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Sylwia Małgorzewicz[1], Danuta Rudnik-Czarnecka[2],
Ewa Aleksandrowicz-Wrona[1], Wiesława Łysiak-Szydłowska[1]

Elements of the Antioxidant Barrier and Nutritional Status of Children with Pneumonia

Elementy bariery antyoksydacyjnej oraz stan odżywienia dzieci chorych na zapalenie płuc

[1] Department of Clinical Nutrition, Medical University of Gdańsk, Poland
[2] Pediatric Unit City Hospital of Gdynia, Poland

Abstract

Background. Advances in recent years have resulted in more effective treatment of lower respiratory tract infections in children; however, pneumonia is still one of the most common illnesses of childhood. This study focused on the assessment of the antioxidant barrier, inflammation intensity, and nutritional status in children with pneumonia.
Material and Methods. The study was carried out on 152 children with pneumonia treated at the Pediatrics Department of the Gdynia City Hospital and 53 children without any infection symptoms, who formed the control group. The tests were performed at the beginning of hospital treatment and after the clinical signs of disease had subsided, about four weeks after diagnosis. The tests included serum concentrations of prealbumin, albumin, alpha 1-acid glycoprotein, glutathione, C-reactive protein, and vitamin E. Urea and creatinine excretion were determined in urine in order to calculate the catabolic index, the ratio of urea to creatinine. The prognostic inflammatory and nutritional index was also calculated. Nutritional status of the children was assessed using centile charts according to Kopczynska-Sikorska.
Results. In the groups of children with infection, increases in C-reactive protein and alpha 1-acid glycoprotein levels and decreases in albumin and prealbumin levels were observed during the first phase of disease compared with the control group. A gradual normalization of these parameters followed treatment. Changes in mean glutathion and vitamin E concentrations were not statistically significant during the observation. The catabolic and prognostic inflammatory and nutritional indexes in all patients were significantly elevated ($p < 0.05$) compared with the controls.
Conclusions. In the case of infectious diseases such as pneumonia, essential information about health status should be gathered based on comprehensive patient evaluation, which means determining inflammation markers, nutritional status, and the antioxidant barrier (**Adv Clin Exp Med 2007, 16, 3, 375–382**).

Key words: pneumonia, oxidative stress, nutritional status.

Streszczenie

Wprowadzenie. Leczenie zakażeń dolnych dróg oddechowych u dzieci jest coraz bardziej skuteczne, ale mimo postępu w tej dziedzinie zapalenie płuc jest jedną z najczęstszych chorób wieku dziecięcego.
Cel pracy. Ocena bariery antyoksydacyjnej, nasilenia stanu zapalnego oraz stanu odżywienia u dzieci chorych na zapalenie płuc.
Materiał i metody. Zbadano 152 dzieci chorych na zapalenie płuc leczonych na Oddziale Dziecięcym Szpitala Miejskiego w Gdyni oraz 53 dzieci bez cech zakażenia, które należały do grupy kontrolnej. Dzieci podzielono na 3 grupy wiekowe. Badania wykonywano na początku leczenia szpitalnego oraz po ustąpieniu klinicznych objawów choroby, około 4 tygodnie od rozpoznania. Oznaczano stężenie w surowicy prealbuminy, albuminy, alfa 1-kwaśnej glikoproteiny (AGP), glutationu (GSH), białka C-reaktywnego (CRP) oraz witaminy E. W moczu oznaczano wydalanie mocznika i kreatyniny w celu obliczenia indeksu katabolicznego. Ponadto obliczano współczynnik prognostyczny zapalenia i odżywienia (PINI). Stan odżywienia oceniano za pomocą siatek centylowych wg Kopczyńskiej-Sikorskiej.
Wyniki. W początkowym okresie choroby w badanych grupach dzieci chorych stwierdzono wzrost stężenia CRP i AGP oraz obniżenie albumin i prealbuminy w stosunku do grupy kontrolnej oraz obserwowano stopniowy powrót tych wskaźników do wartości prawidłowych pod wpływem leczenia. Średnie stężenia GSH oraz witaminy E nie zmieniały się istotnie statystycznie w czasie obserwacji. Indeks kataboliczny oraz PINI były u wszystkich chorych dzieci znamiennie podwyższone ($p < 0.05$) w stosunku do dzieci zdrowych.

