BJN
British Journal of Nursing

EXTRAVASATION & INFILTRATION:

Identifying best practices, improving patient safety, and reducing the economic burden in healthcare settings

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MA Healthcare

Published by MA Healthcare Ltd
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www.markallengroup.com

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Produced by Mark Allen Medical Communications
www.mamedcomms.com

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Supported by ivWatch
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Declarations of interest
The publication of the articles in this supplement was supported by ivWatch

Contents

S3 Foreword
Gary Warren

S4 Extravasation and infiltration: under-recognised complications of intravenous therapy
Andrew Barton

S13 Addressing and mitigating the high costs of extravasation and infiltration to patients and healthcare organisations
Andrew Barton

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Foreword

Gary Warren

Gary Warren, President and CEO, ivWatch

Intravenous (IV) insertion is the most common hospital procedure, performed for over 80% of hospital patients. However, this common and seemingly simple procedure fails up to 50% of time (Piper et al, 2018). This rate of failure is even higher in certain patient populations, such as neonates, in whom over half of IVs fail.

Around 23% of IV failures are attributed to accidental leakage of IV fluid outside the vein and into surrounding soft tissues. This is known as either extravasation if the fluid is directly harmful to the tissue (vesicant) or infiltration if it is not (non-vesicant). Both infiltration and extravasation can have severe consequences, with high rates of significant complications ranging from scarring and skin staining to nerve damage, amputation and death. Deposition of fluid in soft tissue can cause irritation, swelling and pain and, if left unchecked, can lead to amputation. Moreover, the inevitable errors in drug dosing deprive patients of some or all of the intended therapeutic benefit of their prescription. For example, this could lead to death in a patient who needs IV thrombolytics to prevent stroke. In extravasation of a vesicant IV solution, such as vasopressors, iron infusions, hyperosmolar solutions and systemic anti-cancer therapies, as well as any drug with non-physiological pH, injury is often faster and more severe.

IV injuries place a heavy burden on clinical resources and can incur major financial costs. Patients may need additional procedures, use more medical supplies and stay in hospital longer, with further consequences including delays in care, bed shortages and increased risks of hospital-acquired infections. Not only are patients harmed, but clinical staff who witness these failures will have to deal with the fallout and devastation, while hospitals may face litigation for allowing preventable injuries to go undetected. IV infiltration and extravasation are issues that span practically every area of hospital care. Moreover, they are not localised to any one health system but are evident in hospitals all around the world.

The persistence of this failure rate despite all the advances of modern healthcare can be a challenge to explain to patients. Writing in the *Journal of Infusion Nursing*, Robert E Helm questioned why, when a mean failure rate of nearly 50% would be unacceptable for food processing, automobile driving or cell phone use, let alone airplane flights, it has been accepted for the most performed invasive hospital procedure worldwide (Helm, 2015). To have such a critical, high-volume medical procedure overshadowed by failure rates of this magnitude represents an extraordinary opportunity to improve the overall standard of care and protect patients and colleagues from the fallout of preventable injuries. Yet the lack of improvement in the decade since Helm's question suggests that IV therapy safety has not been a priority.

The standard of care for peripheral IVs remains to wait and see if an injury appears. Wherever IVs are inserted, given enough time, infiltration or extravasation will eventually occur. However, by the time an injury occurs, it is often too late to avoid severe consequences. It is important for health professionals to ask why the same clinical practices are kept in place if they continue to injure patients.

It is up to health professionals to choose to minimise this risk and save patients from these injuries by changing the way that they monitor IVs. There is a known gap in clinical education, and clinicians are not being taught what causes an IV to infiltrate, leading to multiple misconceptions and missed diagnoses of extravasations. There is also an opportunity presented by ivWatch's peripheral IV infusion monitoring device.

In the first evaluation of ivWatch in a UK infusion unit, out of 2254 infusions monitored by the device from August 2023 to January 2024, 122 cases of infiltration or extravasation were prevented from causing any harm to the patient, corresponding to a 5.4% 'check IV' notification rate (Barton, 2024). The author also examined how the efficacy of ivWatch's proprietary technology would translate to cost savings for the NHS. Significant cost reductions were identified from decreases in surgery rates, bed per day costs, length of stays, repeat hospital visits and litigation costs. Most importantly, the study showed that IV injury prevention improves not only the financial situation of healthcare organisations, but also the long-term health and wellbeing of their patients.

Health professionals have become used to having real-time information on a patient's pulse and blood pressure at their fingertips, whether or not they are at their bedside. It is now time to extend this continuous monitoring to the IV status of patients everywhere, making IV surveillance as ubiquitous as pulse oximeters in hospitals.

Barton A. Extravasation and infiltration: under-recognised complications of intravenous therapy. Br J Nurs. 2024;33(7):S18–26. https://doi.org/10.12968/bjon.2024.33.7.S18

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Extravasation and infiltration: under-recognised complications of intravenous therapy

Andrew Barton

ABSTRACT

Occasionally, the administration of intravenous (IV) therapies can go wrong. Infiltration or extravasation is a complication when a drug or IV therapy leaks into the tissues surrounding the vascular access device. Extravasation can cause serious and often life-changing injuries. Extravasation is often associated with systemic anti-cancer therapy but non-chemotherapy drugs have been reported as having a greater risk of serious complications. This study outlines the first UK Infusion unit evaluation of the ivWatch infusion monitoring device which was undertaken from August 2023 to January 2024. Out of 2254 infusions monitored with ivWatch, the device prevented 122 cases of infiltration and extravasation from causing any harm to the patient, corresponding to a 5.4% 'check IV' notification rate.

Key words: Intravenous therapy ■ Infiltration ■ Extravasation

Intravenous (IV) therapy is an essential aspect of modern healthcare and commonly used within the NHS. Its advantages include improved patient outcomes and, in some cases, the IV route is the preferred option because it ensures consistent drug bioavailability and reliable therapeutic drug levels in the blood (Price and Patel, 2020). Unfortunately, the use of IV therapies is not without risks. While the benefits usually outweigh such risks, all staff involved in the administration of such therapies need a sound knowledge of potential complications. Infection associated with IV therapy and vascular access devices (VADs) is well known (Munoz-Mozas, 2023) and great efforts have been taken throughout the NHS to mitigate this risk in recent years. However, there are some complications that are less recognised and well known, including infiltration and extravasation.

Infiltration and extravasation are complications often associated with chemotherapy agents; however, non-chemotherapy drugs have been reported as having a greater rate and risk of serious complications (NHS Resolution (NHSR), 2022).

Infiltration is the inadvertent leakage of IV fluid or medication into extravascular tissue from a dislodged IV device, such as a peripheral cannula or central venous catheter (National Infusion and Vascular Access Society (NIVAS), 2024). The resulting injury can be minor depending on the volume of fluid infiltrated but large volumes of infiltrated fluid can lead to compartment syndrome (NIVAS, 2024).

An extravasation occurs if the fluid or medication involved in the infiltration is a vesicant; when extravasation occurs, the risk of tissue damage and serious injury can be very high (Atay et al, 2023; Nickel et al, 2024) because vesicants are drugs or solutions with the potential to cause serious skin or tissue damage including blistering, ulceration and necrosis (David et al, 2020; Nickel et al, 2024).

Four main groups of vesicant drugs are commonly used (NIVAS, 2024): Systemic anti-cancer therapy (SACT); drugs with non-physiological pH; vasopressors; and hyperosmolar solutions.

SACT is perhaps the best known IV therapy in relation to extravasation risk. This is so much so that, in order to administer SACT, oncology nurses need to undertake specialist administration training, including how to reduce the risk of extravasation and recognise when such an injury occurs. In the UK, SACT nurses need to update this knowledge annually; this is the primary reason why the rates of SACT extravasation are lower than in other IV therapy groups (NHSR, 2023).

Drugs with non-physiological pH can have a high or low pH. Every IV drug has a pH and osmolarity and its these chemical characteristics that classify the drug as a vesicant or non-vesicant. A pH range outside of neutral pH of blood (7.35–7.45) has the potential to cause irritation or damage to the tunica intima or the surrounding tissue. The higher or lower the pH range, the more damage extravasation can cause. It is generally considered that a pH value of between 5 and 9 is suitable for peripheral vein administration because the pH value is more likely to be tolerated by the peripheral veins (David et al, 2020; Couissi et

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Accepted for publication: March 2024

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al, 2023). Comparison of pH values between IV therapies and common household chemicals is an impactful tool to raise awareness in those giving IV therapy about the extreme pH values of some of the most common IV therapies given in clinical practice (*Table 1*). IV phenytoin (pH 12) and acyclovir (pH 10–11) have a pH value equivalent to bleach and hand soap. Vancomycin (pH 2.4–4.5) and gentamycin (pH 3–5.5) have a pH values equivalent to cola or vinegar (NIVAS, 2024).

Vasopressor drugs such as noradrenaline and dopamine carry an extremely high risk of serious extravasation injuries if inadvertently administered into tissue. These drugs can also damage fragile peripheral vessels because of their potent vasoconstrictive effects and cause injury following effusion into the tissues with increasing hydrostatic pressure (Stefanos et al, 2023). For this reason, the safest way to administer vasopressors is via a central vein where the tip of the catheter is situated in the lower third of the superior vena cava (NIVAS, 2024).

Hyperosmolar solutions such as parenteral nutrition and contrast media used in CT scanning cause extravasation injuries because of their osmolarity. Studies suggest that hyperosmolar solutions above 600 mOsm/l (normal range 285-310 mOsm/l) should not be administered via a peripheral vein (Manrique-Rodríguez et al, 2021; Pittiruti et al, 2023) because they are associated with a higher risk of tissue damage. Calcium chloride 10% has an osmolarity of 2040 mOsm/l; this extremely high osmolarity can cause devastating damage to limbs if an extravasation occurs during administration into a peripheral venous catheter.

In 2022, NHSR published data in a document called, Did you know? Extravasation. Publication coincided with the start of a project by NIVAS (2024), which has produced a national extravasation and infiltration toolkit to enable hospitals in the UK to become more aware of these and put protocols and guidelines in place to prevent them or recognise them early (NHSR, 2022).

From 1 April 2011 until 31 March 2021, NHS Resolution received 444 claims relating to extravasation injuries. Of those 444 claims, 138 remain open, 197 have settled with damages paid and 109 have closed with nil damages. These have cost the NHS £15.6 million. This includes payment for claimant legal costs, NHS legal costs and damages.

Reviewing the data highlighted trends in infiltration and extravasation injuries. SACT extravasations accounted for only 24% of closed, settled claims; the other 81% were associated with non-SACT drugs. Paediatric injuries accounted for the largest group of non-SACT injuries at 23%. Infiltration of IV iron accounted for 9% of settled claims; these injuries were associated with permanent orange staining of skin rather than extravasation.

