Features of the circadian rhythm of autonomic tone in concomitant severe traumatic brain injury depending on age

Muhitdinova Hura Nuritdinovna

Doctor of Medical Sciences, Full Professor

Center for the Development of Professional Qualifications of Medical Workers,

Yuldasheva Saida Anvarovna

Candidate of Medical Sciences, Head of the department

City Children's Clinical Hospital №1

Abstract

On the first day after injury, the most pronounced sympathotonic reaction (by 90%) was observed in group 1, while in group 2, SVT was increased by 40%, in group 3 - by 50%. during the acute period of CSTBI in group 1, the severity of hypersympathotonia increased even more. Regardless of daytime and nighttime during the day, the SVT indicator in group 1 was significantly higher than in groups 2 and 3 by 50-60%. The hypersympathotonic response was invariably accompanied by a significant increase in MVP in all age groups. The most vulnerable group in terms of the adequacy of the sympathotonic response, compensatory restructuring of the circulatory system in the acute period of CSTBI were traumatized patients over 61 years of age.

Keywords: circadian rhythm, autonomic tone, combined severe traumatic brain injury.

Relevance. Acute brain damage in the initial stage is accompanied by hyperactivation of the sympathetic system, which leads to tachycardia and hypertension. On the one hand, an increase in cardiac output is aimed at a significant increase in the brain's need for oxygen, on the other, a significantly increased functional activity of the components of the cardiovascular system under these conditions requires a significantly increased need for cells and tissues for oxygen under conditions of a hypersympatotonic reaction to a combined severe traumatic brain injury [1-3]. However, there is insufficient information in the literature on the age-related characteristics of the autonomic reaction of hemodynamics in the acute period of concomitant severe traumatic brain injury (CSTBI).

Purpose of the work. To study the features of the circadian rhythm of the autonomic tone in concomitant severe traumatic brain injury, depending on age.

Material and research methods. The indicators of a comprehensive examination of 30 patients with concomitant severe traumatic brain(CSTBI) who were admitted to the ICU of the neurosurgical department of RSCEMA in the first hours after an accident - 28, catatrauma of 2 patients were studied. According to the indications, 29 patients underwent invasive mechanical respiratory support (MRS) on admission. Monitoring was carried out by complex hourly recording of hemodynamic parameters: stroke volume of blood (SVB), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean blood pressure (MBP), pulse blood pressure (PBP), cardiac output (CO), general peripheral vascular resistance (GPVR), estimation of autonomic tone (EAT), the need of myocardium in oxygen (TNMO). Mechanical respiratory support was started with artificial lung ventilation (ALV) for a short time followed by switching to SIMV. The assessment of the severity of the condition was carried out by scoring methods according to the scales for assessing the severity of combined injuries - the CRAMS scale, the assessment of the severity of injuries according to the ISS scale. On admission, impaired consciousness in 29 injured patients was assessed on the Glasgow Coma Scale (GS) 8 points or less. Patients were considered in three age groups: group 1 - 19-40 years old (13), group 2 - 41-60 years old (9), 3 - 61-84 years old (8 patients). In 28 patients, the clinic was dominated by the diencephalic and mesencephalo-bulbar forms, which, due to a critical disorder of the vital systems (respiratory and cardiovascular), required urgent intensive therapy, and sometimes resuscitation. Complex intensive therapy consisted in identifying and timely correction of deviations: MRS, after removing from shock anesthetic, anti-inflammatory, antibacterial, infusion therapy, correction of protein and water-electrolyte balance disorders, surgical early correction to the extent possible, stress-protective therapy.

Result and discussion.

As shown in table 1, on the first day after injury, the most pronounced sympathotonic response (by 90%) was observed in group 1, while in group 2, SVT was increased by 40%, in 3 - by 50%. It should be noted that during the acute period of CSTBI in group 1, the severity of hypersympathotonia increased even more by 6 (by 50%), by 8 days (by 40%), by 9 - by 50%, by 10 - by 60%, 11 - by 40%, by 12 - 60% ($p < 0.05$, respectively).

