

Original

Biochemical and functional indices of malnutrition in patients with operable, non-microcellular lung cancer

L. Piskorz¹, T. Lesiak², M. Brocki¹, E. Klimek-Piskorz³, J. Smigielski¹, P. Misiak¹ and S. Jablonski¹

¹Clinic of The Chest Surgery. General and Oncological Surgery. Medical University of Lodz Clinical Hospital. Poland. ²Clinic of Nephrology, Hypertension and Family Medicine. Medical University of Lodz Clinical Hospital. Poland. ³Department of Clinical Rehabilitation. University School of Physical Education. Krakow. Poland.

Abstract

Introduction: The aim of this study was to assess non-microcellular lung cancer patients' nutritional status impact on psychomotor performance, muscle strength and functional activity.

Material and methods: The study involved 60 consecutive patients admitted to the clinic for surgical treatment due to histologically verified non-microcellular lung cancer. The patients were divided, depending on the stage of weight loss, into two groups: relatively well-nourished — 29 patients and those with malnutrition — 31 patients. History, physical examination, anthropometric data, biochemical parameters as well as functional tests were carefully noted.

Results: Patients qualified for particular groups differed significantly in age, $p < 0.002$. Mean values of albumin, transferrin and total protein for the well nourished patients ranged within proper values. In the malnourished patients they were respectively: 34.05 ± 0.27 g/l, 1.764 ± 0.27 g/l, 68.90 ± 6.39 g/l and the differences were statistically significant. Total loss of urea nitrogen was significantly higher in malnourished patients 13.32 ± 2.92 g/l ($p < 0.005$). The average percentage weight loss in both groups differed significantly 0.111 ± 0.044 vs. 0.031 ± 0.028 at $p < 0.0005$. In the group of malnourished patients the right hand average strength was 26.52 ± 8.06 kg and the left one amounted to 25.35 ± 6.04 kg. The values were significantly lower than the results recorded in well nourished patients: 34.93 ± 11.27 kg, 32.37 ± 11.72 kg, $p < 0.001$. The tapping test average time of the right hand was 19.24 ± 4.04 vs. 16.72 ± 3.06 and of the left one 19.69 ± 3.59 kg vs. 17.48 ± 2.79 kg and were significantly longer in patients suffering from malnutrition ($p < 0.01$). Simple reaction times for dominating hand were longer in the group of patients with malnutrition, for the visual stimulus 0.50 ± 0.08 s vs. 0.45 ± 0.087 s, ($p < 0.05$) and for auditory one 0.43 ± 0.08 vs. 0.39 ± 0.08 s (non significant).

Conclusions: Malnutrition in the course of non-microcellular lung cancer significantly reduces psychomotor

ÍNDICES BIOQUÍMICOS Y FUNCIONALES DE MALNUTRICIÓN EN PACIENTES CON CÁNCER NO MICROCÍTICO DE PULMÓN OPERABLE

Resumen

Introducción: El propósito de este estudio fue evaluar el impacto del estado nutricional de pacientes con cáncer no microcítico de pulmón sobre el rendimiento psicomotor, la fortaleza muscular y la actividad funcional.

Material y métodos: el estudio incluyó 60 pacientes consecutivos ingresados en la clínica para tratamiento quirúrgico por histología comprobada de cáncer de pulmón no microcítico. Se dividió a los pacientes, dependiendo del estado de pérdida de peso, en dos grupos: pacientes relativamente bien nutridos — 29 pacientes, y aquellos con malnutrición — 31 pacientes. Se anotaron cuidadosamente la historia, la exploración física, los datos antropométricos, los parámetros bioquímicos y las pruebas funcionales.

