Original Article

Screening for nutritional risk in hospitalized children with liver disease

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Background and Objectives: Malnutrition is a major contributor to morbidity and mortality from pediatric liver disease. We investigated the prevalence of both malnutrition and high nutritional risk in hospitalized children with liver disease as well as the rate of in-hospital nutritional support. **Methods and Study Design:** A total of 2,874 hospitalized children and adolescents with liver disease aged 1 to 17 years (inclusive) were enrolled. Malnutrition was screened by anthropometric measures (height-for-age, weight-for-height, weight-for-age, and BMI-for-age z-scores). The Screening Tool for Risk on Nutritional Status and Growth (STRONGkids) was used to evaluate nutritional risk status. Nutrition markers in blood, rate of nutritional support, length of hospital stay, and hospital fees were compared among nutritional risk groups. **Results:** The overall prevalence of malnutrition was 38.6%. About 20.0% of children had high nutritional risk, and prevalence of malnutrition was markedly greater in the high nutritional risk group compared with the moderate risk group (67.9% vs 31.3%). Serum albumin and prealbumin differed significantly between high and moderate risk groups ($p<0.001$). Only 8.9% of children with high nutritional risk and 3.5% with moderate nutritional risk received nutrition support during hospitalization. Children with high nutritional risk had longer hospital stays and greater hospital costs ($p<0.001$). **Conclusions:** The prevalence of malnutrition is high in children with liver disease. High nutritional risk is also prevalent at admission. Albumin and prealbumin are sensitive markers for distinguishing nutritional risk groups. High nutritional risk prolongs length of stay and increases hospital costs. The nutritional support rate is still low and requires standardization.

Key Words: children, liver disease, nutritional risk screening, malnutrition, nutritional support

INTRODUCTION

The liver is an important metabolic organ, so liver diseases disrupt the homeostatic regulation of critical nutrients. This may lead to different degrees of malnutrition that seriously affect prognosis.[1] Indeed, malnutrition can increase the risks of complications from primary disease and increase mortality.[2] In China, 15% to 25% of children with liver injury due to a viral infection in infancy or childhood die because of the liver disease or its complications, and most of these complications are related to malnutrition.[3-5] Further, the occurrence and development of liver diseases in adulthood are strongly related to nutrition and health status in childhood/adolescence, so the management of nutrition is especially vital in youth to reduce risk. Nutritional risk screening is the first step in nutritional management. This study screened and evaluated the nutritional status of 2,874 children hospitalized with liver disease, and explored both the prevalence of in-hospital nutritional management and the influence of disease-associated malnutrition on hospital stay and medical costs.

METHODS

Subjects

A total of 2,874 children and adolescents age 1 to 17 years (inclusive) hospitalized in the pediatric liver disease treatment centers of the 302 Military Hospital from June 1, 2013, to May 31, 2015, were included in this study. To be included, children must have been hospitalized for more than 24 h. Infants <1 year of age, children with severe edema, and patients who were confined to bed and whose weight could not be obtained accurately were excluded.

Ethics statement

This study was approved by the Medical Ethics Committee of The 302 Military Hospital of China (2012143A).

Nutritional Risk Screening Using STRONGkids

All participants were screened for nutritional risk within 24 h of admission using the Screening Tool for Risk on Nutritional Status and Growth (STRONGkids),[6] which is graded in four parts: high-risk disease (2 points), subjective clinical assessment (1 point), nutritional intakes and

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losses (1 point), and loss of weight (1 point). A total score of 4 to 5 points means high nutritional risk, 1 to 3 points means moderate nutritional risk, and 0 point means low nutritional risk.

Evaluation of malnutrition in children

Malnutrition in children was assessed using the height and weight as anthropometric measurements. We adopted the child growth standards published by the World Health Organization in 2006 to facilitate international comparisons with children under 5 years of age and the standard scale of children's growth and development (2005) used by nine Chinese provinces.[7] The height-for-age z-score (HAZ), weight-for-height z-score (WHZ), weight-for-age z-score (WAZ), and BMI-for-age z-score (BAZ) were calculated separately. Using z-score criteria, malnutrition assessed by HAZ is defined as growth retardation, malnutrition assessed by WHZ as emaciation, and malnutrition assessed by WAZ as low body weight. Malnutrition is divided according to z value ranges into mild ($-2 \leq z < -1$), moderate ($-3 \leq z < -2$), and severe ($z < -3$). WHZ >2 or BAZ >1 means overweight or obese.[8]

