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Effect of Different Concentration of KCl on Contraction Performance of Gastrocnemius Muscle of *Uromastix hardwickii*

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This paper deals with changes in muscular activity of gastrocnemius muscle of *Uromastix hardwickii* for reptilian buffer having different concentration of KCl. Contraction time, half relaxation time, peak duration time, maximum rate of rise of tension and isotonic tension have been selected as the parameters for evaluation of muscle contraction performance. These studies confirm that, maintenance of K ion to the normal value both in the extra and intra cellular fluid is necessary, because its decrease and increase from the normal value is dangerous for life.

Key words: KCl, Gastrocnemius muscle, *Uromastix hardwickii.*

Introduction

Uromastix hardwickii (Lizard) was chosen for this study because the regeneration of nerves and other organs are the most frequent and important in reptiles (Shaikh *et al* 1993).

The energy requirements of skeletal muscles in hibernating lizards are largely met by an increased degradation of fatty acids. (Pallock and Mac Avoy 1978). Contractile properties of gastrocnemius muscle of *Uromastix hardwickii* neither resembles amphibians nor mammalians but is between the two (Azeem 1973).

It was noted that the contractile apparatus of *Uromastix* is designed to work at relatively high physiological temperatures. (Penny and Goldspink 1979).

Potassium ions play an important role in the ionic exchange of cellular metabolism. Potassium is the predominating cat ion of intracellular fluid and erythrocytes, in which it is present in concentration of about 55 and 95 mM per litre respectively. Potassium deficiency may cause nausea, vomiting, diarrhoea and obdominal cramps while excessive dose may cause hyperkalaemia with paraesthesia of the extremities, restlessness, mental confusion, weakness, paralysis, hypotension, cardiac arrest and arrhythmias. (Martindale 1977; British Pharmaceutical Codex 1973). Potassium maintains intracellular osmotic pressure as KCl. It also maintains intracellular reactions along with bicarbonates, phosphates and proteinates. It constitutes a very important buffer system in the cell. Potassium ions inhibit cardiac contraction and prolong relaxation and muscular contraction in general. (Chatterjee 1970).

Potassium ions plays an important role in the maintenance of electrical excitability of nerve and muscles and in the correction of imbalance acid-base metabolism. These are accumulated in cells by an energy dependent mechanism that extrudes sodium. There is high concentration gradient for potassium from cell to extra cellular fluid, but there is reverse condition for sodium. Rapid and selective changes in the permeability to these ions are of particular importance in excitable tissues. (Goodman and Gilman 1985).

The KCl load might stimulate the increased secretion of aldosterone and this in turn enhances the reabsorption of Sodium and secretion of potassium from the cell by Na^+ - K^+ ATPase pump. A high potassium load (2% KCl) may increase both the intracellular level of sodium and potassium due to Na^+/H^+ antiporter. Na^+/C^{+2} exchanger normalizes the calcium concentration. There is an inverse correlation between serum potassium concentration and blood pressure. High Potassium diet reduces blood pressure by approximately 10 mm Hg during the development of hypertension and is able to abate existing renovascular hypertension (Kausar *et al* 1995).

Muscle stimulated by any means, contracts which is immediately followed by relexation. On stimulation, potassium ions escape from the interior of the muscle. It is believed that the excitability, contractibility and electrical phenomenon of the

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muscle depend largely upon this migration of the potassium ions. The muscle membrane is permeable to potassium ion but not to sodium ion (Chatterjee 1970).

The action potential (simple muscle curve) results from rapid changes in membrane permeability to sodium and potassium ions. The sodium permeability increases about 5000-fold on the onset of the action potential which is followed instantaneously by return of the sodium permeability to normal and hence the potassium permeability increases greatly. Increased permability to sodium causes depolarization phase of action potential while increased potassium permeability makes repolarization phase of action potential. (Guyton 1996).

In the present study different phases of muscle switch action potential have been observed under altered concentrations of KCI in reptilian buffer solution.

Materials and Methods

Selection of experimental animals. Uromastix hardwickii of both sexes weighing 170-230 g were obtained from local market and kept under observation for one week, before being used for investigation.

Dissection. Prior to dissection the animals were anaesthetized by injection of xylocaine (0.05 g kg^{-1}) intramuscularly (Fehmeena and Azeem 1977) and then right and left gastrocnemius muscle were dissected out according to the method described by Azeem and Shaikh (1987).

Solution. The solution used for present study was slightly modified as compared to the reptilian buffer soltion (Latif *et al* 1967). It has following composition.

NaCl 100 mM, KCl 2mM, $CaCl_2$ 2.5mM, Na_2HPO_4 25.36mM, KH_2PO_4 13.14 mM, PH 7.4. Three different concentrations of KCl used were 5mM, 40mM and 50mM, All the chemicals used were obtained either from Merck, Germany or from B.D.H.

