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Extravasation of Concentrated Potassium Chloride: A Case Report

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ABSTRACT

Background: The extravasation of potassium chloride will cause serious harm, especially if it is not diagnosed or treated promptly. Objective:to report the clinical course of a patient who was suffering a potassium extravasation and to discuss steps that can be done to decrease the chances of this event from occurring in other patients.
Methods: After discontinuation of infusion device and withdrawal of intravenous catheter, wet packing with magnesium sulfate and local injection of papaverine and lidocaine were applied.
Results: After 11 days, the extravasation injury had recovered.
Conclusions: To avoid a repeat of such an adverse event, proper sites for administering, accurate dilution of potassium chloride solutions, close observation, and increased awareness of trained personnel of extravasation dangers are vital. Once extravasation occurs, timely wet application with magnesium sulfate and local injection of papaverine and lidocaine may have been useful in producing a favorable recovery.

Introduction

Potassium is an important electrolyte in human beings. When patients are diagnosed with severe kaliopenia, nurses are often ordered to deliver potassium solutions through a venous route.[1] Although this is a common and efficient method to increase plasma potassium, the risk of extravasation should not be underestimated. Potassium solutions are hypertonic and extremely toxic to tissues. These change the balance between intracellular and extracellular fluids.[2,3] Extravasation, which is a known complication of potassium infusions, is characterized by severe local pain that can lead to significant tissue necrosis or even amputation,[4] damage that can result in patient disfunction, increased cost of therapy, and prolonged hospitalization.[5]

Prevention is especially important because the benefits of treatment are limited. Early recognition and early interventions are needed to minimize the effects of extravasation.[2] Delayed diagnosis or ineffective interventions can result in extended necrosis, or the need for plastic surgery[6] or even amputation. A case of tissue damage secondary to apparent extravasation of a concentrated potassium chloride solution prompted this literature search and case report.

Methods/Results

Published literature was searched using the key words *extravasation* or *infiltration* or *leakage* and *treatment* or *therapy* and *intravenous* or *infusion*. The health resources used were the complete Nursing/Academic Edition of the Cumulative Index to Nursing and Allied Health Literature, MEDLINE, Science Direct, Web of Science, Cochrane Library, and the China National Knowledge Infrastructure database. The publication year was limited to the past 10 years and languages were English and Chinese. Of the 1856 articles identified, only 8 studies were considered pertinent to the treatment of potassium extravasation. These extravasation articles listed a number of potential treatments such as local wet packing with 50% magnesium sulfate,[7–9] fresh potato chips[10,11] or hydrocolloid dressing,[12] cutaneous application of mucopolysaccharide polysulfate cream,[13,14] a compounded oil named saifurun,[15] moist exposed burn ointment,[16,17] physical therapy,[13] local injection of hyaluronidase or phentolamine,[2,18,19] and saline washout.[6] These interventions are recommended as a result of personal experience or case reports. An animal research study reported that the best time to apply magnesium sulfate packing to phlebitis in rabbits' ears was within 12 to 24 hours.[20] The limited literature about potassium extravasation in Chinese and English patients reported that the duration of recovery was quite long, ranging from 20 days to several months after treatment with either local magnesium sulfate, potato chips, or burn ointment treatment.[17,21–25]

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Table 1
Blood test.

Parameter	February 14	February 15	February 25	Normal ranges
Plasma K (mMol/L)	2.7	3.7	4.1	3.5–5.3
Platelet count ($\times 10^9$/L)	101	97	120	100–300
Albumin (g/L)	33.9	28.3	39.5	40–55
CRP (mg/L)	57.50	68.72	2.69	≤ 3
Amylase (U/L)	732	686	128	0–220
Lipase (U/L)	1302	1332	59	1–60
TT (sec)	14.7	13.6	15.7	11–17.8
APTT (sec)	25.8	34.6	28.1	23.3–38.1
INR	1.34	1.41	1.02	0.8–1.24
Blood ammonia (μMol/L)	84.9	78.6	36.7	10–47
D-dimer (ng/mL)	11,580.0	12,685	678	0–243

APTT = activated partial thromboplastin time; CRP = C-reaction protein; INR = international normalized ratio;
TT = thrombin time.

