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Early Rehabilitation of Children in Different Age Groups after Correction of Non-Cyanotic Congenital Heart Defects

Siyanotik Olmayan Konjenital Kalp Defektlerini Düzeltme Sonrası Farklı Yaş Grubu Çocukların Erken Rehabilitasyonu

Dragana CIROVIC[1,2], Dejan NIKOLIC[2], Ivana PETRONIC[1,2], Tatjana KNEZEVIC[2], Dragana DZAMIC[2], Polina PAVICEVIC[1,3], Slobodan ILIC[1,4], Vojislav PAREZANOVIC[1,5]

[1]*Faculty of Medicine, University of Belgrade, Belgrade, Serbia*
[2]*Department of Physical Medicine and Rehabilitation, University Children's Hospital, Belgrade, Serbia*
[3]*Department of Radiology, University Children's Hospital, Belgrade, Serbia*
[4]*Department of Cardiosurgery, University Children's Hospital, Belgrade, Serbia*
[5]*Department of Cardiology, University Children's Hospital, Belgrade, Serbia*

Abstract

Objective: The aim of our study was to present and evaluate the duration of an early rehabilitation program and time for the beginning of such a program in a group of children with corrected non-cyanotic congenital heart defects (CHDs), as well to evaluate the proportion of implementation of each technique from the early rehabilitation program.
Material and Methods: We evaluated 274 children with: ventricular septal defect (VSD), atrial septal defect (ASD), and persistent ductus arteriosus (DAP). Patients were classified into 3 groups due to age: group of children younger than 1 year of life, group of children between first and third year of life, and group of children between third and seventh year of life. Three types of early rehabilitation techniques were assessed: kinesitherapy, percussion drainage, and verticalization.
Results: Kinesitherapy and percussion drainage were administered in every child with VSD or ASD, while for children with DAP, percussion drainage was not administered in 1 patient. Duration of the early rehabilitation program for children with corrected VSD was between 5-7 days, between 4-6 days for children with corrected ASD, and between 3-6 days for patients with corrected DAP.
Conclusion: Early rehabilitation should start within the first 2 days after defect correction. Duration of the early rehabilitation program in children with corrected non-cyanotic CHD is more dependent on the type of CHD than on the age of participants. The same applies for the estimation of the period for the beginning of this program.
Key Words: Congenital heart defects, kinesitherapy, percussion drainage, verticalization

Özet

Amaç: Çalışmamızın amacı düzeltilmiş siyanotik olmayan konjenital kalp defekti (KKD) olan çocuk grubunda erken rehabilitasyon programı süresini ve böyle bir programın başlangıç zamanını bildirmek ve değerlendirmek, ayrıca erken rehabilitasyon programındaki her bir tekniğin uygulanma oranını değerlendirmekti.
Gereç ve Yöntemler: Ventriküler septal defekt (VSD), atriyal septal defekt (ASD) ve persistent duktus arteriozusu (PDA) olan 274 çocuğu değerlendirdik. Hastalar yaşa göre 3 gruba ayrıldı: Bir yaşından küçük çocuk grubu, bir ila üç yaş arası çocuk grubu, üç ila yedi yaş arası çocuk grubu. Üç tip erken rehabilitasyon tekniği değerlendirildi: kineziterapi, perküsyon drenaj ve vertikalizasyon.
Bulgular: Kineziterapi ve perküsyon drenaj, VSD veya ASD'li her çocukta uygulanmaktadır, ancak PDA'lı çocuklarda, perküsyon drenaj bir hastada uygulanmadı. Erken rehabilitasyon programının süresi düzeltilmiş VSD'li çocuklar için 5-7 gün arasında, düzeltilmiş ASD'li çocuklar için 4-6 gün arasında ve düzeltilmiş PDA'lı çocuklar için 3-6 gün arasında idi.
Sonuç: Erken rehabilitasyon, defekt düzeltilmesinden sonra ilk 2 gün içinde başlamalıdır. Düzeltilmiş siyanotik olmayan KKD'li çocuklarda erken rehabilitasyon programının süresi katılımcıların yaşından çok KKD tipine bağlıdır. Aynı durum bu programın başlangıcı için dönem tahmininde de geçerlidir.
Anahtar Kelimeler: Konjenital kalp defektleri, kineziterapi, perküsyon drenaj, vertikalizasyon

Address for Correspondence / Yazışma Adresi: Dragana Cirovic, MD, PhD, Physical Medicine and Rehabilitation Department University Children's Hospital, Tirsova 10, 11000 Belgrade, Serbia Phone: +381638133345 E-mail: denikol27@gmail.com

