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Assessing the impact of technology of the physical rehabilitation on functionality of the respiratory system of the children with functional single ventricle

Abstract. ***Purpose****: to evaluate the effectiveness of technology in physical rehabilitation of children with functional single ventricle after hemodynamic correction.* ***Material and Methods****: 35 patients were examined, aimed at conducting hemodynamic correction including 23 boys and 12 girls aged from 6 to 14 years. A study was conducted using spirography at various stages of physical rehabilitation. The data were processed by adequate methods of mathematical statistics.* ***Results****: found reduced function of the respiratory system prior to the surgery. Operation led to a deterioration of most indicators of external respiration. After the rehabilitation course marked by recovery and improvement condition of the respiratory system.* ***Conclusions****: the applied technology of physical rehabilitation was effective.*

Keywords: *heart defect, physical rehabilitation, functional single ventricle of heart, respiratory system.*

Introduction. Medical achievements and development of new surgical methods considerably increased the survival and the expected lifetime of patients with congenital heart diseases (CHD) in recent years which lifts a problem of physical health and rehabilitation of the operated concerning congenital heart diseases.

Researchers note the existence of lag in physical development [1], the decrease in functionality of the respiratory system [55; 7] and tolerances to physical activities at persons with a functionally single ventricle of heart (FSVH) [55; 6].

Communication of the research with scientific programs, plans, subjects. The work performed according to the Built plan of the RW in the sphere of physical culture and sport for 2011-2015 by a subject 4.4 "The improvement of organizational and methodical bases of programming of the process of physical rehabilitation at dysfunctional violations in different systems of a human body". The number of the state registration is 0111U001737.

The objective of the research: to estimate the efficiency of technology of physical rehabilitation of children with FSVH after a haemodynamic correction.

Material and methods of the research. 35 patients with FSVH which are directed on carrying out the expeditious treatment in SI "Scientific and practical medical center of children's cardiology and heart surgery of MHC of Ukraine" for 2013-2015 from them are 23 boys (65,7%) and 12 girls (34,3%) from 6 till 14 years old took part in the research. 29 (82,9%) patients were hospitalized for carrying out an operation of a total kavapulmonary anastomosis, and 6 (17,1%) patients for imposing of the modified anastomosis of Glen.

The spirograph Spirolab III and the software WinspiroPRO for the personal computer were used for an assessment of a condition of external breath that allowed to calculate automatically the value of indicators in percentage from an individual norm. Indicators for children by Knudson were taken for norms which are available in the software of a spirograph and WinspiroPRO [8]. Considering the age range of children and the duration of rehabilitation, the dynamics of the majority of indicators will be analyzed in relative values from a norm.

The applied programs Statistica 7.0. and IBM SPSS Statistics 21 were used for the mathematical processing of numerical data.

Results of the research and their discussion. The technology of physical rehabilitation was based on the analysed by us experience of authors O. I. Yankelevich [3], L. V. Petrunina [2], their combined works [4] and the complex of indicators which were received in the course of the stating experiment. Our technology consists of basic and variable components and includes at itself two stages – stationary and home (6 months) stages of rehabilitation. The combined connection of means of physical rehabilitation belongs to a basic component which promote the acceleration of a postoperative renewal, the improvement of a functional condition of the cardiovascular system and results of the spirography, the formation of a correct posture. The variable component provides the accounting of specific features of patients, among which results of an assessment of a biogeometrical profile of a bearing in the sagitalny and frontal planes, a functional condition of respiratory system, and directed on their improvement.

The comparative analysis of the received results of the test of the vital capacity of lungs (tab. 1) after passing of the stationary stage of PR testified that all indicators, except the breath frequency (BF) statistically authentically differed at patients at the time of an extract from a clinic.

Apparently from the presented data, the average value of the vital capacity of lungs (VCL) decreased by 11,8% of a norm to 63,23±13,40% ($p<0,01$) at the time of an extract, that is for 15,5% of the initial value. The average value of volume of an inspiration (V_{insp}) at an extract made 71,37±20,10%, having authentically decreased by 13,74% of a norm ($p<0,01$) or for 16,1% of the initial value. According to the obtained data the reserve volume of an exhalation (RV_{exh}) after the operation during a stay in a hospital decreased from 65,46±23,76% to 55,69±22,43% ($p<0,01$). That is RV_{exh} lowered by 9,77% of a norm, or for 14,9% of the initial value.

