Executive function deficits in congenital heart surgical patients: prevalence and timing of presentation

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Abstract

Background: Congenital heart patients undergoing congenital heart surgery in the first year of life are at high risk of having a neurodevelopmental disorder. The most common difficulties are related to executive functioning. The following questions were assessed in the current project: Are patients having congenital heart surgery after one year of life at lower risk for neurodevelopmental disorders? At what age do executive function deficits manifest? *Methods:* We evaluated executive function in four groups of congenital heart patients who had undergone congenital heart surgery. These groups were high-risk patients with and without a genetic syndrome associated with a neurodevelopmental disorder and low-risk patients with and without a genetic syndrome associated with a neurodevelopmental disorder. We evaluated executive function using the Behavior Rating Inventory of Executive Function – Preschool Version, Behavior Rating Inventory of Executive Function-2, and Minnesota Executive Function Scale at various ages. We compared the rates of executive function deficits in the high- and low-risk groups as well as compared that to the published norms for age. We also assessed at what age these deficits become apparent. *Conclusion:* We found that both high- and low-risk groups had higher levels of executive functioning deficits compared to the norms for age. The low-risk group's degree of executive function deficits appeared a little lower than the high-risk group. However, it was difficult to comment on the statistical significance. We also saw that executive function deficits often do not become apparent for many years after surgery. This finding highlights the need for continued evaluation of functioning as these kids mature.

Introduction

Congenital heart surgery outcomes have improved over the decades. Patients with complex CHD are living longer, even well into adulthood. Patients with simple CHD can have a repair at an early age with a reasonable expectation that afterwards they could live as long as and with the same quality of life as the general population. However, children with CHD who undergo surgical repair or palliation are at increased risk of neurodevelopmental disorders.

What factors infer the highest risk for neurodevelpmental disorders continues to be a topic of investigation. Patients with obvious, well-described genetic syndromes have the highest risk, and the neurodevelopmental outcome is dominated by the syndrome.[1] For those who do not have a genetic syndrome, the more complex the defect the higher the likelihood of neurodevelopmental disorders.[1] Complex defects are more likely to need surgery as infants, require multiple surgeries, and be cyanotic. Marino et al. defined patients as being high risk if they undergo cardiac surgery before a year of age or if they are cyanotic before repair if repair is done after a year of life.[2] Patients with severe CHD have the highest rate with a reported incidence of neurodevelopmental disorders of 50–60%.[3]

Much effort has been made to determine what contributes to this high incidence. Intraoperative variables have been studied multiple times. The International Cardiac Collaborative on Neurodevelopment Investigators reported that "measured intraoperative and postoperative factors accounted for 5% of the variances in PDI and MDI" (Psychomotor Developmental Index and Mental Development Index).[4] For children undergoing cardiopulmonary bypass surgery in the first year of life, Neukomenm et al. reported "Neither postoperative total brain volume nor perioperative brain injury severity predicted the total IQ, but socioeconomic status ($p < .001$) and longer hospital stay ($p = .004$) did."(5) So far no one has shown one major variable in surgery or postoperative care to dominate the neurodevelopmental outcome. Many are also looking into innate patient variables. In a population-based study, Egbe et al. showed an odds ratio of 2.01 for patients with CHD to also have an extra-cardiac congenital anomaly.[6] This shows that congenital heart patients have an increased incidence of other congenital anomalies.

The majority of neurodevelopmental disorders in congenital heart patients are disorders in executive function. Executive function is responsible for organisation, communication, and connections within the brain and is something that cannot be measured before age 2 years. As children develop and advance in school, they rely more on executive function to accomplish day to day activities and succeed. For this reason, executive function deficits often do not become apparent until later in childhood. Many can go undiagnosed, or kids can be inappropriately labelled as uninterested or a behaviour concern. For these reasons, this project looked at the age that executive function deficits emerge. The rates of executive function deficits in low-risk patient patients undergoing cardiac surgery compared to the general population were another area of interest.

