URINARY AND CAUDATE NUCLEI CATECHOLAMINE LEVELS IN STRESS-SUSCEPTIBLE AND NORMAL SWINE

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Summary

Eight stress-susceptible and eight normal pigs were used in the first portion of the study. Urine samples were collected for 24 hr over 4 consecutive days while the pigs were kept in metabolism cages. Each 24-hr sample was assayed for epinephrine, norepinephrine and dopamine. Urinary levels of dopamine were lower (P<.01) in the stress-susceptible pigs. No significant differences in urinary epinephrine or norepinephrine were observed. The second portion of the study evaluated the catecholamines in the caudate nucleus of the brain. Six stress-susceptible and six control pigs were examined. Immediately after exsanguination, caudate nuclei were excised and frozen in liquid nitrogen. The caudate nuclei were assayed for catecholamines within 2 to 3 days of freezing. Caudate nuclei dopamine levels were lower (P<.01) in stress-susceptible pigs (5,961 ng/g) than in control pigs (10,878 ng/g). No significant differences in norepinephrine levels of the caudate nuclei were observed between the two groups. (Key Words: Pigs, Urine, Brain, Dopamine, Epinephrine, Norepinephrine.)

Introduction

The role of the central nervous system and its association with catecholamine function have received limited attention in studies of the etiology of the porcine stress syndrome (PSS). Kerr et al. (1975) suggested that the central nervous system may play a role in the etiology of the stress syndrome in swine. Lucke et al. (1976) reported large increases in plasma catecholamines after the imposition of stress conditions, and Weiss et al. (1974) concluded that the sympathetic response is a secondary factor in the development of the stress syndrome and is not the triggering mechanism.

Since skeletal muscle tremors and rigidity are signs of PSS and catecholamines can influence muscle functions associated with muscle tremors, this study was conducted to determine whether stress-susceptible pigs differ from normal pigs in urinary levels of catecholamines, epinephrine, norepinephrine and dopamine. Also compared were dopamine and norepinephrine levels in the caudate nuclei of the brain. The caudate nuclei and associated basal nuclei of the brain can influence skeletal muscle tremors and rigidity by regulating a functional balance between the striatal (caudate nucleus and putamen) dopaminergic and cholinergic neurons (Agid et al., 1975).

Materials and Methods

Eight stress-susceptible and eight normal pigs (27 to 68 kg live weight) were used in the first portion of the study. The pigs were classified as normal or stress-susceptible by the halothane screening test (Christian, 1974), the blood typing test (Rasmussen and Christian, 1976) and the blood creatine phosphokinase test (Sigma Chemical Co., 1973). The specific blood types and blood CPK values are shown in table 1. There was no overlap in CPK values between control and PSS pigs. The pigs were placed in individual metabolism cages in the metabolism room at the Iowa State University Meat Laboratory and acclimated to the cages for 7 days before the start of the urine collection period. Urine samples were filtered through glass wool.

1 Journal Paper No. J-9671 of the Iowa Agr. and Home Econ. Exp. Sta., Ames. Project No. 2176. This study was supported in part by the USDA, CSRS contract No. 70442.
2 Appreciation is expressed to Terri Wierenga for her technical assistance and to Dr. P. J. Berger for statistical assistance. The authors thank Dr. Lauren Christian and Dr. R. A. Rasmusson for the blood type and CPK classification information.
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and collected in 10-liter flasks containing 30 ml of 6 M HCl. The flasks were maintained in an ice bath throughout the collection period. The urine samples were collected from each pig every 24 hr for 4 consecutive days. An aliquot of the 24-hr collection was frozen at −20 C until assayed for the catecholamines. Before freezing, 90 mg/ml EGTA and 60 mg/ml glutathione were added to each aliquot. Epinephrine, norepinephrine and dopamine levels were determined by a radioenzymatic method reported by Passon and Peuler (1973), as described and modified by Upjohn Diagnostics (1978).

In the second phase of the study, six stress-susceptible and six control pigs were compared for norepinephrine and dopamine levels in the caudate nuclei of the brain. Within 4 min of exsanguination, the caudate nuclei were excised and frozen in liquid nitrogen. The assay procedure used for determination of dopamine and norepinephrine in the caudate nuclei was also reported by Upjohn Diagnostics (1978).

The data were analyzed statistically by least-squares analysis of variance (Snedecor and Chochran, 1967).

Results and Discussion

Urinary dopamine, epinephrine and norepinephrine levels in the stress-susceptible and control pigs are presented in table 2. Epinephrine and norepinephrine levels did not differ (P<.05) between the two groups. Urinary dopamine levels, however, were lower (P<.01) in the stress-susceptible group (22.97 ug/24 hr) than in the control group (31.09 ug/24 hr). Low dopamine levels can be associated with muscle tremors and muscle rigidity during stress conditions (Hornykiewicz, 1966).

Humans with extrapyramidal diseases often show muscle tremors and muscle rigidity that can be correlated with low dopamine levels in the urine and the caudate nucleus (Barbeau, 1960; Barbeau et al., 1961; Bertler and Rosen gren, 1959; Ehringer and Hornykeiwicz, 1960; Carlsson, 1972). Therefore, dopamine levels in the caudate nuclei area of the brain were determined for the animals used in the second portion of the study (table 3). The mean dopamine levels (5,961.6 ng/g tissue) in stress-susceptible pigs were significantly lower than those in the control pigs (10,878.3 ng/g tissue). The control dopamine values were in the range reported for the pig by Bertler and Rosengren (1959). The caudate nucleus norepinephrine levels did not differ significantly (table 3) between the two groups. This observation, along with the finding of a nonsignificant
difference in urinary epinephrine and norepinephrine between the two groups, supports the conclusions of Gronert et al. (1977) that epinephrine and norepinephrine probably play a secondary role in the etiology of the stress syndrome.

The lower dopamine levels in the caudate nuclei suggest that an abnormality may exist in the function of the striate body (caudate nuclei and putamen) when stress-susceptible pigs are subjected to extreme exercise or other types of physical stress. The caudate nucleus is an important part of the basal ganglia, which, in conjunction with other extrapyramidal structures, function in the initiation and regulation of skeletal muscle functions. It has been suggested that the controls for this mechanism function through a closed loop feedback system in which dopamine acts as an inhibitor. The inhibitory dopamine pathway counteracts the excitatory acetylcholine pathway that is responsible for the stimulation or excitation of skeletal muscle (Sethy and Van Woert, 1974; Agid et al., 1975; Consolo et al., 1975; Bartholini et al., 1975).

A lower dopamine concentration in this portion of the brain could reduce the inhibitory effect on acetylcholine stimulation under stress conditions and result in overstimulation of the motor end plates of skeletal muscle.

This overstimulation would result in excessive Ca$^{2+}$ efflux into the sarcoplasm, muscle tremors and rigidity would develop. This could initiate and contribute to a lactate acidosis in the skeletal muscle (Topel, 1977).

The results of this study suggest that the central nervous system plays an important role in the etiology of the PSS.

**Literature Cited**


BRAIN AND URINARY CATECHOLAMINES


