SAFETY AND EFFICACY OF A CONCENTRATED POTASSIUM CHLORIDE SOLUTION INFUSION FOR RAPID CORRECTION OF HYPOKALEMIA

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ABSTRACT

Twenty children with hypokalemia (plasma potassium concentration ≤ 3.5 mmol/L) with electrocardiographic (ECG) changes were given an infusion of concentrated solution of potassium chloride (200 mmol/L) at a rate of 0.25 mmol per kg per hour till ECG changes reverted to normal, underdose monitoring of vital signs and ECG. The regimen effectively corrected the ECG changes in 1 to 6 hours with a mean increase in serum potassium by 0.75 ± 0.49 mmol/L. No complications occurred. Controlled infusion of a concentrated solution of potassium chloride at a rate of 0.25 mmol/kg/hour is a safe and effective way to achieve rapid correction of hypokalemia with ECG changes, using minimal fluid volumes.

Key **words:** *Hypokalemia, Potassium, Acute renal failure.*

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Hypokalemia can have serious consequences like cardiac arrhythmias, cardiac arrest, muscular paralysis, respiratory failure and paralytic ileus(l). However, there is no unanimity about the treatment and the method of correction of hypokalemia. One common recommendation for intravenous correction is to use a potassium solution of 40-60 mmol/L over 2-4 days. This schedule takes a long time and the patient may receive large volumes of fluids before the desired correction of hypokalemia is achieved. Such volumes may be undesirable in newborn infants, patients with acute renal failure, those with protein energy malnutrition (PEM) and seriously ill patients with hemodynamic instability. In a recently published retrospective analysis of adult patients a concentrated solution of potassium chloride (200 mmol/L) was found safe and effective in correcting hypokalemia(l). We, therefore, prospectively evaluated the efficacy and safety of intravenous infusion of a concentrated potassium chloride solution for correcting Kypokalemia with electrocardiographic changes in children.

Material and Methods

Twenty children admitted to the Pediatric Intensive Care Unit were studied. The age, sex and clinical diagnosis of each patient is shown in the *Table*. The inclusion criteria were: (i) Plasma potassium concentration ≤3.5 mmol/L; (ii) Presence of at least one or more of the following changes on the electrocardiogram (ECG); Decreased amplitude of T waves, U waves and depressed ST segment.

After taking informed consent from the parents, the child was started on infusion of potassium chloride solution of 200 mmol/ L concentration. The fluid was given with an infusion pump through a peripheral vein

in an intravenous line separate from the one used for maintenance fluids and drug therapy. The rate of potassium infusion was 0.25 mmol per kg body weight per hour. During the infusion the child's ECG was continuously monitored. Close and frequent clinical monitoring of heart rate, respiratory rate, blood pressure and neuromuscular status was also done. The infusion was continued till the ECG became normal.

At the beginning of the infusion, venous blood was obtained for estimation of plasma potassium and sodium concentration (by flame photometry), and blood urea, creatinine and glucose. Arterial blood was taken for blood gas analysis (Radiometer, Copenhagen, Model-PHM 71 Mk2B). At the end of the infusion repeat plasma potassium estimation was done. Associated problems like septicemia, PEM, dehydration and hyponatremia were treated according to the standard protocols of our unit.

The paired 't' test was used to analyse the changes in plasma potassium with therapy.

Results

ECG changes successfully reverted to normal in all patients. The duration of infusion required to achieve this ranged from 1 to 6 hours. The mean rise in plasma potassium with the infusion was 0.75 ± 0.49 mmol/L ($p<0.001$). Details of the plasma electrolytes, osmolality and other biochemical values are shown in the *Table*.

None of the children had complications during or after the infusion. In no child did we have to discontinue the infusion before the ECG reverted to normal.

Discussion

Hypokalemia with ECG changes is ominous and in such situations it is important to rapidly correct hypokalemia to avoid potentially life-threatening cardiac complications. We therefore selected those patients for this study who had ECG changes with plasma potassium <3.5 mmol/L. Plasma potassium alone does not reflect the true picture of potassium deficit at the tissue level and cannot be relied upon for grading the hypokalemia.

Some authors do not recommend treatment of mild hypokalemia(2). Others who favor therapeutic correction recommend oral potassium supplements(2-5) or rectal administration of potassium chloride solution(6). Intravenous potassium infusion is generally recommended for severe hypokalemia(2,4,5,7). However, there is no unanimity regarding the concentration of potassium solution to be used, the rate, the duration, and the route (central or peripheral vein) of administration. The concentration of solution used in adults has ranged from 20-480 mmol/L(l) while infusion rates varying from 0.2-1 mmol/kg/hour have been recommended in children(4,5). Most of the time such regimens are based on personal practice and experience.