NIVAS extravasation and infiltration toolkit

The NIVAS extravasation and infiltration toolkit focuses on the prevention, awareness, treatment, reporting and follow-up of these injures.

NIVAS recognised that non-SACT extravasation injuries are often misdiagnosed in the early stages as cellulitis or phlebitis; this misdiagnosis often leads to IV antibiotic or dermatology referrals when the extravasation injury requires urgent treatment, often by the plastics surgical team. After the first few hours since extravasation, the chance of successful treatment is lost and the injury has the potential to evolve into something more serious.

Most extravasations and infiltrations occur when a peripheral IV cannula (PIVC) is involved and often arise because of a placement issue with the vascular access device (VAD). It seems that most of these issues occur in patients who have difficult IV access, often with very limited peripheral vein options. Deeper veins that are more difficult to visualise or palpate require deeper cannulation, which limits the amount of catheter situated in the vein, especially when using a standard length (10 mm-32 mm) cannula. This makes the cannula unstable and can lead to the catheter becoming dislodged from the vein but remaining in the subcutaneous tissue, which is when extravasation occurs (Bahl et al, 2021; NIVAS, 2024). Points of flexion in the wrist or, in particular, in the antecubital fossa are at high risk of causing an infiltration or extravasation owing to mechanical friction from the joint moving the catheters and damaging the tunica intima or causing catheter displacement (Welyczko, 2020).

Different VADs have different risks and complications associated with them; the length of the catheter, the material the catheter is made of and the securement of the device are all risk factors. One complication that all VADs are prone to is the formation of fibroblastic sleeves. Fibroblastic cells can grow along the catheter from the point of vessel entry, so that eventually the catheter tip becomes encased by a closed sleeve of tissue (Rousslang et al, 2020; Passaro et al, 2021; Cutuli et al, 2023). Consequently, the infused fluid flows back between the

Table 1. pH values of common IV therapies given in clinical practice

	pH	IV infusion
Stomach acid	1.5–2.0	Glucagon pH: 2.5–3
Cola	2.5	Vancomycin pH: 2.4–4.5
Vinegar	2.9	Gentamycin pH: 3–5.5
Orange juice	3.5	Glyceryl trinitrate pH: 3.5–6.5
Coffee	5.0	Metoclopramide pH: 3–5
Healthy skin	5.0	Amiodarone pH: 3.5–4.5
Urine	6.0	Glucose 5% pH: 4–4.2
Pure water	7.0	Chlorpheniramine pH: 4–5.2
Human saliva	6.5–7.5	Potassium pH: 4
Blood	7.3–7.5	0.9% Saline solution pH: 7
Sea water	7.7-8.5	Tazocin pH: 5–7
Baking soda	8.4	AnnInophylline pH: 8.8–10
Hand soap	9.0–10.0	Frusemicle pH: 8.3–9.3
Bleach	12.5	Acyclovir pH: 10–11
		Phenytoin pH: 12

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fibroblastic sleeve and the outside of the catheter to the catheter exit site and can potentially infiltrate into the subcutaneous tissue just below the catheter insertion site (*Figure 1*) (Pittiruti et al, 2023).

Consent

IV therapy administration has become routine and is so commonplace in healthcare that, unless SACT is being administered – which requires fully informed written consent – patients receiving non-SACT IV therapy will, at best, give implied consent. The justification for this is often that IV treatment is being given in an emergency or the clinical team looking after the patient may have discussed the need for IV therapy and the patient has agreed in general to IV therapy without ever being told that in some cases they may experience an extravasation.

Intravenous iron is an infusion that is routinely given in clinical practice. While it is not considered a vesicant, if IV iron infiltrates into the tissue, it will leave a permanent orange stain to the skin. When this occurs, it is often a surprise to the patient, when they realise they will have to live with the orange staining for life. Litigation often follows and the first questions asked by the court are: did the patient give consent to have this treatment, and were they informed about the possible side effects? As IV iron is usually an elective treatment, using the defence that it was given in an emergency will not be enough. The NIVAS extravasation toolkit (NIVAS, 2024) has highlighted data from NHS Resolution's (NHSR, 2022) extravasation work and recommends written consent from all patients receiving elective IV iron infusions.

NIVAS white paper

Choosing to administer IV therapy via a peripheral vascular access device is not always an easy decision, especially when the service to place a central vascular access device is not readily available and pathways for patients with difficult IV access are not in place.

Annamaria Dutto

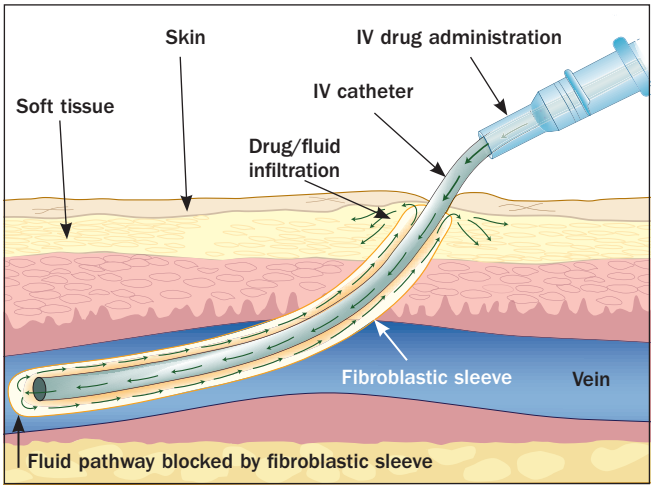
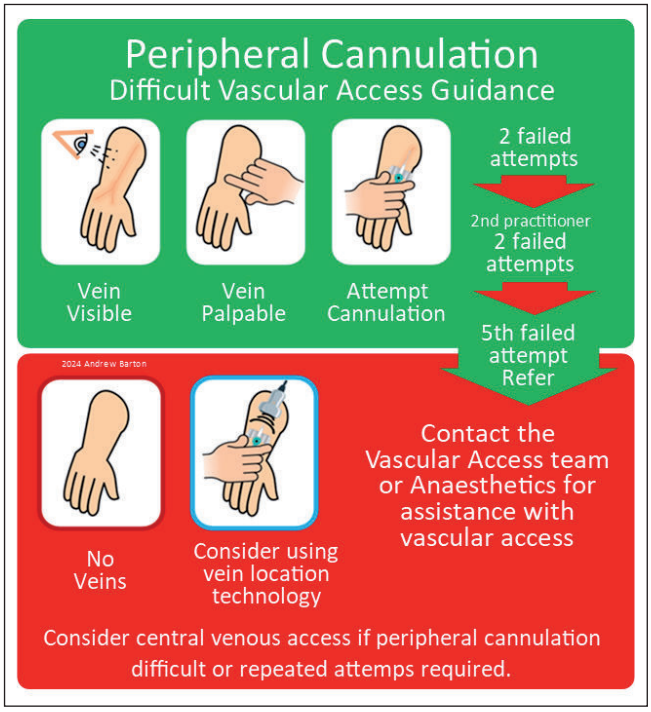


Figure 1. The formation of a fibroblastic sleeve is a complication that can cause leakage of an infusion into surrounding tissue during IV drug administration

Reducing extravasation injuries and other IV-related complications can be difficult in a hospital without a dedicated team to lead in the standardisation of clinical practice and act as a point of contact and clinical expertise. In 2022, NIVAS published a white paper, which supports the effectiveness of standardised vascular access teams with the NHS.

The aim of the white paper was to highlight the additional benefits of having a dedicated team who can support the insertion of all vascular access devices, from long term-devices to managing patients with difficult IV access. According to a NIVAS (2022) survey, so far in the NHS, approximately 55 hospitals have dedicated vascular access teams. Hospitals that do not have a dedicated full-time vascular access service team are less able to provide fast vascular access solutions. Fast, reactive teams who can place reliable vascular access devices can reduce the risk of infiltration and extravasation by reducing the numbers of attempts at peripheral cannulation or are able to place long-term vascular access devices without delay to coincide with the start of the patient's IV treatment, which is especially important for vesicant IV therapy regimes. A vascular access service is also more likely to embed standardised practice and use the most up-to-date technology to make IV therapy administration safer. They can also act as the organisation's extravasation lead.

A protocol for patients with difficult IV access can reduce complications and also improve safety and patient satisfaction (Rodriguez-Calero et al, 2020) (*Figure 2*). Having a simple pathway in place that leads to ultrasound placement for peripheral catheters can make a huge difference to patient experience. Ultrasound-guided placement of peripheral cannulae can increase the success rate and reduce the risk of dislodgement (Tran et al, 2021; Schoch et al, 2023). Multiple attempts at



National Infusion and Vascular Access Society

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Figure 2. Difficult vascular access guidance

placing a PIVC are painful and distressing to the patient and may damage the vessel and surrounding tissue and therefore increase the risk of extravasation (Sweeny et al, 2022), the use of ultrasound for PIVC placement should be considered for all patients with difficult IV access.

The risk of extravasation can be further reduced if the most suitable VAD is selected (Meyer et al, 2020). A VAD decision making tool can be used to ensure that the most suitable vascular access device is selected based on the intended IV therapy (Moureau and Chopra, 2016; Ray-Barruel et al, 2020) (*Figure 3*). NIVAS's (2024) infiltration and extrasvastion toolkit provides a simple example of a VAD decision tool that ward based nurses and doctors can use to ensure they choose the safest device for the intended IV therapy.

Outdated, historical clinical practices associated with IV therapy and peripheral cannulation can play a part in increasing the risk of extravasation. In the absence of a central venous vascular access device, using a large-bore cannula in the antecubital fossa as a substitute for the administration of a vesicant is not safe practice and must be avoided. The use of small-bore catheters in the lower forearm should be the first choice for peripheral IV therapy; this practice is followed for SACT administration. VADs with a smaller diameter allow turbulent blood flow around the outer catheter lumen, thereby reducing the risk of injury to vessel wall caused by repeated pistoning or micromovement. Ideally, a catheter-to-vessel occupancy of less than 45% is recommended (Spencer and Mahoney, 2017; Sharp et al, 2015). Vascular access devices should be inspected at least once a shift and flushed at least daily; they should be removed if not working properly or no longer required (Lv and Zhang, 2020; Welyczko, 2020).

Even when systems are in place to reduce complications with IV therapy and VADs such as dedicated vascular access teams, difficult IV access pathways and vessel health decision-making tools, infiltrations and extravasations will still occur. When these do occur, reducing the level of harm is the next best thing to preventing them in the first place.

Recognising when an extravasation has occurred is vital and, according to Helm et al (2015), the published incidence of infiltration, occlusion, and accidental removal is disturbingly high. Up to 90% of catheters fail before therapy is complete, and catching extravasation early can reduce the amount of tissue damage. This is particularly important for infiltrations of neutral infusions because large volumes of infiltrated fluids can cause compartment syndrome.

