Original Article
Clin Nutr Res 2012;1:3-12
http://dx.doi.org/10.7762/cnr.2012.1.1.3
pISSN 2287-3732 · eISSN 2287-3740

cnr
CLINICAL NUTRITION RESEARCH

Nutritional Intake and Nutritional Status by the Type of Hematopoietic Stem Cell Transplantation

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The aim of this study was to investigate the changes of nutritional intake and nutritional status and analyze the association between them during hematopoietic stem cell transplantation. This was a retrospective cross sectional study on 36 patients (9 Autologous transplantation group and 27 Allogeneic transplantation group) undergoing hematopoietic stem cell transplantation at The Catholic University of Korea, Seoul St. Mary's Hospital from May to August 2010. To assess oral intake and parenteral nutrition intake, 24-hour recall method and patient's charts review was performed. Nutritional status was measured with the scored patient-generated subjective global assessment (PG-SGA). The subjects consisted of 6 (66.7%) males and 3 (33.3%) females in the autologous transplantation group (auto), 12 (44.4%) males and 15 (55.6%) females in the allogeneic transplantation group (allo). The mean age was 40.9 ± 13.6 years (auto) and 37.8 ± 11.0 years (allo). The average hospitalized period was 25.2 ± 3.5 days (auto) and 31.6 ± 6.6 days (allo), which were significant different ($p < 0.05$). Nutritional intake was lowest at Post+1wk in two groups. In addition, calorie intake by oral diet to recommended intake at Post+2wk was low (20.8% auto and 20.5% allo) but there were no significant differences in change of nutritional intake over time (Admission, Pre-1day, Post+1wk, Post+2wk) between auto group and allo group by repeated measures ANOVA test. The result of nutritional assessment through PG-SGA was significantly different at Pre-1day only ($p < 0.01$). There was a significant negative correlation between the nutritional status during Post+2wk and the oral calorie/protein intake to recommended amount measured during Post+1wk and Post+2wk ($p < 0.01$). These results could be used to establish evidence-based nutritional care guidelines for patients during hematopoietic stem cell transplantation.

Key Words: Diet, Hematopoietic stem cell transplantation, Leukemia, Nutritional status

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Received June 1, 2012
Revised June 25, 2012
Accepted June 26, 2012

Introduction

As the method for correcting bone marrow disorder by injecting normal hematopoietic stem cell after complete destroy of bone marrow with bone marrow suppression, malignant disease or genetic disorder, stem cell transplantation is the treatment method that is currently recognized as the only alternative for completely curing various blood diseases [1,2]. However, complications accompanied during the treatment process serve as factors that disrupt successful hematopoietic stem cell transplantation and reduce long-term survival results. Transplantation-related complications largely include toxicity associated with conditioning regimen, toxicity caused by preventive drugs during the transplantation process, complications caused by immunity failure and graft-versus-host disease (GVHD), which integrates immunological side effects

of the allogeneic hematopoietic stem cell transplantation [2]. In particular, as a majority of symptoms accompanied with the complications act as factors that hinder nutritional intake, studies related with nutritional intake, support and malnutrition have been continuously carried out in addition to efforts exerted to minimize complications related with hematopoietic stem cell transplantation [3].

The conditioning regimen composed of high-dose chemotherapy or total body irradiation (TBI) triggers various side effects that disturb nutritional intake, such as stomatitis, nausea, vomiting, loss of appetite and diarrhea [4]. Various studies report that nutritional intake and nutritional status are significantly reduced during the hematopoietic stem cell transplantation period [5], which not only postpones the period of engraftment [6], but also causes GVHD, veno-occlusive disease (VOD) and hospitalization in the ICU [7,8]. Malnutrition is also triggered by other metabolic effects according to cancer diagnosis, such as cachexia, in addition to the reduction of nutritional intake caused by various therapeutic side effects. Malnutrition is generally reported to be experienced among 40-80% of cancer patients [9,10], and various research results have reported malnutrition as the main factor that increases the infection rate, morbidity, mortality, length of hospital stay and medical cost of cancer patients [10-15]. Research results also show that malnutrition increases the length of hospital stay and the risk of early death for hematopoietic stem cell transplantation patients, and presents a correlation between poor prognosis and severe GVHD [8,16-18].

