—Regular Article—

Effects of Nutrition Support Team Services on Outcomes in ICU Patients

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This study examined the effects of nutrition support team (NST) services on nutrition supply type and patient outcomes in the intensive care unit (ICU) of a general hospital in South Korea. We retrospectively analyzed hospital records of patients who received either parenteral or enteral nutrition support during their ICU stays in the second half of NST (Nutrition Support Team) year 1 (2008) and NST year 2 (2009). Several measures of year 1 were compared with those of year 2, when more NST interventions were conducted. Number of nutrition prescriptions delivered to the ICU was 629 in year 1 and 677 in year 2. The increase in NST interventions led to a reduction in costly parenteral nutrition use, especially in surgical units. Number of patients selected for outcome measures was 40 in year 1 and 45 in year 2. There was an average 3.7 days reduction in the length of hospital stays between the two study terms. The average days of fasting were 3.3 days in year 1 and 1.3 days in year 2, which is statistically a significant decrease ($p=0.02$). The duration of parenteral nutrition decreased from 5.6 to 5.0 days as recommended. Compared with the amount of calories required, an average of 89.4% calories was delivered in year 1, and an average of 99.8% calories was delivered in year 2. Providing NST services in the ICU enhanced adequate nutrition support, cost savings, and better outcomes of the patients.

Key words——nutrition support team; parenteral; enteral; intensive care unit

INTRODUCTION

Hospitalized patients need to be kept in great nutritional conditions to improve treatment effects. Malnutrition issues that may arise during their stay in hospital deserve keen attention as they may delay recovery and result in nutrition-related problems. It has been reported that around 70% of hospitalized patients already suffer from malnutrition, with most of them gradually turning nutrition-deficient.[1–3] For malnourished patients, a decline in physical performance often weakens their muscles and damages their immunity, thus slowing the recovery of wounds after surgical operations.[4] Furthermore, immune dysfunction may also be the cause of slower recovery, in-hospital infection and catheter-related infection.[5] For this reason, more active treatment is needed for patients with malnutrition than those without; advanced countries such as the United States have introduced and actively leveraged nutrition support teams (NSTs) in hospitals.

NSTs select malnourished patients in hospitals and examine their nutritional conditions and relevance with disorders to determine what would be the most adequate nutrition to supply and how it should be provided. Previous studies have pointed out that NST activities lead to shorter hospital stay, lower mortality rate, reduced complications and improved nutrition as indices of patient treatment effects.[6,7] These activities may also help save medical expenses as the most suitable and cost-effective nutritional materials are offered to patients and their side effects are properly handled.[8,9] One example of the advantages that NSTs have to offer is improvement in the way nutrition is supplied. Nutrition supply methods for severe patients unable to consume food orally include: (a) enteral nutrition (EN), direct provision of nutrients *via* stomach or intestines through tube injection; and (b) parenteral nutrition (PN), where nutrients are fed directly into the blood. PN has been widely used for severe patients given its relative convenience, but more recently EN is more encouraged than PN as various advantages of EN are reported.[10] EN is a less expensive option than PN, so a decrease in the use of high-priced PN as a result of NST activities may help reduce medical costs.

While advanced countries in Western Europe and North America began research on the basic roles and effects of NSTs as early as in the 1970s, Korea still lacks studies on the definition of basic NST activities,

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the effect of team activities and reduction in medical expenses despite fast-growing attention to NSTs among hospitals in Korea. Against this backdrop, this study takes a look at the activities of a nutrition support team organized in one general hospital and examines change in the content and cost of nutrition services for patients and nutrition-related indices in conjunction with the expansion of nutrition support activity domains over time.

MATERIALS AND METHODS

NST Interventions in Target Hospital by Year Research subjects for this study were selected from a 640-bed general hospital, Daejin Medical Center (DMC) in Gyeong-gi Province, Korea. The hospital formed a nutrition support team for patients in the intensive care unit (ICU) in 2007, but the team's scope of business began to be specified in 2008, since when data on nutrition support patients have been built into a database and the scope of NST activities has been expanded each year.