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Introduction

Congenital heart disease (CHD) is the most prevalent group of congenital anomalies in infants (1). There are reports pointing out the rising prevalence during recent years (2,3). The improvement in medicine and technology that has rapidly progressed in the past few years has brought more children with heart defects surviving to adulthood (4,5). Such trends indicate the importance of rehabilitation medicine implementation in the period after correction of CHD in order to prevent possible complications and to facilitate recovery (6,7). There are studies implicating efficacy of a rehabilitation program in the prevention of cardiovascular risk factors in patients with cardiovascular diseases (8). The majority of studies investigated the effects of aerobic and resistance training in children with CHD (9). The aim of our study was to present and evaluate the duration of an early rehabilitation program and the time for the beginning of such a program in a group of children with corrected non-cyanotic CHD, as well to evaluate the proportion of implementation of each technique from the early rehabilitation program.

Material and Methods

Study Population

In our study, we evaluated a group of 274 children with corrected non-cyanotic CHD that were treated at University Children's Hospital in Belgrade during 2004-2012. The study was retrospective. All patients that underwent CHD correction were candidates for inclusion in the early rehabilitation program. Prior to inclusion in the study, parents or legal guardians were informed about the therapy protocol, and written informed consent was obtained. The study was conducted in accordance with the Declaration of Helsinki and followed the principles of good clinical practice and was approved by the Local Ethics Committee of University Children's Hospital.

The essential criteria for the inclusion of patients were stable vital parameters as blood pressure values and pulse, as well as satisfied oxygen saturation that was observed and evaluated by a board certified specialist-cardiosurgeon and/or cardiologist, absence of venous thrombosis, infection, and elevated body temperature above 37.5°C. Duration of the early rehabilitation program was individually assessed and planned, since patients were with different CHDs and of different age structures. Regarding the type of non-cyanotic CHD, all patients were divided into 3 groups: group with ventricular septal defect (VSD), group with atrial septal defect (ASD), and group with persistent ductus arteriosus (DAP). Among them, 112 (40.8%) children were with VSD, 82 (29.9%) were with ASD, and 80 (29.3%) were with DAP. Regarding the age structure, participants were classified into 3 groups: group of children younger than 1 year of life (group I), group of children between first and third year of life (group II), and group of children between third and seventh year of life (group III). Participants within the first age group included newborns with diagnosed CHD during regular pediatric evaluation; the second and third age groups included the period of increased motoric activity when cardiac problems within CHD were more expressed or the correction of CHD was indicated by cardiac surgeon in a particular age. Distinction between the second and third age groups referred to motoric development in the second age group and increase of such activity within the third age group. We used 3 types of early rehabilitation techniques: kinesitherapy (KTH), percussion drainage (PD), and verticalization (V).

Kinesitherapy included, particularly in young children, passive movements of lower and upper limbs and in older ones with active cooperation passive-active movement, where the physical therapist initiates the segmental movement and the patient finishes the complete range of the exercise. Such therapeutic method is beneficial for the prevention of venous stasis as well as contractures and maintenance of movement range in joints. Percussion drainage, when prescribed, should be done with respiratory exercise, and verticalization is recommended to be gradually introduced. Such therapeutic methods are useful in the prevention of vascular and pulmonary complications and could help in the improvement of oxygen saturation and ventilation.

Our study evaluated duration of the early rehabilitation program and time for the beginning of treatment after correction of CHD separately for each of the 3 CHDs in defined age groups.

The criteria to determine effectiveness of the early rehabilitation program included: better oxygen saturation, absence of respiratory and vascular complications, improvement in segmental movements of upper and lower limbs, and better muscle tonus.

Statistical Analysis

We used percents (%) to describe the proportion of patients that were included in different rehabilitation exercises (KTH, PD, and V). Mean values with standard deviation (SD) were used to describe evaluated results of the early rehabilitation program duration for every exercise separately in different age groups for each of the 3 CHDs as well for the estimation of the time, expressed in days for the beginning of rehabilitation program after correction of CHD. To evaluate the presence and degree of statistical difference between age groups for percentual distribution of evaluated exercises, we used chi-square test. For comparison of mean duration of early rehabilitation between age groups, we used student's t-test. Unifactorial ANOVA was used to evaluate program duration and time for the beginning of early rehabilitation between CHD for each technique regarding age. Statistical significance was set at $p<0.05$. We used SPSS program for statistical analyses.

Results

In Table 1, we presented the proportion of participants included in the early rehabilitation modules and the duration of program for every technique within the early rehabilitation program, expressed in days, in defined age groups for the group of children with corrected VSD, ASD, and DAP.

There were 112 patients with corrected VSD, with a higher proportion of children within the first age group. From 82 patients with corrected ASD, there was an increase in the proportion of children with corrected ASD in the third age group. There were 80 patients with corrected PDA, and a higher proportion of children was recorded in the first age group.