We hypothesised that the low-risk group would have similar rates of neurodevelopmental disorders to the general population as they were not cyanotic and presumably had one cardiac surgery with bypass.

Methods

We divided our patients into four groups. High-risk without genetic syndrome, high-risk with genetic syndrome, low-risk without genetic syndrome, and low-risk with genetic syndrome. High risk was defined as neonates or infants requiring cardiac surgery in the first year of life or those that were cyanotic before surgery if the surgery was done after a year of life. They were placed in the genetic syndrome group if they had a clinical diagnosis of a genetic syndrome with known intellectual disabilities or if they had a pathogenic mutation in a gene that was associated with neurodevelopmental disorders. A patient with a variant of uncertain significance in a gene associated with neurodevelopmental disorders was considered not to have a genetic syndrome. Patients birth to 17 years at time of testing were included. Exclusion criteria were patients with seizure disorder diagnosed prior to surgery, patients with history of extracorporeal membrane oxygenation (ECMO), patients with a history of stroke or perioperative seizures, premature birth less than 32 weeks gestational age, or with other comorbidities as determined by the team.

Patients were then evaluated with previously validated, age-appropriate instruments. For birth to 5 years, the caregiver filled out; Ages and Stages Questionnaire Social Emotional Second Edition, Ages and Stages Questionnaire, Third Edition and a socio-economic status questionnaire. Patients 2 years to 5 years would also complete the Behavior Rating Inventory of Executive Function- Preschool Version and the Minnesota Executive Function Scale. Patients 6 years to 17 years would complete the Behavior Rating Inventory of Executive Function-2, the Minnesota Executive Function Scale, and a socio-economic status questionnaire.

The Behavior Rating Inventory of Executive Function – Preschool Version consists of 63 items that measure various aspects of executive functioning for children ages 2 years to 5 years, 11 months. The clinical scales form three broad indexes including: inhibitory self-control index, flexibility index, and emergent metacognition index, and one composite score (global executive composite). Scores of 65 or greater are considered clinically elevated.

The Behavior Rating Inventory of Executive Function-2 consists of 63 items that measure various aspects of executive functioning for children ages 5 years to 18 years. The clinical scales form three broad indexes including: behavior regulation index, emotional regulation index, cognition regulation index, and one composite score (global executive composite). Scores 60–64 are considered mildly elevated, scores 65-69 are considered potentially clinically elevated, and scores at or above 70 are considered clinically elevated.

Normal population assumes an average score of 50 and standard deviation of 10 on either the Behavior Rating Inventory of Executive Function – Preschool Version or Behavior Rating Inventory of Executive Function-2. For analyses, a score greater than or equal to 65 on the Behavior Rating Inventory of Executive Function – Preschool Version and 70 on the Behavior Rating Inventory of Executive Function-2 was defined as "clinically significant".

The Minnesota Executive Function Scale is a digital game administered on a tablet or laptop computer. It takes less than 5 minutes and is the leading standardised, direct performance measure of executive function. Minnesota Executive Function Scale is normed on over 50,000 typically developing children in the United States. We assessed participants with Minnesota Executive Function Scale ages 2 years to 17 years. Minnesota Executive Function Scale scoring for the general population has a mean of 100 with a standard deviation of 15. A clinically significant Minnesota Executive Function Scale score was defined when the age expected result was "approaching" or less than 85.

Statistical methods

We used descriptive statistics to summarise participant characteristics by group and overall. Frequency and percent were recorded for all categorical variables. Mean, standard deviation, median, interquartile range, and range were recorded for all numerical variables.

We performed a 1-sample *t*-test to determine how participants compared either to a normally developing population or the average population. The first, non-missing Behavior Rating Inventory of Executive Function (either Behavior Rating Inventory of Executive Function – Preschool Version or Behavior Rating Inventory of Executive Function-2) and Minnesota Executive Function Scale score was analysed. Behavior Rating Inventory of Executive Function scores were compared to a normally developing population with mean 50 and standard deviation of 10. Minnesota Executive Function Scale scores were compared to the average population with mean 100 and standard deviation of 15. Analyses were performed for all pooled data and each subgroup.

