

# Clinical Characteristics of Autonomic Support of the Body in Acute Pneumonia in Young Children

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**Abstract Introduction.** Bronchopulmonary diseases in young children, including acute pneumonia, despite significant advances in the study of pathogenesis, clinical manifestations, principles of diagnosis, therapy, and prevention, continue to remain one of the pressing problems in modern pediatrics. **Purpose of the study.** To study the clinical characteristics of the vegetative support of the body during acute pneumonia in young children. **Materials and research methods:** 120 children aged from 3 months to 4 years were under observation. The patients were divided into two groups: group I 65 patients with uncomplicated pneumonia, group II 55 patients with complicated pneumonia. The polysegmental form predominated inpatients with complicated pneumonia 22(40%), whereas in patients with uncomplicated pneumonia the focal form predominated 35 (53.8%). **Results and its discussion.** The results of our study show greater tension of the sympathoadrenal system in complicated pneumonia. This can be seen in the Mo indicators and  $\Delta X$ , which were sharply reduced in both age groups. In patients with uncomplicated pneumonia, although the indicator Mo and  $\Delta X$  were also reduced, but the failure of adaptation mechanisms did not occur, as evidenced by changes in  $\Delta X$  parameters, which were unreliably reduced. Therefore, a reasonable combination of etiotropic pathogenetic therapy with adaptive medicine methods aimed at correcting autonomic imbalance, reactivity and increasing the adaptive capabilities of the body is necessary. **Conclusion.** Generally, the peculiarities of the functioning of the ANS in complicated and uncomplicated forms of community-acquired pneumonia indicate a disturbance not only of reactivity in the respiratory system, but also of the whole organism. Such a violation of reactivity leads to the fact that not only etiotropic agents, but also perinatal pathology, can cause a deterioration in the child's condition during the height of the disease.

**Keywords** Autonomic nervous system, Pneumonia, Adaptation

## 1. Introduction

Bronchopulmonary diseases in young children, including acute pneumonia, despite significant advances in the study of pathogenesis, clinical manifestations, principles of diagnosis, therapy, and prevention, continue to remain one of the pressing problems in modern pediatrics [9,10,17]. According to WHO, about 155 million cases of pneumonia in children are registered annually worldwide, with approximately 1.4 million deaths occurring before the age of five years [16]. In 2023, pneumonia killed more children than any other infectious disease, killing more than 700,000 children under five each year, or about 2,000 every day [16]. Globally, there are more than 1,400 cases of pneumonia per 100,000 children, or 1 in 71 children each year, with the highest incidence in South Asia (2,500 cases per 100,000 children) and West and Central Africa (1,620 cases per 100,000 children).

The prevalence of pneumonia in the general child population according to statistics for Uzbekistan (2015) is 2.91%. A significant role in the development of pneumonia is played by microbial aggression, to which the body is not able to form an adequate response. It is under the influence of nonspecific damaging factors that the body's adaptive capabilities are reduced, which creates conditions for infection of the lung tissue [1,4,12]. There is no doubt that the state of the autonomic nervous system (ANS) plays a significant role in the occurrence and development of respiratory pathology. One can note the dual participation of the nervous system in the formation and development of inflammation: on the one hand, undoubtedly, the influence of the inflammatory process on the nervous system, on the other hand, the participation of altered reactions of the nervous system in the pathogenesis of inflammation [5,6]. Violations of the ANS function in pneumonia occur secondarily and are somatically caused. Also, according to Yurkov A. Yu. [19] ANS dysfunction in diseases is associated with a decrease in the body's vascular supply, high intensity of anabolic processes and changes in the functional state of both of its parts. According to Wayne A.M. [15]. autonomic dysfunction is a

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syndrome of somatic diseases, including pneumonia.

A number of authors have identified dysfunction of the ANS in diseases of the respiratory system in adults and the need for correction of autonomic disorders during their treatment [5,19].

Meanwhile, in the literature, information about the state of the autonomic nervous system (ANS) and autonomic regulation of heart rate in older children with acute pneumonia is scarce [6,13,18]. The functional state of the ANS in young children with acute pneumonia has been studied in modern medical literature few, and the results obtained are contradictory. The authors unanimously admit that the problem of ANS disorders in acute pneumonia really exists.

When assessing the activity of the ANS, its main indicators should be taken into account: autonomic tone (AT), autonomic reactivity (AR) and autonomic support (AS). AT and AR give an idea of the state of homeostatic equilibrium of the body (HER), and AS - about the functional reserves of the body and the adaptive mechanisms of its formation [6,14]. When identifying ANS dysfunction, its nature and level of damage (segmental, suprasedgmental) are taken into account.