Patient story

A patient had a 20 g closed-system cannula inserted in the cephalic vein in the wrist. They had difficult IV access, had COVID and were in a higher-level care unit. The patient had a single dose of IV vancomycin, which has a pH of 2.8–4.5. During the IV administration, the cannula became dislodged and the vancomycin extravasated into the subcutaneous tissue at the IV cannula site. The extravasation was not immediately

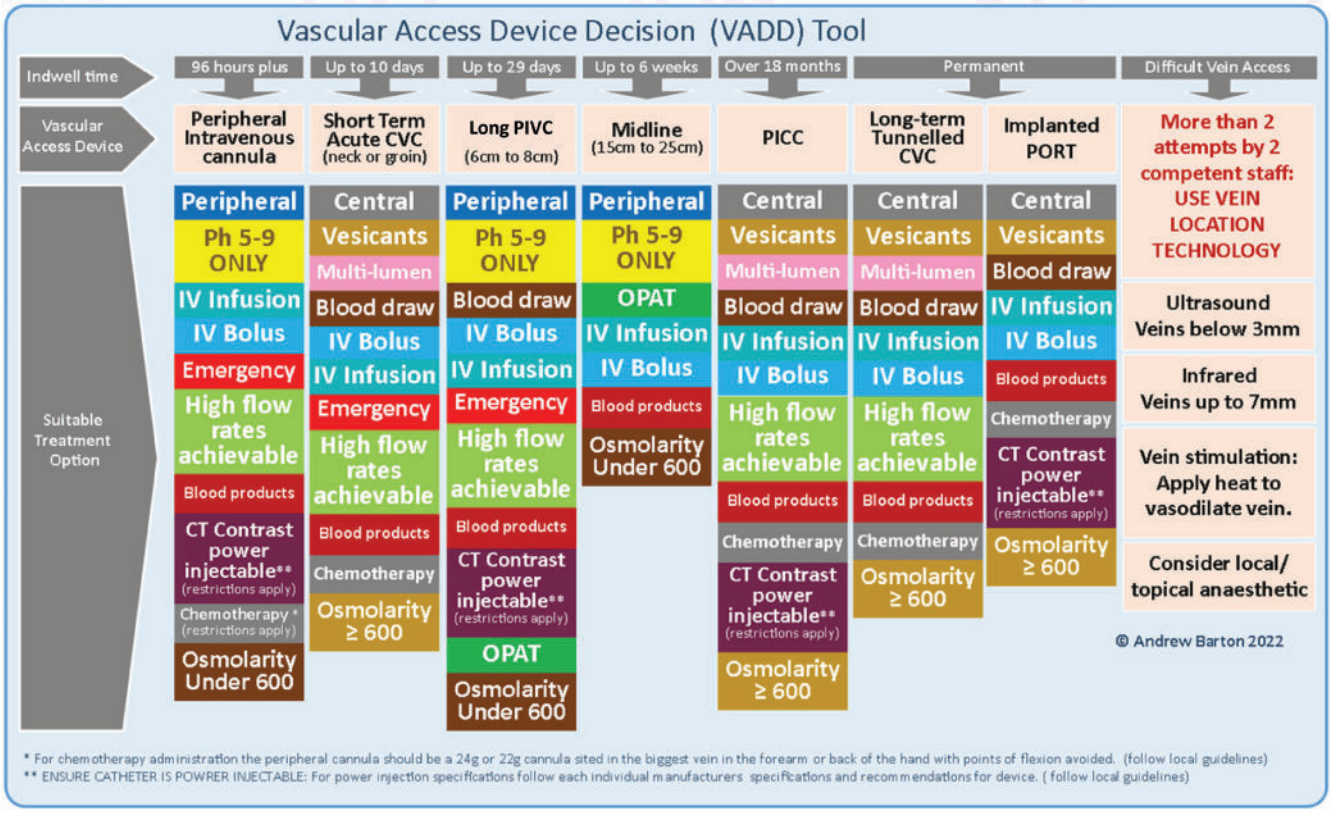

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Figure 3. Vascular Access Device Decision (VADD) Tool

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noticed. The cannula was removed because it had failed to work properly, there was some erythema and swelling at this time and phlebitis was diagnosed. A peripherally inserted central catheter was inserted because the patient had difficult IV access. Seven days later, the injury had evolved into a grade 4 (NIVAS, 2024) extravasation (*Figure 4)*. On investigation, the infusion of vancomycin was found to have taken less than 1 hour so was not within the 1-hour time frame to be visually checked by a nurse, which is the infusion protocol in the hospital. The patient was too unwell to alert staff about any pain at the infusion site. An infusion pump was used; however, the pump alarm pressure was set high and, because the patients' hands and arms were oedematous, the change in infusion pressure was not sufficient enough to set off the alarm before most of the vancomycin had been administered.

It is not possible to visually monitor every infusion with the human eye; some clinical units may be infusing over 20 patients at any one time. It is recommended by the NIVAS infiltration and extravasation toolkit (NIVAS, 2024) that IV infusions sites are monitored at least hourly and that infusions are given via a pump where possible, especially when a vesicant is being administered—but even an infusion pump cannot reduce the risk of infiltration or extravasation on its own.

With the application of new technology, for the first time a device is available in clinical practice that can continuously monitor IV infusion sites and indicate when an infiltration is occurring, often even before the patient or nurse is aware. The device is called ivWatch and its application in clinical practice could revolutionise IV infusion safety.

ivWatch is an IV infusion site monitoring device that applies advanced signal processing at the IV device site that can detect infiltrations in as little as 0.2 ml of IV fluid, with an average detection volume of 2–3 ml (*Figure 5*).

The ivWatch device uses a SmartTouch Sensor, which has two emitters and a detector to transmit and receive light signals to measure the changes in the optical properties and diffuse reflectance of the tissue near a peripheral IV site. The emitters transmit light to the tissue, and the detector, located a few millimetres away from the emitters, measures the reflected light signal. The reflected light signal primarily depends on the scattering and absorption properties of the monitored tissue. The ivWatch device detects the change in photon scattering in the diffuse reflectance signal and issues a check IV notification. When infiltrated fluid is present in the subcutaneous skin tissue, a significantly different diffuse reflectance signal occurs. Changes to diffuse reflectance are received by the SmartTouch Sensor and are analysed by ivWatch's proprietary algorithm to determine whether conditions indicate that an infiltration event may have occurred.

The sterile SmartTouch Sensor has an adhesive to apply to the skin in the area around the insertion point of the IV catheter; the sensor can be attached on top of the transparent part of the IV film dressing. The sensor can then detect when an infiltration occurs in the tissues around the indwelling part of the catheter.

The technology involved in the ivWatch and SmartTouch Sensor relies in light that scatters when a photon, or particle of light, is redirected because it interferes with a structure or particle in the tissue. Scattering structures in the tissue can include cells (eg blood cells and keratinocytes), fibres (eg collagen and elastin fibres) and cellular components (eg. mitochondria and nuclei). When there are more scattering structures in the tissue, more energy will be reflected back to the surface. Likewise, if there are fewer scattering structures in the tissue, less energy will be reflected back to the surface. Absorption occurs when the energy of the photon is absorbed by a structure in the tissue such as haemoglobin in the blood or melanin in the epidermis. When there are more absorption structures in the tissue, less energy will be reflected back to the surface. Likewise, fewer absorption structures result in more energy being reflected back to the surface. Diffuse reflectance refers to the measurement

ivWatch

Figure 4. Grade 4 extravasation

ivWatch

Figure 5. The ivWatch infusion monitoring device in use

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of photons that enter the skin tissue and then reflect back out after many scattering events.

When the SmartTouch Sensor detects an infiltration at the IV device site it will alert on the ivWatch monitor in two ways: a yellow alert, which means there is a potential infiltration; or a red alert, which indicates an infiltration is highly likely. A visible and audible notification from the iv Watch monitor then immediately alerts the practitioner, allowing them to stop the infusion and visually inspect the catheter site and make an assessment about continuing the infusion or resiting the peripheral IV catheter. Previous studies of the ivWatch have shown a high device reliability (ivWatch, 2023) and low false notification frequency, which has also been noted in previous studies (ivWatch, 2023). The quality and high level of clinical evidence available enables the ivWatch to be used with a high degree of confidence.

IV therapy and vascular access services ivWatch study

The first clinical study of the ivWatch infusion monitoring technology in the UK was undertaken at an infusion unit in a large NHS hospital between 14 August 2023 and 22 January 2024. The unit operates Monday to Friday 8am–6pm. The infusion unit administers a range of IV therapy infusions, including monoclonal antibodies, immunoglobulin, blood transfusion and blood products, antibiotics, zoledronic acid, Ferinject iron, electrolyte fluids and other disease-modifying therapies for long term conditions.

The infusion unit is part of a larger IV therapy and Vascular Access Services (IVAS), unit which also encompasses the home infection management service and the inpatient/outpatient vascular access service. Extravasation governance for the hospital falls under the remit of the IVAS unit and the lead for the unit is also the organisational lead for extravasation. Extravasation and infiltration injury reduction is an ongoing focus of the IVAS unit. Preventing iron infusion infiltration was a particular goal for the IVAS unit because the majority of the hospital's elective iron infusions occur in the IVAS unit.

The IVAS study and evaluation of the ivWatch was initially planned for 2 weeks. In that time, it was agreed that all IV therapy infusions in the IVAS unit that met the study criteria would be monitored with the ivWatch. The infusion unit has 23 infusion chairs, and the nursing model is three chairs to one infusion nurse, meaning an infusion nurse could be setting up and monitoring up to three patients at any one time. Infusion times ranged from 30 minutes to 7 hours depending on the drug therapy. Only patients having infusions via a peripheral cannula were selected for ivWatch monitoring. The ivWatch device used in the study is not designed for central venous device infusion monitoring because the SmartTouch Sensor is only effective in subcutaneous tissue because of the depth the sensor can reach.

The ivWatch team supported the infusion unit for the initial 2-week study to ensure the infusion nurses were given real-time, patient-facing education on how to place the adhesive sensors correctly and how to use the device so practice was standardised as much as possible. The ivWatch team also collected the data from each infusion to ensure they were valid and verified. At the end of the 2 weeks, the ivWatch team were able to produce a report containing the downloaded data from each device.

Every patient was given information about the ivWatch and gave consent for the device to be used during their infusion and for the infusion information to be anonymously collected and collated for the study evaluation. Ethical approval for the trial was not required because the use of the ivWatch did not change or increase the risk associated with the infusions, which was scheduled to take place. Before the study, the hospital's medical engineering department undertook an assessment of the 20 ivWatch devices and certified them safe to use in the infusion unit for the study.

