Extravasation injuries

It is common for an intravascular catheter to be inserted to administer various types of therapy. Extravasation occurs frequently, and in the most severe cases plastic surgeons are often summoned to assess the extent of the injury and the possibility for reconstruction. The Department of Plastic and Reconstructive Surgery at Oslo University Hospital assesses approximately 15 severe cases of this type each year.

Kenneth Chiu
kenneth.chiu@ous-hf.no
Tyge Tind Tindholdt
Kim Alexander Tønseth
Department of Plastic and Reconstructive Surgery
Oslo University Hospital

MAIN POINTS

- Extravasation injuries can lead to wound necrosis and significant sequelae
- These injuries are iatrogenic and their prevention is of paramount importance
- Rapid intervention can reduce the extent of injury

Intravascular catheters are used to administer many different medications and fluids. However, leakage from a catheter can result in damage to surrounding tissues, referred to as extravasation injuries. These can vary from small, superficial and reversible skin lesions to large full-thickness skin ulceration with damage to adjacent structures such as tendons, muscles, joints and peripheral nerves – clinically everything from mild local reactions to tissue necrosis and superinfection (1).

More severe cases require surgical debridement, possibly followed by reconstructive surgery. Late complications such as disfiguring scars and contractures are not uncommon. Therapeutic options for extravasation injuries vary depending on the substance, specifically on its toxicity and any available antidote.

This article provides an overview of the pathophysiology, risk factors, classification, clinical picture, prevention and treatment, including reconstruction, of extravasation injuries. The number of medications and fluids that can cause such injuries is large, however, and it will often be necessary to consult literature specific to the substance in question.

This article is based on the authors' clinical experience and established procedures at Oslo University Hospital, as well as a discretionary selection of the most relevant review articles and accompanying references from among the 340 hits generated by a PubMed search for «extravasation injury review».

Pathophysiology

A number of explanations have been proposed for why extravasation injuries vary in severity. Often there are several mechanisms acting at once.

Cytotoxic substances can be divided into irritants and vesicants. Irritants cause inflammation, discomfort and pain. They rarely lead to necrosis or ulceration, except when there is extravasation of large volumes or high concentrations (2). Vesicants to a larger extent cause blisters and carry a greater risk of deeper damage to the skin and underlying structures. They cause severe pain and can lead to necrosis with the need for reconstructive surgery.

Osmotic pressures above plasma pressure (> 290 mmol/l) can cause tissue atrophy, as can substances with pH outside the range of 5.5 to 8.5 (3).

Substances with vasoconstrictive properties can contribute to necrosis development by reducing blood supply to the affected area. High infusion pressure can quickly result in large extravasated volumes. This can also impede local blood flow by producing a pathological increase in tissue pressure. Infection of an extravasation injury can exacerbate the condition by triggering development of necrosis or an increase in existing necrosis. It may take up to 14 days for necrosis and final demarcation to be seen (4).

Risk factors

Individuals with poor peripheral circulation are at increased risk of necrosis upon extravasation. These include patients with diabetes, smokers and haemodynamically unstable patients who require vasopressors. Those who cannot express pain and discomfort are also at increased risk due to the greater difficulty of detecting extravasation at an early stage. This applies to infants, the elderly, patients under sedation and those with peripheral neuropathy. Agitated patients are another high risk group. Other risk factors include atherosclerosis, advanced age and steroid use (4).

Repeated use of the same vein, high pressure infusion, infusion of vasoactive and cytotoxic substances, and inexperienced personnel also increase the risk of extravasation injury. Venepuncture in proximity to tendons and nerves can increase the extent of damage should extravasation occur.

The risk of extravasation injury is also related to the properties of the injected medication. In addition to volume and concentration, different substances have differing effects based on their pH, osmolality, cyto-

Figure 1 *a) Twenty-four hours after extravasation of HyperHAES solution for infusion. b) One week post-injury. c) One week after partial thickness skin graft. d) One year after partial thickness skin graft. Photograph: K. Chiu. Reproduced with permission of the patient and guardians*

toxicity and also their vasoactivity, which will affect the extent of the damage in the event of extravasation (4).

Classification

In 1991, Loth & Eversmann published a proposed classification scheme for extravasation injuries (5). Injuries are divided into mild, moderate and severe on the basis of the clinical picture and the type and volume of extravasated substance.

Mild: Extravasation that results in minor swelling and mild pain, but no erythema or blisters. Treated with elevation. The patient will be asymptomatic within two days.