NST consists of seven medical doctors (a gastroenterologist, two surgeons, two endocrinologists, a pediatrician, and an oncologist), two pharmacists, two nutritionists, a registered nurse in the medical intensive care unit (MICU), and a registered nurse in the surgical intensive care unit (SICU). They are not dedicated solely to NST activities and also assist with other duties in their respective departments.

NST activities held in 2008 include weekly ward rounds for nutrition prescription(s); monthly training for medical staff for case studies on malnourished patients in each department; and education programs for pharmacists and nutritionists. The team's activities were further expanded in 2009, as the number of ward rounds increased from once a week to twice a week and each patient's attending physician joins team ward rounds. The findings from the ward rounds were documented on NST records in the in-hospital program, giving attending physicians access to real-time information on NST engagement activities. Physicians were also encouraged to use the NST advisory program when providing nutrition prescriptions; the program enables them to produce the most adequate nutrition prescriptions for their patients based on specialized advices from physicians, pharmacists and nutritionists. Training sessions for medical staff were also increased to twice a month, with further reinforced field-specific training sessions offered by relevant experts (i.e., medical doctors, pharmacists and nutritionists; Table 1).

Observation Period Selection This study set the period from July 1, 2008 through December 31, 2008 as ''NST Year 1'' and from July 1, 2009 through December 31, 2009 as ''NST Year 2'' to see if any improvement was made in nutrition prescription or nutrition indices for patients between the two periods. The same periods in the two years were chosen to control seasonal changes in patient mix. The number of nutrition prescription training programs increased in 2009 than in the previous year, and the number of ward rounds doubled to increase NST involvement in optimizing nutrition prescriptions. In this sense, it could be expected that the year 2009 would see a decline in unnecessary nutrition prescriptions and relevant costs than in 2008.

Nutrition Prescription and Cost Analysis We first selected adults over 20 years of age who were hospitalized during the periods of research in each year and who were fed nutrients *via* EN or PN due to their inability to consume food orally while they have been in the ICU. For these primary sample subjects, we analyzed EN/PN prescription trends and change in nutrition costs by year.

Analyses on Changes in Patient Outcomes In order to find out if nutrition-related indices improved

Table 1. Nutrition Support Team (NST) Activities in Each Year

NST year 1 (2008)	NST year 2 (2009)
• Weekly ward rounds for nutrition prescription(s) • Monthly training for medical staff • Education programs for pharmacists and nutritionists	• Twice a week of ward rounds for nutrition prescription(s) with patients' attending physicians • Rounding results were recorded into in-hospital computerized NST program • Twice a month of medical staff training • Both regular and irregular education for each part of staff including medical doctors, pharmacists and nutritionists

by year during the hospitalization periods of patients, we chose the patients who stayed in the ICU for three days or longer but less than 60 days and whose serum albumin concentration at the time of hospitalization was less than 3.2 mg/dl. These secondary sample subjects, a subset of all ICU patients, were observed from their admission through discharge (or deceased during ICU stay) from the ICU. We examined changes in patient outcome indices observed throughout their hospital stay.

From the hospital records, we collected basic information on the study subjects such as age, sex, weight upon ICU admission, serum albumin concentration, mortality, ICU admission type and diagnosis. With this basic information, we calculated their total length of hospital stay, length of ICU stay, days on fasting during hospitalization and EN/PN periods during hospital stay in an effort to find out if reinforced nutrition support activities did improve patient indices by year. The fasting period refers to the period when no oral food intake or EN/PN injection is made. The PN period may overlap with the EN period. We calculated calorie energy requirements and total calories energy delivered. Then, we estimated percentage of total calories delivered compared to the calorie requirement to examine change in nutritional adequacy. The nutrition requirements for severe patients in general were calculated at 25 kcal/kg in total calories.

Statistical Analyses Statistical analyses were made using independent sample *t*-test, Pearson chi-square test and one-way ANOVA from SPSS 11.0, assuming that $p<0.05$ represents statistically significant difference.

