Review Article

Extravasation Injuries of the Limbs in Neonates and Children

Development of a Treatment Algorithm

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Summary

Background: Children and neonates very often receive intravenous therapy. There is a lack of systematic data on the incidence of extravasation injuries in children and neonates. Individual studies involving neonates receiving intravenous therapy on intensive care units report incidence rates of 18–46%. Serious complications, such as necrosis and ulceration, develop in 2.4–4% of cases, which in the long term can lead to contractures, deformities, and loss of limb function secondary to unfavorable scar formation. There are no guidelines available to date on the management of pediatric extravasation injuries.

Methods: The present review article is based on a selective search of the literature in PubMed (for the period 1979 until June 2020) and our own clinical experience.

Results: There is a lack of randomized controlled studies on the management of pediatric extravasation injuries, so the level of evidence remains restricted to small comparative studies and case series. Conservative, pharmacological or surgical forms of treatment are used, depending on the volume and type of extravasated fluid as well as patient-specific factors. Firstly, an assessment is made as to whether the extravasated fluid is a substance with no primary toxic properties, a tissue irritating (irritant), or a necrosis-inducing (vesicant) substance. Skin and tissue should be examined for damage, skin color, swelling, capillary refill time, and pulse (distal to the injury). Depending on the substance and volume of the extravasated fluid and the degree of tissue damage, treatment options include conservative forms of treatment, administration of antidotes, hyaluronidase or vasodilators (such as phentolamine), the multiple puncture procedure, flushouts, and liposuction.

Conclusion: Without evidence for the superiority of any particular treatment, therapy remains an individual decision, carrying the risks associated with off-label use.

Cite this as:

Hackenberg RK, Kabir K, Müller A, Heydweiller A, Burger C, Welle K: Extravasation injuries of the limbs in neonates and children—development of a treatment algorithm. Dtsch Arztebl Int 2021; 118: 547–54. DOI: 10.3238/arztebl.m2021.0220

In pediatrics, intravenous drug administration is one of the most common forms of inpatient treatment.

Despite maintaining nursing standards, regular monitoring, and critical assessment of the indication for treatment, fluid leakage from the circulatory system into the surrounding tissue, so-called extravasations, may still

occur as a matter of fate (1). In a retrospective analysis of 42 children, 41 extravasation injuries (98%) involved peripheral intravenous catheters and only one extravasation (2%) a central intravenous catheter; in 40 cases the extremities were affected and only in one case the scalp (1). With their fine skin and thin subcutaneous fat, the veins of the extremities of children are most accessible, but at the same time most susceptible to injury (1–4, e1). In addition, infants and neonates are particularly at risk due to their small vessels with fragile vessel walls, difficulties with cannula fixation, often prolonged intravenous therapy, and their limited ability to communicate pain (1–4). In neonatology, younger age (<32–33 weeks gestation, <28 days of life) and low birth weight (<1500–2500 g; odds ratio [OR] for <1500 g: 1.91) are particularly important risk factors (5–7), and 70% of

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This article has been certified by the North Rhine Academy for Continuing Medical Education. Participation in the CME certification program is possible only over the internet: cme.aerzteblatt.de. The deadline for submission is 22 August 2022.

BOX 1

Mechanisms of tissue damage from extravasation injuries as recognized by Khan and Holmes (22)

- direct cellular toxicity
- osmotic pressure gradient across the cell membrane
- ischaemic necrosis due to vasopressors and cationic solutions
- mechanical compression
- bacterial colonization and superinfection

extravasation injuries occur in extremely preterm infants (≤ 26 weeks gestation) (8). Depending on the type, amount, and location of the extravasation fluid, serious complications can rapidly develop, such as pain, necrosis, tendon and nerve damage, and compartment syndrome, as well as scars, contractures, and deformities that can eventually lead to functional restriction of the extremities or even amputations (1, 9–12, e2–e11). According to a study in 1989 involving 100 neonates, 4% had cosmetically or functionally significant post-extravasation scars on leaving the intensive care unit (e12). Repeated surgical interventions associated with longer hospital stays and expensive aftercare are often necessary to treat these long-term injuries, which can ultimately lead to litigation (13, 14).

