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Research Article

Comparison of Integral Models of Systemic Dynamics of Acid-Base State of Venous and Arterial Circulating Blood in Patients with Surgical Interventions

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Abstract

This article presents the results of comparative studies of the dynamics of systemic models of acid-base metabolism in arterial and venous blood in patients with cardiovascular disease during surgery. The system models were based on the correlation matrix parameters of the acid-base balance in two ways: by calculating the criteria functions characterizing the state of the system of each patient at the point of study and by calculating the group index of several patients at the same point of observation, which is called the quality functional – the local maximum of the system with the division of the acid-base parameters into non-intersecting classes. Nonparametric comparisons of criteria functions in 6 study points between different three groups of patients for arterial and venous blood were made. The system analysis of functional dynamics for the same points and groups of patients is made.

Keywords: Dynamics; Acid-Base; Blood; Patients; System Models; Comparison

Introduction

This article discusses a systematic approach to the study of a set of biochemical parameters of circulating blood of patients. The methodology and methods are described in our previous works [3,4].

This article also discusses the dynamics of models of the biochemical system of the body on the example of acid-base state of the venous and arterial circulating blood in surgical interventions on the heart of patients based on the use of optimization methods and multivariate statistics.

The peculiarity of this approach is based on the need to automate and informatize multiparameter biomedical indicators, the number of records which reaches millions in the medical information system qMS (developer – joint stock company "SPARM", Saint-Petersburg, Russia) stored on servers in Almazov National Medical Research Centre, St. Petersburg, Russia. In addition, the parameter sets themselves can consist of several dozens of indicators. Thus, the task is to give the doctor an integral convolution of indicators of the medical system, adequately describing and understandable to medical personnel. It also presents one of the ways to process Big Data in the medical field.

Materials of experimental studies

The dynamics of acid-base state (ABS) of circulating blood in the artery and in the cavernous sinus (CS) was studied in 3 groups consisting of 391 patients with cardiac pathology in the postoperative period in the operating room and in the cardio-resuscitation Department at 6 points. The ABS system consisting of 21 biochemical parameters was considered. The parameters are given in Table A. The results of dynamics simulation in CS are discussed in article [4]. In the present study, the task was to build similar models for ABS dynamics in the artery and compare it with ABS dynamics in CS by the following methods.

Parameter name	Description of the parameter	Parameter name	Description of the parameter
pH	Acidity	Ca++	Calcium ion concentration
pO2	Oxygen partial pressure	Cl-	Chlorine Ion concentration
pCO2	Carbon dioxide partial pressure	Glu	Glucose concentration
ABE	Excess base	Lac	Lactate content
SBE	Lack of reason	p50	Hemoglobin affinity for oxygen
cHCO3	Plasma bicarbonate	mOsm	Blood osmolarity
cHCO3-st	Bicarbonate (alkali)	pH(T)	Acidity corrected for temperature
sO2	Oxygen boost	pO2(T)	Partial oxygen pressure adjusted for temperature
ctHb	Reference hemoglobin level	pCO2(T)	Carbon dioxide partial pressure adjusted for temperature
K+	Potassium ion concentration	Na+	Sodium ion concentration
Htc	Hematocrit		

Table A: Parameters of ABS

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Mathematical and statistical methods of analysis to assess the state and dynamics of the system of biochemical parameters of ABS

Many researchers offering various indicators were engaged in assessment of a functional condition of an organism: physiological, medical, single, complex, temporary and so on. The most part of the received results is applicable for static assessment of separate parameters. It is not enough works on dynamic modeling of these parameters and practically at all there are no works on creation of complex dynamic models of biological systems. The most significant results in this area are received during the multiple parameter modeling directed to a research of a functional condition of an organism. This approach is in detail described in [3].

In [1] physiological systems are described on the base of the results of researches and scientific representations of the academician P.K. Anokhin (1975). Results of system researches are based on the estimation of average criteria functions (CF) given in [6,7] and functionals [5].

Calculations were performed using standard statistical methods [2] using programs Statistica, version 10. CF and functional calculation programs developed in Statistica Visual Basic environment.

Research result

The average statistical data of the dynamics of the CF of the artery ABS are presented in tables 1-4 and in the graphs Figure 1-4.

	Sample size	Average	Median	Minimum	Maximum	Lower quartile	Upper quartile	Standard deviation.	Standard error
All 3 groups	391	4,576865	4,549811	3,128353	6,666364	4,195717	5,015457	0,591765	0,029927
Group 1	162	4,461230	4,467011	3,223782	6,112677	4,117713	4,879271	0,597174	0,046918
Group 2	178	4,686718	4,661718	3,128353	6,666364	4,305200	5,129228	0,600147	0,044983
Group 3	51	4,560768	4,447022	3,581555	5,810822	4,199280	4,963645	0,470721	0,065914

Table 1: Average values of CF of ABS in artery of 1, 2 and 3 groups at all points.

	Sample size	Average	Median	Minimum	Maximum	Lower quartile	Upper quartile	Standard deviation	Standard error
Point 1	29	4,645221	4,600299	3,238096	6,112677	4,338068	5,149042	0,590528	0,109658
Point 2	29	4,351210	4,417879	3,265667	5,446599	4,213660	4,578577	0,542259	0,100695
Point 3	29	4,350881	4,326932	3,330919	5,455601	4,023725	4,685385	0,515969	0,095813
Point 4	29	4,318552	4,354791	3,330919	5,581825	4,003541	4,597328	0,590564	0,109665
Point 5	25	4,384531	4,374828	3,223782	5,779779	4,118609	4,846143	0,631024	0,126205
Point 6	21	4,799804	4,909974	3,682746	5,657685	4,250626	5,199233	0,624931	0,136371

Table 2: Average values of CF of ABS in the artery in the 1st group at all points.

