Working together
www.rcis.ro

Revista de cercetare și intervenție socială

ISSN: 1583-3410 (print), ISSN: 1584-5397 (electronic)
Selected by coverage in Social Sciences Citation Index, ISI databases

EARLY REPAIR BENEFITS IN COGNITIVE DEVELOPMENT OF PATIENTS WITH TETRALOGY OF FALLOT

Manuel CHIRA, Dana Florica CIOTLAUS, Grigore TINICA,
Simona MANOLE, Diana Maria SACUI, Adrian MOLNAR

Revista de cercetare și intervenție socială, 2017, vol. 57, pp. 78-88

The online version of this article can be found at:
www.rcis.ro, *www.doaj.org* and *www.scopus.com*

Published by:
Expert Projects Publishing House

expert projects
publishing

On behalf of:
„Alexandru Ioan Cuza" University,
Department of Sociology and Social Work
and
Holt Romania Foundation
REVISTA DE CERCETARE SI INTERVENTIE SOCIALA
is indexed by ISI Thomson Reuters - Social Sciences Citation Index
(Sociology and Social Work Domains)

Working together
www.rcis.ro

Early Repair Benefits in Cognitive Development of Patients with Tetralogy of Fallot

Manuel CHIRA[1], Dana Florica CIOTLAUS[2], Grigore TINICA[3], Simona MANOLE[4], Diana Maria SACUI[5], Adrian MOLNAR[6]

Abstract

Assessment of psychological development and cognitive outcome of surgically corrected patients with Tetralogy of Fallot, determined by the preoperative chronic cerebral hypoxia. This paper studies a group of 71 patients operated in our clinic between September 1st 2001 and July 1st 2006, all surgically corrected without prior palliations. The surgical techniques were: transannular patch (n=46), infundibular patch ± pulmonary artery (PA) patch (n=17), and transatrial and transpulmonary correction (n=8). The patients were divided into 2 groups, operated below 1 year of age and above 1 year of age, for comparative study of results. 58 patients were followed up, performing a pediatric psychological evaluation. The effects over patients' IQ of two major components were studied: preoperative chronic hypoxia and family environment. Major differences were noticed between the two groups, as followed: the patient' IQ values were statistically significant different among the two groups (higher values for patients operated below 1 year of age); there is an inverse ratio between IQ values and preoperative hematocrit (statistically significant); the IQ values distribution is slightly different between the two groups of age: the IQ values in patients operated above 1 year of age are significantly different depending on parents scholar degrees. Delay in surgical correction, beyond 1 year of age, in patients with Tetralogy of Fallot, could have deleterious effects over cognitive outcome of these patients (longer period of preoperative chronic cerebral hypoxia). The cognitive outcome also correlates with parents' scholar degrees, in older patients.

[1] "Niculae Stancioiu" Heart Institute, Cluj-Napoca, ROMANIA. E-mail: chiramanuel@gmail.com

[2] "Niculae Stancioiu" Heart Institute, Cluj-Napoca, ROMANIA. E-mail: dana_ciotlaus@yahoo.com

[3] "Prof. Dr. George I. M. Georgescu" Institute for Cardiovascular Diseases, Iasi, ROMANIA. E-mail: grigoretinica@yahoo.com

[4] Emergency Clinic County Hospital, Department of Radiology, Cluj Napoca, ROMANIA. E-mail: simona.manole@gmail.com

[5] Heart Institute, 19-21 Moților Str., 400001, Cluj Napoca, ROMANIA. E-mail: diana_sacui27@yahoo.com (corresponding author)

[6] "Niculae Stancioiu" Heart Institute, Cluj-Napoca, ROMANIA. E-mail: adimolnar45@yahoo.com

Keywords: Tetralogy of Fallot, Intelligence testing, Psychological testing, Intelligence quotient, Cognitive development