In this regard, although various studies emphasize the importance of evaluating nutritional status, monitoring appropriate nutritional intake and the providing nutritional support for hematopoietic stem cell transplantation patients, accurate guidelines for nutritional support remain unestablished [19,20]. By surveying the short-term nutritional status of 34 child transplantation patients, results showed a significant correlation between nutritional intake and nutritional status [21], presented that the nutritional status was more satisfactory in the group that received appropriate nutritional support and proposed that positive effect was presented in lean body mass. However, the results of various studies indicate that more efforts must be made in various aspects, such as the development of indicators for nutritional support [3,22-24].

On the other hand, research results have indicated that the engraftment period of hematopoietic stem cell transplantation patients can differ according to the type of transplantation [25,26], that high oral intake was generally presented in the early engraftment group with short engraftment period [6] and that the nutritional status during transplantation can become an important factor for determining the period of engraftment [27]. Therefore the type of hematopoietic stem cell transplantation can serve as an important variable in researching the nutritional intake and nutritional status of hematopoietic stem cell transplantation patients.

Hereupon, this study investigated changes in nutritional intake and nutritional status during the transplantation period in consideration of the type of hematopoietic stem cell transplantation and analyzed the correlation to provide evidence for establishing nutrition care guidelines of hematopoietic stem cell transplantation patients.

Materials and Methods

Subjects

This study surveyed 36 out of 62 hematologic cancer patients hospitalized at the hematopoietic stem cell transplantation ward of The Catholic University of Korea, Seoul St. Mary's Hospital from May 14 to August 13, 2010. This study excluded 26 patients who refused interviews, were in poor condition to be interviewed, were transferred to the ICU during the research period or were discharged within 2 weeks after the transplantation. As the study used food intake survey data and nutritional assessment results, this study was approved by the Catholic Medical Center IRB for its exemption of subject consent.

Survey content and method

This study is a cross-sectional study that analyzed changes in nutritional intake and nutritional status in the transplantation process and the relationship between nutritional intake and nutritional status according to the hematopoietic stem cell transplantation method. After observing medical records to collect data on the patients' gender, age, diagnosis, hematopoietic stem cell transplantation method, period of engraftment and length of hospital stay, this study analyzed the nutritional intake and nutritional status of patients during hospitalization (Admission), the day before the hematopoietic stem cell transplantation (Pre-1day), 1 week after transplantation (Post+1wk) and 2 weeks after transplantation (Post+2wk) according to the hematopoietic stem cell transplantation method.

http://dx.doi.org/10.7762/cnr.2012.1.1.3

Assessment of nutritional intake

Food intake survey

The 24-hour recall method was used for the food intake survey. To increase the accuracy of the food intake survey, interviews were carried out by certified clinical dietitian. This study developed and used a structured food intake questionnaire and a simple food model to minimize quantitative error in data collection between surveyors. By considering the fact that a restricted number of food types are ingested by patients during hospital stay, this study calculated calorie and protein intake by using Food Exchange System. The recommended nutritional intake can be decided by using various methods. This study used the intermediate value of the recommended intake before and after the transplantation. Calorie and protein were calculated as 30 kcal/kg and 1.1 g/kg, respectively, and the calculated figures were used in the analyses [28].

Parenteral nutrition supply

This study applied the total number of days for providing parenteral nutrition during hospital stay, the type of parenteral nutrition formula and the injection speed to reflect the calculated results.

Hematopoietic stem cell transplantation method

The hematopoietic stem cell transplantation method is decided according to the relationship between the patient and the donor, the source of stem cell, the degree of corresponding with human leukocyte antigen (HLA) and the intensity of conditioning regimen. This study classified subjects into autologous transplantation and allogeneic transplantation according to the patient-donor relationship to compare nutritional intake and nutritional status. The source of stem cell was analyzed by applying basic variables.

Assessment of nutritional status

Although there are various methods that can be used to evaluate nutritional status, this study used the scored patient-generated subjective global assessment (PG-SGA) method, which has been certified by the American Dietetic Association as a method for evaluating the nutritional status of cancer patients and validated in various studies [29,30]. Certified clinical dietitian evaluated changes in weight, changes in food intake, abnormal stomach symptoms and symptoms disturbing oral intake, activities and function, physical examination. The results of each item were divided according to nutrition classification standards presented in PG-SGA (well-nourished, moderately malnourished, severely malnourished) and the most frequent results were used to determine the final nutritional status. PG-SGA scores were also used in analysis to accurately reflect changes in the overall nutritional status.