Data on the incidence of extravasation injuries vary considerably because definitions and documentation are inconsistent and there are no registries. On the one hand, incidences of 2–16% have been reported in hospitalized children receiving intravenous therapy (15–18), while incidences of 18–46% have been reported for neonates (6, 7); severe extravasation injuries and necrosis requiring intervention occur in 2.4–4% of neonates (5, 8, 19). However, a retrospective analysis of extravasation injuries in 25 neonates showed that only nine cases (36%) had been adequately documented (20). Although mild extravasation injuries can heal with conservative treatment, the potential consequences are often underestimated.

In a study of 34 cases of extravasation injuries in a total of 1409 neonates on an intensive care unit, necrosis was recorded in only six cases after immediate intervention (within 30 minutes) (5), resulting in a comparatively low incidence of necrosis (0.4 %) (8, 19).

An extravasation injury is an emergency requiring structured assessment and treatment. Published results are inhomogeneous and randomized controlled trials absent (21), so there is no uniform treatment recommendation, while the treatment options that are available are not always known (4).

The aim of this review article is to provide an overview of the assessment and treatment of extravasation

injuries to the extremities in neonates and children and to develop an algorithm for their treatment.

Method

A selective literature search of Medline/PubMed was conducted using the search terms „extravasation“ and „paravasation“ combined with „pediatric“, „child“, „infant“ and „neonatal“. A preselection of all hits was conducted using the title and abstract, followed by a full text analysis. The publications cover the period from 1979 to June 2020. All publications in English, German and French with available full text, all relevant systematic reviews, meta-analyses, original papers, single case series, single case-reports, and „letters to the editor“ were included. Commentaries, cadaver studies, animal experiments, and narrative reviews were excluded. A treatment algorithm for neonates and children for the emergency treatment of extravasation injuries to the extremities was then developed, based on the included studies and our own clinical experience.

Results

The literature search retrieved 3201 hits. After excluding papers without an appropriate topic or endpoint, 45 studies were included: three reviews, five studies on the implementation of clinical standards, one surgical technique, one prospective comparative study, three prospective non-comparative studies, 11 retrospective case series, 18 case reports, and three case series published as letters. No randomized controlled trials were identified.

Due to inhomogeneity, lack of comparability of the studies, and absence of randomized controlled trials, it was not possible to rate any particular therapeutic procedure as superior and establish it as a standard procedure.

Pathophysiology

Leakage of fluid from the circulatory system leads to damage of the surrounding tissue which can result in tissue death. In 2002, Khan and Holmes (22) identified five mechanisms of tissue damage in extravasation necrosis (Box 1).

Depending on the extravasated fluid, direct cell damage, osmotically induced volume shift or reduced perfusion associated with ischemia due to vasoconstrictive substances can cause tissue death. Volume-related extravasation may result in an increase in tissue pressure with mechanical compression of the arterioles and subsequent ischemia. In addition, the increased tissue pressure can produce compartment syndrome. Bacterial infection may develop from prior colonization of the cannula or infusion solution or as a secondary superinfection after tissue damage has occurred.

Depending on volume and pharmacological-toxic property of the extravasated fluid, subsequent mechanisms can lead to tissue damage in isolation or in combination, potentially acting synergistically and producing an aggravating effect.