As appropriate, we used a log-rank or Wilcoxon test to determine whether the time to developmental delays differs by group. The first, non-missing, and clinically significant Behavior Rating Inventory of Executive Function (either Behavior Rating Inventory of Executive Function – Preschool Version or Behavior Rating Inventory of Executive Function-2) and Minnesota Executive Function Scale score was analysed. A score of 65 on the Behavior Rating Inventory of Executive Function – Preschool Version and greater than or equal to 70 on the Behavior Rating Inventory of Executive Function-2 were defined as clinically significant. Whereas a clinically significant Minnesota Executive Function Scale score was defined when the age expected result was "approaching".

All analyses were performed in R (Version 4.2.2) and assumed a two-sided, 5% level of significance. Due to sample size, we were unable to perform subgroup analyses for group D.[7]

Table 1. Patient demographics by group

	Group A N = 150	Group B N = 27	Group C N = 34	Group D N = 4	Overall N = 215
Age at Enrollment					
Mean (SD)	8.43 (5.22)	5.48 (4.02)	9.54 (4.90)	11.0 (5.41)	8.29 (5.14)
Median (Q1–Q3)	8.71 (3.67–13.2)	4.33 (2.38–7.63)	9.96 (5.06–13.0)	12.2 (8.90–14.3)	8.00 (3.67–13.0)
Range	[0.0833, 17.8]	[0.0833, 16.4]	[1.67, 17.7]	[3.58, 16.0]	[0.0833, 17.8]
Gestational Age					
Mean (SD)	38.4 (1.93)	37.3 (2.37)	39.1 (1.79)	38.8 (1.89)	38.4 (2.01)
Median (Q1-Q3)	39.0 (37.0–40.0)	38.0 (36.0–39.0)	39.5 (38.0–40.0)	39.5 (38.3–40.0)	39.0 (37.0–40.0)
Range	[32.0, 47.0]	[32.0, 41.0]	[34.0, 42.0]	[36.0, 40.0]	[32.0, 47.0]
Gender					
Female	64 (42.7%)	15 (55.6%)	17 (50.0%)	3 (75%)	99 (46%)
Male	86 (57.3%)	12 (44.4%)	17 (50.0%)	1 (25%)	116 (54%)
Race					
African American	13 (8.7%)	5 (18.5%)	4 (11.8%)	1 (25%)	23 (10.7%)
Asian	8 (5.3%)	2 (7.4%)	0 (0%)	2 (50%)	12 (5.6%)
Caucasian	120 (80.0%)	20 (74.1%)	27 (79.4%)	1 (25%)	168 (78.1%)
Latino	9 (6.0%)	0 (0%)	3 (8.8%)	0 (0%)	12 (5.6%)
Primary Diagnosis					
Aortic Valve Stenosis	0 (0.0%)	0 (0.0%)	2 (5.9%)	0 (0.0%)	2 (0.9%)
Atrial Septal Defect	1 (0.7%)	0 (0%)	21 (61.8%)	2 (50.0%)	24 (11.2%)
Atrioventricular Septal Defect	6 (4.0%)	0 (0%)	0 (0%)	1 (25%)	7 (3.3%)
Bicuspid Aortic Valve	0 (0%)	0 (0%)	2 (5.9%)	1 (25%)	3 (1.4%)
Coarctation	19 (12.7%)	7 (25.9%)	0 (0%)	0 (0%)	26 (12.1%)
Congenitally Corrected Transposition	1 (0.7%)	0 (0%)	0 (0%)	0 (0%)	1 (0.5%)
Double Inlet Left Ventricle	7 (4.7%)	0 (0%)	0 (0%)	0 (0%)	7 (3.3%)
Double Outlet Right Ventricle	10 (6.7%	1 (3.7%)	0 (0%)	0 (0%)	11 (5.1%)
Hypoplastic Left Heart Syndrome	15 (10.0%)	0 (0%)	0 (0%)	0 (0%)	15 (7.0%)
Interrupted Aortic Arch	4 (2.7%)	3 (11.1%)	0 (0%)	0 (0%)	7 (3.3%)
Patent Ductus Arteriosus	0 (0%)	0 (0%)	1 (2.9%)	0 (0%)	1 (0.5%)
Pulmonary Atresia with Intact Septum	5 (3.3%)	0 (0%)	0 (0%)	0 (0%)	5 (2.3%)
Pulmonary Atresia with Ventricular Septal Defect	4 (2.7%)	1 (3.7%)	0 (0%)	0 (0%)	5 (2.3%)
Tetralogy of Fallot	28 (18.7%)	7 (25.9%)	0 (0%)	0 (0%)	35 (16.3%)
Total Anomalous Pulmonary Venous Return	2 (1.3%)	0 (0%)	0 (0%)	0 (0%)	2 (0.9%)
Transposition of the Great Arteries	24 (16%)	2 (7.4%)	0 (0%)	0 (0%)	26 (12.1%)
Tricuspid Atresia	4 (2.7%)	2 (7.4%)	0 (0%)	0 (0%)	6 (2.8%)
Truncus Arteriosus	1 (0.7%)	0 (0%)	0 (0%)	0 (0%)	1 (0.5%)
Vascular Ring	1 (0.7%)	1 (3.7%)	0 (0%)	0 (0%)	2 (0.9%)
Ventricular Septal Defect	15 (10.0%)	2 (7.4%)	8 (23.5%)	0 (0%)	25 (11.6%)
Other	3 (2.0%)	1 (3.7%)	0 (0%)	1 (25%)	4 (1.9%)

