The Management of Intravenous Infiltration Injuries in Infants and Children

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Abstract

The intravenous administration of fluids and medications is critical for the treatment of seriously ill patients. Unfortunately, especially in infants and children, fluid infiltration into the surrounding tissue can occur. Early recognition and prompt treatment usually limits the extent of tissue damage. Early treatment may include the injection or application of medication (e.g., hyaluronidase, phentolamine, or nitroglycerin ointment) and appropriate dressings. Research to guide the care of more extensive extravasation injury remains limited. At the author’s institution, the protocol of care for children and infants with extensive tissue damage and necrotic tissue consists of careful debridement followed by the use of oxidized regenerative cellulose (ORC)/collagen dressings and skin replacement if needed. Research to help clinicians develop evidence-based protocols of care for both minor and more severe intravenous fluid infiltration or extravasation injury is needed.

Keywords: IV infiltration, infants, children, wounds, extravasation

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The intravenous route of administering blood, fluid, and medications to patients is a relatively recent phenomenon that provides rapid effect of the fluid or medication without the problems of absorption from the gastrointestinal tract and the uncertainty of giving medication via the intramuscular route. The first recorded intravenous administration of blood to man was done by Jean-Baptiste Denis on June 15, 1667. Due to political issues and the fact that the different blood types and anticoagulation were not well understood, the transfusion of blood did not become acceptable until the early 20th century. The first intravenous administration of saline was performed in the 1830s, but it did not become common practice until the early 1900s. Not until medication was sufficiently pure was intravenous administration considered reasonable. Unfortunately, complications soon followed; most were found to be related to delivery of the fluid and/or medication into the subcutaneous tissues instead of the vein.

Over a 5-year period at the author’s institution, intravenous infiltration injuries were found to have occurred in 10% to 30% of pediatric patients receiving intravenous infusions; 55% of the injuries occurred in neonates (see Figure 1). The high incidence of these injuries in young patients stimulated a review of these cases and resulted in the development of a treatment protocol now in use.

Risk Factors

Case studies have shown several factors are important in the potential development of an intravenous infusion injury. The younger the patient, the more likely the injury is to occur; the smaller catheter size used for the infusion (the larger the gauge of the catheter) and the use of “butterfly” catheters (needles) are associated with a greater chance of extravasation of fluid and medication. According to several case studies, children and neonates with darker skin are more likely to suffer from extravasation because of the difficulty visualizing the very small veins in this population. In addition, injury from extravasation of fluids and medications is directly related to the medication and/or fluid administered (see Table 1). Also, hyperosmolar fluids and fluids containing electrolytes are likely to cause tissue damage when leaked into the tissues, as are many antibiotics and chemotherapeutic agents. As expected, vasopressors (common intravenous medications in these very young and very fragile patients) are caustic to the tissues when leaked out of the vein.

Treatment Considerations

Early recognition. Obviously, early recognition to minimize fluid and/or medication volume deposited into the subcutaneous tissues is important to minimize the tissue damage. Routine evaluation of the catheter insertion site is...
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Once the problem is noted, the infusion should be discontinued immediately and moved to another site if needed. If the catheter is still in the subcutaneous tissues, the author recommends aspirating through the catheter to remove as much residual fluid as possible. The catheter is then removed.

Elevation. Elevating the limb can result in more extensive spreading of the toxic material through the tissue and is not recommended. Although this approach goes against current thinking, the author has observed less tissue damage.

Temperature. Case studies have shown the use of warm or cold compresses to be controversial. The conventional idea is that warm compresses cause vasodilation in the tissues, increasing the blood flow and thus resulting in faster removal of the toxic material. Heat actually may cause more injury to the damaged tissues by increasing the tissue demands for oxygen. Heat is beneficial only for the treatment of extravasation of hypertonic saline solutions. Cold

Table 1. Medications and fluids likely to cause tissue damage following extravasation

- All intravenously administered medications and fluids
- Hyperosmolar solutions (total parenteral nutrition solutions, hypertonic glucose, hypertonic saline)
- Blood
- Electrolytes (calcium, potassium)
- Vasopressors (dopamine, dobutamine, norepinephrine, epinephrine)
- Mannitol
- Digoxin
- All antibiotics (especially tetracyclines, penicillin, vancomycin)
- Aminophylline
- Phenytoin
- All sedative-type medications (sodiumthiopental, diazepam, chlordiazepoxide)
- All chemotherapeutic agents