The IVAS lead nurse asked that any yellow warnings be managed in the same way as a red alert; this meant resiting the peripheral cannula. This decision was made because, if a yellow alert was given by the ivWatch, there was a high probability that the infusion would go on to infiltrate and cause a red alert. Minimum yellow and red detection volumes were 0.20 ml and 0.21 ml. Average detection volumes were 2.02 ml and 2.13 ml for yellow and red, respectively.

The infusion unit staff continued to use ultrasound to place peripheral cannulas for the majority of the patients' infusions. Before the study and despite the use of ultrasound for cannula placement, the infusion unit rate of extravasation and infiltration was an average of five out of a mean 250 infusions per week that were between stage 1 and 3 (*Figure 6*) (NIVAS, 2024). The infusion unit has a policy of written informed consent before iron infusions so patients are aware of the risk of skin staining if infiltration occurred.

Results

During the first 2 weeks of the study, 20 ivWatch Model 400 monitoring systems were studied. A total of 206 infusions and 214 peripheral IV sites were monitored with the ivWatch for a total of 357 hours. The device captured 15 site infiltrations in the 214 peripheral IV sites monitored with an infiltration rate of 7.0%. All 15 infiltrations had been caught in the very early stages, so much so that the majority of patients had felt little if any pain or discomfort. No stageable infiltration or extravasation injuries reported.

All the patients who returned for multiple infusions during the 2-week study requested the use of ivWatch. The feedback from them was that the use of ivWatch made them feel more safe about receiving their infusion. The infusion nurses also felt reassured by the use of ivWatch as it gave them peace of mind too. One member of staff said it was like having a second pair of eyes to monitor the infusion site.

Because of the extraordinary success of the ivWatch study, the positive feedback from staff and patients and the reliability of the technology, it was agreed that the trial would continue.

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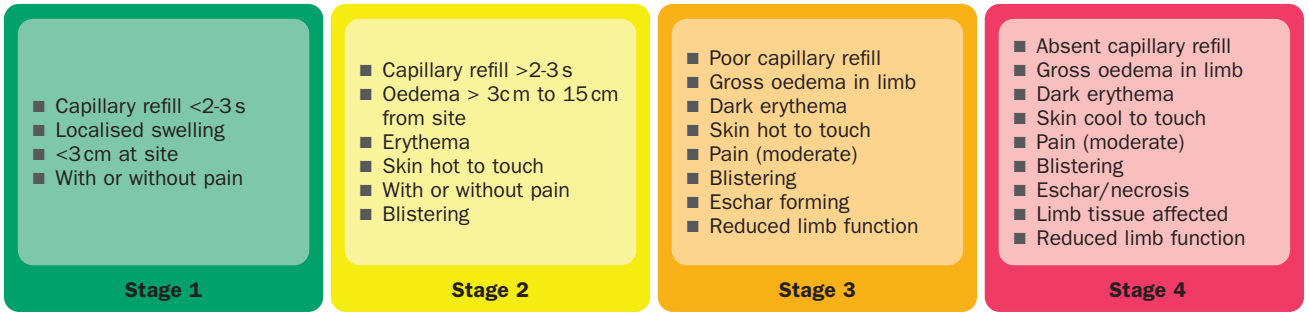

Adapted from: NIVAS, 2024; Pathomjaruwat et al, 2021; Kim et al, 2020; Alexander, 2020; Ong and Van Gerpen, 2020

Figure 6. Extravasation and infiltrations staging

Extended study results

The infusion unit continued to collect data on every peripheral infusion administered between 14 August 2023 and 22 January 2024. A total of 3507 hours of monitoring time was collected (*Figure 7*).

The average monitoring time per peripheral IV was 1.5 hours with the longest run time being 8.0 hours.

One hundred and twenty-two cases of red check IV notifications occurred in the 2254 monitoring runs, corresponding to a 5.4% check IV notification rate.

In addition, 59 cases with a yellow notification were also recorded. These were potential infiltrations, which the infusion unit staff acted on and resited the peripheral cannula.

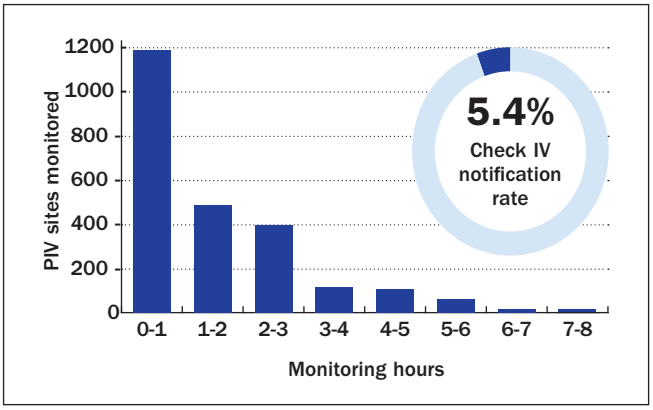

Figure 7. Number of devices and duration of monitoring

Conclusion

The ivWatch study was a great success for the infusion unit. The results showed a higher-than-expected infiltration rate within the infusion unit which was due to the sensitivity of the ivWatch SmartTouch Sensor. When the data was analysed the highest percentage of drugs infiltrations were IV Ferinject (iron) at 45 infusions and zoledronic acid at 26 infusions, which has a pH of 2 (*Figure 8*). An extravasation of iloprost, which has a pH 8.4, was also detected before an injury occurred. In all but one of the cases, the ivWatch device prevented a stageable, noticeable or serious extravasation occurring.

There was one case of iron infiltration occurring during the study that resulted in a noticeable skin staining injury and this was

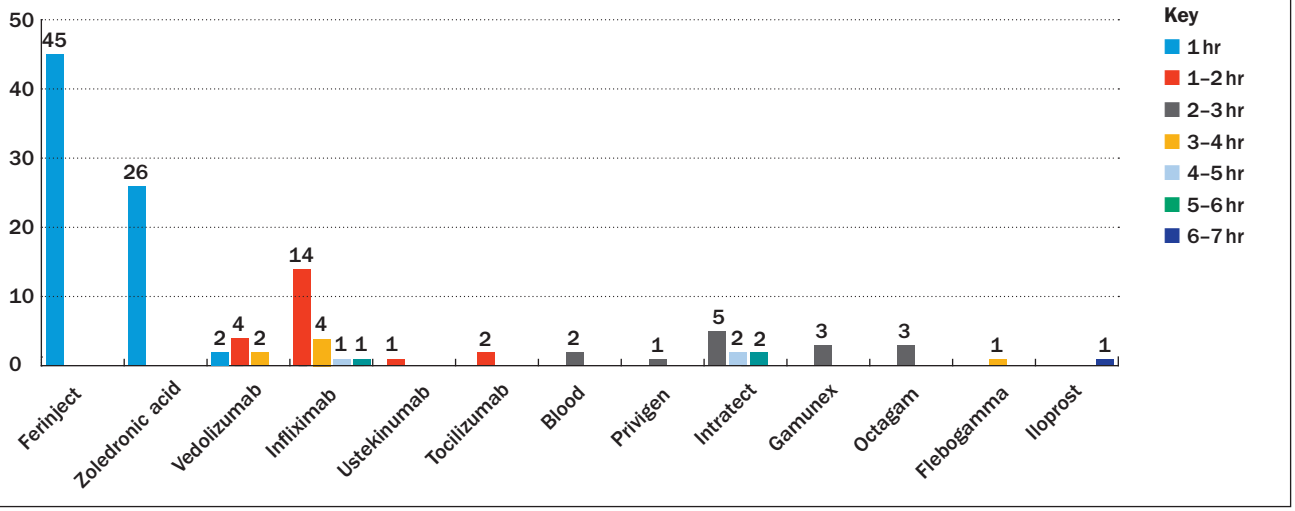

Figure 8. Number of avoided drug extravasations

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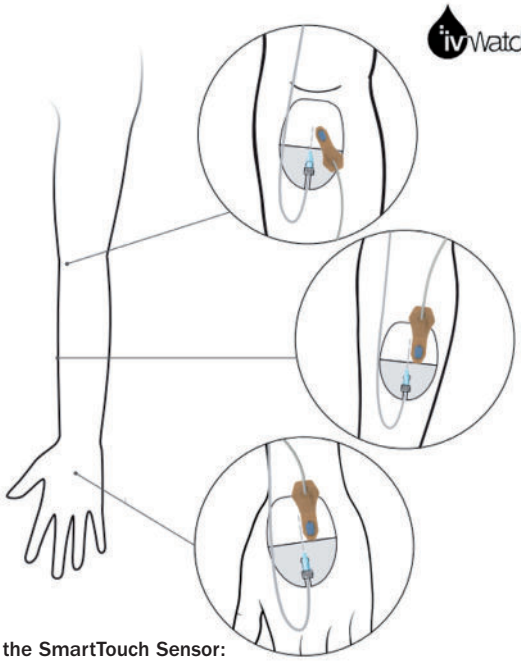
attributed to incorrect placement of the ivWatch SmartTouch Sensor. In this case, the SmartTouch Sensor was applied too far away from the cannula insertion point so, by the time the ivWatch detected the infiltration and a red alert occurred, 10 ml of the iron had infiltrated into the skin. Following this infiltration, further training was given to the infusion nurses and a visual aid was produced to assist in the placement of the SmartTouch Sensor (*Figure 9*).

Discussion

The use of ivWatch has overwhelmingly improved infusion safety within the infusion unit. In a unit where peripheral vascular access devices are placed with ultrasound as a standard of practice, vessel assessment is routinely undertaken and longer length PIVCs are used, the risk of extravasation is already mitigated. For the ivWatch to identify and prevent injuries occurring in 5.4% of the infusion activity is compelling. The patients and staff have even higher confidence in the safety of the infusion therapy they are giving and receiving. The ivWatch study has demonstrated how successful the technology is, with 122 definite infiltration and extravasation injuries prevented and further potential yellow alerts averting 59 more. Based on this outcome, extravasation and infiltration injuries during IV therapy can be prevented. **BJN**

First published as: Barton A. Extravasation and infiltration: under-recognised complications of intravenous therapy. Br J Nurs. 2024;33(7):S18–26. https://doi.org/10.12968/bjon.2024.33.7.S18



Place the SmartTouch Sensor:

- Adjacent to the catheter
- Within 2 inch (2.5 cm of the catheter insertion site)
- On the skin or clear film dressing
- On the dependent side of the peripheral IV site, where gravity will pull fluid

Figure 9. Guide to correct placement of the SmartTouch Sensor

KEY POINTS

- Infiltration or extravasation is a complication when a drug or IV therapy leaks into the tissues surrounding the vascular access device
- Extravasation is often associated with systemic anti-cancer therapy but non-chemotherapy drugs have been reported as having a greater risk of serious complications
- ivWatch can monitor IV infusion sites and indicate when an infiltration is occurring
- The indications for use at the time of this study were for optically clear solutions
- The SmartTouch Sensor is sterilised; however the device label may not include that depending on marketing area

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Addressing and mitigating the high costs of extravasation and infiltration to patients and healthcare organisations

Andrew Barton

ABSTRACT

Infiltration and extravasation injuries are a common complication of intravenous therapy and vascular access practice. However, there remains a lack of awareness and understanding surrounding these injuries. The first of two articles (Barton, 2024) reported on data from a study showing that the use of ivWatch infusion site surveillance technology can dramatically reduce the number of infiltration and extravasation injures with peripheral intravenous infusions of vesicant preparations, which can improve patient safety and have a positive financial impact. This second of two articles on infiltration and extravasation examines the financial and academic burdens.

