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PARTICULARITIES OF HEMODYNAMICS AND OXYGEN STATUS IN INFANTS AND PRESCHOOL-AGE CHILDREN WITH COMPLICATED COMMUNITY-ACQUIRED PNEUMONIAS

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Abstract

Background: The absence of the unanimity of views on the use of plasmapheresis, insufficiently studied issues of the course severity, hemodynamics disorders in children during intensive care (IC) of pneumonias with the use of efferent detoxication methods determine the rationale of the study.

Methods: This was a retrospective-prospective study. Group I included children with discrete plasmapheresis (DPP) in complex IC, group II – children who received baseline therapy (BT), group III – control group. Each of the groups were divided into subgroups: A – children aged 1-3 years old, B – children aged 3-7 years old.

Results: Statistically significant differences in HR between the study group and the comparison group were revealed on the 1st day of BT in infants; during the ROC-analysis, the discrimination point was determined: HR>137 bpm, Se=65.2, Sp=82.4, p=0.004, AUC=0.74

and on the 2nd day of BT: HR>129 bpm, Se=73.3, Sp=70.6, p=0.014, AUC=0.73; arterial oxygen content (CaO_2) ≤126 ml/100 ml, Se=54.5, Sp=93.7, AUC=0.724, p=0.033. The DPP performance contributes to the restoration of circulatory normodynamia (mainly due to tachycardia regression), does not cause arterial hypotension; after its performance, a tendency to a decrease in oxygen delivery and consumption is observed, as well as base deficit reduction; the discrete plasmapheresis performance is associated with more frequent need in red blood cell transfusions.

Conclusion: In infants, the values of HR>137 bpm during Day 1 of BT or HR>129 bpm and/or CaO_2≤126 ml/100 ml during Day 2 of baseline therapy may be considered to be the risk factors of DPP prescription. Study showed effectiveness of discrete plasmapheresis.

Key word: pneumonia; child; plasmapheresis; hemodynamics; oxygen consumption

Introduction. Community-acquired pneumonia is an important cause of morbidity in developed countries and an important cause of morbidity and mortality in developing countries [1], especially among children under five years [2], despite advances in prevention and management of pneumonia [3]. The basis for determining the severity of the condition in pneumonias is blood gas analysis [4]. In turn, ultrasonographic measurement of cardiac output is fast and accurate approach for dynamic measurement of heart function and circulatory performance in children with severe pneumonia [5, 6]. The pathogenesis of the cardiovascular disorders in pneumonia may be schematically described as follows: toxicosis and respiratory failure contribute to spasm of the arterioles of the lesser circulation, causing pulmonary hypertension and an increased load on the right heart, which results in a decrease in myocardial contractility and impairment of peripheral hemodynamics, microcirculation disorders. In severe pneumonia, energy-dynamic myocardial insufficiency (Hagglin syndrome), degenerative changes in the cardiac muscle and vessels, and increased capillary permeability occur [7]. In a number of clinics, plasmapheresis (PP) is successfully used in treatment of pneumonia in children [8], but the use of discrete plasmapheresis in treatment of complicated pneumonia in children remains controversial due to the possible development of complications during plasmapheresis and the lack of a sufficient number of studies indicating its effectiveness in severe bacterial infections. The most common complications are hypotension, hemorrhage or hypercoagulation [9].

The absence of the unanimity of views on the use of plasmapheresis, insufficiently studied issues of the course severity, hemodynamics disorders in children during intensive

care (IC) of pneumonias with the use of efferent detoxication methods determine the rationale of the study.

The aim of the study was to evaluate the impact of the patient's hemodynamics and oxygen transport on prescription of PP in infants and preschool-age children with complicated community-acquired pneumonias (CCAP) and its effectiveness evaluation in our centre.

Methods. This was a retrospective-prospective study (single centre experience) approved by the Ethical Committee of the Zaporizhzhia State Medical University (Protocol No. 1, dated January 25, 2018). Prior to enrollment informed consent was obtained from parents for participation of their children in the study from 2017 (prospective study). Focusing on the nature of the study, the requirement for obtaining informed consent until 2017 from each patient was waived (retrospective study).

