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In Vitro Study on the Inhibitory Effect of Magnesium Cation on Paraquat Removal by Medical Cation Exchange Resin

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Recently, the number of paraquat poisonings has increased and its lethality is 81-97%. The number of deaths by paraquat poisoning was 81 in 1978, 594 in 1984, and 1021 in 1986, particularly 96% of those in 1986 were due to suicide (Tsunenari and Yonemitsu 1987). In order to reduce the number of accidental poisonings, emetics, blue azo dye and specific odor substances were added to paraquat preparations in 1979, 1982 and 1985, respectively (Ukai and Kawase 1985). Furthermore, the manufacture of paraquat preparations of high concentration (24%) was discontinued since the July of 1986.

In the primary therapy for paraquat poisoning, gastrointestinal lavage, administration of an adsorbent, forced diuresis, blood purification and so on, are performed. As paraquat adsorbent, the effectiveness of activated chacoal (Okonek et al 1982-83), clay minerals (Smith et al 1974, Kawai et al 1981) and cation exchange resin (Donald et al 1973, Nokata et al 1984) have been reported. Presently, however, an effective antidote and treatment for paraquat poisoning is not available.

When cation exchange resin is in use as adsorbent, magnesium sulfate as purgative has been administered for prevention of caking of resin. Little work on the effect of magnesium cation on paraquat removal by cation exchange resin has been done so far.

In this work, we discuss the inhibitory effect of magnesium cation on paraquat removal by medical cation exchange resin from the standpoints of removal ratio and time course of paraquat concentration in vitro.

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MATERIALS AND METHODS

Paraquat was obtained as a commercial preparation (Gramoxone S, Nihon Nohyaku Co., Ltd.) and its concentration was indicated as 24%. Medical ion exchange resins used were Kayexalate (sodium polystyrene sulfonate, Torii Co., Ltd.) and Kalimate (calcium polystyrene sulfonate, Nikken Chemical Co., Ltd.), which were used for hyperkalemia. Magnesium sulfate used was extra-pure reagent (Wako Pure Chemical Co., Ltd.).

The adsorption capacity of each resin was determined in vitro. Five hundred milligrams of resin was shaken with 50 ml of paraquat solution diluted with purified water, artificial gastric juice or normal saline solution (ca. 800 mg/L) at a constant temperature of 37 °C for 24 hrs. After extraction usinga Sep-Pak C18 cartridge (Waters Associates) for the filtrate (Tsunoda 1983), the paraquat concentration in eluate was measured by a colorimetric method with an alkaline sodium dithionite solution (Calderbank and Yuen 1965).

The time course of paraquat concentration was measured with paraquat solution / resin system at 37 °C. Five grams of resin was placed in a stirred solution of one liter of paraquat solution (ca. 800 mg/L). Five milliliters of the suspension was taken up at regular intervals, and the paraquat concentration was measured.

Magnesium sulfate was added at the rate of 1, 2 and 5 g/L, respectively.

RESULTS AND DISCUSSION

The removal ratios of paraquat in purified water, artificial gastric juice and normal saline solution are shown in Table 1. Removal ratio was calculated according to the formula,

$$\text{Removal Ratio}(\%) = [(C_0 - C_\infty)/C_0] \times 100$$

Table 1. Removal Ratio of Paraquat.

amount of $MgSO_4$ added (g)	removal ratio(%) by Kayexalate			removal ratio(%) by Kalimate		
	H_2O*	HCl**	NaCl***	H_2O*	HCl**	NaCl***
0	99.6	98.4	88.9	97.2	93.2	85.7
1	99.6	97.1	88.3	94.8	91.1	83.4
2	98.7	95.7	86.7	93.6	89.7	81.5
5	94.4	90.7	82.5	90.0	85.9	78.6

*:purified water, **:artificial gastric juice, ***:normal saline solution.