Statistical analysis

SPSS 12.0K for windows package was used to analyze data. To compare variables. Student t-test, Pearson's chi-square test, Fisher's exact test and Likelihood ratio test were used according to variable. Changes in nutritional intake presented during hospital stay were analyzed through the repeated measures ANOVA test, and the correlation between the nutritional status, oral intake, parenteral nutrition intake through the correlation analysis. The significance test was implemented at $p < 0.05$.

Results

Comparison of general characteristics

Among the 36 research subjects, 9 patients received autologous transplantation whereas 27 received allogeneic transplantation. The two groups were classified according to the type of hematopoietic stem cell transplantation. The results gained from surveying general characteristics are presented in Table 1. The gender ratios of research participants were 66.7% men and 33.3% women. The allogeneic transplantation group was composed of 44.4% men and 55.6% women. The average age was presented as 38.5 and significant difference was not presented between the autologous transplantation group and the allogeneic transplantation group. The ratio of acute myeloid leukemia patients accounted for 36.1%, whereas the ratio of other patients, such as multiple myeloma and severe aplastic anemia (SAA) accounted for 50.0%. The variables that did present significant difference between groups were as follows: source of stem cell, period of engraftment, length of hospital stay and total number of days on total parenteral nutrition (TPN). Peripheral stem cell transplantation accounted for 100.0% of autologous transplantation, whereas bone marrow transplant and peripheral stem cell transplant were surveyed to account for 59.3% and 40.7% of allogeneic transplantation, respectively. The period of engraftment and length of hospital stay were significantly longer in the allogeneic transplantation group and significant differences were found in the TPN supply period.

Table 1. General characteristics of subjects by the type of hematopoietic stem cell transplantation*

Variable	All patients (n = 36)	Auto† (n = 9)	Allo‡ (n = 27)
Gender, n (%)			
Male	18 (50)	6 (66.7)	12 (44.4)
Female	18 (50)	3 (33.3)	15 (55.6)
Age, yr	38.5 ± 11.6	40.9 ± 13.6	37.8 ± 11.0
Diagnosis, n (%)			
Acute myeloid leukemia	13 (36.1)	3 (33.3)	10 (37.0)
Acute lymphoid leukemia	5 (13.9)	0 (0.0)	5 (18.5)
Others	18 (50.0)	6 (66.7)	12 (44.4)
Source of stem cell, n (%)§,¶			
Bone marrow	16 (44.4)	0 (0.0)	16 (59.3)
Peripheral stem cell	20 (55.6)	9 (100.0)	11 (40.7)
Engraftment period, day‖,**		10.7 ± 1.2	13.3 ± 3.4
Hospitalized period, day**		25.2 ± 3.5	31.6 ± 6.6
Recommended energy intake, kcal		1,819.9 ± 330.1	1,742.0 ± 241.1
Recommended protein intake, g		66.7 ± 12.1	63.9 ± 8.8
Number of days on TPN**		9.3 ± 3.7	14.7 ± 7.5

TPN: total parenteral nutrition.
*Values are presented as mean ± SD unless otherwise indicated; †Autologous transplantation group; ‡Allogeneic transplantation group; §Significantly different between autologous transplantation group and allogeneic transplantation group by Pearson's chi-square test; ‖Significantly different between autologous transplantation group and allogeneic transplantation group by Student t-test; ¶$p < 0.01$; **$p < 0.05$.

Changes in nutritional intake

Table 2 presents the results gained from analyzing the changes in nutritional intake during the hematopoietic stem cell transplantation period according to 4 stages: hospitalization (Admission), the day before the hematopoietic stem cell transplantation (Pre-1day), 1 week after transplantation (Post+1wk) and 2 weeks after transplantation (Post+2wk). The oral intake of calorie and protein, which was rapidly decreased from Pre-1day, presented the lowest intake during Post+1wk in both groups. During Post+2wk, the amount of calories ingested fell 20.8% and 20.5% below the recommended amount in the autologous transplantation group and the allogeneic transplantation group, respectively. Also, the amount of protein ingested fell 10.3% and 12.6% below the recommended amount in the autologous transplantation group and the allogeneic transplantation group, respectively. After correcting the effect of time changes, significant changes in overall nutritional intake by the transplantation method disappeared. However, the % of recommended daily oral calorie and protein intake and the % of recommended daily oral calorie and protein intake were significantly high in the autologous transplantation group during Pre-1day. The allogeneic transplantation group presented a significantly high level of total oral protein intake and % of recommended daily oral protein intake during Post+1wk. The daily protein intake, including parenteral nutrition support, was also significantly higher in the allogeneic transplantation group. Significant differences were not present during Post+2wk between the two groups for overall nutritional intake.

