



Adrenalectomy of goats: Studies on plasma minerals and subsequent influence on electrocardiogram

K DAS¹, P ASAITHAMBI², S SANYAL³, P R GHOSH⁴ and P K DAS⁵

West Bengal University of Animal and Fishery Sciences, Kolkata, West Bengal 700 037 India

Received: 11 October 2013; Accepted: 8 October 2014

Key words: Adrenalectomy, Electrocardiogram, Goat, Plasma minerals

Mineral imbalances, as a consequence of adrenal insufficiency produce remarkable electrocardiographic abnormalities in animals. In the present study, the disruption pattern of minerals and cardiac profile in experimentally induced adrenal insufficient Black Bengal goat (*Capra hircus*) were estimated at a regular interval.

Adrenalectomy, surgical extirpation of the adrenal glands, is the most authentic and accessible way to study the enigmatic physiological character of this gland. In the present experiment, an attempt was made to elucidate the effect of bilateral adrenalectomy on mineral profiles and electrocardiogram in Black Bengal goats (*Capra hircus*). Results secured in this laboratory appeared to justify at this time the influence of these elements might be responsible for cardiac dysfunction in adrenal crisis.

Healthy female Black Bengal goats (12), about 12 months old with an average body weight of 8 kg, were equally divided into 2 groups, viz. intact control and experimental. Adrenal insufficiency was induced by single stage bilateral adrenalectomy (Das *et al.* 2007a) on the animals of the experimental group. Blood samples were collected from jugular vein at a regular interval of 24 h after the adrenalectomy up to 168 h with immediate separation of plasma by centrifugation at 1200g for 30 min. The level of plasma sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), zinc (Zn), copper (Cu), iron (Fe) and manganese (Mn) were estimated in atomic absorption spectrophotometer following standard methods (AOAC 1995). Plasma inorganic phosphorous (P) was determined spectrophotometrically. The goats were table trained for electrocardiographic study. ECG was recorded using 12 channel portable ECG machine calibrated as 1mV=10mm of amplitude with a paper speed of 25mm/S in all standard bipolar leads (I, II and III) and 3 augmented leads (aVR, aVL and aVF).

All the parameters were analyzed between post-operative hours by Duncan method (One – way - ANOVA) and the significance (P - value) was recorded at 1 % (P<0.01) level. The complete statistical analyses were done using Statistical Package for Social Scientist (SPSS), Windows Version 10.0.

The mean essential data obtained from the study of all the adrenalectomized (ADX) goats are presented in Table 1. There was no significant variation among the values in different experimental hours of intact control group for a particular parameter. Hence, the 0 h represents the mean value of intact control group. Despite the several alterations in mineral profile within first 48 h, no essential changes were noticed also in the ECG tracing. The classical symptoms of adrenal insufficiency had been started since 48 h after adrenalectomy as supported by our earlier study (Das *et al.* 2007a). As adrenal insufficiency progressed significant (P<0.01) hypokalemia was evident along with hyponatremia, hypercalcemia, hypermagnesemia, hyperphosphatemia. Plasma Cu, Zn were high (P<0.01) and the level of plasma Fe, Mn were low (P<0.01) on several occasions. The significant (P<0.01) declining trend in plasma sodium concentration after 24 h of adrenalectomy might be due to decrement of aldosterone level leading to excretion of more sodium through distal convoluted tubule of kidney (Sreemanarayanan and Phillips 1990). Plasma potassium invariably dropped from its pre-operative level which might be due to hemodilution and/or due to chronic renal failure, a sequel of adrenalectomy found in a similar study by the authors (Asaithambi *et al.* 2007, Das *et al.* 2007b). The usual decline in plasma Na was accompanied by hypercalcemia, hypermagnesemia and hyperphosphatemia in adrenal insufficiency (Gow *et al.* 2009, Peterson *et al.* 1989). The relationship between other divalent cations i.e. Cu, Zn, Fe, Mn and adrenal insufficiency is not clear. Increased level of plasma Zn might be due to corticosteroid deficiency (Wastney *et al.* 2000).

