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Impact of Critical Care Registered Dietitian on Clinical Outcomes of Neurocritically Ill Patients

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Background
To investigate the impact of early nutrition intervention and a critical care registered dietitian on the outcomes of neurocritically ill patients.

Methods
Among neurosurgical patients admitted to the intensive care unit (ICU) in a tertiary hospital from January 2015 to December 2019, A critical care registered dietitian co-management was initiated on May 1, 2017. The primary endpoint was ICU mortality. Propensity score matching (PSM) was used to control selection bias and confounding factors.

Results
In this study, 1,386 patients were included. In the overall study population, nutrition was provided to 719 (51.9%) patients under the supervision of a registered dietitian. Early nutrition was performed for 356 (25.7%) patients. In the overall study population and the PSM adjusted population, rates of early parenteral nutrition (EPN) were higher in the groups managed by a registered dietitian than in the group without a registered dietitian (both $p<0.001$). In the overall and PSM adjusted population, the rates of ICU mortality, 28-day mortality, and in-hospital mortality were not significant different between two groups (all $p>0.05$), but the group managed by a registered dietitian had a shorter hospital stay than the group without a registered dietitian (both $p<0.02$). In the multivariable analysis of the overall population and PSM adjusted population, EPN showed an association with ICU mortality.

Conclusion
The rate of EPN utilization increased after the implementation of co-management with a critical care registered dietitian, and the use of EPN was associated with lower ICU mortality in neurocritically ill patients.

Keywords: Enteral feeding; Prognosis; Neurosurgery; Intensive care unit

INTRODUCTION

Nutrition is a vital aspect of patient care, particularly for critically ill patients. Adequate nutrition support is essential for these patients to maintain their energy balance and achieve optimal outcomes[1-3]. In the neurocritical care setting, where patients often suffer from severe neurological injuries and require prolonged hospitalization, nutrition management becomes even more critical[4-6]. Studies have shown that early initiation of enteral nutrition and the involvement of a registered dietitian in the care team can improve clinical outcomes in critically ill patients[7-9].

However, despite the potential benefits, there is still a significant variability in the delivery of nutrition therapy for critically ill patients, even among specialized units such as neurocritical care units[10]. The reasons for this variability are complex and multifactorial, but they may include differences in clinical practice patterns, staff knowledge and training, and resource availability[5,11]. Given the complexity of the factors that affect nutrition management in the neurocritical care setting, a multidisciplinary team approach that involves close collaboration between healthcare professionals with different expertise, such as neurosurgeons, neurointensivists, nurses, and dietitians, may be necessary to optimize nutrition management for these patients.

Therefore, in this study, we aimed to investigate the impact of early nutrition intervention and multidisciplinary team care that includes a critical care registered dietitian on the outcomes of neurocritically ill patients. We hypothesized that the involvement of a critical care registered dietitian in the neurocritical care team and the early initiation of enteral or parenteral nutrition would improve the clinical outcomes of neurocritically ill patients. We used propensity score matching to control for selection bias and confounding factors, and we assessed the outcomes of interest, including mortality, and length of hospital stay.

METHODS

Study population

The study was approved by the Institutional Review Board (IRB) of Samsung Medical Center (No. SMC 2020-09-082) and patients' records were reviewed and published in accordance with the Declaration of Helsinki. Due to the retrospective nature of the study, the requirement for informed consent was waived by the IRB. We included patients who were hospitalized in the neurosurgical ICU for the management of neurocritical illness or for postoperative care after neurosurgery, as well as those who were hospitalized in the ICU for more than 3 days. Patients who had insufficient medical records, 'do not resuscitate' orders, were admitted to departments other than neurosurgery, or were transferred to other hospitals or had unknown prognoses were excluded from the study (Fig. 1).

Definitions and endpoints

In this study, baseline characteristics such as comorbidities, behavioral risk factors, ICU management, and laboratory data were collected retrospectively using Clinical Data Warehouse. Our center constructed a "Clinical Data Warehouse Darwin-C" designed for investigators to search and retrieve de-identified medical records from electronic archives.

A critical care registered dietitian co-management was initiated on May 1, 2017. The registered dietitian attended the weekly neurocritical care team meetings in person, and on days when not attending the meeting, she provided advice to the neurocritical care team on nutritional issues by phone after morning rounds. Patients who started enteral nutrition or parenteral nutrition within 72 hours of ICU admission were categorized as the early nutrition group. Early enteral nutrition (EEN) or early parenteral nutrition (EPN) was defined as the initiation of enteral nutrition or parenteral nutrition within 72 hours after ICU admission. The primary endpoint was ICU mortality. Secondary endpoint were 28-day mortality, in-hospital mortality and length of hospital stay.