Introduction

In the past 3 decades mortality of congenital heart diseases, in general, and mortality of Tetralogy of Fallot (TOF), in particular, dropped dramatically (Terai *et al.*, 2002), due to various improvements in medical and surgical management and technological upgrade in extracorporeal circulation. This evolution made possible early repair of TOF. Early repair in TOF is important, due to preoperative hypoxia, which could have deleterious effects on postoperative psychological development of Fallot patients. The number of papers studying psychological development of patients with repaired TOF is scarce. The major part of these papers analyze psychological outcome of corrected TOF patients, without regard to surgical technique and especially to surgical timing, bearing in mind that preoperative hypoxia, if prolonged, could affect cognitive development. There are other papers that compare psychological development of patients with cyanotic congenital heart disease (CHD), acyanotic CHD and patients with no CHD.

Materials and methods

We studied a group of 75 patients who underwent surgery in Heart Institute, Cluj Napoca, Romania, between September 1st, 2001 and July 1st, 2006. All the patients were surgically corrected per primam, without prior palliations, with 2.6% mortality. Among these 75 patients we excluded 4 older patients at repair, trying to reduce the influences on statistical data. Thus, we compiled a homogeneous group of 71 patients. The patients were then divided into 2 groups, according to the age at operation: group 1 (25 patients), corrected below 1 year of age, and group 2 (46 patients), corrected above 1 year of age.

Table 1. Studied patients and groups

Study Period	September 1st, 2001 – July 1st, 2006	Group 1	Group 2
Patients	75	25	46
Deceased patients - Early Mortality (2.6%)	2	1 – (8 months of age)	1 – (3.5 years of age)
High age (excluded)	4 (14, 18, 21, 32 years)	Excluded - 4	Excluded - 9
Sex	48M 23F	Follow-up - 21	Follow-up - 37

The 71 patients were surgically corrected with the following techniques: transannular patch (46 patients), infundibular patch ± pulmonary artery (PA) patch (17 patients), transatrial and transpulmonary repair (8 patients).

Among the 71 patients, 58 were followed up for the following period of time: group 1 – 43.24 months ± 14.28, group 2 - 48.6 months ± 18.66. From these 58 patients, 21 were in group 1 (surgery below 1 year of age), and 37 were in group 2 (surgery above 1 year of age). Among the initial group of patients, 13 were not followed up due to: 1 patient with Down syndrome, 2 patients with postoperative stroke, 4 patients with preoperative neurologic injury (stroke or other issues), 2 institutionalized patients (orphanage), and 4 patients lost at follow up. The patients in the followed up group were admitted in a pediatric hospital and were examined by the clinical psychologist.

The psychological examination made an evaluation of cognitive, affective, behavioral and temperamental dimensions, but the present study will analyze only the cognitive development. On the 58 patients was performed also a CBCL test (Child Behavior CheckList), but the results of this test will be the aim of another study.

The evaluation of intelligence quotient (IQ) was performed, according to the age of the patient, through Raven color progressive matrices in younger patients. The intelligence quotient represent the ratio between mental age and chronologic age multiplied by 100, and generally is classified as followed: above 140 – genius or almost genius, 120-140 – superior intelligence, 110-120 – above average intelligence, 90-110 – normal (average) intelligence, 80-90 – below average intelligence, 70-80 – possible mental deficiency, below 70 - mental deficiency. Raven color progressive matrices assess the non-verbal intelligence, being addressed to 4-12 years aged children, rating the clarity of perceiving ability, and the level of cognitive development, as well. The Simon-Binet intelligence scale is used in older children, teenagers and adults, to measure the intelligence quotient.

The statistical analysis was performed using IBM SPSS v.19. When we compared means, we used T test for independent samples, with Monte Carlo test for p value computation. The correlation between IQ values and age and hematocrit values was performed using regressions.

Results

In the followed-up group, there were no late deaths. In order to evaluate the effects of prolonged preoperative cerebral hypoxia on cognitive development, we performed a comparative study of IQ values, between the 2 groups.

Testing the intelligential level, we obtained for both groups scores mainly framed in average intelligence limits (IQ values contained between 90 and 110), with 3 values below average for group 1, and 7 values below average for group 2.