We analyzed the outcomes of intensive care in 90 infants and preschool-age children with CCAP of IV-V degrees of severity, who were undergoing treatment at the Intensive Care Unit (ICU) of the Municipal Non-Commercial Enterprise the Municipal Pediatric Hospital No. 5 of the Zaporizhzhia City Council (MNE MPH No. 5 of ZCC) from 2002 till 2019, and 28 somatically apparently healthy children. Patients, who were undergoing discrete plasmapheresis at the ICU (n=49), were enrolled into the 1st treatment group. In the treatment group, two subgroups were identified depending on the children's age: 1A – infants (1-3-year old), n=23 (girls – 12 (52%), boys – 11 (48%), age of 24.9±1.5 months), 1B – preschool-age children (3-7-year old), n=26 (girls – 11 (42%), boys – 15 (58%), age of 55.7±2.4 months). Patients, who were undergoing background intensive therapy according to the Order of the Ministry of Health of Ukraine No. 18 dd 13.01.2005 [10], were enrolled into the comparison group (2nd, n=40), which was also divided into subgroups: 2A (n=17, girls – 6 (35%), boys – 11 (65%), age of 29.1±1.2 months) and 2B (n=24, girls – 12 (50%), boys – 12 (50%), age of 59.4±2.4 months). Antibacterial therapy was prescribed in both groups, taking into account local microbiological monitoring data [11]. The children, who were preparing for an elective surgery at the Departments of Surgery, Urology, were enrolled into the control 3rd group: 3A (n=14, girls – 2 (14%), boys – 12 (86%), age of 24.14±1.79 months), 3B (n=14, girls – 2 (14%), boys – 12 (86%), age of 57.6±3.63 months). The A subgroups are comparable in age (p=0.06), sex (p=0.07), degree of pneumonia severity on the children's admission to the DAIC (p=0.38), as well as the B subgroups with p=0.58, p=0.06 and p=1.0, respectively.

PP was administered in the absence of sufficient effect from background intensive therapy. For this procedure the central vein must be catheterized, usually it is the subclavian vein. Blood is dispensed into blood containers with anticoagulant in a ratio of 1:4 to the

blood. Anticoagulants were the glygicir or heparin (Ukraine) in solutions of normal saline (Ukraine). Estimated dose of heparin was 2-4 U per ml of blood depending on the degree of hypercoagulation. PP was perfomed with the «OS-6M» medical laboratory centrifuge (Frunze, USSR) or by sedimentation method (in patients with high ESR). Centrifugation at a speed of 1500-2000 rpm during 10-15 minutes. The volume of blood exchange per session should not exceed 10% of blood circulatory volume, which calculated as 80 ml per kg. Then, the plasma is removed and replaced by donor plasma (fresh frozen plasma), and the shaped elements were reinfused. The course of treatment consisted of 1-7 sessions, with the removal of 50-80% the volume of circulating plasma, the number of required sessions was individualized depending on the severity of the disease.

The patients' inclusion criteria: the presence of community-acquired pneumonia of IV-V degrees of severity (according to the classification by Yu. G. Antipkin, V. G. Maidannyk, V. F. Lapshyn et al., 2011) [7] of bacterial and/or viral, and/or fungal origin, 2nd or 3rd-degree respiratory failure, complicated course of community-acquired pneumonia (general disorders: toxic, circulatory, 1st or 2nd-degree DIC, hypoxic encephalopathy, neurotoxicosis; pulmonary: destruction, abscess, pleuritis, pneumothorax; extrapulmonary (inflammation of different organs): sinusitis, otitis, pyelonephritis, meningitis, osteomyelitis), age from 1 to 7-year old, compensated hemodynamic values before efferent therapy initiation, parent's consent to the scheduled type of treatment. Exclusion criteria: the age of children under 1 year and above 7 years of age, significant hemodynamic disorders prior to plasmapheresis initiation, thrombocytopenia less than 50 G/l, steady bleeding or risk of bleeding in active gastric ulcer, 3rd or 4th-degree DIC, edema syndrome, hypoproteinemia (total proteins less than 40 g/l), acute neuropsychiatric disorders, terminal state, refusal of the child's parents to participate in the study.

