Health-related quality of life: A closer look at related research in patients who have undergone the Fontan operation over the last decade

Nancy A. Pike, RN, PhD(c), FNP,[a,b] Lorraine S. Evangelista, RN, PhD,[b] Lynn V. Doering, RN, PhD,[b] Deborah Koniak-Griffin, RN, EdD,[b] Alan B. Lewis, MD,[c] and John S. Child, MD[d]

The advancements in surgical technique and perioperative care have significantly improved the survival of children with single ventricle (SV) congenital heart disease (CHD) over the past decade. The population who have undergone the Fontan operation are growing into adulthood and facing many unique challenges. Past research has focused on functional and neurodevelopmental outcomes with inferences made to health-related quality of life (HRQOL). With the population who have undergone the Fontan operation surviving into adulthood, little research has been directed toward the self-report of HRQOL in adolescents and young adults after surgical palliation. Questions still remain on how these patients will transition into adulthood and whether they will live normal productive lives. This article reviews the literature related to HRQOL in the SV subgroup of CHD. In addition, an overview of newly developed disease-specific HRQOL instruments is presented as well as limitations and future research in HRQOL of the SV Fontan population. (Heart Lung® 2007;36:3–15.)

Health-related quality of life represents the patients' assessment of the impact of illness on their ability to carry out activities or roles that are important to them.[1] Over the past decade, health-related quality of life (HRQOL) has emerged as an important outcome measurement.[2] This measurement is particularly relevant with the increase in the incidence of chronic disease and longevity of the general population.[3]

The concept of HRQOL and quality of life (QOL) are important areas of research to explore in the population with single ventricle (SV) congenital heart disease (CHD). This population is now surviving to adulthood and facing challenges of an uncertain future. The uncertainty of progressive functional limitations, ability to maintain a job, health insurance, SV failure, possibility of heart transplantation, arrhythmias, and sudden death are concerns. Issues related to HRQOL and factors that affect it in this population are poorly understood. Past research in patients with SV CHD has focused on functional and neurodevelopmental outcomes producing a growing body of literature with documented deficits that seem to be multifactoral.[4-10] However, little is known about the other determinants of HRQOL such as social well-being and function. Moreover, earlier studies in this population had identified the perceptions of family members rather than the actual self-perceived HRQOL of the individual, who may not have been of sufficient age to participate in the evaluation. Therefore, additional research to examine HRQOL in the population with SV CHD will provide health care workers, patients, and their families more realistic expectations of outcomes. Such outcomes research can evaluate medical management and surgical approaches, provide information for prenatal counseling, and parent and adolescent transition counseling, and assist in the development of specific interventions tailored to

From the [a]Division of Cardiothoracic Surgery, Childrens Hospital Los Angeles; [b]University of California, Los Angeles, School of Nursing; [c]Division of Pediatric Cardiology, Childrens Hospital Los Angeles; and [d]Division of Cardiology, University of California, Los Angeles

Reprint requests: Nancy A. Pike, RN, PhD(c), FNP, Division of Cardiothoracic Surgery, Childrens Hospital Los Angeles, 4650 Sunset Blvd. Mail Stop #66, Los Angeles, CA 90027.

0147-9563/$ – see front matter

doi:10.1016/j.hrtlng.2006.06.002

improve HRQOL and overall QOL as this population transitions into adulthood.

This article presents a review of the literature related to HRQOL in the SV subgroup of CHD. In addition, an overview of newly developed disease-specific HRQOL instruments is presented as well as a discussion on limitations and future research in HRQOL of the SV Fontan population.

SEARCH STRATEGIES

PubMed and CINAHL searches were performed for studies examining HRQOL in SV CHD after the Fontan procedure. Included in this search were all empirical studies published between 1994 and 2005; were published in English; that assessed children, adolescents, and adults; and evaluated both individual and parent proxy reports of HRQOL. The search terms were "health-related quality of life" combined with "single ventricle" and "Fontan." However, only a limited number of articles were identified. The search terms were expanded to include "quality of life," because HRQOL is a newer term, and "complex congenital heart disease" to fully capture all articles that may have separated CHD according to disease severity. Excluded in this search were editorials, case studies, opinion articles, textbooks, qualitative studies, and conference abstracts.

SINGLE VENTRICLE CONGENITAL HEART DISEASE: A GROWING POPULATION

Congenital Heart Disease affects 40,000 newborns each year in the United States.[11] According to the March of Dimes Prenatal Statistics (2000), CHD is the number one birth defect in the United States.[12] More than 35 types of congenital heart defects have been identified,[11] which represent a broad spectrum of severity ranging from minor defects that may spontaneously self-correct, to more severe, potentially life-threatening defects that require several surgical interventions. Some children born with complex CHD have only one functional ventricle, which pumps to both pulmonary and systemic circulations. Thus, the term "single ventricle" is used to describe a functional SV regardless of anatomic subtype. Various forms of SV CHD, primarily hypoplastic left heart syndrome (HLHS), were considered fatal before the 1980s.[4]