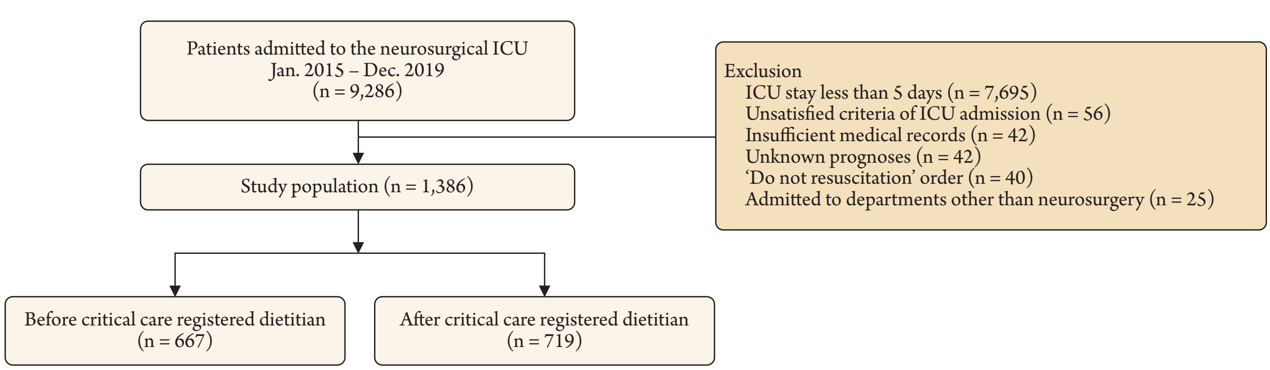

Fig. 1. Study flow chart.
ICU: Intensive care unit.

Statistical analyses

Continuous variables are presented as means ± standard deviations, while categorical variables are presented as frequencies and proportions. Data were compared using Student's t-test for continuous variables and either the chi-square test or Fisher's exact test for categorical variables. To control for selection bias and confounding factors detected in this observational study, we employed several analysis methods, including propensity score matching (PSM)[13]. In the PSM analysis, each patient was matched with one control patient using the nearest neighbor matching method within calipers determined by the propensity score. A caliper width of 0.2 of the standard deviation of the logit of the propensity score was used for the matching[14]. We compared the balance of baseline covariates between nutrition groups by calculating the standardized mean difference (SMD)[15]. If PSM analysis successfully balanced the exposure groups, the standardized mean difference (SMD) should approach zero[16]. Therefore, SMDs less than 10% were considered appropriate for achieving balance between the two groups in this study. To evaluate whether there were differences in ICU mortality according to clinical variables, we performed multiple logistic regression with stepwise variable selection in the overall population and PSM population. We aimed to obtain results that corrected confounding through regression adjustment in the overall population. Furthermore, we performed doubly robust estimation to correct any potential biases that may still exist after PSM. All tests were two-sided and p values of less than 0.05 were considered statistically significant. All statistical analyses were performed with R Statistical Software version 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Baseline characteristics

A total of 9,286 patients were admitted to the neurosurgical ICU during the study period and 1,386 patients were included in the final analysis. In the overall study population, nutrition was provided to 719 (51.9%) patients under the supervision of a clinical dietitian (Fig. 1). Early nutrition was performed for 356 (25.7%) patients. Malignancy (61.8%) and hypertension (34.7%) were the most common comorbidities. Brain tumors (44.6%) and intracerebral hemorrhage (15.2%) were the most common reasons for ICU admission (Table 1). There were no significant differences between before and after clinical dietitian co-management except hypertension, APACHE2 score, and use of continuous renal replacement therapy, glycerin, and vasopressor (Table 1). In PSM adjusted population, there were no significant differences of clinical variables between two groups (Table 2).

Clinical outcomes and early nutrition

In the overall study population, early nutrition was at a similar frequency in both groups (28.1 % vs. 23.5%, $p = 0.068$). However, the group managed by a registered dietitian had higher rate of EPN than the group without a registered dietitian (17.1% vs. 10.0%, $p < 0.001$). In the PSM adjusted population, rate of EPN was also higher in the group managed by a registered dietitian than in the group without a registered dietitian (17.9% vs. 10.1%, $p < 0.001$). In the overall study population and PSM adjusted population, the rates of ICU mortality, 28-day mortality, and in-hospital mortality were not significant different between two groups (all $p > 0.05$), but the group managed by a registered dietitian had a shorter hospital stay than the group without a registered dietitian (both $p < 0.02$) (Tables 1, 2).