Results

Table 1 summarises the patient demographics. Group A is high-risk patients without a genetic syndrome, group B is high risk with a genetic syndrome, group C is low risk without genetic syndrome, and group D is low risk with genetic syndrome.

Table 2 describes the number, timing of surgery, and surgeries with and without bypass. It also reports number of noncardiac surgeries requiring anaesthesia.

Contrary to what we hypothesised, we found that both high- and low-risk groups without a genetic syndrome were different

Table 2. Summary of procedures by group

	Group A N = 150	Group B N = 27	Group C N = 34	Group D N = 4	Overall N = 215
Number of Procedures					
Mean (SD)	4.37 (3.11)	4.04 (3.17)	1.68 (1.01)	4.75 (3.50)	3.91 (3.04)
Range	[1.00, 13.0]	[1.00, 14.0]	[1.00, 5.00]	[1.00, 9.00]	[1.00, 14.0]
Bypass Surgeries					
Mean (SD)	1.71 (1.21)	1.19 (1.08)	1.06 (0.239)	1.75 (0.957)	1.54 (1.12)
Range	[0, 6.00]	[0, 4.00]	[1.00, 2.00]	[1.00, 3.00]	[0, 6.00]
Bypass Surgeries Before 1 Year of Age					
Mean (SD)	1.17 (0.680)	0.889 (0.847)	0 (0)	0.250 (0.50)	0.930 (0.773)
Range	[0, 3.00]	[0, 3.00]	[0,0]	[0, 1.00]	[0,3.00]
Cyanotic Before Surgery					
Mean (SD)	1.16 (1.33)	0.889 (1.19)	0 (0)	0 (0)	0.921 (1.26)
Range	[0, 6.00]	[0, 4.00]	[0, 0]	[0, 0]	[0, 6.00]
Non-Bypass Cardiac Surgeries					
Mean (SD)	0.493 (1.16)	0.593 (0.888)	0.0588 (0.343)	0.25 (0.500)	0.433 (1.04)
Range	[0, 7.00]	[0, 4.00]	[0, 2.00]	[0, 1.00]	[0, 7.00]
Non-Cardiac, Anesthesia Only Surgeries					
Mean (SD)	2.01 (2.22)	1.81 (2.45)	0.500 (0.788)	2.75 (3.20)	1.76 (2.17)
Range	[0, 10.0]	[0, 9.00]	[0, 3.00]	[0, 6.00]	[0, 10.0]
Bypass Surgeries Within 2 Years of Age					
Mean (SD)	1.26 (0.806)	1.00 (0.832)	0.235 (0.432)	0.750 (0.500)	1.06 (0.841)
Range	[0, 4.00]	[0, 3.00]	[0, 1.00]	[0, 1.00]	[0, 4.00]
Cyanotic Cases Within 2 Years of Age					
Mean (SD)	0.960 (1.06)	0.741 (0.944)	0 (0)	0 (0)	0.763 (1.01)
Range	[0, 4.00]	[0, 3.00]	[0, 0]	[0, 0]	[0, 4.00]