It has been established that the tension of autonomic regulation in patients depends on the activity and prevalence of the pathological process [11]. Fluctuations in the parameters of ANS dysfunction make it possible to judge not only the course of the disease, but also to predict its outcome. Underestimation of obvious or hidden disorders of the ANS in the clinic makes it difficult to restore disorders, maintains a low quality of life for patients and leads to a decrease in the effectiveness of treatment [3,6].

Successful rehabilitation of patients with acute pneumonia requires an integrated approach involving not only etiotropic drugs in treatment, but also a targeted effect on ANS dysfunction and restoration of the activity of the body's defense systems [6,8].

These arguments are confirmed by cardiointervalographic studies, which allow early diagnosis of autonomic disorders for the development of algorithms for evidence-based methods of correction and prevention, which is of great importance for medical science and healthcare practice.

## 2. Purpose of the Study

To study the clinical characteristics of the vegetative support of the body during acute pneumonia in young children.

## 3. Materials and Research Methods

120 children aged from 3 months to 4 years were under observation. All patients with acute pneumonia that we examined were divided into two groups: group I consisted of 65 patients with uncomplicated pneumonia, group II consisted of 55 patients with complicated pneumonia. The control or conditional norm group included 55 healthy children of the same age.

When studying age gradation, we found that acute pneumonia was most common in children in the first year of life, so 51.7% of children were aged 3 months or older. Up to 1 year, 28.3% were aged 1 to 2 years and 24% were aged 2 to 4 years. The average age of children under one year was  $6.92 \pm 0.26$  months, for children from 1 to 4 years old it was  $1.92 \pm 0.08$  years. The distribution of patients by gender showed a predominance of boys 73 (60.8%), compared to girls 47 (39.2%).

The radiography picture of damage to the respiratory organs was characterized by the presence of focal shadows on both sides in 86 (71.7%) children, the right-sided nature of the pneumonic process occurred in 22 (18.3%) patients and in 12 (10%) patients the lesion had a left-sided nature.

The distribution of morphological forms of pneumonia during radiography studies showed a predominance of polysegmental forms in patients with complicated pneumonia 22(40%), whereas in patients with uncomplicated pneumonia the focal form predominated 35 (53.8%). Lobar and subtotal pneumonia occurred only in patients with a complicated form of pneumonia 8 (14.5%). The focal confluent form of pneumonia was more common in patients with uncomplicated pneumonia, compared with complicated ones: 8(14.5%) and 24(36.9%), respectively.

The diagnosis was formulated in accordance with the classification adopted at a meeting of pediatric pulmonologists held as part of the XVIII National Congress on Respiratory Diseases in Yekaterinburg (December 2008). When making a diagnosis, the morphological forms of pneumonia, the nature of complications, the course of the disease, the degree of respiratory failure, the localization of the inflammatory process in the lungs, and the premorbid background were also taken into account.

Registration of cardiointervalograms (in the amount of 100 complexes in each case) was carried out on a Kolibri-Carmine cardiointervalograph with subsequent computer processing. The following indicators were calculated and assessed: mode (Mo) - the values of the most frequently occurring values of RR intervals in the series under study, mode amplitude (AMo) - the percentage of values of RR intervals corresponding to the mode; variation range ( $\Delta X$ ) - the difference between the maximum and minimum RR intervals. The voltage index (SI) was directly calculated using the formula  $AMo(\%)/(2 MO \times \Delta X(s))$ .

A general clinical examination of sick children was carried out in the laboratory of the multidisciplinary clinic of Samarkand State Medical University.

## 4. Results and Its Discussion

From the anamnesis it was revealed that the most significant predictors in the development of vegetative visceral dysfunctions in children both groups of mothers had anemia in 65 (%) and 55 (%) cases, allergic diseases in 27 (49.1%) and 32 (49.2%) and chronic otolaryngology pathology in 23 (41.8%) and 26 (40%) of complicated and uncomplicated pneumonia, respectively.

In a detailed study of the anamnesis of the studied children, we identified the manifestation of autonomic disorders in 98 (81.7%) of those studied before 1 year of age, which were characterized by regurgitation in 52 (94.5%) and 51 (78.4%) (respectively complicated and uncomplicated pneumonia), abdominal bloating in 48(87.3%) and 52(80%), restless sleep in 38(69.1%) and 41(63.1%), tendency to constipation 41(74.5%) and 45(69.2%), wakefulness at night in 29(52.7%) and 31(47.7%), as well as colic in newborns in 48(87.3%) and 47(72.3%). In 56(57.1%) children they were observed in various combinations, in 42(42.9%) as one isolated symptom.

