Health-related quality of life for children and adolescents in school age with hypoplastic left heart syndrome: a single-centre study

Author for correspondence:
Dr R. D. Oberhuber, Children's Heart Center Linz, Kepler University Hospital, Krankenhausstrasse 26, Linz 4020, Austria. Tel: +43 664 50 155 63; Fax: +43 576 8084 24734. E-mails: r.oberhuber@eduhi.at; raphael.oberhuber@kepleruniklinikum.at

Raphael D. Oberhuber[1,2] ⬤, Sonja Huemer[2], Rudolf Mair[1], Eva Sames-Dolzer[1], Michaela Kreuzer[1] and Gerald Tulzer[1]

[1]Children's Heart Center Linz, Kepler University Hospital, 4020 Linz, Austria and [2]Department of Inclusive Education, University of Education of Upper Austria, 4020 Linz, Austria

Abstract

Data from neurological and radiological research show an abnormal neurological development in patients treated for hypoplastic left heart syndrome. Thus, the aim of this study was to survey the quality of life scores in comparison with healthy children and children with other heart diseases (mild, moderate, and severe heart defects, heart defects in total). Children with hypoplastic left heart syndrome (aged 6.3–16.9 years) under compulsory education requirements, who were treated at the Children's Heart Center Linz between 1997 and 2009 (n = 74), were surveyed. Totally, 41 children and 44 parents were examined prospectively by psychologists according to Pediatric Quality of Life Inventory, a health-related quality of life measurement. The results of the self-assessments of health-related quality of life on a scale of 1–100 showed a wide range, from a minimum of 5.00 (social functioning) to a maximum of 100 (physical health-related summary scores, emotional functioning, school functioning), with a total score of 98.44. The parents' assessments (proxy) were quite similar, showing a range from 10 (social functioning) up to 100. Adolescent hypoplastic left heart syndrome patients rated themselves on the same level as healthy youths and youths with different heart diseases. The results show that patients with hypoplastic left heart syndrome aged 6–16 years can be successfully supported and assisted in their psychosocial development even if they show low varying physical and psychosocial parameters. The finding that adolescent hypoplastic left heart syndrome patients estimated themselves similar to healthy individuals suggests that they learnt to cope with a severe heart defect.

CAMBRIDGE
UNIVERSITY PRESS

Neurodevelopmental delay has been described in children with critical CHD. Neurological and radiological research results[1–7] show that neonates with hypoplastic left heart syndrome carry an abnormal cerebral microstructure, and their intrauterine brain growth may be delayed. Postnatal treatment of hypoplastic left heart syndrome includes extensive cardiac surgery in the neonatal period using cardiopulmonary bypass often followed by long intensive care stays with haemodynamic instabilities.[8–10] Later, these children undergo at least two further cardiac bypass surgeries (bi-directional Glenn and Fontan operation).[11–13] Whether neurodevelopmental problems are caused primarily by prenatal or postnatal factors is still unclear. On this basis, a poor quality of life and low social integration could be presumed. Many of these patients with hypoplastic left heart syndrome have now reached school age. Children born with CHDs who have had several surgical interventions and numerous hospital stays have experienced very difficult challenges – some as a result of overly lenient (inconsistent) parenting, and others due to excessive demands by their day-to-day educational environment (cognitive and/or social challenges), and others again as a result of dealing with the frustrations of having to interact with healthy peers of the same age.[14–19] Furthermore, these patients are at risk for thromboembolic events including cerebral infarction both before and after completion of a Fontan circulation. These patients may be particularly vulnerable as a result of the technically difficult first-stage Norwood procedures. Finally, altered cerebral blood flow in utero in hypoplastic left heart syndrome-fetuses and a postnatal reduced head circumference have been shown to potentially affect neurodevelopmental outcome.[20,21] Single-centre neurocognitive follow-up studies report these patients to have normal intelligence quotient scores.[22–25] Nevertheless, in several centres around the world, comfort care is still offered to parents of newborn with hypoplastic left heart syndrome or, if diagnosed prenatally, abortion because of an expected unfavourable outcome. In these centres, it is still an ethical question if children with this diagnosis should undergo complex cardiac surgery having the prognosis only to suffer.
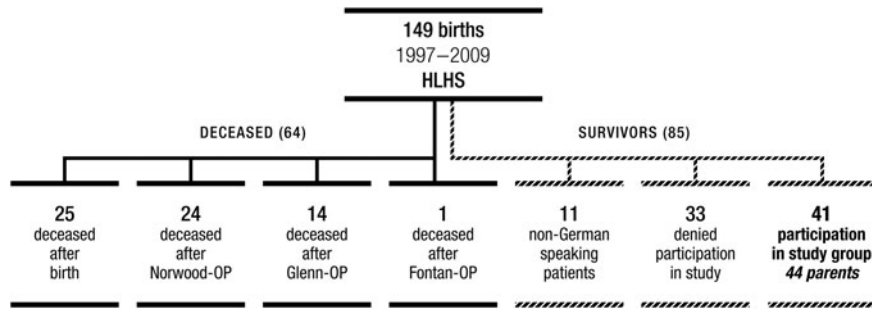
Figure 1. Sample, hypoplastic left heart syndrome 1997–2009.

Therefore, especially for prenatal counselling, information on quality of life of patients with hypoplastic left heart syndrome is important to help couples make well-informed decisions about their pregnancy.

Thus, the aim of this study was to

- survey the assessments of quality of life from the patients' view and the viewpoint of their parents;
- survey the quality of life scores (total, physical, mental, emotional, social, academic) in comparison with healthy children, and
- survey children with other heart diseases (mild, moderate, and severe heart defects, heart defects in total).

