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ORIGINAL ARTICLE

Maternal factors and preoperative nutrition in children with mild cases of congenital heart disease

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Abstract

Aim: The preoperative poor nutrition of children with congenital heart disease (CHD) impacts the postoperative rehabilitation process of pediatric CHD cases. The factors of these children's preoperative poor nutrition, excluding the disease, have been underreported. The aim was to investigate the preoperative nutritional status of children with CHD who required a simple surgical repair and to analyze the maternal characteristics that are associated with poor nutrition in these sick children.

Methods: This was a cross-sectional survey. The weight and height of the children were measured, maternal data were collected via a questionnaire and a univariate analysis and multivariate logistic regression were used to analyze the association between maternal factors and the preoperative poor nutrition of the children with CHD.

Results: A total of 119 children with simple CHD were recruited to the study. The prevalence of poor nutrition was higher in the children with CHD ("cases") than in the healthy children ("controls"). An increased risk of poor nutrition was associated with lower mothers' perception, education level, understanding of the disease, and higher anxiety.

Conclusions: Paying attention to maternal anxiety, depression, and knowledge and providing interventions for the mothers of children with CHD are important in order to promote the nutritional status of these children.

Key words: China, congenital heart disease, cross-sectional survey, maternal factors, poor nutrition.

INTRODUCTION

Congenital heart disease (CHD) is the most common anomaly of newborns, affecting ~8 out of 1000 children worldwide (van der Linde *et al.*, 2011). This disease is made up of the following four categories that differ in severity: (i) single-ventricle (SV) physiology; (ii) two-ventricle heart disease that requires complex repair (CR), designated as "Risk Adjustment for Congenital Heart Surgery" (RACHS) class 3 or higher; (iii) two-ventricle heart disease requiring simple repair (SR), designated as RACHS-1 or -2; and (iv) two-ventricle heart disease not requiring repair (Daymont, Neal, Prosnitz, & Cohen, 2013). Data from a screening in a rural area in Chongqin, China, showed that the incidence of CHD in children aged 0–3 years was 6 per 1000 children (60 cases), including 46 cases of simple CHD (76.7%).(Zhang *et al.*, 2017) Unfortunately, in children with CHD, the rehabilitation process is impaired by poor nutrition. One study reported that, compared with

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normal and overweight patients, the multivariable-adjusted hazard ratio of 1 or 2 year mortality was higher in the patients with poor nutrition (2.05 [95% confidence interval, CI: 1.46–2.87] and 2.07 [95% CI: 1.51–2.83], respectively). Thus, with respect to mid-term survival, special attention should be paid to patients with poor nutrition who are scheduled for cardiac surgery (Zittermann *et al.*, 2014).

Poor nutrition is diagnosed when growth is below the fifth percentile or when growth-for-age *z*-scores fall below –2.0 (WHO, 2008). Numerous studies have shown that weight gain is impaired in infants with complex CHD (SV and CR) (Williams *et al.*, 2011). Using data from a large primary care network, a previous retrospective study also compared the differences between children with simple repair congenital heart disease (SR CHD) and healthy peers (Daymont *et al.*, 2013). Little difference was found at birth; however, the growth of the children with CHD significantly decreased in the first month and persisted throughout the research period. In general, poor nutrition is associated with longer hospital stays, as well as increased rates of readmission and patient morbidity. Increased rates of mortality and postsurgical infection also have been reported for children with a poor nutrition status (Anderson, Kalkwarf, Kehl, Eghtesady, & Marino, 2011). In addition, several interventions were conducted to improve the nutritional delivery and nutrition status in critically ill children with heart disease (Kaufman *et al.*, 2015; Weston *et al.*, 2016). Being different from infants with complex CHD (SV and CR), for preschoolers with SR CHD, 2–4 years of age has been identified as the best term for surgical repair (Wasserman, Zhu, & Schlichter, 2007). Yet, limited studies in the literature have reported on the growth of the children with SR CHD during the period from birth to admission for surgery.