In general, the functional dysfunctions of the gastrointestinal tract that we identified may be a prestage of the development of vegetative dystonia in pneumonia in children.

As is known, the severity of pneumonia is determined by the severity of clinical manifestations and the presence of complications in patients [2,3].

The condition of sick children upon admission largely depended on the form of the disease. Thus, 54 (83.1%) sick children with an uncomplicated form of pneumonia had a moderate condition upon admission, while in patients with complicated pneumonia 12 (21.8%) had an extremely severe condition, 43 (78.2%) – heavy. Our data show that in young children severe forms of pneumonia predominated, amounting to 55%.

As is known, data on what day of illness patients went to the hospital is an important indicator, since the effectiveness of inpatient treatment depends on this [8]. When studying the number of visits to the hospital, we noted that almost half of the visits took place within 4 to 5 days (48.33%). In total, in 24 cases the visit took place on the second and third days of illness (20%). The average rate of hospitalization in patients with complicated pneumonia was  $5.62 \pm 0.2$  days, while in patients with uncomplicated pneumonia  $4.3 \pm 0.15$  days for the entire observed group was  $4.9 \pm 0.2$  days.

Considering the important nature of complaints and clinical manifestations in autonomic dysfunctions, we provide their detailed characteristics in patients with acute pneumonia in Table 1; 2.

The predominance of vagotonia was evidenced by complaints from the mother about sweating in 33 (60%) and 19 (34.5%) (hereinafter: respectively, in patients with complicated and uncomplicated pneumonia); normal body temperature – in 9 (16.4%) and 1 (1.5%); refusal to eat – in 9 (16.4%) and 1 (1.5%); headaches 6(10.1%) and 1(1.5%); periodic abdominal pain – in 15 (27.3%) and 12 (18.46%); increased drowsiness – in 9 (16.4%) and 1 (1.5%); nausea – in 15 (27.3%) and 12 (18.46%); vomiting – in 32 (58.2%) and 28 (43.1%); diarrhea – in 12 (21.8%) and 11 (17%) patients. These patients had such clinical signs as marbling of the skin – in 12 (21.8%) and 11 (17%); red dermographism – in 9 (16.4%) and 1 (1.5%) patients. A tendency to edema was noted in 9 (16.4%) and 1 (1.5%), excess body weight (paratrophy) - in 7 (12.72%) and 11 (17%), bradypnea - in 9 (16, 4%) and 1 (1.5%) patients, as well as allergic reactions in 17 (31%) and 14 (21.5%) and bradycardia in 9 (16.4%) and 1 (1.5%) examined.

**Table 1.** Main complaints in children with acute pneumonia depending on the initial vegetative tone

№	Criteria	Complicated pneumonia n=55	Uncomplicated pneumonia n=65
1.	Body temperature		
	-febrile	27(49.1%)	28(43.1%)
	- subfebrile	19 (34.5%)	36(55.4%)
	-normal	9 (16.4%)	1(1.5%)
2.	Chill-like hyperkinesia	36 (65.4%)	47 (72.3%)
3.	Appetite		
	-Reduced	46(83.6%)	58(89.2%)
	-Relatively normal	-	6(9.2%)
	-Refusal to eat	9 (16.4%)	1(1.5%)
4.	Sweating	33 (60%)	19 (34.5%)
5.	Functional changes in the gastrointestinal tract		
	- Complaints of nausea	15 (27.3)	12 (18.46)
6.	-vomiting	32 (58,212)	28(43.1)
7.	-Diarrhea	12 (21.82)	11 (17%)
8.	-Constipation	21(38.18)	26(40)
9.	Headache	6(10.1)	-
10.	Decreased physical activity	7(12.72)	1(1.5)
11	Stomach ache	15(27.3)	12(18.5)
12.	Sleep disorders		
	- bad sleep	46(83.63)	10(15.4)
	- drowsiness	9 (16.4%)	1(1.5%)

The predominance of sympathicotonia manifested itself febrile temperatures in 46 (83.6%) and 64 (98.4%); pallor of the skin – in 46 (83.68%) and 64 (98.46%) chills-like hyperkinesia – in 36 (65.4%) and 47 (72.3%); tachypnea – in 46 (83.68%) and 64 (98.46%); tachycardia – in 46 (83.68%) and 64 (98.46%) and low body weight – in 38 (69.1%) and 58 (89.2%) patients. Patients with a predominant influence of the sympathetic nervous system were also characterized by coldness of the extremities - in 39 (71%) and 54 (83%); decreased appetite – in 46 (83.6%) and 58 (89.2%); spastic constipation – in 21 (38.2%) and 26 (40%); poor sleep – in 46 (83.6%) and 10 (15.4%) and white dermographism – in 46 (83.68%) and 46 (70.67%).