Resultados: los pacientes que se clasificaban en grupos concretos diferían significativamente con respecto a la edad, $p < 0.002$. Los valores promedio de albúmina, transferrina y proteínas totales de los pacientes bien nutridos estaban dentro de los rangos adecuados. En los pacientes malnutridos, estos valores fueron, respectivamente: 34.05 ± 0.27 g/l, 1.764 ± 0.27 g/l, 68.90 ± 6.39 g/l, siendo las diferencias estadísticamente significativas. La pérdida total de nitrógeno ureico fue significativamente mayor en los pacientes malnutridos, 13.32 ± 2.92 g/l ($p < 0.005$). El porcentaje promedio de pérdida de peso en ambos grupos difería significativamente: 0.111 ± 0.044 vs. 0.031 ± 0.028 , $p < 0.0005$. En el grupo de pacientes malnutridos, la fuerza media de la mano derecha fue de 26.52 ± 8.06 kg y de la izquierda 25.35 ± 6.04 kg; estos valores fueron significativamente menores que los resultados registrados en los pacientes bien nutridos: 34.93 ± 11.27 kg, 32.37 ± 11.72 kg, $p < 0.001$. El promedio de tiempo en la prueba de golpear fue de 19.24 ± 4.04 vs. 16.72 ± 3.06 para la mano derecha y de 19.69 ± 3.59 kg vs. 17.48 ± 2.79 kg para la mano izquierda, siendo significativamente más prolongado en los pacientes con malnutrición ($p < 0.01$). Los tiempos de reacción simple para la mano dominante fueron más prolongados en el grupo de pacientes con malnutrición, para el estímulo visual 0.50 ± 0.08 s vs. 0.45 ± 0.087 s, ($p < 0.05$) y para el estímulo auditivo 0.43 ± 0.08 vs. 0.39 ± 0.08 s (no significativo).

Correspondence: Tomasz Lesiak.
113, Zeromskiego Street.
90-549 Lodz. Poland.
E-mail: tomasz.j.lesiak@gmail.com

Recibido: 13-XII-2010.
Aceptado: 1-II-2011.

function assessed by reaction time to visual and acoustic stimuli as well as efficiency of the functional tests evaluated by tapping test and muscle strength measurement.

(*Nutr Hosp.* 2011;26:1025-1032)

DOI:10.3305/nh.2011.26.5.5170

Key words: *Malnutrition. Lung cancer. Biochemical indices. Functional indices.*

Conclusiones: la malnutrición en el curso del cáncer de pulmón no microcítico reduce significativamente la función psicomotriz evaluada mediante el tiempo de reacción a estímulos visuales y acústicos así como la eficiencia de las pruebas funcionales mediante la medición de la prueba de golpear y la fuerza muscular.

(*Nutr Hosp.* 2011;26:1025-1032)

DOI:10.3305/nh.2011.26.5.5170

Palabras clave: *Desnutrición. Cáncer de pulmón. Índices bioquímicos. Índices funcionales.*

Introduction

In spite of progress in the field of identification, diagnostics and methods of treatment the problem of malnutrition is still a significant clinical issue deteriorating the outcome of treatment. Loss in muscle mass leads to decreased sensitivity to insulin, limits maximum oxygen consumption, results in lowering the level of metabolism, energy expenditure and muscle strength, which disables the patients in their everyday duties and seriously affects their mobility. Immobilisation is a negative prognostic factor and worsens the outcome of treatment.¹

Malnutrition in neoplastic disorders results from general symptoms of the disease, local tumor growth, psychogenic factors, neuro-endocrine and inflammatory "relations" between the patient and the cancer. Malnutrition and cachexia-anorexia syndrome are common in oncology, in the study conducted by Spanish Nutrition and Cancer Group, the presence of malnutrition in 64% of patients treated for cancer was revealed.² The consequences of malnutrition are: impaired ability to combat infection, low tolerance and reduced effectiveness of oncological treatment, increased toxicity of this treatment, increased incidence of postoperative complications, reduced quality of life, prolonged hospitalization and shortened survival.³ It should be noted that in operable cases of non-microcellular lung cancer a high degree of malnutrition is not a major clinical problem, most patients are properly nourished, or exhibit light malnutrition.⁴

In case of neoplastic cachexia with weight loss exceeding 10% of its initial value susceptibility to fatigue is increased, some indices of functional capacity aggravate. Limited mobility related to body mass loss, muscle strength weakening and corresponding

little physical activity caused by illness seriously affects patients' well-being and social life. Research in this area has the key meaning for creating new research tools for assessment of functional condition regardless of the stage of the disease. Assessment of functional efficiency should therefore be commonly used. To enable such procedure proper research tools should not only be correctly selected to measure the factors but also as little complicated and inexpensive as possible.

The aim of this study was to assess the impact of non-microcellular lung cancer patients' nutritional status on psychomotor performance, muscle strength and functional activity.

