Extravasation Injury in a Paediatric Population

Adrian D Murphy MD FRCS (plast)
Robert F Gilmour MBBS FRACS
Chris J Coombs MBBS FRACS

Dept. of Plastic & Maxillofacial Surgery,
Royal Children's Hospital,
Melbourne,
Victoria 3052,
Australia

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Corresponding author:

Prof. Chris J Coombs

Dept. of Plastic & Maxillofacial Surgery,
Royal Children's Hospital,
Melbourne,
Victoria 3052,
Australia

Chris.coombs@rch.org.au

Tel: +61 3 9345 6583

Fax: +61 3 9345 6585

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Abstract

Introduction

Extravasation occurs when a drug is inadvertently administered outside of the vein. Depending on the substance involved this may lead to tissue necrosis with significant long-term morbidity. Children, particularly neonates, are particularly susceptible to extravasation with up to 70% of children in neonatal ICU having some form of extravasation injury. These injuries are commonly referred to plastic surgeons for on-going management.

Methods

We prospectively collected information on all extravasation injuries referred to the plastic surgery department in a children's hospital over an 18-month period. Data collected included the agent involved in the extravasation, treatment and outcomes.

Results

There were 43 extravasation injuries in total recorded on the hospital risk management system during the period of this study. All of these were referred to the plastic surgery team for on-going management. 5 patients (11%) underwent washout of their injuries. 3 patients (7%) suffered injuries which led to significant tissue necrosis, delayed healing, and prolonged morbidity.

Conclusion

Smaller infants, particularly those being cared for in an intensive care setting, are at increased risk for extravasation injury. Early referral and treatment of high-risk extravasation injuries may reduce the incidence of tissue loss and morbidity.

Introduction

Extravasation occurs when a drug is inadvertently administered into the perivascular space or subcutaneous tissue instead of into the vein. This can result in a reaction ranging from local irritation to severe tissue loss. The severity of the tissue damage depends on the drug's properties, how long it remains in the tissue, the amount extravasated, as well as the site of extravasation and the relative size of the patient.

Extravasation injuries are common referrals to plastic surgeons in paediatric hospitals with previous studies having quoted rates of 11%-70% in children receiving intravenous medications^{1 2}. Garland *et al.* studied a paediatric intensive care population and found that extravasation occurred in 179 of 654 cannulations (28%). Irving reports a rate of 70% of cannulas having some degree of extravasation in a premature neonate population³. A survey of regional neonatal intensive care units in the United Kingdom reported the prevalence of extravasation injury resulting in skin

necrosis as 38/1000 neonates, with 70% of these injuries occurring in infants of 26 weeks gestation or less. About 4% of infants leave NICU with cosmetically or functionally significant scars caused by extravasation injuries ⁴. A number of other studies show a lower rate but the criteria for definition and reporting of extravasation vary considerably across publications and patient populations studied ⁵⁻⁷.

Extravasation into the interstitial space may be because of displacement of the intravascular catheter, increased vascular permeability or occlusion of the upstream vein, and subsequent retrograde flow around the outside of the catheter. The mechanism of extravasation necrosis is not completely understood, but the degree of tissue damage appears to be related to osmolality, pH and the dissociability of ions in the infusate as well as direct cytotoxicity. Vesicant extravasation may lead to skin necrosis, infection, nerve or tendon injury and compartment syndrome ⁵. Vesicants are agents capable of causing blistering, tissue sloughing, or necrosis when they escape from the intended vascular pathway into surrounding tissue. Commonly seen vesicants in the paediatric population include Vancomycin, Aciclovir, Phenytoin, hyperosmolar agents such as TPN and >10% dextrose, as well as many chemotherapy drugs. Scarring leading to contractures and disfigurement, functional loss, complex regional pain syndrome and deformities are potential long-term sequelae ^{8,9}.

