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Effect of adrenalectomy on various blood constituents in Bengal goats

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The adrenal gland consists of 2 embryologically and functionally different tissues; cortex and medulla. The cortex is mesodermal in origin and responsible for secretion of various steroid hormones, whereas the medulla is neuroectodermal in origin and produces catecholamines. Steroid hormones exert their primary activity on carbohydrate and electrolyte metabolism whereas catecholamines act similar to those of post-ganglionic-sympathetic neurotransmitter. Both parts of gland appear to be important in the adaptation of animals to the adverse environmental conditions and stress (Reece 2005).

In order to explore the field of adrenal functions, adrenalectomy, the complete surgical extirpation of the adrenal glands were proved to be the most authentic and accessible way. The present experiment was undertaken to develop a caprine model of adrenalectomy for a close study on adrenal insufficiency, which might shade a fundamental light to the animal biologists on adrenal physiology especially in case of small ruminants.

Healthy female Bengal goats (*Capra hircus*; n, 12) of about 12 months of age with an average body weight of 10 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) in the animals of experimental group (Fig. 1). The adrenalectomized (ADX) animals received no post-operative supportive therapy except topical antibiotic and dressing of surgical wounds. Goats of both the groups were quartered in separate metabolic cages within an animal house maintained at a constant temperature of 30°C and relative humidity of 65%. In the present study, entire experimental protocol along with feeding, watering and maintenance of the animals were as per the standard practice and was approved by the Institutional Animal Ethical Committee.

The animals were observed continuously day and night after surgery. Heparinized blood samples were collected from jugular vein at 24, 36, 48, 72, 96, 120, 144 and 168 h after adrenalectomy. Similar collection schedule was followed for the goats of intact control group. Immediately after collection, the pH of the blood sample was determined using a pH meter. Plasma was immediately separated by centrifugation (1200g for 30 min) and stored at –20°C till analysis. Blood samples were collected separately using fluoride as anticoagulant for immediate estimation of plasma glucose (Tietz 1995). The other biochemical parameters i.e. plasma total protein, plasma total cholesterol and blood urea were estimated as per the standard spectrophotometric methods (Tietz 1995).

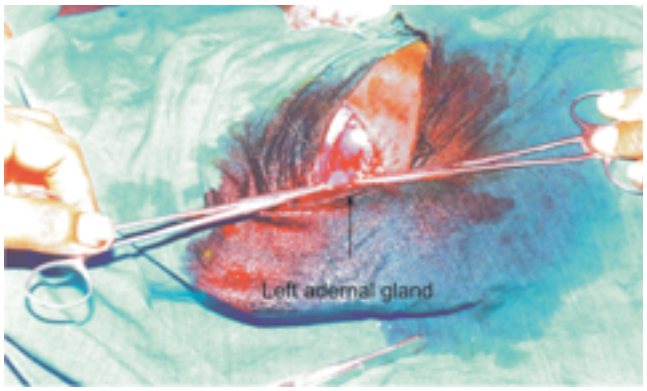

Fig. 1. Surgical adrenalectomy in Bengal goat.

The observations were subjected to statistical analysis by one-way analysis of variance and mean significant difference was studied by Duncan Multiple Analysis Test using SPSS software (SPSS 1999).

All the parameters in the present study showed significant differences ($P<0.01$) when compared to the intact control animals (Table 1). After adrenalectomy a significant ($P<0.01$) decreasing trend of blood pH was found throughout the experiment. The level of plasma glucose concentration also decreased significantly ($P<0.01$) in majority of the occasions but certain fluctuations above the control value were noticed. There were significant increase ($P<0.01$) in total plasma protein, total plasma cholesterol and blood urea following adrenalectomy.