	Sample size	Average	Median	Minimum	Maximum	Lower quartile	Upper quartile	Standard deviation	Standard error
Point 1	31	4,839967	4,973946	3,268462	5,638092	4,416336	5,335702	0,618217	0,111035
Point 2	31	4,729376	4,852473	3,749294	5,794777	4,309234	5,129228	0,567595	0,101943
Point 3	31	4,583042	4,538568	3,507748	5,625190	4,172913	5,092465	0,552879	0,099300
Point 4	31	4,644376	4,576069	3,213370	5,789197	4,172913	5,042530	0,586084	0,105264
Point 5	27	4,674192	4,629222	3,128353	6,666364	4,351992	4,974776	0,663393	0,127670
Point 6	27	4,641962	4,580206	3,537319	6,397511	4,201894	5,063797	0,634624	0,122134

Table 3: Average values of CF of ABS in the artery in the 2nd group at all points.

	Sample size	Average	Median	Minimum	Maximum	Lower quartile	Upper quartile	Standard deviation	Standard error
Point 1	25	4,586351	4,435145	3,588634	5,810822	4,248986	4,965087	0,541231	0,108246
Point 2	2	4,740173	4,740173	4,407210	5,073136	4,407210	5,073136	0,470881	0,332963
Point 6	24	4,519169	4,518431	3,581555	5,325792	4,194979	4,750253	0,401333	0,081922

Table 4: Average values of CF of braids in the artery in the 3rd group at all points.

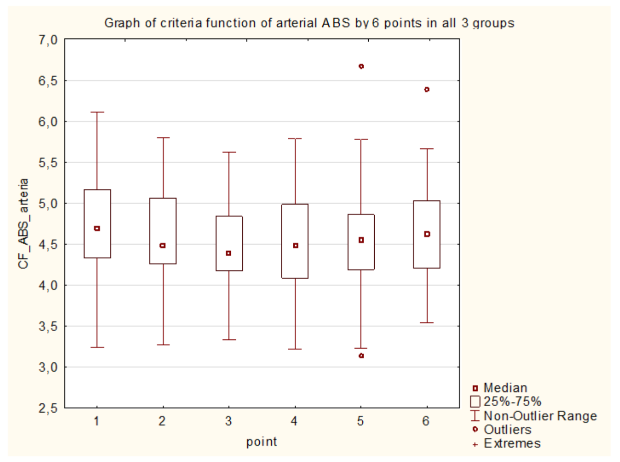

Figure 1: Average dynamics of arterial CF of ABS in three groups.

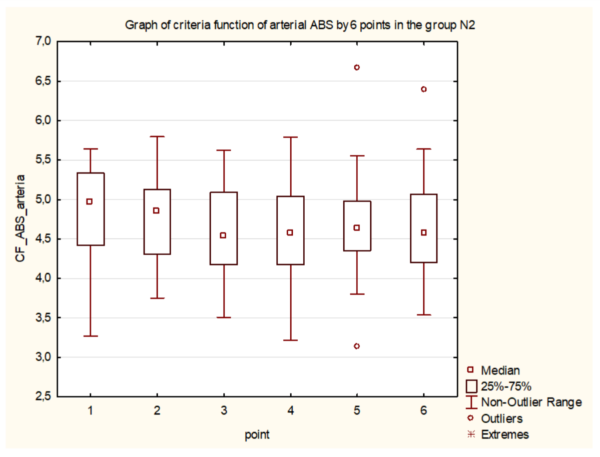

Figure 3: Average dynamics of CF of arterial ABS in group 2.

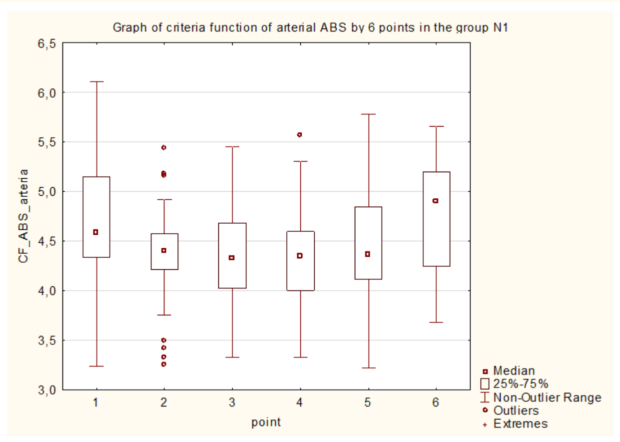

Figure 2: Average dynamics of CF of arterial ABS in group 1.

