State of the Sympathoadrenal System in Patients with Traumatic Injury to the Spinal Cord

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Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 119, № 2, pp. 149-151, February, 1995
Original article submitted January 5, 1994

Measurement of plasma catecholamines (epinephrine, norepinephrine, and dopamine) by the method of high-performance liquid chromatography showed significantly elevated epinephrine levels in patients with spinal and spinal cord trauma as compared to healthy donors and patients with craniocerebral trauma. The neuroendocrine abnormalities detected in patients with traumatic disease of the spinal cord aggravated this disease. The elevated blood level of epinephrine, which is a sign of heightened activity of the sympathoadrenal system, points to an important role of neurotransmitters in the establishment of a pathological state in traumatic injuries to the vertebral column and spinal cord.

Key Words: *brain catecholamines; spinal and spinal cord trauma*

The pathogenesis of complications of traumatic spinal cord disease is not completely understood. The condition of "spinal" patients is made worse by trophic disturbances and persistent abnormalities in the functioning of internal organs and organ systems (stomach, liver, pancreas, cardiovascular system), this being associated not only with spinal cord injuries but also with the involvement of other parts of the central nervous system in the pathological process.

The various autonomic disturbances developing in spinal cord injuries are believed to result from changes of a neuroendocrine nature. Since the regulatory and effector functions are coupled at the neurotransmitter level [1], it is interesting to find out what contribution neurotransmitters might make to the formation of a pathological state in patients with spinal/spinal cord trauma. In this study, catecholamine levels were measured in the general circulation of patients 1.5 to 2 months after such trauma.

MATERIALS AND METHODS

Plasma catecholamines (epinephrine, norepinephrine, and dopamine) were measured in 9 patients with traumatic spinal cord disease 1.5-2 months posttrauma (group 1) and also, for comparison, in 17 patients with craniocerebral trauma (1 week after trauma in 8 [group 2] and 2-3 weeks after trauma in 9 [group 3]), 9 healthy donors (group 4), and 3 patients with spinal/spinal cord trauma in the acute phase (day 1 posttrauma) (group 5). Plasma samples were stored at -50°C and assayed for catecholamines by high-performance liquid chromatography in a Beckman apparatus with an electrochemical detector (BAS) [2]. The results were treated statistically using Student's t test.

RESULTS

Measurements of plasma catecholamines showed significantly elevated epinephrine, but not norepi-

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0007-4888/95/0002-0140$12.50

nephrine or dopamine, levels in group 1 patients as compared to healthy donors (controls) (Table 1). In group 3 patients (those with craniocerebral trauma), the levels of all three catecholamines were close to those in the control group. The blood content of catecholamines in central nervous system (CNS) injuries is known to depend on the time that has elapsed after the traumatic event. In the three patients with acute spinal/spinal cord trauma (group 5), the sympathoadrenal system was activated 24 h posttrauma, with a severalfold increase in epinephrine. Surgery on the spinal cord is traumatic and may have a similar effect on blood catecholamines (Table 2). In group 2, where catecholamines were measured 1 week after craniocerebral trauma, both epinephrine and norepinephrine were significantly above their control values.

Comparison of the results obtained for groups 3 and 1 revealed significant differences between them in blood levels of epinephrine and norepinephrine: whereas in group 3 (patients with craniocerebral trauma) these catecholamines had returned to near-normal levels by the time of measurement (2-3 weeks posttrauma), group 1 patients (those with traumatic spinal cord disease) still had very high epinephrine levels 1.5 to 2 months after the traumatic event.

The choice of "spinal" patients for examination 1.5-2 months posttrauma was not accidental. By that time such patients show substantial individual differences in clinical manifestations of the disease, and, as indicated by the present study, they also differ widely with regard to blood levels of epinephrine: while the mean epinephrine level of this catecholamine in group 1 was 913 pg/ml, its highest level was 2115 pg/ml and the lowest level only 162 pg/ml. The patients with a high epinephrine concentration in their blood were found to have multiple complications, these including cystitis, pyelonephritis, bronchopleuritis, bedsores, anemia, and general intoxication.

In the literature, CNS trauma is regarded as a cause of endocrine imbalance with adverse consequences. There is evidence that adrenocorticotropic hormone and glucocorticoid levels rise in various forms of stress, including those induced by