Demographic and clinical assessments

General clinical-demographic data, such as name, sex, age, and diagnosis, were recorded upon hospital admission. For preterm children younger than 24 months, age was calculated according to the correct gestational age. Children's height and weight were recorded on the morning of the day after admittance. Weight was recorded to 0.1 kg and height to 0.1 cm. Fasting venous blood was obtained on the second day of hospitalization. Routine biochemical indices were measured and the serum levels of albumin, prealbumin, and hemoglobin were recorded. The length of stay, cost of hospitalization, and application of nutritional support were recorded at discharge. Nutritional support included enteral nutrition and parenteral nutrition. Enteral nutrition included tube feeding and oral nutritional supplements (ONS). These enteral nutritional preparations included medicinal preparations and foods for special medical purposes. Parenteral nutrition included fat emulsion, glucose, essential and non-essential amino acids, vitamins, electrolytes, and trace elements.

Statistical analysis

All data were analyzed using SPSS software (SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to conduct nutritional risk screening and malnutrition evaluation. Count data are expressed by number and percentage, and group means were compared by X^2 tests. Measurement data are expressed as the mean±SD. If the distribution was normal, means were compared by analysis of variance. If not normally distributed, the results were compared by rank-sum test. A $p<0.05$ was considered significant for all statistical analyses.

RESULTS

Clinical characteristics

A total of 2,874 children were included in this study (1,926 boys [67%] and 948 girls [33%]). The mean (±SD) age was 8.43±4.93 years, with 429 under 3 years (14.9%), 708 aged 3 to 5 years inclusive (24.6%), 939 aged 6 to 11 years inclusive (32.7%), and 798 aged 12 to 17 years inclusive (27.8%). The etiological classifications included 1,221 cases with chronic viral hepatitis B (42.5%), 579 cases with chronic viral hepatitis C (20.1%), 309 cases with non-hepatotropic viral hepatitis (10.8%), 285 cases with hereditary and metabolic liver diseases (Wilson's disease, glycogen storage disease, galactosemia, muscle damage, congenital hepatic fibrosis, Crigler-Najjar syndrome, and others) (9.9%), 102 cases with drug-induced liver injury (3.5%), 87 cases with autoimmune hepatitis (3.0%), 63 cases with non-alcoholic steatohepatitis (2.2%), and 228 cases of unknown etiology (7.9%).

Assessment of nutritional status

Basic anthropometric variables are presented by age (one-year range) and sex in Table 1. The prevalence of malnutrition was calculated by the z-score. As shown in Table 2, 38.6% of all patients (1110 of 2,874) were malnourished, and 13.4% (384 of 2,874) were moderately to severely malnourished. In contrast, only a small minority were

Table 1. Basic anthropometric measures by age and sex

Age[†]	Height (cm)		Weight (kg)		BMI (kg/m^2)	
	Boys	Girls	Boys	Girls	Boys	Girls
1	81.4±4.8	79.5±6.9	11.4±1.2	10.6±1.8	17.3±2.2	16.6±1.3
2	92.5±6.0	92.5±6.9	13.9±2.3	13.0±2.1	16.2±1.8	15.2±1.7
3	100.7±7.1	98.0±6.1	16.3±2.4	15.1±2.2	16.2±3.1	15.7±1.5
4	107.2±5.8	106.8±7.0	17.7±2.5	17.3±2.4	15.4±1.7	15.2±1.8
5	114.7±6.2	112.6±7.2	20.2±3.8	18.9±2.8	15.3±2.1	14.9±2.1
6	119.2±7.1	117.7±4.8	22.5±4.6	20.9±2.3	15.7±2.1	15.1±1.2
7	125.9±6.0	124.9±7.6	25.3±4.6	23.5±3.9	15.9±2.4	15.0±1.6
8	132.1±8.2	130.6±8.4	28.2±5.8	26.1±4.3	16.0±2.3	15.3±2.4
9	135.7±8.7	138.7±7.4	31.5±8.3	30.8±4.9	16.8±2.9	16.0±2.5
10	141.9±8.4	141.5±8.1	37.5±13.5	31.6±6.1	18.2±4.6	15.7±1.9
11	151.0±10.9	144.7±8.0	46.1±13.9	33.4±7.7	19.9±4.1	15.8±2.8
12	157.4±12.5	153.8±9.6	49.6±12.9	42.9±15.3	19.8±3.7	17.8±4.7
13	162.7±11.3	158.0±5.0	51.8±18.0	43.3±6.7	19.1±4.4	17.3±2.0
14	167.5±8.3	161.3±6.8	53.4±12.6	48.2±9.2	18.9±3.4	18.5±3.1
15	170.2±5.9	160.0±3.2	57.5±10.8	47.5±4.3	19.8±3.2	18.6±1.7
16	173.1±5.6	161.9±3.3	60.8±11.1	52.7±6.7	20.3±3.4	20.1±2.3
17	174.8±4.8	167.9±7.3	66.6±12.9	53.0±7.2	21.7±3.6	18.8±2.2

