

Lidocaine Treatment of Experimental Cutaneous Lesions from Potassium Chloride Injection

Rahim Behnia, M.D.,* and Carolyn J. Wilkinson, M.D.†

Potassium chloride (KCl) given subcutaneously in high concentrations causes necrosis of skin, possibly from vasoconstriction around the injection site. The authors studied guinea pigs given subcutaneous injections of various volumes and concentrations of KCl and observed the severity of the cutaneous lesions. In further experiments, therapeutic agents were injected subcutaneously 10 minutes after KCl infiltration. The severity of cutaneous lesions was not affected by various volumes of KCl of the same concentration, but was correlated positively with increasing concentrations of the salt when concentration was varied. Dextrose, 5 per cent, and sodium bicarbonate, 1 M, had no effect on the cutaneous lesions caused by KCl, while hyaluronidase, 150 U/ml, lessened them. Lidocaine, 1 per cent, a vasodilator, eliminated cutaneous lesions caused by KCl. KCl-induced lesions may be due to vasoconstriction, which can be relieved by lidocaine. (Key words: Ions, potassium; Complications, skin; Anesthetics, local, lidocaine; Toxicity, potassium chloride.)

POTASSIUM SALTS are given orally or parenterally to treat acute or chronic hypokalemia. Complications of the oral intake of potassium ion include stomatitis, gastric and small-bowel ulceration, and gastrointestinal bleeding.^{1,2} In contrast to many reports of such complications of oral therapy, there is virtually no report in the medical literature describing the results of inadvertent subcutaneous infiltration of potassium solutions. Potassium chloride (KCl) is caustic in high concentration, which may account for a Russian report³ of delayed healing when wounds were irrigated with potassium salts.

We have observed severe cutaneous lesions from inadvertent subcutaneous infiltration of KCl being given intravenously. One patient received approximately 50 ml of a solution containing 15 mEq KCl/100 ml into a subcutaneous site estimated to be 4 × 5 cm in size. The subcutaneous KCl concentration was estimated to be 0.37 mEq/cm². The overlying skin became a red to black mottled color with no capillary refill. This problem was managed successfully by the subcutaneous infiltration of lidocaine, bicarbonate and hyaluronidase, but the choice and dose of these agents were empirical. The present study was designed to determine whether total dose of KCl or simply its local concentration is more

TABLE I. Severity of Cutaneous Lesions as a Function of Concentration of KCl Given

m KCl	Severity of Lesion
0	0
0.15	1+
0.2	1+
0.4	1+
0.50	2+
0.60	2+
0.66	3+
0.80	3+
1.00	4+

important in governing toxicity of KCl given subcutaneously and also to evaluate the relative values of the agents given to treat the patient described above.

Methods

Guinea pigs were used because of the anatomic and histologic similarities between their skin and that of man. Light-haired animals of 500-600-g weight were chosen, after inspecting their skin to assure the absence of scratches and infections. Their backs were shaved and the skin was washed with alcohol. Sterile syringes and 25-gauge needles were used to inject KCl, prepared in sterile 5 per cent dextrose in water solution. A total of 24 injections was made in two animals each at nine molar concentrations of KCl ranging from 0 to 1.0, produced by varying the KCl dose from 0 to 2 mEq and the volume of injection from 0.5 to 2 ml.

Cutaneous lesions produced by these injections were graded according to onset, discoloration, severity of inflammation, and size and depth of the area of necrosis. Injection sites were inspected 10, 30, 60, 120 and 180 minutes after injection, as well as 24 hours later. These observations were graded as follows:

Grade	Description
0	No reaction
1+	Reddened area, disappearing within 10 minutes
2+	Reddened area for 30 minutes with no induration or necrosis
3+	Mottled reddening with induration and central necrosis within 24 hours
4+	Severe discoloration, obvious induration and necrosis, deep punctuate wound within 24 hours

* Assistant Professor of Clinical Anesthesia.

† Assistant Professor of Anesthesia.

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Address reprint requests to Dr. Behnia.

The efficacies of various solutions in preventing or aborting the severity of lesions from subcutaneous KCl were also studied. Groups of two guinea pigs each were given a 1-ml injection containing 1 mEq KCl, which had been shown to produce severe cutaneous lesions. Ten minutes later, the injection sites were infiltrated with one of the following 1-ml injections: 5 per cent dextrose in water; hyaluronidase, 150 units; sodium bicarbonate, 1 mEq; lidocaine 1 per cent. Lesions were graded 10, 30, 60, 120, 180 minutes and 24 hours later. In another pair of animals, 0.4 ml of a solution containing KCl, 2 mEq/ml, was injected. Ten minutes later injections were made of combinations of lidocaine 1 per cent (0, 0.8 or 1.6 ml), hyaluronidase (0 or 0.8 ml), and sodium bicarbonate (0 or 0.8 ml). The total volume, including the prior KCl injection, was held constant at 2 ml. Cutaneous lesions produced by these injections were judged according to the scale described above.

Results

No consistent correlation of KCl dose with severity of the lesions was observed. However, a direct relation between KCl concentration and the severity of the lesions was observed (table 1). This can be expressed by a regression line through the origin, response = 4.22 [KCl]. The slope, 4.22, is highly significant ($P < .001$) and has a 95% confidence limit of ± 1.04 .

Neither dextrose nor bicarbonate had any apparent beneficial effect in altering the severity of cutaneous lesions produced by 1 ml of 1 M KCl, whereas hyaluronidase aborted the lesions moderately well, and lidocaine almost entirely prevented lesion

TABLE 2. Effects of Agents Injected 10 Minutes after 1 ml of 1 M KCl on Subsequent Development of Cutaneous Lesions

Agent Given 10 Minutes after KCl	Severity of Lesion
Dextrose, 5 per cent, 50 mg	4+
NaHCO ₃ , 1 mEq	4+
Hyaluronidase, 150 U	2+
Lidocaine, 1 per cent, 10 mg	1+

TABLE 3. Effects of Combinations of Therapeutic Agents on Severity of KCl-induced Cutaneous Lesion*

1 Per Cent Lidocaine, (ml)	Hyaluronidase, 150 U/ml (ml)	M NaHCO ₃ (ml)	Cutaneous Reaction
0	0.8	0.8	4+
0.8	0	0.8	2+
0.8	0.8	0	1+
1.6	0	0	0

* Therapeutic agents, 1.6 ml, were injected 10 minutes after KCl (2 M, 0.4 ml) injection into two animals.

development (table 2). Solutions containing lidocaine were more effective than those containing just hyaluronidase or sodium bicarbonate in altering the severity of the cutaneous lesions produced by the solution containing 2 M KCl (table 3).

Discussion

Potassium chloride is an extremely caustic agent in high concentrations. This study suggests that subcutaneous infiltration of KCl can produce ischemic necrosis, which may be due to severe vasoconstriction.⁴⁻⁶ The severity of this reaction correlates well with the concentration of KCl. Local infiltration of lidocaine, 1 per cent, had a superior effect in preventing these cutaneous lesions, presumably by preventing severe local vasoconstriction.

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