The objective of this article is to report the clinical course of a patient who was given a previously unreported treatment for a potassium extravasation and to discuss steps that can be done to decrease the chances of this event from occurring in other patients.

Case Description

A 71-year-old Chinese man was admitted to the gastroenterology department from the emergency department for the evaluation and treatment for 2 days of abdominal pain. Vital signs showed armpit temperature 37.6°C, heart rate 110 beats/min, respiratory rate 23 breaths/min, and blood pressure 146/78 mm Hg. He was intermittently unconscious and unable to answer questions. Computed tomography revealed swelling of the pancreas with inflammatory exudation. Blood tests (Table 1) revealed some abnormal parameters consistent with his diagnosis of pancreatitis and hepatic encephalopathy. Treatment strategies included complete fasting (including oral liquids), inhibiting pancreatic secretion, and reducing blood ammonia level. The patient had a 10-year history of gallstones and cirrhosis for 2 years. He had not followed any previously suggested diet and said he "likes fatty food." He had drunk about 52% wine 150 mL/d for 42 years. He did not stop drinking until his family took him to the hospital for abdominal pain. These factors were felt to have contributed to his pancreatitis.

The patient was prescribed a venous infusion of potassium chloride because of hypokalemia (plasma potassium, 2.4 mMol/L). The patient had both a central venous catheter in his right internal jugular vein and a peripheral catheter (24 gauge) in his right forearm. The potassium chloride infusion solution was prepared by the ward nurse by mixing 30 mL 15% (w/v) potassium chloride with 20 mL 0.9% (w/v) sodium chloride. The concentration of the resulting, diluted potassium chloride solution was 90 mg/mL (1.2 mEq/mL). Then the diluted solution was placed in an infusion pump. The solution was however accidentally infused via the peripheral venous vein rather than the jugular vein as planned. The infusion was given at a rate of 0.9 g/h (12 mEq/h) for approximately 1 hour after which the nurse noted that the skin along the peripheral vein was dark red. The discolored area was about 16 cm $\times$ 1 cm.

After immediate discontinuation of the infusion device and withdrawal of the intravenous catheter, infusion of the potassium chloride solution was switched to the central venous catheter. Wet packing of the injured area with 50% magnesium sulfate 10 mL was applied. When the gauze was dry, it was replaced with another gauze with 10 mL fresh 50% magnesium sulfate. When the nurse observed the discolored skin, she informed her head nurse immediately. The head nurse then told the family about the error and made efforts to limit the injury. After 12 hours, the color of the skin along the peripheral vein changed from dark red to black, and there was a 3cm $\times$ 4cm pale area in the elbow fossa. The arm

Figure 1. Photograph 1: After 12 hours.

was slightly swollen. Due to the expectation of continuing severe injury, an alternative therapy was considered. After fully informing the patient's relatives of the potential for skin necrosis, aggravated extremity swelling, and subcutaneous hemorrhage, informed consent was obtained to implement local subcutaneous injections of lidocaine hydrochloride 100 mg (5 mL), papaverine hydrochloride 90 mg (3 mL), and NS 20 mL. Local 20 mL perivascular injections were made into the area along the injured vein, and into the cubital fossa site. Photograph 1 (Figure 1) was taken after the first local subcutaneous injections. After 36 hours, the whole involved limb was swollen. There were some blisters on the surface of the involved skin. However, the color of previous blackened blood vessels and skin gradually became lighter, which was considered as a good sign for recovery. Therefore, the local subcutaneous injections with lidocaine hydrochloride 100 mg (5 mL), papaverine hydrochloride 90 mg (3 mL) and NS 20 mL were reimplemented again 36 hours after potassium chloride extravasation. Photograph 2 (Figure 2) was taken after the second local subcutaneous injection. Three days after injury, the limb was still swollen, but the blisters began to absorb (see photograph 3 [Figure 3]). After 9 days, the surface of the blisters dropped off and the underlying new pink skin surface was dry. No swelling was noted (see photograph 4 [Figure 4]). The injury at the elbow fossa turned into a scab. Wet packing therapy with 50% magnesium sulfate was abandoned at that time. Treatment and symptom progression are listed in Table 2. After 11 days, the injury had recovered. When