Material and methods

Characteristics of the group

The study included 60 consecutive patients admitted to the clinic for surgical treatment due to histologically verified non-microcellular lung cancer (table I, II). All patients, according to Declaration of Helsinki, were informed about the research, its aims and the possibility to resign at any time. All trials were performed after receiving the consent from Committee on Ethics in Research, preserving the anonymity guaranteed by the act dated 29 August, 1997 about protection of personal details (Statute Book No 133 position 883). All measurements: anthropometric, functional and biochemical were performed on admission to avoid the nutritional influence of hospitalization, and known from the literature hospital malnutrition. For all patients we registered prospective set of measurements: anthropometric, clinical, physical, laboratory and functional.

Table I

Morphological characteristic of 60 patients suffering from lung cancer participating in the research

Sex	St. index	Age (years)	Height (cm)	Weight (kg)	BMI
Females	$\bar{x} \pm SD$	47-74 64,36 \pm 7,25	152-170 170,08 \pm 5,74	46-97 72,54 \pm 5,82	19,65-39,21 27,09 \pm 5,96
Males	$\bar{x} \pm SD$	49-80 63,60 \pm 7,06	160-184 159,54 \pm 5,58	52-108 71,77 \pm 10,75	17,47-36,50 23,98 \pm 3,88

Table II
The coexisting diseases

Disease	Females		Males		All	
	N	%	N	%	N	%
1. Emphysema	5	8,33	28	46,66	33	54,99
2. Coronary heart disease	6	10,00	9	15,00	15	25,00
3. Hypertension	6	10,00	13	21,66	19	31,66
4. Atherosclerosis	6	10,00	20	33,33	26	43,33
5. Diabetes	2	3,33	5	8,33	7	11,66
6. Heart rhythm disorder	2	3,33	3	5,00	5	8,33
7. Depression	0	0,00	2	3,33	2	3,33
8. Peptic ulcer	1	1,66	3	5,00	4	4,66
9. Gallbladder lithiasis	1	1,66	3	5,00	4	6,66
10. BPH	0	0,00	4	6,66	4	6,66
11. Hypothyroidism	3	5,00	0	0,00	3	5,00
12. Glaucoma	1	1,66	1	1,66	2	3,33
13. Epilepsy	0	0,00	1	1,66	1	1,66
14. Tuberculosis in history	1	1,66	0	0,00	1	1,66
15. Heart failure	3	5,00	4	6,66	7	11,66
16. Stroke in history	0	0,00	2	3,33	2	3,33
17. Rheumatoid arthritis	0	0,00	1	1,66	1	1,66
18. Hyperthyroidism	0	0,00	1	1,66	1	1,66
19. Heart defects	1	1,66	0	0,00	1	1,66
20. Celiac disease	0	0,00	1	1,66	1	1,66
21. Without any coexisting diseases	1	1,66	5	8,33	6	10,00

Somatic measurements

Body height and weight were measured, and BMI for all participants was calculated. Height was measured in standing position with Sieber Hegner antropometer, produced in Switzerland, with accuracy to 0.1 cm. Body mass was measured in light clothes, without shoes on German Sartorius scales type F 150 S 02-A with accuracy to ± 10 g.

Muscle strength assessment

The measurement of left and right hand strength was made with American *Jamar* dynamometer. The maximum static strength moments of muscle groups were measured according to principles developed by Mathiowetz et al.⁵ and Nitsche et al.,⁶ so called maximum strength.

Speed of hand movements (tapping test)

Fast touching of two adequately placed discs with a chosen hand (tapping test, plate tapping) expresses the ability to perform simple alternating movements. For the "start" signal the patient was doing 25 such move-

ments one way and another (50 touches together) as fast as he/she could move the hand from one disc to another above the other hand which was placed in the middle (the distance between the discs was 40 cm). Out of the two tests we took the better outcome into consideration. The time needed to touch every disc 25 times measured with accuracy to 0.1 sec decided about the result.

Simple reaction time assessment

Simple reaction time was measured with MRK-432 meter produced by ZEAM company which emits visual and auditory stimuli. We performed a series of measurements of simple reaction time in tests for precise stimulus with the dominating hand for 12 following stimuli. The measurements were made in a sitting position, the forearm of tested arm was resting on the edge of the table to eliminate additional static tension of muscles. Every stimulus was emitted for 1 second $\pm 2\%$. During the measurement of the simple reaction time the patient kept the manual button of the meter in his/her hand with the thumb resting on the button waiting for the emission of the stimulus. We rejected the extreme measurements and calculated the averages from the rest.