The factors that are associated with the poor nutrition of children with CHD have been analyzed and the high-risk factors include inadequate nutritional support, low caloric intake, chronic cyanosis, more frequent hospital readmissions, increased mean pulmonary arterial pressure, and higher oxygen saturation (Anderson *et al.*, 2010; Kelleher, Laussen, Teixeira-Pinto, & Duggan, 2006; Williams *et al.*, 2011); yet, most of the studies have focused on the factors related to the disease.

As primary caregivers, mothers have shown the strongest influence on the nutritional status of their children (healthy or ill). Their education level, age (Chirande *et al.*, 2015; Nagahori, Tchuani, & Yamauchi, 2015), feeding anxiety, perception of childhood disease and care (Hill *et al.*, 2014) all have a strong influence on childhood nutrition. Increased levels of psychosocial difficulties have been reported in the mothers of children who require surgery for CHD (Skladzien *et al.*, 2011). The mother's perception of the disease also was important. For example, if the parents of children with CHD knew the correct preventive measures for infective endocarditis, they would take or instruct their children to take preventive measures and then episodes of infective endocarditis could be avoided (Knochelmann, Geyer, & Grosser, 2014). However, the correlation between the accuracy of the maternal perceptions of childhood CHD, maternal characteristics, maternal psychological variables, and the growth of the children prior to surgery for SR CHD has been underreported.

The purpose of this study focused on comparing the nutritional status between children with SR CHD, who had been monitored by cardiologists and were candidates for surgery, and healthy children. In addition, the maternal characteristics that are associated with the poor nutrition of sick children were analyzed. Healthy children were selected as the control group in order to represent the common nutritional status of preschool children in China, in particular, which is known to be different from the World Health Organization (WHO) growth curves and which represent summarized multinational data (Mo *et al.*, 2016; Zong & Li, 2012). According to the representativeness of samples in China, a 1:10 matching ratio was selected (Daymont *et al.*, 2013) to account for the proportion of children with CHD being much smaller than that of healthy children. Moreover, the children with SR CHD were selected to exclude some high-risk factors that are associated with severe disease, such as frequent hospital readmissions and the increased mean pulmonary arterial pressure that is found in children with more severe deformities.

METHODS

Study design

This cross-sectional survey was conducted between 1 May and 1 August, 2015, and enrolled both children with SR CHD who were 2–4 years of age, waiting for corrective surgery, and their mothers as the case group. The CHD category and the best time for surgical repair were determined by the pediatric cardiologist. Children who were born prematurely (i.e. <37 weeks of gestation) and those with complex non-cardiac chronic conditions

(including malignancy, neuromuscular, respiratory, renal, or gastrointestinal disorders, immunodeficiency, metabolic, genetic, and other congenital anomalies) were excluded. Also excluded were those whosemother was not the primary care provider. The survey was conducted at four hospitals in Hunan, China (Hunan Children's Hospital, Xiangya Hospital, Second Xiangya Hospital, and Third Xiangya Hospital), which provide care for patients with CHD. One cardiology nurse in each hospital was recruited to act as part of the research team by completing the data collection using a communication strategy based on face-to-face information gathering and administration of the questionnaires. The children and mothers who were included in this study were recruited on their routine visits to the outpatient department of the hospital. Evaluation of the growth parameters of a cohort of healthy children in the same primary care network revealed a distribution of the growth parameters that was not well described by the WHO growth curves (de Onis, Garza, Onyango, Rolland-Cachera, & le Comite de Nutrition de la Societe Francaise de **Pédiatrie**, 2009; Wright, Inskip, Godfrey, Williams, & Ong, 2011). Consequently, a control group that was10-fold larger than the case group was used to compare growth (Daymont *et al.*, 2013). The controls were age- ($\pm$2 months) and sex-matched healthy children with a socioeconomic status and mother's education level that were similar to the case group. The healthy children were recruited between 1 May and 1 November, 2015 during routine care visits to the Child Healthcare Department of the Third Xiangya Hospital. Written informed consent was obtained from the mothers before they and their children were enrolled in the study. The recruitment period was longer for the control group than for the case group because the control group was 10-fold larger.