Changes in nutritional status

Table 3 presents the results gained from analyzing the nutritional status according to control group during the hematopoietic stem cell transplantation period. Although the autologous transplantation group and the allogeneic transplantation group presented weight loss of 5.1% and 3.7%, respectively, during the hematopoietic stem cell transplantation period, no significant difference was present between the two groups in relation to ideal body weight and weight reduction ratio. The results of nutritional assessment conducted through PG-SGA during Pre-1day presented significant differences compared to the control group and the autologous transplantation group presented significantly higher PG-SGA score during Post+1wk.

http://dx.doi.org/10.7762/cnr.2012.1.1.3

Table 2. Change of nutritional intake by the type of hematopoietic stem cell transplantation (n = 36)*

		N	Admission	Pre-1day	Post+1wk	Post+2wk	F	p‖
Calorie intake by oral diet, kcal	Auto†	9	1,770.3 ± 323.2	1,000.6 ± 538.6§,††	80.6 ± 195.1	372.8 ± 256.9	2.303	0.138
	Allo‡	27	1,650.5 ± 519.5	378.9 ± 500.0	249.9 ± 316.8	342.1 ± 352.8		
Protein intake by oral diet, g	Auto	9	66.0 ± 11.2	28.1 ± 21.2††	1.5 ± 4.1††	7.2 ± 7.3	1.109	0.300
	Allo	27	60.8 ± 25.7	10.6 ± 17.1	6.7 ± 10.3	7.5 ± 11.1		
% calorie intake by oral diet¶	Auto	9	98.2 ± 14.0	58.2 ± 34.5††	4.6 ± 11.3	20.8 ± 13.5	1.247	0.272
	Allo	27	95.3 ± 30.0	22.5 ± 30.9	15.2 ± 20.2	20.5 ± 21.4		
% protein intake by oral diet	Auto	9	100.8 ± 20.1	45.2 ± 37.5††	2.4 ± 6.6††	10.3 ± 9.5	0.672	0.418
	Allo	27	95.3 ± 39.1	40.3 ± 29.7	11.0 ± 17.6	12.6 ± 18.8		
% calorie intake by oral	Auto	9	98.2 ± 13.9	64.7 ± 42.2	47.7 ± 27.6	55.1 ± 26.8	0.181	0.674
diet and TPN**	Allo	27	97.4 ± 28.2	40.3 ± 30.0	60.2 ± 21.8	55.8 ± 30.1		
% protein intake by oral	Auto	9	100.8 ± 20.1	45.2 ± 37.5	41.7 ± 25.7	41.5 ± 21.7	1.965	0.170
diet and TPN	Allo	27	98.4 ± 36.4	39.7 ± 32.7	72.0 ± 23.6††	60.3 ± 36.8		

TPN: total parenteral nutrition.
*Values are presented as mean ± SD; †Autologous transplantation group; ‡Allogeneic transplantation group; §Significantly different between autologous transplantation group and allogeneic transplantation group by Student t-test; ‖Significance determined by repeated measures ANOVA between-subject's effects; ¶Calorie intake by oral diet divided by recommended intake; **Calorie intake by oral diet and TPN divided by recommended intake; ††$p < 0.01$; †$p < 0.05$.