TABLE

Selection of irritant and vesicant substances (13, 23, 30, 33)

Substance class	Vesicant	Irritant	Potentially irritant	Antidot
Anti-infective agents	<ul style="list-style-type: none"> – acyclovir – doxycycline – ganciclovir – gentamycin – oxacillin 	<ul style="list-style-type: none"> – amoxicillin/clavulanic acid – amphotericin B – cidofovir – ciprofloxacin – metronidazole – vancomycin 	<ul style="list-style-type: none"> – ampicillin/sulbactam – cephalosporins – clindamycin – carbapenems – piperacillin/tazobactam 	<ul style="list-style-type: none"> – hyaluronidase* optional
Parenteral nutrition	<ul style="list-style-type: none"> – amino acids $\geq 10\%$ – arginine – dextrose $\geq 12.5\%$ – glucose $\geq 10\%$ – TPN > 950 mOsmol/L 	<ul style="list-style-type: none"> – amino acids $< 10\%$ – dextrose $< 12.5\%$ – lipid solution – partial parenteral nutrition – TPN ≤ 950 mOsmol/L 	<ul style="list-style-type: none"> – D5RL (5 % dextrose and Ringer's lactate solution) 	<ul style="list-style-type: none"> – hyaluronidase* optional
Oncology products/chemotherapeutic agents	<ul style="list-style-type: none"> – actinomycin – anthracyclines (daunorubicin, epirubicin, idarubicin) – cisplatin > 0.4 mg/dL – mechlorethamine – mitomycin C – mitoxantrone – oxaliplatin – paclitaxel – vinca alkaloids (vinblastine, vincristine) 	<ul style="list-style-type: none"> – antibodies (alemtuzumab, rituximab) – busulfan – carboplatin – cisplatin < 0.4 mg/dL – cyclophosphamide – etoposide – gemcitabine – ifosfamide 	<ul style="list-style-type: none"> – bleomycin 	<ul style="list-style-type: none"> – dexrazoxane (anthracyclines) – DMSO 99 % topical (amsacrine, cisplatin, dactinomycin, mitomycin C, mitoxantrone) – hyaluronidase* optional
Vasopressors	<ul style="list-style-type: none"> – (nor-)adrenaline – dopamine – (nor-)epinephrine 			<ul style="list-style-type: none"> – nitroglycerin topical – phentolamine – hyaluronidase* optional
Miscellaneous	<ul style="list-style-type: none"> – aminophylline – calcium salts – caffeine citrate – diazepam – digoxin – furosemide – potassium > 60 mEq/L – magnesium sulfate – mannitol $\geq 20\%$ – sodium bicarbonate – sodium chloride $> 3\%$ – phenobarbital – promethazine – propofol – valproate 	<ul style="list-style-type: none"> – acetazolamide – allopurinol – gadolinium – potassium < 60 mEq/L 	<ul style="list-style-type: none"> – blood products – heparin – interferons – interleukins – insulin – immunoglobulins – morphine – sodium chloride $< 3\%$ – contrast medium – phenytoin – Ringer's lactate solution 	<ul style="list-style-type: none"> – hyaluronidase* optional

All substances with the following properties are regarded as potentially vesicant: pH < 5 , pH > 9 , > 600 mOsmol/kg, vasopressors.

All substances with the following properties are regarded as being at least irritant: > 450 mOsmol/kg.

DMSO, dimethyl sulfoxide; TPN, total parenteral nutrition

* CAUTION: Hypersensitivity reaction, hyperhydration in the presence of renal impairment

The extravasated substances are divided into three groups, based on their pharmacological properties (Table):

- substances without a primary toxic quality
- substances with a potentially tissue irritating quality (irritant) and
- substances with a tissue necrotizing quality (vesicant).

In general, any hypertonic/hyperosmolar, hypotonic/hypoosmolar (serum osmolality 280–295 mOsmol/kg) and vasoconstrictive solution constitutes an irritant or vesicant fluid. Furthermore, acidic (pH < 5) and alkaline solutions (pH > 9) can cause tissue damage (23). The Table includes a graduated plan based on the risk assessment of the most common substances as developed by Clark et al (23).

Clinical presentation

The acute stage is usually characterized by local pain and edema. Depending on the extravasated fluid and volume, erythema or pale to discolored and cool skin may also present. Massive extravasation is associated with shiny skin and reduced sensory function. Capillary refill time may be prolonged, and the pulse may be diminished or absent distal to the extravasation. Once the integrity of the skin becomes compromised, skin lesions with weeping epidermolysis develop. Maximum severity is characterized by tissue loss associated with multi-layered skin and soft-tissue defect, tendon and nerve damage, necrosis and ulceration, and risk of compartment syndrome and infection (1, 9, 11, e2–6, e8, e9) (Figure 2).

