A Case Report From the Anesthesia Incident Reporting System

Case 2013-3: Out of Sight, Out of Mind

A 55-year-old woman presented for exploratory laparotomy, total abdominal hysterectomy, bilateral salpingo-oophorectomy and tumor de-bulking. Her past medical history was significant for a one-week history of partial large bowel obstruction. Vascular access was difficult, but a 16g peripheral I.V. (PIV) was eventually placed in the left hand, distal to the noninvasive blood pressure cuff. Both arms were tucked at the patient's side during the procedure. Intravenous induction of general anesthesia and tracheal intubation were without complication. During the case, the patient suffered significant blood loss, leading to phenylephrine and blood product administration.

After emergence and extubation of the trachea, the patient complained of significant left arm and hand pain. The extremity was swollen, tender and cool, and the diagnosis of I.V. infiltration was made. The radial pulse was difficult to palpate. A plastic surgeon recommended elevation of the left hand and observation in the ICU. By the following day, the left arm symptoms and signs had resolved: “sensory and motor function were intact and back to baseline.”

Discussion: I.V. Infiltration and Extravasation

PIV-associated complications are not infrequent in the operating room. An analysis of 6,894 claims in the ASA Closed Claims Database from 1997-2000 found that 127 (1.8 percent) were related to complications from peripheral I.V.s.1 Of these, 35 were for skin slough or necrosis, 22 for nerve damage and 20 for scars resulting from fasciotomy for treatment of compartment syndrome. The Closed Claims database, like AIRS, by its nature does not include numerator or denominator data. However, rates of I.V. infiltration in other settings may be extrapolated to the O.R. In a study of 69,657 radiology patients receiving CT contrast, 475 (0.7 percent) suffered extravasation of contrast material.2

Four hundred thirty two of these patients had no apparent sequelae, and there was only one patient with less than 50ml of extravasated contrast who had a significant complication. Only two complications were classified as severe.

Unique characteristics of the O.R. may result in increased frequency and severity of events. In the perioperative setting, patients receive greater volumes of medications and fluids – and at higher rates of administration. Many O.R. therapeutics are vesicants (i.e., blistering agents, which directly cause tissue or cellular injury). Further, diagnosis may be delayed during anesthesia due to diminished patient response and invisibility of I.V. sites under the surgical drapes. Other risk factors include frequent blood pressure cuff cycling, use of relatively large I.V. catheters and high-pressure rapid infusion devices. On the other hand, anesthesia providers are experts at vascular access, and patients under anesthesia are less likely to “twiddle” an I.V. catheter out of position.

The literature distinguishes between I.V. infusion injuries based on the nature of the infiltrate.3 If the agent is a vesicant, then the event is termed an “extravasation.” If a non-vesicant is involved, it is termed an “infiltration.” Although minor infiltration events are frequent, and usually inconsequential, large-volume infiltrations may result in mechanical tissue injury. Compartment syndrome ensues when tissue perfusion is diminished by vascular compression or increased extravascular pressure, resulting in ischemia and eventual necrosis of tissue. Although most commonly associated with direct trauma and closed fractures, compartment syndrome may also develop following large-volume infiltration or extravasation of vesicants. Vesicants may contribute to the development of compartment syndrome by direct vasoconstriction.

Extravasation can lead to serious necrotic injury even in the absence of compartment syndrome. Factors determining the degree of injury in the case of extravasation are multifactorial, including the volume and quantity of vesicant involved, the anatomic location, host factors such as perfusion to the affected area, and chemical and biologic properties of the involved agents, such as pH, osmolality,
cytotoxicity and vasoconstrictor potency. Paradoxically, although vesicants may cause severe tissue necrosis, the initial extravasation event may present with only minor discomfort. Propofol, painful when injected intravenously, is usually painless when infiltrated and is considered a non-vesicant based on its moderate pH and osmolality, and lack of cytotoxic properties. While traditional formulations of propofol appear to be low risk for extravasation injury, large-volume infiltration and/or host factors, such as extremes of age or serious illness, should increase the index of suspicion for serious injury.

In the case under discussion, a difficult PIV placement was complicated by the BP cuff on the same arm, and led to infiltration of blood products and phenylephrine. Although phenylephrine is a vasoconstrictor and could be expected to cause extravasation injury with a sufficient volume and concentration, it is also approved for use by subcutaneous and IM routes and was diluted by the volume of fluid administered with it. In addition – in contrast to the cytotoxic vesicants – the effects of phenylephrine infiltration should be short-lived. The most concerning factor related to the infiltration of large volumes of blood products is mechanical compression of the hand/forearm. The poor pulses, pain and appearance of the swollen forearm led to urgent assessment for compartment syndrome.

There is no simple algorithm for this diagnosis (see table), but important factors include symptoms (paresthesia, pain, pressure and late findings: paresis and pulselessness), clinical exam and interval monitoring of intra-compartment pressures. In this case, symptoms improved rapidly with discontinuation of the I.V. and mild elevation, and no further therapy was required. Immediate fasciotomy is recommended when the signs or symptoms are more concerning. In fact, it may be appropriate to proceed directly to fasciotomy when compartment syndrome is suspected due to I.V. extravasation – even prior to emergence from anesthesia for the original case. Although intraoperative diagnosis of compartment syndrome is hampered by the inability of the anesthetized patient to report symptoms, the benefit is rapid, definitive treatment and patients may awaken without significant pain. In this case, consideration of intraoperative fasciotomy was not possible, as attention was first brought to the site by the patient herself.