At the same time at the time of an extract the respiratory volume (RV) decreased statistically authentically by 0,07 l to 0,36±0,10 l ($p<0,01$). At this FB didn't change, and the minute ventilation of lungs (MVL) due to the reduction of RV

authentically decreased by 1,55 l·min^{-1} to 8,43±2,79 l·min^{-1} (p<0,01).

Statistically reliable changes were experienced also by the vital index (VI). It lowered from 56,68±9,18 ml·kg^{-1} to 47,80±9,12 ml·kg^{-1}.

Table 1

Average indicators of the test of the vital capacity of lungs of children with functionally single ventricle of heart at different stages of the experiment

Indicators of the test of VCL	Stages of the experiment					
	At a hospitalization (n=35)		At an extract (n=35)		In the remote period (n=31)	
	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s
VCL, % from the due	76,03	11,45	64,23**	13,40	83,00**	11,83
V_{insp}, % from the due	85,11	19,82	71,37**	20,10	88,74**	20,88
RV_{exh}, % from the due	65,46	23,76	55,69**	22,43	78,08**	24,85
RV, l	0,43	0,14	0,36**	0,10	0,40	0,10
FB, $_{insp}$.·min^{-1}	23,76	3,69	23,20	3,42	19,53**	2,07
MVL, l·min^{-1}	9,98	3,47	8,43**	2,79	7,75**	2,14
VI, ml·kg^{-1}	56,68	9,18	47,80**	9,12	59,36**	7,55**

Note. *Statistically significant difference of the value of an indicator concerning the size which is registered by the beginning of classes: * – p<0,05; ** – p<0,01.*

The comparative analysis of the results which are received at a hospitalization and in the remote period after passing of the rehabilitation course showed the improvement of almost all indicators of the test of the vital capacity of lungs in the remote period.

Apparently from the presented data, the average value of VCL in the remote period increased in comparison with initial results by 6,97% to 83,00±11,83% (p<0,01), that is for 9,2% of the initial value. From the presented data it is visible that the average value of V_{insp} in the remote period increased by 3,63% to 88,74±20,88% (p<0,01). Thus, V_{insp} in the remote period increased by 4,3% of the initial value. The indicator of RV_{exh} increased from 65,46±23,76% to 78,08±24,85% (p<0,01) during passing of a rehabilitation that is grew by 12,6% of a norm, or for 19,3% of the initial value.

Considering the stated it is possible to draw a conclusion that VCL, after carrying out the expeditious treatment with sternotomy and the termination of a course of physical rehabilitation, grows in a bigger measure for the account of RV_{exh}. Thus that the difference between average results at the time of an extract and in the remote period makes respectively 17,4% and 22,4% for indicators of V_{insp} and RV_{exh}.

In the remote period RV didn't change authentically. At the same time statistically authentically FB decreased on 4,23 insp.·min^{-1} to 19,53±2,07 l (p<0,01), and MVL on 2,23 l·min^{-1} to 7,75±2,14 l·min^{-1} (p<0,01).

In comparison with initial results, in the remote period of VI statistically authentically increased from 56,68±9,18 ml·kg^{-1} to 59,36±7,55 ml·kg^{-1}, pointing to the increase in volume of VCL which is the share on a kilogram of body weight.

The comparative analysis found the existence of statistically reliable changes of indicators of the test of the forced vital capacity of lungs in the course of passing of PR (tab. 2). The carried-out comparative analysis established the reliable decrease in indicators by a certain percent from a norm after the expeditious treatment and passing of the stationary stage of PR: VCL (FVCL) for 11,86% to 59,63±13,45% is forced (p<0,01); the volume of the forced exhalation for the first second (VFE_1) for 13,14% to 63,89±13,85% (p<0,01); the peak volume speed of an exhalation (PVS_{exh}) for 10,04% to 62,42±17,53% (p<0,01); the average volume speed at the level of 25-75% of FVCL (AVS_{25-75}) for 10,31% to 83,69±28,74%; the instantaneous volume velocity at the time of an exhalation of 25% of FVCL (IVV_{25}) for 7,00% to 61,43±17,31% (p<0,05); the instantaneous volume velocity at the time of an exhalation of 50% of FVCL (IVV_{50}) for 7,93% to 74,01±23,98% (p<0,05); the instantaneous volume velocity at the time of an exhalation of 75% of FVCL (IVV_{75}) for 9,00% to 90,57±36,03% (p<0,05); FVCL of an inspiration ($FVCL_{insp}$) for 8,83% to 55,14±11,73% (p<0,01); the volume of the forced inspiration for the first second (VFI_1) for 7,29% to 60,57±13,69% (p<0,01); the peak volume speed of an inspiration (PVS_{insp}) for 6,83% to 39,63±8,96% (p<0,01);