BOX 2

Clinical assessment of extravasation injuries

- Is an irritant or vesicant extravasated solution involved?
- Is there tissue damage present (blisters, weeping skin, multilayer skin/soft-tissue defect, necrosis, ulceration)?
- Is the skin pale, cold and/or discolored?
- Is the pulse distal to the extravasation diminished or not even palpable? Is the capillary refill time distal to the extravasation prolonged (≥ 4 seconds)?
- Is there significant swelling or severe edema present ($> \text{one third}$ of the limb involved, $> \text{one-third}$ increase in circumference)? Is a joint involved in the swelling or edema?

As soon as a question is answered with „yes“, specific treatment should be considered and a specialist in the field of pediatric surgery, plastic surgery and/or hand surgery should be consulted.

According to the extravasation injury scale developed by Millam in 1988 (24) for adults and the subsequently adapted scales for children (3, 13, 25), extravasation injuries can be classified according to three to four grades. Since, in acute cases, no guiding principle can be derived directly from this scale classification, the questions formulated in Box 2 were developed on the basis of which it is easier to derive the course of action that needs to be immediately taken (3, 13, 24, 25).

If any one of these questions is answered positively, colleagues from pediatric surgery, plastic surgery, or hand surgery should be consulted.

Treatment

Available therapeutic measures include conservative, pharmacological, and surgical procedures with the aim of achieving pain relief, improvement of tissue perfusion and wound healing, and prevention of tissue necrosis (13). To achieve these goals, the general consensus is to initiate therapy without delay, despite the lack of guidelines. The various forms of therapy can be used isolated or combined.

We developed a treatment algorithm for the emergency treatment of extravasation injuries (*Figure 1*).

The first action is to stop the infusion or injection immediately. Further management based on the injury severity and the extravasated fluid should be planned before removing the intravenous cannula. It is important to ascertain whether the fluid is irritant or vesicant, whether an antidote is available, and whether it should be administered locally via the in-situ venous cannula. This applies in particular to those neonates and children who are high-risk surgical patients and cannot undergo immediate surgery, or who have only received a small amount of extravasation. The cannula should then be removed as soon as possible while aspirating any possible residual drug (e13).

The further course of action depends on the type of extravasated fluid. Conservative therapy may be used for extravasation injuries not involving irritant or vesicant substances; otherwise, antidote administration and surgical therapy must be considered, regardless of the degree of injury. Apart from the extent of the extravasation injury and antidote availability, patient-specific factors such as age, pre-existing conditions, surgical risk, and operability are also taken into account when considering further therapeutic management.

With complications, such as compartment syndrome, necrosis or infection, complication-specific therapy must be initiated immediately, regardless of the extravasated substance.

Conservative management

Conservative treatment includes pain control, elevation, application of heat or cold, immobilization, elastic bandaging and manual lymphatic drainage, and local dressings (1, 26–28, e14–e23), with the aim of providing pain relief, reducing swelling, and absorbing extravasation fluid to avoid mechanical compression. Recommendations of conservative therapeutic measures are based on expert opinions and case series.

Adequate analgesia according to the WHO three-step analgesic ladder, with strict indications in children (29), and elevation are uniformly recommended. When applying an elastic bandage, avoid dressings that are too tight and constricting. These measures can be supplemented with careful manual lymphatic drainage. Immobilization with a soft padded plaster splint can be applied if the child tolerates it. Especially with neonates and infants, care must be taken to ensure adequate padding and to avoid further damage such as pressure sores. Close monitoring of local findings must still be possible, despite the plaster splint.

There is some controversy concerning the application of heat and cold, especially with the extravasation of irritant and vesicant substances (13, 30). Cold can reduce the inflammatory reaction and further diffusion of the substance into the tissue. However, degradation of the substance and the healing process may also be delayed, while heat increases tissue perfusion and the associated absorption of the extravasated fluid. On the other hand, heat can also lead to more rapid metabolism and accelerated tissue damage.