The laboratory and imaging examination of the patients was performed at the MNE MPH No. 5 of ZCC: at the clinical diagnostic laboratory, the values of the acid-base balance and blood gases were determined with the blood gas analyzer EasyBloodGas (Medica Corporation, USA), as well as venous blood hemoglobin concentration with the photometric MiniHEM-540 hemoglobinometer (Technomedica, Russia), capillary blood hemoglobin concentration with the Micros 60 hematological analyser (ABX Diagnostics, Japan); echocardiography with the US scanner SSI-1000 SonoScape (SonoScape Co. Ltd., China); HR, arterial blood pressure, arterial blood oxygen saturation with the Datascope Passport V Patient Monitor (Mindray DS USA, Inc.). The oxygen delivery values were calculated using the following formulas: the oxygen delivery index (O_2DI) was determined as the product of

the cardiac index and the arterial oxygen content (CaO_2); the oxygen consumption index (O_2CI) is calculated as the product of the cardiac index and the arteriovenous oxygen difference [12]; for determining the oxygen content in the arterial/venous blood, the following formula was used (1) [13]:

$$Ca(v)O2 = [1,34 \times Hb \times Sa(v)O2)/100 \quad (1)$$

where 1.34 is the Gufner constant;
Hb is the arterial/venous blood hemoglobin;
$Sa(v)O_2$ is hemoglobin oxygen saturation in the arterial/venous blood.
Inotropic score (IS) was calculated using the following formula: (2) [15]:

$$"IS = dopamine\ dose"(\mu g"/kg/min) + dobutamine\ dose\ (\mu g/kg/min)" + 100 \times "epinephrine\ dose\ (\mu g/kg/min)" \quad (2)$$

The studied values were evaluated on admission to the ICU (1st stage), on Day 1 (2nd stage), on Day 2 (3rd stage) of IC; in Group 1 – before PP (4th stage), in a day after PP (5th stage), in three days after PP (6th stage); in Group 2 – on Days 3 and 5 of IC (4th and 5th stages); in the control group – prior to the surgical intervention.

The Statistica 13 for Windows (StatSoft Inc., No. JPZ804I382130ARCN10-J) software was used. The Shapiro-Wilk test was used to verify the normality of distribution in the samples. The data that did not conform the normal statistic distribution law have been presented that a median with interquartile range: Me (Q25-Q75); nonparametric methods were used for their processing. For the normally distributed data, parametric processing methods were used; the data have been presented as an arithmetic mean of a group with a standard error of the mean: M±m. Also, the risk ratios (RR), odds ratios (OR), 95% confidence intervals (CI), specificity (Sp), sensitivity (Se) of the diagnostic methods were calculated; Impact of the parameter was established using the receiver operating characteristics (ROC) curves and the area under the curve (AUC).

Results. On the children's admission to the ICU, the study and comparison groups were comparable in terms of their HR, blood pressure (diastolic, systolic, mean), the cardiac index (CI) and stroke volume index (SVI) values. At the 1st stage, tachycardia was observed (Tab. 1). In the comparison group, there was a gradual decrease in tachycardia with a tendency to normalization of the HR on Day 5 of IC; while in the study group, the HR also

decreased during the first days of treatment; but tachycardia increased again at a certain IC stage; and after DPF, stable positive changes were already noted with a decrease in tachycardia at the 6th stage (Tab. 1).

Table 1. Hemodynamic parameters in infants and preschool-age children at the stages of the study