Key words: Extravasation ■ Non-systemic anti-cancer therapies ■ ivWatch continuous peripheral IV site monitoring technology

The first article in this two-part series focused on the clinical awareness of infiltration and extravasation (Barton, 2024), particularly associated with non-systemic anti-cancer therapies (non-SACT) and introduced ivWatch technology by sharing data from a clinical trial. ivWatch was trialled in an outpatient infusion unit in a large acute hospital in England between August 2023 and January 2024. The results of the trial were compelling: 2254 infusion sites were monitored with ivWatch, detecting 122 red alerts and a further 59 yellow alerts, averting a total of 181 infiltration and extravasation injuries. This follow-up article demonstrates the benefits of using ivWatch by examining the economic and public burden of infiltration and extravasation injuries in more detail.

Complications arising for intravenous (IV) therapy can be serious and sometimes life changing (Nickel et al, 2024). Historically, complications associated with IV therapy and vascular access devices (VADs) used to administer IV infusions have predominantly focused on infection, thrombosis and drug reactions, including anaphylaxis. Less well-known complications such as infiltration and extravasation are now being more widely discussed in the literature, most recently by the National Infusion and Vascular Access Society (NIVAS).

Historically, extravasation has been considered a concerning complication in oncology, associated with the administration of IV systemic anti-cancer therapies (SACTs), especially anthracycline cytotoxics. Extravasation awareness is an essential element of SACT training for nurses and is included in their annual updates (Casey et al, 2023). The same level of training and awareness is not placed on non-SACT IV therapy practice, yet this is where most extravasations occur.

It is important to note that the dangers of extravasation and infiltration are not as widely known as other patient harm risks and, as a result, are often not recognised in clinical practice. Because of this, the costs cited in this article are only a partial representation of potentially staggering liabilities affecting healthcare organisations due to continued misdiagnosis or failure to properly identify extravasation and infiltration events as they occur.

NHS Resolution (2022) has published a breakdown of the cost of claims for infiltration and extravasation against the NHS it received between 1 April 2010 until 1 December 2021. The figures show that over these 10 years NHS Resolution received 467 claims from patients who had suffered such injuries. Of this number, 214 were settled with damages and 112 closed with nil damages, with the cost to the NHS reaching £16 million. This sum includes payments for claimant legal costs, NHS legal costs and damages.

Publication of these figures coincided with the launch of the national campaign from NIVAS to raise awareness about

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Accepted for publication: August 2024

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infiltration and extravasation in the UK, which included the recently published national toolkit (NIVAS, 2024). This aims to improve the awareness, prevention, recognition, treatment, follow-up and reporting of infiltration and extravasation injuries, in particular those associated with non-IV SACTs, although SACT is an important element of the toolkit.

The true financial cost of infiltration and extravasation within the NHS is difficult to quantify. Poor awareness and recognition of extravasations when they occur has led to misdiagnosis of these injuries, leading to missed opportunities to incident report locally. This has resulted in a lack of local and national reporting data, making it impossible to know the true rate of infiltration and extravasation including the financial cost. A national change in awareness and prevention is leading the way, with the support of the NIVAS national infiltration and extravasation toolkit (NIVAS 2024). Despite the absence of national data, it is possible to approximate the economic burden of infiltration and extravasation by looking at local case studies from NHS organisations.

Awareness and recognition rely on health professionals knowing how to differentiate between infiltration and extravasation. Infiltration is the inadvertent administration of IV therapy or fluids into the tissue surrounding a VAD (Kim et al, 2020). Although infiltrations can cause harm to the patient, the severity of injury is usually not serious unless large volumes of fluid are involved, in which case compartment syndrome is a risk. Non-vesicant therapies such as IV iron preparations can also cause harm, leading to permanent staining of the subcutaneous tissue and skin, which can lead to psychological trauma and negative body-image issues.

Extravasation occurs when IV therapy infiltrates the surrounding tissue, particularly when the therapy or drug involved is a vesicant (David et al, 2020). A vesicant is a broad term describing a group of drugs and IV therapies that can cause irritation or damage to skin, tissues, veins and cells (Ong and Van Gerpen, 2020). Vesicants can lead to mild localised irritation, pain, limb swelling, blistering, deep-tissue damage, cell damage, tissue necrosis, limb loss and, in extreme cases, death (Giménez Poderós et al, 2024). Vesicants broadly fall into four categories (Barton, 2024; NIVAS, 2024), which are (NIVAS, 2024):

- SACTs
- Drugs with non-physiological pH
- Vasopressors
- Hyperosmolar solutions.

Systemic anti-cancer therapy

Previously called chemotherapy, SACT can be further classified as vesicant, irritant, exfoliant, inflammatant or neutral, DNA-binding or non-DNA binding (Tanay, 2020). DNA-binding SACT such as anthracyclines and alkylating agents are capable of causing the most severe tissue damage (Khanna and Khanna, 2023). Non-DNA binding compounds such as vinca alkaloids and taxanes cause irritation, but tend to cause less severe injuries, and exfoliants cause inflammation and shedding of skin without causing underlying tissue death (Alexander, 2020).

The incidence and prevalence of cancer are increasing worldwide, with the number of patients requiring first-line chemotherapy treatment estimated to increase by 53% between 2018 and 2040, from 9.8 million to 15 million (Wilson et al, 2023). The most recent available figures for 2016-2017 show that SACT is the single biggest spend within the NHS budget and accounts for an estimated £1.4 billion a year (NHS England, 2016). The cost of SACT is growing rapidly, with an annual increases of around 8% due to rising demand and higher charges from drug companies (Royal College of Radiologists, 2023).

The cost of IV SACT per patient regimen can be as high as £30 000 (Cortes et al, 2020). To mitigate this, local and national initiatives to reduce SACT drug waste have been implemented through better prescribing and dispensing practices, although there are currently no mandatory systems in place within the NHS. Incidence rates of SACT extravasation in the UK vary due to the absence of a centralised register, but have been estimated at 0.5-6% of patients receiving chemotherapy (NHS England, 2018). The amount of drug wastage and missed or delayed doses of SACT due to extravasation have not been considered in the literature, nor is this recorded nationally for the UK. Consequently, it is impossible to know the true figures, and research is therefore required to determine this.

The physical cost to patients who suffer an extravasation is better understood through published case studies. A stage 3 or 4 anthracycline extravasation injury can be life changing and every effort should be made to reduce the risk of its occurrence (Nedomansky et al, 2021). More research is needed to understand the impact of missed doses of SACT on successful cancer outcomes (Pham and Tsunoyama, 2024).

The ivWatch trial data cited and described in the previous article (Barton, 2024) demonstrates that the device can identify an infiltration around the infusion site even before the patient notices that it has occurred. When a decision to administer a vesicant using a peripheral cannula has been made, the use of ivWatch can ensure the infusion is as safe as possible (Van Rens et al, 2023; Barton, 2024). ivWatch's advanced signal processing can detect infiltrations in as little as 0.2 ml of IV fluid, with an average detection volume 2–3 ml (ivWatch, 2014, ivWatch, 2019).

Drugs with non-physiological pH

The data reveal that most infiltration and extravasation injuries associated with IV therapy administration occur in non-SACT practice (NHS Resolution, 2022). It is essential to know the pH of IV drugs in order to administer them safely (Manrique-Rodríguez et al, 2021). It is generally considered that a drug pH of between 5 and 9 is safe to administer via a peripheral cannula (Ong and Van Gerpen, 2020; Manrique-Rodríguez et al, 2021).

However, any drug pH outside normal blood pH range (7.35-7.45) has the potential to cause a degree of injury or irritation to tissue if an extravasation occurs. For this reason, infusion-site surveillance using ivWatch technology should be considered for all peripheral IV infusions, alongside other

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evidence-based practices, such as using an infusion pump, and adhering to vessel health and preservation protocols to protect the patient, their vessels and the infusion site.

Vasopressors

Vasopressor IV therapy is fundamental in the treatment of septic shock-induced hypotension because it can correct vascular tone depression and improve organ perfusion pressure (Sanchez et al, 2023). However, vasopressors are known to be high-risk vesicants which can cause significant damage to the tissue; if extravasation occurs, there is a higher risk of limb loss. (David et al, 2020). It is recommended that vasopressors are administered via central venous access (Nickel et al, 2024).

Peripheral administration of vasopressors, however, can occur in emergency situations (Tian et al, 2020; Haimovich et al, 2021). Many NHS hospitals have local protocols to administer vasopressors such as noradrenaline via a peripheral cannula in pre-defined clinical situations. The use of peripheral vasopressors has been shown to be effective in stabilising patients in septic shock long enough to admit them to a critical care unit (CCU) and place an acute central venous catheter for further vasopressor support (Tian et al, 2020; Haimovich et al, 2021), although the risk of severe extravasation injuries remains high. ivWatch can easily be used in CCUs and emergency department (ED) resuscitation rooms for just this type of infusion scenario. ivWatch can be set up quickly to monitor infusions in emergency situations.

Sepsis and risk of extravasation

In the UK, there are at least 200 000 episodes of sepsis in adults each year, with up to 52 000 deaths occurring as a result (Flaherty, 2022). It claims more lives than breast, bowel and prostate cancers combined, with estimated costs to the NHS of £1.5–£2 billion each year (Aschroft and Oakeshott, 2022). The UK Sepsis Trust (Daniels and Nutbeam, 2022) developed the Sepsis 6, which is a set of six tasks (enlist senior help, administer oxygen, take bloods, give IV antibiotics, consider IV fluids, monitor lactates and urine output) - to be instituted within 1 hour of identifying sepsis (Evans et al, 2021). This short time frame for treatment undoubtedly saves lives; however, the increased pressure on healthcare staff to gain IV access, administer IV antibiotics and start IV fluids within that hour can increase the risk of infiltration and extravasation. Gaining IV access can be difficult in patients who are septic due to the peripheries being shut down, which can be exacerbated in individuals who already have difficult IV access. The percentage of patients with difficult IV access across all hospital settings is estimated to be between 35% and 40% (Paterson et al, 2022).