Over the past decades, the concept of quality of life has been of paramount importance for evaluating the quality and outcome of health care.[26] The first study on quality of life in patients with CHD was published more than 40 years ago.[27] It is known that quality of life is a complex construct with no uniform definition which causes a conceptual haziness, and quality of life research has been criticised for a lack of conceptual clarity and clear definition of quality of life. This may result in inaccurate measurements of "true" quality of life and in inconclusive study findings. To direct more attention to this phenomenon, Gill and Feinstein[28] evaluated the quality of existing quality of life research. On the basis of the Gill and Feinstein criteria and the findings in previous reviews,[26,27,29] there are proposals for recommendations for quality of life.

Therefore, we used a very clear research design by comparing our results with well-defined studies and a valid, reliable, and objective measurement as it will be mentioned.

Knowledge about quality of life is important for understanding the consequences of illness and treatment and for medical decision making across age groups and culture. Quality of life is an important endpoint in medical and health research, and quality of life research involves a variety of target groups and research designs. The term health-related quality of life is described as referring to the health aspects of quality of life (and is used as a scale unit in Varnis Pediatric Quality of Life), generally considered to reflect the impact of disease and treatment on disability and daily functioning; it has been considered to reflect the impact of perceived health on an individual's ability to live a fulfilling live. However, more specifically, health-related quality of life is a measure of the value assigned to duration of life as modified by impairments, functional states, perceptions, and opportunities, as influenced by disease, injury, treatment, and policy.[28]

Material and methods

Patients

From 1997 to 2009, 149 children (n = 149) with hypoplastic left heart syndrome were admitted to the Children's Heart Center Linz. Sixty-four patients died before entering school. Of these, 25 newborns died before surgical treatment due to circulatory collapse or because the parents chose comfort care. All other patients (n = 124) underwent a Norwood Stage I operation in the newborn period, a bi-directional Glenn at the age of 3–4 months, and a Fontan operation around the age of 3 years, all at our institution. About 39 children (31%) died before entering school; 24 between stage 1 and 2; 14 children died after bi-directional Glenn surgery between stages 2 and 3; and 1 child died after Fontan operation; of the remaining 85 patients, 42 patients did not participate in the study: 33 children whose parents denied informed consent (without giving reasons, mean age 10.2 ± 3.14 years; range: 7.5–16.5 years, 12 male, 21 female), 1 boy with severe hypoxic encephalopathy after the Fontan procedure, and 11 children from non-German-speaking foreign countries. Thus, 41 patients (mean age 10.3 ± 3.16 years; range: 6.3–16.9 years) and 44 parents underwent tests and questioning for our empirical research. We obtained complete results for 41 patients and 44 parents[30] (see Figure 1).

Twenty-one children had been diagnosed prenatally; 26 were male; 33 had received a Sano-shunt at the time of the Norwood operation and 8 had a modified Blalock-Taussig shunt; 26 patients had aortic atresia; 15 had aortic stenosis; 5 were operated in deep hypothermic circulatory arrest; 9 patients were operated using antegrade cerebral perfusion, and 27 patients underwent double perfusion technique.

There were no data in the investigated group concerning morphological changes of the brain, no sonographic or MRI examinations which could be related to the results. Patients with hypoplastic left heart syndrome who participated in the study attended the following school types: primary school (n = 20), secondary school (n = 8), academic secondary school (n = 2), special needs school (n = 4), secondary school with a business emphasis (n = 2), apprenticeship (n = 1), Montessori or Freinet school (n = 2), and unemployed after compulsory schooling (n = 2).

Three patients were diagnosed with attention-deficit hyperactivity disorder, 2 with protein-losing enteropathy, 8 with sensorimotor disorders (such as problems with coordination of sensory and motor signals while writing, holding crayon; spatial

Table 1. Sample description

41 Patients with HLHS	
21 Prenatally diagnosed	20 Diagnosed after birth
28 Children (6–12 years)	13 Adolescents (13–16 years)
26 Male	15 Female
33 Sano shunt	8 Blalock Taussig Shunt
26 Aortic atresia	15 Aortic stenosis
Cerebral Perfusion technique	5 Deep hypothermic circulatory arrest
	9 Antegrade cerebral perfusion
	27 Double perfusion technique
School	20 Primary School
	8 Secondary School
	2 Academic Secondary School
	4 Special Needs School
	2 Secondary School with Business Emphasis
	1 Apprenticeship
	2 Montessori or Freinet School
	1 Unemployed after Compulsory School
Comorbidity	3 Attention-Deficit Hyperactivity Disorder
	2 Protein-Losing Enteropathy
	8 Sensorimotor Disorder
	2 Seizures
	1 Autism Spectrum Syndrome

HLHS = hypoplastic left heart syndrome

orientation deficits, etc.), 2 with seizures, and 1 with autism (see Table 1).

This study was approved by the local IRB (ID-number J16-01).

Pediatric quality of life inventory

Health-related quality of life is defined as the impact of a specific illness, medical therapy, or health services policy on a patient's ability to function in various life contexts and draw personal satisfaction from physical, psychological, and social functioning perspectives.[31,32] The Pediatric Quality of Life Inventory Version 4.0 Generic Core Scales (PedsQL) is a reliable, valid generic health-related quality of life measurement tool that is widely used in paediatric populations to determine health-related quality of life in patients with chronic disease and healthy controls.[33] The Pediatric Quality of Life Inventory can be used to characterise the impact of therapies and disease processes on the health-related quality of life of children and adolescents with CHD and to compare impacts with those in children and adolescents with other chronic diseases. Using the Pediatric Quality of Life Inventory, children self-reports, and parent reports from Varni,[34] a health-related quality of life measurement by means of patient self-assessments and parent assessments was used to obtain patients' quality of life ratings for physical, social, emotional, and school areas. The questionnaire comprised 23 items that contribute to four subscales: physical, emotional, social, and school functioning. Maximum score is 100, and minimum score is 0. The three latter subscales can be combined as psychosocial functioning. The questionnaire was translated into German according to the guidelines[34] and approved by the authors of the questionnaire. The Pediatric Quality of Life Inventory scales are composed of parallel child self-report and parent proxy-report formats, and the wording and content are as similar as possible across formats. The reliability and validity of the Pediatric Quality of Life Inventory generic core scales have been demonstrated in healthy and patient populations and their parents.[31,35] Haraldstad[29] showed in a systemic review of quality of life research in medicine and health science that the Pediatric Quality of Life Inventory was used most frequently as an instrument to measure health-related quality of life. We used the cardiac module by Varni.[34]