In the multivariable analysis of the overall population, EEN (adjusted OR: 0.27, 95% CI: 0.09–0.68) and EPN (adjusted OR: 0.40, 95% CI: 0.18 – 0.82) showed an association with ICU mortality, whereas the presence of a registered dietitian (adjusted OR: 1.23, 95% CI: 0.76–2.00) did not demonstrate any significant association. Similar to the findings in the overall population, EPN was found to be significantly associated with ICU mortality (adjusted OR: 0.35, 95% CI: 0.12–0.86) in PSM adjusted population. However, neither EEN nor co-management with a registered dietitian showed any significant association with ICU mortality in PSM adjusted population (Table 3). In the PSM-adjusted population with a GCS below 13, there was no significant change in in-hospital mortality among those who received dietitian consultations ($p = 0.497$). However, a significant reduction in the incidence of infections ($p = 0.007$) and an enhanced early nutritional support ($p = 0.018$) were observed.

DISCUSSION

In this study, we investigated the impact of early nutrition intervention and multidisciplinary team care that includes a critical care registered dietitian on the outcomes of neurocritically ill patients. Major findings of this study were as follows. First, approximately one-fourth of neurocritically ill patients received early nutrition, with about one-seventh of these patients receiving support in the form of EPN. Second, following the initiation of co-management with a critical care registered dietitian, there was an increase in the rate of EPN utilization. Third, the group that received management from a registered dietitian had a shorter hospital stay compared to the group that did not receive this service. Finally, in both the overall population and the population adjusted by PSM, multivariable analysis indicated a significant association between EPN and ICU mortality.

Table 1. Baseline characteristics and clinical outcomes according to co-management of critical care registered dietitian

	Overall study population			
	Before (n = 667)	After (n = 719)	p value	SMD
Patient demographics				
Age (year)	49.2 ± 23.82	49.1 ± 24.0	0.964	0.002
Sex, male	322 (48.3)	380 (52.9)	0.099	0.092
Comorbidities				
Malignancy	396 (59.4)	449 (62.4)	0.263	0.063
Hypertension	250 (37.5)	231 (32.1)	0.042	0.113
Diabetes mellitus	95 (14.2)	102 (14.2)	0.999	0.002
Chronic kidney disease	38 (5.7)	50 (7.0)	0.396	0.052
Cardiovascular disease	24 (3.6)	23 (3.2)	0.793	0.022
Chronic liver disease	23 (3.4)	19 (2.6)	0.473	0.047
Behavioral risk factors				
Current alcohol consumption	119 (17.8)	154 (21.4)	0.108	0.09
Current smoking	60 (9.0)	74 (10.3)	0.468	0.044
Cause of ICU admission			0.028	0.224
Brain tumor	292 (43.8)	326 (45.3)		
Intracerebral hemorrhage	86 (12.9)	125 (17.4)		
Traumatic brain injury	82 (12.3)	65 (9.0)		
Subarachnoid hemorrhage	81 (12.1)	82 (11.4)		
Elective vascular surgery	58 (8.7)	65 (9.0)		
Spinal surgery	18 (2.7)	16 (2.2)		
Central nervous system infection	14 (2.1)	16 (2.2)		
Cerebral infarction	9 (1.3)	13 (1.8)		
Others	27 (4.0)	11 (1.5)		
APACHE II score on ICU admission	6.6 ± 6.4	5.9 ± 5.8	0.048	0.106
Glasgow coma scale on ICU admission	13.2 ± 3.5	13.5 ± 3.1	0.084	0.093
ICU management				
Mechanical ventilation	357 (53.5)	382 (53.1)	0.926	0.008
Continuous renal replacement therapy	22 (3.3)	9 (1.3)	0.017	0.138
ICP monitoring	279 (41.8)	279 (38.8)	0.275	0.062
Use of mannitol*	290 (43.5)	336 (46.7)	0.245	0.065
Use of glycerin*	200 (30.0)	289 (40.2)	<0.001	0.215
Use of vasopressors	52 (7.8)	178 (24.8)	<0.001	0.472
Early nutrition†	157 (23.5)	202 (28.1)	0.068	
Early enteral nutrition	90 (13.5)	79 (11.0)	0.179	
Early parenteral nutrition	67 (10.0)	123 (17.1)	<0.001	
Clinical outcomes†				
In-hospital mortality	121 (18.1)	127 (17.7)	0.872	
28-day mortality	108 (16.2)	125 (17.4)	0.602	
ICU mortality	93 (13.9)	106 (14.7)	0.728	
ICU length of stay (hour)	257.2 ± 768.7	198.4 ± 206.5	0.049	
Hospital length of stay (day)	80.1 ± 284.0	45.5 ± 134.4	0.003	

Data are presented as numbers (%) or means ± standard deviations.
*Some patients received more than one hyperosmolar agent.
†Variables are not retained in propensity score matching.
SMD: Standardized mean difference, APACHE II: Acute Physiology and Chronic Health Evaluation, ICP: Intracranial pressure, ICU: Intensive care unit, ICP: Intracranial pressure.