The mean IQ values, for the 2 groups, were: group 1 (surgery below 1 year of age) – 98.67 ± 8.71, group 2 (surgery above 1 year of age) – 93.38 ± 9.17. Performing T test for independent samples, we obtained statistically significant differences between the mean IQ values of the 2 groups ($p<0.05$).

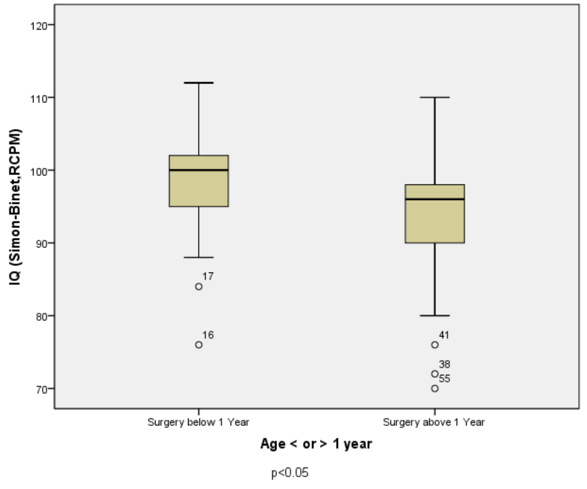

Figure 1. *IQ values over the 2 groups (mean, standard deviation, range, extreme values)*

When we performed, through regression, the correlation between IQ values and age at surgery we obtained an inverse ratio, meaning the higher the age at surgery, the lower the postoperative IQ value, but the p value was above 0.05. An interesting correlation, not found in international studies, is the one between postoperative IQ values and preoperative hematocrit values. We obtained an inverse ratio between these 2 values, meaning the higher the hematocrit value, the lower the IQ value. This correlation was statistically significant ($p<0.05$).

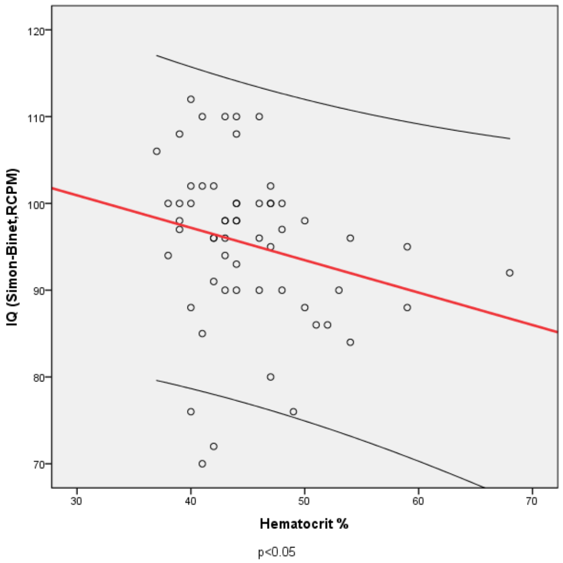

Figure 2. Correlation postoperative IQ – Preoperative Hematocrit

We analyzed also the IQ values distribution, over the 2 groups, and we distinguished several differences between groups. In group 1 the IQ values are less scattered compared to group 2 (Kurtosis index – group 1: 1.186, group 2: 0.743). When we analyzed the values preponderance, we obtained slightly different results over the 2 groups. In group 1 values between 95 and 110 are more frequent, in group 2 values between 90 and 100 are more frequent (Skewness index – group 1: -0.813, gropu2: -0.637). These histograms are concordant with comparative study of mean intelligence quotient values over the 2 groups of age.