Wnioski. W przypadku chorób infekcyjnych, takich jak zapalenie płuc, jest wskazana kompleksowa ocena pacjenta pod względem nasilenia stanu zapalnego, ocena stanu odżywienia oraz bariery antyoksydacyjnej (**Adv Clin Exp Med 2007, 16, 3, 375–382**).

Słowa kluczowe: zapalenie płuc, stres oksydacyjny, stan odżywienia.

Advances in recent years have resulted in more effective treatment of lower respiratory tract infections in children. However, pneumonia is still one of the most common illnesses of childhood. The development of inflammatory changes in the respiratory tract mucosa and the occurrence of unfavorable symptoms accompanying inflammation are caused by very complex mechanisms which depend on the release of inflammatory mediators. The most important mediators of the vascular phase of inflammation include histamine, kinins, prostaglandins, leukotriens, platelet-activating factor (PAF), and nitric oxide. Neutrophils and eosinophils stimulated by cytokines release highly toxic proteins, lizosomal enzymes, neutral proteases, and oxygen radicals. Cytokines and neuropeptides also play significant roles in the development and intensity of chronic inflammation in the respiratory tract and, moreover, they can induce the development of allergic processes [2–4].

The presence of the inflammatory process in an organism is associated with an increased production of free radicals and the synthesis of acute-phase proteins such as alpha 1-acid glycoprotein, alpha 1-antitripsin, alpha 2-macroglobulin, haptoglobin, ceruloplasmin, and C-reactive protein (CRP). Negative acute-phase proteins, i.e. prealbumin, albumin, and transferrin, can also be applied as markers of nutritional status [5]. Hanson [6] showed that CRP was the most sensitive among the examined acute-phase indicators (compared with alpha 1-antitripsin, haptoglobin, alpha 1-acid glycoprotein, prealbumin, and transferrin) and it demonstrated the earliest response to recovery.

Studies by Sauwerwin et al. [7] indicate that in children showing signs of protein-caloric malnutrition, a substantially greater intensity of inflammatory process was observed than in children with good nutritional status. The PINI (Prognostic Inflammatory and Nutrition Index) is one of the parameters which can be used to evaluate the relationship between nutritional status and the level of inflammatory processes [8, 9]. Severe and also mild under-nutrition can be the cause of defense mechanism impairment of the organism in a disease situation. This affects the patient's clinical status and response to treatment and often leads to complications and prolongation of recovery. The aim of this study was an evaluation of nutritional status, selected elements of the antioxidant barrier, and inflammatory state in children diagnosed with pneumonia.

Material and Methods

One hundred fifty-two children, patients of Gdynia City Hospital, diagnosed with pneumonia were examined. Diagnosis of pneumonia was based on the chest X-ray. The control group consisted of 53 healthy children. Laboratory tests were performed within the first three days of hospital admission (t = 0) after confirmation of pneumonia and four weeks after the diagnosis (t = 1). The patients were divided into three groups according to age: 0–3 months (group I), 4–12 months (II), and over 12 months to 14 years of age (III). Antibiotics (cephalosporin II and III generation group) were used intravenously at the beginning of hospitalization. The therapy was subject to change depending on bacteriological test results.

The control group consisted of 53 healthy children who were admitted for check-ups. Infection in these children was excluded based on physical examination and laboratory tests: complete blood count with differential counts, CRP, urine analysis, and urine culture. The ages of the healthy children ranged from 3 months to 14 years. The healthy children were also divided into three age groups, analogously to sick children.

Clinical Features and Etiology

In the majority (79%) of the children admitted to hospital because of illness, typical signs of pneumonia on auscultation were found; in 12.5% the dominating symptom was bronchial obturation and in 8.5% of the cases episodes of cyanosis and respiratory distress were detected. In the youngest group the cause of pneumonia was most often *Enterobacteriacae* development, then *Staphylococus aureus*, *Escherichia coli*, and *Klebsiella*. In the oldest children, *Escherichia coli* was the most frequently found in bacteriological tests, then *Enterobacteriacae*, *Streptoccocus pneumoniae*, *Staphyloccocus aureus* and, sporadically, *Seratia marcescens*.