Table III
Age, height and weight and a percentage of body mass loss during last three months in patients suffering from lung cancer both well nourished and with malnutrition of a slight degree

Research group	Stat. index	Age (years)	Height (cm)	Actual weight (kg)	Previous weight (kg)	% of body mass loss
I	$\bar{x} \pm SD$	60.76 ± 6.79	169.8 ± 0.07	72.93 ± 13.90	75.03 ± 13.30	0.031 ± 0.028
II	$\bar{x} \pm SD$	66.26 ± 6.89	170.0 ± 0.06	69.39 ± 12.45	77.76 ± 11.48	0.111 ± 0.044
	t	-3.109	-0.09785	1.0413	0.0863	-3.6514
	p <	0.002	n.s.	n.s.	n.s.	0.0005

Table IV
Average values of albumin concentration, transferrin, total proteins, lymphocytes and 24 hour nitrogen loss in patients with lung cancer well nourished and with malnutrition of a slight degree

Group	Stat. index	Albumins (g/l)	Transferrin (g/l)	Total protein (g/l)	Total lymphocytes (1/mm ³)	Urea nitrogen (g/24 h)
I	$\bar{x} \pm SD$	41.614 ± 2.07	2.184 ± 0.32	72.34 ± 5.24	2,023.10 ± 825.68	11.34 ± 2.42
II	$\bar{x} \pm SD$	34.05 ± 0.27	1.764 ± 0.27	68.90 ± 6.39	1,692.26 ± 556.40	13.32 ± 2.92
	t	10.52	5.52	2.27	1.831	-2.85
	p <	0.001	0.001	0.02	n.s.	0.005

Statistical analysis

While applying the methods of descriptive statistics we counted: arithmetic mean, standard deviation. Correlation between the variables of normal distribution was presented with Pearson's factor of correlation. To compare groups with normal distribution of variables we applied t-Student test for independent tests. For statistically significant ones we took tests for which the level of probability was higher or equal $p < (0.05)$.

Results

The patients were divided into groups depending on the level of body mass loss, the results are presented in table III. We created two groups: the first group was a population of relatively well nourished patients, whose body mass loss was slight and we treated them as a control group and, the other group included patients with malnutrition of a slight degree whose body mass loss was more than 6%.

The justification of such material selection is a hypothesis presented above about the negative influence of cancerous cachexia on functional efficiency. The patients qualified for particular groups differed significantly in terms of age, $p < 0.002$.

Biochemical tests

In the population of relatively well nourished patients the concentration of albumins was in the narrow normal range. In the second group 31 patients had significantly lower serum albumin concentration, $p < 0.001$, which indicates malnutrition of a slight degree.

Changes in the concentration of transferrin were similar. The average value of this index in the first group was within the normal range. Larger deficiencies in the second group indicate malnutrition of a slight degree. Noted differences between the groups assessed with one-dimensional variation analysis ANOVA were statistically significant with $p < 0.001$. The above regularity can also be noticed with reference to total proteins. The results in both groups appeared in this case to be different and statistically significant, $p < 0.02$ (table IV).

The level of total urea nitrogen in the first group of examined patients was characteristic for people on an average diet, in the second group the loss of nitrogen was significantly higher and resulted from greater body mass loss, mainly disintegration of proper proteins in the course of intense catabolism related to neoplastic disease, $p < 0.005$.

Similarly to the above parameters we managed to confirm the mentioned regularities expressed in respectively lower average number of erythrocytes ($p < 0.01$), average values of hemoglobin ($p < 0.0001$) and levels of hematocrite ($p < 0.001$) in patients with malnutrition (table V).

The amount of leukocytes in the group of well nourished patients was in the range of proper values, in the second group it was significantly higher ($p < 0.05$) (table V).

Muscle strength changes

The distribution of muscle strength values was very diverse, in patients with malnutrition lower results dominated quantitatively. Differences in mean values of muscle strength were statistically significant ($p < 0.01$) for left as well as right hand (table VI).

