Anesthesia Quality Institute®
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Anesthesia Incident Reporting System (AIRS)

Case 2023-1: Management and Prevention of Peripheral I.V. Infiltration and Extravasation

An 11-year-old patient with complex past medical history, including known difficult vascular access, history of central access complications, and neuromuscular scoliosis, presented for posterior spine fusion. There was difficulty securing peripheral I.V.s, even with ultrasound guidance. A small-gauge I.V. was placed in the left saphenous vein as a backup and connected to a pump infusing maintenance fluid at 50 cc/hr for seven hours. At the end of the case, the intraoperative team discovered severe, limb-threatening compartment syndrome of the left lower extremity. Emergency fasciotomy was performed; the patient returned to the OR four times for I&D and progressive wound closure. The limb was ultimately saved.

Peripheral intravenous (PIV) catheter insertion is the most common procedure in modern medicine. PIV catheters are used for I.V. delivery of fluids, medications, and blood products. I.V. delivery is often preferred or necessary due to drug bioavailability or other clinical scenarios (Vascular Anesthesia Procedures. 2021).

Dislodged PIV catheters can lead to infiltration and/or extravasation, also known as PIVIEs. I.V. infiltration occurs when a non-vesicant solution (e.g., saline) leaks into the surrounding tissue. I.V. extravasation occurs when an irritant/vesicant leaks into the surrounding tissue (*Journal of the Association for Vascular Access* 2019;24:44-7).

Most hospitals have guidelines regarding the regular assessment of PIV catheter sites. However, these may be difficult to adhere to in the OR, where the patient's limbs are commonly inaccessible and covered by opaque surgical drapes. Infiltration risk increases with high-risk infusates (e.g., vasoactive agents, hyperosmotic solutions, and certain medications such as calcium or chemotherapy), smaller catheter diameter, poor securement, multiple attempts, and length of stay (asamonitor.pub/3tejHrQ; *Rev Lat Am Enfermagem* 2016;24:e2833). The pediatric population, especially neonates, is particularly at risk due to their weight, small vessel size, catheter length, high activity level, and limited communication (*Journal of the Association for Vascular Access* 2019;24:44-7). Some recent studies suggest that ultrasound use is a risk factor; however, this may be confounded by otherwise challenging vasculature, choice of vessel, operator inexperience, or wrong choice of a catheter (*Acad Emerg Med* 2016;23:918-21).

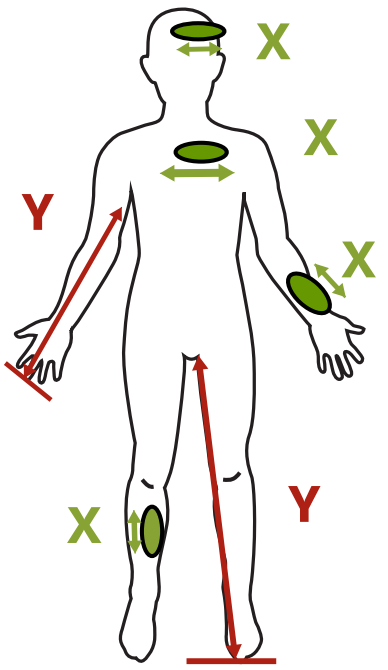
The reported incidence of infiltration in patients ranges widely from 16%-78%, with adult populations tending toward the lower end and pediatric populations leaning toward the higher end (*Journal of the Association for Vascular Access* 2019;24:44-7). Reported extravasation injuries range from 0.1%-6.5% of inpatients (*ISRN Dermatol* 2013;2013:856541). PIVIEs have a wide range of consequences depending on the severity and can increase the pain, stress, and suffering of the patient and their family during a vulnerable time. They also lead to increased costs for the hospital; one pediatric study estimated that each event resulted in $500 of added expense on average. The Closed Claims Project database shows that 2.1% of injury claims between 1970 and 2001 arose from peripheral catheter complications, with 54% resulting in successful litigation for plaintiffs and compensation up to $10,500,000.

Symptoms of I.V. infiltration include swelling, redness, or leaking. Symptoms of I.V. extravasation include chemical burns, blisters, or tissue necrosis with subsequent functional impairment and residual cosmetic defects (*Journal of the Association for Vascular Access* 2019;24:44-7). In severe cases, PIVIEs can lead to compartment syndrome, a surgical emergency in which mechanical compression of limb arteries/veins can lead to tissue ischemia, necrosis, and limb loss. Symptoms include pallor (discolored/mottled skin), pain (severe), paresis (difficulty moving limb), paresthesia (numbness, tingling), pulselessness (late sign), and delayed capillary refill >3 seconds.

Assessment begins with comparing the contralateral limb and outlining the affected area. The percentage of swelling is calculated (Figure) by dividing the amount of swelling (X) by either arm length (for upper-extremity infiltrates) or leg length (for lower-extremity infiltrates) (Y).