One of most common antibiotic regimens used for first-dose administration for sepsis with unknown source in NHS hospitals is currently a combination of IV gentamycin, amoxicillin and metronidazole, providing that the patient is not allergic to penicillin. Gentamycin is a vesicant with a pH of 3.8. An extravasation of gentamycin can cause significant tissue damage. Consequently, for patients who are already at risk of infiltration and extravasation due to poor peripheral vein availability, which makes it harder to gain IV access, the administration of a vesicant can increase the risk of injury significantly.

In the ED, when managing these patients, for whom gaining central IV access can take time, using a peripheral IV and monitoring the vesicant infusion with ivWatch can not only reduce the risk of extravasation, but can also ensure that the whole infusion/dose of antibiotic is given in that first hour of sepsis.

Hyperosmolar solutions

Hyperosmolar drugs and fluids have a high osmolarity, above 600 mOsm/L (David et al, 2020), and should be given via a centralVAD. Osmolarity can influence the degree of tissue injury, and the extravasation of hypertonic fluids, such as 10% dextrose or parenteral nutrition solutions, can cause skin necrosis and serious tissue damage (Stefanos et al, 2023). Dextrose solutions are rarely administered alone; other products such as potassium are often added, which can increase osmolarity even more.

Extravasation of hypertonic solutions causes a shift of fluid from inside the cells into the interstitial space, which disrupts cell function (Ong and Van Gerpen, 2020). The shift from subcutaneous cells to interstitial tissues leads to swelling and increased local pressure, which can cause acute limb compartment syndrome (Borrelli and Donohue, 2022) (*Figure 1*). Hyperosmolar solutions can shrink cells and collapse the internal structures, whereas hypo-osmolar solutions can swell cells and lead to cell rupture (Giménez Poderós et al, 2024). IV fluids such as 5% dextrose with 40 mmol potassium can cause a significant injury if infiltration and extravasation occur.

Intravenous iron infusions

Intravenous iron preparations are not vesicant in nature; however, infiltrations of IV iron can lead to significant mental anguish due to the permanent staining of skin. When iron infusions infiltrate tissue this causes a permanent orange stain that is visible under the skin (Crowley et al, 2020). Depending on the preparation of IV iron used, an infusion of 100 ml can run over as short a time as 15 minutes, so by the time an infiltration is noticed most, if not all, of the infusion will have been infused. This can lead to extensive skin staining (*Figure 2*). There is no effective

Figure 1. An infiltration of 5% dextrose with 40 mmol potassium

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Figure 2. Skin staining of the tissue of the anticubital fossa caused by an intravenous iron infusion

treatment for the skin staining, which is permanent. This type of injury was among those reported to NHS Resolution (2022).

A secondary consequence of IV iron infiltration is that the patient will require an additional infusion to ensure they get the prescribed amount of drug into the circulatory system. This entails the additional cost of an infusion session as an outpatient, the cost of the drug and also the equipment required. The cost of a 1000 mg dose of IV iron is £154.23 (British National Formulary (BNF), 2024), and the additional outpatient infusion appointment would be on top of this. Aside from the extra clinical cost, the patient will be nervous about having a subsequent iron infusion, because the previous one infiltrated and caused a disfiguring injury.

There is also the possibility of litigation costs. For example, between 2019 and 2024, lawyers secured large compensation settlements against NHS trusts for harm suffered as a result of iron infiltrations. A client who had suffered a permanently discoloured arm was awarded £25 000 in compensation (Angwin-Thornes, 2019). In other cases, five-figure sums were awarded to two other patients who had suffered an iron infiltration (Leahy, 2021; Demetriou, 2023). The main aspects of the claim described by Demetriou (2023) centred on the fact that the trust had failed to:

- Obtain proper consent from the patient for the IV iron infusion preparation
- Failed to use the correct technique in siting the cannula before commencing the procedure in both of the patient's arms
- Failed to exercise caution to avoid leakage of iron into the patient's arm
- Failed to suspect extravasation and/or subsequently stop the infusion immediately in both arms, once it had been realised the patient had suffered an extravasation.

The common themes in these other cases of successful litigation against NHS trusts due to negligent iron infusion infiltrations (NHS Resolution, 2022) were the lack of informed consent with regard to possible iron infiltration skin staining, lack of monitoring of the infusion site, and lack of awareness that an infiltration had occurred and how to treat it (Shi et al, 2023; Barton, 2024; NIVAS, 2024). The ivWatch trial data reported in the previous article (Barton, 2024) showed the success of the technology in preventing potential harm from IV iron infiltrations, and the infusion unit has since continued to use ivWatch to monitor all IV iron infusions. From the start of the trial in August 2023 up to the time of writing this article (August 2024) there have been zero cases of iron infiltrations causing skin staining in patients with whom ivWatch was used; over this period one patient had an infiltration of iron; however in this case ivWatch was not used.

Challenges facing health care

In 2023, the Health Foundation published a paper outlining nine challenges facing health care in the UK (Dunn et al, 2023). Among these were the fact that patients are living longer but in many cases with major long-term health conditions, many of which are likely to require the use of IV therapies.

Patients surviving conditions such as cancer often require long-term IV infusions such as zoledronic acid, which is a vesicant (Salbaş et al, 2018), long after they have had the all-clear from their oncologist. Individuals living longer due to having lifelong infusions of high-cost drugs such as monoclonal antibodies or IV immunoglobulin are at increased risk of infiltration and extravasation. This should be even more of a motivation to adopt and embed technology, such as ivWatch, for infusion site surveillance, to enable cost savings in the long term, helping avoid drug wastage and extravasation injuries. In 2022-2023, the highest spend was on high-cost drugs, categorised under *Malignant Disease and Immunosuppression* in the BNF: £3.26 billion was expended on items dispensed in the community. This was the net ingredient cost before any discounts, with £3.09 billion being spent on medicines issued and dispensed in hospitals (NHS Business Services Authority, 2023).

The financial cost

The NHS tariff for 2022-2023, for an inpatient ward bed day, was £320.00 (NHS England, 2023; 2024). This includes all the basic nursing care and clinical interventions, food and estate costs. Other costs such as specialist treatment, surgical interventions and high-cost drugs are calculated separately. When a patient has a serious infiltration or extravasation, an extended hospital stay is often indicated, and outpatient follow-up and community treatment are usually required after discharge. Even without additional interventions the cost is high, including increased pressure on inpatient beds.

Bed shortages alongside high occupancy rates are unsafe for patients and staff. It can increase delays in ED, delay transfer from intensive care units and between wards, and increase stress for staff and patients. Using ivWatch to monitor infusion sites can therefore help prevent infiltrations and extravasation injuries, and the ensuing costs.

Stages of extravasation and associated costs

- Stage 1: assessment and close monitoring
- Stage 2: requires treatment action

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- Stage 3 and 4: clinical emergencies requiring urgent action (*Figure 3*).

The cost of treating an infiltration or extravasation can vary, and depends on the stage of injury and what type of treatment is required. Other factors to consider are whether the patient is an inpatient or whether they have been discharged, with the injury developing in the community. For someone who attends an urgent care centre and receives the lowest level of investigation and treatment, the average cost in 2024-2025 is £91 (King's Fund, 2024). For an individual treated in ED who receives more complex investigations and treatment, the costs range from £137 to £445, depending on level of care required (King's Fund, 2024).

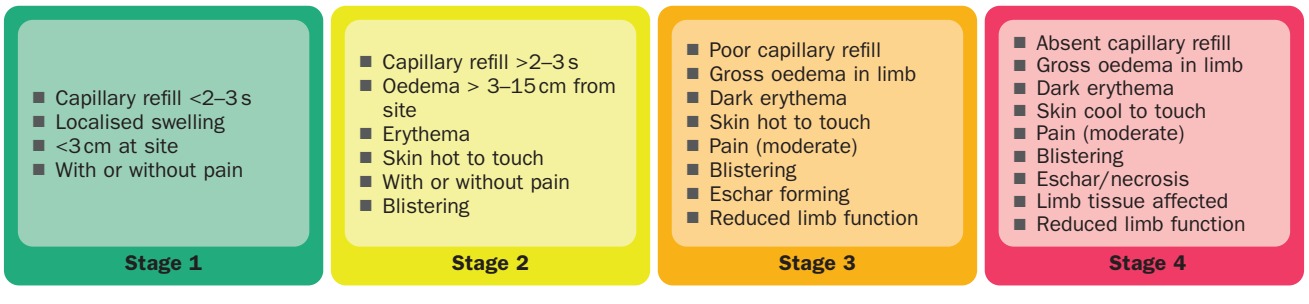
For an outpatient consultation with a consultant plastic surgeon the cost is £163 for a 30 min consultation (NHS England, 2024). Using the 2023-2025 NHS Payment Scheme data (NHS England, 2024), which establish the amount payable for provision of NHS-funded secondary health care, it is possible to approximate the cost of an infiltration/extravasation.

The NHS uses individual healthcare resource groups (HRGs), which include clinically similar treatments using common levels of healthcare resources, to produce a tariff or payment for treatment provided by NHS trusts (Amies-Cull et al, 2023) (*Table 2*). HRGs for plastic surgery for skin conditions (or injuries) are categorised depending on patient age (under/over 18 years old) into minor skin procedures (£593–£1074) including excision of skin lesions; full-thickness grafts and local flaps; intermediate skin procedures (£1045–£1362) including abdominoplasty and tissue expanders; and major skin procedures (£2326–£11 916) including skin debridement or split-skin grafting (Seaward et al, 2007).

Stages 3 or 4 extravasation injuries or infiltration related compartment syndromes are likely to require surgical skin procedures, which will depend on the degree of tissue damage, with associated high costs of repairing such injuries.

Case studies

The following case studies outline recent extravasation injuries sustained in one acute NHS foundation hospital in England. All these extravasations were investigated and changes in practice made to reduce the risk in future. Had ivWatch had been used to monitor these infusions, this may have prevented these injuries. In the case of the iron infusion used at the hospital, there have been no infiltrations while using ivWatch in the infusion unit in the hospital.