In all the patients, the serum concentrations of prealbumin, albumin, alpha 1-acid glycoprotein (AGP), glutathione (GSH), CRP, and vitamin E as well as the urine concentrations of urea and creatinine (measured by colorimetric methods) were determined. The catabolic index was calculated as the ratio of excreted urea to creatinine in a single urine sample. Prealbumin, CRP, and alpha 1-acid glycoprotein concentrations were measured in serum using the immunoturbidimetric method (Boeringer Manheim test sets). Glutathione concentration was measured by a colorimetric method (Calbiochem test sets). Albumin concentration was determined by the Cormay Albumin test set. Vitamin E plasma concentration was measured by the Hansen and Warwic method [10]. The prognostic Inflammatory and Nutrition Index (PINI) was calculated according Ingenbleek [8].

PINI = alpha 1 AGP × CRP/albumin × prealbumin

The reference value of PINI was 0.28–0.47 [11]. The tests were performed in the laboratories of the Gdynia City Hospital and the Department of Clinical Nutrition and Diagnostics Laboratory, Medical University of Gdansk.

The material for the biological tests was collected by aspiration of the upperrespiratory tract. Susceptibility to antibiotics was determined on cultured microorganisms.

Nutritional status was assessed using the centile charts for girls and boys according to Kopczyńska-Sikorska [1]. Values contained between the 25th to 75th centiles were assumed to be within the narrow normal range, which should include 50% of weight measurements according to age during the normal development of a child.

Statistics

The data were expressed as the mean ± *SD* (standard deviation). Significant differences were defined with $p < 0.05$. Correlation and statistical significance were evaluated using non-parametric tests included in the commercial software Statistica 6.0 (licensed to the Department of Clinical Nutrition, No. ABPP609739329AR).

Results

The results obtained in group I of patients (0–3 months of age) are shown in Table 1. Confirming the disease characteristics, a low level of prealbumin, significantly elevated levels of inflammation

Table 1. The concentrations of the studied parameters of nutritional status, acute-phase proteins, and oxidative stress in children 0–3 months of age (group I)

Tabela 1. Stężenie badanych wskaźników stanu odżywienia, białek ostrej fazy i stresu oksydacyjnego w grupie dzieci 0–3 miesięcy (grupa I)

Parameters (Wskaźniki)	Patients 0–3 months (Pacjenci 0–3 mies.) n = 49		Controls (Grupa kontrola) n = 11
	t = 0	t = 1	
Prealbumin – mg/dl (Prealbumina – mg/dl)	10.3 ± 8.6	12.1 ± 9.3	13.4 ± 6.7
Albumin – g/dl (Albumina – g/dl)	3.6 ± 0.4	3.8 ± 0.3	3.7 ± 0.3
Alpha 1-acid glycoprotein – mg/dl (Alpha 1-kwaśna glikoproteina – mg/d)	49.8 ± 34.4**	40.3 ± 20.5	24.9 ± 18.0*
Glutathione – nmol/gHb (Glutation – nmol/gHb)	5.6 ± 3.5	5.8 ± 3.4	5.0 ± 2.4
CRP – mg/dl (CRP – mg/dl)	2.0 ± 4.5**	0.9 ± 2.1	0.6 ± 0.5*
Vit. E – µg/ml (Witamina E – µg/ml)	12.6 ± 5.5	13.1 ± 8.3	13.8 ± 8.9
Catabolic index (Indeks kataboliczny)	28.0 ± 15.4	30.0 ± 29.0	25.9 ± 10.8
PINI (Prognostyczny współczynnik zapalenia i odżywienia)	53.7 ± 158.4**	12.9 ± 41.5	0.3 ± 0.5*

The data are expressed as mean ± *SD*.
Control vs. children with pneumonia, * $p < 0.05$.
T = 0 vs. t = 1, ** $p < 0.05$.
T = 0 measurements during the first 3 days after hospital admission.
T = 1 measurements after 4 weeks of treatment.