[†]Chronological age in years (e.g., 1 is ≥1 year and < 2 years).

Table 2. Prevalence of malnutrition

Nutrition status	n	%
Mild malnutrition	726	25.3
Moderate malnutrition	267	9.3
Severe malnutrition	117	4.1
Overweight or obese	81	2.8

overweight or obese.

Liver disease etiology and nutritional status

The effects of these different liver disease etiologies on nutritional status are summarized in Table 3. Substantial minorities of patients with chronic viral hepatitis, non-hepatotropic viral hepatitis, and hereditary and metabolic liver diseases were malnourished. In contrast, the majority of children (90.5%, 57 of 63) with non-alcoholic steatohepatitis were overweight or obese. Patients with drug-induced liver injury and autoimmune hepatitis exhibited both malnutrition and overnutrition, but the proportion with malnutrition was higher. Patients with chronic hepatitis C had the highest low-weight rate (150 of 579), patients with hereditary and metabolic liver diseases had the highest growth retardation rate (69 of 285), and patients with drug-induced liver injury had the highest emaciation rate (30 of 102).

Nutrition risk scores and associations with malnutrition

While most patients were not malnourished as defined, almost all were at nutritional risk, with 20% at high nutritional risk (576 of 2,874) (Table 4). The proportion at high nutritional risk was largest in the youngest age cohort (34.3% of children under 3 years) and remained relatively stable thereafter (19.9% of children age 3 to 5 years inclusive, 18.2% of children age 6 to 11 years inclusive, and 14.7% of adolescents age 12 to 17 years inclusive). Specifically, the prevalence of high nutritional risk was greater among those under 3 years than for all other age groups: 3-5 years (X^2=29.086, p<0.001), 6-11 years (X^2=42.541, p<0.001), and 12-17 years (X^2=63.499, p<0.001). The majority of children with high nutritional risk were malnourished (67.9%, 391 of 576), while a sizeable minority of those at moderate risk were also malnourished (31.3%, 719 of 2,298). The difference in malnutrition prevalence between moderate and high risk groups was statistically significant (X^2=260.168, p<0.001).

Nutritional markers in blood distinguishing nutritional risk groups

Significant differences were found in serum albumin and prealbumin between the high nutritional risk group and the moderate nutritional risk group (p<0.001) (Table 5).

Nutritional support rates

The nutritional support rates for children with high nutritional risk and moderate nutritional risk were only 8.9% (51 of 576) and 3.5% (81 of 2,298), respectively (Table 6). The parenteral nutritional support rate was only 1.3% overall (36 of 2,874), and all such cases used compound amino acid single-dose input. The enteral nutritional support rate was 3.3% (96 of 2,874), and all were cases which administered foods for special medical purposes. The mean length of stay and the cost of hospitalization were both significantly greater in cases with high nutritional risk compared to those with moderate nutritional risk.

DISCUSSION

Nutritional status of children with liver disease

In children, proper nutrition demands not only the basic elements and energy required to maintain homeostasis, but also surplus materials and energy for growth and development. The connective tissue of the liver is still underdeveloped in childhood, and liver cells are immature and vulnerable to infections, drugs, hypoxia, and other insults, which can lead to damage and decreased function.[9] Optimal liver function is critical for the nutritional status of children. Indeed, almost all children with hepatic lesions have some level of malnutrition.[10] In mainland China, the estimated malnutrition rate for hospitalized children is 24.1%,[8] within the range of estimates from Europe (15% to 30%).[11] Thus, nutritional status is strongly dependent on metabolic disruption due to disease, rather than lack of food.