In the last 30 years, advances in treatment of CHD have enabled approximately 1 million U.S. children with significant heart defects to survive into adulthood.[11] At the present time, there are as many adults with CHD as there are children with this disease.[13] Therefore, a new specialized adult population with chronic disease has emerged and is estimated to grow at a rate of 5% per year.[14] Adolescents and young adults with CHD represent a growing subspecialty in adult cardiology. The first specialized center in the United States to treat adults with CHD is the UCLA Adult Congenital Heart Disease Center, founded in 1978.[15] Specialized centers provide medical care focused on the natural sequelae or residual effects after surgery and long-term health care needs of patients with CHD.[15] Other issues that present challenges to this population and areas for future research are employability, insurability (medical/life), contraception/pregnancy, genetic transmission, and exercise.[15,16]

FONTAN PROCEDURE

Over the past two decades, life expectancy for children with SV CHD has increased significantly. This is related to advancements in surgical technique and perioperative care. SV CHD generally requires three or more staged palliative heart surgeries at various developmental stages (neonatal, 6 months, and 2–5 years of age). The goal of surgical palliation is to improve hemodynamics through gradual separation of the pulmonary and systemic circulations, thereby relieving cyanosis and volume overload of the SV. The Fontan procedure is the final staged palliative surgery, which usually provides complete separation of the two circulations.

The Fontan operation was first described by Fontan and Baudet[17] for the repair of tricuspid atresia. The underlying principle of Fontan circulation is that the pulmonary circulation can be perfused without a ventricular pump.[18] The SV becomes the systemic pump for blood flow to the aorta and the body. The pulmonary circulation receives passive nonpulsatile blood directly from the superior and inferior vena cavae through direct anastamosis or the use of synthetic graft material (eg, Gore-Tex, W.L. Gou and Associates, Inc, Newark, DE). The original Fontan procedure has undergone various modifications and can be applied to all types of SV anatomy. Thus, completion of the Fontan while providing satisfactory palliation, still leaves the patient with a single right or left ventricle at risk for late cardiac failure, exercise intolerance, and arrhythmias. A portion of the population who have undergone the Fontan procedure may ultimately require heart transplantation related to long-term postoperative morbidities associated with SV failure.[6]

DIFFERENTIATION BETWEEN HRQOL AND QOL

Quality of life defined by Padilla and colleagues[19] is a subjective, multidimensional experience that involves a summary evaluation of the positive and negative attributes that characterizes one's life. It is a dynamic concept affected by one's ability to adapt to discrepancies between expected verses experienced well-being,[19] as well as one's ability to maintain a level of functioning that allows the individual to pursue life goals.[20] HRQOL differs from QOL in that the summary evaluation of attributes that characterize one's life is made at a point in time when health, illness, or treatment conditions are relevant to the individual.[19] Patrick and Erikson[21] further defined HRQOL as a subjective outcome that reflects the person's perception of his or her health status and has been defined as the specific impact of an illness or injury, medical treatment, or health care policy on an individual's QOL. In addition, the Rand Medical Outcome Study defined HRQOL as the extent to which health impacts an individual's ability to function and his/her perceived well-being in physical, mental, and social domains of life.[22]

In evaluating QOL, Moons and colleagues[23,24] recently defined QOL as the degree of overall life satisfaction that is positively or negatively influenced by individuals' perception of certain aspects of life important to them, including matters both related and unrelated to health. This definition argues the notion that health status, HRQOL, or functional status cannot be substituted for QOL. The definition also stresses the individual's perception of life satisfaction as the only direct indicator of QOL, whereas other variables, such as health, social function, or emotional function are all determinants of QOL.[23] In this respect, QOL is viewed as a unidimensional construct that is influenced by multiple factors (multifactorial). Although QOL experts view this construct as multidimensional, most are evaluating determinants of QOL and not direct indicators.

These definitions emphasize that the major difference between QOL and HRQOL is the impact of a disease, illness, or treatment on QOL. However, the literature still lacks a universally accepted definition of HRQOL and QOL. Yet, there are some areas of conceptual agreement. Namely, most would agree that HRQOL is a multidimensional, subjectively perceived concept, influenced by health, illness, or disease, and viewed as a continuous life evaluation or process that changes with aging.[19-22]

RELATED RESEARCH IN HEALTH-RELATED QUALITY OF LIFE IN PATIENTS WHO HAVE UNDERGONE THE FONTAN OPERATION

The historical trajectory of related HRQOL research in the population who have undergone the Fontan operation has been summarized in chronologic order in Table I. Despite the medical and surgical advancements in the population who have undergone the Fontan operation, most conclude that SV CHD continues to affect the daily life of the growing child into adulthood. Therefore, research in HRQOL and QOL has amplified, resulting in an emerging field of investigation that addresses these concerns. Unfortunately, because most children who underwent the procedure during the last decade have not reached an appropriate age to contribute meaningful data on this phenomenon, most published data on HRQOL or QOL in SV CHD are by appraisals of proxy respondents, primarily parents. Furthermore, earlier studies of HRQOL focus more on specific functional determinants such as exercise ability and neurodevelopmental or cognitive outcomes. More recent research has focused on a more global conceptual measurement of HRQOL in the population with CHD.[4-10,24-30]