Adapted from: NIVAS, 2024; Pathomjaruwat et al, 2021; Kim et al, 2020; Alexander, 2020; Ong and Van Gerpen, 2020

Figure 3. Extravasation and infiltrations staging

Table 1. Surgical skin procedures: 2023-2025 NHS Payment Scheme (costed on 2024–2025 prices)

Healthcare resource groups are standard groupings of clinically similar treatments that use common levels of healthcare resource	Outpatient procedure	Combined day case/ordinary elective spend (£)	Ordinary elective long-stay trim point (days)	Non-elective spell (£)	Non-elective long stay trim point (days)	Per day long-stay payment for days exceeding trim point
Very major skin procedures	-	£2879	5 Days	£19200	61 Days	£308
Major skin procedures	£175	£2326	5 Days	£11916	45 Days	£308
Intermediate skin procedures, ≥19 years	£283	£1045	5 Days	£1105	5 Days	£308
Intermediate skin procedures, ≤18 years	£302	£1116	5 Days	£1362	5 Days	£308
Minor skin procedures, ≥19 years	£143	£593	5 Days	£627	5 Days	£308
Minor skin procedures, ≤18 years	£157	£949	5 Days	£1,074	5 Days	£308

For patients who remain in hospital beyond an expected length of stay for clinical reasons, there is a reimbursement in addition to the unit price called a 'long-stay payment' (sometimes referred to as 'excess bed day payment'). The long-stay payment applies at a daily rate where length of stay of the spell exceeds a 'trim point' specific to the healthcare resource groups (HRGs). A long-stay payment on a daily rate basis applies to all HRGs where length of stay of the spell exceeds a specified trim point specific to the HRG and point of delivery (NHS England, 2024)

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Case study 1: calcium chloride extravasation

A 78-year-old patient was seen in the ED. He was feeling unwell with a pyrexia and had shortness of breath; additionally, he had a chronic left leg ulcer that was infected. He lived independently alone, despite having had a previous below-right-knee amputation, and he used a wheelchair. When he was admitted to the ED, a 20-gauge peripheral cannula was placed into the right antecubital fossa and bloods were taken.

The bloods showed a potassium level of 8.8 mmol/L (normal range 3.4–4.5 mmol/L), blood pH was 7.166 (normal range 7.35–7.45), and lactate level 2.9 (normal range 0.5–2.2 mmol/L); he had a C-reactive protein level of 208 (normal range 0-5 mg/L) and was in renal failure, with an estimated glomerular filtration rate (eGFR) of 6 (normal range 60–120 ml/min). A hyperkalaemia, or elevated level of potassium in the blood, was diagnosed in addition to sepsis and acute renal failure. Left untreated, hyperkalaemia can cause life-threatening cardiac arrhythmias, muscle weakness or paralysis,(Palmer et al, 2021).

Intravenous antibiotics were prescribed and given, alongside IV calcium chloride to reduce the risk of ventricular fibrillation associated with hyperkalaemia. Due to its high osmolarity, 2040 mOsm/L, calcium chloride is considered a vesicant capable of causing severe vessel irritation, skin blistering and tissue destruction (Ong and Van Gerpen, 2020). The patient was given 10 ml of calcium chloride 10% via a slow bolus injection; as soon as the drug was administered he complained of pain and the nurse noticed localised swelling around the cannula site. The nurse recognised an infiltration, reporting this to the doctor. The cannula was removed, a new one sited in the left arm and a repeat bolus of IV calcium chloride 10% administered with no complication to ensure the patient received the full-dose of calcium chloride.

Although the infiltration of the the first dose of calcium chloride was documented, it was unclear whether the staff involved understood the terminology used. It was not recorded that calcium chloride 10% was a vesicant or that an extravasation had occurred, and no action was taken directly at that time to minimise the risk of tissue damage.

The patient was admitted from the ED to a level 1 medical unit where the hyperkalaemia improved, as did the acute renal failure. However, after 48 hours the skin and tissue around the right antecubital fossa started to blister and non-blanching erythema developed (*Figure 4 a–f*). The patient reported severe pain in the right arm, which limited the range of movement. At this time, cellulitis was diagnosed at the site of the peripheral cannula and antibiotics were prescribed. A referral to the vascular access team was made for a peripherally inserted central catheter (PICC) to be placed for ongoing IV therapies.

When the vascular access team reviewed the patient at 48 hours, a calcium chloride extravasation was suspected, and the patient was referred to the plastics team.

By the time of diagnosis after 48 hours post extravasation, it was too late to instigate a subcutaneous saline wash-out or to inject hyaluronidase as an antidote. The management plan from the plastics team was to allow the injury to develop and manage the patient's pain until such time as surgical debridement was indicated, with or without skin grafting. The injury continued to develop over the next 7 weeks, at which point the patient had a plastic surgical procedure to debride necrotic tissue from the injury. He remained an inpatient for a further 5 weeks until week 12, at which point a skin graft procedure was undertaken. The patient recovered from the skin grafting for a further 26 days in hospital, following which he was transferred to a community rehabilitation unit. *Figure 4f* shows progress of the wound after 110 days while he was in rehabilitation.

Figure 4. Case study 1: calcuim chloride extravasation

What went wrong?

The patient had three cannulas sited in the ED, which were all used appropriately; he remained stable, but had the potential to deteriorate rapidly. There was no acknowledgement that calcium chloride 10% was a vesicant or that an extravasation had even occurred. An extravasation was documented, but there was no understanding of what the term meant, so proper treatment did not begin in time.

The patient's extravasation was misdiagnosed as a cellulitis, and he was already having antibiotics for his infected leg ulcer.

What was learnt?

That this was not the first missed extravasation associated with IV calcium chloride 10%. Six significant extravasation injuries were discovered via the incident reporting system over the previous 8 months in other departments of the hospital through a review undertaken by the infusion unit, with the data showing a lack of awareness and recognition of infiltration and extravasation in the ED and the level 1 medical unit.

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What was changed in practice?

Recommendations for first-line treatment for hyperkalaemia and hypocalcaemia are to administer calcium gluconate 10% where appropriate. Compared with the osmolality of around 2040 mOsm/kg for a calcium chloride ampoule, calcium gluconate is twice-hypertonic to body fluids, at 680 mOsm/kg. So, although calcium gluconate is still an irritant, it is considered to have less of a vesicant effect than calcium chloride 10% (Lindner et al, 2020). Intravenous 30 ml calcium gluconate 10% is an alternative to 10 ml calcium chloride 10%.

Calcium chloride is preferred in patients with cardiac arrest due to hyperkalaemia because it releases active calcium immediately upon infusion, unlike calcium gluconate, which requires hepatic metabolism to release calcium.

Education was provided to staff in the ED and in critical care, departments that are both high users of calcium chloride. Trustwide awareness-raising was also undertaken to ensure the correct dose of calcium gluconate is administered, as this has previously been an issue to ensure the correct dose of calcium gluconate 10% is given. An NHS National Patient Safety Alert (Medicines Healthcare products Regulatory Agency, 2023) has previously been issued on the potential risk of underdosing with calcium gluconate in severe hyperkalaemia – this was issued as the result of confusion in cases in which a calcium chloride 10% 10 ml dose was given instead of the 30 ml calcium gluconate dose.

If calcium chloride 10% is prescribed to treat hypercalcaemia, this should be given via central venous catheter due to its vesicant nature, except if the patient is in cardiac arrest, in which case any IV route is permissible (NIVAS, 2024).

What was the impact on the patient?

Despite using a wheelchair due to a previous amputation, the patient was independent prior to this episode of care. Following the extravasation the patient lost their ability to be independent with their activities of daily living. The pain and loss of function in the right arm was debilitating. After 110 days as an inpatient in the acute hospital the patient was transferred to a community rehabilitation unit. Sadly, they never returned home to live independently.

What was the estimated economic cost?

Based on available data on the cost of an NHS bed day and HRG tariffs (NHS England, 2023; 2024) the approximate cost to the NHS of this extravasation injury, without possible litigation costs was an estimated £38 996. The costs break down as follows (see *Table 1*):

- Hospital stay of 7 weeks (49 days) at £320 per day (standard bed day cost), totalling £15 680
- Plastic surgery to debride at week 7 (HRG minor skin procedure tariff, +5-day post-operative trim point, totalling £620.
- Followed by a 35-day hospital stay, at £308 per day, until skin graft procedure at week 12, totalling £10 780
- Major skin procedure (HRG tariff, including 45 days post-operative trim point), totalling £11 916.

Had the extravasation not occurred and the patient had not required an acute hospital stay, or had been treated promptly, the estimated treatment would have cost less than one-tenth of this amount. The patient would have remained in hospital for less than 10 days, with a total bed cost of less than £3200 (bed-day cost £320).

Case study 2: anthracycline extravasation

A 54-year old patient was admitted to the inpatient oncology unit to undergo SACT for treatment of diffuse large B-cell lymphoma (DLBCL). A 24-gauge cannula was placed in a vein in the back of the right hand (*Figure 5*) for intravenous R-Pola-CHP C2D1. This type of SACT is a combination of IV polatuzumab vedotin (irritant), rituximab (neutral), cyclophosphamide (neutral), doxorubicin (vesicant-anthracycline), and prednisone orally administered.

Prior to administration, consent was gained in line with local policy. The IV administration of the first three drugs was unremarkable; however, towards the end of the fourth and final infusion of doxorubicin, the patient reported a mild burning sensation. The SACT nurse documented that the cannula was still patent, so the remainder of the doxorubicin was administered. The next day he knocked the back of his right hand on the bedside table on the ward, causing trauma to the area where the 24-gauge peripheral cannula was sited. The cannula was removed and the patient was given analgesia.

Over the following week the back of the patient's right hand became more painful, an area of erythema developed around the peripheral cannulation site. Small fluid filled blisters formed on the skin in the area of erythema. The right hand was examined by the oncology team and the patient was referred to the plastic surgeons for review.

The plastics team examined the right hand, they took a brief history and were told that a peripheral cannula had been sited on the hand, and that the patient had experienced a contusion to the hand while the cannula was in situ. The plastics team were not

Figure 5. Case study 2: extravasation of doxorubicin

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told about the potential SACT extravasation because at that time an extravasation diagnosis had not been made, and they diagnosed a cannula-related trauma injury to the soft tissue caused by the contusion, recommending conservative management.

Four weeks later the patient was preparing for discharge from the acute oncology unit. A PICC had been placed for the administration of the SACT after the injury to the right hand. He was referred back to the vascular access team for review because the wound on the back of the right hand was not healing, and the tissue had become necrotic and more painful.

The vascular access team lead reviewed the patient notes and realised that this was an extravasation of R-Pola-CHP C2D1: the doxorubicin is an anthracycline known to cause extravasation injuries, which was consistent with the wound that had developed on the hand.

A referral was made back to the plastic surgeons, where the patient was reviewed in the plastics clinic after discharge home. The plastics plan was to watch and wait for the extravasation to fully evolve and consider surgical intervention at a later date, managing the patient's pain in the meantime. The SACT treatment continued, but the patient was readmitted 2 weeks later with further complications associated with the extravasation injury which had become infected. This was likely to have been due to the SACT therapy inducing neutropenia and increasing the risk of infection.

The patient remained an inpatient for 2 months, experiencing ongoing complications associated with the extravasation. He underwent skin debridement and continued to have repeated infections to the wound. Nine months after the extravasation had occurred the patient completed the SACT therapy, but has since continued to require weekly dressing changes for the extravasation wound.