Dane są wyrażone jako średnia ± odchylenie standardowe.
Grupa kontrolna *vs* dzieci z zapaleniem płuc, * $p < 0,05$.
T = 0 *vs* t = 1, ** $p < 0,05$.
T = 0 pomiary wykonane w czasie 3 pierwszych dni po przyjęciu do szpitala.
T = 1 pomiary wykonane po 4 tygodniach leczenia.

markers (CRP and alpha 1 AGP), and a high value of PINI were observed in this group at the time of hospital admission. The levels of GSH, vitamin E, albumin, and the urea/creatinine index were similar to those obtained in the group of healthy children of the same age. The receding of clinical signs was mainly associated with considerable decreases in CRP, alpha 1 AGP, and PINI; however, these parameters were still elevated compared with the healthy controls.

In group II the inflammation symptoms were accompanied by elevated levels of alpha 1 AGP, CRP, and PINI and a high catabolic index. Low levels of prealbumin were observed. The decline of clinical symptoms of inflammation was associated with a partial return of these parameters to the values observed in healthy children. Similarly to group I, albumin and GSH levels were comparable to those of the healthy children.

In patient group III the levels of the acute-phase markers (CRP and alpha 1 AGP) were found to be the highest compared with groups I and II, and elevated values of PINI and the catabolic index were also observed. Moreover, a statistically significant difference ($p < 0.05$) between mean prealbumin concentrations in patients and healthy children was found. In this age group a decrease in GSH concentration in children with infection compared with healthy children was observed. Levels of albumin and vitamin E did not differ between the patients and healthy controls in this age group.

After four weeks of treatment, when the clinical signs of pneumonia had diminished, the examined biochemical parameters (prealbumin, GSH, CRP, PINI, and the catabolic index) still had not returned to the values found in the healthy children. The mean prealbumin level was 10.3 mg/dl in the group of the youngest patients during the first phase of disease and it rose to 12.1 mg/dl during the period of clinical improvement, while in healthy children it reached 13.4 mg/dl. In group II, the level of prealbumin increased from 13.1 to 15.6 mg/dl (18.8 mg/dl in healthy children) during the observation period. In group III the results were similar to those obtained in group II. In all age groups, an increase in prealbumin levels was observed after four weeks of treatment. The increase was significantly lower in the infants compared with the other age groups. The results of tests in the control group were similar to reference values [12].

The mean albumin level at onset of the disease as well as after four weeks of observation was significantly lower in the youngest children compared with the other age groups. This observation is consistent with the trends described in the literature [1, 12]. The values of albumin obtained in the control group and in the patient groups, independent of clinical status, were within the normal range [12].

Alpha 1-acid glycoprotein level was also found to be lowest in the youngest group. It decreased significantly in all age groups subsequent to treatment ($p < 0.05$). However, the mean values were significantly higher than those of the control group (with the exception of children in group III, whose alpha AGP levels returned to the normal range after four weeks; Table 3). The mean AGP level was 24.9 ± 18.0 in the youngest infants, 44.3 ± 23.3 in group II, and 46.4 ± 28.4 in the oldest children, this being similar to the reference values for adults (25–135 mg/dl) [13].

GSH levels in the different phases of disease analyzed independently of the age group of the children did not show significant changes, displaying a high scattering of results at the same time, especially in the patient groups. The mean GSH concentrations in group III were significantly lower ($p < 0.05$) than in the controls (Table 3).

The lowest initial levels of vitamin E were found in patient group III (Table 3). In group II the mean vitamin E level was 13.4 μg/ml and differed significantly from the level measured after four weeks (10.0 μg/ml) and in healthy children (17.8 μg/ml). The observed difference in vitamin E concentrations in children after treatment compared with those in healthy children was statistically significant (Table 2). In the oldest children an increase in vitamin E level from 9.0 do 12.2 μg/ml occurred during the observation period. The level measured at $t = 1$ was not different from the level in the control group. The vitamin E levels both in the controls and in the patient groups were within the reference range (2.0–9.0 μg/ml) or even exceeded it [12].