Data collection

The weight and height of the children in the case group and control group were measured in duplicate at the time of enrollment by either one of two members of the research team. A third measurement was made if the first two measurements were not within 0.1 kg for the weight or within 1.0 cm for the height. Growth was assessed by weight- and height-for-age *z*-scores. The patients' age, sex, and time from diagnosis to enrollment and family data, including the mothers' age, education level, socioeconomic level, and maternal perception were collected by the research team members during face-to-face interviews by using questionnaires that were completed by each mother. The maternal perception of the disease was evaluated by asking "How severe do you think the child's disease is—mild or serious?," compared to the cardiologist's perception. From the view of the cardiologist, SR CHD is a relatively mild condition. If the mother answered "mild," it was recorded as an accurate perception and considered that it clearly reflected the mother's perception of the severity of SR CHD. The survey tools included the State–Trait Anxiety Inventory (STAI), Self-Rating Depression Scale (SDS), and Parent Understanding Questionnaire for Congenital Heart Disease (PUQ–CHD). A small gift of ~US$1 in value was given to encourage participation.

State–Trait Anxiety Inventory

The Chinese version of the STAI (published Cronbach's alpha = 0.73–0.86, goodness-of-fit index [GFI] = 0.94, confirmatory factor analysis = 0.93) (Ferreira & Murray, 1983; Zheng *et al.*, 1993) was used. It is a self-reporting instrument that had been developed by Spielberger *et al.* (1970) and consists of 40 items that evaluate the state and trait anxiety levels of an individual. The first 20 items assess the state of anxiety, 10 items for positive and 10 for negative emotions. State anxiety can be defined as an unpleasant emotional arousal in response to threatening demands or dangers. The second 20 items assess anxiety traits, nine for positive and 11 for negative emotions. Trait anxiety refers to a general level of stress that is characteristic of an individual; that is, related to personality. State anxiety reflects the anxiety related to a current event, whereas trait anxiety is a personality characteristic that reflects a more long-term form of anxiety. The responses were scored on a four-point Likert scale, including "not at all" (1), "mild" (2), "moderate" (3), and "very much so" (4) and were summarized by a score ranging from 20–80. Higher scores indicated a higher level of anxiety. The alpha value of this study was 0.81 for the anxiety state and 0.79 for the anxiety trait.

Self-Rating Depression Scale

The Chinese version of the SDS has demonstrated acceptable psychometric properties in previous studies (Wang, Cai, & Xu, 1986; Zung, 1965), a good criterion validity with the Hamilton Depression Scale (Spearman's correlation = 0.783), and a published Chronbach's alpha of 0.87. It includes 20 items covering the affective, psychological, and somatic features of depression. Ten items have symptomatically positive wording and 10 have symptomatically negative wording. The scale is

designed to assess how the respondent felt during the previous week and it was used to assess the depressive status of the patients' mother. The responses were scored on a four-point Likert scale, including "not at all" (1), "very much" (2), or "most of the time" (3). The scores ranged from 20 ("no depression") to 80 ("major depression"), with a cut-off value of 49, indicating significant depression. The alpha value of this study was 0.89.

Parent Understanding Questionnaire for Congenital Heart Disease

The PUQ–CHD was based on information that was deemed necessary for parents to understand when they had a child with CHD (Williams *et al.*, 2008) and is used to measure parents' knowledge in five relevant domains: knowledge about their child's doctors; knowledge of CHD; knowledge of the surgical procedure; knowledge on reproductive issues; and knowledge on follow-up care. Now, it has been translated and modified by the investigators, according to Brislin's translation model. Good validity was tested by a confirmatory factor analysis (χ^2/d.f .= 3.06, root mean square error of approximation = 0.07, GFI = 0.92). The Cronbach's alpha was 0.84. Each of the five domains was scored 0 ("no answer correct"), 1 ("some answers correct"), or 2 ("all answers correct"). The answers that were left blank were coded as "incorrect." The total understanding score ranged from 0 to 10 points, with a higher score indicating a better understanding of the disease.