Comparison

The health-related quality of life scores of patients with hypoplastic left heart syndrome as well as parent assessments were compared with Pediatric Quality of Life Inventory results of the general population of primary school children according to the 2008 Felder-Puig study[36] and to the results of a comprehensive survey conducted by Mellion (healthy sample and samples with different heart diseases, mild defects, CHD 1, biventricular heart defects, CHD 2, and single ventricle, CHD 3).[31] Both studies used the same questionnaire and investigated comparable samples with healthy children from Austria and healthy children and healthy adolescents and children and adolescents with different heart diseases all over the world. Our sample was divided into a children group, n = 28, 6–12 years, and an adolescent group, n = 13, 13–16 years.

A study by Felder-Puig et al
In total, 1412 children from Austrian public schools (age 8–12 years) and 1185 parents completed child- and parent-versions of the Pediatric Quality of Life Inventory. These children demonstrated a good health-related quality of life. About 15% of children showed a notably low health-related quality of life, 47% of parents had higher school education, 85% were Austrian citizens, and 54% had a good to very good household income. Their Pediatric Quality of Life Inventory scores were similar to those of children from other developed countries (Cincinnati Urban Area, United States of America, n = 525 children aged 6–13 years; South Wales, Great Britain, n = 1033 children aged 8–18 years; 3 urban and 2 rural areas in Norway, n = 419 adolescents aged 13–15 years; San Diego school district, United States of America, n = 2435 children aged 8–18 years; State of Victoria, Australia, n = 1456 children aged 9–12 years).[36]

A comprehensive survey conducted by Mellion et al
Pediatric clinics in Cincinnati, Philadelphia, Boston, Dallas, Waco, Milwaukee, Phoenix: Healthy probands (healthy children: n = 445, youth: n = 202), patients with mild heart defects (CHD mild, septal defects, pulmonary venous anomaly, right heart lesions, left heart lesions, children: n = 99, youths: n = 94), patients with bi-ventricle heart defects (CHD bi-ventricular, children: n = 371, youths: n = 333), patients with single ventricle (CHD single ventricle, children: n = 123, youths: n = 72), all heart defects combined (CHD composite, children: n = 593, youths: n = 499) were compared with the results of children (6–12 years, n = 27) and youth (13–16 years, n = 13) from our normative sample of hypoplastic left heart syndrome patients. By means of a 95% confidence

Table 2. Descriptive Statistics: Health-Related Quality of Life Score/patients (n = 41, n = 40) and parents (n = 44)

	n	Minimum	Maximum	Mean	SD
Physical HSS	41	18.75	100.00	79.12	19.39
Emotional functioning	41	20.00	100.00	74.26	20.66
Social functioning	41	5.00	100.00	74.14	20.39
School functioning	40	30.00	100.00	71.62	17.22
Total Score	40	28.44	98.44	74.64	15.17
Psychosocial HSS	40	31.67	100.00	73.16	15.37
Physical HSS	44	28.13	100.00	79.90	19.68
Emotional functioning	44	15.00	100.00	69.88	21.00
Social functioning	44	10.00	100.00	73.29	21.21
Emotional functioning	44	15.00	100.00	66.47	18.47
Total Score	44	34.69	100.00	72.38	16.57
Psychosocial HSS	44	31.67	100.00	69.88	16.68

HSS = health summary score

interval, the d-value was calculated to show a given or non-given significance between the respective groups.[31]

Performed data collection

The psychological assessments for children living at some distance from the Children's Heart Center in Linz were combined with medical check-up appointments and took place between November 2014 and April 2015. (Psychological care is a part of the holistic concept in our Children's Heart Center since families of a child with CHD know about the heart problem. Children with CHD who come to the medical check-up are invited to undergo and follow psychological counselling and were asked to participate in the study.)

The parents were notified of the results in May 2015.

Statistical analysis

The data are presented as mean ± standard deviation. For comparison of the Pediatric Quality of Life Inventory scores of the hypoplastic left heart syndrome group with published Pediatric Quality of Life Inventory scores of healthy children and children with other chronic diseases, Hedges' g (bias-corrected) and its 95% confidence interval were calculated.[37] Group differences are considered statistically significant if the 95% confidence interval does not include 0.

Results

Health-related quality of life: patients and parents, descriptive statistics

The results for 41 children with hypoplastic left heart syndrome aged 6.3–16.9 years showed self-assessments of health-related quality of life on a scale from 0 to 100 ranging from a minimum of 5.00 (social functioning) to 100 (physical health-related summary score, emotional functioning, social functioning, school functioning), with 98.44 as a total score (74.64 ± 15.17). The parents' assessments (proxy) were quite similar, showing a range from 10 (social functioning) up to 100 (72.38 ± 16.57) (see Table 2).

Twenty-one patients had a prenatal diagnosis and 22 were diagnosed after birth. However, there was no significant difference in all health-related scores between both groups. Also, we did not find any significant difference between shunt types and perfusion techniques at the time of the Norwood operation, hypoplastic left heart syndrome anatomy, gender, and types of school.