This study prospectively looked at reported extravasation incidents within our hospital. We analysed referrals to the Department of Plastic and Maxillofacial Surgery, as well as extravasation injuries recorded on the hospital risk management system over an 18-month period. Our aim was use this information to identify

processes that might prevent the occurrence of extravasation injuries and to improve management.

Methods

For each extravasation injury that was referred to the Department of Plastic and Maxillofacial Surgery during the 18-month audit period (August 2014 to January 2016 inclusive) a data sheet was completed (Fig. 1). Data collected included: age, gender, referring ward, extravasation agent, site of extravasation, time of incident, time of review by plastic surgeon, treatment and outcome.

This data was collated at the end of the audit period. It was compared with the extravasation injuries recorded by the hospital risk management system during the same period. The number of recorded extravasation incidents was also compared with the overall number of cannulations and their site as recorded by the hospital Electronic Medical Record system.

Results:

During the study period there were 43 extravasation injuries recorded by the hospital risk management system. All 43 of these were referred to the Department of Plastic and Maxillofacial Surgery for review and management.

Hyperosmolar dextrose solutions (>5%) and total parenteral nutrition (TPN) accounted for almost half (44%) of recorded extravasations. Close to 20% of extravasations involved a mix of drugs running simultaneously. Flucloxacillin was the causative agent in 5 cases (12%) (Table 1). The extremities were most commonly involved; the hand or wrist accounting for 74% of incidents, and the foot or ankle a further 20%.

Over 60% of all extravasation injuries occurred in the neonatal or paediatric intensive care units. Four patients had injuries when not being regularly monitored: two occurred whilst in transit, one in the operating theatre with the site obscured beneath surgical drapes, one in the emergency department.

Administration of first aid was documented in almost all cases (94%). This involved attempted aspiration of fluid through the IV access cannula followed by removal of the cannula. Elevation of the affected limb was performed in all cases. This often consisted of a limb being placed upon a rolled towel within the confines of an incubator.

After review by the plastic surgery team a subcutaneous washout procedure similar to that described by Gault was performed⁵ when there was a significant fluid collection, concern regarding skin viability and/or vesicant extravasation (Fig. 2a & 2b). This occurred in 5 cases in this cohort (11%). Washout was not performed when the injury was referred more than 12 hours after the extravasation had occurred or the skin was already clearly non-viable.

All areas of extravasation were initially dressed with paraffin impregnated dressing and reassessed between 24 and 48 hours to ascertain depth and extent. At this point if skin integrity was satisfactory an absorbent dressing (Mepilex Border (Mölnlycke Health Care)) was applied or if the injury was felt to be deeper then a nanocrystalline silver containing dressing was placed (Acticoat (Smith & Nephew Healthcare Ltd.)). The silver dressing was changed every third day until the wound was healed. None of the patients required operative intervention for management of their wounds in the acute phase.

The majority of the superficial wounds were healed within 7 to 10 days and did not require longterm follow-up There were three cases that had delayed healing and required prolonged dressings.

- 1) A flucloxacillin extravasation that took 60 days to heal.
- 2) A hyperosmolar dextrose extravasation (approximately 200ml), which took greater than 90 days to heal
- 3) A lipid containing TPN extravasation into a foot that took greater than 150 days to heal and resulted in the loss of the medial three toes of that foot

(Fig. 3a & b). The child involved was undergoing a Norwood procedure on Day 1 of life for hypoplastic left heart. The extravasation was only noticed at the end of the procedure on removing the surgical drapes. It was estimated that the injury might have occurred up to 6 hours previously.

The skin was already clearly non-viable at the time of review by the plastics team.

All of these had delayed referrals to the plastic surgery team and did not undergo washout.

During the period under review there were 25,029 intravenous cannulations performed, giving a reported extravasation rate of 0.17%. Of note, however, the neonatal ICU setting was responsible for only 6% of cannulas placed, but accounted for 56% of reported extravasation injuries.

Discussion

Invasive access in paediatric patients is necessary to deliver fluids, nutrition and/or medications. A variety of devices and routes may be used. When these devices fail and there is leakage into the surrounding tissues significant injuries may occur. Management of these injuries is controversial with little strong evidence ¹⁰.