Statistical analysis

Growth was assessed by the *z*-scores of height-for-age (HFAZ), weight-for-age (WFAZ), and weight-for-height (WFHZ) (WHO Multicentre Growth Reference Study Group, 2006). The *z*-scores were calculated by using WHO Anthro software (v. 3.2.2, January, 2011) for personal computers. The children with SR CHD were stratified by a *z*-score into two groups, indicating either normal growth or growth consistent with poor nutrition. Following WHO guidelines, poor nutrition was characterized by stunting, underweight, and wasting. "Stunting" was defined as a HFAZ of ≤2, "underweight" was defined as a WFAZ of ≤2, and "wasting" was defined as a WFHZ of ≤2 (WHO, 2006, 2008).

The study data were coded by questionnaire serial number and analyzed by using the IBM SPSS statistical software package v. 17.0 (IBM Corporation, Armonk, NY, USA). A *P*-value of <0.05 was considered to be statistically significant. The results were expressed as means ± standard deviation and *z*-scores were calculated for each subgroup of the study population. The prevalence of stunting, underweight, and wasting was calculated and differences in poor nutrition rates were tested for significance by using the chi-squared test. A univariate analysis was conducted by usingthe chi-squared test or *t*-test and a multivariate logistic regression analysis was carried out in order to identify the variables that are associated with poor nutrition. A backward stepwise regression was used and the model included all of the study variables; namely, the patient's age, sex, time since diagnosis, accurate maternal perception, household income, mother's age, mother's education level, STAI state, STAI trait, SDS, and PUQ–CHD.

Ethical approval

Approval for this study was obtained from Central South University, Hunan, China (no. 2015-s137). The study was conducted following the ethical principles of the Helsinki Declaration. All the mothers who agreed to participate after hearing a verbal explanation of the study's objectives and procedures gave written consent for themselves and their child. Information was collected anonymously to protect individual confidentiality.

RESULTS

Study population

In total, 212 patients with CHD who were scheduled for reparative surgery were enrolled between 1 May and 1 August, 2015. Of these, 93 patients were excluded for the following reasons. Thirty-seven patients were not classified as SR CHD and 31 were not 2–4 years old. The mothers of 10 patients were not interviewed, the mothers of nine patients could not understand the questionnaire, and six mothers refused to participate. The remaining 119 patients and mothers were evaluated and compared with 1265 healthy children who were included in the control group. The demographic characteristics of the study population are shown in Table 1 and the primary diagnoses of the patients included atrial septal defect (n = 38), ventricular septal defect (n = 43), patent ductus arteriosus (n = 29), and simple tetralogy of fallot (n = 9).

Poor nutrition in the patients simple repair congenital heart disease and the controls

The HFAZ, WFAZ, and WFHZ scores of the patients with SR CHD were significantly lower (P < 0.01) than the control group's values (Table 2). Figure 1 shows the

Table 1 Demographic characteristics of the cases and the controls

Characteristic	Case group†	Control group†	t/χ^2-value	*P*-value
Number	119	1265	–	–
Male	61 (51.3)	653 (51.6)	0.030	0.953
Age (months)	36.53 ± 11.25	36.72 ± 10.39	0.580	0.610
Household income			1.680	0.790
High	18 (15.1)	214 (16.9)		
Middle	52 (43.7)	556 (43.9)		
Low	49 (41.2)	495 (39.2)		
Mothers' age (years)	32.29 ± 9.78	31.58 ± 10.31	1.238	0.220
Mothers' education level			2.870	0.580
Graduate school	8 (6.7)	78 (6.2)		
College/university	31 (26.8)	382 (30.1)		
Senior high school	33 (27.8)	368 (29.1)		
Junior high school	32 (26.9)	313 (24.7)		
Elementary school	15 (12.6)	124 (9.8)		

† Data are shown as either the mean ± standard deviation or N (%).