Using this information, infiltrations can be staged and used to guide treatment. Advanced stages require more frequent monitoring and likely intervention. Generally, four stages are defined; however, criteria vary between studies and institutions. At Johns Hopkins All Children's Hospital, the following criteria are used:

- Stage 1: Swelling volume <30%; no blisters or necrosis
- Stage 2: Swelling volume 31%-59%; clear blisters <2 cm with or without swelling
- Stage 3: Swelling volume >60%; clear blisters >2 cm; cloudy or blood-filled blisters; tissue damage; areas of demarcated color change; necrosis without swelling
- Stage 4: Signs of arterial compromise or compartment syndrome.



X = maximum dimension of swelling
Y = arm length = axilla to tip of longest finger
Y = leg length = groin to tip of longest toe

Figure: Assessment of Swelling of PIVIEs
Adapted from Johns Hopkins All Children's Hospital, Intravenous (I.V.) Infiltration Staging Tool & Treatment Recommendations.

Alternatively, in adults, the length of swelling/edema can be used alone, with cutoffs of <1 inch, 1-6 inches, and >6 inches, respectively, in place of the swelling volume ranges above (*J Infus Nurs* 2006;29:S1-92).

Diagnosis of PIVIEs typically relies on providers visually checking I.V. sites at regular intervals. The frequency varies by hospital, patient population, and context. In adults, checks may occur every one to four hours; in pediatrics, many hospitals recommend minimum hourly checks. More frequent observations may occur if patients are actively receiving I.V. medications or infusions (*Journal of the Association for Vascular Access* 2019;24:44-7). In the OR, when sites cannot be checked without disturbing the sterile surgical field, providers regularly perform PIV assessments at the start and the end of the procedure.

When a PIVIE is detected, the use of the I.V. should immediately stop. Aspiration of fluid from the site should be attempted and the I.V. clamped. If there is potential for treatment through the catheter, it should be left in place. If there is no evidence of compartment syndrome, the limb may be elevated. The use of warm and cold compresses is controversial, and some clinicians recommend avoiding them. Warm compresses cause vasodilation and promote reabsorption of extravasated fluid, but direct application may cause tissue maceration and sloughing. Cold compresses cause vasoconstriction but may increase local tissue damage and cause frostbite (*J Infus Nurs* 2013;36:392-6). If the hospital has a dedicated vascular access team trained in PIVIE management, they should be consulted for further staging and treatment recommendations.

Further treatment is recommended if there is any evidence of tissue damage. If vesicant/vasoactive medications were involved, phentolamine is indicated; for other medications, hyaluronidase is indicated. These medications are injected at the affected site as soon as possible, ideally within one hour of discovery but no later than 12 hours after. Any signs of compartment syndrome warrant an emergency consultation for potential surgical intervention.

Surgical patients are at higher risk for severe extravasation complications due to the nature and speed of the fluids and medications given, surgical positioning leading to less frequent I.V. site checks, and lack of patient feedback regarding painful or irritated I.V. sites. Clinicians should strive for prevention and early-stage detection.

Wake Up Safe, a national pediatric anesthesia collaborative sponsored by the Society for Pediatric Anesthesia, has proposed an improvement initiative led by Imelda Tjia, MD, which features several change concepts. These include initial and frequent I.V. checks, vein visualization technology, proper securement, familial collaboration, pump use, I.V. site monitoring technology, and established post-event protocols.

Initial I.V. checks include direct visualization and flushing with 10 cc of saline to confirm patency before use. Frequent I.V. checks include visual checks every one to two hours, implementing EMR reminders, and collaborating with surgeons to allow regular I.V. checks intraoperatively. Vein visualization technology includes using near-infrared vein finders and ultrasound to identify veins correctly and to aid in selecting the proper catheter gauge and length. Proper securement includes avoiding excess tape and maintaining site visibility. Familial collaboration involves family checking I.V. sites postoperatively so they can notify providers of any new

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concerns about appearance or pain. Pumps may be used to infuse a low rate of fluid through an otherwise unused I.V. to maintain patency rather than intermittent flushing every few hours; a pump occlusion alarm may be an early warning sign of infiltration. Hospital post-event protocols should be established to assess, stage, and treat PIVIEs consistently and promptly.

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Recently, I.V. site monitoring technology using visible and infrared light sensors has come to market. These devices monitor changes in tissue volume, and some manufacturers claim to have validated the technology for all age groups. Few independent studies exist; one peer-reviewed study suggests that such devices can detect infiltrations at a median of 15 hours before clinicians with 80% sensitivity (*Journal of the Association for Vascular Access* 2019;24:44-7). Further studies are required to validate their use, but they may be considered an adjunct when I.V. site visualization is challenging or in high-risk situations.

PIVIEs remain a constant issue, particularly in the perioperative arena. The consequences of an unrecognized PIVIE range widely but can be devastating to the patient. We recommend that each hospital develop a PIVIE protocol incorporating the above detection, treatment, and avoidance strategies. ■

Each month, the AQI-AIRS Steering Committee abstracts a patient history submitted to AIRS and authors a discussion of the safety and human factors challenges involved. Absence of commentary should not be construed as agreement with the clinical decisions described. Reader feedback can be sent to **airs@asahq.org**. Report incidents or download the AIRS mobile app at **www.aqiairs.org.**