Functional status outcomes

From the 1990s, the SV CHD research primarily addressed functional status and functional outcomes. The increased survival and parent-reported deficits in physical activity prompted functional status testing in this population. The functional status literature used a variety of objective measures such as New York Heart Association (NYHA) classification, SV ejection fraction, mortality and morbidity outcomes, visual motor testing, and exercise testing using aerobic capacity measurements of maximum VO2 to quantify functional status.[9,26] Furthermore, on the basis of these data, assumptions were made on HRQOL or QOL without confirmation. Subsequently, child and parent proxy report questionnaires were instituted to assess functional status either alone or in conjunction with objective measures.[6,25] The terms "functional status" and "HRQOL" or "QOL" are often used interchangeably. However, empirical studies have substantiated that these are related, but distinct concepts that should not be used interchangeably.[27]

The functional status research in the population who have undergone the Fontan operation has reported that despite an apparent healthy appear-

Table I
Results of related Health-Related Quality of Life research in single ventricle congenital heart disease

Article	Subjects/age	Focus	Study design
Casey FA et al[28]	26 children with a single functional ventricle 5–15 y of age with a mean age of 8.78 y	Symptoms, exercise tolerance, and participation in activities	Cross-sectional
Harrison DA et al[9]	47 patients seen 6.7 ± 3.9 y after the Fontan operation, 25.7 ± 6.3 y of age	Exercise status	Prospective
Gentles TL et al[6]	363 patients who underwent the Fontan operation 3.1–42 y of age (median age 11.1 y)	Functional outcome	Cross-sectional
Uzark K et al[8]	32 patients who underwent the Fontan operation 26 mo to 16 y of age (median age 5.3 y)	NDO and functional status	Cross-sectional
Driscoll DJ and Durongpisitkul[29]	Patients who underwent the Fontan operation Multiple small samples reviewed Age not mentioned	Review of literature on exercise testing/functional capacity pre- and post-Fontan	Retrospective
Goldberg CS et al[7]	51 patients who underwent the Fontan operation with HLHS and other single ventricle defects 34–96 mo with a mean age of 57.6 ± 4.7 mon	NDO and functional status	Cross-sectional
Mahle WT et al[4]	115 HLHS patients after staged palliation Mean age 9.0 ± 2.1 y	NDO, functional status, school performance, and subjective QOL	Cross-sectional

Methods/measurements	Results/conclusion
Medical history and activity, investigator-developed questionnaire, physical examination, treadmill test, oxygen saturation level, 24-hour Holter monitor	Breathlessness (92%), URI (35%), and leg cramps (31%) most common disorders. Exercise tolerance significantly reduced compared with control; 89% moderate exercise, 11% severe limitations. Parents underestimate the child's exercise tolerance (80%). Surgery allows child to increase activity level; subjective estimations are inaccurate in this group.
Cycle ergometry to determine maximal exercise capacity, treadmill test, and measurements of EF% at rest and during exercise with gaited radionuclide angiography	93% Fontan group in functional class I or II. Systemic ventricular EF was lower at rest (38% ± 12% vs 58% ± 7%) and during exercise (40% ± 15% vs 70% ± 8%). Clinical impression of good function but by objective measures they have significant cardiovascular limitations late after the Fontan.
Developed questionnaire to assess age-specific functional status and medical history. Chart review to assess postoperative status	91% in NYHA class I or II; 8.9% in class III or VI. Poor functional status associated with length of follow-up ($P < .001$), prior atrial septectomy ($P = .03$), and prior PA to ascending aorta anastomosis ($P = .05$). Poor functional outcome is uncommon after the Fontan operation but worsens with length of follow-up.
Stanford-Binet Intelligence (IQ) Scale and the Visual Motor Integration (VMI). Parents completed the Achenbach Child Behavioral Checklist. Chart review to assess pre- and postoperative status	Majority with mean IQ within normal range (97.5 ± 12.1). Below VMI scores in 21.4%. No significant relations between IQ, VMI, preoperative oxygen saturation, or age of Fontan. Children who had DHCA with a Norwood had lower IQ scores. Majority of children with intellectual function in normal range. VMI deficits prevalent in Fontan group.
Aerobic capacity (VO2), heart rate response, blood pressure response, cardiac output, blood oxygen saturation, arrhythmias, ventilatory response, Fontan type	Literature review with compiled results (no statistical tests). Aerobic capacity increased after the Fontan but remains subnormal; all other variables were subnormal, no difference in the type of single ventricle or type of Fontan.
(WPPSI-R), Bayley Scale of Infant Development, Vineland Adaptive Behavior Scale, and parents completed the Child Behavioral Checklist and the Family Inventory of Life Events and Changes. Chart review for medical history	Full mean IQ score 101.4 ± 5.4, for HLHS group IQ score 93.8 ± 7.3, for non-HLHS group IQ score 107 ± 7.0. HLHS group was significantly lower than non-HLHS group. SES, circulatory arrest, and preoperative seizures were predictive of NDO. NDO and behavioral outcome is good in the preschool and early school years with IQ scores in the normal range but lower than the non-HLHS group.
Questionnaires, Wechsler Intelligence Scale for Children (WISC-III), Woodcock-Johnson Psychoeducational Battery (WJPB) -revised, Clinical Evaluation of Language Fundamentals (CELF-R), VMI, and Achenbach Child Behavior Checklist	Questionnaires have parents describe their child's health as good (34%) or excellent (45%) and academic performance average (42%) or above average (42%). However, one third of children receive a form of special education. Cognitive testing in local group with median IQ score 86 (range: 50–116). Mental retardation (IQ < 70) in 18% of patients. Occurrence of preoperative seizures predicted lower IQ score. Majority of school-age children with HLHS had IQ scores within normal range, mean performance was lower than that of the general population.