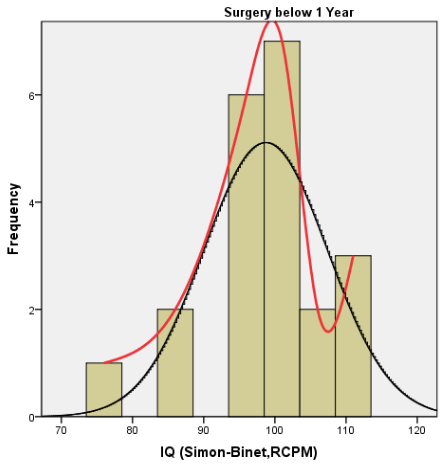

Figure 3. IQ values distribution in patients operated below 1 year

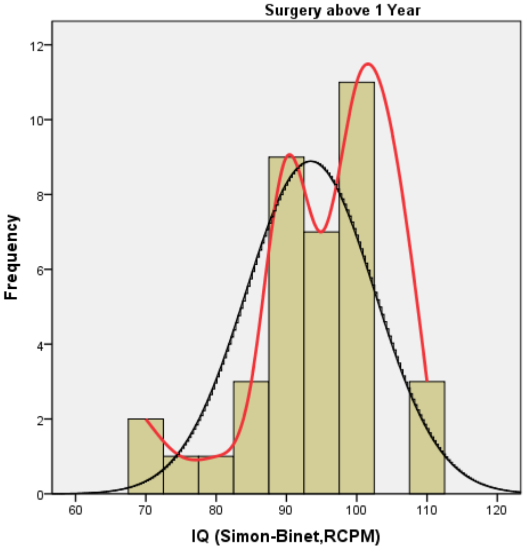

Figure 4. IQ values distribution in patients operated above 1 year

The family environment is another factor that could affect cognitive development of patients. Thus, we studied the parents‘ scholar degree. The distribution of parents‘ scholar degree over the 2 groups is the following: group 1 (surgery below 1 year of age): 7 – elementary or middle school degree, 14 – high school or college degree, group 2 (surgery above 1 year of age): 16 – elementary or middle school degree, 21 – high school or college degree.

At comparative study of IQ values, correlated with parents‘ scholar degree, over the 2 groups, the following results were obtained:

Group 1 – IQ 97.29 ± 10.468 (elementary or middle school), IQ 99.36 ± 8.035 (high school or college) – no statistical significance;

Group 2 – IQ 89.88 ± 8.709 (elementary or middle school), IQ 96.05 ± 8.783 (high school or college) – statistical significance ($p<0.05$)

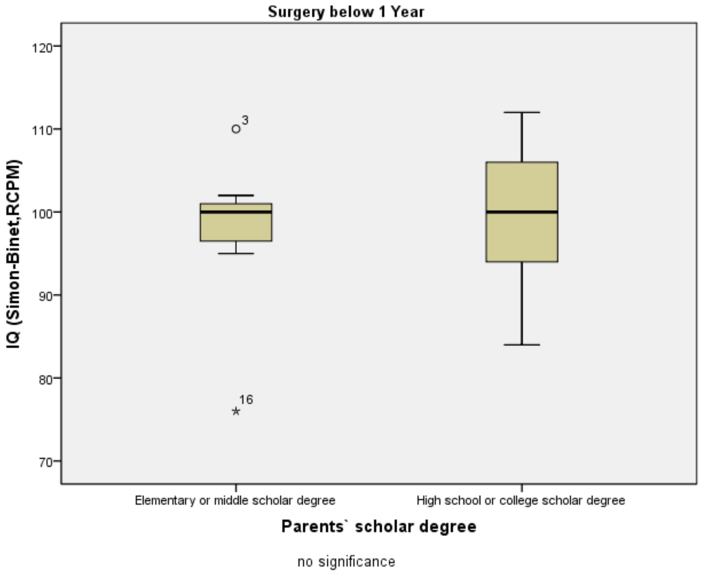

Figure 5. Correlation Patients IQ value – Parents'scholar degree (group 1)