than the normal population in regard to executive function scores on the global executive composite as well as Minnesota Executive Function Scale.

With the BRIEF the results were as follows.

Our high-risk group was statistically different in the global executive composite and subcategories: EMI, BRI, ERI, CRI. While the low-risk group was statistically different in the global executive composite, it also was not statistically significant in all subgroups. In fact, of the subgroups that were statistically different were in the emotional regulation index and cognition regulation index. These two subgroups are from the Behavior Rating Inventory of Executive Function-2 which is for older kids.

Figure 1 looks at time or age of first significant Behavior Rating Inventory of Executive Function – Preschool Version or Behavior Rating Inventory of Executive Function-2. Data suggest the time at which clinically significant Behavior Rating Inventory of Executive Function scores emerge differ by group (*p*-value < 0.001). By age 10, 14.5 (7.8, 20.7) percent of participants in groups A and 5.6 (0, 15.6) percent in group C had clinically significant result.

This shows an increased rate of drop off after age 10 years with an increased slope for group A. Our numbers show 50% incidence of a clinically significant Behavior Rating Inventory of Executive Function in group A by age 18 years. Group C did not show as much of a drop off with 40% clinically significant result by 18 years;

however, the error bars for this group are quite large. A limitation to our collection of this though is that we started analysing patients at all ages and not repeatedly since birth or surgery. This means that clinically significant results could have been their earlier if we had been following all patients since birth.

Results of the MEFS was as follows. We used the first MEFS performed for each patient for analysis (Tables 3–5). Table 6 shows the results. Both high- and low-risk groups show significant deviation from the mean.

Figure 2 shows time or age until first clinically significant MEFS score. This was defined as an Minnesota Executive Function Scale score below 85. This also shows a difference in time to diagnosis between groups (*p*-value < 0.001) with 16.3 (9.4, 22.7) percent in group A, 7.9 (0, 18.1) percent in group C, and 68.8 (29.3, 86.2) percent in group B having a clinically significant Minnesota Executive Function Scale score by age 10.

Discussion

Not one preoperative, surgical, postoperative factor, or small group of variables has been shown to be the major determinate of neurodevelopmental outcomes in congenital heart surgery. The Boston Circulatory Arrest Trial compared deep hypothermic cardiac arrest to low flow bypass for patients with d-Transposition.

Table 3. BRIEF-2 and BRIEF-P global executive composite versus norms

Global Executive Composite		
Sample	Estimate (95% CI)	*p*-value
Overall	58.46 (57.06,59.85)	0.0000
Group A	57.43 (55.76, 59.11)	0.0000
Group B	66.48 (62.35, 70.61)	0.0000
Group C	56.62 (53.02, 60.23)	0.0007

Table 4. BRIEF-P subcategories versus normal

	Inhibitory Self-Control Index		Flexibility Index		Emergent Metacognition Index	
Sample	Estimate (95% CI)	*p*-value	Estimate (95% CI)	p-value	Estimate (95% CI)	*p*-value
Overall	53.07 (51.67, 54.46)	0.0000	52.72 (51.33, 54.12)	0.0002	57.29 (55.9, 58.69)	0.0000
Group A	50.89 (49.21, 52.57)	0.2965	51.39 (49.71, 53.07)	0.1038	54.78 (53.1, 56.45)	0.0000
Group B	59.29 (55.16, 63.41)	0.0001	57.57 (53.44, 61.7)	0.0009	65.71 (61.59, 69.84)	0.0000
Group C	51.71 (48.11, 55.32)	0.3397	50.86 (47.25, 54.46)	0.6312	52.71 (49.11, 56.32)	0.1348