Regular monitoring of local findings, including peripheral sensation, motor function and blood flow, and assessment of the initiated therapy, is particularly important during the initial phase.

Topical antiseptic and anti-adhesive dressings may be applied. The application of special wound dressings, such as hydrocolloid or foam dressings, may be considered over the further course (1, 26, 27, e14, e15, e18–e20, e23), but are regarded as secondary in the acute phase.

FIGURE 1

Treatment algorithm for the emergency management of an extravasation injury

* for example, consultant pediatric surgeon, plastic surgeon or hand surgeon

In the presence of massive swelling, the „multiple puncture“ procedure described by Chandavas et al. 1986 (31) can be applied as a semi-invasive method of treatment in isolated cases. This procedure was particularly recommended for extravasation injuries involving hypertonic solutions and low pH solutions. After extensive disinfection and under sterile conditions, multiple puncture wounds are made with a cannula in the area of greatest swelling; the fluid is then carefully massaged out via these puncture sites. This is then followed by the application of dressings containing gauze swabs soaked in hypertonic saline solution. Use of a scalpel blade tip as an alternative has also been reported (e24).

The intention of this procedure is to reduce pressure and promote drainage of the fluid. However, it must be borne in mind that the multiple puncture wounds can cause additional damage to the fragile skin.

Pharmacological treatment

After extravasation of irritant and vesicant substances, it is necessary to consider whether an antidote is available. Specific antidotes are available for individual chemotherapeutic agents (32, 33); their administration is specified in guidelines issued by the specialist societies for oncology. However, the approval of most antidotes is limited to adults. Studies and data on their use in children are only available in exceptional cases.

Figure 2: Preterm neonate (33 + 3 weeks gestation, birth weight 1740 g) with pulmonary artery atresia. Extravasation of glucose in the third week of life at the right forearm/wrist. Initial presentation three days after extravasation (a) with development of severe necrosis (b). Healed appearance after four months of extensive conservative management with the typical constellation of a critically ill neonate and operability only with purely vital indication, rendering early elective plastic reconstruction impossible. Image (c) shows findings six months after injury and conservative scar treatment. Surgical intervention is to be expected over time to avoid contractures/soft-tissue deformities.

Administration of an antidote in children may therefore be off-label use.

Pharmacological treatment for vasoconstrictive substances

The extravasation of vasoconstrictive agents (for example adrenaline, dopamine, epinephrine) can result in ischemic necrosis by way of their vasopressor action. The topical application of 2% nitroglycerin as a dressing at a dose of 4 mg/kg body weight is possible for those extravasated fluids which cause peripheral tissue ischemia (26, e25, e26). However, absorption through the skin is associated with a potentially systemic effect, so nitroglycerin should not be used on perforated or damaged skin and only in children aged ≥ 21 days (3, 13).

The non-selective alpha-adrenoceptor blocker phentolamine, as an antagonist to alpha adrenergic substances, may also be applied (13, e17, e27, e28). This can reduce tissue ischemia by vasodilatation and thus prevent ischaemic necrosis. Titrated doses of approximately 1–7.5 mL phentolamine at a concentration of 0.5 mg/mL can be injected subcutaneously into the involved tissue (13, e27). This usually produces immediate vasodilation and improves tissue perfusion. Application can be repeated if a good response is achieved. 5–10 mg may be given to adults (30).

Since either drug can produce hypotension and reflex tachycardia as side effects, we recommend cardiovascular monitoring during their application.

Hyaluronidase

Hyaluronidase has been reported in the context of a wide variety of extravasation substances and is an

enzyme that hydrolyses hyaluronic acid in connective tissue, rendering the tissue more permeable. This allows the extravasated fluid to diffuse more easily and be broken down more quickly. Hyaluronidase is injected subcutaneously into the affected area via several puncture wounds. It can be given alone (34, 35, e17, e29–e32) or in combination with a saline flushout (9, 28, 36–38, e7). The dosage can vary, depending on the manufacturer. With an isolated injection of hyaluronidase, the total dose is about 150 IU (30, 34); combined with flushouts and depending on the severity of injury, this can be increased to 1500 IU (9, 28, 36, 38).