Multiple risk factors have been identified in the aetiology of extravasation injuries ^{1,11}. Previous studies have identified that limbs are at increased risk of extravasation injuries with up to 60% occurring in upper limbs ^{1,7}. Our study had a similar number (70%). Younger children are at more risk with previous studies showing almost 60% of injuries in a paediatric population happen to those under 1 year of age ⁷. In our study 65% were younger than 1 year of age. In our cohort over 60% of extravasation injuries occurred in NICU or ICU, which is again in keeping with other studies in this area, despite the fact that these children represent a minority of the IV cannulations carried out. This susceptibility is likely due to the fragility and size of the veins in these, often premature, babies. These patients are also more closely monitored than those on general wards with 1:1 nursing, which may lead to an increased rate of reporting, particularly in the less serious extravasation injuries, maintenance fluids for example, many of which are likely to go unnoticed and/or unreported elsewhere in the hospital.

Drug factors that contribute to the risk and extent of the extravasation include extremes of pH, osmolality, vasoconstrictive effects and cytotoxic effects. Much

attention in the literature is paid to the effects of extravasation of anti-neoplastic chemotherapeutic agents. In children, however, chemotherapy is usually administered via central lines or long lines, with reduced risk of extravasation injury. There were no anti-neoplastic chemotherapeutic agent extravasation injuries reported during this study.

TPN and hyperosmolar (>5%) dextrose were involved in many injuries in our study cohort (44%), these figures are comparable to other paediatric studies⁷. While there is no antidote for a TPN or hyperosmolar dextrose extravasation it has been postulated that hyaluronidase aids dispersion of extravasated fluid by breaking down hyaluronic acid, and reduces the degree of injury. There are advocates for this treatment alone, as well as combining it with saline washout, but no robust data has been produced to support either intervention^{5,12,13}.

Since Gault's original description of early invasive intervention of extravasation injuries with liposuction or saline washout with or without hyaluronidase a number of reports have published promising results with these techniques. Gault's paper was a retrospective review of the outcome of extravasation injury following referral to a plastic surgical unit. Patients were divided into two groups - 'early', that is within the first 24 hours of extravasation and 'late', which is after 24 hours of the injury. The 'late' group was offered conservative wound management only. Of the 52 patients referred late, 8 (15%) healed without any tissue necrosis, 17 (33%) suffered only minor sloughing of the skin and in 27 (52%) extensive damage to the soft tissue was observed. In the 'early' group where saline

irrigation was used, there were no signs of soft tissue damage in 39 (88.5%) cases and only five (11.5%) showed minor skin blistering with delayed healing. The range of agents causing extravasation was similar in both groups ⁵.

Subsequent data from the same institution showed a significant decrease in complications due to extravasation following implementation of a hospital-wide extravasation policy, which required early plastic surgical review and saline washout as appropriate compared to a historical control group. Mean time to referral was 8 h. 26% of the injuries required washout treatment. Tissue necrosis occurred in 3 cases (6%) but required no surgical intervention due to the small area affected – compared to 33% in the historical control cohort ⁷.

Aspiration of TPN through the cannula followed by washout of the remaining TPN through cutaneous puncture sites was done with good effect in 5 patients in this study. This was also successful in treating a hand that exhibited signs of circulatory compromise after hyperosmolar dextrose infusion.

Three cases in our cohort had skin necrosis with delayed healing. The agent involved was TPN in two cases and hyperosmolar dextrose in the other case. In all cases there was a delay in time to referral and the skin was already clearly non-viable at the time of first review, so washout was not performed. These wounds were of a size that precluded direct closure and due to medical complexity the decision was taken that surgical intervention was too high a risk and wounds were treated non-operatively and allowed to heal by secondary intention. These cases that took longest to heal had the largest residual defects. Long-term follow up with both plastic

surgeons and therapists to monitor scars and scar contracture and to assess the need for future intervention is on going.