Registered dietitians are healthcare professionals specialized in nutrition and dietetics, possessing the credentials to assess, diagnose, and treat nutritional problems[17]. Their role encompasses a broad range of responsibilities, including the planning and implementation of medically recommended diets, patient education, and monitoring the effectiveness of dietary interventions[17]. In the neurocritical care area, the role of registered dietitians is particularly pivotal[18]. Neurological patients, whether due to traumatic brain

Table 2. Baseline characteristics and clinical outcomes according to co-management of critical care registered dietitian in propensity score-match adjusted papulation

	PSM adjusted population			
	Before (n = 542)	After (n = 542)	p value	SMD
Patient demographics				
Age (year)	46.4 ± 24.3	47.6 ± 25.0	0.423	0.049
Sex, male	274 (50.6)	268 (49.4)	0.761	0.022
Comorbidities				
Malignancy	353 (65.1)	342 (63.1)	0.527	0.042
Hypertension	177 (32.7)	184 (33.9)	0.699	0.027
Diabetes mellitus	70 (12.9)	78 (14.4)	0.536	0.043
Chronic kidney disease	28 (5.2)	29 (5.4)	0.999	0.008
Cardiovascular disease	14 (2.6)	16 (3.0)	0.853	0.022
Chronic liver disease	14 (2.6)	17 (3.1)	0.716	0.033
Behavioral risk factors				
Current alcohol consumption	105 (19.4)	107 (19.7)	0.939	0.009
Current smoking	51 (9.4)	50 (9.2)	0.999	0.006
Cause of ICU admission			0.996	0.067
Brain tumor	273 (50.4)	261 (48.2)		
Intracerebral hemorrhage	73 (13.5)	76 (14.0)		
Traumatic brain injury	46 (8.5)	52 (9.6)		
Subarachnoid hemorrhage	54 (10.0)	57 (10.5)		
Elective vascular surgery	53 (9.8)	51 (9.4)		
Spinal surgery	13 (2.4)	15 (2.8)		
Central nervous system infection	12 (2.2)	14 (2.6)		
Cerebral infarction	8 (1.5)	7 (1.3)		
Others	10 (1.8)	9 (1.7)		
APACHE II score on ICU admission	5.8 ± 5.6	6.3 ± 6.1	0.158	0.086
Glasgow coma scale on ICU admission	13.6 ± 3.0	13.6 ± 2.9	0.951	0.004
ICU management				
Mechanical ventilation	259 (47.8)	271 (50.0)	0.504	0.044
Continuous renal replacement therapy	6 (1.1)	7 (1.3)	0.999	0.017
ICP monitoring	239 (44.1)	234 (43.2)	0.806	0.019
Use of mannitol*	238 (43.9)	228 (42.1)	0.581	0.037
Use of glycerin*	182 (33.6)	183 (33.8)	0.999	0.004
Use of vasopressors	51 (9.4)	60 (11.1)	0.423	0.055
Early nutrition†	135 (24.9)	162 (29.9)	0.088	
Early enteral nutrition	80 (14.8)	65 (12.0)	0.212	
Early parenteral nutrition	55 (10.1)	97 (17.9)	<0.001	
Clinical outcomes†				
In-hospital mortality	76 (14.0)	79 (14.6)	0.862	
28-day mortality	68 (12.5)	79 (14.6)	0.375	
ICU mortality	56 (10.3)	63 (11.6)	0.560	
ICU length of stay (hour)	264.4 ± 838.6	194.7 ± 213.0	0.061	
Hospital length of stay (day)	63.6 ± 154.0	42.9 ± 116.82	0.013	

Data are presented as numbers (%) or means ± standard deviations.
*Some patients received more than one hyperosmolar agent.
†Variables are not retained in propensity score matching.
SMD: Standardized mean difference, APACHE II: Acute Physiology and Chronic Health Evaluation, ICP: Intracranial pressure, ICU: Intensive care unit, ICP: Intracranial pressure, PSM: Propensity score-match.

injuries, strokes, or other neurodegenerative diseases, often present with unique nutritional challenges. These can include dysphagia, altered metabolic rates, and specific nutrient requirements or restrictions[19]. A registered dietitian in this context plays a critical role in ensuring that these patients receive adequate and appropriate nutrition to support brain health, promote recovery, and prevent