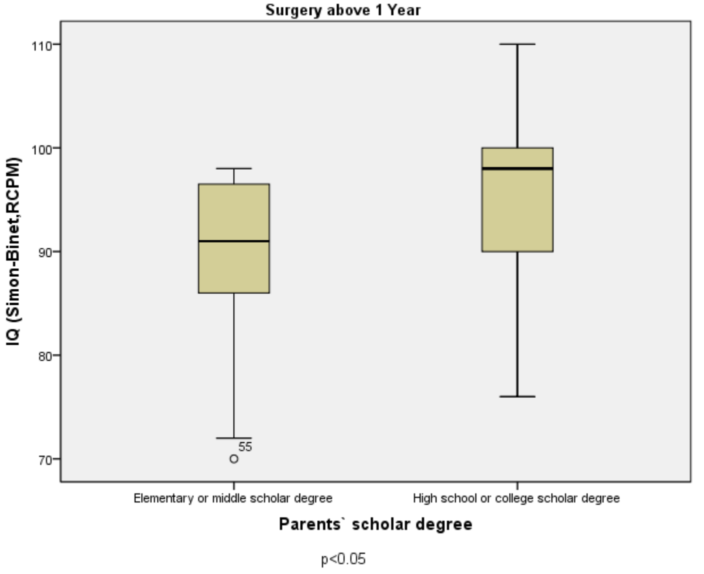

Figure 6. Correlation Patients IQ value – Parents'scholar degree (group 2)

We also divided the patients in group 2 in the following subgroups: surgery at 1-3 years, surgery at 3-7 years, surgery at 7-12 years, and we obtained the mean IQ values:

- 1 - 3 years – IQ – 90.43 ± 8.492 (elementary or middle school), IQ 95.92 ±8.196 (high school or college)
- 3 - 7 years – IQ 91.83 ± 5.601 (elementary or middle school), IQ 97.00 ±10.420 (high school or college)
- 7 - 12 years – IQ 84.67 ±14.048 (elementary or middle school), IQ 90.00 (high school or college)

In these subgroups the differences between mean IQ values are obvious, as well, without statistical significance, however, due to small number of patients in each subgroup (1-3 years – 19 patients, 3-7 years - 14 patients, 7-12 years - 4 patients). The age at surgery (meaning addressability) is important, as demonstrated by numerous international papers, for early, midterm and late development of these patients. The correlation between age at repair and parents‘ scholar degree is statistically significant ($p<0.05$). The mean age at repair was 41.09 ± 37.69 months, on patients with parents with elementary or middle school degree and 25.43 ± 21.92 months, on patients with parents with high school or college degree. A better addressability could hereby noticed on patients with parents with higher scholar degree.

Discussion

There are a few papers that study psychological development, in general, and cognitive outcome; in particular, of patients with corrected TOF, therefore results analysis of this study is somewhat difficult. We split the study group in this manner because there are a lot of studies that emphasize the postoperative issues in patients with late TOF repair (Fuster *et al.*, 1980; Katz *et al.*, 1982; Lillehei *et al.*, 1986; Kavey, Blackman, & Sondheimer, 1982; Niwa *et al.*, 2002; Marie *et al.*, 1992; Garson *et al.*, 1979; Garson *et al.*, 1985; Dean & Lab, 1989; Kirklin *et al.*, 1989).

There are international papers that analyze psychological development of adult patients with repaired TOF, without studying differences between corrected patients, palliated patients, and corrected patients with prior palliations (Rascanu, 2004; Miatton *et al.*, 2007; Meijboom *et al.*, 1994; Aigueparse *et al.*, 1990). Likewise, there are papers that study comparative psychological outcome of TOF patients and acyanotic CHD patients (Hövels-Gürich *et al.*, 2006; Daliento *et al.*, 2002; Wray & Sensky, 2001). All these studies set on from basic assumption that cerebral hypoxia affects brain development (Nyakas, Buwalda, & Luiten, 1996), furthermore has deleterious effects on brain functioning, therefore on cognitive outcome of TOF patients. We found a single paper that studies differences in psychological outcome in patients with cyanotic CHD, according to surgery timing (Oates *et al.*, 1995), given that early correction in these patients provides better somatic and psychological outcome.