Key Points

- Infiltration of vesicant or nonvesicant intravenous solution or medication into the surrounding tissue is a potentially serious complication of intravenous therapy.
- Patients at both ends of the age continuum are at highest risk for this injury.
- Prevention, early recognition, and prompt treatment usually limits tissue damage, and these wounds will heal in a timely fashion.
- The author describes a protocol of care developed to address this complication.
compresses often are thought beneficial by causing vasoconstriction and preventing the spread of the toxic material. However, the vasoconstrictive effect of cold causes the tissue to become ischemic and makes most infusion injuries worse.10 Medications. According to a review of the literature,11 certain medications have been found beneficial in extravasation injuries.11 One is hyaluronidase, an enzyme that allows the infiltrated fluid to diffuse through the tissues. Its effects last 24 to 48 hours. The medication should be diluted to 15 units/mL; 1 mL is injected into the tissues either through the catheter, if still present, or subcutaneously. It is most effective if used within the first 2 hours post-infiltration, but has been found beneficial if given up to 12 hours after infiltration.7,11 The injuries that respond well to hyaluronidase are listed in Table 2.

Phentolamine is beneficial for use following infiltration of medications causing vasoconstriction.11 This vasodilator improves blood flow to the area to facilitate removal of the toxic medication and to protect the damaged tissue. The dose is 0.1 to 0.2 mg/Kg to a maximum of 10 mg given through the catheter or subcutaneously. It is effective up to 12 hours after the infiltration.11 It should not be given to premature infants, and all patients should be monitored for hypotension and tachycardia.10 The injuries best treated with phentolamine are listed in Table 3.

Nitroglycerin also has been found to be beneficial following infiltration of medications causing vasoconstriction.11 It also causes vasodilatation of local vessels, improving blood flow to the area and facilitating removal of the toxic medication and increasing the blood flow to the injured tissues. Only small amounts should be used, and care should be taken because of the possibility of hypotension and tachycardia.5 The injuries best treated with nitroglycerin ointment are listed in Table 4.

Dressings. The area of injury should be protected with a nonadherent dressing and followed closely. Many of these injuries will be self-limited and resolve with no further treatment.

Debridement. Tissue necrosis can occur as a result of the tissue damage; in such cases, the author recommends using the enzymatic debriding agent collagense to remove the eschar. In vivo research12, and a review of the literature13 have shown that collagenase does not damage normal tissue, making it a good treatment choice. Although experience using this product in this age group is limited, the author has found it to be a useful and safe alternative for these patients (see Figure 2).

In the author’s experience, aggressive sharp debridement in these very small and delicate patients can result in more tissue damage. However, as the eschar loosens, sharp debridement can be used to completely remove only the necrotic tissue. If a significant amount of tissue has been lost, a practitioner familiar with children and neonates should be consulted for sharp debridement.

Following removal of the eschar in wounds not requiring skin replacement, case studies14 suggest the use of an oxidized regenerated cellulose (ORC)/collagen product can be beneficial. ORC/collagen is composed of 55% type 1 bovine collagen and 44% ORC. The collagen component has been shown in vitro15 to provide structural support for cellular and capillary ingrowth and is capable of reducing proinflammatory cytokines and mediators and proteases. The product dissolves into the wound bed within 2 to 3 days, making the dressing changes easy and comfortable for these fragile patients (see Figure 3). Other collagen dressings and nonadherent dressings can be considered.

Table 2. Injuries best treated with hyaluronidase11

- TPN solutions of all types
- Electrolyte infusions
- Antibiotics
- Aminophylline
- Manitol
- Chemotherapeutic agents including vinca alkaloids

Table 3. Injuries best treated with phentolamine or nitroglycerin ointment11

- Dopamine
- Dobutamine
- Epinephrine
- Norepinephrine

Figure 3. Treatment of intravenous infiltration injury with ORC/collagen. A. Before therapy in 26-week gestation baby at 1 day of age; B. After 2 weeks of therapy with ORC/collagen.
Silver-containing dressings should be used with great care in children and neonates; while dressings releasing very low levels of silver have been found in pediatric case studies to be well-tolerated and not damage the cells in the wound bed, toxicity of silver dressings, a growing concern in children, has resulted in systemic serum levels 800 times normal\(^{18,19}\) and their use should be avoided.

Skin replacement. If the tissue defects are large, closure may be difficult and require skin replacement. Skin grafting in very young children is fraught with hazard and produces another wound just as difficult to close as the original lesion. The author and other clinicians have found that the use of cell-containing tissue-engineered skin products that have been approved for use in chronic wounds can have a great benefit in these patients.\(^{20-23}\) (Although these products are only approved for use with diabetic foot ulcers, Apligraf [Organogenesis, Inc, Canton, MA] has approval for humanitarian use in infants and children with epidermolysis bullosa.) These products are designed to provide healthy cells to the wound bed to stimulate and accelerate healing (see Figure 4).