Pediatric Quality of Life Inventory results compared with the 2014 Mellion analysis and the 2008 Felder-Puig study

Healthy children from both studies (Mellion, Felder-Puig) aged 6–12 years showed, in their self-assessments as well as in assessments by their parents, significantly higher health-related quality of life scores in all parameters (total score, physical HSS, psychosocial health summary score, social functioning, school functioning) than the hypoplastic left heart syndrome probands except for in emotional functioning, where a small difference was noted, g = −0.34 (see Table 3).[31,36]

Self-assessments by adolescents (ages 13–16 years), compared to the Mellion study, showed, in their self-assessments as well as in assessments by their parents, marginal significant differences (g = 0.5 ≤ 0.8) between healthy youths and hypoplastic left heart syndrome adolescent patients, except in emotional functioning: g = −0.105 (see Table 4).

Children with less severe heart defects (CHD Mild) gave themselves higher health-related quality of life scores (without emotional and school functioning) than children with hypoplastic left heart syndrome from our sample as well in assessments by their parents (see Table 5).

There were no significant differences between our sample and children with biventricular CHD and children with single ventricle defects. A tendency was observed that children with hypoplastic left heart syndrome from our sample and their parents gave higher scores than patients with CHD with single ventricle physiology from the Mellion study, but without significance (see Table 5).

Comparing our hypoplastic left heart syndrome adolescent sample (n = 13) with the different heart defect groups (CHD 1, CHD 2, and CHD 3) by Mellion, there was no significant difference

Table 3. PedsQL-Scores – HLHS-Children versus Healthy Samples

				Felder-Puig et al[36] (general population)						Mellion et al[31] (healthy sample)					
							Comparison with HLHS-Children						Comparison with HLHS-Children		
	HLHS-Children							95%-CI						95%-CI	
	n	M	SD	n	M	SD	ES	lower	upper	n	M	SD	ES	lower	upper
Self-report															
Total Score	27	72.04	15.97	1412	81.9	12.6	−0.778	−1.160	−0.396	445	86.2	11.7	−1.182	−1.578	−0.786
Physical HSS	28	75.78	20.72	1412	87.8	11.9	−0.991	−1.367	−0.615	443	90.3	11.6	−1.18	−1.569	−0.791
Psychosocial HSS	27	70.86	15.94	1412	79.9	14.1	−0.64	−1.022	−0.258	444	84	13.2	−0.983	−1.377	−0.589
Emotional functioning	28	70.71	21.37	1412	76.9	18.1	−0.341	−0.715	0.033	445	81.6	17.3	−0.62	−1.004	−0.236
Social functioning	28	71.60	17.05	1412	82.6	17.3	−0.636	−1.011	−0.261	444	87.5	15.3	−1.032	−1.420	−0.644
School functioning	27	71.29	17.62	1412	80.0	16.7	−0.521	−0.902	−0.140	441	82.8	15.5	−0.737	−1.128	−0.346
Proxy-report															
Total Score	31	71.53	17.39	1185	84.9	10.5	−1.247	−1.607	−0.887	525	84.9	12.9	−1.014	−1.381	−0.647
Physical HSS	31	78.72	21.7	1185	90.6	10.6	−1.079	−1.438	−0.720	525	89.1	15.3	−0.661	−1.025	−0.297
Psychosocial HSS	31	69.13	17.2	1185	83.1	11.6	−1.187	−1.547	−0.827	525	82.7	13.6	−0.982	−1.349	−0.615
Emotional functioning	31	66.45	21.57	1185	79.4	15.5	−0.826	−1.184	−0.468	525	80.9	16.8	−0.845	−1.211	−0.479
Social functioning	31	73.38	20.05	1185	88.1	14	−1.038	−1.397	−0.679	524	86.6	16.1	−0.809	−1.174	−0.444
School functioning	31	66.45	21.57	1185	81.7	14.2	−1.057	−1.416	−0.698	519	80.3	17.1	−0.797	−1.162	−0.432

CI = confidence interval; ES = effect size (hedges g); HLHS = hypoplastic left heart syndrome; HSS = health summary score; PedsQL = Pediatric Quality of Life Inventory

Table 4. PedsQL-Scores – HLHS-Adolescents versus Healthy Sample

				Mellion et al[31] (healthy sample)					
							Comparison with HLHS-Adolescents		
	HLHS-Adolescents							95%-CI	
	n	M	SD	n	M	SD	ES	lower	upper
Self-report									
Total Score	13	80.4	12.18	202	86.9	11.8	−0.55	−1.113	0.013
Physical HSS	13	86.3	14.34	202	90.2	12.4	−0.312	−0.874	0.250
Psychosocial HSS	13	77.94	13.42	202	85.1	13.5	−0.531	−1.094	0.032
Emotional functioning	13	81.92	17.38	202	83.7	17	−0.105	−0.666	0.456
Social functioning	13	79.61	26.17	202	90.2	15.2	−0.661	−1.225	−0.097
School functioning	13	72.13	17.3	201	81.2	16.2	−0.558	−1.121	0.005
Proxy-report									
Total Score	13	74.42	14.89	241	85	12.8	−0.82	−1.383	−0.257
Physical HSS	13	82.69	14.12	241	88.6	15.7	−0.378	−0.937	0.181
Psychosocial HSS	13	71.66	16.11	241	83	14.1	−0.798	−1.360	−0.236
Emotional functioning	13	78.07	17.74	241	83.1	16.4	−0.305	−0.864	0.254
Social functioning	13	73.07	24.62	241	87.6	15.9	−0.885	−1.448	−0.322
School functioning	13	63.84	18.04	241	78.1	18.4	−0.776	−1.338	−0.214

CI = confidence interval; ES = effect size (hedges g); HLHS = hypoplastic left heart syndrome; HSS = health summary score; PedsQL = Pediatric Quality of Life Inventory

to be seen. However, again there was a tendency that patients with hypoplastic left heart syndrome and their parents showed higher health-related quality of life scores than adolescents with single ventricle defects (CHD 3) (see Table 6).