Differences between mean IQ values over the 2 groups signify an intellectual level closer to superior limit for group 1, and an intellectual level closer to inferior limit for group 2, both groups ranging within the average intellectual limits, with some extreme values. The outmost important correlation of this study that underlines the deleterious effect of preoperative cerebral hypoxia on cognitive outcome is the inverse ratio between preoperative hematocrit values and postoperative IQ values. The preoperative hematocrit value is the best indicative for both duration and severity of hypoxia and brain hypoxia, bearing in mind that the human body adapts to chronic hypoxia by erythropoiesis augmentation, meaning raise in oxygen transportation and delivery. This particular correlation was not found in specific papers.

The subjects included in this study are framed within preschool or school age; therefore the cognitive development is also dependent on intellectual stimulation through family environment and scholar community, intelligence being considered a permanent, progressive knowledge acquisition. Thus, we found a statistically significant correlation between mean IQ values of patients corrected above 1 year of age and parents‘ scholar degree (the higher the parents‘ scholar degree, the higher the patients IQ mean value). In group 1 (surgery below 1 year of age) this correlation did not appear, probably due to small age of patients, therefore parental factor being not so important, yet.

Study limitations

We are not aware of the condition of institutionalized children, which were not followed up, and the condition of children lost at follow up. In this study psychological evaluation was made early, in preschool and school period, hoping that all the discovered issues could be addressed by the clinical psychologist, and corrected in due time. In the future, we intend to continue longitudinally this study, in attempt to draw exhaustive conclusions on cognitive outcome after TOF correction.

Conclusions

This study results entitle us to draw the following conclusion: delay in surgical correction of Tetralogy of Fallot, and thus a prolonged period of general and brain hypoxia, could have deleterious effects on cognitive outcome and delay in knowledge acquisitions, by insufficient stimulation of nervous centers, affected by insufficient oxygenation, cognitive deterioration being directly influenced by duration and severity of brain hypoxia. Cognitive outcome depends also on family environment, on parents' scholar degree, respectively. Hereby, we tried continuously to lower the age at operation, knowing all the issues that could affect early, midterm and late outcome of patients with TOF, especially when they are corrected late in childhood. Nowadays, in Romania as well, more than 60% of Fallot patients benefit of an early correction, below 1 year of age.

Acknowledgements

Another version of this paper, partly modified and written in Romanian, has appeared in the „Romanian Journal of Cardiology", *26*(2), 2011. Also, some units of the text in this article were included in the doctoral thesis entitled „The early therapeutic approach of Fallot monology: Indications, Techniques, Results and Perspectives" by Dr. Manuel Chira.

References

Aigueparse, J., Marechal, M.C.(1991). Evaluation of the quality of life in adulthood of 158 patients surgically treated for tetralogy of Fallot. *Archives des maladies du coeur et des vaisseaux*, *84*, 685-690.

Daliento, L., Mazzotti, E., Mongillo, E., Rotundo, M., Dalla Volta, S. (2002). Life expectancy and quality of life in adult patients with congenital heart disease. *Italian Heart Journal*, *3*, 339-347.

Dean, J.W., Lab, M.J. (1989). Arrhythmia in heart failure: Role of mechanically induced changes in electrophysiology. *Lancet*, *1*, 1309-1312.

Fuster, V., McGoon, D.C., Kennedy, M.A., Ritter, D.G., Kirklin, J.W. (1980). Longterm evaluation (12–22 years) of open-heart surgery for tetralogy of Fallot. *American Journal of Cardiology*, *46*, 630-642.

Garson, A. Jr, Randall, D.C., Gillette, P.C., Smith, R.T., Moak, J.P., McVey, P., McNamara, D.G. (1985). Prevention of sudden death after repair of tetralogy of Fallot: Treatment of ventricular arrhythmias. *Journal of the American College of Cardiology*, *6*, 220-227.

Garson, A., Nihill, M.R., McNamara, D.G., Cooley, D.A. (1979). Status of the adult and adolescent after repair of tetralogy of Fallot. *Circulation*, *59*, 1232-1240.