Factor	Group	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
HR, bpm.	1A	148,1±5,0	141,8±3,9§	134,7±4,1§	139,8±3,5	129,5±4,2*#	127,2±2,4*#
	1B	135,3±4,2	125±3,3*	117±4,5*	128±3,8*	118±4*#	113,8±3,7*#
	2A	141,2±4,9	127,2±4,1*§	122,5±3,6*§	119,5±4*	120,6±3,9*	
	2B	129,9±5,1	123,4±3,8	116,7±2,9*	112,1±3,5*	105,5±3,6*	
	3A	101±2,5					
	3B	98,5±0,7					
MAP, mm Hg	1A	77,7(72,7-84)	76 (68,3-81)	76,3 (74-84)	76,7 (71-83,7)	78,2 (74,3-83,3)	78,2 (72-88,4)
	1B	76 (71-90)	76,7(72,7-81,7)	74 (73-77,7)	79,7 (74-84,3)	76,7 (74-82,3)	76,3 (72,7-82)
	2A	75,3(71,7-80,3)	73,3(70,7-75,7)	76 (73-80,3)	82 (76-87)	75 (73,3-79,3)	
	2B	75 (70-84)	74,7 (71-78,3)	79,3(75,7-82,7)	79 (76,3-83)	75,7 (71,3-79,3)	
	3A	73,3 (71,7-73,3)					
	3B	73,3 (68,3-76,7)					
CI, l/min/ m^2	1A	5,7 (5,3-6,4)	5,6 (5,1-7,1)	5,1 (4,8-6,5)	5,3 (5,1-6,5)	5,1 (4,6-6)	5,2 (4,7-5,6)
	1B	6,4 (5,8-7,8)	5,7 (5,3-6,2)	5,6 (5,2-6,3)	5,7 (5,2-6,4)*	5,0 (4,7-5,9)*#	5,3 (4,4-6,2)*
	2A	6,7 (5,7-7,0)	5,6 (5,2-6,8)	5,3 (5,2-8)	5,69 (4,21-6)	5,38 (4,78-6,1)	
	2B	5,9 (5,3-6,3)	5,3 (4,9-5,7)	5,5 (5,0-6,7)	4,9 (3,8-6,2)	4,5 (3,5-5,3)	
	3A	4,6 (4,5-4,8)					
	3B	3,73 (3,2-4,0)					

Statistically significant differences in HR between the study group and the comparison group were revealed on the 1st day of BT in infants; during the ROC-analysis, the discrimination point was determined: HR>137 bpm, Se=65.2, Sp=82.4, p=0.004, AUC=0.74 (Figure 1), RR=3.94 (CI of 1.32-11.79), OR=10.67 (CI of 2.2-51.78) and on the 2nd day of BT: HR>129 bpm, Se=73.3, Sp=70.6, p=0.014, AUC=0.73, RR=2.49 (CI of 1.09-5.72), OR=6.6 (CI of 1.32-33.06) (Figure 2). In preschool-age children, no differences in HR were revealed between Groups 1 and 2 at the 1st-3rd stages. The study of the relationship between plasmapheresis and the HR level on the 1st and 2nd days of BT with the use of a nonlinear logistic model of statistical regression revealed a statistically significant relationship: p=0.01 and p=0.02, respectively. There were no statistically significant changes in the mean arterial pressure (MAP) during IC; in the preschool-age children, at the corresponding stages, it was

equal to normal (Tab. 1). Based on the blood pressure monitoring data prior to PP and immediately after its completion, statistically significant differences were not either revealed: in Group 1A, the MAP was 76.7 (71-83.7) mmHg and 73.3 (63.7-86.0) mmHg, respectively; in Group 1B, it was 79.7 (74-84.3) and 80 (72.7-85) (mmHg), respectively. In the course of IC, in both subgroups of infant, no significant changes were revealed on the cardiac index (CI), but there was a tendency to a reduction – normalization of the CI values in Group 1A in three days after DPF, in group 2A, on Day 5 of therapy (Tab. 1). In the preschool-age children, circulation hyperdynamia was observed with a statistically significant change in the CI at the 4th-6th stages in Group 1B and a tendency to the CI normalization in Group 2B. There were no statistically significant changes in the stroke volume index (SVI) in the course of BT.

The therapy with sympathomimetics (predominately dopamine) was administered to 7 patients from Group 1A (30.4%); IS=4 in 2 patients; IS=5 in 3 patients; and IS greater than 10 was in 2 patients for a short time during a day; then the IS was equal to 6-7. In Group 1B, 8 a patients (34.8%) received therapy with sympathomimetics: 6 children with IS=4, 1 child with IS=5, 1 child with an IS of up to 10. The duration of the use of sympathomimetics was 12 (6-14) in the infants, 7 (6-11) in the preschool-age children. Sympathomimetics were not used in the comparison group; the nitrate drugs were used in one case in pronounced broncho-obstructive syndrome for reduction of pulmonary hypertension.