In this study we found that infusion of concentrated potassium chloride solution at a rate of 0.25 mmol/kg/hour was effective in correcting ECG changes of hypokalemia. The regimen was safe, as evidenced by the total lack of complications, even in neonates and patients with renal failure. This regimen could effectively be used in an intensive care setting to eliminate complications due to hypokalemia. The benefits are obvious. The immediate danger to the patient is removed, the time spent in intensive care could be decreased and correction is achieved without the use of large fluid volumes. This may particularly be useful

TABLE—*Clinical Characteristics, Plasma Potassium Concentrations and Biochemical Profile of Study Subjects*

Sl.	Age	Sex	Diagnosis	Plasma potassium (mmol/L)				Other plasma biochemical values				Arterial blood gas values			
				Initial	Post-correction	Difference	Duration (hours)	Sodium (mmol/L)	Creatinine (mg/dl)	Urea (mg/dl)	Glucose (mg/dl)	Osmolality (mosm/kg)	PH	HCO_3 (mmol/L)	pCO_2 (mm Hg)	pO_2 (mm Hg)
1.	6.5 m	F	Chronic diarrhea, PEM	3	4.6	1.6	2	131	1.2	44	108	282	7.34	6.8	13	53
2.	11 m	M	Chronic Diarrhea, PEM Septicemia, ARF	2	2.5	0.5	4.2	120	3.0	30	110	273	7.45	15.1	22	105
3.	14 m	M	Postnecrotic cirrhosis	2.0	2.4	0.4	6	135	0.7	22	96	283	7.46	19.7	28	76
4.	30 m	M	Chronic diarrhea, PEM	3.2	4.4	1.2	3	130	1.0	40	88	278	7.42	14.8	23	80
5.	10 Y	M	Fulm hepatic failure	3.3	3.6	0.3										
6.	7 m	F	ARF	3.0	3.2	0.2	1	137	1.0	24	120	291	7.34	7.8	15	110
7.	2 m	M	Septicemia, Pari ileus	2.5	3.0	0.5	2.8	140	0.5	36	80	296	7.53	27	31	65
8.	11 Y	M	PEM	2.2	2.7	0.5	2.2	120	0.5	24	185	256	7.44	16.8	25	100
9.	3 Y	M	PEM, Acute diarrhea	1.8	2.8	1.0	3									
10.	2 Y	F	PEM, Chronic diarrhea	3.0	3.7	0.7	5	136	0.6	24	112	289	7.58	17.8	19	105
11.	9.5 m	M	HUS	1.4	1.5	0.1	2	128	4.3	124	110	287	7.40	9.8	16	115

TABLE (*contd.*)

Sl.	Age	Sex	Diagnosis	Plasma potassium (mmol/L)				Other plasma biochemical values					Arterial blood gas values			
				Initial	Post-correction	Difference	Duration (hours)	Sodium (mmol/L)	Creatinine (mg/dl)	Urea (mg/dl)	Glucose (mg/dl)	Osmolality (mosm/kg)	PH	HCO_3 (mmol/L)	pCO_2 (mm Hg)	pO_2 (mm Hg)
12.		F	PEM, Acute diarrhea	2.0	2.9	0.9	2									
13.	12 D	M	Septicemia, ARF	2.8	4.5	1.67	2	132	2.0	132	90	298	7.36	15.5	28	70
14.	9 Y	M	AGN, ARF	3.4	4.3	0.9	1	131	4.0	160	110	303				
15.	12 m	F	PEM	2.8	4.5	1.7	3	134	0.8	24	200	289	733	11.4	22	120
16.	6 D	M	Septicemia, ARF	2.6	2.5	-0.1	2	135	2.0	458	110	289	7.26	10.0	23	72
17.	3 Y	M	X-linked hypo-gammaglo-bulinemia, Amphotericin	2.7	3.0	0.3	1									
18.	8 Y	M	Enteric fever, IV Hemolysis, ARF	2.8	3.2	0.4	1	120	2.5	180	90	283	7.45	21.0	30	120
19.	10 Y	F	Rapidly progressive glomerulonephritis	2.7	3.5	0.8	2.5									
20.	8 Y	M	Tuberculous meningitis	2.7	3.3	0.6	2.2	134	0.7	24	90	283	7.52	22.3	27	90

Abbreviations: D = Days, m = Months, Y = Years, M = Male, F = Female, PEM = Protein energy malnutrition, ARF = Acute renal failure, AGN = Acute glomerulonerphritis, HUS = Hemolytic uremic syndrome.

in severe PEM, where correction of hypokalemia may be difficult. However, all such infusions should be given with an infusion pump under close and continuous ECG and hemodynamic monitoring.

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