Moderate: Local inflammation in an area < 10 cm in diameter but no necrosis. Effective pain relief with non-opioid analgesics.

Severe: Seen with extravasation of large volumes and vesicants. Severe pain and significant swelling; blistering and possibly skin necrosis.

Mild and moderate injuries should be monitored, and will usually heal spontaneously. Severe injuries almost always require intervention in the form of surgical debridement and reconstruction.

Clinical picture

Swelling, erythema, pain, blistering, induration and pallor can initially be observed (Fig. 1). A bluish discolouration or blanching of the skin can be a sign of impaired circulation, which can lead to necrosis. In the latter case, the skin will often be dry and black to begin with, but secondary infection may result in moist necrosis with possible production of pus.

Compartment syndrome with pain, reduced function and compromised distal neurovascular status may also occur. In such cases there may be pain or reduced sensibility, fast or slow capillary response, absent pulses, pallor or functional impairment.

Prevention

Extravasation injuries are iatrogenic and should therefore be largely preventable. When inserting a venous catheter, one should flush with saline to confirm intravascular placement. A proper dressing is required to secure the catheter so that it does not change position; however, it is important not to cover too much of the area as this could prevent detection of local signs of extravasation, such as swelling and erythema.

Good locations for inserting venous catheters should be prioritised. In general, flexion creases and periarticular areas should be avoided as these locations are prone to catheter displacement, which can in turn lead to extravasation. Soft tissue coverage is often more vulnerable in these areas too. Ongoing infusions require regular monitoring to allow any extravasation to be detected early.

Use distal sites, then proximal sites – not vice versa – to prevent leakage via previous injection sites.

The patient must also be given good quality information and should be told to report any pain, swelling or infusion stoppage. Care is required when moving the arm during an infusion; it is especially important to avoid sudden/rapid movements and twisting, and to ensure that nothing pulls on the intravenous line. This is particularly important for toxic substances.

Monitoring during infusions should be stepped up in cases with known increased risk of extravasation injury. A central venous catheter should be considered when administering high risk substances. Special equipment can also be used for monitoring (6).

Intervention and treatment

Conservative measures

If an extravasation injury has occurred, it is important that the infusion is stopped immediately and that aspiration is performed from the venous catheter in question. The identity and concentration of the substance given should be recorded, and the volume and duration estimated. The infusion method should also be noted, whether a gravity drip or one of the various types of active pump. It is useful to draw around any skin lesions with a marker pen so that progression can be monitored. For severe injuries photographs should also be taken.

Beyond this, general advice includes elevation, immobilisation, cooling, warming in certain cases and observation. A range of injectable or topical antidotes have been described for different substances (7). Elevation reduces hydrostatic pressure and is recommended for 48 hours after extravasation.

Cooling seems to relieve pain by reducing nerve conduction, and the ensuing vasoconstriction additionally reduces dispersion of the extravasated substance. The downside is that cooling prolongs the duration of action of many substances. The Poisons Information Centre can often provide valuable assistance (8). With respect to cooling, twenty minutes four times a day is recommended for the first 1–2 days, and care must be taken to avoid frostbite. Fluid bags that remain at approximately 4 °C may be used.

Local warming is recommended for certain substances where it is thought that increased blood flow and metabolism may reduce the extent of injury. For most substances, however, warming can lead to exacerbation. It is essential to guard against burns. Fluid bags at temperatures > 40 °C should not be used.