Table 2 *Z*-scores of the cases with congenital heart disease and the controls

Z-score	Case group (mean ± SD)	Control group (mean ± SD)	*t*-value	*P*-value
HFAZ	–1.29 ± 1.74	0.07 ± 1.06	10.51	0.00
WFAZ	–1.29 ± 1.33	0.21 ± 1.02	12.68	0.00
WFHZ	– 0.85 ± 1.56	0.23 ± 1.06	8.54	0.00

HFAZ, height-for-age score; WFAZ, weight-for-age score; WFHZ, weight-for-height score.

differences in prevalence of stunting, underweight, and wasting in the case group and the control group. The prevalence of stunting was 28.6% in the case group and 9.8% in the control group ($\chi^2 = 70.25$, $P < 0.01$). The corresponding percentages were 25.3% and 5.4% for underweight ($\chi^2 = 71.83$, $P < 0.01$) and 25.3% and 6.1% for wasting ($\chi^2 = 69.2$, $P < 0.01$).

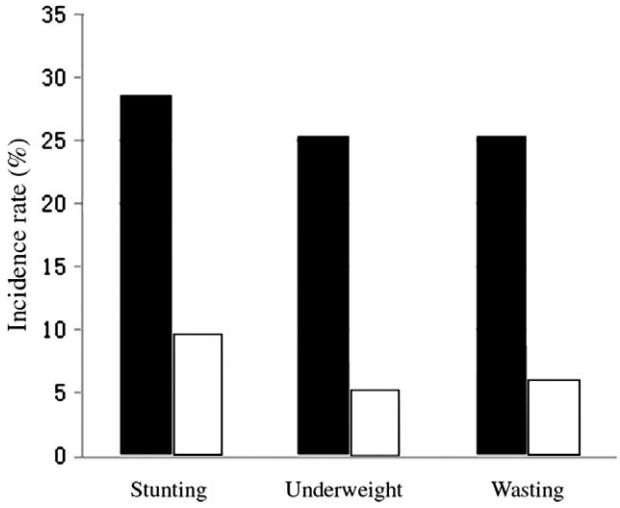

Figure 1 Prevalence of underweight, stunting, and wasting in the case group with simple repair congenital heart disease and the control group. (■) Case group; (□) control group.

Maternal factors and the risk of poor nutrition in patients with simple repair congenital heart disease

In order to compare the patients with normal nutrition and the patients with poor nutrition (Table 3), several maternal factors had significant influence on the patients' nutritional status, including the mother's perception of the disease, her education level, STAI score, and understanding of the disease, as shown by the PUQ–CHD score ($P < 0.05$). The occurrence of poor nutrition was more frequent in the children with mothers who had low education levels, increased anxiety, and poor understanding of the disease ($P < 0.05$). The patient's age and sex, time since diagnosis, household income, mother's age, marital status, employed status, and depressive status were not associated with poor nutrition. The multivariate logistic regression analysis, including all the surveyed variables, found that an accurate maternal perception reduced the risk of poor nutrition. (On the contrary, an inaccurate maternal perception would significantly increase the risk.) The mother's increased anxiety trait score corresponded with high rates of stunting, underweight, and wasting. The mother's education level was associated with stunting and underweight but not with wasting and their level of understanding the disease was associated with