In this study, the prevalence of malnutrition among 2,874 children with liver disease was 38.6%, with 13.4%

Table 3. Etiologies of live disease and effects on nutrition status

Etiological classification	N	Growth retardation n (%)	Low body weight n (%)	Emaciation n (%)	Overweight or obese n (%)
Chronic hepatitis B	1221	159 (13.0)	207 (16.9)	276 (22.6)	0
Chronic hepatitis C	579	123 (21.2)	150 (25.9)	99 (17.1)	0
Non-hepatotropic viral hepatitis	309	63 (20.4)	60 (19.4)	36 (11.6)	0
Hereditary and metabolic liver diseases	285	69 (24.2)	54 (18.9)	48 (16.8)	0
Drug-induced liver injury	102	12 (11.8)	18 (17.6)	30 (29.4)	15 (14.7)
Autoimmune hepatitis	87	15 (17.2)	6 (6.9)	6 (6.9)	9 (10.3)
Non-alcoholic steatohepatitis	63	0	0	0	57 (90.5)
Unknown etiology	228	42 (18.4)	48 (21.0)	51 (22.4)	0
Total	2874	483 (16.8)	543 (18.9)	546 (19.0)	81 (2.8)

Table 4. STRONGkids Nutritional Risk Scores

Score	n (%)	1-2 years	3-5 years	6-11 years	12-17 years
1-3 points	2298 (80.0)	282 (65.7)	567 (80.1)	768 (81.8)	681 (85.3)
4-5 points	576 (20.0)	147 (34.3)	141 (19.9)	171 (18.2)	117 (14.7)

Table 5. Comparison of nutritional markers in blood between moderate and high nutritional risk groups

Nutritional risk	Albumin (g/L)	Prealbumin (mg/L)	Hemoglobin (g/L)
Moderate	37.1±3.8	157±51.2	113±15.1
High	33.5±4.2	111±50.5	112±14.9
Statistical value (T)	-17.123	-17.599	-1.546
p value	<0.001	<0.001	0.122

suffering from moderate to severe malnutrition which was higher than reported in previous domestic and foreign studies. Thus, malnutrition occurs more easily and to a greater degree in children with liver disease. The HAZ is used as a long-term index of nutritional status, as chronic malnutrition causes slowed growth, while the WHZ is used to reflect recent nutritional deprivation manifested as emaciation. Alternatively, the WAZ reflects immediate and long-term nutrition, manifesting as low body weight. In this study, all these rates were higher than in the general Chinese population (growth retardation: 16.8% vs 9%; emaciation: 19.0% vs 1.8%; low body weight: 18.9% vs 3.1%),[12] indicating that children with liver disease exhibit the effects of both long-term and acute malnutrition.

Etiological analysis revealed that hereditary and metabolic liver diseases were associated with the highest growth-retardation rates, while chronic viral hepatitis C was associated with the highest low-weight rate, suggesting that children with hereditary and metabolic liver diseases, and those with chronic viral hepatitis, had the poorest long-term nutritional status. Drug-induced liver injury was associated with the highest emaciation rate; thus, a recent reduction in a child's weight may be associated with a decrease in diet caused by acute liver injury. Conversely, 90.5% of children with non-alcoholic steatohepatitis were overweight or obese, suggesting that non-alcoholic fatty liver disease is the predominant liver presentation of metabolic syndromes, such as hyperglycemia, hypertension, obesity, high triglycerides, and low HDL. The current increases in the rates of overweight and obesity among children have led to higher rates of liver pathology.[13,14]

Nutritional risk assessment of children with liver disease

Malnutrition not only stunts growth but also reduces immunological and important visceral functions, leading to an increased incidence of infection, delayed wound healing, and other disease complications that affect prognosis.[15] There appears to be a frequent deterioration in the nutritional status of hospitalized pediatric patients, and this is even more common in children already malnourished on admission.[16,17] In order to prevent and treat malnutrition, especially the malnutrition and complications associated with hospitalization, it is necessary to identify the risks.[18,19] Nutritional screening on admission can identify children who will most benefit from nutritional interventions or therapy.[7,20]

The ideal nutritional risk screening tool should be simple and quickly administered by busy medical staff. Many nutrition screening tools are available for hospitalized children, each with pros and cons, but there is no widely adopted standard, and those available require further validation and comparison through large sample surveys.[21] This study used STRONGkids to assess the nutritional risk of children with liver disease, a tool with simple clinical application and strong practicability. One-fifth of all cases screened were at high nutrition risk, and the rate of malnutrition was particularly high within this group. High nutritional risk was most common among children under 3 years, likely because their nutritional status is more strongly influenced by external factors.