Table 5. BRIEF-2 subcategories versus normal

|	Behavior Regulation Index		Emotional Regulation Index		Cognition Regulation Index	
Sample	Estimate (95% CI)	*p*-value	Estimate (95% CI)	*p*-value	Estimate (95% CI)	*p*-value
Overall	56.48 (555.09, 57.87)	0.000	59.24 (57.84, 60.83)	0.0000	57.2 (55.8, 58.59)	0.0000
Group A	55.97 (54.3, 57.65)	0.000	58.72 (57.05, 60.4)	0.0000	56.42 (54.74, 58.1)	0.0000
Group B	68 (63.87, 72.13)	0.000	67.77 (63.64, 71.9)	0.0000	63.46 (59.33, 67.59)	0.0000
Group C	52.63 (49.02, 56.24)	0.147	57.52 (53.91, 61.12)	0.0002	57.19 (53.58, 60.79)	0.0003
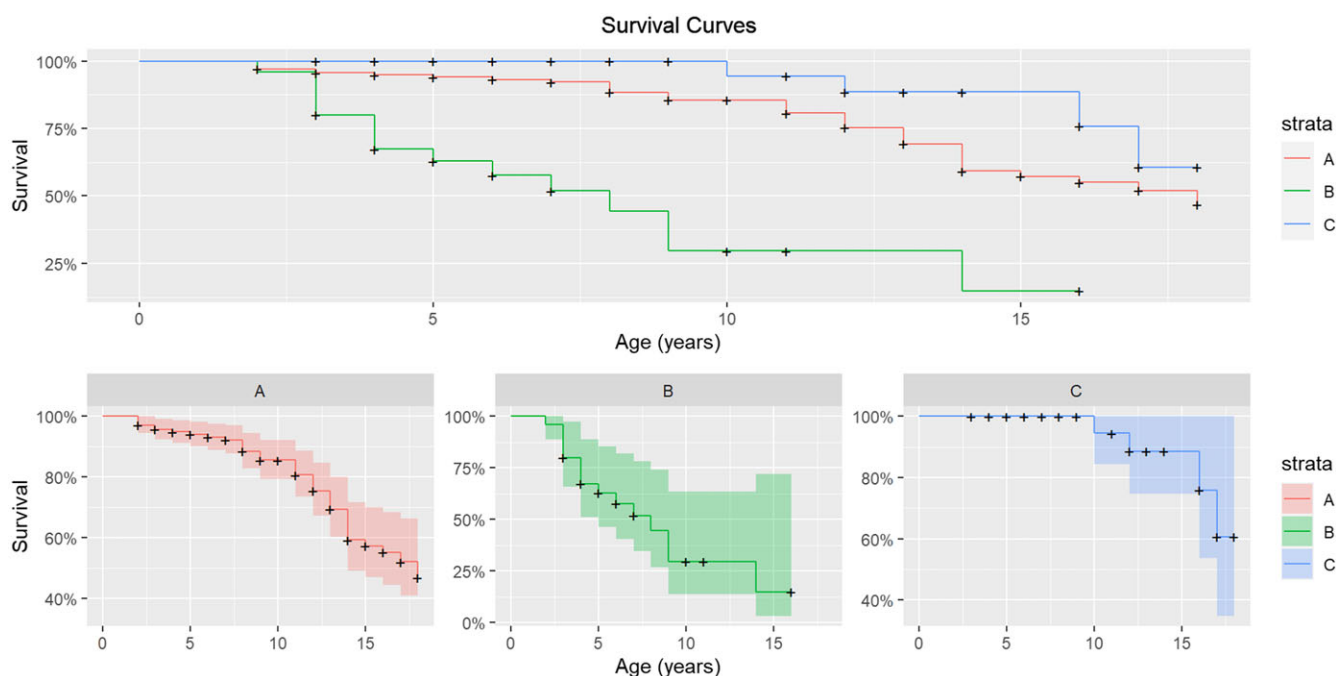
Figure 1. Time to clinically significant BRIEF.