PINI and the catabolic index in all the patients were elevated compared with the healthy controls. High PINI values were also found in the group of children with malnutrition. The mean PINI values in all age groups showed a declining tendency after four weeks from diagnosis, in the period when the clinical symptoms were subsiding, but the values remained elevated in comparison with the control group. The PINI level in the groups of healthy children was low, with values ranging from 0.2 to 0.4, similarly to those reported by Pressac [11]. According to Ingenbleek [8], values below 1.0 are characteristic of healthy and well-nourished people, and a level above 21.0 is associated with high-risk patients.

Nutritional State and Examined Parameters

A high degree of malnourishment was not observed in the population of the patients of this

Table 2. The concentrations of the studied parameters of nutritional status, acute-phase proteins, and oxidative stress markers in children 4–12 months of age (group II)

Tabela 2. Stężenie badanych wskaźników stanu odżywienia, białek ostrej fazy i stresu oksydacyjnego w grupie dzieci 4–12 miesięcy (grupa II)

Parameters (Wskaźniki)	Patients 4–12 months (Pacjenci 4–12 mies.) n = 39		Controls (Grupa kontrola) n = 8
	t = 0	t = 1	
Prealbumin – mg/dl (Prealbumina – mg/dl)	13.1 ± 8.8	15.6 ± 12.6	18.8 ± 4.5*
Albumin – g/dl (Albumina – g/dl)	4.0 ± 0.4	4.0 ± 0.3	4.2 ± 0.4
Alpha 1-acid glycoprotein – mg/dl (Alpha 1-kwaśna glikoproteina – mg/d)	72.2 ± 44.7	76.3 ± 40.7	44.3 ± 23.3*
Glutathione – nmol/gHb (Glutation – nmol/gHb)	6.5 ± 4.9	5.1 ± 2.3	6.1 ± 2.5
CRP – mg/dl (CRP – mg/dl)	1.2 ± 1.8	0.7 ± 0.9	0.4 ± 0.8
Vit. E – μg/ml (Witamina E – μg/ml)	13.4 ± 7.2	10.0 ± 5.2	17.8 ± 7.5*
Catabolic index (Indeks kataboliczny)	36.6 ± 18.4**	31.6 ± 18.9	29.4 ± 14.0
PINI (Prognostyczny współczynnik zapalenia i odżywienia)	60.8 ± 203.8**	6.9 ± 16.8	0.4 ± 0.8*

The data are expressed as mean ± *SD*.
Control vs. children with pneumonia, * $p < 0.05$.
T = 0 vs. t = 1, ** $p < 0.05$.
T = 0 measurements during the first 3 days after hospital admission.
T = 1 measurements after 4 weeks of treatment.

Dane są wyrażone jako średnia ± odchylenie standardowe.
Grupa kontrolna *vs* dzieci z zapaleniem płuc, * $p < 0,05$.
T = 0 *vs* t = 1, ** $p < 0,05$.
T = 0 pomiary wykonane w czasie 3 pierwszych dni po przyjęciu do szpitala.
T = 1 pomiary wykonane po 4 tygodniach leczenia.

study. Eleven percent of the children showed nutritional status below the 3rd centile (group C) and in 19% of the children it was in the range of the 3rd–25th centile (group B). In the patients, who differed in nutritional status (Table 4), no statistically significant changes in the levels of prealbumin, alpha 1 AGP, vitamin E, and albumin were found. The level of GSH was significantly higher in the children with good nutritional status ($p < 0.05$). However, differences between the groups were found regarding the values of CRP, PINI, and catabolic index: these parameters were higher in malnourished children (groups B and C) compared with the well-nourished (group A), as indicated in Table 4.

Discussion

The nutritional status in the studied groups of children was good. Only 14 children were classified below the 3rd centile. No severely malnourished children were found among those examined, though the population included children whose body weights differed by 2 standard deviations from the mean value for the appropriate age. The intake of various nourishing elements, including microelements and antioxidants, could be abnormal in these children, even though the mean vitamin E levels did not indicate its deficiency. The results regarding vitamin E concentrations do not allow drawing conclusions about the role of this vitamin in the phase of diagnosis and intensive therapy of pneumonia in children [14–16]. However, a very low plasma concentration level of vitamin E seems to be a suitable parameter to confirm severe malnutrition [17–20].

