Possible Relation of Plasma Testosterone Level to Aggressive Behavior of Male Prisoners

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Analysis of testosterone concentration in the blood and urine concentration of norepinephrine and epinephrine showed that testosterone level in aggressive prisoners was higher than in moderately aggressive prisoners, although both concentrations were near the low boundary of normal. The level of norepinephrine was also higher in aggressive prisoners than in moderately aggressive jailed inmates. These data and published reports attest to pronounced role of norepinephrine in the formation the aggressive behavior.

Key Words: *aggressive behavior; stress; testosterone; norepinephrine*

Violence and aggression belong to the most acute problems confronting humanity [1]. The mechanisms of aggressive behavior are intricate and heterogeneous. Various genes, neuroanatomic structures, neurotransmitters, and hormones participate in the realization of this behavior. The problem of chemical inducers of aggressive behavior is still a matter of vigorous discussion. Many exo- and endogenous substances can trigger or aggravate this behavior. Among them, the greatest, if not the overwhelming attention, is given to testosterone and various biogenic amines [1,10,11].

Here we measured the level of some hormones and neurotransmitters in men who committed major or minor crimes.

MATERIALS AND METHODS

Since aggressive behavior is infrequent in human population this study was carried out on persons that committed various crimes. By ethical considerations, such studies are often limited to examination of correlation between aggressiveness and the level of a particular hormone [8].

The examined prisoners (n=45) committed the major crimes and kept in a prison in Tbilisi (Georgia). The experimental group comprised criminals that repeatedly committed violent crimes (murders, robbery, and beating) [14]. The control group included prisoners (n=25) committed minor crimes. Such composition of the control group instead of a group of free citizens is explained by the fact that free persons are not affected by severe emotional stress and other factors characteristic of the prisons (for example, the necessity to adhere to a certain aggressive behavioral pattern needed for individual survival). Therefore, we compared only individuals kept in more or less similar environment.

Examination included measurement of blood testosterone (TS) and urinary norepinephrine (NE) and epinephrine.

After drawing the blood, the samples were immediately frozen at -80°C. Analysis of TS concentration was performed by radioimmunoassay employing a TESTO-CT2 kit (CIS Bio International Filiale de Schering S.A.). Urine concentration of catecholamines was determined by HPLC with electrochemical detection (HPLC, BioRad, Model 1330 Pump, Model 1340 Electrochemical Detector). The urine was collected over 24 hours.

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The study protocol was approved by Ethical Committee of I. Beritashvili Institute of Physiology and Prison Administration (Tbilisi).

The data were processed statistically using Mann–Whitney nonparametric *U* test and Kendall τ rank correlation coefficient.

RESULTS

The persons committed aggressive crimes (experimental group) demonstrated significantly higher serum level of TS than those committed minor crimes (control group, Table 1). Epinephrine concentration did not significantly differ in both groups, while that of NE was higher in the experimental group.

Correlation analysis performed with Kendall τ rank correlation coefficient revealed no correlation between NE, TS, and epinephrine in the experimental (aggressive) group. In contrast, a significant correlation of 0.306 was revealed in the control group between NE and epinephrine ($p<0.05$).

Thus, our results on TS level in prisoners confirm published data on high level of TS in dominant animals and/or in winners in agonistic encounters [12] or winners in human contests [8]. On the other side, frustration is a basic inducer of aggressive behavior [1,7,13]. In turn, frustration is related to emotional stress, which inhibits synthesis of androgens [15]. During permanent encounters, agonistic interaction can be similarly stressful for both winners and losers [13]. Thus, TS is not always an inducer of aggressive behavior. This inference agrees with studies denying the involvement of TS in genesis of aggressive behavior [6,11].

Logically, chronic emotional stress in prisoners should manifest itself in inhibition of their reproductive function. As expected, TS level in prisoners was below the normal (3-10 ng/ml). On the one hand, aggressive prisoners demonstrated higher TS level than the control jailed inmates; on the other, TS concentration in the control and experimental groups did not surpass the level characteristic of free-living male population (far less aggressive) and was even slightly below the normal. We found no papers focusing on this contradictory evidence and propose our explanation of this phenomenon.

According to the principles of TS organizing-activating model, in the prenatal period androgens promote the development of neural networks mediating aggressive behavior in the future. During sexual maturation these networks are activated by TS and aggressive behavior in response to corresponding stimuli is realized [5]. This peculiarity of the effects of TS probably results in the development of structures promoting enhanced aggressive response to external stimulation.

If aggressive/dominant subject organizes strict vertical hierarchy eliminating hazard to his status, the neurogenic emotional stress decreases, which improves TS dynamics. Thus, the positive correlation between TS and aggression can also result from favorite dominant conditions.

Taking the above into account, we hypothesized that the role of adequate hypothetical inducer of the aggressive behavior can be played by a factor, which not only aggravates aggressive behavior, but also: *a*) is present in high basal concentrations in dominating/aggressive subjects, and *b*) is more intensively synthesized and released during stressful or agonistic encounters.

Among all agents involved into genesis of aggressive behavior, only NE is characterized by both these features. Specifically, there is a positive correlation between NE content in various stress-reactive cerebral structures and the number of dominating males in the group [2]. NE aggravates aggressive behavior [9]. Synthesis and release of NE is enhanced during aggressive behavior in animals and in healthy or mentally ill humans [3,4,14]. In our study, NE level in the aggressive prisoners surpassed that in jail inmates. The most important component of stress reaction is activation of the sympathetic nervous system, which in turn, stimulates secretion of NE and elevates its concentration in the blood and stress-reactive cerebral structures during acute stress [10]. NE is the endogenous factor produced by living organism to adapt to the action of the stressors (activation of transmitter element of the sympathoadrenal system). This is a necessary component of stress reaction.

Thus, evidence is accumulating in favor of the leading role of NE in the formation of aggressive behavior: this agent is involved in inducing such behav-

TABLE 1. Concentration of TS, NE, and Epinephrine in Blood Plasma and Urine of Prisoners (*M*±*m*)

Group	Mean age, year	Blood TS, ng/ml	Urine epinephrine, μg/day	Urine NE, μg/day
Aggressive prisoners (experimental)	30.66±1.10	2.56±0.20*	8.33±0.86	23.33±1.31*
Moderately aggressive prisoners (control)	31.2±1.8	1.9±0.3	7.91±0.88	18.22±1.46

Note. *$p<0.05$ compared to the control.

ior and its synthesis is stimulated during the period, when aggressive behavior is required for adaptation to stressful environment.

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