As can be seen from the characteristics of the complaints presented, sympathicotonia prevailed among patients in both groups, and this was more pronounced in patients with complicated pneumonia. It should be noted that all those examined had a large number and variety of complaints, and in each patient they affected almost all organs and systems. We observed similar results during an objective examination (Table 2).

Of the 62 (51.7%) studied patients under 1 year of age, in 50 upon admission to the hospital during the period of severity of clinical manifestations of the disease, we identified a change in the functional state of the gastrointestinal tract, which was manifested by 1-2 times vomiting per day, flatulence, stool upset, as well as constipation In patients under 4 years

of age, abdominal pain predominated.

**Table 2.** Main clinical manifestations of acute pneumonia in children depending on the initial vegetative tone

№	Criteria	Complicated pneumonia n=55	Uncomplicated pneumonia n=65
1.	Color of the skin		
	- Pale skin - Tendency to blush	46(83.63) 9(16.36)	64(98.46) 1(1.5)
2.	Vascular pattern		
	- Marbling	12(21.82)	11(17)
3.	Hand temperature		
	- cold extremities	39(71)	54(83)
4.	Increased sweating	4(7.27)	7(10.67)
5.	Dermographism		
	-pink	9(16.36)	1(1.5)
	- white	46(83.63)	46(70.67)
6.	Pastosity of tissues (tendency to edema)	9 (16.36)	1(1.5)
7.	Body mass		
	-reduced	38(69.1)	58(89.23)
	-excessive	7(12.72)	1(1.5)
	-normal	10(18,18)	6(9.23)
8.	Breathing rate		
	-tachypnea	46(83.63)	64(98.46)
	-bradypnea	9(16.36)	1(1.5)
9.	Heart rate		
	- tachycardia	46(83.63)	64(98.46)
	- bradycardia	9(16.36)	1(1.5)
10.	Allergic reactions	17(30.1)	14(21.5)

Upon admission to the hospital, analysis of CIG data showed that in complicated pneumonia, hypersympathicotonic VI predominated 29 (52.7%), while in patients with uncomplicated pneumonia, sympathicotonia predominated 36(55.4). Vagotonia was detected in 5 (9.1%) patients with complicated and 1 (1.5%) patient with uncomplicated pneumonia. Whereas, inpronounced vagotoniaregisteredonly in 4 (7.3%) patients with complicated pneumonia.

It should be noted, that atcomplicated and uncomplicated

pneumoniain young children, in no case upon admission registereutonic variant of VI.

**Table 3.** Distribution of sick children taking into account VI

Types of vegetative tone	Control, n=55		Uncomplicated pneumonia, n=65		Complicated pneumonia, n=55	
	abs	%	abs	%	abs	%
Hypersympathicotonia	0	0	28	43.1	29	52.7
Sympathicotonia	18	32.7	36	55.4	17	30.9
Vagotonia	8	14.5	1	1.5	5	9.1
Pronounced vagotonia	0	0	0	0	4	7.3
Eitonia	29	52.8	0	0	0	0
Total	55	100.0	65	100.0	55	100.0

As follows from the data obtained, the period of height of clinical manifestations of pneumonia, regardless of the nature of the complication, is characterized by tension of sympathoadrenal mechanisms. This is evidenced by a decrease Mÿ and variation range (ΔX), increase in AMo value and voltage index (VI) (P<0.001), which is a constant of the functional activity of this particular section of the ANS, Table 4.

As can be seen from Table 4. CIG indicators indicate greater tension of the sympathoadrenal system in complicated pneumonia. This can be seen in the MO indicators and ΔX, which were sharply reduced in both age groups. In patients with uncomplicated pneumonia, although the indicator Mo and ΔX was also reduced, but the failure of adaptation mechanisms did not occur, as evidenced by changes in ΔX parameters, which were unreliably reduced.

At the same time, the indicators of VI in children with hypersympathicotonia increased 12 times, sympathicotonia by 9.6 times relative to standard values (P<0.001). These data once again show the intensity of adaptive reactions in general.

Another confirmation of the stated position is the decrease during the height of pneumonia ΔX and Mo, which indicates a minor state of the functional activity of parasympathetic and neurohumoral mechanisms in the structure of the processes of adaptation and life support of the organism.