Table 3 Univariate analysis of the factors influencing poor nutrition

	HFAZ		WFAZ		WFHZ	
Factor	Normal (n = 85)	Stunting (n = 34)	Normal (n = 89)	Underweight (n = 30)	Normal (n = 89)	Wasting (n = 30)
Patient age: (months) (mean ± SD)	37.77 ± 10.72	33.42 ± 12.15	37.31 ± 10.96	34.22 ± 12.02	36.37 ± 11.27	37.00 ± 11.44
Male: N (%)	45 (52.9)	16 (47.1)	46 (51.7)	15 (50.0)	45 (50.6)	16 (53.3)
Time since diagnosis: (months) (mean ± SD)	22.26 ± 16.63	25.04 ± 14.71	22.72 ± 15.71	24.04 ± 17.45	23.26 ± 15.79	22.43 ± 17.23
Maternal accurate perception: N (%)	58 (68.2)*	7 (20.6)*	55 (61.8)*	10 (33.3)*	55 (61.8)*	10 (33.3)*
Middle-lower-household income: N (%)	73 (86.2)	28 (82.4)	76 (85.4)	25 (83.3)	75 (84.3)	26 (86.7)
Mother's age (years) (mean ± SD)	30.17 ± 8.43	31.21 ± 9.16	30.95 ± 8.72	30.73 ± 10.14	30.27 ± 9.15	31.54 ± 11.24
Mother'seducationallevel						
Middle-lower[†]: N (%)	51 (59.9)*	29 (85.2)*	52 (58.7)*	28 (93.4)*	52 (58.7)*	28 (93.4)*
Married: N (%)	85 (100.0)	32 (94.1)	88 (98.9)	29 (96.7)	87 (97.7)	30 (100.0)
Mother's employment: N (%)	70 (82.3)	25 (73.5)	72 (80.9)	22 (73.3)	72 (80.9)	22 (73.3)
STAI state: mean ± SD	50.11 ± 9.13*	54.96 ± 8.41*	49.90 ± 8.97*	55.09 ± 8.32*	50.93 ± 9.08	52.04 ± 9.13
STAI trait: mean ± SD	49.14 ± 8.70*	55.38 ± 7.42*	48.85 ± 7.46**	55.85 ± 9.03**	49.88 ± 7.41*	55.30 ± 10.59*
SDS: mean ± SD	0.55 ± 0.11	0.56 ± 0.08	0.54 ± 0.10	0.58 ± 0.10	0.55 ± 0.10	0.54 ± 0.10
PUQ–CHD: mean ± SD	6.49 ± 1.91*	5.58 ± 1.45*	6.65 ± 2.23*	5.53 ± 1.99*	6.74 ± 2.49*	5.49 ± 1.86*

[†] Middle-to-lower educational level includes senior high, junior high, and elementary school.
Comparison of patients with z-scores within normal limits with patients with poor nutrition (χ^2-test for difference in proportions and t-test for difference in means). *P < 0.05 and **P < 0.01.
HFAZ, height-for-age score; PUQ–CHD, Parent Understanding Questionnaire for Congenital Heart Disease; STAI, State-Trait Anxiety Inventory; SD, standard deviation; SDS, Self-Rating Depression Scale; WFAZ, weight-for-age score; WFHZ, weight-for-height score.

wasting. The presence of depression was associated with wasting in the multivariate, but not in the univariate, analysis. The multivariate logistic model analyses are shown in Table 4.

DISCUSSION

With WHO standards and methods, the nutritional status of children with SR CHD and the maternal factors that were associated with their risk of poor nutrition when they were waiting for reparative surgery were evaluated. The children's nutritional status was significantly lower than that of the healthy children who were assessed. Several maternal factors, such as education level, perception of illness severity, and increased anxiety and depression were found to be associated with a risk of preoperative poor nutrition in children with SR CHD.

Similar to the results of Tao, Xu, Tang, Wu, and Cai (2007), it was found that the prevalence of poor nutrition was significantly higher in the children with SR

Table 4 Predictors of stunting, underweight, and wasting by using a logistic backward stepwise regression analysis