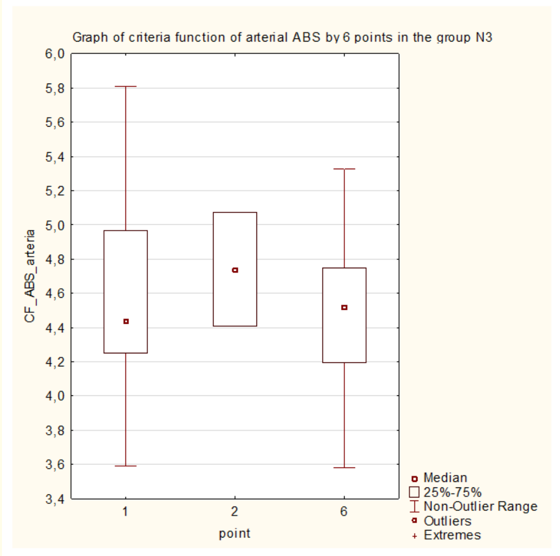

Figure 4: Average dynamics of CF of arterial ABS in group 3.

Results table 5 show a significant difference in the mean group values of the arterial CF ABS between the 1st and 2nd groups.

Rank sum		**U**	**Z**	**p-value**	**Sample size**	
group 1	**group 2**				**group 1**	**group 2**
24699,00	33271,00	11496,00	-3,22739	0,001249	162	178
group 1	**group 3**				**group 1**	**group 3**
16955,50	5835,500	3752,500	-0,984766	0,324740	162	51
group 2	**group 3**				**group 2**	**group 3**
21068,00	5267,000	3941,000	1,432417	0,152025	178	51

Table 5: Comparison of KF ABS in the artery 1, 2 and 3 groups at all points: 1,2,3,4,5,6 on the criterion of Mann-Whitney U Test.

Table 6 indicates a pairwise difference in the CF ABS of the second and fourth points of the study between the 1st and 2nd groups and the first points between the 2nd and 3rd groups.

Rank sum		**U**	**Z**	**p-value**	**Sample size**	
group 1 point 2	group 2 point 2				group 1 point 2	group 2 point 2
733,0000	1097,000	298,0000	-2,23369	0,025504	29	31
group 1 point 4	group 2 point 4				group 1 point 4	group 2 point 4
745,0000	1085,000	310,0000	-2,05618	0,039766	29	31
group 2 point 1	group 3 point 1				group 2 point 1	group 3 point 1
1007,000	589,0000	264,0000	2,027251	0,042638	31	25

Table 6: Pairwise comparison at the corresponding points in the study of CF ABS in the artery of all groups by the Mann-Whitney U Test.

The results of Table 7 show a pairwise difference in the 1st group of CF of the artery ABS between the 1st point of the study and the 4th point, between the 2nd point of the study and the 6th point, between the 3rd point of the study and the 6th point, between the 4th point of the study and the 6th point, between the 5th point of the study and the 6th point.

Rank sum		**U**	**Z**	**p-value**	**Sample size**	
point 1	point 4				point 1	point 4
985,0000	726,0000	291,0000	2,006117	0,044845	29	29
point 2	point 6				point 2	point 6
615,0000	660,0000	180,0000	-2,43735	0,014796	29	21
point 3	point 6				point 3	point 6
611,0000	664,0000	176,0000	-2,51598	0,011871	29	21
point 4	point 6				point 4	point 6
613,0000	662,0000	178,0000	-2,47667	0,013262	29	21
point 5	point 6				point 5	point 6
489,0000	592,0000	164,0000	-2,16117	0,030683	25	21

Table 7: Pair wise comparison of CF of an artery ABS by points in group 1 by Mann-Whitney U Test.

The remaining pairwise comparison points of the study in the 1st group, significant differences were not given.

The results of Table 8 show a pairwise difference in the 2nd group of CF of the artery ABS between the 1st point of the study and the 3rd point.

Rank sum		U	Z	p-value	Sample size	
point 1	point 3				point 1	point 3
1116,000	837,0000	341,0000	1,956922	0,050	31	31

Table 8: Pairwise comparison of KF ABS artery points in the 2nd group using Mann-Whitney U Test.

The remaining pairwise comparisons in the 2nd group, significant differences were not given.

Comparison of points in group 3. A pairwise comparison of KF ABS artery points of the study in the 3rd group of significant differences was not given.

Conclusion on the section

- Mean group values of CF of arterial ABS between the 1st and the 2nd groups differ significantly. From studies [4] CF average for the groups values of ABS CS between the 1st and 2nd groups differ significantly also (p<0,05).
- Pairwise, the mean values of the second and fourth points of CF of arterial ABS of the study between the 1st and 2nd groups and the first points between the 2nd and 3rd groups differ significantly (p<0,05). However pairwise significantly differ average values of CF of ABS of CS between 1 point of a research from each of the 2, 3, 4, 5 and 6 points in average on points of all three groups [4].
- A pairwise difference was obtained in the 1st group of CF of the artery ABS between the 1st point of the study and the 4th point, between the 2nd point of the study and the 6th point, between the 3rd point of the study and the 6th point, between the 4th point of the study and the 6th point, between the 5th point of the study and the 6th point. In contrast, the comparison of CF in the cavernous sinus gives other results [4]:
    - The paired difference of CF of ABS in CS between 1 point of the research from each of the 2, 3, 4, 5 and 6 points in the 1st group is revealed;
    - The paired difference of CF of ABS in CS between 1 point of the research from each of the 2, 3, 4, 5 and 6 points in the 2nd group is revealed;
    - Pairwise differ CF of ABS in CS between 1 point of the research and the 6th point in the 3rd group.
- A pairwise difference in the 2nd group of CF of the artery ABS between the 1st point of the study and the 3rd point was revealed. Also in the third points of research CF ABS in a cavernous sinus between the 1st and 2nd groups significantly differ [4].

