

# A STUDY OF THE ELECTROLYTE CHANGES IN PLASMA DURING HYPOTHERMIA\*

By

K. SOMASUNDARAM, P.B. SHAH, N.C. SEBASTIAN, R.M. BHATTY AND J.P. SAXENA  
*Department of Physiology, Medical College, Baroda.*

The present study of electrolyte changes in plasma in dogs during hypothermia has been done to evaluate, if these changes can account for the cardiac irregularities during hypothermia.

## MATERIALS AND METHODS

Thirty healthy mongrel dogs weighing between 10—20 kg., of either sex, were anaesthetised with chloralose 80 mg per kg, intravenously. Arterial Blood pressure was recorded on a kymograph with a mercury manometer connected to a carotid artery. Heart rate was calculated from the blood pressure recordings. Tracheotomy was done. A tracheal cannula was inserted through the tracheotomy hole and connected to a Marey's tambour to record the respiratory excursions.

The animals were immersed in ice cooled bath of 4°C and were cooled till the rectal temperature came down to 25°C. The animals were kept on spontaneous respiration throughout. No artificial respiration was resorted to.

Prior to induction of hypothermia the dogs were heparinised (3 mg/kg intravenously.) Blood samples were collected in heparinised bulbs, first sample before induction of hypothermia, second sample at 30°C and the third at 25°C.

The following estimations were carried out on all the blood samples and the results were compared:—

- (1) Plasma sodium and potassium concentrations by Flame photometry using external standards (EEL's flame photometer, Model 100/2562).
- (2) Plasma calcium was determined as described by Wilkinson (12) using EEL's titrator (Model 29/200/134) and EDTA as chelating agent.
- (3) Bicarbonate was estimated by Vanslyke's method immediately after the separation of plasma as described by E. Goldberger, (4).
- (4) Plasma chloride was determined by EEL's chloridometer (Model 92/1449).

\*This paper was presented in the 15th Annual conference of the Association of Physiologists and Pharmacologists of India held at Kanpur in Dec. 69.

\*Received 25-2-1970.



## RESULTS

The Table I summarises the statistical data of the electrolyte changes in plasma at different temperatures. The main features are as under.

TABLE I  
Showing Statistical Analysis of Plasma Electrolyte changes in Hypothermia.

Body temp. (°C)	Sodium mEq/l	Potassium mEq/l	Calcium mg %	Chloride mEq/l	Bicarbonate mEq/l
38.6	149.4 ± 1.05	3.7 ± 0.08	10 ± 0.09	117.1 ± 0.87	23.8 ± 0.0
30.0	149.0 ± 1.03	4.1 ± 0.09	10 ± 0.08	115.4 ± 1.11	23.8 ± 0.0
25.0	149.0 ± 0.97	4.3 ± 0.11	10 ± 0.08	115.4 ± 1.28	20.3 ± 0.0

NOTE:—Each value indicates the mean ± S.E. in a group of 30.

- (1) The blood pressure showed a linear drop with the fall of temperature while heart rate showed a slight rise at 30°C and then a fall at 25°C (fig 1).

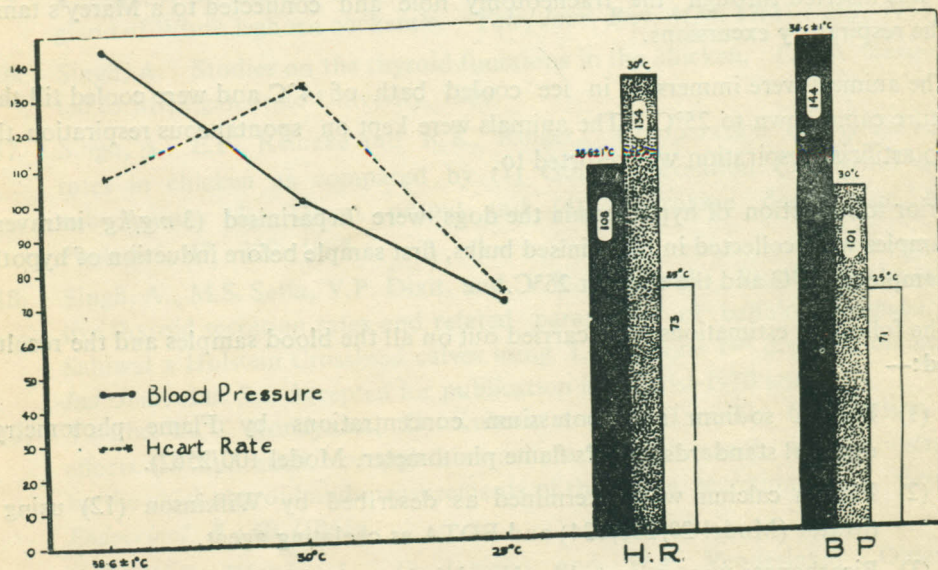


Fig 1

Showing the mean heart rate and blood pressure during Hypothermia

- (2) Plasma potassium showed a significant rise during hypothermia (fig. 2).  
 (3) There is no significant change in plasma bicarbonate level at 30°C but a significant fall at 25°C (fig 2).