Table 1. Proportion of participants included in early rehabilitation modules and duration of program

Participants age group and CHD type		KTH			PD			V		
		(%)	Mean±SD (days)	F value	(%)	Mean±SD (days)	F value	(%)	Mean±SD (days)	F value
I age group	VSD (N=40)	100.0	6.68±3.04	6.309**	100.0	6.68±3.04	5.612**	25.0	5.40±2.55	0.350
	ASD (N=11)	100.0	5.00±0.63		100.0	5.00±0.63		54.5	4.67±0.58	
	DAP (N=41)	100.0	4.74±2.49		97.6	4.88±2.42		24.4	4.63±2.72	
II age group	VSD (N=37)	100.0	5.13±1.84	3.808*	100.0	5.13±1.84	3.808*	78.4	4.88±1.33	3.443*
	ASD (N=32)	100.0	5.12±1.33		100.0	5.12±1.33		71.9	4.50±1.38	
	DAP (N=20)	100.0	4.00±1.54		100.0	4.00±1.54		75.0	3.75±1.36	
III age group	VSD (N=27)	100.0	5.90±3.14	2.793	100.0	5.90±3.14	2.793	81.5	4.94±0.97	1.947
	ASD (N=39)	100.0	4.58±0.94		100.0	4.58±0.94		97.4	4.17±1.12	
	DAP (N=19)	100.0	5.48±2.85		100.0	5.48±2.85		84.2	4.77±2.74	

CHD: congenital heart disease; KTH: kinesitherapy; PD: percussion drainage; V: verticalization; SD: standard deviation; VSD: ventricular septal defect; ASD: atrial septal defect; DAP: persistent ductus arteriosus; *p<0.05; **p<0.01

Table 2. Time for beginning of early rehabilitation program for evaluated congenital heart defects in different age groups

Age groups	VSD (Mean±SD) (days)	ASD (Mean±SD) (days)	DAP (Mean±SD) (days)	F values
I age group	1.50±0.88	1.05±0.23	1.07±0.19	5.953**
II age group	1.93±1.71	1.42±0.90	1.09±0.14	3.325*
III age group	1.13±0.34	1.03±0.08	1.14±0.36	1.689

SD: standard deviation; VSD: ventricular septal defect; ASD: atrial septal defect; DAP: persistent ductus arteriosus; *p<0.05; **p<0.01

Table 3. Statistical analysis of early rehabilitation program duration between different age groups for evaluated congenital heart defects

	T-test values								
	KTH			PD			V		
Early rehabilitation program between different age	VSD	ASD	DAP	VSD	ASD	DAP	VSD	ASD	DAP
I and II age group	2.74**	0.29	1.22	2.74**	0.29	1.48	0.86	0.29	1.08
II and III age group	1.23	2.00*	2.03*	1.23	2.00*	2.03*	0.18	1.02	1.30
I and III age group	1.06	1.39	1.02	1.06	1.39	0.84	0.76	1.06	0.13

KTH: kinesitherapy; PD: percussion drainage; V: verticalization; VSD: ventricular septal defect; ASD: atrial septal defect; DAP: persistent ductus arteriosus; *p<0.05; **p<0.01

There was a statistical difference in age groups I and II regarding duration of KTH and PD and for the time for the beginning of the program between the 3 evaluated types of CHD (for age group I, early rehabilitation for VSD participants was longer versus ASD and DAP patients; for age group II, early rehabilitation for VSD and ASD participants was longer versus DAP patients), while this difference was noticed in age group II regarding duration of V between the 3 evaluated types of CHD (the longest duration for VSD participants and the least one for DAP).

Verticalization was introduced in a lower proportion of children within the first age group, since they were either not mature enough to be completely verticalized or had contraindications for the safe implementation of such an exercise. Therefore, they were included either in the KTH or PD exercises or both of them.

Time for the beginning of early rehabilitation after correction of non-cyanotic CHD is presented in Table 2 for every evaluated CHD in different age groups. The results show that the early rehabilitation program can begin in every participant with observed non-cyanotic CHD within 1 to 2 days after correction. It is essential to point out that the timing for the inclusion in early rehabilitation is assessed individually and separately for every patient, since they are with different types and severities of CHD and of different ages.

In Table 3, we presented the statistical analysis of the duration of the early rehabilitation therapeutic tools in the evaluated population regarding age of participants for the observed CHDs. Our results pointed out that regarding KTH and PD, there was a statistical difference between age groups I and II for the duration of the early rehabilitation program in the group of children with VSD (longer in I age group), while the presence of a statistical difference was also observed regarding duration of KTH and PD in the group of children with ASD but between age groups II and III (longer in II age group) and in the group of children with DAP (longer in age group III). For other comparisons between different age groups regarding observed CHD, we found no statistical difference (p>0.05).