Table I
Continued

Article	Subjects/age	Focus	Study design
Wernovsky G et al[5]	133 patients evaluated 6 y after the Fontan operation 3.7–41 y of age (mean 11.1 y)	Cognitive development	Cross-sectional
Williams DL et al[10]	106 children with HLHS undergoing staged palliation 6 d to 34 mon	QOL, survival, developmental status, and medical costs	Cross-sectional
Saliba Z et al[32]	89 patients with univentricular hearts. 17–49 y (median 21 y)	6 QOL domains and 4 dysfunctional domains	Retrospective cross-sectional
Connolly D et al[33]	50 children with CHD (14 with single ventricle), 42 healthy control group 6 mo to 20 y of age	Physical, social, and mental well-being domains of QOL	Comparison CHD and healthy group, cross-sectional
Kamphuis M et al[34]	78 patients with operations for complex CHD (16 with single ventricle) 18–32 y of age	8 domains of QOL with one tool and 12 domains with a developed tool	Retrospective cross-sectional

Methods/measurements	Results/conclusion
Questionnaires and chart review for historical information. Standardized testing includes: WISC-III, WPPSI-R, WAIS-R, and Kaufman Assessment Battery for Children Scale (K-ABC) and Wide Range Achievement Test Revised (WRAT-R)	Mean full-scale IQ was 95.7 ± 17.4 ($P < .006$ vs normal), 10 patients (7.8%) with IQ scores 70 ($P = .001$). After SES adjustment, lower IQ was associated with circulatory arrest before the Fontan operation ($P = .002$), HLHS ($P < .001$), and other ($P = .05$). Mean composite achievement score 91.6 ± 15.4 ($P < .001$ vs normal), 14 patients (10.8%) scored < 70 ($P < .001$). After SES adjustment, lower scores in HLHS ($P = .004$), than others ($P = .003$), associated with use of circulatory arrest ($P = .03$) and reoperation with CPB within 30 d of the Fontan ($P = .01$). Cognitive outcome and academic function within normal range but lower than the general population.
Infant and Toddler Child Health Questionnaire (IT CHQ) or Child Health Questionnaire (CHQ) Parent Format-28, Ages and Stages Questionnaire (ASQ), Kaplan-Meier method for survival and assessment of medical costs	Norwood stage I achieved fewer developmental benchmarks than those who survived to subsequent stages. CHQ — Parent Format 28 scores 48.5 ± 6.3 and 42.8 ± 9.9 for physical and psychosocial health is lower compared with a healthy population; 1- and 5-year survivals were 58% and 54%. Median medical costs were $33,892–$52,183 per stage. A prospective, large-scale study of comprehensive outcomes of staged repair and transplantation is needed as well as long-term developmental/QOL outcomes.
Duke Questionnaire - generic health status measurement	Scores were similar to those of healthy population. Cyanosis worse scores for physical ($P = .05$) and perceived health status ($P = .02$). Higher education had better score for physical ($P = .004$), mental ($P = .01$), and general health ($P = .02$). Ortho problems worsened social score ($P = .05$), and psychosocial worsened with pain score ($P = .02$). Satisfactory QOL, which is similar to healthy population. Cyanosis predicted a worse score for physical and perceived health status.
New York University Children's Heart Health Survey and NYU Pediatric Heart Failure Index - disease-specific HRQOL measurement. Evaluation of new instruments psychometric properties.	Average internal consistency reliabilities were similar between group with heart disease (alpha = .84) and healthy control (alpha = .82), subscales (range = .48–.90). Validity assessed through differences between mean scores of subjects. Heart disease was associated with impairment on all subscales except psychologic function. Adolescent self-report did not differ significantly between cardiac and non cardiac groups.
SF-36, TACQOL, TAAQOL questionnaires, Physical Index, Summerville Index, and NYHA classification	HRQOL was lower than general population in motor function and vitality ($P < .01$). Relation between HRQOL and physical status were poor. Patients had worse subjective health status than the general population in physical role function, vitality, and general health perception ($P < .01$). Relation was weak between subjective health status and physical indices. Adult survivors experienced only limitations in the physical dimensions of HRQOL and perceived health status.

Table I
Continued

Article	Subjects/age	Focus	Study design
Uzark K et al[35]	256 patients with CHD 2–18 y of age	Six scales: heart problem/treatment, treatment II, physical appearance, treatment anxiety, cognitive problems, and communication	Comparison CHD and healthy group, cross-sectional
Kamphuis M et al[31]	156 patients with mild to complex CHD (16 with single ventricle) 17–32 y of age	Three disease-specific scales: worries, impact cardiac surveillance, and symptoms	Cross-sectional

CHD, Congenital heart disease; *NYHA,* New York Heart Association; *SF-36,* 36 item Short Form health survey; *NDO,* neurodevelopmental outcomes; *HLHS,* hypoplastic left heart syndrome; *PA,* pulmonary artery; *DHCA,* deep hypothermic circulatory arrest; *SES,* socioeconomic status; *QOL,* quality of life; *HRQOL,* health-related quality of life; *EF,* ejection fraction; *TAAQOL,* Netherlands Organization for Applied Scientific Research Academic Medical Center - adult quality of life and *TACQOL,* child quality of life; *TAAQOL-CHD,* congenital heart disease module; *URI,* upper respiratory infection; *VMI,* ; *WPPSI-R,*.