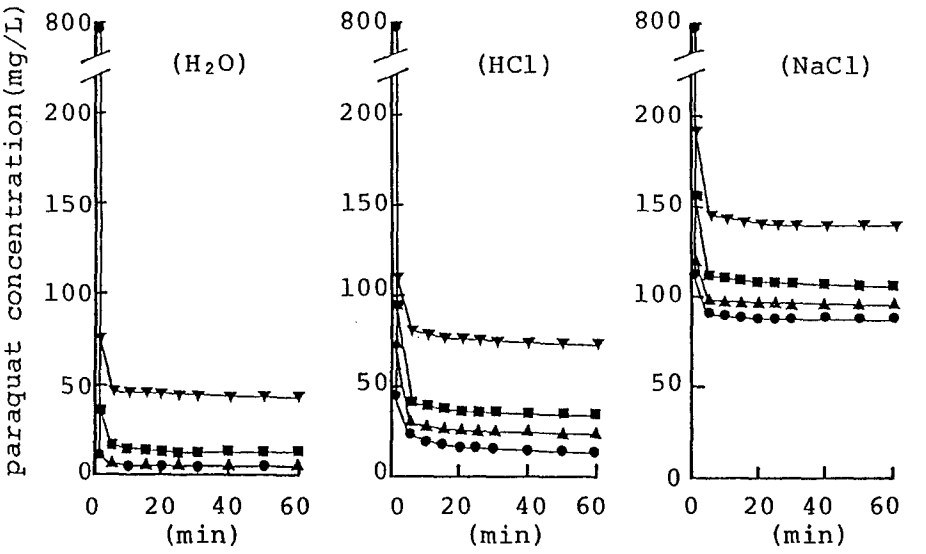

Figure 1-a. Time Course of Paraquat Concentration by Kayexalate. Amount of $MgSO_4$ added;●:0g,▲:1g,■:2g,▼:5g. Initial Paraquat Concentration; 799.6-800.6mg/L. Potassium Exchange Capacity; 3.1mEq/g.

where C_0 is the initial concentration and C_∞ is the equilibrium concentration at after 24 hrs of adsorption time. Removal ratio was lowered successively with purified water, artificial gastric juice and normal saline solution. It was assumed that the difference of removal ratio was not due to the pH of the solution, but due to the coexistent sodium cation. As the amount of magnesium sulfate was increased, therefore the magnesium cation, the removal ratio was lowered. This indicated that the magnesium cation interfered with the removal of paraquat by the resin. Furthermore, it was found that Kalimate which is a resin of the calcium type was easily influenced rather than Kayexalate which is a resin of the sodium type.

Figure 1 shows the time course of paraquat concentration in coexistence with magnesium cation by Kayexalate (Fig.1-a) and Kalimate (Fig.1-b) in purified water, artificial gastric juice and normal saline solution, respectively. In purified water, the paraquat concentration was extremely lowered and was successively higher in the order: artificial gastric juice > normal saline solution. Paraquat concentration was abruptly lowered within 5 minutes of adsorption time, and then reached at plateau within 20 minutes of adsorption time. In all cases, the decline of paraquat concentration was depressed with an increase in the amount of magnesium sulfate.

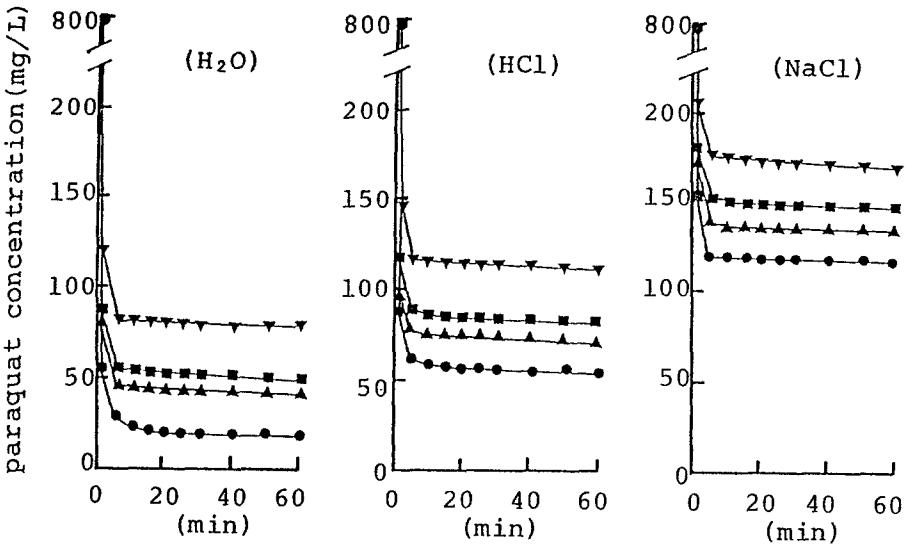

Figure 1-b. Time Course of Paraquat Concentration by Kalimate. Amount of $MgSO_4$ added; ●:0g,▲:1g,■:2g,▼:5g. Initial Paraquat Concentration; 799.7-801.0mg/L. Potassium Exchange Capacity; 1.6mEq/g.

Kayexalate and Kalimate as medical cation exchange resins are antidotes which have the largest removal capacity for paraquat among several paraquat adsorbents. However, one has to pay attention to the electrolyte balance of the body fluid when these resins are used (Kosaka et al 1982). Administration of an adsorbent has been performed at the same time as gastrointestinal lavage. When the gastrointestinal lavage is performed with normal saline solution, one has to pay attention to the effect of the sodium cation on paraquat removal by the resin. Furthermore, if administration of magnesium sulfate as a purgative is performed at the same time as administration of a resin as as adsorbent, the inhibitory effect of magnesium cation on paraquat removal must be considered. It is to be desired that castor oil, sorbitol or mannitol as purgative is used at the practical use of these resins.

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