Thus, criterion functions of ABS in the artery and cavernous sinus at a certain synchronization have many significant fundamental differences in their dynamics.

From table 9, our work [4] and Figure 5 it follows that in both cases, both arterial and venous ABS functionals change in the general case in the antiphase with the threshold of materiality of the bonds. Only in the case of arterial ABS there is an antiphase of 2 waves, and in the case of venous ABS, a single-wave antiphase is detected. Table 10 presents the results of the dynamics of the division into disjoint classes of ABS elements of arterial blood. Where it is clear that in comparison with ABS of venous blood (table 9 and [4]) in the third and fourth points in ABS artery is the maximum imbalance of the system because the system "disintegrates" into 11 disjoint classes of elements of ABS, but the thresholds, relations are greatly increased to values of 0.678 and 0,701. This indicates a strong "stress" in the ABS system during this period.

Group system-statistical indicators-functional acid-base state (ABS) of the artery in the dynamics of surgical interventions on the heart

Functionals and thresholds ABS in arterial blood during operations

In Table 11,12 and Figure 6 shown indicators of functionals, of the thresholds of connections and the number of classes of partitions ABS arteries and CS [4] in the 1st group. From table 11 similarly with tables 9-10, it follows that at the time of transition to the fourth point of the ABS artery, the greatest tension in the system is observed, since the system "disintegrates" into 12 classes and there are maximum changes in the functional index from the value of 71,797 at the third point to the value of 21,870 at the fourth point, which from the position of article [8] is characterized by a capacious word crisis.

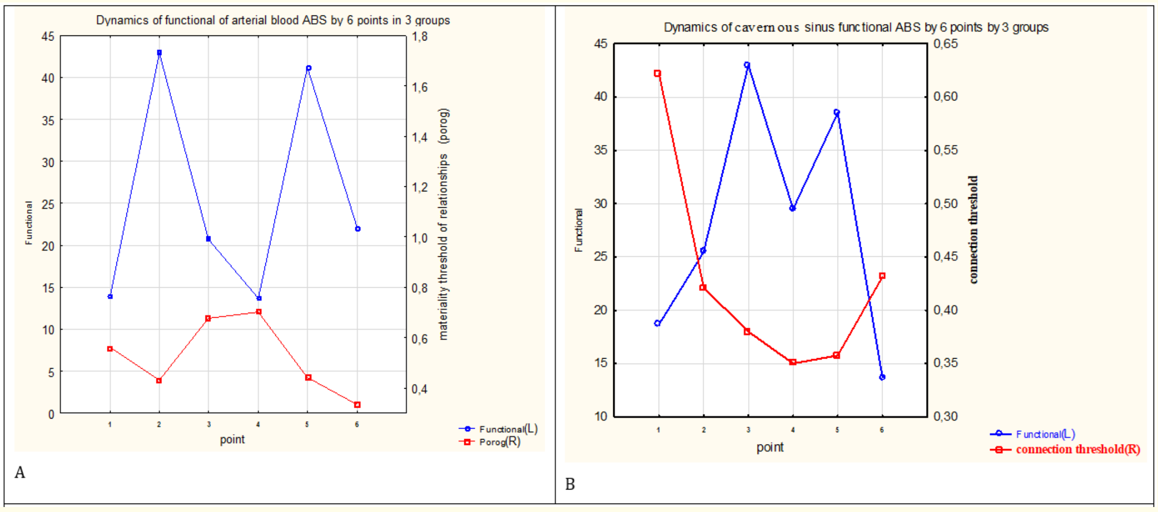

Figure 5: Dynamics of functionals and of the thresholds of the relations (porog) of the parameters of ABS arteries (A) and CS (B) in all 3 groups.

Point	Arterial Functional	Connection arterial threshold	Quantity of arterial classes	Functional CS	Connection threshold CS	Quantity of classes CS
1	14,037	0,559	10	18,667	0,622	9
2.	42,911	0,431	5	25,475	0,421	8
3.	20,737	0,678	11	43,011	0,380	2
4.	13,655	0,701	11	29,492	0,350	5
5.	41,224	0,441	4	38,515	0,358	4
6	22,050	0,333	7	13,694	0,431	8

Table 9: Indicators of functionals, thresholds of connections and number of classes of splits of arterial and CS [4] ABS in all 3 groups.

Label of classes	1 Point	2 Point	3 Point	4 Point	5 Point	6 Point
Var_Klass_1	Lac sO2 pCO2 pH	pO2(T) pH(T) mOsm p50 Lac Glu Ca++ Na+ K+ cH	pH(T) cHCO3-st cHCO3 SBE ABE pH	pH(T) Lac K+ pH	pO2(T) pH(T) Lac Cl- Ca++ K+ Htc ctHb sO2 cH	pO2(T) pH(T) pO2 pH
Var_Klass_2	pO2(T) pO2	pCO2(T) pCO2	pO2(T) pO2	pO2(T) pO2	pCO2(T) p50 pCO2	pCO2
Var_Klass_3	Glu Ca++ Na+ ABE	sO2	pCO2(T) p50 pCO2	pCO2(T) pCO2	mOsm Na+	pCO2(T) mOsm p50 Lac Glu Na+ K+ cHCO3-st cHC
Var_Klass_4	pH(T) cHCO3-st cHCO3 SBE	Htc ctHb	sO2	cHCO3-st cHCO3 SBE ABE	Glu	sO2
Var_Klass_5	Htc ctHb	Cl-	Htc ctHb	sO2		Htc ctHb
Var_Klass_6	K+		K+	Htc ctHb		Ca++
Var_Klass_7	Cl-		mOsm Na+	mOsm Na+		Cl-
Var_Klass_8	p50		Ca++	Ca++		
Var_Klass_9	mOsm		Cl-	Cl-		
Var_Klass_10	pCO2(T)		Glu	Glu		
Var_Klass_11			Lac	p50		

Table 10: Partitions into disjoint classes of cavernous sine ABS parameters in all 3 groups.