Variable	OR	95% CI	*P*-value
Stunting			
Full model			
Patient's age (months)	1.02	0.95–1.09	0.58
Male	1.67	0.16–2.24	0.44
Time since diagnosis (months)	1.68	0.94–3.02	0.09
Maternal accurate perception	0.38	0.23–1.06	0.06
Household income (middle-to-low)	1.76	1.09–2.84	0.02
Mother's age (years)	1.89	0.95–3.77	0.17
Mother's education level (middle-to-lower)	2.32	1.14–4.71	0.03
STAI state	1.85	0.85–4.02	0.16
STAI trait	2.95	1.21–7.19	0.02
SDS	3.08	0.93–5.05	0.11
PUQ–CHD	0.46	0.16–1.31	0.09
Final model			
Maternal accurate perception	0.40	0.19–0.85	0.01
Mother's education level (middle-to-lower)	1.43	1.13–1.79	0.03
STAI trait	4.00	1.36–11.78	0.02
PUQ–CHD	0.56	0.53–1.13	0.08
Underweight			
Full model			
Patient's age (months)	1.28	0.83–1.99	0.27
Male	1.14	0.29–4.45	0.85
Time since diagnosis (months)	1.42	0.97–2.09	0.22
Maternal accurate perception	0.37	0.15–0.98	0.04
Household income (middle-to-low)	1.71	0.85–3.44	0.21
Mother's age (years)	2.12	0.90–5.01	0.09
Mother's education level (middle-to-lower)	2.80	1.12–7.01	0.04
STAI state	1.04	0.86–1.26	0.41
STAI trait	2.60	1.31–5.15	0.03
SDS	0.82	0.27–2.48	0.29
PUQ–CHD	0.61	0.30–1.26	0.21
Final model			
Maternal accurate perception	0.49	0.27–0.89	0.04
Mother's education level (middle-to-lower)	2.74	1.25–5.99	0.04
STAI trait	3.41	1.42–8.19	0.01
PUQ–CHD	0.78	0.48–1.26	0.16
Wasting			
Full model			
Patient's age (months)	1.02	0.95–1.09	0.44
Male	0.59	0.16–2.24	0.58
Time since diagnosis (months)	1.85	0.94–3.63	0.19
Maternal accurate perception	0.41	0.22–0.78	0.01
Household income (middle-to-low)	1.62	0.91–2.89	0.18
Mother's age (years)	0.79	0.58–1.09	0.09
Mother's education level (middle-to-lower)	1.53	0.81–2.89	0.08
STAI state	1.33	0.85–2.07	0.16
STAI trait	2.77	1.28–6.02	0.03
SDS	1.74	1.03–2.93	0.05
PUQ–CHD	0.36	0.19–0.88	0.03
Final model			
Maternal accurate perception	0.32	0.18–0.59	0.00
Mother's education level (middle-to-lower)	1.33	0.87–2.04	0.06
STAI trait	3.36	1.58–7.14	0.03
SDS	2.11	1.15–3.89	0.02
PUQ–CHD	0.31	0.12–0.79	0.02

CI, confidence interval; OR, odds ratio; PUQ-CHD, Parent Understanding Questionnaire for Congenital Heart Disease; STAI, State–Trait Anxiety Inventory; SDS, Self-Rating Depression Scale.

CHD. But, another study from Egypt showed a much higher rate of poor nutrition (84.0% in children with CHD and 20% in the controls) than in this study (Hassan *et al.*, 2015). Excluding the difference of living conditions and environment of the children between China and Egypt, an important reason was that Hassan *et al.* recruited all the categories of CHD, including both SV and CR. This difference, however, gave some information that the nutritional status of the children with CHD could be influenced by some factors, besides the disease itself. Researchers and medical staff should be made aware of this topic in order to better understand the importance of developing new interventions to improve the nutritional status of children while they are awaiting CHD surgery (Hill *et al.*, 2014).

The results of this study confirmed the importance of the mother's accurate understanding of CHD to protect their child against poor nutrition. A parent's inaccurate

perception of their child's weight status has been reported and cited as a factor that affects the child's feeding behavior, which might bring about growth problems (i.e. the presence of overweight or obesity) (Almoosawi *et al.*, 2016). A mother's inaccurate perception of her child's disease, as resulting from a poor understanding of the CHD diagnosis, can lead to increased psychological problems (Doherty *et al.*, 2009). Also, the mother's anxiety state and the presence of depression were found to be significantly related with poor nutrition of the child; this result was consistent with the findings of another study (Wright, Parkinson, & Drewett, 2006). The question, therefore, was how could maternal emotions have an impact on a child's nutrition? Perhaps, maternal psychological problems can cause changes in caring behavior (Carey, Nicholson, & Fox, 2002), such as maternal feeding anxiety (Wright *et al.*, 2006) or strong maternal promotion of dietary intake (Hill *et al.*, 2014). Such maternal abnormal caring behavior can influence children's eating avoidance behavior and consequently their calorie intake (inadequate). A study previously has shown that maternal symptomatic characteristics (anxiety, depression, and dysfunctional eating attitudes) were reciprocally involved in infantile anorexia (Lucarelli, Cimino, D'Olimpio, & Ammaniti, 2013). Though prospective studies are needed to confirm this study's findings, effective interventions to alleviate maternal anxiety and to increase maternal understanding of the disease will be useful approaches in order to improve the nutritional status of children with SR CHD.