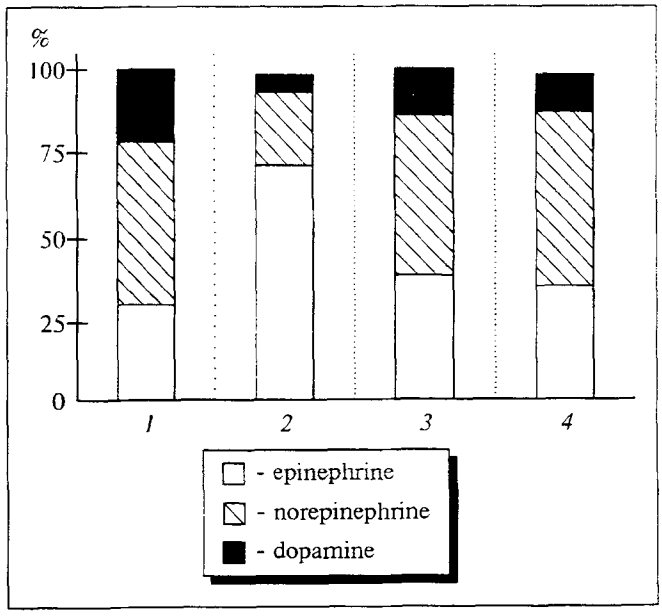

Fig. 1. Percentage ratios of catecholamines in patients with different CNS traumas. *1*) control subjects; *2*) spinal trauma (2–3 weeks); *3* and *4*) craniocerebral trauma (1 week and 2–3 weeks, respectively).

CNS trauma, and that the severity and duration of endocrine changes depend on how severe is the damage to the brain [4,7,9]. In our studies, blood levels of catecholamines were found to be very high 1 to 7 days after craniocerebral trauma, which is consistent with the widely held view that the sympathoadrenal system is activated following a CNS injury. Other authors, too, have reported elevated epinephrine, norepinephrine, and dopamine concentrations several hours posttrauma; highest catecholamine levels were recorded during the first few days, at which time epinephrine and norepinephrine rose severalfold above their normal values and the level of catecholamines as a whole corresponded to trauma severity [9].

As can be seen in Fig. 1, which shows ratios of epinephrine, norepinephrine, and dopamine in four of the five groups, the greatest increase in the proportion of epinephrine occurred in the group with spinal/spinal cord trauma. A high epinephrine concentration in the blood of spinal patients may influence many aspects of metabolism. Epinephrine, for example, is capable of lowering blood levels of

TABLE 1. Catecholamine Levels in Blood Plasma from Patients with CNS Trauma, pg/ml

Group	Trauma	№ of subjects	Epinephrine	Norepinephrine	Dopamine
I	Spinal (1.5–2 months)	9	913±230**	290±48.8	76.2±30.3
II	Craniocerebral (up to 1 week)	8	270.7±53.7*	355.6±35.9*	106±33.5
III	Craniocerebral (2–3 weeks)	9	108.8±24.3	170.3±56.4	39.6±12.9
IV	Control group (donors)	9	131.1±25.3	226.5±36.4	97.7±25.8

Note. *$p \leq 0.01$, **$p \leq 0.05$ in comparison with the control group.

TABLE 2. Catecholamine Levels in Blood Plasma from Patients with Spinal/Spinal Cord Trauma, pg/ml

Patient	Observation time	Epinephrine	Norepinephrine	Dopamine
B.	1st postoperative day	2095	278	75
Ch.	1st posttrauma day	1040	109	31
G.	1st posttrauma day	311	69	2

amino acids and thus of affecting the functioning of the liver and other organs [10]. Levels of epinephrine and other hormones rise during stress, which may result in the inhibition of protein synthesis in skeletal muscle [11]. Moreover, epinephrine is a powerful vasoactive agent and as such can alter the state of many bodily systems. A considerable deviation of epinephrine from its physiological norm, such as that found in this study, may adversely affect the functioning of the entire organism by altering the state of central structures.

Epinephrine release into the bloodstream has been reported to reflect the type of emotional reaction [5,8]. In spinal patients, a powerful negative emotional stimulus is their awareness of the loss of motor activity. Anxiety and depression set in. The elevation of blood epinephrine found in our patients with traumatic cord injury is therefore a result of not only physical but also emotional stress. According to the concepts developed by Sudakov [6] and Val'dman [3], emotional stress has its origin in such entities as the cortex and limbic structures of the brain, while the motor component of stress reactions derives from diencephalic structures. An understanding of the structural organization of emotional behavior, coupled with knowledge of the subtle biochemical reactions involved, should make it possible to devise a pharmacological means of preventing the development of somatic disorders during stress reactions caused by psychogenic factors [2]. The significant deviation of epinephrine from its control level recorded in this study can incur a secondary functional impairment of central brain structures. High epinephrine concentrations have a particularly strong impact on denervated tissues because these possess increased hormonal sensitivity. Autonomic disturbances arising in traumatic cord disease become more persistent if hypothalamic structures are involved in the pathological process under conditions of a protracted stress reaction.

In conclusion, this study has shown that traumatic spinal cord disease can be aggravated by endocrine disturbances. An understanding of the morbid processes occurring after a traumatic injury to the spinal cord and of the role neurotransmitters play in impairing the functions of internal organs should make it possible to develop a set of therapeutic measures to mitigate the undesirable consequences of stress in patients with such injuries.

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