Table V
Average values of erythrocytes, leucocytes, hematocrite and hemoglobin concentration in patients with lung cancer properly nourished and with malnutrition of a moderate degree

Group	Stat. index	Erythrocytes (min/mm ³)	Leucocytes (thousand/mm ³)	Hematocrite (%)	Hemoglobin (g/100ml)
I	x ± SD	4.595 ± 0.5741	9.031 ± 4.4933	41.131 ± 4.4634	13.638 ± 1.4788
II	x ± SD	4.233 ± 0.5327	12.742 ± 8.1888	36.777 ± 5.2942	12.087 ± 1.8134
	t	2.53527	-2.15498	3.43173	3.61562
	p <	0.01	0.05	0.001	0.000

Table VI
Average values of hand strength and speed of movement in patients with lung cancer correctly nutrished and with slight malnutrition

Group	Stat. index	Right hand strength (kg)	Left hand strength (kg)	Statis strength of hands (kg)	Speed of right hand movements	Speed of left hand movements
I	x ± SD	34.93 ± 11.27	32.37 ± 11.72	66.38 ± 23.46	16.72 ± 3.06	17.48 ± 2.79
II	x ± SD	26.52 ± 8.06	25.35 ± 6.04	51.61 ± 13.41	19.24 ± 4.04	19.69 ± 3.59
	t	3.34626	2.94507	3.01741	-2.70131	-2.65376
	p <	0.001	0.004	0.003	0.009	0.01

Speed of right and left hand movements (tapping test)

The average times of measurements in tapping test were significantly longer in the group of patients with malnutrition and related to right hand as well as the left one (p < 0,01) (table VI).

Simple reaction time

Reaction time to light stimulus in the group of malnourished patients was significantly longer for the left hand and right (p < 0.05). The average reaction time to acoustic stimuli was also longer, but the differences obtained were not statistically significant (table VII).

Correlation between chosen parameters

The differences observed in the groups were confirmed by the correlation analysis. We proved a linear

significant correlation between the concentration of albumins and the strength of left as well as right hand, respectively r = 0.4072, r = 0.3406. For the static force r = 0.3640 which is statistically highly significant, p < 0.01. Negative correlation index for right hand r = -0.4036 and left one r = -0.4410, p < 0.001 indicates that as albumin concentration lowers the time of movement lengthens. Similar correlations were found in concentration of albumins with the time of reaction to visual stimulus (respectively r = -0,3247, p < 0,01 and r = -0,4248, p < 0,001) as well as the auditory one (r = -0,3440, p < 0,01 and r = -0,3640, p < 0,01).

Discussion

A number of changes in the functioning of organism develop as the disease progresses and this has specific clinical consequences.

The main diagnostic criterion is the albumin concentration as the most documented parameter of nutritional status, of proven prognostic value. Its level

Table VII
The average values of reaction times for exposition on the visual and auditory stimuli and the heart rate in patients suffering from lung cancer well nourished and with malnutrition of a slight degree

Group	Stat. index	Time of reaction to visual stimulus	Time of reaction to visual stimulus	Time of reaction to auditory stimulus	Time of reaction to auditory stimulus	Heart rate
		Right hand	Left hand	Right hand	Left hand	
I	x ± SD	0.45 ± 0.087	0.48 ± 0.06	0.39 ± 0.08	0.40 ± 0.07	88.62 ± 8.07
II	x ± SD	0.50 ± 0.08	0.51 ± 0.07	0.43 ± 0.08	0.45 ± 0.12	88.90 ± 11.62
	t	-2.02646	-2.94507	-1.80042	-1.69276	-0.10862
	p <	0.05	0.05	n.s.	n.s.	n.s.

demonstrates rather short-term lowering of protein supply, but has limited value as an indicator for monitoring nutritional therapy because of the long half-life and a large extravascular pool. In this respect, it is rather a hydration rate of the patient.^{7,8} Plasma albumin is one of the most important factors of complex models analysing mortality and postoperative complications incidence,^{9,10} it correlates with the severity of the disease.^{11,12} The level of albumin is also an indirect indicator of hypercatabolism.^{7,8}

The studied groups showed statistically significant differences in albumin, transferrin and total protein concentrations. In 4 patients albumin levels below 30 g/l were noted, which is a critical value in the assessment of nutritional status, and in 25 patients serum albumin was in the range of 30-35 g/l. Abnormal albumin levels were found only in a group of patients with malnutrition. Based on the percentage of weight loss malnutrition was found in 31 subjects, 4 of them presented a moderate degree of malnutrition, with serum albumin below 30 g/l. According to obtained results, plasma protein levels illustrated the progression of the disease.