Compared to youths with single ventricle (86.3 ± 14.34), youths with hypoplastic left heart syndrome rated themselves significantly higher in the physical area (physical HSS), g = 0.723 (see Table 6).

Table 5. PedsQL-Scores – HLHS-Children versus Chronic Heart Disease

| | HLHS-Children | | | Mellion et al.[31] (Mild CHD1) | | | Comparison with HLHS-Children | 95%-CI | | Mellion et al.[31] (BV CHD2) | | | Comparison with HLHS-Children | 95%-CI | | Mellion et al.[31] (SV CHD3) | | | Comparison with HLHS-Children | 95%-CI | |
	n	M	SD	n	M	SD	ES	lower	upper	n	M	SD	ES	lower	upper	n	M	SD	ES	lower	upper
Self-report																					
Total Score	27	72.04	15.97	99	81.3	14.1	−2.939	−3.498	−2.380	371	76.6	15.8	−1.447	−1.850	−1.044	123	68.8	15.3	0.989	0.558	1.420
Physical HSS	28	75.78	20.72	101	83.4	15.1	−2.168	−2.663	−1.673	373	78.9	17.8	−0.884	−1.273	−0.495	124	70.1	16.4	1.573	1.126	2.020
Psychosocial HSS	27	70.86	15.94	99	80.3	14.8	−2.89	−3.445	−2.335	371	75.3	16.5	−1.353	−1.755	−0.951	123	68.2	16.9	0.748	0.323	1.173
Emotional functioning	28	70.71	21.37	101	76.4	19.0	−1.364	−1.814	−0.914	372	71.4	21.1	−0.167	−0.551	0.217	124	66.2	20.4	1.047	0.620	1.474
Social functioning	28	71.6	17.05	101	87.7	14.7	−4.95	−5.685	−4.215	372	80.2	19.6	−2.258	−2.673	−1.843	124	71.1	20.9	0.118	−0.292	0.528
School functioning	27	71.29	17.62	99	76.8	17.2	−1.468	−1.931	−1.005	371	74.3	18.1	−0.836	−1.231	−0.441	123	67.5	18.9	0.955	0.525	1.385
Proxy-report																					
Total Score	31	71.53	17.39	107	82.7	13.6	−3.771	−4.369	−3.173	386	75.1	16.6	−1.148	−1.522	−0.774	132	67.3	16.2	1.29	0.875	1.705
Physical HSS	31	78.72	21.7	107	85.9	17.7	−1.887	−2.345	−1.429	386	78.5	21.3	0.055	−0.311	0.421	132	69	19.8	2.415	1.944	2.886
Psychosocial HSS	31	69.13	17.2	107	81	14.7	−3.807	−4.408	−3.206	386	73.2	16.5	−1.317	−1.694	−0.940	132	66.4	16.6	0.818	0.417	1.219
Emotional functioning	31	66.45	21.57	107	76	17.8	−2.504	−3.001	−2.007	386	69.6	18.6	−0.896	−1.267	−0.525	132	66.4	19.8	0.012	−0.379	0.403
Social functioning	31	73.38	20.05	107	87	16.9	−3.785	−4.384	−3.186	386	78.1	20.3	−1.247	−1.623	−0.871	132	67.7	19.8	1.434	1.013	1.855
School functioning	31	66.45	21.57	107	80	18.9	−3.403	−3.970	−2.836	386	72	20.3	−1.458	−1.837	−1.079	132	65.1	20.9	0.322	−0.071	0.715

CI = confidence interval; ES = effect size (hedges g); BV = biventricular; SV = single ventricle; HLHS = hypoplastic left heart syndrome; HSS = health summary score; PedsQL = Pediatric Quality of Life Inventory

Table 6. PedsQL-Scores – HLHS-Adolescents versus Chronic Heart Disease

	HLHS-Adolescents			Mellion et al.[31] (Mild CHD1)						Mellion et al.[31] (BV CHD2)						Mellion et al.[31] (SV CHD3)					
							Comparison with HLHS-Adolescents						Comparison with HLHS-Adolescents						Comparison with HLHS-Adolescents		
								95%-CI						95%-CI						95%-CI	
	n	M	SD	n	M	SD	ES	lower	upper	n	M	SD	ES	lower	upper	n	M	SD	ES	lower	upper
Self-report																					
Total Score	13	80.4	12.18	94	82.9	15.1	−0.169	−0.749	0.411	333	79.3	14.8	0.075	−0.479	0.629	72	72.5	16.9	0.485	−0.110	1.080
Physical HSS	13	86.3	14.34	94	84.9	15.6	0.091	−0.489	0.671	333	82.4	16.7	0.235	−0.319	0.789	73	73	19	0.723	0.123	1.323
Psychosocial HSS	13	77.94	13.42	94	81.9	15.9	−0.253	−0.834	0.328	333	77.6	15.6	0.022	−0.532	0.576	72	72.3	17.7	0.329	−0.264	0.922
Emotional functioning	13	81.92	17.38	94	80.7	19.1	0.065	−0.515	0.645	333	77.2	20.2	0.235	−0.319	0.789	73	75.2	21.9	0.315	−0.277	0.907
Social functioning	13	79.61	26.17	94	87.8	16	−0.469	−1.052	0.114	333	83.4	16.7	−0.221	−0.775	0.333	73	75.7	21	0.179	−0.412	0.770
School functioning	13	72.13	17.3	94	77.1	19.5	−0.258	−0.839	0.323	333	72.3	20.1	−0.008	−0.562	0.546	72	66.6	21.1	0.269	−0.323	0.861
Proxy-report																					
Total Score	13	74.42	14.89	96	79.1	17.1	−0.277	−0.857	0.303	335	75	17.1	−0.034	−0.588	0.520	76	64.6	18.3	0.55	−0.044	1.144
Physical HSS	13	82.69	14.12	96	83.2	19.5	−0.027	−0.606	0.552	335	78.3	20.3	0.218	−0.336	0.772	76	67.2	23.4	0.693	0.096	1.290
Psychosocial HSS	13	71.66	16.11	96	76.9	18.1	−0.293	−0.874	0.288	335	73.2	17.7	−0.087	−0.641	0.467	76	63.2	18.6	0.463	−0.129	1.055
Emotional functioning	13	78.07	17.74	96	77	19.4	0.056	−0.523	0.635	335	73	20.1	0.253	−0.301	0.807	76	65.3	19.5	0.663	0.067	1.259
Social functioning	13	73.07	24.62	96	80.5	22	−0.333	−0.914	0.248	335	76.9	21.8	−0.175	−0.729	0.379	76	63.4	25.6	0.38	−0.211	0.971
School functioning	13	63.84	18.04	96	73.2	21.3	−0.447	−1.029	0.135	335	69.8	22	−0.272	−0.826	0.282	76	60.9	21	0.143	−0.446	0.732