It was found that even though the clinical and radiological signs of pneumonia had diminished, some of the parameters did not return to their normal values, for example CRP. After four weeks of treatment a significant decrease in the mean CRP values was observed compared with the values at the onset of the disease, though the values were still considerably higher than those in the control group (Tables 1–3). Similar trends were noted in AGP, PINI, and the catabolic index. Opposite trends were observed in prealbumin levels: there

Table 3. The concentrations of the studied parameters of nutritional status, acute-phase proteins, and oxidative stress in children from 12 months to 14 years of age (group III)

Tabela 3. Stężenie badanych wskaźników stanu odżywienia, białek ostrej fazy i stresu oksydacyjnego w grupie dzieci powyżej 12 miesięcy do 14. roku życia (grupa III)

Parameters (Wskaźniki)	Patients > 12 months–14 years (Pacjenci > 12 mies.–14 lat) n = 64		Controls (Grupa kontrola) n = 34
	t = 0	t = 1	
Prealbumin – mg/dl (Prealbumina – mg/dl)	14.1 ± 10.3	18.2 ± 16.3	22.3 ± 10.1*
Albumin – g/dl (Albumina – g/dl)	4.0 ± 0.4	4.2 ± 0.4	4.1 ± 0.4
Alpha 1-acid glycoprotein – mg/dl (Alpha 1-kwaśna glikoproteina – mg/d)	76.3 ± 42.9**	46.4 ± 33.1	46.4 ± 28.4
Glutathione – nmol/gHb (Glutation – nmol/gHb)	5.2 ± 2.7	5.0 ± 70.0	7.8 ± 5.8*
CRP – mg/dl (CRP – mg/dl)	2.4 ± 5.2**	0.5 ± 0.6	0.3 ± 0.5*
Vit. E – μg/ml (Witamina E – μg/ml)	9.0 ± 2.7	12.2 ± 7.0	12.2 ± 5.8
Catabolic index (Indeks kataboliczny)	31.2 ± 27.4**	25.3 ± 19.5	21.3 ± 12.5*
PINI (Prognostyczny współczynnik zapalenia i odżywienia)	53.8 ± 212.7**	11.2 ± 35.2	0.2 ± 0.5*

Control vs. children with pneumonia, * $p < 0.05$.
T = 0 vs. t = 1, ** $p < 0.05$.
T = 0 measurements during the first 3 days after hospital admission.
T = 1 measurements after 4 weeks of treatment.

Grupa kontrolna *vs* dzieci z zapaleniem płuc, * $p < 0,05$.
T = 0 *vs* t = 1, ** $p < 0,05$.
T = 0 pomiary wykonane w czasie 3 pierwszych dni po przyjęciu do szpitala.
T = 1 pomiary wykonane po 4 tygodniach leczenia.

Table 4. Mean values of the studied parameters depending on nutritional status

Tabela 4. Średnie wartości badanych wskaźników w zależności od stanu odżywienia

Nutritional status (Stan odżywienia)	Group C (Grupa C) < 3rd centile n = 14	Group B (Grupa B) 3rd–25th centile n = 23	Group A (Grupa A) > 25th centile n = 80
Prealbumin – mg/dl (Prealbumina – mg/dl)	12.6 ± 8.3	13.7 ± 15.2	12.0 ± 12.1
Albumin – g/dl (Albumina – g/dl)	4.0 ± 0.3	4.0 ± 0.5	3.8 ± 0.5
Alpha 1-acid glycoprotein – mg/dl (Alpha 1-kwaśna glikoproteina – mg/d)	84.9 ± 9.3	75.8 ± 68	80.9 ± 47.3
Glutathione – nmol/gHb (Glutation – nmol/gHb)	5.2 ± 2.7	5.1 ± 3.1	5.9 ± 4.3**
CRP – mg/dl (CRP – mg/dl)	3.9 ± 8.5*	1.6 ± 2.3	1.3 ± 3.5
Vit. E – μg/ml (Witamina E – μg/ml)	10.8 ± 2.0	11.1 ± 9.4	11.7 ± 6.0
Catabolic index (Indeks kataboliczny)	47.8 ± 48.5*	30.5 ± 15.9	28.9 ± 15.2
PINI (Prognostyczny współczynnik zapalenia i odżywienia)	105.5 ± 291.7	121.2 ± 353	57.4 ± 196**

The data are expressed as mean ± *SD*.
* $p < 0.05$, C vs. AB.
** $p < 0.05$, A vs. BC.