Table 3. Change of nutritional status by the type of hematopoietic stem cell transplantation (n = 36)*

		N	Admission	Pre-1day	Post+1wk	Post+2wk	F	p¶
PIBW, %†	Auto§	9	115.3 ± 18.9	114.0 ± 18.6	109.5 ± 18.8	109.5 ± 18.8	1.130	0.295
	Allo‖	27	108.4 ± 13.2	107.6 ± 12.5	104.7 ± 12.2	104.3 ± 12.3		
Weight loss, %‡	Auto	9	-	1.0 ± 2.6	5.1 ± 3.0	5.1 ± 2.8	1.384	0.248
	Allo	27	-	0.6 ± 2.8	2.3 ± 2.6	3.7 ± 3.4		
PG-SGA score	Auto	9	2.44 ± 3.3	11.0 ± 4.6	21.0 ± 5.6§§	17.7 ± 4.0	0.843	0.365
	Allo	27	3.5 ± 4.0	12.8 ± 4.1	16.1 ± 4.0	16.1 ± 3.8		
PG-SGA assessment, N (%)								
	Auto	N**	9 (100.0)	6 (66.7)††	0 (0.0)	1 (11.1)		
		M††	26 (96.3)	4 (14.8)	1 (3.7)	2 (7.4)		
	Allo	N	0 (0.0)	3 (33.3)	9 (100.0)	8 (88.9)		
		M	1 (3.7)	23 (85.2)	26 (96.3)	25 (92.6)		

*Values are presented as mean ± SD unless otherwise indicated; †Percentage ideal body weight; ‡Percentage weight loss compare with admission weight; §Autologous transplantation group; ‖Allogeneic transplantation group; ¶Significance determined by repeated measure ANOVA between-subject's effects; **Well-nourished status; ††Malnourished status; ††Significance determined by Fisher's exact test, $p < 0.01$; §§Significantly different between autologous transplantation group and allogeneic transplantation group by student t-test, $p < 0.05$.

Correlation between nutritional status and oral intake

The correlation analysis conducted to investigate the relationship between the nutritional status during Post+2wk and nutritional intake presented a negative correlation with the % recommended daily oral calorie and protein intake measured during Post+1wk and Post+2wk (Table 4).

Correlation between oral intake and nutritional support

To investigate whether appropriate nutritional support was achieved according to the decrease in oral intake, this study analyzed the correlation between oral intake and nutritional support from Pre-1day to Post+2wk, the period in which the oral intake is rapidly reduced. The results are as presented in Table 5. Significantly negative correlation between calorie and protein intake from oral diet and TPN supply during Pre-1day and Post+1wk, however, no significant difference was found during post+2wk period.

Discussion

This study analyzed the nutritional intake and nutritional status by classifying subjects into groups according to the hematopoietic stem cell transplantation method. Compared with allogeneic transplantation, autologous transplantation generally presented a shorter length of hospital stay and engraftment period as well as a relatively favorable condition during hospital stay. Furthermore, As the source of stem cell can serve as factors that influence the period of engraftment, this study also surveyed bone marrow transplant and peripheral blood stem cell transplant [25,26]. Analysis results showed that among 36 patients, 9 received autologous transplantation whereas 27 received allogeneic transplantation. The ratio of patients that received peripheral blood stem cell transplant accounted for 100% of the autologous transplantation group and 40.7% of the allogeneic transplantation group, showing a significant difference. The period of engraftment was nearly 3 days longer in the allogeneic transplantation group when compared with the autologous transplantation group. This is stipulated to be related with the source of stem cell when considering the research results that reported the correlation between the collect rate of hematopoietic stem cells and early engraftment [25,26]. The allogeneic transplantation group presented a significantly longer period of receiving nutritional support due to the decline in oral intake. The autologous transplantation group received nutritional support for 9.3 days on average, thus analyzed to receive nutritional support for a shorter period than the 17.5 days presented in the study conducted by Roberts et al. [22], who studied breast cancer patients receiving autologous hematopoietic stem cell transplantation. On the other hand, the result presented in this study is similar to the 9 days reported in the study conducted on acute myeloid leukemia patients receiving hematopoietic stem cell transplantation [19]. The average period of engraftment was 10.7 days in autologous transplantation and 13.3 days in allogeneic transplantation, which are shorter than the 16.5 days presented in a study conducted on acute myeloid leukemia patients that received allogeneic transplantation [27]. A study conducted on 416 hematopoietic stem cell transplantation patients randomly established the early engraftment group as subjects below the 50 percentile. Results showed that the period of engraftment was longer than 11.2 days in the early engraftment group and shorter than 15.6 days in subjects above the 50 percentile [6]. This result is stipulated to be produced by the different classification standards for research subjects and control groups. The results gained from the study conducted by Kim et al. [6] presented high oral intake in the early engraftment group. Although Kim et al. [6] analyzed the days of vomiting and stomatitis, factors hindering oral intake, as variables for explaining the period of engraftment, the present