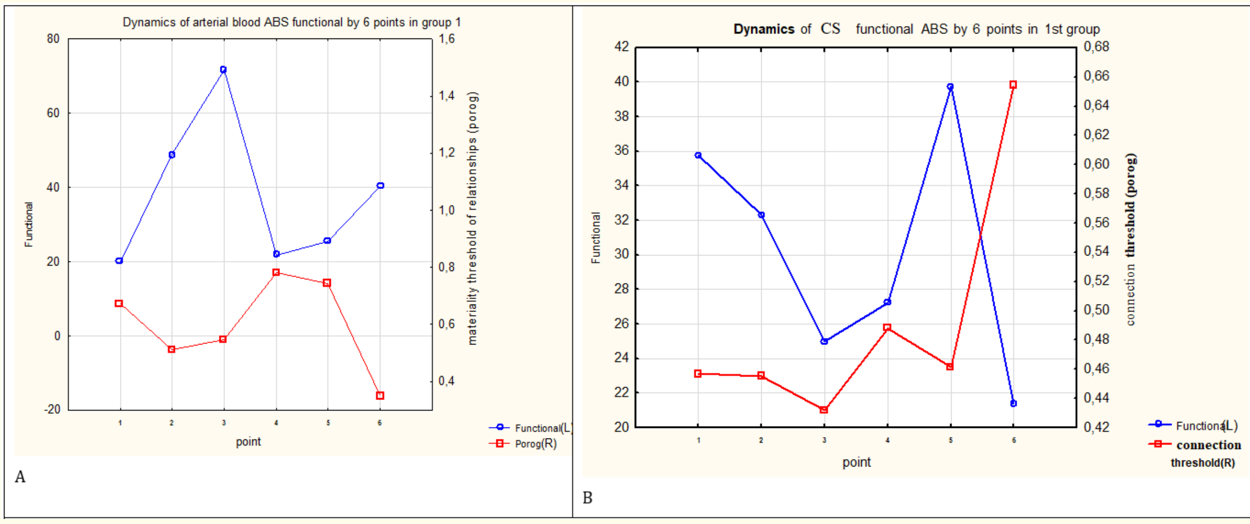

Figure 6: Dynamics of functionals and of the thresholds of the relations of the parameters of ABS arteries (A) and CS (B) in the 1st group.

Point	Arterial Functional	Connection arterial threshold	Quantity of arterial classes	Functional CS	Connection threshold CS	Quantity of classes CS
1	19,945	0,674	11	35,794	0,457	5
2	48,869	0,511	4	32,341	0,455	6
3	71,797	0,548	3	24,975	0,432	5
4	21,870	0,782	12	27,221	0,488	7
5	25,475	0,743	9	39,753	0,462	5
6	40,254	0,350	4	21,355	0,654	10

Table 11: Indicators of functionals, of the thresholds of connections and the number of classes of partitions ABS arteries and CS [4] in the 1st group.

Label of classes	1 Point	2 Point	3 Point	4 Point	5 Point	6 Point
Var_Klass_1	pH(T) cHCO3-st cHCO3 SBE ABE pH	pH(T) mOsm p50 Lac Glu Cl- Na+ K+ sO2 cHCO3-	pCO2(T) pO2(T) pH(T) mOsm p50 Lac Cl- Ca++ K	pH(T) cHCO3-st cHCO3 SBE ABE pH	pH(T) cHCO3-st cHCO3 SBE ABE pH	pCO2(T) pO2(T) pH(T) p50 Lac K+ Htc ctHb sO2
Var_Klass_2	pO2(T) pO2	pO2(T) pO2	Na+	pO2(T) pO2	pO2(T) pO2	pO2
Var_Klass_3	pCO2(T) pCO2	pCO2(T) Htc ctHb pCO2	Glu	pCO2(T) pCO2	pCO2(T) sO2 pCO2	pCO2
Var_Klass_4	sO2	Ca++		sO2	p50 Htc ctHb	mOsm Glu Cl- Ca++ Na+
Var_Klass_5	Htc ctHb			Htc ctHb	K+	
Var_Klass_6	K+			K+	mOsm Ca++ Na+	
Var_Klass_7	mOsm Na+			mOsm Na+	Cl-	
Var_Klass_8	Glu Ca++			Ca++	Glu	
Var_Klass_9	Cl-			Cl-	Lac	
Var_Klass_10	Lac			Glu		
Var_Klass_11	p50			Lac		
Var_Klass_12				p50		

Table 12: Splits into disjoint classes of parameters of arterial ABS in group 1.