Table 3. The relationship between critical care registered dietitian, EEN, EPN, and ICU mortality

	Adjusted Odds Ratio (95% CI)[a]	p value
Overall population		
Critical care registered dietitian	1.23 (0.76 – 2.00)	0.409
EEN	0.27 (0.09 – 0.68)	0.011
EPN	0.40 (0.18 – 0.82)	0.018
Propensity score-matched population		
Critical care registered dietitian	1.35 (0.77 – 2.37)	0.295
EEN	0.32 (0.09 – 0.90)	0.051
EPN	0.35 (0.12 – 0.86)	0.034

[a]Adjusted for age, sex, comorbidities, cause of ICU admission, utilization of organ support modalities, use of invasive ICP monitoring device, hyperosmolar therapy, and APACHE II score on ICU admission.
CI: Confidence interval, APACHE: Acute Physiology and Chronic Health Evaluation, ICP: Intracranial pressure, ICU: Intensive care unit, EEN: Early enteral feeding, EPN, Early parental feeding.

further complications. Their expertise is crucial in designing individualized nutritional plans that account for the complex interplay between neurological status, metabolic demands, and nutrient availability. Thus, the collaboration between neurocritical care teams and registered dietitians can significantly enhance patient outcomes by addressing the intricate nutritional needs inherent in this population[18)].

In the management of neurocritically ill patients, the role of registered dietitian is particularly important[20)]. Neurological disorders can lead to dysphagia, which can result in malnutrition and dehydration. In addition, these patients often require specialized diets to manage their conditions and prevent further complications[21)]. Critical care registered dietitian can work closely with the neurocritical care team to assess the nutritional status of these patients, develop personalized nutrition plans, and monitor their response to nutrition therapy. Critical care registered dietitian can also provide recommendations for feeding modalities, such as enteral or parenteral nutrition, and work to prevent complications such as refeeding syndrome. The timely initiation of nutrition has been shown to improve patient outcomes, and registered dietitian can play an important role in developing and implementing personalized nutrition plans for neurocritically ill patients[21)]. Overall, the involvement of registered dietitian in the care of critically ill neurological patients can improve outcomes, reduce complications, and ultimately contribute to their recovery.

In early stages of neurocritically ill patients, providing adequate nutritional support is crucial due to the hypermetabolic response that often follows brain injury[12,22)]. Increased intracranial pressure can lead to sympathetic hyperactivation, which may have an impact on gastrointestinal dysfunction[23-25)]. Furthermore, EEN on in neurocritically ill patients can elevate the risk of complications such as high gastric residual volume, delayed gastric emptying, and aspiration pneumonia[11)]. Despite ongoing discussions about the ideal timing and method of feeding, a recent meta-analysis has demonstrated that EPN is more effective than EEN in reducing mortality rates and infectious complications, as well as improving outcomes in patients with traumatic brain injury during the acute gut-intolerant phase[5,26)].

This study is subject to several limitations, including the fact that it relied on a retrospective review of medical records and utilized data extracted from a Clinical Data Warehouse. The use of nonrandomized registry data in this study may have introduced selection bias into the results. This study is a type of before-and-after study, so when the registered dietitian initially began working with the neurocritical care team, there may have been a window period that should have been excluded from the analysis in order to minimize the risk of bias in the study. Nutritional support for neurocritically ill patients was occasionally administered using non-protocol methods. Finally, the distribution of neurosurgical diseases in our study population differed from that typically seen in a general neurosurgical ICU, with a particularly high proportion of patients with brain tumors.

CONCLUSION

Neurocritically ill patients can face challenges in receiving appropriate nutritional support due to issues like decreased consciousness, elevated intracranial pressure, and gastrointestinal dysfunction caused by excessive sympathetic nerve activity, distinguishing them from general intensive care patients. A critical care registered dietitian considers these unique characteristics of neurocritically ill patients to provide suitable nutritional support. This tailored approach could potentially improve the overall prognosis for these patients.

NOTES

Ethics statement

The study was approved by the Institutional Review Board (IRB) of Samsung Medical Center (No. SMC 2020-09-082) and patients' records were reviewed and published in accordance with the Declaration of Helsinki. Due to the retrospective nature of the study, the requirement for informed consent was waived by the IRB.

Author contributions

Conceptualization: HK, HJK, JAR. Methodology: HJK, JAR. Data curation: HK, JAR, Writing – original draft: HK, JAR. Formal analysis: All authors.

Conflict of interest

There is no conflict of interest to disclose.

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Data availability

None.

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