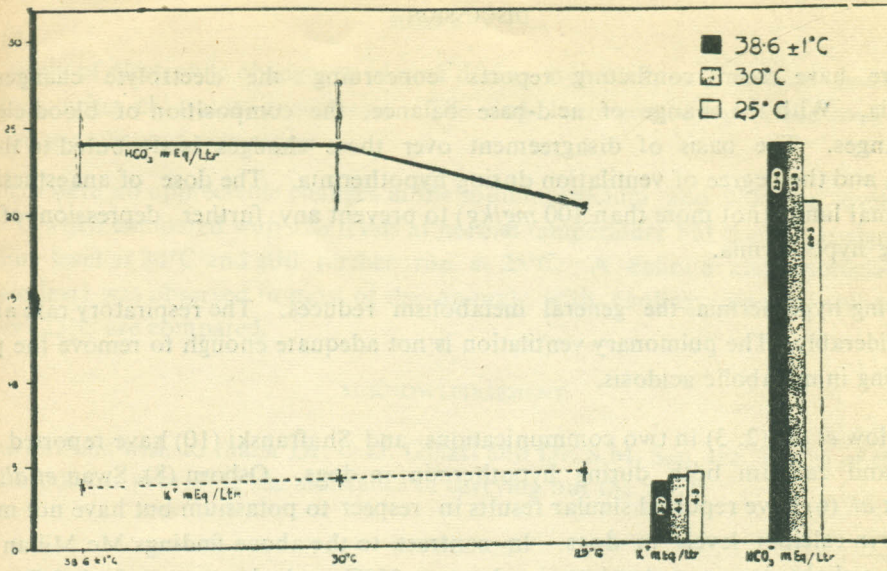


Fig 2

Showing mean changes in Potassium and Bicarbonate concentration at normal body temperature, at 30° C and at 25° C

(4) Plasma sodium, chloride, and calcium did not show any change during hypothermia (fig 3).

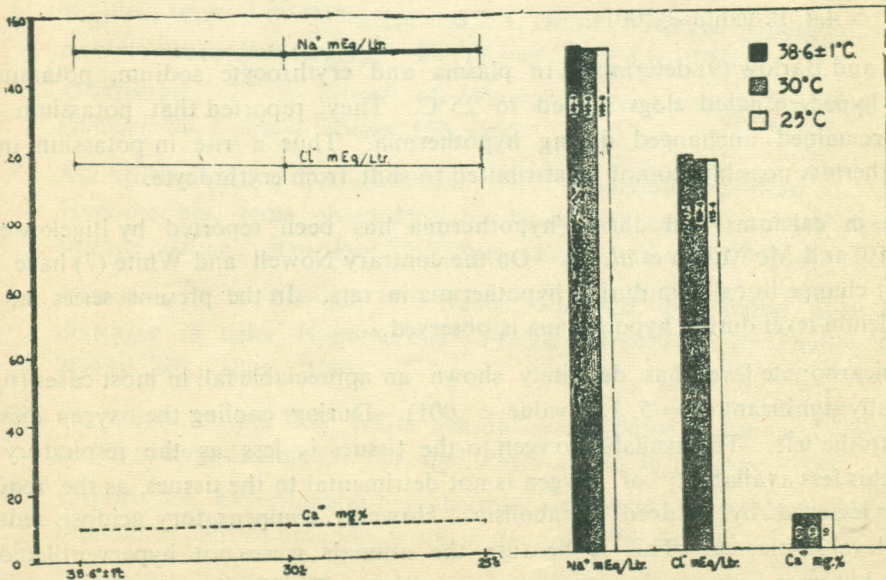


Fig 3

Showing mean changes in Sodium, Chloride and Calcium concentration at normal temperature at 30° C and at 25° C



## DISCUSSION

There have been conflicting reports concerning the electrolyte changes during hypothermia. With the change of acid-base balance, the composition of blood electrolytes rapidly changes. The basis of disagreement over these changes is attributed to the type of anaesthesia and the degree of ventilation during hypothermia. The dose of anaesthesia is kept within normal limits (not more than 100 mg/kg) to prevent any further depression of respiration during hypothermia.

During hypothermia the general metabolism reduces. The respiratory rate also drops down considerably. The pulmonary ventilation is not adequate enough to remove the produced CO<sub>2</sub> resulting in metabolic acidosis.

Bigelow *et al.* (2, 3) in two communications and Shafranski (10) have reported a rise of potassium and calcium both during hypothermia in dogs. Osborn (8), Swan *et al.* (11) and Messmer *et al.* (6) have reported similar results in respect to potassium but have not mentioned any change in calcium levels in dogs. In contrast to the above findings Mc Millan *et al.* (5) have shown a slight rise in potassium in dogs at 25°C and then a gradual fall when the temperature reached to 19°C, while Arasimowiz *et al.* (1) have determined concentration of potassium in plasma in 11 human subjects during deep hypothermia and have quoted a decrease in potassium level with the fall of temperature to 25°C, but on further cooling up to 15°C they have reported a rise in the potassium level.