ance, when challenged with exercise testing, functional limitations are evident.[6,9,28,29] Some studies showed a poor correlation between NYHA classification or ejection fraction and performance on exercise testing.[6,9,28,29] Of note, an average of 90% of patients who have undergone the Fontan operation reported an NYHA class I or II.[6,9] Patients who have undergone the Fontan operation with NYHA classification III or IV were associated with longer duration of follow-up, a prior atrial septectomy, and prior main pulmonary artery-ascending aorta anastomosis.[6] Overall, the patient who has undergone the Fontan procedure has a decreased aerobic exercise capacity that further declines with age and time from the Fontan procedure. The multiple factors that contribute to reduced functional outcomes are abnormal heart rate and rhythm, oxygen desaturation (especially with a fenestrated Fontan) during exercise testing, and the inability to improve stroke volume related to impaired SV function.[30] One study demonstrated no correlation between exercise capacity and the type of SV or type of Fontan procedure.[29]

Neurodevelopmental and cognitive outcomes

In the late 1990s to early 2000s, several studies evaluated the neurodevelopmental and cognitive outcomes after the Fontan operation. The population who have undergone the Fontan operation has significant risk factors for neurodevelopmental deficits such as congenital brain abnormalities, heart failure, cyanosis, failure to thrive, sequelae from multiple staged surgical palliations with cardiopulmonary bypass and deep hypothermic circulatory arrest, hypoxic ischemic insult, thromboembolic event, seizure, acidosis, and cardiac arrest. The majority of authors identified similar neurodevelopmental outcomes, but variations were noted depending on the severity of the SV anatomy and sample selection.[4,5,7,8]

Uzark et al[8] provided one of the first neurodevelopmental outcome studies in the population who have undergone the Fontan operation. Neurodevelopmental testing in patients 2 to 16 years of age found that the majority of children had intellectual function within the normal range.

Methods/measurements	Results/conclusion
Evaluate the psychometric properties of the PedsQL Cardiac Module Scales - disease-specific HRQOL measurement	Group comparison revealed significant differences ($P <$ .001) except on the child self-report physical function scale ($P = .114$). All internal consistency reliability coefficients exceeded minimum standards for group comparison (0.72–0.96) except for the child 5–7 years of age group. Results support feasibility, reliability, and validity of the PedsQL Generic Core Scales and Cardiac Module to assess HRQOL in children with CHD.
Assessed psychometric Properties of TAAQOL-CHD - disease-specific HRQOL measurement	Cronbach's alpha for the three scales symptoms, impact cardiac surveillance, and worries were .77, .78, and .82, respectively. Convergent validity with other instruments (TAAQOL, SF-36) showed satisfactory results. The TAAQOL-CHD module together with the TAAQOL supported satisfactory reliability and validity in assessing HRQOL in adolescents to adults with CHD.

However, visual motor deficits were more prevalent in this group compared with population norms. Wernovsky et al[5] reached a similar conclusion with a larger sample size that demonstrated cognitive outcomes and academic performance within normal range, but the overall performance was lower when compared with the general population.

Some neurodevelopmental studies separate the patients who have undergone the Fontan procedure into anatomic subgroups of SV CHD. The hypoplastic left heart syndrome (HLHS) group seemed to have more neurodevelopmental deficits compared with other SV defects.[4-5,7,8,10] In addition, the patients with HLHS who had deep hypothermic circulatory arrest during their first-stage surgical palliation were noted to have worse outcomes.[5,7,8]

Mahle et al[4] evaluated outcomes in school-aged adolescents with HLHS and identified IQ scores within normal range with mean performance of the group lower than that of the general population. Of note, the majority of parents or guardians in this study described their child's health as good (34%) or excellent (45%) and their academic performance as average (42%) or above average (42%). However, one third of the children were receiving some form of special education and mental retardation was noted in 18% of patients. Goldberg et al[7] noted a similar decrease in overall performance scores in a group of patients with HLHS who underwent the Fontan operation compared with a non-HLHS group.

Currently, the research emphasis is changing to investigate more HRQOL and QOL outcomes in SV CHD. The impetus for change could be attributed to the functional limitations and neurodevelopmental deficits identified in the previous research.

HRQOL and QOL outcomes

Findings on the impact of CHD on determinants of HRQOL and QOL remain controversial. Some studies indicate deficits in physical function and role function domains,[31-35] whereas others show no significant difference compared with the general population.[24,32] Few studies have addressed HRQOL or QOL in only the SV Fontan patients. Most studies examine all subtypes of CHD, including the population with SV CHD, who usually represent a small portion of the study sample. In addition, this makes it difficult to draw conclusions for

the population who have undergone the Fontan operation unless the study stratifies according to CHD defect or disease severity.