RESULTS

Change in ICU Nutrition Prescription and Costs

The total number of patients in the ICU was 1015 in NST year 1 and 1066 in year 2 (see Table 2). The percentage of patients being either EN or PN prescribed among ICU patients was similar between the two years. The total number of PN patients in the ICU was 449 in year 1 and 472 in year 2, increased by 5% in one year. The total number of PN formulas prescribed decreased by 13.6% from 1853 in 2008 to 1632 in 2009 (see Table 3). Surgical ICU patients soared by 32% from 240 in NST Year 1 to 319 in NST Year 2, while PN prescriptions decreased by around 8 % from 1182 to 1083 during the same period. Meanwhile, the number of patients prescribed with EN as a less expensive option than PN grew 13.8% from 180 to 205, and the number of prescriptions also increased by 13.6% from 1715 to 1948. The number of prescriptions per patient remained largely unchanged over years for EN, while that of PN prescriptions declined from 4.1 to 3.5 on average. The number of PN prescriptions for patients in the SICU, in particular, fell dramatically from 4.9 to 3.4 on average, suggesting that proactive NST activities reduce the proportion of expensive PN uses for severe surgical patients.

Average PN costs per patient fell by 20356 Korean won from 114193 won in 2008 to 93837 won in 2009, suggesting around 20% cost reduction. Per-patient PN costs for patients in the SICU dropped by 40240 won from 118269 won in NST year 1 to 78029 won in NST Year 2, helping save medical expenses by around 34%; PN costs for those in the MICU remained largely unchanged compared to those for their surgical counterparts. The total medical expenses for EN increased overall in line with growth in the number of patients, but the per-capita medical costs rarely varied

Table 2. Number of Patients in the ICU during the Observation Period

	Year 1			Year 2		
	Total number of patients admitted to the ICU	Number of patients being either EN or PN prescribed	% of patients being either EN or PN prescribed among ICU patients	Total number of patients admitted to the ICU	Number of patients being either EN or PN prescribed	% of patients being either EN or PN prescribed among ICU patients
Total	1015	629	61.8	1066	677	63.5
SICU[1)]	469	327	69.7	523	411	78.6
MICU[2)]	546	302	55.3	543	266	49.0

[1)] SICU: Surgical Intensive Care Unit. [2)] MICU: Medical Intensive Care Unit.

Table 3. Number of Nutrition Prescriptions Delivered to the ICU Patients

Type		NST					
		Year 1			Year 2		
		Number of patients (a)	Number of prescriptions (b)	Number of prescriptions per patient (b) ÷ (a)	Number of patients (a)	Number of prescriptions (b)	Number of prescriptions per patient (b) ÷ (a)
Parenteral	Total	449	1853	4.1	472	1632	3.5
	SICU[1)]	240	1182	4.9	319	1083	3.4
	MICU[2)]	209	671	3.2	153	549	3.6
Enteral	Total	180	1715	9.5	205	1948	9.5
	SICU	87	857	9.9	92	1024	11.1
	MICU	93	858	9.2	113	924	8.2

1) SICU: Surgical Intensive Care Unit. 2) MICU: Medical Intensive Care Unit.

Table 4. Costs of Nutrition Formula Delivered to the ICU Patients

Type		NST					
		Year 1			Year 2		
		Number of patients	Total cost (in thousand Korean won)	Average cost per patient (in thousand won)	Number of patients	Total cost (in thousand won)	Average cost per patient (in thousand Korean won)
Parenteral	Total	449	51272	114	472	44290	93
	SICU[1)]	240	28384	118	319	24891	78
	MICU[2)]	209	22888	109	153	19399	126
Enteral	Total	180	6911	38	205	7850	38
	SICU	87	3453	40	92	4126	45
	MICU	93	3457	37	113	3723	33

1) SICU: Surgical Intensive Care Unit. 2) MICU: Medical Intensive Care Unit.

by year (see Table 4).

Change in Patient Outcomes The number of study subjects included in this analysis is 40 in NST Year 1 and 45 in NST Year 2. Their general characteristics are illustrated in Table 5, with no significant difference found between secondary sample patients in NST Year 1 and NST Year 2 in terms of age, weight, sex, albumin concentration (as nutrition index), mortality, ICU admission type, and distribution by diagnosis.