Table 6. MEFS standard score versus norms

	MEFS Standard Score	
Sample	Estimate (95% CI)	*p*-value
Overall	89.66 (87.58, 91.74)	0.0000
Group A	90.05 (87.54, 92.56)	0.0000
Group B	84.56 (78.37, 90.75)	0.0000
Group C	93.67 (88.35, 98.99)	0.0211
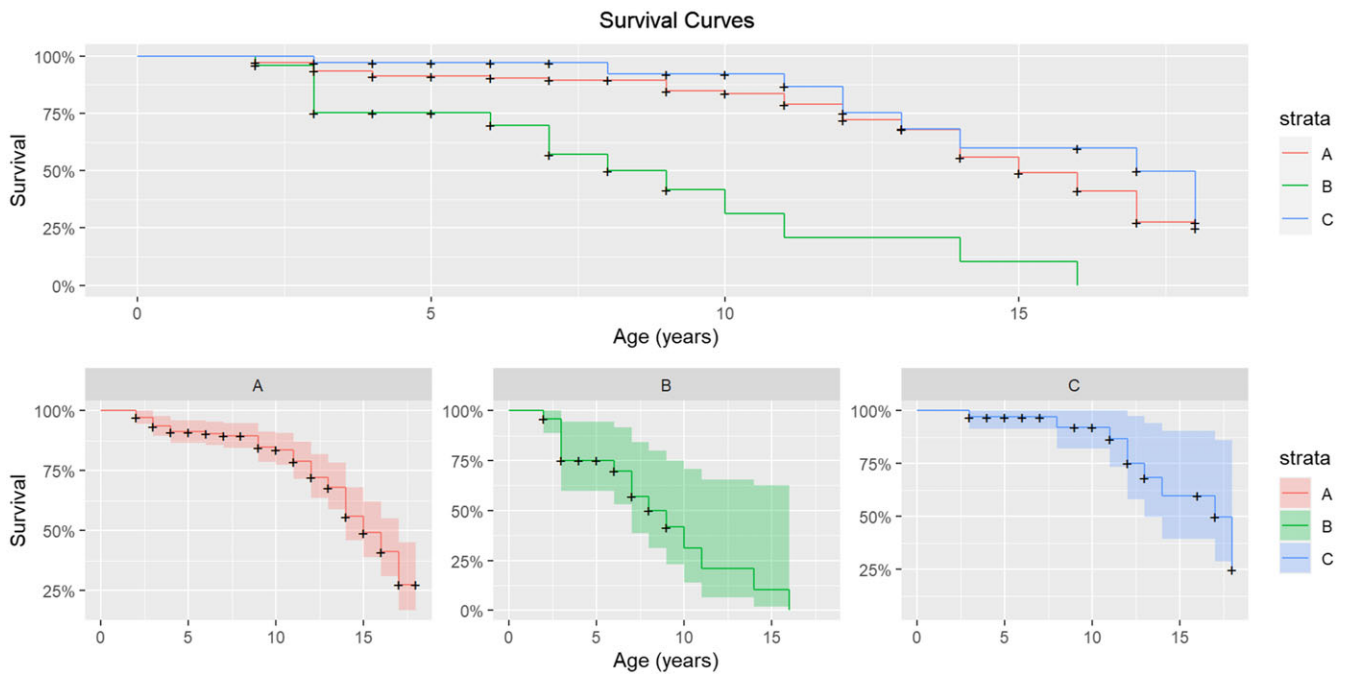
Figure 2. Time to abnormal MEFS.