The values of venous saturation and partial pressure of oxygen in the venous blood in the IC course had no statistically significant changes in any of the groups and corresponded to normal and subnormal levels. Thus, in Group 1A, SvO_2 was 69.9 (56.2-77.9)% at the 1st stage, 71.4 (63.5-77.6)% prior to PP; at the 6th stage, it was 75.6 (64.4-77.1)%; in Group 1B, it was 74.8 (65.4-79.9), 70.1 (65.9-72.7), 70.1 (68-71.4)%, respectively; in Group 2A, it was 65 (61-71)% on admission, 69 (66-72.8)% at the 5th stage; in Group 2B, it was 80.9 (73.9-82), 72.2 (72-75.7)%, respectively; in the control group, it was 75 (74-76) in children aged 1-3 years, 74 (73-74)% in children aged 3-7 years.

The pH was characterized as a compensated value and subcompensated metabolic acidosis in preschool-age children from Groups 1B and 2B at the 1st-2nd stages. At the 5th-6th stages, the pH values were compensated in all groups due to the base deficit reduction: thus, in Group 1A, on admission BDv=«-»3.0 («-»5-«-» 1.6), at the 6th stage: «-»1.0 («-»1.8-«+»2.6); in Group 1B: «-» 6.4 («-»9.3-«-»4.1) and «-»2.8 («-»3.2-«-»1.5), respectively. There was a repeated increase in base deficit at a certain stage prior to PP: in Group 1A – «-» 2.7 («-»3.7-«-»0.5); in Group 1B – «-»5.6 («-» 9-«-» 0.9).

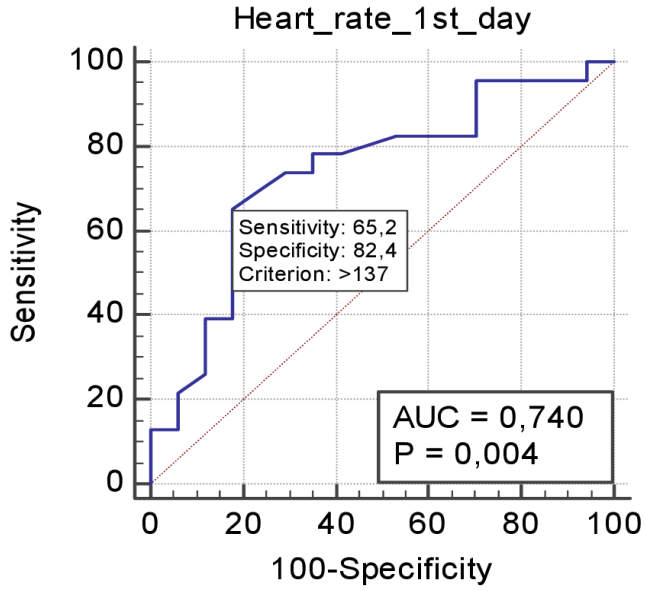

Figure 1. ROC-curve for heart rate with the distribution point, calculated AUC, *P*-value in subgroups A on the first day of background therapy

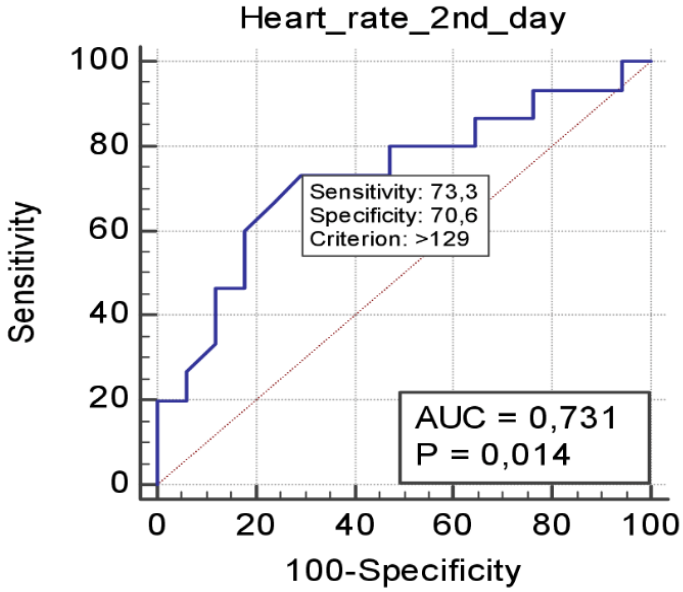

Figure 2. ROC-curve for heart rate with the distribution point, calculated AUC, *P*-value in subgroups A on the second day of background therapy