According to Williams and colleagues,[10] parent proxy reports in children with HLHS showed that physical and psychologic health was lower compared with the healthy population. However, self-reported HRQOL studies demonstrated a wide variation in responses related to severity of the study population. Results ranged from no difference from the general population to impairment in all subscales.[32-34]

Saliba et al[32] evaluated QOL and perceived health status in adolescents and adults with both surgically corrected and shunt-palliated SV CHD. The subjects living with residual cyanosis had worse physical and perceived health status scores. Overall, scores were similar to those of the general population.

These two studies represent the only QOL studies specifically for the population with SV CHD.[10,32] Contradictory results are identified from parent proxy reports and studies from the European population with SV CHD.[32-34] This further identifies the need for HRQOL studies in the U.S. population with SV CHD.

In addition, there remain major conceptual and methodologic issues in HRQOL and QOL research in the general population with CHD.[23] Few studies identify operational definitions for HRQOL or QOL as well as conceptual or theoretical frameworks. Different people value different things, which make HRQOL and QOL hard to define and not readily defined in the literature.[25,26] Future HRQOL studies need to convey rigorous conceptualization, operational definition, and a sound HRQOL or QOL measurement that is congruent with the operational definition.

Disease-specific HRQOL instruments for CHD

The literature is filled with a plethora of generic HRQOL and QOL instruments for use in pediatrics and adults. However, generic HRQOL measures may lack specificity to assess unique differences encountered by specific conditions, but has the advantage of broad applicability across diagnoses. The use of generic and disease-specific HRQOL measurements in tandem provides complementary information and the strengths of both approaches. Disease-specific HRQOL and QOL instruments have been designed and tested extensively in populations with heart failure and acquired heart disease.[36] However, there is a lack of disease-specific instruments for use in pediatric and adult CHD. With continued growth of the population with CHD, appropriate disease-targeted tools will need to be designed and implemented to adequately measure change in HRQOL outcomes in this population overtime.

Recently, disease-specific measures were developed for HRQOL research in CHD (eg, New York University Child Heart Health Survey, Pediatric Quality of Life Inventory (PedsQL, Mapi Research, Frust, France) cardiac module, Congenital Heart Disease Quality of Life Questionnaire (ConQol), and TNO/AZL Adult Quality of Life Congenital Heart Disease Module [TAAQOL-CHD]).[31,33,35,37] The instruments are summarized in Table II. The PedsQL cardiac module and TAAQOL-CHD are designed as cardiac modules for an existing generic HRQOL tool. This provides a consistent format for the generic and disease-specific tools to be used in conjunction with one another. The NYU-CHHS and the PedsQL cardiac module have both parent proxy report and child self-report forms for various age groups, whereas the ConQol has two child self-report forms for ages 8 to 11 and 12 to 18 years. The NYU-CHHS and PedsQL cardiac module accommodates subjects up to 20 and 18 years of age, respectively. However, the TAAQOL-CHD is designed as a self-report form for adolescents to adults with CHD and accommodates subjects 16 years of age and older. The four instruments measure various disease-specific determinants of HRQOL such as symptoms, anxiety or worries, physical appearance, function, and social roles. Data on reliability and validity are limited because the instruments are relatively new. Further empirical testing of the instruments is required to evaluate psychometric properties and clinical application. The sensitivity to detect clinically important changes over time will be needed to evaluate the transition of the population with SV CHD into adulthood.

DISCUSSION

The literature review on HRQOL in the patient who has undergone the Fontan operation over the past decade has addressed functional status and neurodevelopmental outcomes with recent HRQOL studies and disease-specific tool development. The research demonstrates significant functional limitations with exercise testing, despite a healthy physical appearance.[6,9,28,29] Furthermore, the majority of HRQOL deficits were identified in physical function and role function domains.[31-35] The neurodevelopmental studies demonstrate normal IQ score but overall performance scores lower than that of the general population. The subgroup of those with HLHS were noted to have a higher risk for neurodevelopmental deficits associated with prolonged

Table II
HRQOL Disease-specific instruments for congenital heart disease

Author/instrument	Age range/respondent	Disease-specific determinants	Studies using instrument
Mascha Kamphuis, MD TNO/AZL Adult Quality of Life (TAAQOL) CHD Module	>16 y—adolescent/adult	Symptoms Impact cardiac surveillance Worries	Kamphuis et al[31] Moons[23]
James W. Varni, PhD Pediatric Quality of Life Inventory (PedsQL) Cardiac Module	2–18 y—parent 5–18 y—child/adolescent	Heart problems - symptoms Physical appearance Treatment anxiety Cognitive problems Communication	Uzark et al[35]
Dana Connolly, RN, PhD New York University Child Heart Health Survey (NYU-CHHS)	6 mo-20 y—parent 12–20 years—child/adolescent	Symptoms Health care use Emotional indicators Behavioral indicators Work, school, role fulfillment Age-appropriate activities	Connolly et al[33]
Susan Macran, PhD, and Yvonne Birks, PhD Congenital Heart Disease Quality of Life Questionnaire (ConQol)	8–18 y—child/adolescent	Symptoms Activities Relationships Control/coping	Macran et al[37]

periods of DHCA, congenital brain abnormalities, or hypoxic-ischemic insult.[4,5,8,38,39]

The majority of the studies reviewed sampled the population who underwent the Fontan operation in the late 1970s and early 1990s. Patient selection and surgical techniques, however, have advanced over the past decade. Therefore, the results can only be applied to previous surgical techniques and not the most current approach to SV CHD.[5] Of further note, the studies reviewed are mostly retrospective cross-sectional designs and with small sample sizes. The small sample sizes were attributed to lack of subject participation or resources to access the study center. Future prospective longitudinal study designs are needed to assess this population throughout adulthood and include the impact of additional surgical procedures (eg, pacemakers, valve replacements, and heart transplantation).