Table 1

Dynamics of the mesor of the circadian rhythm of vegetative tone

Days	Group 1	Group 2	Group 3
1	1.9±0.2	1.4±0.2*	1.5±0.3
2	1.9±0.1	1.4±0.1*	1.3±0.1*
3	2.1±0.1	1.4±0.1*	1.4±0.1*
4	2.2±0.1	1.4±0.1*	1.3±0.1*
5	2.1±0.1	1.5±0.1*	1.4±0.1*
6	2.4±0.1‴	1.6±0.1*	1.4±0.1*
7	2.3±0.2	1.6±0.1*	1.4±0.1*
8	2.3±0.1‴	1.5±0.1*	1.4±0.1*
9	2.4±0.1‴	1.5±0.1*	1.4±0.1*
10	2.5±0.1‴	1.4±0.1*	1.3±0.2*
11	2.3±0.1‴	1.6±0.1*	1.3±0.1*
12	2.5±0.2‴	1.4±0.1*	1.5±0.1*
13	2.0±0.2	1.5±0.1*	1.2±0.1*
14	1.9±0.1	1.4±0.1*	1.4±0.1*
15	1.9±0.1	1.4±0.1*	1.4±0.1*
16	1.9±0.1	1.4±0.1*	1.4±0.1*
17	1.7±0.1	1.5±0.1	1.4±0.1*
18	1.7±0.1	1.6±0.1	1.3±0.1*
19	1.6±0.1	1.6±0.1	1.3±0.1*
20	1.7±0.1	1.5±0.1	1.2±0.1*
21	1.9±0.1	1.8±0.1	1.3±0.1*
22	2.0±0.2	1.6±0.2	1.3±0.2*
23	2.0±0.1	1.6±0.1	1.4±0.1*
24	1.9±0.1	1.7±0.1	1.4±0.1*
25	1.8±0.2	1.8±0.2	1.6±0.2

*- reliably relative to the indicator of group 1

‴ - reliably relative to the indicator on the first day

In the following days, the degree of tension in the function of the sympathoadrenal system was restored to the level of 1 day after injury. In group 2, during the first 25 days, a steadily increased SVT was noted at the level of the indicator on the first day. It is noteworthy that in patients of group 2, SVT remained significantly less than the indicator in group 1 during the first 12 days by 50-70%. In group 3, the level of activity of the sympathetic nervous system remained unchanged on average. Thus, the SVT circadian rhythm mesor in group 3 was increased by an average of 40-20% throughout the observation period. However, the indicator was significantly less than in group 1 by 50-60% ($p < 0.05$, respectively).

The hourly assessment of the average circadian rhythm of SVT depending on age made it possible to state that, regardless of daytime and nighttime, during the day, the SVT indicator was significantly higher than in groups 2 and 3 by 50-60% (fig. 1).

Hourly average SVT circadian rhythm score by age

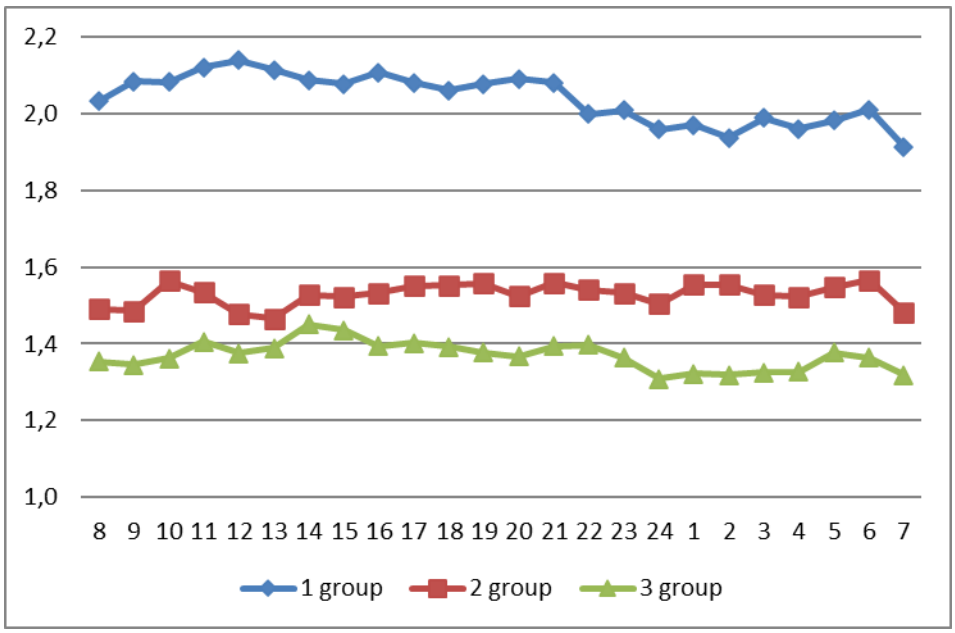

Fig.1

The greatest amplitude of the SVT circadian rhythm was detected per day, amounting to 0.6 units in group 1, 0.76 units in group 2, and 1.2 units in group 3. That is, on the first day, the most pronounced instability of the stress response of the sympathetic nervous system was found in patients over 61 years of age. Low-amplitude daily fluctuations of SVT on days 2-12 were replaced by an increase in the indicator in group 1 to 0.6 units, in group 2 to 0.8 (on day 21), remaining at the initial level (0.3 units) in group 3 (fig. 2).