**Conclusion**

Extravasation injury from intravenous fluid is a potentially serious complication in infants and children. When prevention efforts fail, early recognition and appropriate treatment are essential to minimize the extent of the injury. Most injuries will heal spontaneously without complications. Per opinion and research,\(^{16}\) having a clinical practice guideline in place before injuries occur is critical to encourage early recognition and immediate and informed treatment. The guideline used by the Institute for Advanced Wound Care at Baptist Medical Center, Montgomery, AL (see Table 4) has worked well in the author’s center; use by others is pending. Fortunately, technology has provided treatment options for the patients with significant injuries that have been useful in the author’s clinical practice. Additional work will be required to accomplish earlier recognition of these injuries, if possible, and continued research with various wound dressings will be required to find the optimal treatment of wounds in this age group.

**References**

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**Figure 4.** Treatment of intravenous infiltration injury with bilayered tissue-engineered skin. A. Injury due to dopamine infiltration: before debridement; B. Post debridement; C. Application of bilayered, tissue-engineered skin; D. Healed 3 weeks post-application of bilayered, tissue-engineered skin.
Discontinue the infusion
If catheter is out of the vein, aspirate to remove as much residual fluid as possible
Remove catheter
Elevation of limb is not needed
Use of warm or cold compresses – controversial
a. Only benefit of warm compress is on hypertonic saline infiltration
b. Heat may cause further damage with chemotherapy infiltration
c. Vinca alkaloid infiltration made worse by cold compresses
Consider infiltration of medications to relieve tissue damage
a. Hyaluronidase is an enzyme that temporarily decreases viscosity of the ground substance and allows the infiltrated fluid to diffuse through the tissues. The increased permeability is transient lasting only 24 to 48 hours. Dilute to 15 units/mL, then inject 1 mL into tissues either through the catheter, if still present, or subcutaneously. It is most effective if used with the first 2 hours post infiltration but is still beneficial if given up to 12 hours after infiltration
b. Phentolamine for use following infiltration of vasoconstrictor products. It is a vasodilator that inhibits vasoconstriction caused by the infiltrate and improves blood flow to the area. Available in 5 mg/1 mL vials and should be diluted to 5 to 10 mL. The dose is 0.1–0.2 mg/Kg to a maximum of 10 mg given through the catheter or subcutaneously. It is effective up to 12 hours after the infiltration. It should not be given to premature infants, and all patients should be monitored for hypotension and tachycardia
c. Nitroglycerin ointment for use following infiltration of vasoconstrictor products. It is absorbed through the skin and causes vasodilatation of local vessels improving blood flow to the area. Care should be taken in its use because its absorption can result in systemic effects, including hypotension and tachycardia. The amount of nitroglycerin ointment required to cause a systemic effect varies from patient to patient, so great care should be taken in its use, especially in unstable patients.
Cover the injured area with a protective dressing and change daily noting any changes in the tissue
If necrosis of the skin at the infiltration site occurs, apply a small amount of collagenase to the area (enough to cover the eschar with a thin coat) and cover with a moist dressing. Change the dressing twice daily
Consult physician for decision about sharp debridement of necrotic tissue
Following debridement or enzymatic removal of the necrotic tissue, moist wound care with collagenase, ORC/collagen products, nonadherent dressing, or similar dressings should be continued. The wound should be monitored on a regular basis to evaluate for healing, worsening, or infection
Additional wound treatment and coverage will be determined by the consulting physician

Table 4. Institute for Advanced Wound Care Guidelines for the Treatment of Intravenous Extravasation Injuries

- Discontinue the infusion
- If catheter is out of the vein, aspirate to remove as much residual fluid as possible
- Remove catheter
- Elevation of limb is not needed
- Use of warm or cold compresses – controversial
  - Only benefit of warm compress is on hypertonic saline infiltration
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- Cover the injured area with a protective dressing and change daily noting any changes in the tissue
- If necrosis of the skin at the infiltration site occurs, apply a small amount of collagenase to the area (enough to cover the eschar with a thin coat) and cover with a moist dressing. Change the dressing twice daily
- Consult physician for decision about sharp debridement of necrotic tissue
- Following debridement or enzymatic removal of the necrotic tissue, moist wound care with collagenase, ORC/collagen products, nonadherent dressing, or similar dressings should be continued. The wound should be monitored on a regular basis to evaluate for healing, worsening, or infection
- Additional wound treatment and coverage will be determined by the consulting physician