Precise assessment of nitrogen balance includes losses from urine, stool, sweat, as well as through the skin and respiratory system. It should be stressed that although the amount of nitrogen lost in sweat, or stool is relatively constant, loss in the urine varies in different clinical situations and is an indirect indicator of catabolism (4/5 nitrogen is excreted in the urine).

The total amount of urea nitrogen in patients with smaller losses of weight was characteristic for those on the average diet, in the second group nitrogen losses were higher due to larger weight loss (negative nitrogen balance), mainly breakdown of its proteins in the course of increased catabolism associated with cancer. The reported differences were statistically significant.

In routine clinical practice immunity level is estimated on the basis of total lymphocytes number (CLL) in 1 mm³ of blood, it is also a well established marker of nutritional status. Malnutrition is diagnosed with a decrease in the absolute number of lymphocytes to the level of 1,200-1,499/mm³. The border level of lymphocytes 800-1,199/mm³ indicates an average degree of malnutrition, while below 800 indicates severe degree of malnutrition and is a poor prognostic factor.¹³ Malnutrition causes a drop in total lymphocyte counts, weakening the immunity of the body and skin response to antigens. Malnourished patients are particularly susceptible to infection, which is their main postoperative complication.

The average values of total lymphocytes number in both groups were within the normal range. In the group without significant weight loss 3 patients demonstrated levels of lymphocytes in the range of 1,200-1,499/mm³, no lower levels were noted. In the group of malnourished patients 6 of them demonstrated total lymphocytes level in the range 800-1,199, while 11 people between 1,200-1,499, in the remaining 13 individuals

from this group, despite the significant body weight loss, there was no reduction in the number of lymphocytes.

With age, not only in patients treated for cancer, a series of changes in bodily functions affecting the course of the disease develop: muscle mass is reduced (about 3-8% for every 10 years after 30 years of age, and after 60 years of age even more),¹⁴ the force of muscle contractions decreases,¹⁵ neuromuscular conductivity disturbances appear (frequency and intensity of nerve impulses reaching the muscle are reduced),¹⁶ ATP synthesis is impaired, cellular metabolism is reduced,^{17,18} electrolyte imbalance at the level of the muscle cell appears, resistance to insulin occurs. Reduction of physical activity as the cause of these disorders is frequently emphasised. During this mechanism of positive feedback exercise capacity is further reduced, patients gradually become to rely on other people's help, which results in deterioration of quality of life.^{19,20,21,22,23} Thus, muscle weakness is not simply the result of reduction in muscle mass following hypercatabolism. The hypothesis that reduced muscle contractility is also responsible for hypotension, hypovolaemia, and the relative weakness of respiratory muscles was put forward.^{24,25}

Hand grip strength measurements correlate well with nutritional status, forecasting the course of surgery, and they are a useful bedside method which reflects early changes in muscle activity, and changes arising as a consequence of muscle mass reduction following malnutrition. It was found that the distribution of average values of force fully corresponds with preferences for performing actions which require one hand. Dynamic asymmetry caused by more frequent use of the right hand is diminished with age in the group of malnourished people. The decrease in the dynamic asymmetry is caused by greater recourse of dominant hand grip strength. It is worth noting that all these characteristics showed significant variation, demonstrating high variability of these parameters. Hand grip strength reflects the effectiveness of conscious contraction of muscles and is linked to the efficiency of movement.

The study groups' individual muscle strength results were highly differentiated, but in the malnourished patients lower values dominated compared to the relatively well-fed. The average values showed a statistically significant reduction in muscle strength in malnourished patients ($p < 0.01$). One can point to the age factor as a reason for poor results in this group. When compared with the tables of the healthy individuals muscle strength values, it is clear that the loss of muscle strength in malnourished patients is higher than would result from the age.²⁶

Psychomotor performance can also be modified by metabolic changes that occur in the brain of undernourished people. Under normal conditions, the main energy substrate for brain cells is glucose. In malnutrition the brain increasingly uses other energy sources, such as ketoacids produced in the liver. Partial replace-

ment of glucose in the brain by ketoacids occurs when the concentration of this energy substrate in the blood reaches a relatively high level.²⁷

Physiological processes' disturbances caused by malnutrition prolong response to simple stimuli at rest. The deterioration of coordination and speed of movement is also associated with reductions in blood glucose.²⁷ The structural basis of this is the reflex arc.