Table 2
Treatment and Symptom Progression

Time point	Treatments	Skin color	Size	Other characteristics
When event discovered, 1 h postinfusion start	① Discontinuation of infusion device ② Withdraw of intravenous catheter ③ Wet packing with 50% magnesium sulfate	Dark red	16 cm × 1 cm	No swelling
12 h	① Local injections with lidocaine hydrochloride, papaverine hydrochloride, and normal saline ② Wet packing with 50% magnesium sulfate	Black; pale	16 cm × 1 cm; 3 cm × 4 cm	Local swelling
36 h	① Local injections with lidocaine hydrochloride, papaverine hydrochloride, and normal saline ② Wet packing with 50% magnesium sulfate	Light red	16 cm × 1 cm; 3 cm × 4 cm	Blisters; aggravated swelling
3 d	Wet packing with 50% magnesium sulfate	Red	16 cm × 1 cm; 3 cm × 4 cm	Absorbed blisters; swelling
9 d	None	Pink	11 cm × 1 cm; 1 cm × 1 cm	Blisters dropped; no swelling

Figure 2. Photograph 2: After 36 hours.

Figure 3. Photograph 3: After 3 days.

discharged, the patient did not complain of discomfort and daily activities were not restricted.

Discussion

The osmolarity of 7.45% potassium chloride is 2000 mOsm/L and its pH is 5.0 to 7.0.[26] In this case, the exact osmolarity of 9% potassium chloride is 2416 mOsm/L. Intravenous infusion of potassium chloride can cause dehydration, hypoxia, congestion, and edema of vascular endothelial cells, causing vasoconstriction and spasm.[27] The permeability of the vein wall increases, leukocytes infiltrate and produce inflammatory changes, and histamine is released at the same time, which makes the vein shrink and harden, and the patient experiences pain.[22] When potassium chloride extravasates, damage and necrosis of surrounding tissues are usually found.[17,21–25] The Naranjo Adverse Drug Reaction Probability Scale score for this event was 7, which means the causality is definite.[28] The severity of the harm in this case was serious because it jeopardized the patient and medical intervention was used to prevent skin necrosis and skin implantation.[29]

Figure 4. Photograph 4: After 9 days.

A root cause analysis of this case suggests a number of ways that this adverse event could have been prevented. The use of a concentrated potassium chloride solution in this patient can be questioned. Whereas the patient's potassium concentration met the definition of severe hypokalemia (ie, < 2.5 mEq/L), the rate of correction ordered (12 mEq/h) is high; especially in a patient with no serious signs of hypokalemia. The physician's order to give potassium chloride should also have clearly stated which site (peripheral or central only) was to be used. Nursing procedures should clearly state that concentrated potassium chloride solutions should not be given into peripheral veins and that whenever used they should be observed for a minimum time after the start of the infusion; preferably with echocardiograph monitoring. This infusion was continued for an hour without observation of the infusion site or patient.

The recovery from this extravasation in 11 days, suggests, but of course does not prove, that the treatments utilized may be ef-

fective. It is important to review the rationale used to select the treatments given to this patient.