Initial treatment for serious I.V. infiltration and extravasation hinges on rapid identification and treatment, informed by the observation that serious extravasations may present with minimal symptoms. For extravasation of chemotherapeutic agents, oncology, pharmacology and surgical expertise should be engaged. There are case series and case reports of specific therapy for vasoconstrictor extravasation treatment with phentolamine. Subcutaneous hyaluronidase administration is thought to decrease extravasation injury by increasing systemic absorption of toxic agents via increased diffusion – and therefore dilution – of the offending agent and a transient increase in tissue permeability.

The mainstay of extravasation therapy remains prevention, starting with identification of the risky situation – patients with lack of venous integrity, difficult I.V. placement and use of high-risk medications. Placing I.V.s in observable areas using clear securement devices/tape and frequently assessing the I.V. prior to and during infusion can prevent large-volume infiltration/extravasation. In this case, the difficult I.V. start, the blood pressure cuff and the placement of the I.V. on the dorsum of a tucked hand all increased the risk of a significant infiltration/extravasation. The history of difficult venous access implies that the anesthesia team was grateful to have at least one large-bore PIV and may not have been able to place another. Although five liters of blood loss was more than expected, the planned procedure was at risk for significant hemorrhage. The anesthetic plan might have included placement of a central line, especially given difficult PIV placement. Unfortunately, central lines do not completely protect against infiltration (multi-orifice lines can allow extravasation from a proximal port following relatively little migration) and are associated with complications of their own. In fact, any vascular access device can be complicated by infiltration or extravasation.

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Since the need for vascular access is a fact of perioperative life, the anesthesiologist and perioperative team must adapt. The BP cuff should be placed on a different extremity. When possible, clear drapes should be used over critical areas. Prior to draping and tucking, a mental checklist should be engaged that includes final examination and testing of all infusion sites. This should be repeated prior to initiation of vesicant or high-volume I.V. therapy. Central lines should be used when appropriate, but not regarded as a panacea; while extravasation may be less likely, the resultant injury may be more severe. Finally, when doubts arise the practitioner should not hesitate to climb under the drapes and have a look. Out of sight may be out of mind, but out of sight does not mean out of danger.

### Table: Techniques to Detect IV Dysfunction and Prevent Infiltration and Extravasation in the Perioperative Setting

<table>
<thead>
<tr>
<th>Test or Practice</th>
<th>Comments</th>
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| Rate of fluid flow gestalt               | • May be non-specific: flow may be decreased for many reasons including partial catheter obstruction (e.g., clot/fibrin); catheter against vein wall or valve; position of extremity kinking vessel.  
  • May not detect all I.V. problems (e.g., disconnected I.V. has high flow).  
  • Important that I.V. is secured so that it is not “positioned” and that I.V. patency is maintained with a “TKO” infusion or periodic crystalloid flushes to keep I.V. flowing well. |
| Visual Inspection of IV Site             | Limited when I.V. site is draped/tucked. For central lines and ports, area along subcutaneous portion of catheter should also be inspected; partial removal of the line should also be ruled out.                      |
| Infusion Pump Settings                   | Note that significant extravasation complicated by compartment syndrome has been reported in association with a properly functioning infusion pump.                                                           |
| Proximal NIBP Cuff Test                  | Caution with excessively frequent cuff inflation when infusion/bolus are administered under pressure, as this procedure itself can lead to an I.V. infiltration event.                                      |

References

### Intravenous Medication Tests

Medication given via I.V. catheter should have effect commensurate with I.V. potency of dose administered, with expected time course.

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<tr>
<th>Medication</th>
<th>Consider I.V. Malfunction, Including Infiltration if…</th>
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<tbody>
<tr>
<td>Small dose of I.V. Anesthetics, such as Propofol</td>
<td>No signs of increased depth (e.g., vital sign changes; BIS changes).</td>
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<tr>
<td>Small dose of I.V. Opioid</td>
<td>No increased depth of anesthesia; no change in respiratory rate or EtCO2 (if patient spontaneously breathing)</td>
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<tr>
<td>Small dose of I.V. Sodium Bicarbonate</td>
<td>Dilute, small dose should show rapid, short-lived rise in EtCO2 for mechanically ventilated patients – in adults (50 ml of 4.2% solution was compared to 0.9% NaCl solution) and infants (1ml/kg of a 2.1% solution) Caution: as sodium bicarbonate may itself cause tissue injury if extravasated. Dilute solutions appear safe in animal studies.</td>
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### Other Warning Signs of IV Malfunction

- Complaints of pain, especially upon (attempted) injection into the affected catheter. Useful for the awake patient, but not useful for the sedated or anesthetized patient.
- Patient receiving I.V. anesthetics becomes “light” without increase in surgical stimulation.
- Retrograde flow of infusate up I.V. tubing in circuit without a one-way check valve in line.
- Loss of pulse oximeter signal or change in arterial line waveforms; Loss of neuro-monitoring signals


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**ERRATUM:**

The AIRS Steering Committee would like to apologize for an error in Case 2012-7 (ASA Newsletter, July 2012), concerning the possibility of lethal air embolus during ERCP procedures. We described the patient as “... suddenly hypoxic followed by ... hypoxemia (end-tidal CO₂ 8 mmHg).” While the end-tidal measurement is accurate, it is of course implausible that the patient was actually hypoxic, since blood carbon dioxide concentration begins rising as soon as pulmonary clearance is impaired. We thank sharp-eyed reader Martin Dauber, M.D., of the University of Chicago Department of Anesthesia and Critical Care for pointing out this oversight.