Dane są wyrażone jako średnia ± odchylenie standardowe.
* $p < 0,05$, C *vs*. AB.
** $p < 0,05$, A *vs*. BC.

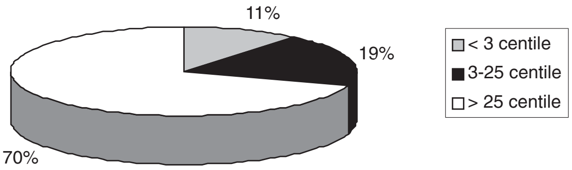

Fig. 1. Nutritional status in children with pneumonia using the centile charts according to Kopczynska-Sikorska [1]

Ryc. 1. Stan odżywienia dzieci z zapaleniem płuc mierzony za pomocą siatek centylowych według Kopczyńskiej-Sikorskiej [1]

was a significant decrease in prealbumin content in the acute phase of the disease compared with the values in the control group. The increase in prealbumin concentration in the subsequent measurement still did not reach the level observed in the control group. Prealbumin level is a measure of nutritional status, but it has to be borne in mind that the production of prealbumin can be inhibited by the presence of inflammation [17].

Albumin levels in all patients were slightly reduced at the onset of disease in comparison with the control group, although their levels later rose (Tables 1–3). GSH levels in patient groups II and III were lower than in the control group, and in group I they were insignificantly higher. These results can be explained by the process of intensified degradation of erythrocytes containing fetal hemoglobin and by a greater manifestation of inflammation in the youngest group of children [21]. On the basis of the results obtained in the groups of older children (groups II and III) it can be assumed that the inflammatory process is associated with a decline in the serum level of GSH. Other studies also showed a large drop in total antioxidant potential (including glutathione concentration) at the onset of infection [22].

The catabolic index in all age groups was higher during the disease than in the corresponding control groups. The value of the catabolic index is influenced by the dynamics of the disease. The presence of proinflammatory cytokines results in increased muscle protein degradation, which causes a rise in urea excretion and the index value also increases. In all patient groups the index value was considerably higher in the first phase of the disease and decreased during therapy, but it did not reach the values observed in the control groups. This indicates that the catabolic process persists, with a lower intensity, also after clinical improvement has been achieved. The catabolic index is a simple, unburdensome test and it can be used as an indicator of the current catabolic state in an organism [8, 11].

PINI was elevated in all patient groups compared with the control groups. This index can be a helpful indicator in monitoring the inflammation status and the effectiveness of the therapy. PINI reveals the presence of inflammatory process even though the components used for calculating the index are still within the normal range. It is especially useful in patients when protein-caloric malnutrition coexists with an inflammatory process [11, 23].

The analysis of the other parameters shows that in well-nourished children, lower values of the catabolic index and PINI were observed than in malnourished ones. However, there were no significant differences between mean albumin and prealbumin concentrations of well-nourished children compared with malnourished (Table 4).

In all the examined children the disease ended in recovery; however, it has to be noted that after the treatment was finalized, the organism's disturbed homeostasis had not returned to normal and the children entered the convalescence phase.

The authors concluded that in infectious diseases such as pneumonia, essential information about health status should be gathered based on comprehensive patient evaluation, which means the determination of inflammation markers, indicators of nutritional status, and the antioxidant barrier. The most sensitive, single biochemical markers of inflammation in an organism is CRP and alpha 1-acid glycoprotein [5]. From a clinical point of view it seems that PINI and the catabolic index could be more valuable markers.

References

[1] **Kopczyńska-Sikorska J:** Normy w pediatrii. PZWL, Warszawa 1996.

[2] **Duarte DM, Botelho C:** Clinical profile in children under five year old with acute respiratory tract infections. Jornal de Pediatria 2000, 76 (3), 207–212.

[3] **Funke A, Berner R et al.:** Frequency natural course and outcome of neonatal neutropenia. Pediatrics 2000, 106, 60–69.