CI = confidence interval; ES = effect size (hedges g); BV = biventricular; SV = single ventricle; HLHS = hypoplastic left heart syndrome; HSS = health summary score; PedsQL = Pediatric Quality of Life Inventory

Discussion

Several studies have explored quality of life (not health-related quality of life!) of Fontan patients. Some reported normal quality of life[38,39] and others reduced quality of life.[40,41] However, differences in patient age and in quality of life assessment instruments being employed together with quality of life being a highly subjective matter and differing among individuals make the comparison between studies difficult.

In general, findings from quality of life research in CHD have been inconsistent.[32,42] This may, in part, not only be due to methodological issues such as small sample sizes, use of proxy reports, and variable assessments of quality of life, but may also reflect the fact that psychological responses to the stress of chronic illness are highly individualised and influenced by many factors such as personal perceptions, expectations, presence of functional limitations, cognitive delay, and comorbid conditions. Severity of disease is not a reliable predictor of quality of life.[43]

Advances in diagnosis, medical management, and surgical intervention have improved the longevity and quality of life for children with CHD. Despite this, there are few research studies specifically examining the psychosocial concerns of adolescents and young adults with CHD. For the purpose of exploring the subjective experiences and dilemmas of this population during the transition from adolescence to young adulthood, nine adolescents and young adults were interviewed by Tong et al[44] using a semi-structured protocol. An understanding of these experiences by health professionals can be beneficial in helping this clinical population as they grow up and face the challenges of an uncertain yet promising future.

Children with CHD requiring open-heart surgery are a group at high risk for health-related sequelae. Little consensus exists regarding their long-term psychological adjustment and health-related quality of life. Thus, Latal et al[42] conducted a systematic review to determine the current knowledge on long-term outcomes in this population. Randomised controlled trials, case–control, and cohort studies published between 1990 and 2008 evaluating self- and proxy-reported psychological adjustment in patients aged between 2 and 17 years with follow-ups of at least 2 years after open heart surgery for CHD were included. A significant proportion of survivors of open-heart surgery for CHDs are at risk for psychological maladjustment and impaired quality of life. Future research needs to focus on self-reports, quality of life data, and adolescence.[42]

It was shown that a worse medical history and worse present medical status did not only predict worse physical parent-reported and self-reported health-related quality of life but also worse psychosocial health-related quality of life and subjective cognitive functioning.[45]

The results of this study showed that the spectrum of self-assessments and external evaluations by parents with regard to the health-related quality of life of hypoplastic left heart syndrome survivors (ages 6 through 16) is very broad. These data show that several children from our sample have developed quite a high quality of life; on the other hand, there are some children who rate their own quality of life as rather low, or their quality of life is assessed as rather low by others. Thus, the necessity for providing extra support to hypoplastic left heart syndrome patients may be considered an additional psychological and educational result of this study.

Looking into more detail, it was interesting to note that:

- Patients with hypoplastic left heart syndrome with high health-related quality of life scores in physical areas also assessed psychosocial areas as high. Equally, high values given by the children corresponded to high values given by their parents. There were no significant differences between patient self-assessments and parents' assessments. When stabilisation of physical areas is achieved in the life of an hypoplastic left heart patient, psychosocial areas become stabilised as well. When hypoplastic left heart syndrome patients have developed a high quality of life, they are able to adequately deal with the challenges that severe heart defects and their accompanying medical and surgical interventions involve. This is reflected in high scores of psychosocial quality of life. The fact that physical stability and the promotion of cognitive skills are the basis for psychosocial quality of life for patients with hypoplastic left heart syndrome was shown by Oberhuber et al.[22]
- Our survey shows that the children from our normative sample attend a broad spectrum of schools within the Austrian educational system. The quality of life scores show no significant correspondence with the school type. In description, it can be noted that youths with hypoplastic left heart syndrome who are attending a college of higher vocational education recorded the highest quality of life scores (97.5) in the Pediatric Quality of Life Inventory level, whereas children with special education needs recorded the lowest (48.86).
- The comparison of health-related quality of life scores from hypoplastic left heart syndrome patients and parents' assessments with the Pediatric Quality of Life Inventory results from children and their parents from the Austrian Felder-Puig-study[36] and children and youths and their parents who were taken from the comprehensive survey by Mellion et al[31] showed significantly higher health-related quality of life scores for all parameters (total score, physical health summary score, psychosocial health summary score, emotional functioning, social functioning, school functioning) than the hypoplastic left heart syndrome probands in healthy children (6–12 years) and in children with mild heart defects (CHD Mild), based on self-assessment and parents' assessments. But adolescent hypoplastic left heart syndrome patients (13–16 years) showed no significant differences compared to all other comparison groups except for in the social area; this finding suggests that they learnt to cope with a severe heart defect; however, this did not hold true for the parents' assessment as compared to the group of healthy youths.