Figure 6 shows dynamics of functionals and of the thresholds of the relations of the parameters of ABS arteries and CS (See also previous article [4]) in the 1st group. The illustrations show a mirror image of the dynamics of threshold relations of functionality and materiality of connections in the case of ABS arteries in contrast to such dynamics in the cavernous sinus. Dynamics can be either synchronous anti-phase (Figure 6-A) or asynchronous with the change of synchrony in the phase inversion (Figure 6-B).

In Table 13,14 and Figure 7 shown indicators of functionals, of the thresholds of connections and the number of classes of partitions ABS arteries and CS [4] in the 2nd group. From table 13 similarly with tables 11-12, it follows that at the time of transition to the fourth point of the ABS artery, the greatest tension in the system is observed, since the system "disintegrates" into 7 classes and there are maximum changes in the functional index from the value of 50,401 at the third point to the value of 27,183 at the fourth point, which from the position of article [8] is characterized, also as 1st group, by a word crisis.

Figure 8 shows the dynamics of ABS functional of arteries (A) and cavernous sinus (B) in groups 1 and 2 (synchronicity of indicators between 1 and 2 groups).

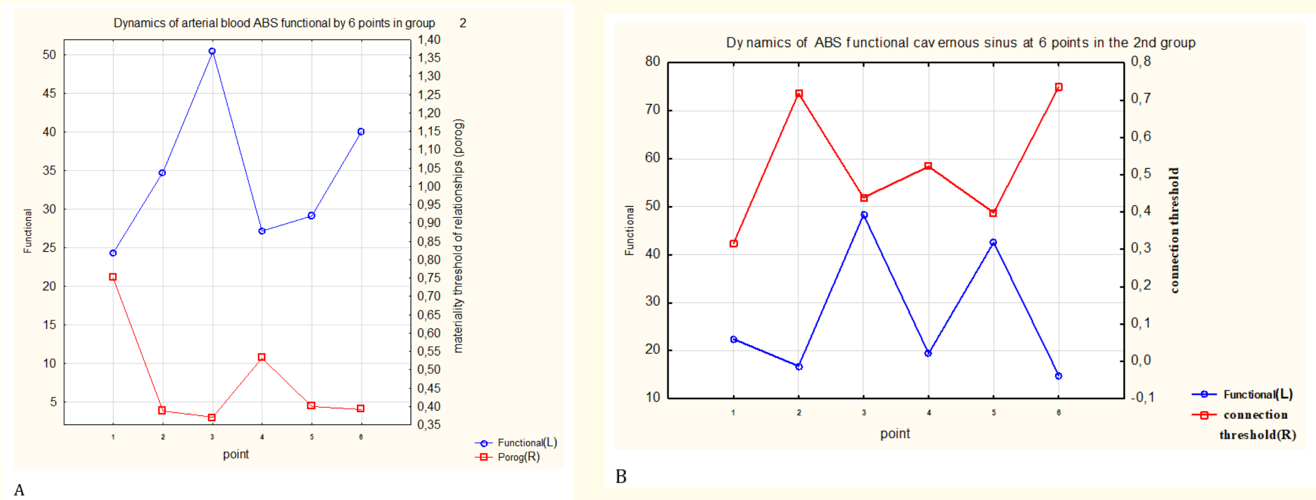

Figure 7: Dynamics of functionals and of the materiality thresholds of the relations (porog) of the parameters of ABS artery (A) and CS (B) in the 2nd group. Observed mirror-antiphase dynamics of materiality thresholds linkages and functional ABS the arteries and CS.

Point	Arterial Functional	Connection arterial threshold	Quantity of arterial classes	Functional CS	Connection threshold CS	Quantity of classes CS
1	24,259	0,751	10	22,438	0,316	6
2	34,795	0,388	4	16,794	0,718	12
3	50,401	0,371	5	48,309	0,439	5
4	27,183	0,533	7	19,426	0,522	8
5	29,070	0,400	6	42,570	0,398	4
6	40,068	0,391	4	14,884	0,735	11

Table 13: Indicators of functionals, of the materiality thresholds of ties and the number of classes of partitions ABS artery and SC in the 2nd group.

Label of classes	1 Point	2 Point	3 Point	4 Point	5 Point	6 Point
Var_Klass_1	pH(T) cHCO3-st cHCO3 SBE ABE pH	pH(T) cHCO3-st cHCO3 SBE ABE pH	pCO2(T) pO2(T) pH(T) mOsm p50 Lac Ca++ Na+ c	pCO2(T) pH(T) Lac Glu Ca++ Htc ctHb sO2 pCO2	pH(T) mOsm Cl- cHCO3-st cHCO3 SBE ABE pO2 pH	pCO2(T) pO2(T) pH(T) mOsm p50 Lac Glu Cl- Na
Var_Klass_2	pO2(T) pO2	pCO2(T) pO2(T) p50 Lac Glu Cl- Ca++ Htc ctHb	Glu sO2	pO2(T) pO2	pCO2(T) p50 Lac Glu Ca++ Htc ctHb pCO2	Ca++ cHCO3-st cHCO3 SBE ABE
Var_Klass_3	pCO2(T) p50 pCO2	K+	Htc	cHCO3-st cHCO3 SBE ABE	sO2	sO2
Var_Klass_4	sO2	mOsm Na+	K+	K+	K+	Htc ctHb
Var_Klass_5	Htc ctHb		Cl-	mOsm Na+	Na+	
Var_Klass_6	K+			Cl-	pO2(T)	
Var_Klass_7	mOsm Na+			p50		
Var_Klass_8	Ca++					
Var_Klass_9	Cl-					
Var_Klass_10	Lac Glu					

Table 14: Splits into disjoint classes of parameters of arterial ABS in group 2.