Table 4. Correlation coefficients between PG-SGA score (D+2wk) and nutritional intake (n = 36)

Oral diet intake	Stage	PG-SGA score (D+2wk)	p value*
% calorie intake by oral diet†	Post 1wk	-0.461	0.005
	Post 2wk	-0.641	0.000
% protein intake by oral diet	Post 1wk	-0.495	0.002
	Post 2wk	-0.553	0.000

*Significance determined by Pearson correlation analysis; †Calorie intake by oral diet divided by recommended intake.

Table 5. Correlation coefficients between oral intake and parenteral nutrition intake (n = 36)

Oral diet intake	Stage	TPN calorie	TPN protein	TPN calorie	TPN protein	TPN calorie	TPN protein
		Pre-1day		Post+1wk		Post+2wk	
Calorie intake by oral diet	Pre-1day	-0.356*†	-0.422†				
Protein intake by oral diet		-0.336†	-0.375†				
Calorie intake by oral diet	Post+1wk			-0.383†	-0.292		
Protein intake by oral diet				-0.442†	-0.375†		
Calorie intake by oral diet	Post+2wk					-0.292	-0.311
Protein intake by oral diet						-0.203	-0.110

*Significance determined by Pearson correlation analysis; †$p < 0.05$; ‡$p < 0.001$.

http://dx.doi.org/10.7762/cnr.2012.1.1.3

study did not show significant results between the period of engraftment and nutritional intake. This can be assumed to be related with fact that the outcome of the bone marrow transplant is influenced by various factors, such as disease, age, medical history, condition of disease during transplantation, HLA-correspondence, conditions of donor and GVHD [2,19]. In this regard, in order to provide efficient nutritional care for patients, it is important to analyze factors that can influence nutritional intake and nutritional status and develop a protocol based on the analysis results, rather than approaching the issue simply based on the transplant method.

The main factor that disrupts oral intake during the hematopoietic stem cell transplantation period is side effects produced by conditioning regimen. As the oral intake is generally reduced by such side effects for 1-2 weeks during the transplantation period, it is common to receive nutritional support. In this regard, many studies are conducted in relation to this issue [22,23,31], but accurate guidelines have not been provided. The study conducted by Arfons & Lazarus [24], who evaluated the necessity of parenteral nutrition support by analyzing the period of engraftment, infection rate, survival rate and length of hospital stay of hematopoietic stem cell transplantation patients, proposes that it is essential to consider the use of parenteral nutrition support for patients that are unable to ingest orally. The study conducted by Iestra et al. [19] reports that TPN is not required by all patients and concludes that support must be provided through appropriate assessment of nutritional status and oral intake monitoring at the beginning of treatment. However, it is difficult to find accurate guidelines in relation to this matter. Hereupon, this study judged that it is essential to accurately assess the nutritional intake of hematopoietic stem cell transplantation patients in order to provide appropriate nutritional support and thus evaluated the appropriateness of nutritional intake during the hematopoietic stem cell transplantation period. The nutritional intake was largely classified into oral intake, oral intake to recommended amount and nutritional intake including TPN to recommended amount. In both groups, the nutritional intake was gradually decreased from Pre-1day and reached the lowest value during Post+1wk. The oral calorie intake to recommended amount was presented as 4.6% and 15.2% in the autologous transplantation group and allogeneic transplantation group, respectively. Furthermore, it was analyzed that both groups presented nutritional intake that fell below the recommended amount by 47.7% and 60.2%, respectively, even when considering TPN. This is similar to the results presented by Hadjibabaie et al. [32], who evaluated the nutritional status of 50 hematopoietic stem cell transplantation patients and reported that the lowest intake quantity was measured as 51% of the recommended amount and was shown on the 10th day after transplantation. Another study conducted on hematopoietic stem cell transplantation patients reported that the early engraftment group presenting relatively satisfactory intake quantity ingested 1,555.0 mL during admission, 1,053.2 mL during Pre-1day, 765.7 mL during Post+1wk and 893.3 mL during Post+2wk, which is generally higher than the intake quantity of this study [6]. This result is judged to be produced from the difference generated by analyzing food intake in volume and in accurate calories [6]. Nutritional intake was very low in hematopoietic stem cell transplantation even when compared with solid cancer patients that are mainly treated through chemotherapy due to the high-intensity conditioning regimen composed of the high-dose chemotherapy and total body irradiation. The study conducted by Kim et al. [33], who studied solid cancer patients receiving chemotherapy, presented that the average calorie intake as 1,476 kcal/d, 47.8 g/d, which is higher than those measured in this study. The study conducted by Yang & Lee [34] showed that the intake quantity decreased from 1,450.48 cc/d to 1,120.52 cc/d, thus presenting a smaller decrease than hematopoietic stem cell transplantation patients. The study conducted by Yang et al. [35], who researched gastric cancer patients, presented that the nutritional intake was decreased from 863.12 kcal to 802.63 kcal during the chemotherapy period. In particular, it is important to note that both control groups presented 20% of oral calorie intake to recommended amount during Post+2wk. Also, it is most essential to increase the oral intake to the recommended level as quickly as possible before discharge. This is related with the fact that various studies have reported that nutritional intake and nutritional status can decrease even after discharge due to factors such as chronic graft-versus-host disease and changes in palate, thus influencing the survival rate after transplantation. Also, there are no effective alternatives related with recovery and increased oral intake after receiving hematopoietic stem cell transplantation. In the retrospective study conducted by Barker et al. [7], most of the 132 hematopoietic stem cell transplantation patients complained of stomach-related side effects, such as stomatitis, vomiting, abdominal pain and diarrhea, even after being discharged. These side effects are presented as the main factors that

