidote. &lt;br&gt; - Frequent monitoring.</td>
<td>- Leave cannula in place and use a 3-5 mL syringe to aspirate as much infusate as possible. &lt;br&gt; - Remove cannula unless it will be used for antidote administration. &lt;br&gt; - Elevation of affected extremity. &lt;br&gt; - Pharmaceutical antidote. &lt;br&gt; - If the skin is tight and skin is blanching consider surgical consult.</td>
</tr>
</tbody>
</table>
**Treatment Algorithm for the Management of Pediatric Infiltration and Extravasation Injuries**

**STOP THE INFUSION AND NOTE MEDICATION INFUSING, CALL PHARMACY TO VERIFY IF VESICANT SOLUTION**

**COMPLETE POST-PIVIE ASSESSMENT (SEE APPENDIX A)**

**ASSIGN PIVIE GRADE BASED ON THE ASSESSMENT FINDINGS**

**CONNECT A 3-5 ML SYRINGE TO CATHETER AND ATTEMPT TO ASPIRATE RESIDUAL MEDICATION**

**EXTRAVASATION ➔ EMERGENT**
- Notify Care team.
- Elevate Extremity
- Administer antidote.

**INTERVENTIONS:**
- Elevation
- Hyaluronidase Administration
- Wound RN/Plastic surgery Consult
- Ongoing RN assessments every 1-2 hours for 12 hours.

**VASOPRESSORS**

**NO**

**INFECTION ➔ Assessment Driven**
Are any of these findings present?
- Tissue damage (blistering, weeping)
- Significant swelling (>30%)
- Prolonged capillary refill (>4 seconds)
- Diminished or difficult to palpate pulse?

**YES**

**CONSERVATIVE MANAGEMENT:**
- Elevation
- Frequent monitoring: every hour for 4 hours, regrade.

**INTERVENTIONS:**
- Elevation
- Administer Hyaluronidase
- Wound RN consult
- Ongoing RN assessments every 1-2 hours for 12 hours.

**IMPROVEMENT?**

**NO**
- Continue conservative management
- Continue frequent monitoring.

**YES**
- Assess every 4 hours until resolution.

**INTERVENTIONS:**
- Elevation
- Hyaluronidase Administration
- Wound RN/Plastic surgery Consult
- Ongoing RN assessments every 1-2 hours for 12 hours.

**VASOPRESSORS**

**NO**

**INTERVENTIONS:**
- Dry Heat
- Elevation
- Phentolamine administered subcutaneously.
- Wound RN/Plastic surgery Consult.
- Ongoing RN assessments every 1-2 hours for 12 hours.

**YES**

**CONSERVATIVE MANAGEMENT:**
- Elevation
- Frequent monitoring: every hour for 4 hours, regrade.

**INTERVENTIONS:**
- Elevation
- Administer Hyaluronidase
- Wound RN consult
- Ongoing RN assessments every 1-2 hours for 12 hours.

**NO**

**INTERVENTIONS:**
- Continue conservative management
- Continue frequent monitoring.

**YES**
- Assess every 4 hours until resolution.

---

Hackenberg et al., 2021; Odom et al., 2018; Ong & Van Gerpen, 2020; Santos et al., 2021
Appendix B:

**AGREE II Appraisal Instrument Stakeholder(s) Appraisal**

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>REVIEW 1</th>
<th>REVIEW 2</th>
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<tbody>
<tr>
<td>1. The overall objectives of the guidelines were specifically described.</td>
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<tr>
<td>2. The clinical question(s) covered by the guideline is (are) specifically described.</td>
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<tr>
<td>3. The patients to whom the guideline is meant to apply are specifically described.</td>
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<tr>
<td>4. The guideline development group includes individuals from all the relevant professional groups.</td>
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<tr>
<td>5. The patients’ views and preferences have been sought.</td>
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<tr>
<td>6. The target users of the guideline are clearly identified.</td>
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<td>7. The guideline has been piloted among target users.</td>
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<td>8. Systematic methods were used to search for evidence.</td>
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<td>9. The criteria for selecting the evidence are clearly described.</td>
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<td>10. The methods used for formulating the recommendations are clearly described.</td>
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<tr>
<td>11. The health benefits, side effects and risks have been considered in formulating the recommendations.</td>
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<td>12. There should be explicit link between the recommendations and the supporting evidence.</td>
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<td>13. The guideline has been externally reviewed by experts prior to this publication.</td>
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<td>14. A procedure for updating the guideline is provided.</td>
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<td>15. The recommendations are specific and unambiguous.</td>
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<td>16. The different options for management of the condition are clearly presented.</td>
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<td>17. Key recommendations are easily identifiable.</td>
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<td>18. The guideline is supported with tools for application.</td>
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<td>19. The potential organizational barriers in applying the recommendations have been discussed.</td>
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<td>20. The potential cost implications of applying the recommendations have been considered.</td>
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<td>21. The guideline presents key review criteria for monitoring and/or audit purposes.</td>
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<td>22. The guideline is editorially independent from the funding body.</td>
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<td>23. Conflicts of interest of guideline development members have been recorded.</td>
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<td>24. Would you recommend these guidelines for use in practice?</td>
<td>“Strongly recommend”</td>
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References