In the remote period the reliable improvement of indicators for a certain percent from a norm is recorded, namely: FVCL for 7,54% to 79,03±11,55% (p<0,01); VFE for 9,42% to 86,45±12,74% (p<0,01); PVS_{exh} for 12,57% to 85,03±19,32% (p<0,01); IVV_{25} 15,09% to 83,52% (p<0,01); IVV_{50} for 13,51% to 95,45±25,69%; $FVCL_{insp}$ for 9,29% to 73,26±9,88% (p<0,01); VFE_1 for 12,24% to 80,10±11,79% (p<0,01); PVS_{insp} for 16,09% to 62,55±13,53% (p<0,01).

Index of Tiffno (VFE_1/ FVCL) and index of Gensler (VFE_1/ FVCL) authentically didn't change.

Table 2

Average indicators of the test of the forced vital capacity of lungs of children with functionally single ventricle of heart at different investigation phases

Indicators of the test of FVCL	Stages of the experiment					
	At a hospitalization (n=35)		At an extract (n=35)		In the remote period (n=31)	
	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S
FVCL, % from the due	71,49	13,07	59,63**	13,45	79,03**	11,55
VFE_1, % from the due	77,03	12,86	63,89**	13,85	86,45**	12,74
VFE_1/ VCL, % from the due	97,26	8,84	97,29	10,09	100,52	5,18
VFE_1/ FVCL, % from the due	104,07	6,83	104,59	6,70	105,74	3,44
PVS_{exh}, % from the due	72,46	19,95	62,42**	17,53	85,03**	19,32
AVS_{25-75}, % from the due	94,00	24,02	83,69**	28,74	96,26	26,03
IVV_{25}, % from the due	68,43	18,14	61,43*	17,31	83,52**	17,92
IVV_{50}, % from the due	81,94	20,86	74,01*	23,98	95,45**	25,69
IVV_{75}, % from the due	99,57	30,31	90,57*	36,03	90,21	14,89
$FVCL_{insp}$, % from the due	63,97	11,97	55,14**	11,73	73,26**	9,88
VFI_1, % from the due	67,86	14,00	60,57**	13,69	80,10**	11,79
PVS_{insp}, % from the due	46,46	11,84	39,63**	8,96	62,55**	13,53

Note. *Statistically significant difference of value of an indicator concerning the size registered by the beginning of classes: * – p<0,05; ** – p<0,01.*

It is necessary to emphasize that at the time of an extract of VFE_1 decreases authentically more for VFI_1 as we revealed the statistically reliable difference between quantitative changes of indicators in absolute (p<0,05) and relative (p<0,01) sizes at an extract. That is VFI_1 statistically decreased less by the extract moment in comparison with VFE_1. In the remote period the similar comparison didn't establish the reliable difference in increases of VFI_1 and VFE_1 (p>0,05).

Calculations show that PVS_{exh} and PVS_{insp} decrease equally at the time of an extract as we didn't revealed statistically reliable differences (p>0,05) between quantitative changes of indicators at the time of inspection at an extract. The similar situation is developed with the improvement of peak speeds at inspection in the remote period.

Conclusions. Considering the stated, we come to a conclusion that the vast majority of indicators of an external breath don't renew to the initial level after surgery at an extract from a hospital which demands the continuation of rehabilitation actions. On the termination of a course of physical rehabilitation indicators of the spirography renewed and improved that testifies to the efficiency of the offered technology of physical rehabilitation concerning the functionality of the respiratory system.

Prospects of the subsequent researches consist in the research of the remote results of the influence of the conducted rehabilitation course, the research of changes of the quality of life and the improvement of technology of physical rehabilitation.

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