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Secretory Responses of Plasma Insulin, Glucagon, Cortisol and Glucose to Heat Exposure in Calves

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ABSTRACT. Secretory responses of plasma insulin, glucagon, cortisol and glucose to heat exposure (33°C, 60% RH) were investigated using Holstein calves. Plasma glucagon concentration had a significant increase, but plasma insulin, cortisol and glucose had significant decreases within 24 h following heat exposure. Concerning subsequent responses to heat exposure, plasma glucagon level maintained increased concentrations for 8 days of heat exposure. Plasma insulin level increased on and after day 4 of heat exposure. However, plasma cortisol and glucose levels maintained declined levels throughout the heat days.—**KEY WORDS:** calf, glucocorticoids, heat exposure.

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Recently, the relation between heat stress and endocrine systems in young animals has been investigated. Some studies that heat exposure caused increases in plasma prolactin [11] and catecholamines [1], and decreases in plasma glucocorticoids [4] and thyroid hormones [2] in calves have been reported. Previous report using calves showed that heat exposure inhibited the arginine-induced insulin secretion and accelerated the arginine-induced glucagon and 11-OHCS secretions[13].

The purpose of the present study is to ascertain the changes of insulin, glucagon, cortisol and glucose in peripheral blood following heat exposure by using calves.

Eleven castrated Holstein calves aged 4 to 5 months, weighing 102 to 180 kg were used. They were housed in climatic room at a thermoneutral (T.N.) temperature of $22\pm1^{\circ}\text{C}$ with $60\pm10\%$ relative humidity (RH) and constant light-dark cycles (light on; 6:00–18:00 h), and were offered alfalfa hay and concentrates daily. Venous blood was obtained through the catheter which

had been inserted into the jugular vein previously, before the feeding. Blood sampling was performed before (basal level) and 0.5, 1, 3, 6 and 24 h after the onset of heat exposure ($33\pm1^{\circ}\text{C}$, $60\pm10\%$ RH) using 8 animals. As a control experiment of early responses following heat exposure, the same calves as the heat-exposed ones were taken blood similarly. The control experiment was conducted before the onset of heat exposure. Blood was then collected daily for 8 days of heat exposure using 11 animals. The blood sampling was conducted almost similar time (9:00 a.m.) every day. A blood sample collected into a heparinized syringe was immediately transferred into a polyethylen tube in ice water and centrifuged at 4°C . A part of a blood sample for glucagon assay was placed in another tube containing 500 KIU/ml blood of trypsin inhibitor (Antagosan, Hoechst Co., Ltd., Germany) and was centrifuged similarly. Plasma insulin [7], glucagon [9] and cortisol [8] were determined by radioimmunoassay. Anti-glucagon serum G-42E, which reacts

Fig. 1. Early changes in plasma insulin, glucagon, cortisol and glucose following heat exposure. Closed and open circles indicate values obtained in T.N. (22°C, 60% RH) and heat (33°C, 60% RH) environment, respectively. Each point and vertical bar represents the mean $\pm$ S.E. of 8 animals. Significance of difference between values in the T.N. and heat environments is indicated as follows: * $P < 0.05$, ** $P < 0.01$.

only with pancreatic glucagon, was employed [10]. Plasma glucose was determined by glucose oxidase method [5]. Rectal temperature was measured with a mercury thermometer, and respiratory rate and heart rate were measured with a stethoscope.

Respiratory rate and rectal temperature increased significantly, and heart rate slightly increased following heat exposure.

Fig. 1 and 2 denote changes in plasma insulin, glucagon, cortisol and glucose in peripheral blood following heat exposure. No diurnal rhythms in those hormone levels were observed in T.N. environment. The insulin level prior to the onset of heat

Fig. 2. Subsequent changes in plasma insulin, glucagon, cortisol and glucose following heat exposure. Closed and open circles indicate values obtained in T.N. (22°C, 60% RH) and heat (33°C, 60% RH) environment, respectively. Each point and vertical bar represents the mean $\pm$ S.E. of 11 animals. Significance of difference from the value at zero time is indicated as follows: * $P < 0.05$, ** $P < 0.01$.

exposure (basal insulin level) was 18.0 ± 0.9 μ U/ml. The level significantly declined 0.5, 1 and 6 h after heat exposure (Fig. 1). Inversely, the level had a gradual increase on and after day 4 of heat exposure (Fig. 2).

Basal glucagon level was 133.8 ± 5.3 pg/ml. The level had significantly increased in both early (Fig. 1) and subsequent (Fig. 2) responses to heat exposure. The present data was consistent with the previous study performed by employing arginine injection test in calves [13]. The acceleration of glucagon in heat environment may be due to an increase in catecholamines following heat exposure [1] since catecholamines was

observed to increase directly glucagon secretion [3].

Basal cortisol level was $1.6 \pm 0.2 \mu\text{g/dl}$. The level promptly declined following heat exposure (Fig. 1). Heat exposure also maintained decreased plasma cortisol levels for the entire 8 days (Fig. 2). The present result was consistent with the previous study [13] and the study by Gwazdauskas *et al.* [4] using calves. The decline in plasma cortisol level might be related to the decline of immunological function since heat exposure suppressed the immune response in calves [5] and temperature-induced immunosuppression was mediated by adrenal gland in domestic fowl [12].

The present study indicated that heat exposure caused a decrease in plasma glucose level. The result was in good agreement with those indicated by Tripathi *et al.* [14] and the previous experiment [13].

From the present results, it was suggested that those endocrine hormones of calves had capacities to respond swiftly to heat stress.

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要 約

仔牛における暑熱暴露にともなう血漿インスリン、グルカゴン、コンチゾールおよびグルコースの分泌反応：高橋秀之・村田英雄¹⁾・松本英人²⁾（農林水産省家畜衛生試験場東北支場，¹⁾総合診断研究部，²⁾東北農業試験場）——ホルスタイン雄仔牛を暑熱環境（33℃，60%RH）に暴露したときの血漿インスリン，グルカゴン，コンチゾールおよびグルコース濃度の変化を8日間にわたり調べた。暑熱暴露24時間以内に血漿グルカゴンの有意な上昇が認められたが，血漿インスリン，コンチゾールおよびグルコースは低下した。その後，血漿グルカゴンの全観察期間にわたる上昇と，血漿インスリンの暴露4日以降の持続的上昇があった。血漿コンチゾールおよびグルコースは全観察期間にわたって低下が続いた。