Limitations and strengths

The major limitation of this study is the small sample size. Several parameters might become significant with larger patient numbers, which can only be achieved by multicentre studies. One strength of this study, however, is that all patients were treated at the same centre and that all stage I Norwood procedures were performed by one single surgeon (RM). Another limitation is the retrospective analysis of the anatomy and the clinic course which involved at least three surgeries. Further alternatives of analysis (multivariate methods) are limited due to the small sample. Possible covariates could not be monitored. It is well known that patients with serious diseases can reach a high quality of life by increasing resilience and

coping strategies. It is new that adolescent patients with hypoplastic left heart syndrome treated by one surgical team can get similar health-related quality of life scores as healthy adolescents.

Conclusion

From a psychological viewpoint, these data suggest that a substantial number of patients with hypoplastic left heart syndrome have developed a high level of quality of life behaviour and have improved markedly in dealing with the challenges of living with a life-threatening heart defect. High quality of life may be possible for patients with hypoplastic left heart syndrome in physical and psychosocial areas. Pedagogic and educational assistance and support systems can build on first-class medical treatment; children with hypoplastic left heart syndrome and their families can receive support in successfully coping with life and in achieving the full potential of children and adolescents with hypoplastic left heart syndrome. The finding that adolescent patients with hypoplastic left heart syndrome estimated themselves similar to healthy adolescents suggests that they learnt to cope with a severe heart defect.

Perspectives/Translational Outlook. The children with hypoplastic left heart syndrome can accomplish successful school careers, and by means of appropriate tutoring and individual development of resilient personality, they can tap a high quality of life.

Commentary. The data of this paper were recently presented as a poster at the 53rd Annual Meeting of the Association for European Pediatric and Congenital Cardiology in May 2019, which was awarded as a finalist of the poster price competition.

References

1. Brosig CL, Mussatto KA, Hoffmann G, et al. Neurodevelopmental outcomes for children with hypoplastic left heart syndrome at the age of 5 years. Pediatr Cardiol 2013; 3: 1597–1604.
2. Kramer HH. Development of personality and intelligence in children with congenital heart disease. J Child Psychol Psychiatry, 1989; 30: 299–308.
3. Li Y, Yin S, Fang J, et al. Neurodevelopmental delay with congenital heart disease is mainly from prenatal injury not infant cardiac surgery, current evidence based on a meta-analysis of functional magnetic resonance imaging. Ultrasound Obstet Gynecol 2015; 45: 639–648.
4. Mahle WT, Wernovsky G. Neurodevelopmental outcomes in hypoplastic left heart syndrome. Semin Thorac Cardiovasc Surg Pediatr Card Surg Annu 2004; 7: 39–47.
5. Mahle WT, Lu M, Ohye RG, et al. A predictive model for neurodevelopmental outcome after the Norwood procedure. Pediatr Cardiol 2013; 34: 327–333.
6. Paquetta LB, Wisnowski R, Ceschin JD, et al. Abnormal cerebral microstructure in premature neonates with congenital heart disease. Am J Neuroradiol 2013; 34: 2026–2033.
7. Rychik J. Hypoplastic left heart syndrome: can we change the rules of the game? Circulation 2014; 130: 629–631.
8. Hoffmann GM, Brosig CL, Mussatto KA, Tweddell JS, Ghanayem NS. Perioperative cerebral oxygen saturation in neonates with hypoplastic left heart syndrome and childhood neurodevelopmental outcome. J Thorac Cardiovasc Surg 2013; 146: 1153–1164.
9. Sarajuuri A, Jokinen E, Mildh L. Neurodevelopmental burden at age 5 years in patients with univentricular heart. Pediatrics 2012; 130: 1636–1646.
10. Tabbutt S, Nord AS, Jarvik GP, et al. Neurodevelopmental outcomes after staged palliation for hypoplastic left heart syndrome. Pediatrics 2008; 121: 476–483.
11. Brosig CL, Mussatto KA, Hoffmann G, et al. Neurodevelopmental outcomes in preschool survivors of complex congenital heart disease: implications for clinical practice. J Pediatr Health Care 2007; 21: 3–12.
12. Brosig CL, Mussatto KA, Kuhn EM, Tweddell JS. Psychosocial outcomes for preschool children and families after surgery for complex congenital heart disease. Pediatr Cardiol 2007; 28: 255–262.
13. Gaynor JW, Ittenbach RF, Gerdes M, et al. Neurodevelopmental outcomes in preschool survivors of the Fontan procedure. J Thorac Cardiovasc Surg 2013; 147: 1276–1282.
14. Fteropoulli T, Stygall J, Cullen S, Deanfield J, Newman SP. Quality of Life of adult congenital heart disease patients: a systematic review of the literature. Cardiology in the Young 2013; 23: 473–485.
15. Goldberg CS, Mussatto K, Licht D, Wernovsky G. Neurodevelopment and quality of life for children with hypoplastic left heart syndrome: current knowns and unknowns. Cardiol Young 2011; 21: 1–8.
16. Law, M, Hanna S, Anaby D, Kertoy M, King G, Xu L. Health related quality of life of children with physical disabilities: a longitudinal study. BMC Pediatr 2014; 14: 26.
17. Mellander M, Berntsson L, Nilsson B. Quality of Life in children with hypoplastic left heart syndrome. Acta Pediatr 2007; 96: 53–57.
18. Pike NA, Evangelista LS, Doering LV, Eastwood JA, Lewis AB, Child JS. Quality of life, health status, and depression: comparison between adolescents and adults after the Fontan procedure with healthy counterparts. J Cardiovasc Nurs 2011; 27: 539–546.
19. Ferry PC. Neurologic sequelae of open-heart surgery in children. An 'irritating question'. Am J Dis Child 1990; 144: 369–373.
20. Donfrio MT, Bremer YA, Schieken RM, et al. Autoregulation of cerebral blood flow in fetuses with congenital heart disease: the brain sparing effect. Pediatr Cardiol 2003; 24: 436–443.
21. Kaltmann JR, Di H, Tian Z, Rychik J. Impact of congenital heart disease on cerebro-vascular blood flow dynamics in the fetus. Ultrasound Obstet Gynecol 2005; 25: 32–36.
22. Oberhuber RD, Huemer S, Mair R, Sames-Dolzer E, Kreuzer M, Tulzer G. Cognitive development of school-age hypoplastic left heart syndrome survivors: a single center study. Pediatr Cardiol 2017; 38: 1089–1096.
23. Goldberg C. Neurocognitive outcomes for children with functional single ventricle malformations. Pediatr Cardiol 2007; 28: 443–447.