The majority of the HRQOL research in CHD has been conducted at Canadian and European centers.[24,28,31,32,34] The studies used a combination of European and U.S. instruments. However, the generalizability of the result to the population with SV CHD in the United States is questionable because of cultural, social, and economic influences. A high percentage of the CHD samples were composed of individuals with acyanotic heart disease who were surgically repaired with one operation.[28,31,32,34] Furthermore, a portion of the patients with SV CHD who were sampled in these studies did not undergo Fontan completion and are living with residual cyanosis.[28,32,34] Future HRQOL studies need to provide evidence for reliability and validity of disease-specific instruments and describe HRQOL in the SV Fontan population in the United States.

Finally, the HRQOL and QOL literature in CHD is primarily based on parent proxy reports. Studies have shown inconsistencies in parent proxy reports with both over- and underestimations of health and performance abilities.[4,28] Adolescent self-report

could provide insight into potential health, psychologic, or social concerns not identified by parents and give a voice to help others living with SV CHD.

IMPLICATIONS FOR PRACTICE

The periodic application of HRQOL assessments will be imperative as the population with SV CHD transitions to adulthood. Disease-specific tools will need to be used that assess HRQOL change over time to newer surgical techniques such as the modified Fontan procedure or late Fontan revisions, various medication regimes, use of dual-chamber pacing, or the recent development of intraoperative regional cerebral perfusion techniques that could potentially improve neurodevelopmental outcomes for this subgroup with SV CHD. In addition, any noncardiac or psychosocial deficits that are identified can be addressed through prevention and early detection measures. The dissemination of both subjective HRQOL data supplemented with objective clinical data can assist health care providers with a better understanding of specific physical, emotional, and social concerns. Furthermore, the physical function deficits identified in the literature have yet to be explored with the concept of cardiac rehabilitation and the potential for future benefits in physical and emotional well-being.

SUMMARY

A comprehensive review of the literature supports the need for further investigation of HRQOL outcomes in the population who have undergone the Fontan operation. Self-report measurements of HRQOL will provide individual perspectives of health within chronic illness and reduce the potential for proxy report bias. Generic and disease-specific HRQOL instruments will require further empirical testing to provide evidence to support reliability and validity in this population. In addition, larger sample sizes and more prospective longitudinal studies will provide valuable information in a population with an uncertain future related to the fate of the SV. Although survival for all stages of surgical palliation has significantly improved over the last three decades, continued outcomes research will help to identify factors that impact HRQOL in this complex and challenging population with SV CHD.

REFERENCES

1. Schipper H, Clinch JJ, Olweny CLM. Quality of life studies: definitions and conceptual issues. In: Spilker B, ed. Quality of life and pharmacoeconomics in clinical trials (2nd edition). Philadelphia, PA: Lippincott-Williams & Wilkins; 1996, p. 11-23.
2. McSweeny AJ, Creer TL. Health-related quality of life assessment in medical care. Dis Mon 1995;41(1):171.
3. Schlenker EA, Erlin JA, Dunbar-Jacob J, McDowell J, Engberg S, Sereika SM, et al. Health-related quality of life in chronic disorders: a comparison across studies using the MOS SF-36. Qual Life Res 1998;7:57-65.
4. Mahle WT, Clancey RR, Moss EM, Gerdes M, Jobes DR, Wernovsky G. Neurodevelopmental outcome and lifestyle assessment in school-aged and adolescent children with hypoplastic left heart syndrome. Pediatrics 2000;105(5): 1082-9.
5. Wernovsky G, Stiles KM, Gauvreau K, Gentles TL, du Plessis AJ, Walsh AZ, et al. Cognitive development after the Fontan operation. Circulation 2000;102:883-9.
6. Gentles TL, Gauvreau K, Mayer JE, Fishberg SB, Burnett J, Colan SB, et al. Functional outcome after the fontan operation: factors influencing late morbidity. J Cardiothorac Surg 1997;114:392-403.
7. Goldberg CS, Schwartz EM, Brunberg JA, Mosca RS, Bove EL, Schork MA, et al. Neurodevelopmental outcome of patients after the Fontan operation: a comparison between children with hypoplastic left heart and other functional single ventricle lesions. J Pediatr 2000;137:646-52.
8. Uzark K, Lincoln A, Lamberti JJ, Mainwaring RD, Spicer RL, Moore JW. Neurodevelopmental outcomes in children with Fontan repair of functional single ventricle. Pediatrics 1998; 101(4):630-3.
9. Harrison DA, Lui P, Walters JE, Goodman JM, Sui SC, Webb, GD, et al. Cardiopulmonary function in adult patients late after the Fontan. J Am Coll Cardiol 1995;26:1016-21.
10. Williams DL, Gelijns AC, Moskowitz, AJ, Weinberg AD, Ng JH, Crawford E, et al. Hypoplastic left heart syndrome: valuing the survival. J Thorac Cardiovasc Surg 2000;119:720-31.
11. American Heart Association. Heart and stroke statistical update. 2005; Dallas: Author. Available at: http://www.americanheartorg/presenter.jhtml?identifier=4576.
12. March of Dimes. Prenatal statistics on congenital heart defects, 2000; Author. Available at: http://www.marchofdimes.com/pnhec/4439_1212.asp.
13. Hoffman JI, Kaplan S, Liberthson RR. Prevalence of congenital heart disease. Am Heart J 2004;147:425-39.
14. O'Brien P, Boisvert JT. Current management of infants and children with single ventricle anatomy. J Pediatr Nurs 2001; 16(5):338-50.
15. Canobbio MM. Health care issues facing adolescents with congenital heart disease. J Pediatr 2001;16(5):363-70.
16. Skorton DJ, Garson A, Allen HD, Fox JM, Truesdell SC, Webb GD, et al. Task Force 5: adults with congenital heart disease: access to care. J Am Coll Cardiol 2001;37(5):1193-8.
17. Fontan F, Baudet E. Surgical repair of tricuspid atresia. Thorax 1971;26:240-8.
18. Bickner ME, Hillis LD, Lange RA. Congenital heart disease in adults. First of two parts. N Engl J Med 2000;342:256-63.
19. Padilla GV, Grant MM, Ferrell BR, Presant CA. Quality of life-cancer. In: Spilker B, ed. Quality of life and pharmacoeconomics in clinical trials. New York: Lippincott-Raven; 1996, p. 301-8.
20. Shumaker SA, Naughton MJ. The international assessment of health-related quality of life: a theoretical perspective. In: Shumaker SA, Berzon RA, eds. The international assessment of health-related quality of life: theory, translation, measurement, and analysis. Oxford: Rapid Communication; 1995, p. 3-10.
21. Patrick DL, Erikson P. Health status and health policy. New York: Oxford University Press; 1993.
22. Stewart AL, Sherbourne CD, Hays RD, Wells KB, Nelson EC, Kamberg CJ, et al. Summary and discussion of MOS measures. In: Stewart AL, Wares JE, eds. Measuring function and well-being: the medical outcomes study approach. Durham, NC: Duke University Press; 1992, p. 345-71.