It also was found that the middle-to-lower educational level of the mothers was associated with a high risk of stunting and underweight in the children with SR CHD. Similarly, Emamian, Fateh, Gorgani, and Fotouhi (2014) reported that the education level of mothers was an important factor that was associated with the risk of poor nutrition. This result can be explained, in that mothers with higher levels of education will have a better understanding of the disease and then they will easily learn to parent a child with CHD and to provide better nutrition to the child. Hence, medical staff must be reminded that an effective health education program for the mothers of children with SR CHD is important, if not necessary.

Interestingly, this study found that the majority of patients (85%) came from middle-to-lower income families and that 67.3% of the mothers in this study population had middle-to-lower-level education, with an average PUQ–CHD score of 5.82 ± 2.10 out of a possible 10, which was lower than that reported from the previous survey by Williams *et al.* (2008) (Table 1). The possible interference of differences in family income and the mother's education level was effectively avoided by comparing patients with income-matched controls in this study. Thus, the results highlight the need to not only pay attention to the relationship of poor nutrition and CHD, but also to the profile of prevalence of CHD. Yet, another study already has demonstrated that the occurrence of CHD is associated with the mother's educational level (Liu *et al.*, 2009), raising the possibility that there could be some correlation between the morbidity of CHD and household income level.

Study limitations

Several limitations were related to the study's population sample. First, although the patients and controls were recruited at the four largest hospitals in Hunan, the generalizability of the findings is limited by cluster sampling. Second, the generalizability of the results might be limited by the preponderance of mothers with a middle-to-lower income and education levels. In future studies, the conditions within the families of children with CHD in China should be investigated. Third, the use of self-reported questionnaires might have led to a response bias. Fourth, the psychological status of the mother prior to surgery might have been influenced by this particular period in time, but the main purpose of this study was to show the conditions during this period. Fifth, the aim of excluding children with conditions that are more serious than SR CHD was to avoid the influence of the disease; even so, different symptoms both within and among different diagnoses in SR CHD also should have an influence on the nutritional status. Finally, the possibility cannot be ignored that the children's nutritional status could have had an adverse effect on the mothers' anxiety; however, the association is clear and interventions to alleviate maternal anxiety nevertheless would be beneficial.

An increase in the number of patients who have been diagnosed with CHD highlights the need to provide effective medical care. This study evaluated the growth and nutrition of patients with SR CHD before surgery in Hunan, China, using growth-for-age *z*-scores and controls. This study found that their nutritional status was significantly lower than that of the healthy children and that an accurate maternal perception of the disease was a protective factor, while a maternal low education level and an increased maternal anxiety trait score were the most important factors for poor nutrition. More studies are needed on this group of patients to gain a

more comprehensive understanding of the maternal nutritional status, feeding problems, and maternal behavior in relation to these diseased children. Nonetheless, the results from this study can be useful in the development of medical strategies to improve the nutrition of patients with SR CHD. A cognitive behavioral therapy and/or patient health education program, similar to the effective group-based parenting program that was developed by Kendall, Bloomfield, Appleton, and Kitaoka (2013), might be used as an intervention in the future.

DISCLOSURE

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

C. X. Q., Y. L., and D. J. W. conducted the investigation; C. X. Q. and R. Y. carried out the statistical analysis; D. W. and S. Y. T. conceived the study, participated in its design, and helped to draft the manuscript. All the authors read and approved the final manuscript.

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