increase GVHD, vein occlusion syndrome, ICU hospitalization rate and the death rate within 100 days after transplantation. The study conducted by Iestra et al. [36] evaluated nutrition-related physical symptoms and compliance with recommended intake level 50, 75, 125, 200, 350 days after transplantation. Results showed that 66% of patients experienced meal intake disorders 50 days after transplantation. The main factors were analyzed as nausea, drying of mouth, changes in palate and fatigue. Studies focused on palate changes presented that patients experienced palate changes related with sweet and salty tastes according to the assessment of palate and salivation rate of 3 groups: 150 days after hematopoietic stem cell transplantation (n = 20), 151-1,095 days after hematopoietic stem cell transplantation (n = 20) and more than 1,095 days after hematopoietic stem cell transplantation (n = 21). As the symptoms are reported to last more than 3 years after receiving transplantation, it can be viewed as a long-term problem [37]. The cohort study conducted by Epstein et al. on patients that received hematopoietic stem cell transplantation (day 90-100 post HCT) also proposes that subjects experienced various oral complications that can also affect their quality of life [38]. Thus, although this study focused on nutritional intake during the hematopoietic stem cell transplantation period, results showed that it is more important to find post-discharge nutritional care methods that can increase the overall transplant success rate.

On the other hand, although this study predicted that different nutritional intake will be presented in autologous transplantation and allogeneic transplantation groups, no significant difference was shown in the changes of nutritional intake according to the transplantation period. Although the autologous transplantation group presented a significantly favorable level of oral intake during Pre-1day, the allogeneic transplantation group presented a relatively higher level of oral calorie intake and significantly higher level of oral protein intake during Post+1wk. The effect of intensity of conditioning regimen can be considered according to the source of stem cell [25,26]. Nutritional care considering stomach-related side effects according to the intensity of conditioning regimen is required based on the research results that analyzed the symptoms disturbing oral intake, such as vomiting and stomatitis, as significant factors that influence early engraftment [6]. Furthermore, by comparing the transplantation progress of the TPN group and oral intake group among autologous hematopoietic stem cell transplantation patients, the TPN group was shown to ingest 1,494 kcal/d, 60 g protein/d whereas the oral intake group ingested 951 kcal/d, 36 g protein/d on average. The weight and body measurement indicators were favorably maintained in the TPN group. Nutritional care plan focused on the regulation of nutritional support quantity according to period can be viewed efficient when considering the fact that the provision of TPN to patients must be considered for patients suffering from nutritional deficit due to transplantation, patients experiencing complications after the transplantation and patients that have reduced oral intake for a long period [22].