Surgical treatment: Flushout and liposuction

Surgical treatment is based on the flushout method described by Gault 1993 (9), using a sterile technique under analgesedation or general anesthesia (5). Flushouts with a saline solution (for example, 0.9% sodium chloride) are repeatedly applied via puncture wounds or small stab incisions in the affected tissue to remove the extravasated fluid from the tissue. The tissue is flushed with a total amount of 60–500 mL of saline solution, divided into 30–50 mL aliquots (5, 9, 28). The use of blunt ended cannulae is recommended to avoid injury to vessels, nerves or tendons. It is possible to flush out the extravasated fluid more intensely with the additional use of hyaluronidase. For this purpose, the affected tissue is once, or repeatedly, infiltrated with hyaluronidase prior to the flushout.

Alternatively, the flushouts may be combined with one or, between flushouts, repeated liposuction(s) (9, 37, 38, e7). This combination has been reported both with (9, 37, 38, e7) and without (37, 39) prior hyaluronidase application. Where there is a sufficient

layer of subcutaneous tissue, it is possible to perform liposuction alone to aspirate the extravasated fluid (9, 40, e33). Due to the loss of subcutaneous fat tissue during liposuction, patients should be informed about the risk of cosmetic and functional restrictions. It is recommended not to suture the incisions primarily in order to assure further postoperative discharge. There have been no reports to date on the combination of liposuction with prior hyaluronidase infiltration but without flushouts.

Given the lack of comparative studies, the value of hyaluronidase remains uncertain.

On completing the surgical therapeutic measures, an approach applying the general principles of conservative therapy, with elevation and measures to reduce swelling, is generally recommended.

Surgical treatment with flushouts should be initiated within 24 hours, with one case series demonstrating that this was most effective within six hours (37). Treatment of extravasations of vasoconstrictive fluids should be undertaken within four to six hours (37).

Antibiotics should be given in the presence of an infection. There are no recommendations for their preventive use in the absence of any signs of infection.

Conflict of interest statement

The authors declare that no conflict of interest exists.

Manuscript received on 18 December 2020, revised version accepted on 20 April 2021

Translated from the original German by Dr. Grahame Larkin, MD

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Cite this as:

Hackenberg RK, Kabir K, Müller A, Heydweiller A, Burger C, Welle K: Extravasation injuries of the limbs in neonates and children—development of a treatment algorithm. *Dtsch Arztebl Int* 2021; 118: 547–54. DOI: 10.3238/arztebl.m2021.0220

► **Supplementary material**

eReferences:

www.aerzteblatt-international.de/m2021.0220

CLINICAL SNAPSHOT

Hornstein–Knickenberg Syndrome: Potential Diagnosis at a Glance

Figure 1: The patient's facial fibrofolliculomas

Figure 2: Coronal high-resolution computed tomography of the thorax in a female patient with numerous pulmonary cysts of varying size, predominantly basal

A 67-year-old woman, a multimorbid ex-smoker with heart failure, was transferred to our department for weaning from mechanical ventilation after suffering acute respiratory insufficiency due to bilateral pneumonia. Intubation had been followed by bilateral pneumothorax. Weaning was successful. There were four main differential diagnoses for the thin-walled pulmonary cysts seen on thoracic computed tomography: lymphangioleiomyomatosis, pulmonary Langerhans cell histiocytosis, lymphocytic interstitial pneumonia, and Hornstein–Knickenberg syndrome (also known as Birt–Hogg–Dubé syndrome), which is associated with facial fibrofolliculomas. Facial fibrofolliculomas had been histologically confirmed in our patient 20 years previously, but in spite of her recurring episodes of spontaneous pneumothorax the diagnosis of Hornstein–Knickenberg syndrome had never been made. This autosomal dominant hereditary syndrome, caused by a mutation in the *folliculin* gene, is associated with an elevated risk of benign and malignant tumors of the kidney: renal cell cancer ensues in approximately 20% of cases, usually from the age of 50 years onward. The patient and her relatives were advised accordingly and recommended to undergo genetic counseling. Renal neoplasia was not present at the time of diagnosis.