In the present findings the rise of potassium during hypothermia has been statistically significant ( $t = 4.4$ , P. value  $< .001$ ).

Spurr and Barlow (9) determined in plasma and erythrocyte sodium, potassium, and chloride in hyperventilated dogs cooled to 25°C. They reported that potassium level in erythrocyte remained unchanged during hypothermia. Thus a rise in potassium in plasma during hypothermia possibly cannot be attributed to shift from erythrocyte.

A rise in calcium level during hypothermia has been reported by Bigelow *et al.* (2), Shafranski (10) and Mc Millan *et al.* (5). On the contrary Nowell and White (7) have reported no significant change in calcium during hypothermia in rats. In the present series no change in plasma calcium level during hypothermia is observed.

The bicarbonate level has definitely shown an appreciable fall in most cases (fig 2). It was statistically significant ( $t = 5.1$ , P value  $< .001$ ). During cooling the oxygen dissociation curve shifts to the left. The available oxygen to the tissues is less as the respiratory rate is poor. But this less availability of oxygen is not detrimental to the tissues, as the requirement for oxygen is lessened by reduced metabolism. However, compensatory acidosis reduces the bicarbonate level in plasma. This is because the animals were not hyperventilated during hypothermia but were kept on spontaneous respiration. The findings are in agreement with other workers (2, 3).



#### SUMMARY

A study of electrolyte changes in plasma during hypothermia has been done in thirty healthy dogs, using chloralose anaesthesia. The dogs were cooled by surface cooling to 25°C and kept on spontaneous respiration.

There were no appreciable changes in the sodium, calcium and chloride levels at 30°C and at 25°C when compared with the levels at normal temperature but there was significant rise in potassium level at 30°C and still further rise at 25°C. A definite and appreciable fall in bicarbonate level was observed in most of the animals with cooling, especially when the levels at 30°C and 25°C are compared.

#### ACKNOWLEDGEMENT

The authors wish to thank Dr. O.D. Gulati and Dr. S.M. Sen, the Deans of the Medical College, Baroda for providing the assistance in carrying out the work.

#### REFERENCES

1. Arasimowicz, Czeslaw and Helena Lopatka, Poziom potasu W osoezu krwi ludziw przebiegu hypotermii. *Pol Tyg Lek*, **21**(3) : 99-101 Illus 1966.
2. Bigelow, W.G., W.K. Lunsday and W.F. Greenwood. Hypothermia : Its possible role in cardiac surgery : An investigation of factors governing survival in dogs at low body temperatures. *Ann. of surg.*, **132** : 849, 1950 a.
3. Bigelow, W.G., J.C. Callaghan and J.A. Hopps. General hypothermia for experimental intracardiac surgery. *Ann. of surg.*, **132**: 531, 1950 b.
4. Goldberger, E. A primer of Water, Electrolyte and Acid-Base syndromes, Philadelphia, Lea and Febiger, **153**, 1965.
5. Mc Millan, I.K.R., D.G. Melrose., H.C. Churchill Davidson and R.B. Lynn. Hypothermia, some observation on blood gas and electrolyte changes during surface cooling. *Ann. Roy. Coll. Surg. (Engl)*, **16**: 186, 1955.
6. Messmer, K., W. Brendel, H.J. Reulen and K.J. Nordmann. Elek trolitveran-derungen in tiefer Hypothermia. *Pflugers Arch Gesamte Physiol Mens Tiere*. **288**(3): 240. Illus. 1966.
7. Nowell, N.W. and D.C. White. Seasonal variation of magnesium and calcium in serum of hypothermic rat. *J. Appl. Physiol.*, **18**: 967, 1963.
8. Osborn, J.J. Experimental hypothermia; respiratory and blood pH changes in relation to cardiac function. *Am. J. Physiol.*, **175**: 389, 1953.
9. Spurr, G.B. and George Barlow. Plasma and erythrocyte sodium, potassium, chloride and water in hypothermic dogs. *Am. J. Physiol.*, **197**: 648, 1959.



10. Shafranski, L.V. Ab roli Solyei kaliyu i kal tryyn pry apyerasyyakh padkompleksnai hipartermpl u sabak u eks pyerymyentsye. *Vyesti Akad Navuk Byelaruskaisr Syeyya Biy Lahichnykh Navuk*, 4: 98, 1965.
11. Swan, H., I. Ieavin, S. G. Blount Jr., R. W. Virtue. Surgery by direct vision in the open heart during hypothermia. *J. Am. Med. Ass.*, 153: 1081, 1953 a.
12. Wilkinson, R.H. A micromethod for serum calcium and magnesium estimations. *J. Clin. Path.*, 10: 126, 1957.