In the control animals no significant variations were noticed in the ECG tracing (Fig. 1A) throughout the experimental period. The ECG record shown in tracing (Fig. 1B) was taken at the height of adrenal crisis at 72 h of adrenalectomy. Recording showed fast and progressive decrease of P wave, widening of QRS complex, shortening

Present address: ^{1,4}Assistant Professor (kinsukdas@yahoo.co.in, drprghosh@gmail.com), ³Professor (sanyal57@rediffmail.com), ⁵Associate Professor (pkdaskol@rediffmail.com), Department of Veterinary Physiology. ²Research Assistant (drasai2004@rediffmail.com), Department of Animal Husbandry, Government of Tamil Nadu.

Table 1. Plasma minerals and electrocardiographic changes in ADX goats at different hours.

Minerals (mmol/L)	Duration after surgery (hours)							
	0	24	48	72	96	120	144	168
Sodium	139.33 ^a ± 1.23	141.57 ^a ± 0.67	131.56 ^b ± 0.68	121.75 ^c ± 1.45	118.50 ^c ± 2.50	121.73 ^c ± 0.40	132.28 ^b ± 3.21	125.15 ^c ± 3.90
Potassium	5.87 ^a ± 0.01	5.23 ^b ± 0.13	4.89 ^{bc} ± 0.25	4.46 ^c ± 0.29	4.49 ^c ± 0.32	4.30 ^c ± 0.09	4.82 ^{bc} ± 0.08	4.69 ^{bc} ± 0.09
Calcium	3.45 ^c ± 0.21	2.90 ^c ± 0.13	3.08 ^c ± 0.02	3.75 ^{bc} ± 0.49	4.25 ^{ab} ± 0.48	3.85 ^b ± 0.06	4.20 ^{ab} ± 0.18	4.49 ^a ± 0.38
Magnesium	4.49 ^b ± 0.21	4.48 ^b ± 0.06	4.60 ^b ± 0.24	5.08 ^{ab} ± 0.28	5.96 ^a ± 0.54	5.66 ^a ± 0.08	5.27 ^{ab} ± 0.01	5.42 ^{ab} ± 0.63
Inorganic Phosphorus	2.84 ^c ± 0.02	2.38 ^d ± 0.08	2.97 ^c ± 0.01	3.43 ^b ± 0.14	4.08 ^a ± 0.02	3.85 ^a ± 0.22	3.77 ^a ± 0.12	3.87 ^a ± 0.18
Copper	135.48 ^b ± 8.24	127.38 ^b ± 6.56	131.57 ^b ± 6.08	150.80 ^{ab} ± 8.00	151.94 ^{ab} ± 9.85	144.46 ^{ab} ± 13.61	168.74 ^a ± 11.97	130.54 ^b ± 12.45
Zinc	58.83 ^{cd} ± 0.92	46.61 ^d ± 3.46	59.77 ^{cd} ± 5.57	65.77 ^{bc} ± 5.57	65.44 ^{bc} ± 3.61	78.68 ^b ± 7.37	98.16 ^a ± 2.32	108.67 ^a ± 3.20
Iron	171.10 ^a ± 16.45	50.98 ^d ± 7.55	63.56 ^{cd} ± 16.10	83.20 ^{bcd} ± 7.00	77.10 ^{bcd} ± 2.65	74.88 ^{bcd} ± 2.33	99.06 ^{bc} ± 14.28	106.65 ^b ± 5.78
Manganese	34.58 ^a ± 2.45	23.31 ^{ab} ± 1.73	24.40 ^{ab} ± 4.00	13.20 ^b ± 2.00	15.06 ^b ± 2.65	22.32 ^b ± 0.85	22.06 ^b ± 2.69	21.51 ^b ± 6.34
ECG records	Normal tracing (Figure A)	No essential changes	No essential changes	Depression of ST segment, peaked T wave (Figure B)	Essentially as previous	Flat P wave, ST depression (Figure C)	Previous changes more marked	P lost, T wave tented with wide QRS complex (Figure D)

Values bearing different superscripts i.e. a, b, c.....in a row differs significantly (P<0.01).