Understanding of the effectiveness of papaverine in the treatment of drug extravasation is limited. Papaverine, which is widely known as a nonspecific inhibitor of phosphodiesterase, is usually utilized for vasospasm prevention.[30] It is popular for treating intraoperative vasospasm in microsurgery.[31] Little is known about its effectiveness as an alternative local treatment in extravasation treatment, although it is known to have effects on artery reperfusion.[32] Papaverine in combination with systemic steroids in stellate ganglion blocks has been reported to have a moderate degree of success in the treatment of extravasation of promethazine in intra-artery injection.[33] These facts were the basis of using papaverine for this extravasation.

Lidocaine hydrochloride is commonly used to inhibit pain.[34] In this case, this local anesthetic was used to relieve pain from the tissue damage, the repeated injections, and swelling discomfort. NS was used to dilute any remaining extravasated potassium solution. Wet packing with 50% magnesium sulfate is commonly used in the management of local tissue swelling caused by infusion extravasation.[7–10,35] It can dilate capillaries, improve local blood circulation, and promote absorption of water.[22] Magnesium ions may relax the subcutaneous blood vessels in the extravasation area, which would not only be beneficial to restore blood supply, but could also inhibit the release of acetylcholine from the extremities, block impulse conduction, and help relieve local pain.[36] This is why it is widely used in China to reduce inflammatory reactions such as redness and swelling.[7–10]

Accurate evaluation and proactive intervention are important.[26] When the nurse found the blood vessel was discolored, she immediately disconnected the intravenous infusion and applied wet packing, in an attempt to limit potassium chloride from further eroding local tissues.[37] The peripheral vessel entered the deep tissues in the elbow fossa but no blackened vessel was found in this area. It is speculated but not known whether the vein here was seriously injured. For this reason, the papaverine/local anesthetic solution was also injected into elbow fossa area in an attempt to minimize or prevent damage. Subsequently, discoloration and blisters appeared in this area but resolved. This suggests that this early intervention was effective.

The method of injections differed from traditional methods.[38] Injection sites were distributed to match the strip-shaped extravasation area. Radial artery injections around the extravasation were not used. The agents were injected instead directly into the subcutaneous tissue on both sides of the blood vessel in an attempt to reach all injured skin and blood vessels.

As a result of this incident, the procedures for potassium delivery have been revised. When doctors prescribe potassium infusion, they must state the solution is to be given only through a central venous line. Doctors must clarify how dilutions are to be made in their order. When nurses review the order, a high-risk sign is marked, which is a warning to nurses.

In this case, because of the lethargy of hepatic encephalopathy, the patient was unable to inform the nurse of pain at the infusion site. His son, who accompanied the patient, was unaware of the need and lacked the ability to check the infusion site. Therefore, the high-risk sign now alerts nurses to pay more attention to patients' venous access and caregivers are educated on how and why to review the infusion sites frequently.

Ethical Consideration

Consent was approved by the hospital ethic committee before the information and photographs used for the article were submitted for publication.

Limitation

Due to lack of control group and the open design, the causal link between the treatment and recovery is lacking. No photograph was taken when the extravasation was first noted, which is another limitation, as is the fact that the exact duration of the infusion is not known and its actual concentration or osmolarity were not measured.

Conclusions

The extravasation of potassium chloride will cause serious harm, especially if it is not diagnosed or treated promptly. In this case, the cause of the potassium chloride extravasation is clear: The inappropriate infusion of concentrated potassium chloride into a peripheral venous line. To avoid a repeat of such an adverse event, several key elements have been implemented, including proper sites for administering concentrated potassium chloride (ie, central line), accurate dilution of potassium chloride solutions, close observation during intravenous infusions, and increased awareness of trained personnel of the dangers of potassium chloride administration. Once extravasation occurs, timely wet application with magnesium sulfate and local injection of papaverine and lidocaine may have been useful in producing a favorable recovery. Further animal and, where feasible, human trials of this therapy are suggested.

Conflicts of Interest

The author has indicated that he has no conflicts of interest regarding the content of this article.

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