The hospitalization period declined by around 3.7 days from 42.6 days in NST Year 1 to 38.9 days in NST Year 2, though the difference was statistically insignificant ($p=0.62$); the duration of ICU stay also dropped from 19.1 days to 18.1 days, which is not a statistically significant change ($p=0.75$). The fasting period decreased by 2.0 days from 3.3 days to 1.3 days on average, and this difference was statistically significant ($p=0.002$). The average duration of EN increased by 1.6 days from 10.7 days in NST Year 1 to 12.3 days in NST Year 2, while the average duration of PN was similar between NST Year 1 and Year 2 with no statistically significant differences (see Table 6).

The calorie requirements for the patients in NST Year 1 were 1400.9 kcal on average, and the average calories delivered stood at 1234.9 kcal. The average calorie requirements and calories delivered for the patients in NST Year 2 were 1366.8 kcal and 1296.8 kcal, respectively. Percentage of total calories actually delivered compared to the calorie requirement for each patient was around 89.4% in 2008 and 99.8% in 2009, reaching almost 100% in NST Year 2, although no statistically significant difference exists (see Table 7).

DISCUSSION

The study results suggest that NST activities for se-

Table 5. General Characteristics of the Patients Selected for Outcome Measures

Characteristics	Year 1 (n=40)	Year 2 (n=45)	p-value for change (t-test or chi-square test)
Age (years)	68.1(13.9)	72.5(14.9)	0.50
Weight (kg)	56.9(8.6)	56.1(11.6)	0.74
Concentration of Albumin on the first day of hospitalization (g/dl)	3.0(0.4)	3.1(0.5)	0.98
Sex, Male (%)	23(57.5)	26(57.8)	0.98
Deceased during ICU stay	19(47.5)	18(40.0)	0.49
ICU admission type	40(100.0)	45(100.0)	0.59
SICU	21(52.5)	21(46.7)	
MICU	19(47.5)	24(53.3)	
Diagnosis (%)	40(100.0)	45(100.0)	0.67
Respiratory system	12(30.0)	18(40.0)	
Circulatory system	1(2.5)	2 (4.4)	
Nervous system	13(32.5)	9(20.0)	
Neoplasm	3(7.5)	4(8.9)	
Infection/Parasite diseases	1(2.5)	0(0.0)	
Injury/Intoxication diseases	3(7.5)	3(6.7)	
Musculoskeletal/Urogenital diseases	2(5.0)	1(2.2)	
Digestive system	4(10.0)	8(17.8)	
Others	1(2.5)	0(0.0)	

* Values are expressed as the mean (S.D.) or number of patients (%) as appropriate.

Table 6. Changes in Patient Outcome Measures

Duration[1] (days)	Year 1	Year 2	Change	p-value[2]
Total length of hospital stay	42.6±39.6	38.9±28.4	−3.7	0.62
Length of ICU stay	19.1±16.8	18.1±12.7	−1.0	0.75
Days on fasting during hospitalization	3.3±2.3	1.3±1.3	−2.0	0.002*
Days on parenteral nutrition	5.6±6.3	5.0±5.7	−0.6	0.62
Days on enteral nutrition	10.7±11.4	12.3±11.7	1.6	0.52

[1] Mean±S.D. [2] By t-test, *$p<0.05$.

Table 7. Estimated Calorie Requirement and Actual Calorie Delivered by EN or PN

Amount[1] (kcal)	Year 1	Year 2	p-values for change (t-test)
Calories required	1400.9±153.6	1366.8±224.2	0.43
Calories prescribed	1234.9±344.8	1296.8±288.5	0.37
Percentage of total calories delivered compared to the calorie requirement	89.4±27.4	99.8±36.4	0.16

[1] Mean±S.D.

verely ill patients during their ICU stays reduce high-priced PN use and there was a trend toward improved outcome indices, although statistical significance was not reached.

Shorter hospital stays as a result of NST activities may be used as an index representing a decline in basic medical expenses. The duration of ICU stay decreased by one day on average from 19.1 days in NST Year 1 to 18.1 days in NST Year 2 (Table 6), although the difference was smaller than a 5.1-day decline (from 21 days to 15.9 days) indicated in a previous study.[11] One reason for this small change may be due to the fact that relatively older patients were included in our study. One study stated that the average age of ICU patients in Korean general hospitals was 64.[12] The research subjects for this study were aged around 70 on average, suggesting that their disease severity and mortality rate would be

relatively higher.