In patients with malnutrition significantly longer reaction time was noted when compared to well-nourished patients, so it can be concluded that longer reaction time of patients suffering from malnutrition is a common clinical symptom.

The aim of this study was to assess the impact of patients' nutritional status with operable non-microcellular lung cancer on psychomotor performance, muscle strength and functional activity. Undoubtedly, there is no universal tool for assessing nutrition, which would facilitate comparisons between patients treated surgically. The data presented in this study clearly showed that the clinical assessment of nutritional status depends on the method used. Hence, it is necessary to use several methods in parallel, and not just selected parameter to reliably assess the nutritional status and to identify promptly patients at risk of developing malnutrition or malnourished because the nutritional intervention can potentially improve the survival rate of patients with lung cancer.^{28,29,30} The results have confirmed the impact of malnutrition on the muscle strength, movement speed and reaction time.

Limits of the study

While looking for an explanation why malnutrition influences functional effectiveness we could not find correlation between anthropometric measurements and biochemical parameters assessing the state of nutrition. An attempt to connect the results of these examinations did not actually bring any firm solution but revealed an interesting tendency manifesting itself in lower concentration of proteins and lower values of anthropometric parameters in the group of patients with higher weight losses. Anthropometric measurements require high proficiency from the researcher, moreover, measuring the skin fold over triceps with caliper require a lot of skill and differences between results of different researchers may reach even 20%. Those measurement differences may be a result of an individual variability of fat tissue susceptibility to pressure (hard, unsusceptible or soft, easy to deform fat tissue, extreme obesity and inability to grab the fold). The difference in results of adipose and non-adipose body mass assessment on the basis of body mass and skin folds' thickness is estimated on the level of 3-9%. The subjects were not homogeneous in age, we just qualified to the study all 60 consecutive patients admitted to the clinic for the surgical treatment diagnosed with non-microcellular lung cancer.

Conclusions

Malnutrition in the course of non-microcellular lung cancer significantly reduces psychomotor functions assessed by reaction time to visual and acoustic stimuli as well as functional efficiency assessed by tapping test and muscle strength measurement.

The risk of malnutrition in the course of non-microcellular lung cancer increases with age.

Evaluation of functional capacity indirectly indicates the nutritional status of the patient.

The problem requiring detailed assessment is the relationship between the results of functional tests and the clinical course after surgical treatment of lung cancer.

References

1. Seymour DG, Pringle R. Post-operative complications in the elderly surgical patient. *Gerontology* 1983; 29: 262-267.
2. Marín Caro MM, Gómez Candela C, Castillo Rabaneda R et al. Evaluación del riesgo nutricional e instauración de soporte nutricional en pacientes oncológicos, según el protocolo del grupo español de Nutrición y Cáncer. *Nutr Hosp* 2008; 23: 458-468.
3. Leandro-Merhi VA, Braga de Aquino JL. Nutritional status and length of hospital stay for surgical patients. *Nutr Hosp* 2010; 25: 468-469.
4. Win T, Ritchie AJ, Wells FC, Laroche CM. The incidence and impact of low body mass index on patients with operable lung cancer. *Clin Nutr* 2007; 26: 440-443.
5. Mathiowetz V, Kashman N, Volland G, Weber K, Dowe M, Rodgers S. Grip and pinch strength: normative data for adults. *Arch Phys Med Rehabil* 1985; 66: 69-72.
6. Nitsche JE et al. When is a Change a Genuine Change. A clinically meaningful interpretation of grip Strength measurements in healthy and disabled women. *Journal of Hand Therapy. Hanley and Belfus* 1998; 12 (1): 25-30.
7. Bernstein J. Measurement of visceral protein status in assessing protein and energy malnutrition: standard of care. Prealbumin: in Nutritional consensus Group. *Nutrition* 1995; 11: 169.
8. Nataloni S, Gentili P, Marini B, Guidi A, Marconi P, Busco F, Pelaia P. Nutritional assessment in head injured patients through the study of rapid turnover visceral proteins. *Clin Nutr* 1999; 18: 247.
9. Gibbs J, Cull W, Henderson W, Daley J, Hur K, Khuri SF: Pre-operative serum albumin level as a predictor of preoperative mortality and morbidity. *Arch Surg* 1999; 134: 36-42.
10. Bozzetti F, Gianotti L, Braga M, Di Carlo V, Mariani L. Post-operative complications in gastrointestinal cancer patients: The joint role of the nutritional status and the nutritional support. *Clin Nutr* 2007; 26: 698-709.
11. Franch-Arcas G: The meaning of hypoalbuminemia In clinical practice. *Clin Nutr* 2001; 20: 265-269.
12. Gluszek S, Matykiewicz J, Czerwaty M: Znaczenie zywienia pozajelitowego pozajelitowego dojelitowego w raku zoladka i wpustu. *Gastroenterol Pol* 1999; 6: 119-124 (in Polish).
13. Feller AG et al. Nutrition support in the stroke patient. *Nutrition and stroke*. W: Guesry P et al. Nestle Nutrition Workshop Series. Lippincott-Raven Publishers 1997; (Suppl. 1): 159-170.
14. Pichard C, Meguid MM. Wasting diseases: still searching for the weapons of (lean body) mass destruction. Editorial comment. *Curr Opin Clin Nutr Metab Care* 2004; 7: 403-404.
15. Norman K, Stobäus N, Smoliner C, Zocher D, Scheufele R, Valentini L, Lochs H, Pirlich M. Determinants of hand grip strength, knee extension strength and functional status in cancer patients. *Clin Nutr* 2010; 29: 586-591.
16. Correia TD, Waitzberg DL. The impact of malnutrition on morbidity, mortality, length of hospital stay and costs evaluated