In order to further clarify the effects of nutritional risk on children with liver disease, we compared the average hospitalization time and hospitalization expenses of children with different nutritional risk levels. Both mean length of time and the cost of hospitalization were greater in the high nutritional risk group, suggesting that high nutritional risk can indeed impede recovery. Alternatively, standardized clinical nutrition management may improve recovery and reduce hospitalization costs.

Serum albumin, prealbumin, and hemoglobin are commonly used to assess nutritional status. The levels of serum albumin and prealbumin were significantly lower in patients with high nutritional risk than in moderate risk patients, indicating that protein status in the high risk group had been poor for some time and that both albumin and prealbumin are sensitive nutritional markers. It is possible that children with high nutritional risk have more serious liver injury, which in turn leads to a decline in protein synthesis, while at the same time, the quantity and quality of dietary proteins decreases due to loss of appetite.

Nutritional support for children with nutritional risk

In this study, only 8.9% of the children with high nutritional risk received nutritional support, despite studies showing that intervention and management of hospitalized children with high nutritional risk improves clinical outcomes.[22,23] Therefore, clinical staff and nutritionists should develop an appropriate medical nutrition therapy plan for all children showing nutritional risk. Appropriate nutritional support can promote the healing of damaged liver tissue, protect liver function, reduce further liver

Table 6. Comparison of nutritional support rates, length of stay, and hospital costs between moderate and high nutritional risk groups

Nutritional risk	Nutritional support (%)	Hospital stays (d)	Hospital costs ($)[†]
Moderate	3.5	9.9±2.5	2495.9±833.3
High	8.9	14.0±2.8	2932.2±746.0
Statistical value	X^2=29.852	Z=-22.600	Z=-9.495
p value	<0.001	<0.001	<0.001

[†]Total cost in US dollars.

damage caused by pathogenic factors, and promote faster recovery.[9] Thus, nutritional intervention for children with liver disease is an important component of comprehensive clinical treatment.

ONS are widely used by patients with chronic diseases. In recent years, enteral nutrition using elemental diets, intact protein-based non-elemental diets, and module diets in the form of ONS has been applied in clinical practice to provide patients with additional energy and nutrients.[24-27] The clinical efficacy of ONS has been confirmed by a large number of studies as indicated by reduced length of hospital stay, medical costs, and risk of readmission within 30 days.[28,29] ONS are particularly beneficial for patients who are malnourished or at risk of malnutrition.[25] As the prevalence of malnutrition is high in children with liver disease, and children with liver disease cannot achieve the desired nutritional intake through their ordinary diet, ONS should be considered to help maintain weight and improve nutritional status.

Most children with liver disease have difficulty digesting fat, therefore, consideration should be given to controlling both total fat intake and the proportion of saturated fatty acids. For these children, a low-fat diet may be most appropriate.[10] Given that medium chain triglycerides (MCTs) can enter mitochondria directly without carnitine, ONS such as Peptamen JUNIOR, Nutren JUNIOR, and Nutren Optimum, containing high MCTs (20% to 60% of the total fat) could prove beneficial by reducing the burden on the liver, thereby promoting recovery of liver function and nutritional status.[30] For children with liver disease, improper protein uptake may also aggravate the disease.[31] Branched chain amino acids (BCAAs) as the main nitrogen source can help reduce the burden on the liver, which is especially beneficial for immature livers.[9,32] However, no complete and balanced nutrition with high BCAAs is available for children in mainland China. Also, for children with hereditary and metabolic liver diseases, like glycogen storage disease and galactosemia, prohibiting or limiting the intake of lactose is an indispensable measure. These children need special formulae to replace milk and milk products. At present, all lactose-free formulae sold in the mainland Chinese market contain a certain amount of lactose and are suitable only for lactose intolerance in children and adults.