The median of arterial hemoglobin oxygen saturation in Group 1A was 94 (92-96)% at the first stage; in Group 1B it was 94 (92.5-97.5)%; perioral cyanosis was observed in all

children; at the 2nd-6th stages, it was characterized by stability: 96-98%, taking into account the fact that 5 children from Group 1A, 3 children from Group 1B, 1 child from Group 2B were placed in ALV, and all children, at a certain stage, received oxygen therapy in the form of insufflation of moistened oxygen through a facial mask or nasal cannula/catheter. The respiratory rate (RR) on admission, was 50 (43-60) in Group 1A, 52 (40-60) in Group 1B, respectively; in Group 2A, it was 48 (42-51) and in Group 2B, 40 (36-47), respectively. So, the RR was increased by 50-100% of the age norm on the children's admission to the Department.

On the children's admission to the ICU, corresponded to the 1st degree and progressed in the course of the background intensive therapy. Thus, in Group 1A, Hbart was 100.1±4 at the 1st stage, 95±2.4, p=0.1 at the 4th stage (prior to PP), 102.3±2.8 (g/l) at the 5th stage; in Group 1B, it was 110.9 ±2.3, 103.1±2.0, p=0,01, and 103.4±2.3 (g/l), respectively. In the comparison group, anemia was less pronounced, although statistically insignificant. Thus, in Group 2A, Hbart was 110±3.6 at the 1st stage, 105.1±4.3 (g/l) at the 5th stage; in Group 2B, it was 112.4±2.5 and 107.5±4.1 (g/l), respectively. RBC transfusion was administered to 13 children from Group 1A (56.5%), 11 children from Group 1B (42.3%), 2 children from Group 2A (11.8%), 2 children from Group 2B (8.3%), i.e. the need in the RBC transfusion was statistically more significant in the children from the treatment group, $p<0.05$.

CaO_2 did not change in the preschool-age children in the course of IC and remained lower than in the control group by 20.9% (1st stage) and 19.2% (6th stage) in Group 1 and by 18% (1st stage), 20.3% (5th stage) in Group 2, mostly due to the 1st-degree anemia. The arterial oxygen content was statistically significantly different in subgroups A on Day 2 of BT: it was lower in the study group mainly due to a low hemoglobin level; the ROC-analysis revealed the discrimination point $CaO2 \leq 126$ ml/100 ml, Se=54.5, Sp=93.7, AUC=0.724, p=0.033; calculated OR=26.3 (2.2-314.5), RR=10.2 (1.32-78.7); statistically significant relationship (p=0.02). CvO_2 also remained without statistically significant changes in the course of IC and, when compared with the control group, was decreased at the 1st stage by 26.4% and 23.2% in Groups 1B and 2B, respectively, and by 25.3% and 25% in Groups 1A and 2A. In the course of IC, O_2DI had a tendency to normalization (Tab. 2). Table 2 shows that, in the comparison group, until Day 5 of therapy, the O_2DI value had been normalized. In the course of IC, O_2CI had a tendency to normalization in the treatment group. In the comparison group, until Day 5 of therapy, the O_2CI had a tendency to normalization in the infants, in Subgroup 2B, it increased (Tab. 2).

Table 2. Oxygen transport values in infants and preschool-age children at the stages of the study

Factor	Group	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
O_2CI, ml/min/m^2	1A	204,6(157,3-385,2)	245,95 (197,45-297,84)	256 (180,55-319,46)	220,0 (181,6-246,2)	219,4 (158,76-275,9)	197,23 (170,67-236,64)
	1B	235,95 (147,5-288,85)	193,35 (175,65-226,3)	229,1 (108,4-355,9)	227,6 (167,3-338,31)	220,3 (163,9-275,5)	197,5 (158,2-249,4)
	2A	252,55 (210,92-362,0)	205,85 (153,14-281,3)	238,3 (186,4-259,8)	224,4 (210,67-303,12)	202,15 (118,73-301,55)	
	2B	159,15 (119,6-201,4)	145,7 (117,1-171,9)	157,9 (116,0-236,5)	177,98 (133,34-227,7)*	194,8 (109,87-221,49)*	
	3A	186,62 (159,94-206,35)					
	3B	167,39 (155,76-185,33)					
O_2DI, ml/min/m^2	1A	792,5 (537,6-931,6)	696,8 (631,8-867,2)	703,8 (617,0-830,0)	689,75 (617,85-824,5)	708,9 (664,2-818,0)	686,8 (625,15-870,65)
	1B	899,11 (800,7-976,3)	772,8 (702-883,2)	788,85 (437,5-845,8)	811 (713-900,5)	708 (643,4-796)	725,2 (618,5-837)
	2A	880(759,56-1001,45)	701,6 (688,2-792,9)	813,9(688,75-1172,4)	804,0 (597,96-1026,1)	656,4 (582,34-1047,9)	
	2B	870,9(773,4-984,9)	796,0 (681,6-814,2)	726,6 (580-734,6)	726,6(653-817,7)	629,3(485-723)*	
	3A	755,76 (707,94-778,36)					
	3B	623,27 (540,24-737,77)					