Dynamics of the SVT circadian rhythm amplitude, **units**

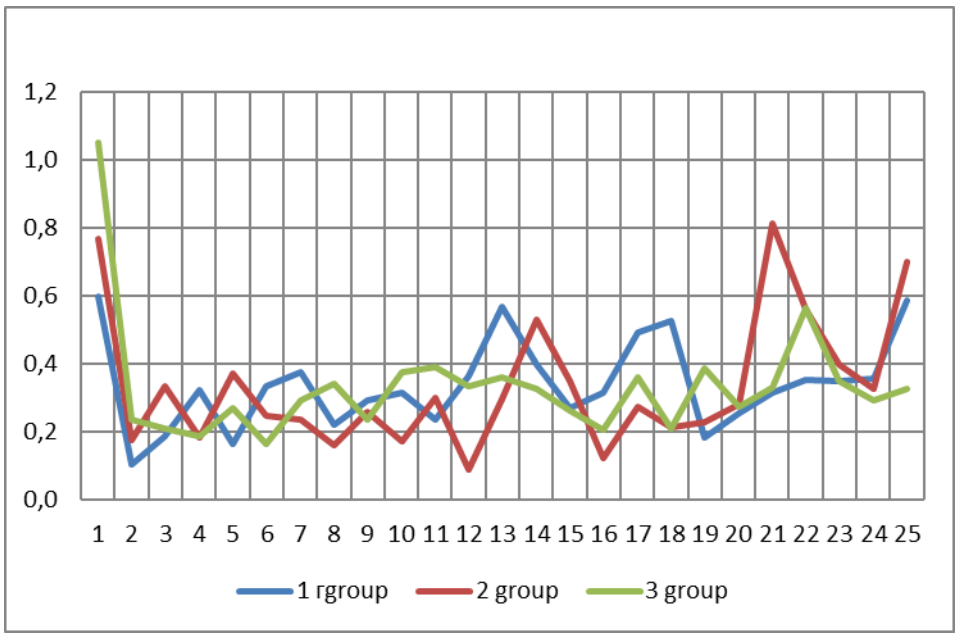

Fig.2

Dynamics of the diurnal range of SVT changes

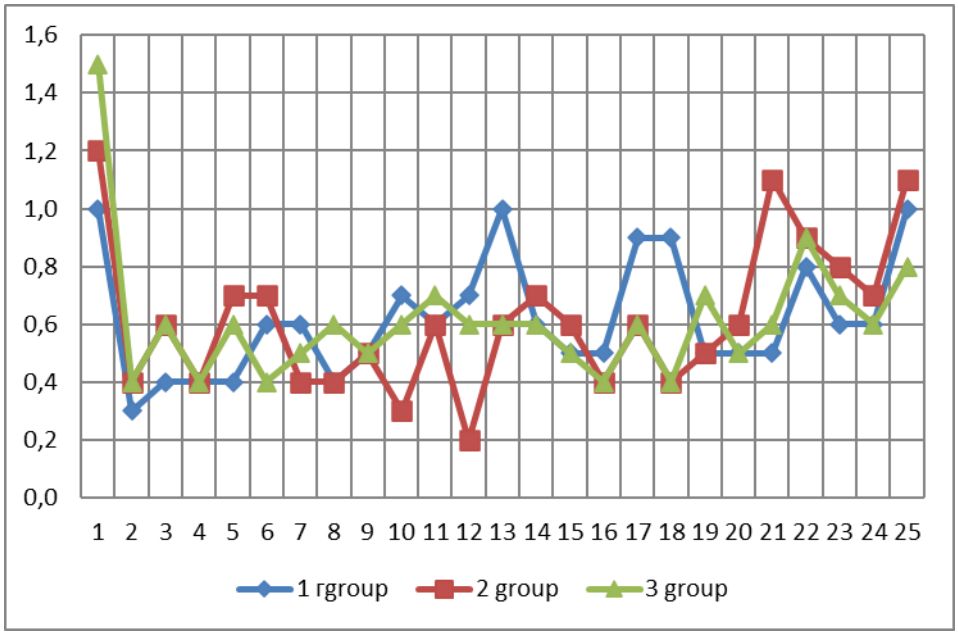

Fig.3

Fig. 3 shows the dynamics of the maximum diurnal SVT changes. The greatest changes in the SVT mesor were observed on day 1 in all patients, the most significant were in patients of group 3 (1.5 units), and the smallest (1 unit) in group 1. After a 9-day period of minimal SVT fluctuations (within 0.3 units), an increase in daily SVT instability was noted on the following days, with a more pronounced tendency to increase in patients of groups 2 and 1.