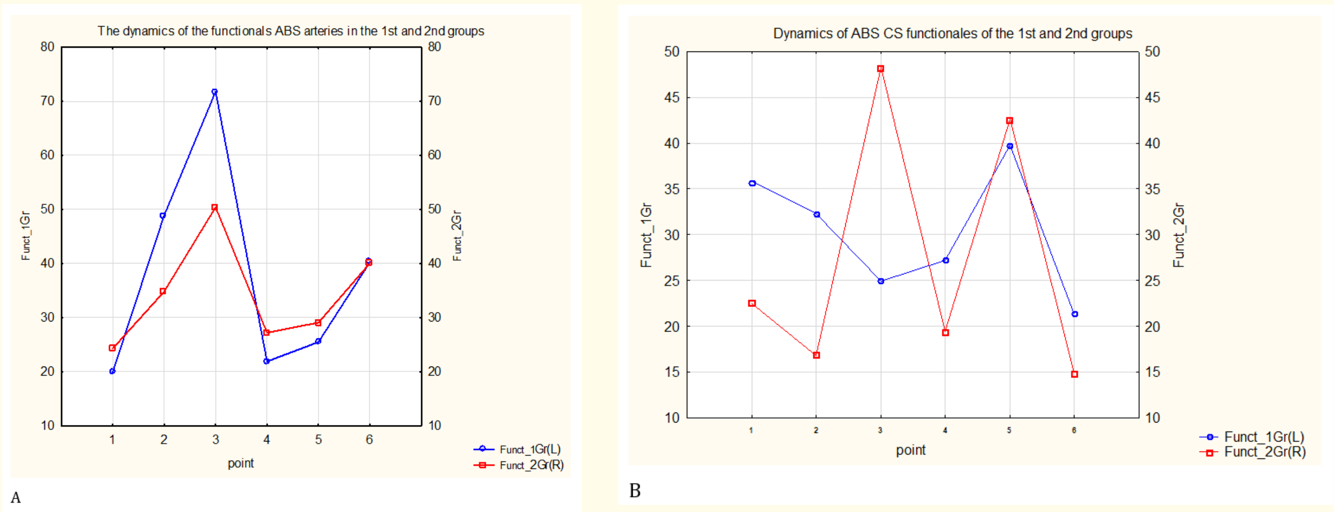

Figure 8: Dynamics of functionals ABS arteries (A) a cavernous sinus (B) in the 1st and 2nd groups. In figure 8.A dynamics of artery functionals ABS demonstrates full synchronicity, then how in figure 8.B can be seen the phase inversion to the fourth point is replaced by a complete synchronicity.

Comparison of the thresholds of the significance of the links between ABS elements in arterial and venous blood is shown in figure 9. From these positions, no significant differences in the synchronization processes between the first and second groups were not revealed, except for a more pronounced amplitude of the parameters of ABS parameters in the artery in the 1-st group and the same thresholds of ABS parameters in the cavernous sinus in the 2-nd group.

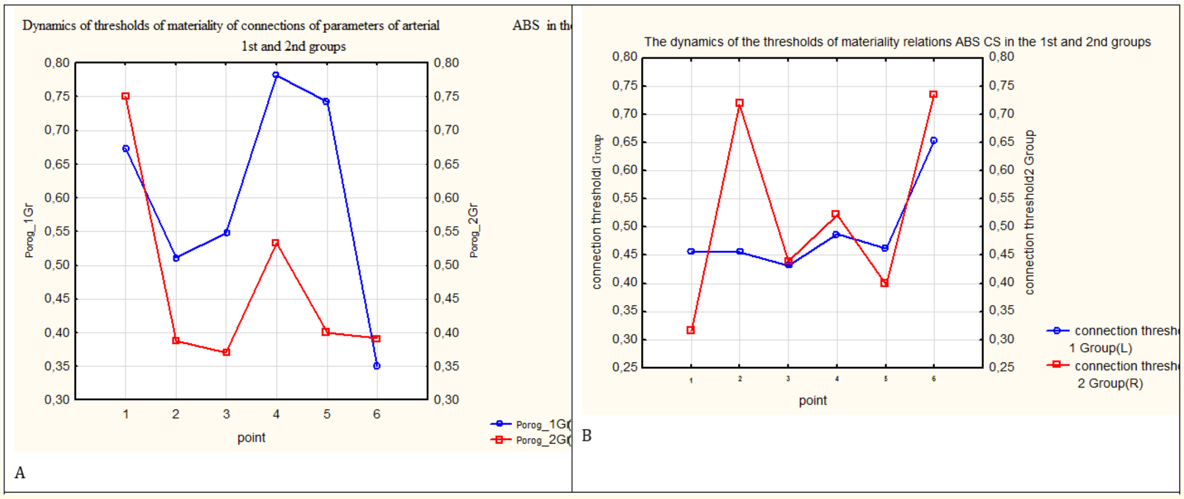

Figure 9: Dynamics of thresholds of materiality of connections (porog) of parameters of arterial (A) and cavernous sinus (B) ABS in the 1st and 2nd groups. In both cases, full synchronization of the processes is detected.