Muscle fixation. The proximal end of the muscle was fixed with a stainless steel pin, while the distal end of the muscle was attached by means of a thread to the muscle lever. A pair of stimulating electrodes were placed above the muscle in such a way that cathode and anode were 1cm distante apart.

Muscle stimulation. Massive supramaximal stimulation was achieved by passing 100V square wave D.C. pulses via electrode. A pulse of 50V for 5ms duration was passed to record isotonic twitch. The drum speed was maintained at 640mm sec^{-1}. On Kymograph, twitch has three main phases, i.e. a latent period, contraction phase (depolarization) and a relaxation phase (repolarization).

Measurement of parameters. Contraction time, half relaxation time, peak duration time. maximum rate of rise of tension and isotonic tension were measured from twitch according to the method of Shaikh *et al* (1979 a & b).

Results and Discussion

Results have been summerized in Table 1. Statistical analysis of these values shows that when concentration of KCl

Table 1

Measurements of various parameters of twitch contraction cycles obtained from the normal gastrocnemius muscles of *Uromastix hardwickii*

S. No.	Measurement	2mM	5mM	40mM	50mM
1.	Contractions times (mS)	48.637±0.70 (12)	120.000±14.316 (10) (NS)	152.667±14.550 (15) (<.001)	156.000±13.355 (15) (<.001)
2.	Half relaxation times (mS)	31.984±2.598(12)	121.000±18.886(10) (<.001)	168.000±29.901 (15) (<.001)	144.000±17.808 (15) (<.001)
3.	Peak durations (mS)	2.596±0.02(12)	41.000±6.176 (10) (NS)	50.000±4.403(15) (<.001)	47.333±2.939(15) (<.001)
4.	Maximum rate of tension (cm sec^{-1})	155.612±9.490(12)	201.667±19.979(10) (<.001)	177.777±11.220 (15) (<.001)	180.684±13.955 (15) (<.001)
5.	Isotonic tensions (cm cm^{-2})	4.992±0.317 (12)	5.957±0.161 (10) (<.01)	7.493±0.932 (15) (<.02)	6.294±0.764 (15) (NS)

increased to 10mM and 50mM the contraction time, significantly increased (p0.001) for each concentration, indicating that in high concentration of KCl in extra cellular fluid, the muscle contracts for longer time period; but this change was non-significant for the concentration of 5mM.

Half relaxation time is also significantly increased by increasing KCl concentration to 5mM, 50mM and 50mM from 2mM (p0.001) showing that muscle takes more time to relax than in normal concentration.

It was observed that with increase in KCl concentration, peak duration of muscle contraction also increases and this increase is significant in concentrations of KCl 40 mMand 50mM (p0.001) while non-significant for concentration of 5mM.

Increased concentration of KCl to 5mM, 40mM and 50mM from 2mM shows significant results on maximum rate of rise of tension, i.e. this parameter is significantly increased for increased concentration of KCl (p0.001).

Increased concentration of KCl shows variable effects on isotonic tension when concentration increased to 5mM and 40mM from 2mM. The isotonic tension was increased significantly (p0.001) but in 50mM concentration the results were non-significant.

Maintenance of K^+ ion to the normal value both in the extra and intracellular fluids is necessary , because its decrease and increase from the normal value is dangerous.

If K^+ increases in the serum, as in case of renal failure, results in advanced dehydration, shock and adrenal insufficiency I.V. administration of K^+ at an excessive rate results in cardiac and CNS depression, cardiac arrest, mental confusion, weakness of the respiratory muscle and flaccid paralysis of the extremities. On the other hand, in case of its decreased level in the body fluid, due to chronic wasting disease with malnutrition, prolonged negative nitrogen balance, diarrhoeas, gastrointestinal fistulas, metabolic alkalosis, cushing syndrome, or primary aldosteronism, use of excessive quantities of corticosteroids, diuretics and administration of water and sodium to correct dehydration, results in muscle weakness, irritability and paralysis, tachycardia and dilation of the heart.

Administration of K^+ in heart failure patients receiving digitalis and diuretic agents, prevents digitalis intoxication and arrhythmias.

When 1g of glycogen is stored, 0.36mM of potassium is simultaneously retained. In diabetic coma, treated with insulin and glucose, glycogenesis is rapid and potassium is quickly withdrawn from the extra cellular fluid resulting in hypokalemia which may be fatal. In this condition administration of KCl may prevent the risk.

In familial periodic paralysis, potassium is rapidly transferred into the cells lowering extra cellular concentration.

Intracelluar potassium plays important role in muscle metabolism; when glycogen is deposited in muscle and protein is being synthesized a considerable amount of 'potassium is also incorporated into the tissue'. Muscle weakness is a cardinal and is also a sign of potassium deficiency. (Harper 1967). It may be corrected with K^+ administration.

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