Correlations between SVT and hemodynamic parameters in the first 25 days of the acute period of CSTBI

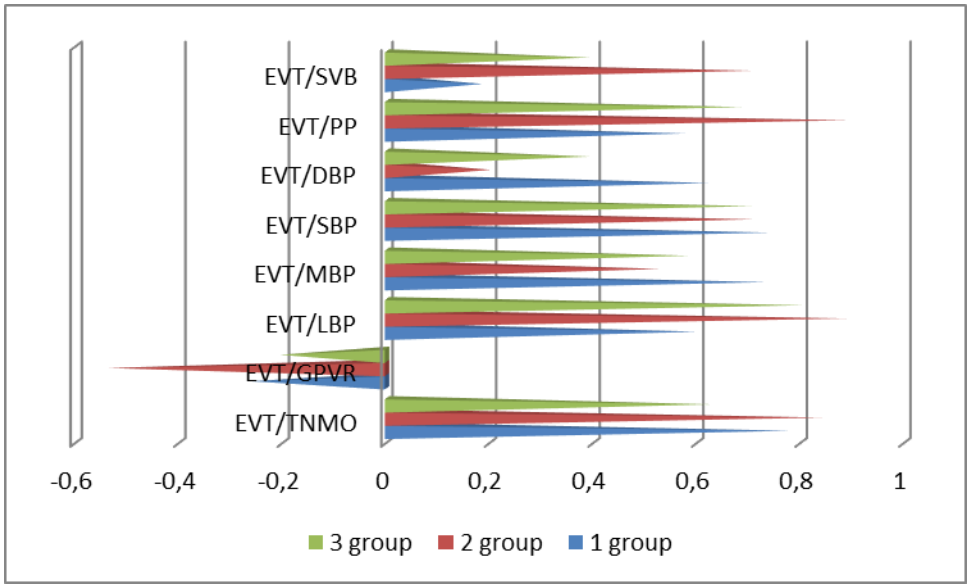

Fig.4

As can be seen from the data in fig. 4, in the acute period of CSTBI (25 days) in group 1, there was a strong direct correlation between SVT and SBP, MBP, MVP (0.7; 0.7; 0.8) and inverse with GPVR (-0.3). That is, at the age of up to 40 years, the hypersympatotonic reaction was accompanied by a hyperdynamic type of hemodynamics, a tendency to increase SBP, PBP with an increase in myocardial oxygen demand. In group 2, in contrast to the first, the negative correlation of SVT and GPVR (-0.5) and SVT and SBP (0.7), SVT and PBP, SVT and CO increased. That is, the hyperdynamic type of hemodynamics was manifested by an increase in cardiac output with a compensatory tendency towards a decrease in GPVR.

In group 3, the age difference was manifested by the fact that a significant tendency towards the formation of correlations was revealed under conditions of the sympatotonic reaction of SVT and MBP and MVP to traumatic stress. That is, even vasoactive drug support was not observed adequate restructuring of the function of central and peripheral hemodynamics, aimed at maintaining the necessary intracranial capillary perfusion under CSTBI conditions.

Table 2

Correlations of SVT in the dynamics of the acute period of CSTBI

	1 - 8 days			9-17 days			18-25 days		
	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
SVT/MVP	0.9	0.7	0.8	0.9	0.8	0.4	0.9	0.7	0.2
SVT/GPVR	-0.7	-0.7	-0.4	-0.4	-0.8	0	-0.9	-0.5	-0.6
SVT/CO	0.8	0.9	0.9	0.5	0.9	0.8	1	0.8	0.6
SVT/SVT	0.7	0.2	0.6	0.8	0.4	0.6	0.3	0.4	-0.3
SVT/SBP	0.5	0.6	0.8	0.9	0.6	0.7	0.8	0.5	-0.2
SVT/DBP	0.7	-0.3	0.4	0.7	0	0.4	-0.2	0	-0.4
SVT/PBP	0.3	0.5	0.7	0.6	0.9	0.6	0.9	1	0.3
SVT/SV	-0.1	0.7	0.4	-0.2	0.6	0.6	0.9	0.8	0.5

In the first 8 days, patients of group 1 showed a strong direct correlation between SVT and MVP (0.9), CO (0.8), average BP (0.7), DBP (0.7). In the second week of treatment, the direct correlation with CO (0.5) and inverse with GPVR (-0.4) decreased, and the direct correlation with SBP significantly increased (0.9). In the next 8-25 days in group 1, the tendency to form a hyperdynamic type of hemodynamics increased. Throughout the acute period of CSTBI, the direct correlation of sympatotonic response with myocardial oxygen demand (MVP) at the level of 0.9 remained stably significant. Thus, at the age of up to 40 years after CSTBI, the hyperdynamic type of blood circulation somewhat weakened in the second week, but on days 18-25 it intensified again with the appearance of a strong direct relationship between SVT and SV (0.9).