At sixteen years out they did not find any statistical difference in neurodevelopmental outcomes.[8] The International Cardiac Collaborative on Neurodevelopment Investigators reported that intraoperative and postoperative factors accounted for only 5% of the variances in psychomotor development index and mental development index.[4] Billotte et al.[3] reported patients with severe CHD as having increased neurodevelopmental disorders with a prevalence of 60%.[3] We sought to determine if surgery done after one year of life then inferred less risk. We hypothesised that the low-risk group would have similar neurodevelopment as the general population. As executive function deficits are the most common neurodevelopmental disorders in congenital heart patients, we choose to evaluate executive function using both the Behavior Rating Inventory of Executive Function – Preschool Version or Behavior Rating Inventory of Executive Function-2 and the Minnesota Executive Function Scale. We also looked to see at what age executive function deficits emerged. Our low-risk group without genetic syndrome did have slightly better scores on the Behavior Rating Inventory of Executive Function – Preschool Version, Behavior Rating Inventory of Executive Function-2, and Minnesota Executive Function Scale compared to the high-risk group without genetic syndrome; however, they were statistically different than the controls or normal population. This was not what we hypothesised. Low-risk younger age patients evaluated

with the Behavior Rating Inventory of Executive Function – Preschool Version did not show statistical difference from the normal in any of the three subgroups, while patients evaluated at older ages with the Behavior Rating Inventory of Executive Function-2 showed clinically significant differences in two of the three subgroups. Also, when reviewing the survival curves of freedom from clinically significant BRIEF or Minnesota Executive Function Scale, they are fairly similar in both the high-risk and low-risk groups, though the low-risk group was a little better. The high-risk group had 50% survival on the BRIEF compared to 60% for the low-risk group at 18 years. Both groups showed increase drop off after 10 years of age. This helps us better understand the timing of when executive function deficits emerge. Executive function is not present at birth and develops over time into adulthood. As we get older and the demands for executive skills increase, we rely more on executive function to be successful in managing daily life and school. Executive function deficits may not be detectable then until they fail to develop. This underlines the importance of continued neurodevelopmental assessment especially in the older, school age children and not just concentrating on early development. Executive function assessment or neuropsychological testing is also critical in the school age population to prevent many from going undiagnosed and struggling in school. Also, the similar survival curves of the high- and low-risk groups

would not support delaying surgery, when possible, on a neurodevelopmental basis.

Other reports have not found a correlation with surgical variables or to age of operation. One example is International Cardiac Collaborative on Neurodevelopment Investigators[4] who concluded that innate patient variables may be more responsible for long-term neurodevelopment. One possibility is underlying genetic disorders. We placed participants with a genetic result of variant of uncertain significance in the group without genetic syndrome even if the variant was associated with developmental disorders. We also did not uniformly test every patient with a whole exome or genome. As our knowledge of genetics increases, we may find many mutations that are associated with less severe cardiac defects that do not require repair before a year of age but still affect the neurodevelopmental outcome of these patients. Egbe et al.[6] showed an odds ratio of 2.01 for patients with CHD to have other extracardiac anomalies. This would support a genetic diagnosis contributing to expression of physical congenital anomalies, and many known genetic syndromes have associated neurodevelopmental disorders.

Sample size, particularly in the low-risk group, was a limitation of our study contributing to large confidence intervals. Additionally, age at enrollment and length of follow-up varied by participant. This may bias the analysis of when deficits first emerge, as clinically significant results are not able to be identified until follow-up and assessment begin. Data were captured longitudinally; however, analyses were limited to a single endpoint leading to a loss of information. Lastly, our control group was the published norms for the general population rather than an assessment of congenital heart patients that did not require surgery or matched for gestational age, birthweight, or other noncardiac surgeries.

Conclusion

Our study shows like many others that surgical variables including age of surgery may be less important than innate patient variables. We also show that many executive function deficits seen in congenital heart patients do not present until adolescents and teenage years. This emphasises the importance of executive function screening and or testing for patients with CHDs and the importance of continued neurodevelopmental evaluation into young adulthood. This will help assure appropriate resources and support to be more successful in school and ultimately adult life.

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