Discussion. Following characteristics are typical for children with the 3rd-4th degree CCAP at the early stages of the disease course: hyperdynamic type of circulation due to tachycardia, mild hypoxemia (SpO_2=92-94%), subcompensated and compensated metabolic acidosis, increased oxygen delivery and consumption, 1st-degree anemia. Differences in the HR and CaO_2 between the study and the comparison groups in infants and the absence of these differences in preschool-age children may probably indicate a more severe course of pneumonias in children aged 1-3 years due to less adaptive capabilities in younger children than in older ones. CI and SVI monitoring allows to reveal achieving the goal of intensive care in children with community-acquired pneumonia on a timely basis [5]. According to a study by FAN Juan et al. [6] where hemodynamic parameters were compared in children with severe pneumonia and in the group of children with mild pneumonia, it was found that the

study group had a significantly higher HR level and lower cardiac output than in the control group ($P<0.05$); there were no significant differences in CI ($P>0.05$). In the study group, the HR, the cardiac output, and the cardiac index improved significantly after treatment ($P<0.05$), which was also found in our study. In a study by Yu Kawai et al. [16], when using plasmapheresis in children with sepsis-induced MODS (pneumonia in 13 out of 14 children) placed on extracorporeal life support, a relationship was found between the use of PP and the functional recovery of organs (regression of multiple organ dysfunction), an improvement of hemodynamic status, and a decrease in the need for vasoactive and/or inotropic drugs. Thus, our results are consistent with the published studies regarding the potential benefit of plasmapheresis in the terms of influencing hemodynamics.

The clinical signs of Grade II respiratory failure are as follows: shortness of breath of expiratory or inspiratory nature; it may be of a mixed nature with the participation of accessory muscles; the respiratory rate increases by 50-100% of the age norm; perioral cyanosis appears, as well as tachycardia; the blood oxygen saturation is about 90%, but not lower [7]. Therefore, in our study of children with CCAP aged 1-7, 2nd-degree respiratory failure was observed. According to the recommendations of the British Thoracic Society, oxygen therapy is prescribed for children with pneumonia at $SpO_2 \leq 92\%$ [17], however, in our opinion, the need to supply moistened oxygen through a nasal catheter or facial mask arises somewhat earlier: at $SpO_2 \leq 94\%$ and the clinical signs of the 2nd-degree respiratory failure. Thompson M. et al. also note that $SpO_2 < 94\%$ is one of the signs of severe infection development in children [18].

The arterial/venous oxygen content differed with lower values both in the control group and in the study and comparison groups due to the hemoglobin value that was lower than the reference one of 140 g/l used in the formula [12], which may indicate the need to specify the above criterion values in terms of the hemoglobin level in the absence of anemia.

Conclusions. The PP performance contributes to the restoration of circulatory normodynamia (mainly due to tachycardia regression, the CI value is normalized), does not cause arterial hypotension; after its performance, a tendency to a decrease in oxygen delivery and consumption is observed, as well as base deficit reduction; the discrete PP performance is associated with more frequent need in RBC transfusions. In infants, the values of HR>137 bpm during Day 1 of IC or HR>129 bpm and/or $CaO_2 \leq 126$ ml/100 ml during Day 2 of BT may be considered to be the risk factors of PP prescription. However, there is a need for further studies to confirm our findings.

Conflict of interest: none.

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