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Table 1. Mean (±SE) values of various blood constituents at different hours of pre- and post-adrenalectomized goats

Parameters (Units)	Mean (±SE) at different hours								
	Control	24	36	48	72	96	120	144	168
Blood pH	7.23^{c}±0.01	7.30^{d}±0.01	7.05^{a}±0.03	7.06^{a}±0.01	7.17^{b}±0.01	7.13^{b}±0.01	7.07^{a}±0.01	7.04^{a}±0.01	7.04^{a}±0.01
Plasma glucose (mg/dl)	50.40^{d} ±1.14	42.78^{bc} ±3.04	47.90^{c} ±1.84	36.99^{b} ±1.20	46.24^{bc} ±2.07	56.58^{d} ±5.21	47.08^{bc} ±4.30	24.58^{a} ±2.14	45.29^{bc} ±0.16
Plasma total cholesterol (mg/dl)	132.75^{a} ±1.67	220.25^{c} ±24.05	126.75^{a} ±3.02	102.24^{a} ±9.00	185.32^{b} ±12.55	181.33^{b} ±13.33	231.47^{c} ±12.80	206.00^{bc} ±24.00	169.75^{ab} ±5.32
Plasma total protein (gm/dl)	6.19^{a} ±0.09	6.43^{a} ±0.23	6.45^{a} ±0.54	5.84^{a} ±0.15	6.49^{a} ±0.31	6.36^{a} ±0.48	7.36^{a} ±0.74	8.89^{b} ±0.44	7.50^{a} ±0.82
Blood urea (mg/dl)	33.73^{a} ±0.91	43.05^{b} ±3.22	27.66^{a} ±0.66	64.89^{c} ±6.49	46.16^{b} ±3.76	35.78^{ab} ±3.05	31.89^{ab} ±1.36	34.13^{ab} ±0.64	40.40^{b} ±2.62

Values bearing different superscripts in a row differ significantly (P<0.01).

In the present experiment, the step-wise disruption of the physiologic functions of the body following extirpation of the adrenal glands illustrated the importance and utter dependence of the organism on these glands.

After adrenalectomy, the result of blood pH indicated the development of a systemic acidosis in the animals. This acidosis might be principally due to mineralocorticoid deficiency leading to a marked sodium diuresis as well as loss of bicarbonate and/or due to hypoglycaemia, as also reported by Kearney and Dang 2007. As the hemoglobin has a potent buffering capacity, lowering of its concentration after adrenalectomy evident a similar study in this laboratory (Asaithambi *et al*. 2007), might also be responsible for the development of acidosis to some extent. Complete removal of adrenal glands definitely results a marked glucocorticoid deficiency (Das *et al*. 2007a) which in turn might have suppressed the hepatic gluconeogenesis with subsequent hypoglycaemia (Pineda and Dooley 2003). The erratic fluctuations of blood glucose in some occasions might be due to irregular feeding habit or species specific differences as suggested by Cowie and Stewart (1949).

Cholesterol is the precursor for steroid synthesis. It might be considered that in absence of the steroid synthesizing adrenal cortical cells after adrenalectomy, the cholesterol remain unutilized in the blood leading to an increase in its circulating level (Cole 1982). Glucocorticoids inhibit the protein synthesis and stimulate the breakdown of proteins in muscle, skin, adipose, lymphoid and connective tissues (Pineda and Dooley 2003). In this study, experimentally induced adrenal insufficiency glucocorticoid deficiency might have facilitated the protein synthesis as well as inhibited its catabolism leading to an increase in plasma protein level (Quan 1991). Chronic renal failure is commonly associated with the patients with adrenal insufficiency as well as in the ADX-animals (Das *et al*. 2007b). Significant rise in blood urea in these ADX-goats might be due to impairment of renal function (Cowie and Stewart 1949).

Evidences from this present and previous studies have exposed some of the salient features of adrenal insufficiency, especially in goats. It also revealed the effects of adrenal glands on various metabolic processes which are essential for maintenance of homeostasis and for survival in these animals. From the present study it can be concluded that the adrenal glands serve as one of the major endocrine organ in goat with such a wide range of physiological actions.

SUMMARY

The physiologic functions of the adrenal glands was ascertained by single stage bilateral adrenalectomy in female Bengal goats (*Capra hircus*; n, 6) of same age group. Blood samples were collected at regular interval in post-operative periods for the estimations of blood pH, plasma glucose, total protein, total cholesterol and blood urea. All the blood biochemical parameters in the present study showed significant differences when compared to the intact control animals. There was a significant increase in plasma total protein, plasma total cholesterol and blood urea, and a significant decrease in blood pH and plasma glucose. The present study indicating the sensitive changes occurred in the blood biochemical profile resulting body-wide disruption of function on adrenal insufficiency which assists an elucidation of adrenal gland physiology in small ruminants.

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