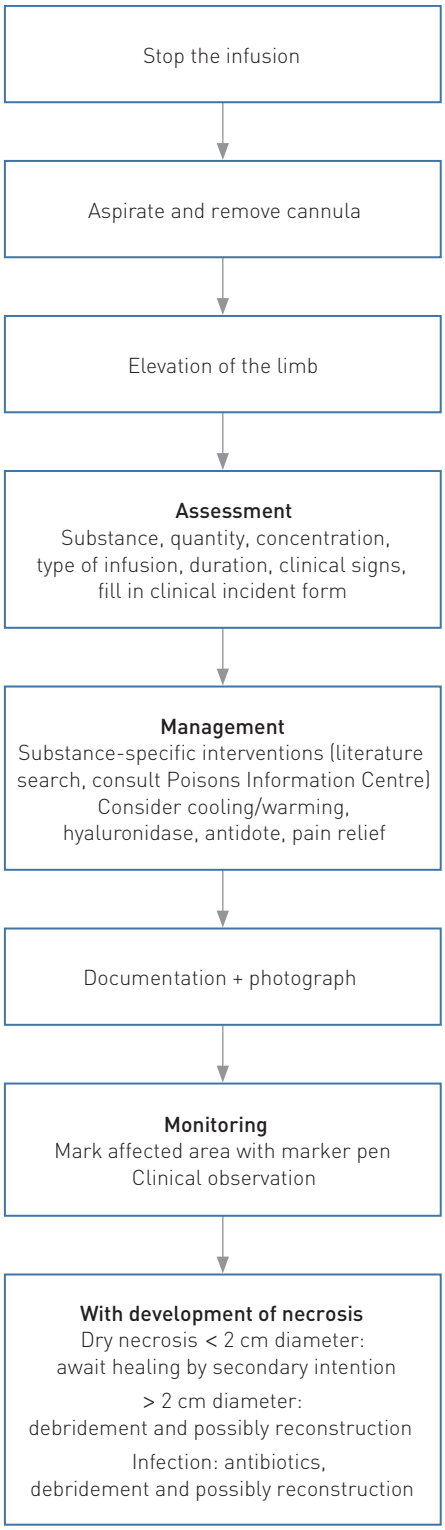

Figure 2 *Algorithm used at Oslo University Hospital for extravasation injuries*

In a study of eight patients with extravasation of cytostatic agents, Giunta and colleagues showed that necrosis was avoided in all those in whom subcutaneous flush-out with 0.9 % NaCl solution was performed at an early stage (9). There is otherwise weak evidence regarding the benefits of early intervention.

The affected area is usually dressed with impregnated gauze, dry gauze and a circular bandage. In general, the use of silver-containing cream is discouraged, especially at early stages, as this can make it difficult to assess the extent of the injury.

Subcutaneous hyaluronidase injection

Hyaluronic acid is a component of subcutaneous tissues and acts as a barrier in the interstitial space. Injection of hyaluronidase leads to breakdown of hyaluronic acid and improves resorption of extravasated substances from the skin's extracellular matrix (10).

Surgical interventions

Acute surgical interventions include subcutaneous flush-out and liposuction (11–13). Subcutaneous flush-out entails making small incisions in the affected area such that the entire area can be flushed to reduce the concentration of the extravasated substance (14). There is a risk that the flush-out fluid may not find its way out again – this can exacerbate the injury by increasing oedema and hydrostatic pressure. Liposuction is another option for removing as much as possible of the extravasated substance.

If there are signs of compartment syndrome, a surgeon must be contacted immediately to assess the indication for surgical decompression.

At later stages, surgery is indicated by the presence of necrotic tissue, chronic ulceration and infection. Conservative management is recommended initially due to the slow development of clinical signs. In this way, insufficient and inaccurate excision of tissue can be avoided (3). When surgical debridement is performed, all necrotic tissue must be removed.

Reconstruction

Patients in whom extravasation injuries lead to ulceration or necroses requiring debridement are often left with skin defects in need of reconstructive surgery. It is important to take account of the patient's age, comorbidities and general prognosis when considering reconstruction.

The reconstructive ladder should be followed in the usual way – that is, small wounds can be closed directly if there is enough surrounding skin available, while skin grafting can be used for larger defects, assuming that the wound bed is suitable (Fig. 1). If there are exposed structures such as tendons or bone, more extensive reconstruction is often necessary in the form of local flap surgery or microvascular free tissue transfer. Vacuum-assisted closure can also be used to promote granulation tissue formation in small defects over tendons and bones, to allow a successful outcome to be achieved with partial thickness skin grafts. Figure 2 shows an algorithm for managing extravasation injuries.

Conclusion

Extravasation is a relatively frequent iatrogenic event, which can result in anything from no damage to major injury requiring surgical management and reconstruction. Preventing and limiting the extent of extravasation injuries is of paramount importance.

However, there is currently no consensus regarding the classification, management or treatment of such injuries. Interventions must be tailored to the individual patient: comorbidities must be taken into account, along with the specific nature of the extravasation, including the identity, quantity and volume of extravasated substance.

Kenneth Chiu (born 1978)
specialist in plastic surgery.
The author has completed the ICMJE form and reports no conflicts of interest.

Tyge Tind Tindholdt (born 1968)
PhD, specialist in plastic surgery and senior consultant.
The author has completed the ICMJE form and reports no conflicts of interest.

Kim Alexander Tønseth (born 1974)
PhD, specialist in plastic surgery and head of department.
The author has completed the ICMJE form and reports no conflicts of interest.

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