24. Idorn L, Jensen AS, Juu K, et al. Quality of life and cognitive function in Fontan patients, a population-based study. Int J Cardiol 2013; 168: 3230–3235.

25. Wernovsky G. The neurodevelopmental consequences of congenital heart disease. Pediatr Crit Care Med 2016; 17: S232.

26. Moons P, Budts W, De Geest S. Critique on the conceptualization of life: a review and evaluation of different conceptual apoaches. Int J Nurs Stud 2006; 43: 891–901.

27. Bratt EL, Moons P. Forty years of quality-of-life research in congenital heart disease: temporal trends in conceptual and methodological rigor. Int J Cardiol 2015; 195: 1–6.

28. Gill T, Feinstein, AR. A critical appraisal of the quality of quality-of-life measurements. JAMA 1994; 272: 619–626.

29. Haraldstad K, Wahl A, Andenaes R, et al. A systemic review of quality of life research in medicine and health sciences. Qual Life Res 2019; 28: 2641–2650.

30. Lambert LM, Minich LL, Newburger JN, et al. Parent versus child reported functional health status after Fontan procedure. Pediatrics 2009; 124: e942–e949.

31. Mellion K, Uzark K, Cassedy A, et al. Health-related quality of life outcomes in children and adolescents with congenital heart disease. J Pediatr 2014; 164: 781–788.

32. Drotar D. Measuring Health-Related Quality of Life in Children and Adolescents. Lawrence Erlbaum, Mahwah, 1998.

33. Varni JW, Burwinkle TM, Seid M, Skarr D. The PedsQL 4.0 as a pediatric population health measure: feasibility, reliability and validity. Ambul Pediatr 2003; 3: 329–334.

34. Varni J, Limbers CA, Burwinkle TM. Impaired health-related quality of life in children and adolescents with chronic conditions: a comparative analysis of 10 disease clusters and 33 disease categories/severities utilizing the PedsQL 4.0 Generic Core Scales. Health Qual Life Outcomes 2007; 16: 5–43.

35. Varni JW, Seid M, Kurtin PS. PedsQL 4.0: reliability and validity of the Pediatric Quality of Life Inventory version 4.0 generic core scales in healthy and patient populations. Med Care 2001; 39: 800–881.

36. Felder-Puig R, Baumgartner M, Topf, R, Gadner H, Formann AK. Health-related quality of life in Austrian elementary school children. Med Care 2008; 46: 432–439.

37. Kline RB. Beyond Significance Testing: Reforming Data Analysis Methods in Behavioral Research. American Psychological Association, Washington, DC, 2004.

38. Pike NA, Evangelista LS, Doering LV, Eastwood JA, Lewis AB, Child JS. Quality of life, health status, and depression: comparison between adolescents and adults after the Fontan procedure with healthy counterparts. J Cardiovasc Nurs 2011; 27: 539–546.

39. d'Udekem Y, Cheung MM, Setyapranata S, et al. How good is a good Fontan? Quality of life and exercise capacity of Fontans without arrhythmias. Ann Thorac Surg 2009; 88: 1961–1969.

40 Marino BS, Sher D, Wernovsky G, et al. The development of the pediatric cardiac quality of life inventory: a quality of life measure for children and adolescents with heart disease. Qual Life Res 2008; 17: 613–626.

41. McCrindle BW, Williams RV, Mitchell PD, et al. Relationship of patient and medical characteristics to health status in children and adolescents after the Fontan procedure. Circulation 2006; 113: 1123–1129.

42. Latal B, Helficht S, Fischer JE, Bauersfeld U, Landolt MA. Psychological adjustment and quality of life in children and adolescents following open-heart surgery for congenital heart disease: systematic review. BMC Pediatr 2009; 9: 6.

43. Moons P, Van DK, Budts W, De GS. Caliber of quality-of-life assessments in congenital heart disease: a plea for more conceptual and methodological rigor. Arch Pediatr Adolesc Med 2009; 158: 1062–1069.

44. Tong EM, Sparacino PS, Messias DA, Foote D. Growing up with congenital heart disease: the dilemmas of adolescents and young. Cardiol Young 1998; 8: 303–309.

45. Dulfer C, Bossers SSM, Utens EMWJ, Duppen N. Does functional health status predict health-related quality of life in children after Fontan operation? Cardiol Young 2015; 6: 459–468.