In light of these findings, and the positive effects demonstrated by other authors of having an extravasation protocol, we have elected to introduce a protocol advocating prevention, early recognition of extravasation, and prompt treatment and referral when extravasation has taken place, to attempt to reduce the morbidity we see associated with these injuries. Along with a guide to the signs and symptoms of extravasation, and a list of commonly seen vesicants in the paediatric population, this protocol advocates early washout of vesicant extravasation by suitably qualified personnel. In many cases we envisage this being done by trained neonatal ICU staff so as to minimise delay to treatment. Furthermore, we have changed practice at our institution where all parenteral nutrition infusions are stopped during transfers and intra-operatively, as this appears to be a high-risk time for extravasation going unnoticed. We plan to re-audit our practice after a suitable period of implementation of the protocol.

Conclusion

Smaller infants, particularly those being cared for in an intensive care setting, are at increased risk for reported extravasation injury. Adequate training in the care of central and peripheral lines is the most effective way of preventing extravasation injury. Early recognition of an extravasation event with referral and treatment of high

risk injuries should help reduce the incidence of skin necrosis in these patients and subsequent surgical intervention needed to treat the immediate and delayed consequences of these potentially devastating injuries.

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Table 1. Vesicant and non-vesicant agents reported in cases referred to plastic surgery service during the audit period.

Fig. 1. Data collection sheet showing information collected prospectively regarding extravasation injuries referred to the plastic surgery team

Fig 2a & b. Illustration of subcutaneous washout technique as described by Gault

Fig. 3a & b. Unrecognized extravasation of parenteral nutrition leading to extensive scarring on the foot with loss of medial three toes

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Extravasation Injury

ID Number	<input type="text" value="(New) UR"/>	Data Collector	<input type="text"/>	Date of Extravasation	<input type="text"/>
ReferringTeam	<input type="text"/>	Date of Referral	<input type="text"/>	Time of Extravasaion	<input type="text"/>
Site of Extravasation	<input type="text"/>	Time of Referral	<input type="text"/>		
Fluid Extravasated	<input type="text"/>	Drugs/Additives	<input type="text"/>	Diagnosis/under lying condition	<input type="text"/>
Approx volume infused 2 hours prior	<input type="text" value="0"/> ml				

Assessment at time of referral

Swelling ☐ Yes ☐ No	Redness ☐ Yes ☐ No	Pallor ☐ Yes ☐ No	Eschar ☐ Yes ☐ No	Ulceration ☐ Yes ☐ No	Distal Ischaemia ☐ Yes ☐ No	Blisters ☐ Yes ☐ No	Other <input type="text"/>
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Immediate Management (within 48 hrs of injury)

Massage/Physio/Limb elevation ☐ Yes ☐ No	Stab incisions ☐ Yes ☐ No	Debridement (including de-roofing of blisters) ☐ Yes ☐ No	Dressings ☐ Yes ☐ No	List Dressings <input type="text"/>
				Other Immediate Management <input type="text"/>

Later Assessment (>48 hours)

Skin/Tissue Loss ☐ Yes ☐ No	Ulceration ☐ Yes ☐ No	Eschar ☐ Yes ☐ No	Management <input type="text"/>	Surgical Management <input type="text"/>
			List Dressings <input type="text"/>	
Prolonged hospital or ICU stay due to injury ☐ Yes ☐ No	Scar Sequelae <input type="text"/>	Comment <input type="text"/>		

Extravasation Data Form.JPG

Saline washout.jpg

Agent	Number	Percentage
TPN	10	23%
>10% Dextrose	9	21%
Flucloxacillin	5	12%
Dobutamine	2	5%
Gentamycin	1	2%
Normal Saline	6	14%
Contrast medium	2	5%
Phenytoin	2	5%
Immunoglobulin	1	2%
Calcium gluconate	2	5%
5% Dextrose	2	5%

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Author/s:

Murphy, AD;Gilmour, RF;Coombs, CJ

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