During the hematopoietic stem cell transplantation period, the autologous transplantation group presented 5.1% weight loss whereas the allogeneic transplantation group presented 3.7% weight loss, thus presenting similar results with the 3.5% weight loss reported in the study carried out on allogeneic transplantation patients [27]. The decrease rate was lower than the 5.6% reported in the study conducted by Iestra et al. [19] on acute myeloid leukemia patients that received hematopoietic stem cell transplantation. Appropriate nutritional support complying with the recommended oral intake is required when considering the fact that weight loss is a representative indicator that presents nutritional status and the fact that the period of engraftment is delayed by excessive weight loss and deficit of albumin and protein [27,32]. Although significant difference in weight changes was not presented, the PG-SGA score, as the nutritional assessment results presenting food intake, symptoms disturbing oral intake, activity and function, showed that the autologous transplantation group presented significantly poor nutritional status during Post+1wk. On the other hand, the results of PG-SGA assessment presented that the ratio of patients with poor nutritional status was significantly high in the allogeneic transplantation group during Pre-1day. Furthermore, although there was only 1 malnourished patient (3.7%) when the patients were admitted, 35 patients (97.2%) were malnourished during Post+1wk. The study conducted by Horsely et al. [16], who analyzed the nutritional condition of 66 patients before transplantation through PG-SGA, presented that 27% of patients with favorable nutritional status showed a rapid deterioration in nutritional status after transplantation. This corresponds with the results of various studies that during the hematopoietic stem cell transplantation period, subjects not only lose body tissue due to catabolic metabolism, but also present rapid decrease in nutritional status due to reduced oral intake [5,6,32,39]. On the other hand,

http://dx.doi.org/10.7762/cnr.2012.1.1.3

the severity of malnutrition is indisputable [40] as it can lead to weight loss, reduced nutritional status due to chronic GVHD and changes in palate, which in turn reduces the quality of life [39] and increases death rate [17,18]. The study conducted by Jacobsohn et al. [41] reported that among the 93 patients diagnosed with chronic GVHD, 43% presented malnutrition (BMI below 21.9) whereas 14% presented severe malnutrition (BMI below 18.5). In this regard, it can be assumed that a considerable number of subjects cannot solve malnutrition even after transplantation. Thus, active nutritional care is required to recover the nutritional status of patients during the hematopoietic stem cell transplantation period and after discharge.

By conducting the correlation analysis to analyze nutritional intake factors that influence the nutritional status at discharge, this study analyzed that the oral intake reduced from Post+1wk was not recovered by Post+2wk. Hereupon, it is more effective to analyze the oral intake for 1 week after transplantation to provide education for enhancing the food intake of patients with reduced oral intake after discharge. Furthermore, although nutritional support was appropriately provided according to the decrease in oral intake, nutritional support was not provided according to changes in oral intake during Post+2wk. This can be viewed in relation to the intentional reduction of TPN to prevent loss of appetite, it is essential to provide timely education for increasing food intake to prevent reduced nutritional status according to the decrease in oral intake.

On the other hand, this study holds significance in that it minimized the quantitative error in data collection between surveyors by using a structured food intake questionnaire and a simple food model and reflected TPN in the nutritional intake survey. Furthermore, it is judged that the accuracy of research was increased by using the validated PG-SGA assessment method for evaluating the nutritional status of cancer patients. However, the limitations of this study are as follows: the calorie and protein intake was calculated by using Food Exchange System, the lack of research subjects due to short research period and the cross-sectional design of study. These limitations must be complemented in follow-up studies.

Conclusion

When considering the fact that the changes in nutritional intake did not present significant differences according to the hematopoietic stem cell transplantation method, it is more important to analyze factors that can influence nutritional intake and nutritional status and develop a protocol based on the analysis results, rather than approaching the issue simply based on the transplant method, in order to achieve efficient nutritional care of patients. On the other hand, when considering the fact that the oral intake reduced from Post+1wk did not recover by Post+2wk and the fact that appropriate nutritional support was not provided despite the low recovery rate of oral intake during the Post+2wk, it is important to provide intensive education for increasing food intake during Post+1wk and discharge. Furthermore, to increase the overall transplant success rate, it is crucial to search nutritional care methods that can be applied during hospitalization and after discharge.

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http://dx.doi.org/10.7762/cnr.2012.1.1.3