Hövels-Gürich, H.H., Konrad, K., Skorzenski, D., Nacken, C., Minkenberg, R., Messmer, B.J., Seghaye, M.C. (2006). Long-Term Neurodevelopmental Outcome and Exercise Capacity After Corrective Surgery for Tetralogy of Fallot or Ventricular Septal Defect in Infancy. *The Annals of Thoracic Surgery*, *81*, 958-966.

Katz, N., Blackstone, E.H., Kirklin, J.W., Pacifico, A.D., Bargeon, L.M. (1982). Late survival and symptoms after repair of Fallot. *Circulation*, *65*, 400-410.

Kavey, R.E., Blackman, M.S., Sondheimer, H.M. (1982). Incidence and severity of chronic ventricular dysrhythmia after repair of tetralogy of Fallot. *American Heart Journal*, *103*, 342-350.

Kirklin, J.K., Kirklin, J.W., Blackstone, E.H., Milano, A., Pacifico, A. (1989). Effect of transannular patching on outcome after repair of tetralogy of Fallot. *The Annals of Thoracic Surgery*, *48*, 783-791.

Lillehei, C.W., Varco, R.L., Cohen, M., Warden, H.E., Gott, V.L., DeWall, R.A., Patton, C., Moller, J.H. (1986). The first open heart corrections of tetralogy of Fallot: A 26–31 years follow-up of 106 patients. *Annals of Surgery*, *204*, 490-502.

Marie, P.Y., Marcon, F., Brunotte, F., Briancon, S., Danchin, N., Worms, A.M., Robert. J., Pernot, C. (1992). Right ventricular overload and induced sustained ventricular tachycardia in operatively 'repaired' tetralogy of Fallot. *American Journal of Cardiology*, *69*, 785-789.

Meijboom, F., Sraturati, A., Deckers, J.W., Utens, E.M.W.J., Roelandt, J.R.T.C., Bos, E., Hess, J. (1994). Cardiac status and health-related quality of life in the long-term after surgical repair of tetralogy of Fallot in infancy and childhood. *Journal of Cardiovascular Surgery*, *110*, 883-891.

Miatton, M., De Wolf, D., François, K., Thiery, E., Vingerhoets, G. (2007). Intellectual, neuropsychological, and behavioral functioning in children with tetralogy of Fallot. *The Journal of Thoracic and Cardiovascular Surgery*, *133*, 449-455.

Niwa, K., Hamada, H., Nakazawa, M., Terai, M., Tateno, S., Sugimoto, S., Watanabe, H., Murakami, A., Ohta, M., Ishizawa, A., Katoki, T., Mori, K., Yasui, S., Kawahira, Y., Akagi, T., Haraquchi, N., Gatzoulis, M.A. (2002). Mortality and risk factors for late deaths in tetralogy of Fallot: The Japanese nationwide multicenter survey. *Cardiology in the Young*, *12*, 453-460.

Nyakas, C., Buwalda, B., Luiten, P.G.M. (1996). Hypoxia and brain development. *Progress in Neurobiology*, *49*, 1-51.

Oates, R.K., Simpson, J.M., Cartmill, T.B., Turnbull, J.A. (1995). Intellectual function and age of repair in cyanotic congenital heart disease. *Archives of Disease in Childhood*, *72*, 298-301.

Rascanu, R. (2004). *Introduction in clinic psychodiagnosis*, Bucharest: Ed. University.

Shampaine, E.L., Nadelman, L., Rosenthal, A., Behrendt, D., Herbert, S. (1990). Longitudinal psychological assessment in tetralogy of Fallot. *Pediatric Cardiology*, *10*, 135-140.

Terai, M., Niwa, K., Nakazawa, M., Tatsuno, K., Segami, K., Hamada, H., Kohno, Y., Oki, I., Nakamura, Y. (2002). Mortality from congenital cardiovascular malformations in Japan, 1968 through 1997. *Circulation*, *66*, 484-488.

Wray, J., Sensky, T. (2001). Congenital heart disease and cardiac surgery in childhood: effect on cognitive function and academic ability. *Heart*, *85*, 687-691.