Only 96 of the cases in this study used enteral nutrition support, and all for special medical purposes without doctor's advice, which indicates that the clinical nutritional therapy of children with liver disease has yet to be regulated. A large amount of information about pediatric liver injury is now available, but there are few reports on the role of nutritional interventions in comprehensive clinical treatment, and there is a lack of data based on clinical research and evidence-based medicine. Consequently, it is still important to study the effects of pediatric liver disease on nutritional status, strengthen the screening for nutritional risk of hospitalized children, conduct early nutritional interventions, and monitor the nutritional status of children with liver disease.

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AUTHOR DISCLOSURES

The authors declare no conflict of interest.

REFERENCES

1. Fan C, Wu Y, Ding H, Zhang B, Dong P, Zhou L, Ping C, Zhao C. Energy metabolism and substrate oxidation in patients with severe chronic hepatitis B. Chin J Clin Nutr. 2006;14:110-4. doi: 10.3760/cma.j.issn.1674-635X. 2006.02. 010.
2. Jiao G, Jiang Z. Clinical Nutriology. Beijing: People's Medical Publishing House; 2002. p. 282.
3. Chinese Society of Hepatology and Chinese society of infectious diseases, Chinese Medical Association. The guideline of prevention and treatment for chronic hepatitis B. Chin J Infect Dis. 2005;23:421-31.
4. Ghany MG, Strader DB, Thomas DL, Seeff LB; American Association for the Study of Liver Diseases. Diagnosis, management, and treatment of hepatitis C: an update. Hepatology. 2009;49:1335-74. doi: 10.1002/hep.22759.
5. Lok AS, McMahon BJ. Chronic hepatitis B: update 2009. Hepatology. 2009;50:661-2. doi: 10.1002/hep.23190.
6. Hutst JM, Zwart H, Hop WC, Joosten KF. Dutch national survey to test the STRONGkids nutritional risk screening tool in hospitalized children. Clin Nutr. 2010;29:106-11. doi: 10.1016/j.clnu.2009.07.006.
7. Pediatric Collaborative Group, Society of Parenter and Enteral Nutrition, Chinese Medical Association. Guidelines for clinical application of parenteral and enteral nutrition support in pediatric patients in China. Chin J Pediatr. 2010; 48:436-41. doi: 10.3760/cma.j.issn.0578- 1310.2010.06.008.
8. Tao Y, Xu Y, Tang Q, Wu J, Cai W. Nutrition assessment in hospitalized children. Chin J Clin Nutr. 2007;15:214-7. doi: 10.3760/cma.j.issn.1674-635X.2007.04.004.
9. Yang J, Tian X, Chen Y, Xu Z, Zhao W, Lin Y. Effect of liver disease special-purpose enteral nutrition preparation on protein metabolism and liver function in children with liver injury. J Appl Clin Pediatr. 2008;23:1518-9, 1550. doi: 10. 3969/j.issn. 1003-515X.2008.19.016.
10. Lu Z. Nutritional support of liver and renal inadequacy in children. Chin Pediatr Emerg Med. 2006;13:103-5. doi: 10. 3760/cma.j.issn.1673-4912. 2006.02.003.
11. Shang E, Hasenberg T, Schlegel B, Sterchi AB, Schindler K, Druml W, Koletzko B, Meier R. An European survey of structure and organization of nutrition support teams in Germany, Austria and Switzerland. Clin Nutr. 2005;24: 1005-13. doi: 10.1016/j.clnu.2005.07.005.
12. Wang L. Investigation report on nutrition and health status of Chinese residents. Beijing: People's Medical Publishing House; 2004. pp. 37-9.
13. MA G. A survey on nutrition and health status of school aged children in China. Beijing: Chinese People Publishing House; 2006. p. 5.
14. Zhao W, Zhai Y, Hu J, Wang J, Yang Z, Kong L, Chen C. Economic burden of obesity related chronic diseases in China. Chin J Epidemiol. 2006;27:555-9. doi: 10.3760/j.issn: 0254-6450. 2006.07.002.
15. Sun Z, Hu R, Wan J. Clinical application of Nutritional Risk Screening 2002. Chin J Clin Nutr. 2009;17:332-4. doi: 10. 3760/cma.j.issn.1674-635X. 2009.06.004.
16. Li R, Peng L, Zhao W, Chen Y, Liu C, Qi J, Ding J, Mo X, Li X. Screening for nutritional risk in hospitalized children with congenital heart disease. Chin J Pediatr Surg. 2013; 34:101-4. doi: 10.3760/cma.j.issn.0253-3006.2013.02.006.
17. Hartman C, Shamir R, Hecht C, Koletzko B. Malnutrition screening tools for hospitalized children. Curr Opin Clin Nutr Metab Care. 2012;15:303-9. doi: 10.1097/MCO.0b013 e328352dcd4.