In group 2, in the first week, the hyperdynamic type of hemodynamic reaction to sympathotonic stress reaction was manifested by a direct strong correlation of SVT with CO (0.9) and SV (0.7) and inverse with GPVR (-0.7), remaining at this level for a quick and third week of observation.

In group 3, in the first week, a strong direct correlation was found between SVT and CO, SBP, PBP. In the next 9-17 days, the treatment decreased slightly. But in the third week, a significant weakening of correlations was found. A decrease in the correlation between SVT and MVP at later periods of CSTBI (9-25 days) is most likely due to the failure of the mitochondrial system to adequately respond, to increase the intensity of oxidative phosphorylation at the mitochondrial level. At the age of over 61, unstable correlations aimed at the hyperdynamic type of blood circulation, which is of a compensatory nature, practically disappeared on the 18-25th day of the acute period of CSTBI. Thus, the most vulnerable group in terms of the adequacy of the sympathotonic response, as well as compensatory restructuring of the circulatory system in the acute period of CSTBI, were traumatized patients over 61 years of age.

Duration of SVT circadian rhythm acrophase shifts

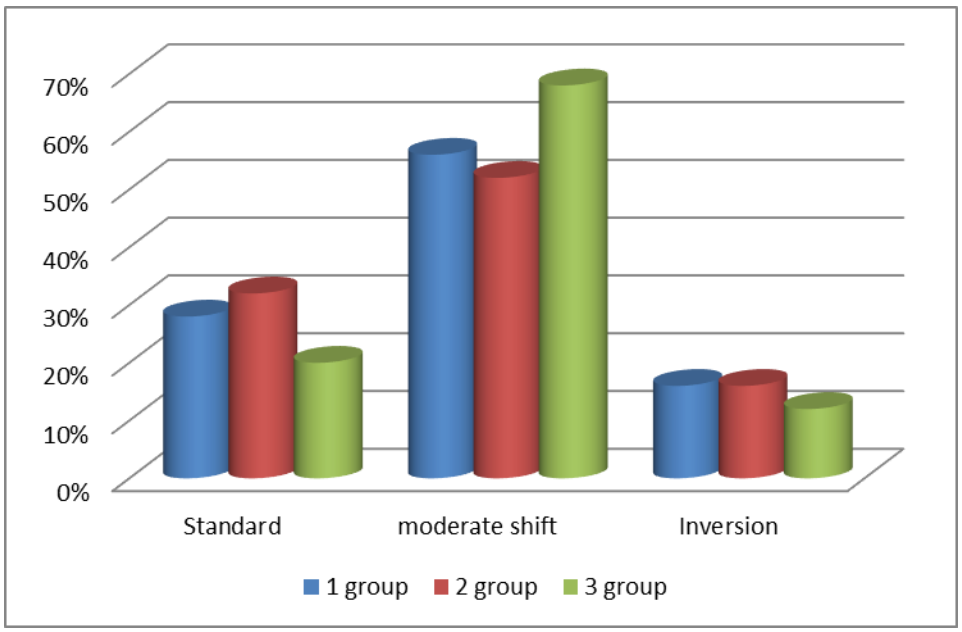

Fig.5

As shown in fig. 5, in all age groups, a moderate shift in acrophase prevailed, the most prolonged in group 3 (68%).

Conclusion. On the first day after injury, the most pronounced sympathotonic reaction (by 90%) was observed in group 1, while in group 2, SVT was increased by 40%, in group 3 - by 50%. during the acute period of CSTBI in group 1, the severity of hypersympathotonia increased even more. Regardless of daytime and nighttime during the day, the SVT indicator in group 1 was

significantly higher than in groups 2 and 3 by 50-60%. The hypersympathotonic response was invariably accompanied by a significant increase in MVP in all age groups. The most vulnerable group in terms of the adequacy of the sympathotonic response, compensatory restructuring of the circulatory system in the acute period of CSTBI were traumatized patients over 61 years of age.

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