23. Moons P. Caliber of quality of life assessments in congenital heart disease. Arch Pediatr Adolesc Med 2004;158:1062-9.
24. Moons P, Van Deyk K, Marquet K, Raes E, De Bleser L, Budts W, et al. Individual quality of life in adults with congenital heart disease: a paradigm shift. Eur Heart J 2005;26(3):298-307.
25. Oleson M. Subjectively perceived quality of life. J Nurs Scholarsh 1990;22(3):187-90.
26. Meeberg GA. Quality of life: a concept analysis. J Adv Nurs 1993;18:32-8.
27. Smith KW, Avis NE, Assmann SF. Distinguishing between quality of life and health status in quality of life research: a meta-analysis. Qual Life Res 1999;8:447-59.
28. Casey FA, Craig BG, Mulholland HC. Quality of life in surgically palliated complex congenital heart disease. Arch Dis Child 1994;70:382-6.
29. Driscoll DJ, Durongpisitkul D. Exercise testing after the fontan operation. Pediatr Cardiol 1999;20:57-9.
30. O'Brien P, Boisvert JT. Current management of infants and children with single ventricle anatomy. J Pediatr 2001;16(5):338-50.
31. Kamphuis M, Zwinderman KH, Vogels T, Vliegen HW, Kamphuis RP, Ottenkamp J, et al. A cardiac-specific health-related quality of life module for young adults with congenital heart disease: development and validation. Qual Life Res 2004;13:735-45.
32. Saliba Z, Butera G, Bonnet D, Bonhoeffer P, Villain E, Kachaner J, et al. Quality of life and perceived health status in surviving adults with univentricular heart. Heart 2001;86(1):69-73.
33. Connolly D, Rutkowski M, Auslender M, Artman M. Measuring health related quality of life in children with heart disease. Appl Nurs Res 2002;15(2):74-80.
34. Kamphuis M, Ottenkamp J, Vliegen HW, Vogels T, Zwinderman KH, Kamphuis RP, et al. Health related quality of life and health status in adult survivors with previously operated complex congenital heart disease. Heart 2002;87(4):356-62.
35. Uzark K, Jones K, Burwinkle TM, Varni JW. The Pediatric Quality of Life Inventory™ in children with heart disease. Prog Pediatr Cardiol 2003;18:141-8.
36. Bennett SJ, Oldridge NB, Eckert GJ, Embree JL, Browning S, Hou N, et al. Comparison of quality of life measures in heart failure. Nurs Res 2003;52(4):207-16.
37. Macran S, Birks Y, Lewin R, Parsons J, Sloper P, Hardman G, Kind P, et al. The development of a new measure of quality of life for children with congenital heart disease (ConQol). Cardiol Young 2006;16(2):165-172.
38. Kern JH, Hinton VJ, Nereo NE, Hayes CJ, Gersony WM. Early developmental outcome after the Norwood procedure for hypoplastic left heart syndrome. Pediatrics 1998;102:1148-52.
39. Rogers BT, Msall ME, Buck GM. Neurodevelopmental outcome of infants with hypoplastic left heart syndrome. J Pediatr 1995;126:496-7.