In Table 15-16 and Figure 10 shown indicators of functionals, of the thresholds of connections and the number of classes of partitions ABS arteries and CS [4] in the 3rd group.

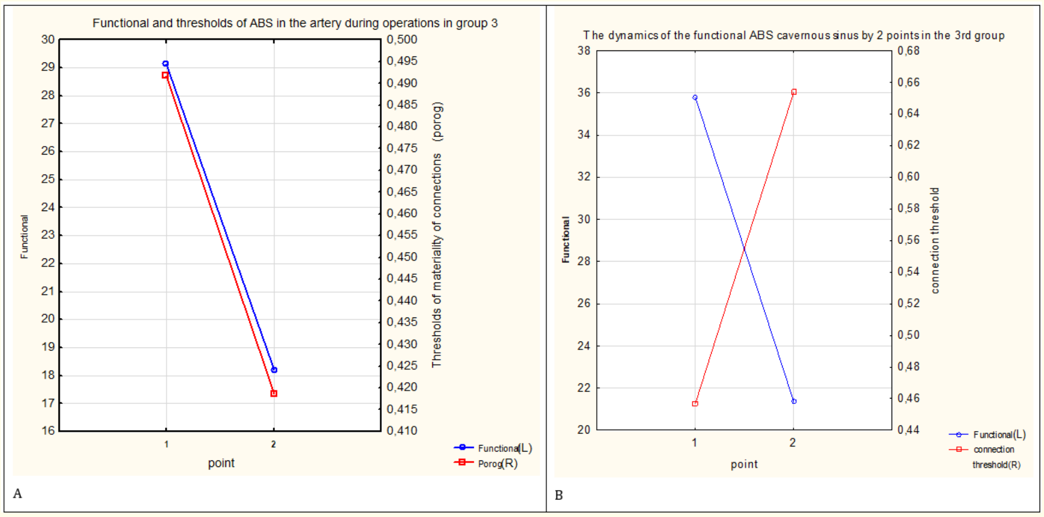

Figure 10: Dynamics of functionals and of the materiality thresholds of the relations of the parameters of ABS artery (A) and CS (B) in the 3rd group.

Point	Arterial functional	Connection arterial threshold	Quantity of arterial classes	Functional CS	Connection threshold CS	Quantity of classes CS
1	29,131	0,492	7	35,794	0,457	5
2	18,200	0,419	7	21,355	0,654	10

Table 15: Indicators of functionals, of the connection thresholds of ties and the quantity of classes of partitions ABS artery and CS [4] in the 3rd group.

Label of classes	1 point	2 point
Var_Klass_1	pCO2(T) Ca++ sO2 pCO2 pH	pCO2(T) pH(T) Glu Cl- ABE pH
Var_Klass_2	pO2(T) pO2	pO2(T) sO2 pO2
Var_Klass_3	ABE	p50 K+ cHCO3-st cHCO3 SBE pCO2
Var_Klass_4	pH(T) mOsm Glu Cl- Na+ K+ cHCO3-st cHCO3 SBE	Htc ctHb
Var_Klass_5	Htc ctHb	mOsm Na+
Var_Klass_6	Lac	Ca++
Var_Klass_7	p50	Lac

Table 16: Splits into disjoint classes of parameters of arterial ABS in group 3.

From tables 15-16 and figure 10 it follows that the functional parameters of ABS decreases from the first to the second point of the study in the artery and in the cavernous sinus. In the case of arterial blood, the number of partitions of ABS parameters into disjoint classes is the same and is equal to 7 at the first and second points (Table 15-16). When considering CS, the number of classes increases from 5 to 10 (table 15), which is accompanied by a drop in the functionality of ABS CS from 35,794 to 21,355 and can also be characterized by the word crisis. The dynamics of the functional and the threshold of connections in parallel are reduced in the case of considering the parameters of the ABS artery (figure 10-A), whereas the study of these parameters of the ABS cavernous sinus revealed a multidirectional change in the functional and thresholds of connections (figure 10-B).

Conclusion

The results of the study showed the effectiveness of comparison of integral correlation models for the analysis of acid-base state of patients. The use of integrated models allowed us to move from the description of ABS, presented in the form of measurement results of each of the 21 parameters of ABS patients in the artery and cavernous sinus, to a much more capacious representation of integral curves without loss of information.

Dynamic ABS model allows you to describe in practice the course of changes in the system. Dynamic models based on the calculation of criteria functions as an individual system indicator of an individual patient and functional as a group assessment of changes in the system are shown. The first model allows a deeper understanding of changes in the acid-base state of each patient, to identify critical periods in his condition. The second model allows to reveal distinctive features of ABS for various groups of patients and features of change of conditions in the postoperative period.

Thus, criterion functions of ABS in the artery and cavernous sinus at a certain synchronization have many significant fundamental differences in their dynamics.

The methodology applied by us allowed to reveal the synchronicity and asynchrony of dynamics, the effects of mirroring when comparing the dynamics of ABS changes in the artery and venous blood of the circulatory system.

The results showed that the 3 groups of patients studied by these methods allow to detect subtle differences between them, which are difficult to find in other ways.

The scope of the proposed solution is not limited to the analysis of acid-base state, but also used by us in the modeling of other biochemical parameters of blood, leukocyte system and other bioparameters.

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