There was a statistical difference in age groups I and II regarding duration of KTH and PD and for the time for beginning of the program between the 3 types of CHD evaluated (for age group I, early rehabilitation for VSD participants was longer versus ASD and DAP patients; for age group II, early rehabilitation for VSD and ASD participants was longer versus DAP patients), while this difference was noticed in age group II regarding duration of V between the 3 types of CHD evaluated (the longest duration for VSD participants and the least one for DAP).

Discussion

In our previous reports, we have shown the benefits of early rehabilitation in children after correction of CHD (10,11). Since

there are big differences in age of correction, from few days to adulthood, our aim was focused on evaluation of an early rehabilitation program in defined age groups of children. On the other side, physiological development of children within the first year is an important state for postulating early rehabilitation protocols, since some exercise types can not be properly implemented.

Due to impaired hemodynamics, elevated pulmonary blood pressures, and low oxygen saturation, these children are more prone to develop complications than others (12). Beside these impairments that can lead directly to the presence of pulmonary or vascular complications, impaired oxygen saturation can result in hypotonic conditions, with muscular atrophies and contractures as secondary consequences. Therefore, the need for estimation of when to begin early rehabilitation after correction of non-cyanotic CHD is essential, because by timely induction of the program, we are preventing possible complications and facilitating recovery.

The third important condition and need for establishment of early rehabilitation protocols is socioeconomic burden. There are numerous studies addressing economic aspects for various health conditions worldwide (13,14). Therefore, we have presented our experience of the duration of early rehabilitation programs in children after correction of CHD.

It is of great importance to know when and how long early rehabilitation should be implemented for hospitalized children.

Results from our study point out that kinesitherapy and PD are administered in every child with VSD or ASD in the period after correction, when cardiopulmonary conditions allow the beginning of early rehabilitation, while for children with DAP, PD was not administered in 1 patient. On the other side, verticalization showed a positive trend in older children with corrected CHD, especially between the first and second age groups for every evaluated CHD where we found a statistically significant difference ($p<0.01$). A possible explanation for such a discrepancy is physiological development. Verticalization was implemented in every fourth patient with VSD or DAP in the first age group, while the same exercise for the same age group was administered twice as much in children with ASD. In older age groups, there was a statistically significant rise in frequency of verticalization implementation, where two of three children underwent such exercise.

Our findings stress that median duration of an early rehabilitation program for children with corrected VSD is between 5 and 7 days. Further, they pointed out that children from the first age group had significantly ($p<0.01$) longer duration of KTH and PD compared with the duration of the same techniques in the second age group. Regarding duration of the verticalization program, a statistical difference was found not to be significant regarding all age groups.

In the group of children that underwent early rehabilitation after correction of ASD, the duration of the rehabilitation program was between 4 and 6 days. Also, we have noticed that children from the second age group had significantly ($p<0.05$) longer duration of KTH and PD compared with the duration of the same techniques in the third age group. Duration of the verticalization program was found not to be significantly different regarding all age groups, pointing out that age is not an influential parameter determining duration of early rehabilitation in patients with ASD.

For the group of patients with corrected DAP, the duration of the early rehabilitation program was between 3 and 6 days. Our study stressed that children from the third age group had significantly ($p<0.05$) longer duration of KTH and PD compared with the duration of the same techniques in the second age group. As for those patients with corrected VSD and ASD, there was not a statistical difference regarding duration of the verticalization program in all age groups.

These findings implicate that duration of the verticalization program within early rehabilitation is not influenced by age of participants for evaluated CHD.

We have demonstrated that for children younger than 3 years of life, duration of KTH and PD are CHD type-dependent, while the duration of the verticalization program shows a CHD type dependence for the group of children between the first and third years of life.

Besides evaluation of the duration of early rehabilitation programs, it is essential to estimate after what period of time children with corrected non-cyanotic CHD should begin with such a program. Our results point out that for children with corrected VSD, early rehabilitation should start within the first 2 days after defect correction. The same conclusions apply to those patients with corrected ASD or DAP. Further, study findings stressed that for children younger than 3 years of life, time for inclusion in the early rehabilitation program is CHD type-dependent.

Conclusion

The results of our study pointed out that early rehabilitation should be individually assessed and planned, closely monitored, and evaluated daily in patients with corrected CHD.

However, further studies should address evaluation of the parameters mentioned above on other types of CHD in order to create complete early rehabilitation protocols for children with corrected CHD.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of University Children's Hospital.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

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