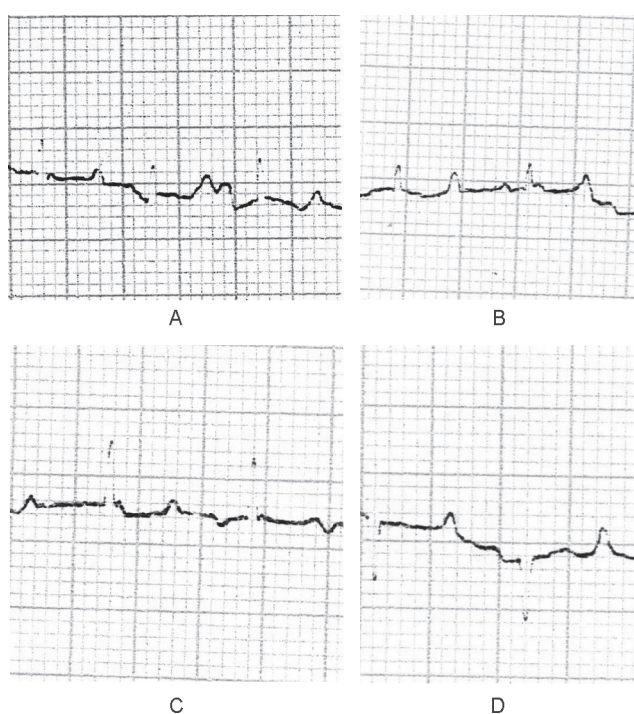


Fig.1. (A-D). Successive electrocardiograms of goats at different experimental hours. A. Control tracing in lead II; B. tracing in lead II at 72 h; C. tracing in lead aVF at 120 h; D. tracing in lead aVL at 168 h.

of ST segment and wide, tall and pointed T wave. Flat P wave and further exaggeration of the ST segment depression and tented T wave were noticed at 120th hours of adrenalectomy (Fig. 1C). The ECG record of one goat was taken during collapsed period and while it was prostrated (Fig. 1D). Record showed extra systolic pattern with inverted P wave. In this study, as plasma K decreased, the ST segment became progressively more depressed and produced a rather characteristic undulating appearance to the baseline. Although hypokalemia decreases the rate of repolarization of the cardiac cell thus prolonging the

recovery time but the depression of ST segment occasionally becomes a manifestation of hypercalcemia due to the changes in transe membrane action potential (Schlant and Alexander 1994). In clinical tracing the effects of hypermagnesemia on the ECG are difficult to identify because the changes are dominated by calcium and the interdependence of the electrophysiological effects of Mg, Ca, Na and K (Schlant and Alexander 1994). Although there was a graded independent association between serum phosphate level and cardiovascular events, its confirmative reflection in ECG tracing was difficult to identify in this study (Kanbay *et al.* 2009). The relationship among minerals, trace elements and cardiovascular changes appeared to be rather complex.

SUMMARY

In the present study, the disruption pattern of minerals and cardiac profile in experimentally induced adrenal insufficient Black Bengal goat were estimated at a regular interval. Significant elevations of plasma calcium, magnesium, inorganic phosphorous, copper, zinc were found whereas the level of sodium, potassium, iron, manganese reduced significantly. Marked deviation of electrocardiographic pattern characterized with fast and progressive decrease of P wave amplitude, widening of QRS complex, shortening of ST segment and wide, tall and pointed T wave. Significant deviations in ECG pattern might be due to hypokalemia, hypercalcemia and hypermagnesemia per se. Other factors such as low plasma Na, Fe, Mn and high plasma inorganic phosphorous, Cu, Zn might have some role on electrocardiogram in adrenal insufficiency.

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