What went wrong?

Because the SACT regimen contained an anthracycline, a PICC should have been placed prior to the administrant – this would have mitigated the risk of a peripheral extravasation.

There was no recognition that an extravasation had occurred by the SACT nurse, the oncology team or the plastics team, and the hand injury was treated as cannula trauma.

What was learnt?

Any patient having active SACT who presents with a similar injury needs to have extravasation ruled out fully and, until a SACT extravasating can be ruled out, this should be the primary suspect.

What was changed in practice?

For anthracycline-containing SACT the use of a central VAD is advised and recommended due to the vesicant nature of the drug.

The patient was traumatised by the incident, losing confidence in the entire team, due to the misdiagnosis of the extravasation and conflicting clinical information provided by different staff. The hand extravasation was originally misdiagnosed as a cannula trauma injury, and there was disagreement between plastics, the SACT lead and the extravasation lead about the cause of the injury. It was as the injury developed that it became evident that this was a serious extravasation.

For any vesicant SACT administration the patient should be given the option to have a PICC.

Following this review, regular training was set up to ensure that oncology unit staff had an awareness of and were able to recognise the signs of extravasation for SACT, and this is now delivered as a mandatory annual update.

What was the impact on the patient?

The patient lost confidence in the oncology team because of the extravasation misdiagnosis at the time. Up until the second review by the plastics team he received inaccurate information from a number of different health professionals and, although this was not intentional, it was confusing.

He subsequently required multiple admissions, an operation on the right hand to debride the extravasation, and lost functionality in the hand; this has still not returned and he continues to experience pain. The 54-year-old has been left with extensive damage to the tendons and nerves of the hand.

Due to the severity of the injury, he has not been able to return to work, even 10 months after the extravasation, despite successful treatment for cancer. He is also unable to drive and has to pay for transport every week to attend the hospital for dressing changes. The injury has had major impact on his earnings potential and financial stability: on his estimation, he has lost in the region of £50 000 a year after tax. Due to the injury, he is now relying on his life savings and having to plan for early retirement, but it will be more than 10 years before he can receive the state pension at 67 years of age.

What was the estimated economic cost?

Based on available data on the cost of an NHS bed day and HRG tariffs (NHS England, 2023; 2024), the approximate cost to the NHS of this extravasation injury, without litigation costs, was £6003). It is difficult to calculate the total financial costs for this case, but the additional plastic surgery procedure and the ED attendances and outpatient visits can be taken into account. Because the injury occurred when the patient was already an inpatient, there was no extra cost to treat the extravasation. The costs could be approximated as follows (see *Table 1*):

- HRG minor skin procedure tariff, plus 5-day post-operative trim point, totalling £620
- Plus 15 additional inpatient days after trim point (£308 per day), totalling £4620
- ED visits x2 (majors at £137), totalling £274
- Plastic surgeon consultant outpatient clinics x3 (£163 for a 30 min), totalling £489.

Case study 3: peripheral vasopressor extravasation

A 30-year-old patient was admitted to the ED with a sore throat, tonsillitis, abdominal pain and chest pain. She deteriorated rapidly in the resuscitation room and was quickly intubated and

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taken for a CT scan. The CT of the abdomen and pelvis showed left lower-lobe pleural effusion, right-sided empyema with loculations, bilateral consolidation, thickening of the transverse colon, focal splenic lesions and moderate ascites, suspicious for an abdominal abscess. A bedside ultrasound indicated severe left ventricular (LV) dysfunction, and there was further evidence of acute liver and renal impairment.

The patient had multiple peripheral cannulas sited in ED for life-saving IV therapies. The patient was transferred to the CCU and had peripheral noradrenaline administered through a cannula in the left forearm.

The patient spent 28 days in the CCU, and 3 days into the stay developed blisters at the site of the left forearm canula. This was not recognised as an extravasation at the time. The patient had been intubated and placed on a ventilator almost immediately on admission, so had been unable to indicate if there was any pain in the left forearm. A dermatology referral was made and the patient was seen by a dermatologist who was unsure of the cause of the blisters and thought this might be a localised skin reaction, prescribing an emollient.

On the day the patient was stepped down from CCU to a surgical ward, the extravasation had not been diagnosed. However, a large area of skin, 5 cm by 10 cm, had become necrotic and an eschar had formed (*Figure 6*). The patient was referred to the vascular access team for a peripheral cannula placement with ultrasound. The vascular access nurse recognised the injury as an extravasation and initiated an investigation. At this point a referral was made to the plastics team, to surgically debride the wound.

The patient remained on the surgical unit a further 14 days recovering from the critical care admission, following which she underwent an intermediate surgical skin procedure involving a skin graft of the extravasation wound. She was finally discharged after a further 5 days. The total inpatient stay was 47 days, the extravasation injury contributed 5 additional days to this stay as the patient was critically unwell and required 42 inpatient days.

What went wrong?

The patient was critically unwell and required a critical care admission which happened very quickly after admission. Once on the CCU the patient was stabilised, and her life was saved despite being so unwell. As the patient was intubated before the noradrenaline was administered via the peripheral cannula in the left forearm, she was unable to indicate if there was any pain from the cannula site, something they undoubtedly would have been able to do had they been conscious.

There is always a risk of extravasation when vasopressors are administered peripherally. The blisters that formed a few days after the injury in this patient's case are a known sign of extravasation, but this was not recognised.

The cannula was removed while the patient was still ventilated, when it was noticed that it would not flush, and the skin and tissue around the cannula site had developed non-blanching erythema. This change was not recognised as an extravasation.

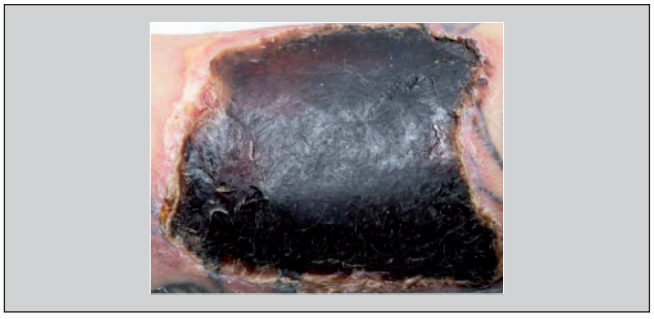

Figure 6. Case study 4: necrotic tissue on the patient's arm

What was learnt?

When vasopressors are administered peripherally, surveillance of the cannula site is essential, especially when a patient is unable to indicate whether the cannula site is painful, for example, if they the are intubated and ventilated. Any signs of extravasation should be acted on immediately.

What was changed in practice?

Staff in the CCU have been provided with education on how to recognise an extravasation in all stages (see *Figure 3*) and about the risks of vasopressors administered peripherally.

What was the impact on the patient?

The patient did not lose function of the left hand and arm, recovering well from the extravasation. The skin grafting was successful. However, she had to remain in hospital for an additional 5 days and has been left with permanent scarring from the extravasation and skin grafting, both of which have caused emotional distress.

What was the estimated economic cost?

- HRG minor skin procedure tariff, plus 5-day post-op trim point, totalling £620
- Consultant plastic surgeon outpatient clinics x3 (£163 for a 30 min), totalling £489
- Approximate additional cost of £1109, as the patient required additional procedures.

ivWatch monitoring versus no monitoring

This article has illustrated the cost of infiltration and extravasation to the NHS using different clinical scenarios, either through showing additional treatment costs, drug waste or additional bed days, outpatient appointments and litigation. The highest cost remains to the patient through physical and psychological harm.

It is difficult to quantify the degree of emotional and psychological harm that an extravasation injury can incur not only for the patient, but also for the nurses and doctors involved. If the patient requires future IV therapy, they may experience additional stress, as they will always be concerned that an extravasation might occur once again.

In the first article in this series on infiltration and extravasation the ivWatch clinical trial data were detailed. One aspect that all case studies have in common is that had ivWatch been used to

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KEY POINTS

- ivWatch technology can reduce the number of injuries associated with intravenous infiltrations and extravasations
- The emotional and psychological toll associated to extravasation injuries for the patient and the nurse or doctor involved should be considered, and support should be provided to all those affected
- The use of calcium chloride 10% can be switched to calcium gluconate 10%. Care must be taken to give the correct dose, but the additional time and effort can make a huge difference to the outcome of an extravasation injury
- This article has limitations, due to the lack of published information to support quantification of the full extent of an extravasation injury and the lack of education on how to correctly diagnose an extravasation injury

monitor the infusion site, the extravasation injuries would not have occurred to the degree that they did, based on the finding reported in the first article.

The estimated financial savings from the case studies alone would easily justify the investment in ivWatch to prevent infiltration and extravasation from occurring: ivWatch technology helps both the patient, giving them confidence that an extravasation injury was not likely to occur during IV therapy administration, and clinical staff, who can rely on the technology to monitor patients and identify potential problems.

Added to the savings outlined in this article are the positive effects of early identification and risk mitigation that the ivWatch technology makes possible. These include decreased lengths of stays, reduced number of procedures, elimination of delays in care, reduction of drug dosing errors, decreased risk of hospital-acquired infections, reduced pressure on beds, minimal medical supply usage, less wastage, and lessening of the burdens on clinical resources. Of additional importance is reducing the revolving door of hospital care with patients returning to have the injuries incurred through extravasation subsequently managed and treated.

It is also evident from the case studies and data presented in the previous article that adopting this technology brings great benefits to both the organisation and the patient. It is worth the financial investment to the organisation, because it not only improves patient outcomes and wellbeing, but also improves its safety profile, and minimises litigation related to infiltration and extravasation injuries. Above all, however, the use of ivWatch results in a continued perception by the patient that they are being cared for by a healthcare organisation that places great emphasis on safety and prioritises protecting them from avoidable infiltration and extravasation injuries. **BJN**

CPD reflective questions

- Consider how ivWatch technology can be utilised in your infusion practice to eradicate infiltration and extravasation injuries
- Do you know the signs and symptoms of infiltration and extravasation?
- Who is your hospital extravasation lead, and are you aware of your local guidelines for infiltration and extravasation?
- What would you do if you noticed an infiltration or extravasation?

Data sharing: Data are available from the author on reasonable request.

NB: The indications for use at the time of this study were for optically clear solutions. The author's hospital used ivWatch with all infusates, which may have reduced sensitivity if used with dark, coloured or cloudy fluids. The ivWatch Model 400, which was the device used in the author's hospital is not intended for use with power injectors. At the time of use in the author's hospital, the ivWatch Model 400, which is CE Marked, was still under review to expand its indications for use to include iron infusates.

First published as: Barton A. Addressing and mitigating the high costs of extravasation and infiltration to patients and healthcare organisations. Br J Nurs. 2024; 33(16) https://doi.org/10.12968/bjon.2024.0270

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