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Conflict of interest statement: The authors declare that no conflict of interest exists.

Translated from the original German by David Roseveare.

Cite this as: Klein M, Koch M, Pfeifer M: Hornstein–Knickenberg syndrome: potential diagnosis at a glance. *Dtsch Arztebl Int* 2021; 118: 554. DOI: 10.3238/arztebl.m2021.0070

Questions on the article in issue 33–34/2021:

Extravasation Injuries of the Limbs in Neonates and Children

cme plus+

The submission deadline is 22. August 2022. Only one answer is possible per question.

Please select the answer that is most appropriate.

Question 1

Which substances are classified as “vesicant”?

- a) Substances which easily leak from vessels
- b) Substances which are stored within the vesicles of cells
- c) Substances which are released from intracellular vesicles
- d) Substances which contribute to the release from vesicles
- e) Substances which cause tissue necrosis

Question 2

Which of the following intravenously administered substances is most likely to develop tissue necrosis in the event of extravasation?

- a) Ringer's lactate solution
- b) Interleukins
- c) Glucose $\geq 10\%$
- d) Cephalosporins
- e) Heparin

Question 3

What is the first action immediately after discovering an extravasation injury in a child?

- a) Remove the cannula
- b) Stop the infusion
- c) Consult a specialist
- d) Contact the parents
- e) Apply a firm bandage

Question 4

What is the name of the procedure mentioned in the text which should be considered for treating a massive swelling?

- a) “multiple needle” procedure
- b) “single incision” procedure
- c) “single puncture” procedure
- d) “multiple puncture” procedure
- e) “sharp needle” procedure

Question 5

Assessing capillary refill time distal to the extravasation also forms part of the clinical assessment of an extravasation injury. At which capillary refill time should specific therapy be initiated, or a specialist consulted?

- a) ≥ 2 sec
- b) ≥ 3 sec
- c) ≥ 4 sec
- d) ≥ 5 sec
- e) ≥ 6 sec

Question 6

In an extravasation injury involving which of the following substances would you use topical nitroglycerin as an antidote?

- a) Actinomycin
- b) Acyclovir
- c) Amino acids $< 10\%$
- d) Ampicillin
- e) Adrenalin

Question 7

What effect does treatment of the tissue with hyaluronidase have?

- a) The tissue becomes less permeable for fluids
- b) The tissue become more permeable
- c) The arterioles contract
- d) More hyaluronic acid is produced in the tissue
- e) Toxic substances in the tissue are neutralized

Question 8

When applying which of the following substances is cardiovascular monitoring recommended due to the risk of reflex tachycardia?

- a) DMSO 99 % (topical)
- b) Hyaluronidase
- c) Phentolamine
- d) 0.9% normal saline solution
- e) Dexrazoxane

Question 9

What is the reported incidence range of extravasation injuries in neonates receiving intravenous therapy on intensive care units?

- a) 1–5%
- b) 4–10%
- c) 11–18%
- d) 15–30%
- e) 18–46%

Question 10

Which factor speaks against the topical application of 2 % nitroglycerin?

- a) Perforated or damaged skin
- b) Child's age < 4 months
- c) Extravasation of a vasoconstrictive substance
- d) Evidence of peripheral tissue ischemia
- e) Body weight < 3500 g

Supplementary material to:

Extravasation Injuries of the Limbs in Neonates and Children

Development of a Treatment Algorithm

by Roslind K. Hackenberg, Koroush Kabir, Andreas Müller, Andreas Heydweiller, Christof Burger, and Kristian Welle

Dtsch Arztebl Int 2021; 118: 547–54. DOI: 10.3238/arztebl.m2021.0220

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