[4] **Kabra SK, Singhal T, Lodha R:** Pneumonia. Indian J Pediatr 2001, 68 Suppl., 19–23.

[5] **Smith RP, Lipworth BJ:** C-reactive protein in simple community-acquired pneumonia. Chest 1995, 107, 1028–1031.

[6] **Hansson LO, Hedlund JU, Ortquist AB:** Sequential changes of inflammatory and nutritional markers in patients with community-acquired pneumonia. Scand J Clin Lab Invest 1997, 57, 111–118.

[7] **Sauwerwein RW, Mulder L, Lowe B, Peschu N, Denacker PN, Van Der Meer JW, Marsch K:** Inflammatory mediators in children with protein-energy malnutrition. Am J Clin Nutr 1997, 65, 1534–1539.
[8] **Ingenbleek Y, Carpentier YA:** A prognostic inflammatory and nutritional index scoring critically ill patients. Int J Vitam Nutr Res 1985, 55, 91–101.
[9] **Jacob RA, Burri J:** Oxidative damage and defence. Am J Clin Nutr 1996, 63, 91–101.
[10] **Hansen LG, Warwick WJ:** A fluorimetric micromethod for serum vitamins A and E. Am J Clin Pathol 1978, 70, 922–923.
[11] **Pressac M, Vignoli L, Aymard P, Ingenbleek Y:** Usefulness of prognostic inflammatory and nutritional index in pediatric clinical practice. Clin Chim Acta 1990, 188, 129–136.
[12] **Soldin SJ, Brugnara C, Gunter KC, Hicks JM:** Pediatric Reference Ranges. AACC Press Washington 1997.
[13] **Burtis CA:** Clinical Chemistry Research. Wood WB. Saunders Company 1994.
[14] **Kelly F:** Use of antioxidants in the prevention and treatment of disease. JIFCC 1998, 1, 21–23.
[15] **Ondreicka R, Beno I, Cerna O, Grancikova E, Staruchova M,Volkovova K, Bobek P, Tatara M:** Relation between levels of vitamins C, E, A and beta-carotene and activity of antioxidant enzymesin blood. Bratisl Lek Listy 1998, 99, 250–254.
[16] **Pacht ER, Davis WB:** Failure of high-dose vitamin E to correctceruloplasmin ferroxidase deficiency in cigarette smokers. Am Rev Respir Dis 1990, 142, 1063–1067.
[17] **Rock CL, Jacob RA, Bowen PE:** Update on the biological characteristics of the antioxidant micronutrients: vitamin C, vitamin E, and the carotenoids. J Am Diet Assoc 1996, 96, 693–704.
[18] **Shakur S, Malek MA, Bano N, Islam K:** Zinc Status in Well Nourished Bangladeshi Children Suffering from Acute Lower Respiratory Infection. Indian Pediatr 2004, 41, 478–481.
[19] **Sies H, Stahl W:** Vitamin E and vitamin C, beta-carotene and other carotenoids as antioxidants. Am J Clin Nutr 1995, 62, 1315–1321.
[20] **Silva da R, Lopes EJ, Sarni RO, Taddei JA:** Plasma vitamin A levels in deprived children with pneumonia during the acute phase and after recovery. J Pediatr 2005, 81, 162–168.
[21] **Jurges ES, Henderson DC:** Inflammatory and immunological markers in preterm infants: correlation with disease. Clin Exp Immunol 1998, 105, 551–555.
[22] **Jerca L, Busuioc A, Nastasia G, Haulic I:** Glutathione a biochemical indicator for different types of cellular stress. Rev Med Chir Soc Med Nat Iasi 1996, 100, 143–147.
[23] **Moshage HJ, Janssen JAM, Franssen JH, Hafkenscheid JCM, YapSH:** Study of the Molecular Mechanism of Decreased Liver Synthesis of Albumin in Inflammation. J Clin Invest 1987, 79, 1635–1641.

Address for correspondence:

Sylwia Małgorzewicz
Department of Clinical Nutrition
Medical University
Debinki 7
80-211 Gdańsk
Poland
Tel.: +48 58 3492724
E-mail: sylwia@tetra.pl

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