- through a multivariate model analysis. *Clin Nutr* 2003; 22: 235-239.
17. Stump CS, Short KR, Bigelow M, Schimke JM, Nair KS. Effect of insulin on human skeletal muscle mitochondrial ATP production, protein synthesis, and mRNA transcripts. *Proc Nat Acad Sci USA* 2003; 100: 3343-3347.
 18. Volpi E, Nazemi R, Fujita S. Muscle tissue changes with aging. *Curr Opin Clin Nutr Metab Care* 2004; 7: 406-410.
 19. Inui A. Cancer Anorexia-Cachexia Syndrome: Are Neuropathies the Key? *Cancer Research* 1999; 9: 4493-4501.
 20. Natanson PM. The cancer cachexia syndrom. *Semin Oncol* 1997; 24: 277-287.
 21. Ruci ska M, Wojtkiewicz M: Zespół wyniszczenia nowotworowego. *Nowotwory* 1999; 49: 53-62 (in Polish).
 22. Toomey D et al. Cachexia as a Multifactorial Syndrome. *Cancer* 1995; 76: 2418-2426.
 23. Mohan A, Singh P, Kumar S, Mohan C, Pathak AK, Pandey RM, Guleria R. Effect of change in symptoms, respiratory status, nutritional profile and quality of life on response to treatment for advanced non-small cell lung cancer. *Asian Pac J Cancer Prev* 2008; 9: 557-62.
 24. Latronica M et al. Critical illness myopathy and neuropathy. *Lancet* 1996; 347: 1597.
 25. Wagenmakers AJM. Muscle function. 22nd ESPEN Congress, Madrid, 9-13.09.2000; Educational Programme, 1.
 26. Mateo Lázaro ML, Penacho Lázaro MA, Berisa Losantos F, Plaza Bayo A. Nuevas tablas de fuerza de la mano para población adulta de Teruel. *Nutr Hosp* 2008; 23: 35-40.
 27. Kozłowski S, Nazar K. Wprowadzenie do fizjologii klinicznej. PZWL, Warszawa, 2000 (in Polish).
 28. Gupta D, Lammersfeld CA, Vashi PG, King J, Dahlk SL, Grutsch JF, Lis CG. Bioelectrical impedance phase angle in clinical practice: implications for prognosis in stage IIIB and IV non-small cell lung cancer. *BMC Cancer* 2009; 9: 37.
 29. Tanimura S, Hirata T, Hirai K, Mikami I, Kubokura H, Shimizu K. Surgical results of lung cancer associated with postobstructive pneumonia. *Ann Thorac Cardiovasc Surg* 2009; 15: 297-303.
 30. Lai SL, Perng RP. Impact of nutritional status on the survival of lung cancer patients. *Zhonghua Yi Xue Za Zhi (Taipei)* 1998; 61: 134-40.