**Table 4.** CIG indicators in patients under 1 year (numerator) and from 1 to 3 years (denominator) with acute pneumonia

Group	MO, with	AMO, %	ΔX, s	VI c.u.
Healthy (n=25)	0.96±0.02	44±2.2	0.14±0.004	163.7±18.5
	0.58±0.02	28±2.5	0.23±0.04	134±17.7
Complicated pneumonia (n=55)	0.68±0.05 P<0.001	65.17±4.12 P<0.001	0.12±0.02 P<0.001	993.21±178.10 P<0.001
	0.48±0.12	59.2±4.90	0.15±0.04	411.08±124.1
Uncomplicated pneumonia (n=65)	0.72±0.07 P<0.001	62.11±5.03 P>0.1	0.13±0.01 P>0.1	525.09±39.86 P<0.001
	0.72±0.05	60±3.11	0.13±0.02 P<0.05	404.4±49.2

Note: P - reliability of indicators in relation to the healthy group

At the same time, a comparative analysis of these changes, depending on the nature of the complications, reveals a tendency for greater tension in the sympathoadrenal mechanisms in neurotoxicosis and to a somewhat lesser extent in patients with cardiovascular insufficiency. Moreover, if a decrease in values  $M_0$  is almost identical for all variants of complicated pneumonia, then changes in parameters  $\Delta X$  observed in pneumonia with cardiovascular failure. This led to the fact that the final integral indicator of the intensity of adaptive mechanisms - VI - revealed a tendency to increase in patients specifically with CVS.

Thus, we can conclude that in phase 1 of infectious stress, which the classics defined as sympathoadrenal, it is impossible to completely exclude the role of parasympathetic mechanisms in maintaining the adequacy of life support processes.

Upon admission to the hospital, 4 (3.33%) children under 1 year of age were in extremely serious condition prevailed a pronounced vagotonic effect and in 5 (4.17%) patients aged 2 to 4 years vagotonia. Patients with a pronounced vagotonic type of IAT were admitted to the hospital late, on the 7th, 10th day of the disease. With radiography diagnosed polysegmental pneumonia. An increase in the indicator was revealed  $M_0 = 1.12 \pm 0.02$  s,  $\Delta X = 0.4 \pm 0.06$  s and a sharp decrease in  $AM_0 = 28 \pm 1.4$  and  $VI = 26.2 \pm 0.09$  c.u. compared to indicators of healthy children ( $P < 0.001$ ). These patients showed a failure of adaptation, i.e. a change from hypersympathicotonia to vagotonia, which indicated a pronounced tension in compensatory mechanisms and gross imbalance in the autonomic regulation system. In dynamic observation, the CIG indicators on the 5th day of treatment did not change and the patients' condition remained extremely severe. Vascular hemodynamic disorders were manifested by marbling of the skin, acrocyanosis, cyanosis of the nasolabial triangle, coldness of the hands and feet. There was an expansion of the boundaries of the heart and a significant decrease in blood pressure. The clinical picture was dominated by bradycardia, lethargy of the child, adynamia, decreased body temperature, cold extremities, and flatulence.

The autonomic nervous system reacted somewhat differently in sick children with vagotonic IAT. In 4.17% of patients with vagotonic IVT in dynamic observation, the CIG indicators changed on the 10th day; upon discharge from the hospital, eutonia was noted.

In general, the distribution results obtained types of IVT in the examined patients upon admission show a significant increase in hypersympathicotonic variants of autonomic regulation in relation to normative indicators, regardless of the form of pneumonia.

The results obtained indicate overexcitation of adaptive-compensatory reactions of the sympathetic division of the ANS, and in some cases, failure of adaptation in children with acute pneumonia.

Thus, we can conclude that recently there has been a change in the clinical picture and form of pneumonia in young children. If earlier focal, interstitial forms of pneumonia were often found in young children [7,10], now we see focal-confluent, segmental, and sometimes lobar forms with

an abortive course. We associate this with the pathological course of pregnancy and the birth of children with perinatal pathology, which lead to autonomic dysfunction syndrome in the future, and they aggravate the course of the inflammatory process. Thus, a vicious circle is created when autonomic disorders lead to aggravated pneumonia, and this in turn further aggravates autonomic disorders.

## 5. Conclusions

Generally, the peculiarities of the functioning of the ANS in complicated and uncomplicated forms of community-acquired pneumonia indicate a disturbance not only of reactivity in the respiratory system, but also of the whole organism. Such a violation of reactivity leads to the fact that not only etiotropic agents, but also perinatal pathology, can cause a deterioration in the child's condition during the height of the disease. Therefore, a reasonable combination of etiotropic pathogenetic therapy with adaptive medicine methods aimed at correcting autonomic imbalance, reactivity and increasing the adaptive capabilities of the body is necessary.

## Conflict of Interest

The authors declare no conflicts of interest or special funding for the current study.

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