18. Beck AM, Balknäs UN, Camilo ME, Fürst P, Gentile MG, Hasunen K et al. Practices in relation to nutritional care and support-report from the Council of Europe. Clin Nutr. 2002; 21:351-4.
19. Kondrup J, Allison SP, Elia M, Vellas B, Plauth M; Educational and Clinical Practice Committee, European Society of Parenteral and Enteral Nutrition (ESPEN). ESPEN guidelines for nutrition screening 2002. Clin Nutr. 2003;22:415-21. doi: 10.1016/S0261-5614(03)00098-0.
20. Agostoni C, Axelson I, Colomb V, Goulet O, Koletzko B, Michaelsen KF et al. The need for nutrition support teams in pediatric units: a commentary by the ESPGHAN committee on nutrition. J Pediatr Gastroenterol Nutr. 2005;41:8-11.
21. Liu P, Zhan X. Introduction of nutritional risk screening tools for hospitalized children. J Pediatr Pharm. 2013;19:48-50. doi: 10.13407/j.cnki.jpp.1672-108x.2013.12.001.
22. Xie Q, Hong L, Lin Y, Chen Z, Xie L. Investigations on nutritional status and nutritional risk in hospitalized pediatric patients. J Clin Pediatr. 2013;31:748-51. doi: 10.3969/j.issn.1000-3606.2013.08.013.
23. Peng L. Research status of nutritional risk screening and nutrition therapy for hospitalized children. Chin J Evid Based Pediatr. 2012;7:155-9. doi: 10.3969/j.issn.1673-5501.2012.02.016.
24. Smedley F, Bowling T, James M, Stokes E, Goodger C, O'Connor O, Oldale C, Jones P, Silk D. Randomized clinical trial of the effects of preoperative and postoperative oral nutritional supplements on clinical course and cost of care. Br J Surg. 2004;91:983-90. doi: 10.1002/bjs.4578.
25. Baldwin C, Spiro A, Ahern R, Emery PW. Oral nutritional interventions in malnourished patients with cancer: a systematic review and meta-analysis. J Natl Cancer Inst. 2012;104:371-85. doi: 10.1093/jnci/djr556.
26. Arends J, Bodoky G, Bozzetti F, Fearon K, Muscaritoli M, Selga G et al. ESPEN guidelines on enteral nutrition: non-surgical oncology. Clin Nutr. 2006;25:245-59. doi: 10.1016/j.clnu.2006.01.020.
27. Jiang Z. Clinical treatment guidelines: Parenteral and enteral nutrition (2008 Edition). Beijing: People's Medical Publishing House; 2009.
28. van der Meij BS, van Bokhorst-de van der Schueren MA, Langius JA, Brouwer IA, van Leeuwen PA. n-3 PUFAs in cancer, surgery, and critical care: a systematic review on clinical effects, incorporation, and washout of oral or enteral compared with parenteral supplementation. Am J Clin Nutr. 2011;94:1248-65. doi: 10.3945/ajcn.110.007377.
29. Philipson TJ, Snider JT, Lakdawalla DN, Stryckman B, Goldman DP. Impact of oral nutritional supplementation on hospital outcomes. Am J Manag Care. 2013;19:121-8.
30. Kong Y, Peng S, Han L, Lu Y. Enteral nutritional intervention in pediatric patients with acute liver failure. Med J Chin PAPF. 2013;24:761-3. doi: 10.3969/j.issn.1004-3594.2013.09.008.
31. Heyman JK, Whitfield CJ, Brock KE, McCaughan GW, Donaghy AJ. Dietary protein intakes in patients with hepatic encephalopathy and cirrhosis: current practice in NSW and ACT. Med J Aust. 2006;185:542-3.
32. Dejong CH, van de Poll MC, Soeters PB, Jalan R, Olde Damink SW. Aromatic amino acid metabolism during liver failure. J Nutr. 2007;137:1579S-85S; discussion 1597S-8S.