The nutritional conditions of hospitalized patients may worsen with the protraction of their fasting period when medical workers do not provide nutrition for the patients for examination, surgery or other reasons. The nutrition support team has reinforced training for medical staff to minimize the fasting period. More specifically, the team emphasized that the provision of nutrition should begin as fast as possible once surgeries are over, pointing out that frequent fasting weakens the immunity of patients and thus put them at greater risk of in-hospital infection.[13] It also encouraged using the time when patients go to sleep and thus have no dietary intake as part of the fasting period required for medical examinations. With the growth of NST activities, the in-ICU fasting period dropped by 2.0 days from 3.3 days in NST Year 1 to 1.3 days in NST Year 2, showing statistically significant change (Table 6).

The PN period within the ICU also slightly declined although this change may not be statistically significant (Table 6). Previous studies suggest that shorter length of PN period is associated with less occurrences of adverse events relevant to PN-induced catheter infection and metabolic side effects.[9,14] PN injection in the ICU is usually done *via* peripheral vessels rather than *via* central ones. The duration of PN injection *via* peripheral vessels is generally limited to seven days or less; if PN injection is needed for longer than seven days, medical workers are trained to use central veins to prevent potential side effects in peripheral vessels. In this regard, it is a positive sign that reinforced NST activities in the hospital shifted the PN period to less than seven days as recommended. The findings of this study may be viewed as more significant than those from previous studies that indicated a shift in average PN period to 10 days.[9]

This study was prepared under the assumption that percentage of total calories delivered compared to the calories requirement would reach 100% as a result of NST involvement. We found that reinforced NST activities helped the level of nutritional adequacy reach around 100% in NST Year 2 (Table 7). The figures are even greater than that in a previous study on Canadian ICU patients.[15]

It is possible that providing more calories to patients have potential adverse effects, such as increased incidence of hyperglycemia and aspiration pneumonia (in EN patients) although patients' nutritional needs are being met. As a part of NST activities, periodical blood test results for either EN or PN patients were reviewed in order to monitor possible metabolic side effects. Furthermore, NST nurses have checked residual volume of EN prior to (or during) EN feeding to prevent incidence of aspiration pneumonia.

The results of this study demonstrate that reinforced NST activities reduce the number of expensive PN prescriptions per patient and thus lead to a decline in nutrition prescription costs per patient (Tables 3, 4). The extent of reduction was greater especially for surgical patients than for internal medicine patients. Given that many patients in the surgical ICU undergo operations, it would be more beneficial to emphasize the fact that helping patients promptly use their stomach after surgical operations (*i.e.*, through EN initiation), as part of nutrition support activities led by surgeons, has better impacts on their post-surgery recovery.[10,16,17] The lack of improvement in the MICU is associated with the fact that the patients in the MICU are older than those in the SICU. In particular, some elderly patients are admitted to the MICU before they die and these patients are already so critically ill that nutrition supports are not working effectively any longer.

We calculated costs only with the price of nutritional formulas, while previous studies took into account treatment costs and indirect costs (*e.g.*, costs incurred by side effects) as well to estimate the impact of NST activities. We also sought to calculate the costs caused by side effects, but analysis on hospital records in our hospital did not clearly indicate whether the side effects were attributable to PN or complications from the patients' diseases, making it impossible to pursue such a study. As the training sessions from NST are not compulsory, potential differences in the levels of learning and implementation among medical doctors could not be calibrated.

The health care systematic environment surrounding NST activities also needs to be improved since most NST services are not covered under Korea national health insurance payment system. Thus, several hospitals facing budget pressures are not interested in expanding NST services in their institutions. In terms of human resources, NST members also assist with other duties in their respective departments. In the future, health care institutions need to have medical specialists who are dedicated solely to NST for im-

provement of nutrition services to the patients. Despite these limitations, the findings of this study—NST activities as a team of medical doctors, pharmacists, and nutritionists, are helpful in improving patient outcome indices and saving medical costs—hold great significance as an important example that medical institutions in Korea may actively follow to enhance the quality of service for patients while controlling medical expenses that are growing year by year.

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