대한중환자의학회지 : 제 25 권 제 3 호
Vol. 25, No. 3, September, 2010 / DOI: 10.4266/kjccm.2010.25.3.136

■ 원 저 ■

# Physician Compliance with Tube Feeding Protocol Improves Nutritional and Clinical Outcomes in Acute Lung Injury Patients

**Sungwon Na,** M.D., **Hosun Lee,** R.D.*, **Shin Ok Koh,** M.D., **Ai Soon Park,** R.N.† and **A Reum Han,** R.N.†

Department of Anesthesiology and Pain Medicine, Anesthesia and Pain Research Institute, Yonsei University College of Medicine, *Department of Nutrition and Dietetics, †Medical/Surgical Intensive Care Unit, Department of Nursing, Severance Hospital, Yonsei University Health System, Seoul, Korea

**Background:** Nutrition delivery is frequently interrupted or delayed by physicians' ordering patterns. We conducted this study to investigate the effect of physician compliance with tube feeding (TF) protocol on the nutritional and clinical outcomes in acute lung injury (ALI) patients.

**Methods:** After implementing a TF protocol, 71 ALI patients with mechanical ventilation (MV) for $\geq$ 7 days were observed. A dietician assessed the nutritional status of the patients and established individualized nutrition plans according to the protocol. If the physicians followed the dietician's recommendation within 48 hours, the patients were classified under the compliant group (Group 1).

**Results:** Forty patients (56.3%) were classified into Group 1. Prealbumin was comparable in both groups at ICU admission but higher in Group 1 at the time of discharge from the ICU (228 ± 81 vs 157 ± 77 mg/dl, p = 0.025). Nitrogen balance was only improved in Group 1. The time to reach calorie goal was shorter and non-feeding days were reduced in Group 1. The proportion of parenteral nutrition to nutritional support days was lower and delivered calories on the $4^{th}$ and $7^{th}$ day of TF were higher in Group 1 ($p < 0.001$). ICU mortality/stay and hospital mortality failed to show differences but hospital stay was prolonged in the noncompliant group (Group 2) (p = 0.023). Arterial oxygen tension and $PaO_2/FiO_2$ were maintained during the $1^{st}$ week of ICU stay in Group 1 but were decreased in Group 2.

**Conclusions:** Physicians' compliance with the TF protocol contributed to the likelihood of nutritional improvement and a shorter hospital stay in ALI patients with prolonged MV.

**Key Words:** acute lung injury, mechanical ventilation, nutrition status, protocol compliance, tube feeding.

## INTRODUCTION

Successful commencement of enteral feeding within 48 hours of mechanical ventilation (MV) is associated with up to a 20% decrease in mortality in the ICU and a 25% decrease in hospital mortality in artificially ventilated patients.[1)] Therefore, enteral nutrition is increasingly becoming the standard of care for critically ill patients and furthermore, nutritional strategies alleviating inflammation and limiting carbon dioxide production have been developed for acute lung injury (ALI) or acute respiratory distress syndrome (ARDS) patients.[2)] However, many clinicians often underestimate nutritional needs in critically ill patients, resulting in delay in initiating nutritional support or hesitation in increasing enteral caloric intake, even if patients are eligible for tube feeding (TF).[3,4)] Gastrointestinal (GI) dysfunction, elective procedures, and patient intolerance are frequently limiting delivery of TF.[3,5)] In a prospective study by McClave and coworkers,[4)] critically ill patients received about one-half of their goal calories because physicians ordered only 66% of calorie requirements and 78% of the volume ordered was actually infused, which were similar to the result of the other Korean study in 2009.[6)] Most enteral feeding cessations can be avoided by education regarding standardized feeding processes.[5,7)] Implementing an enteral TF protocol demonstrated increased nutritional delivery and minimized risks of TF,[4,8,9)] but poor compliance limited its effectiveness.[4)]

We hypothesized that physician compliance to nutritional support protocol exerts a great influence on not only nutri-

Received on June 11, 2010, Accepted on August 8, 2010
Correspondence to: Shin Ok Koh, Department of Anesthesiology and Pain Medicine, Anesthesia and Pain Research Institute, Yonsei University College of Medicine, 134 Sinchon-dong, Seodaemun-gu, Seoul 120-752, Korea
Tel: 82-2-2228-2420, 2403, Fax: 82-2-312-7185
E-mail: sokoh@yuhs.ac

tional outcomes but also clinical results of ALI because decreased nutritional support causes respiratory muscle injury[10] and sufficient calorie intake prevents muscle wasting.[11] Therefore, we applied a continuous TF protocol to ALI patients with MV for more than 7 days in the ICU and investigated the effects of physician compliance.

## MATERIALS AND METHODS

This study was conducted in the medical ICU (30 beds) of Severance Hospital. It was approved by the Institutional Review Board of Severance Hospital, Yonsei University Health System, Seoul, Korea. Written and informed consent was obtained. We identified the problems in ICU TF practices and developed a TF protocol after reviewing the ICU nutrition literature and benchmarking protocols of other institutes in ICU nutrition support team meetings. The protocol incorporated continuous feeding using a feeding pump via nasogastric tube and defined procedures for residual volumes exceeding 100 ml to minimize interruption and delay in resuming feeding after cessation of TF in the ICU. Daily calorie goal was calculated by a registered dietitian. Basal energy expenditure was calculated with Harris-Benedict equation and it was multiplied by injury factor of 1.2 for ALI. If the calculated value was out of the range of 25−35 kcal/kg/day, the calorie goal was adjusted to stay within the range. Through meetings with intensivists, dietitians, and medical and nursing staff in the ICU, we modified and set up the protocol for 2 months before implementing it. Nutrition education for medical and nursing staff was given for 1 hour/week for 4 weeks, and the printed protocol was placed at the bedsides (Table 1, Fig. 1). Other than implementing the feeding protocol, the medical treatment for all the enrolled subjects including mechanical ventilation was directed by critical care physicians equally based on the standardized guidelines.

After implementing the protocol, we collected data from all newly admitted ALI patients to the ICU older than 18 years of age with MV support for more than 7 days from April 2005 to March 2006. ALI was defined as acute onset of hypoxemia: $PaO_2/FiO_2 < 300$ mmHg and bilateral infiltrates on chest radiography, in the absence of left atrial hypertension as the principal cause of acute pulmonary edema.[12] Patients were divided into 2 groups according to physician compliance to the protocol. The compliant group was defined as patients whose

**Table 1.** Tube Feeding Protocol

1. Start enteral feeding via nasogastric tube as soon as possible.
2. The nasogastric tubes were placed by the physician and confirmed with auscultation of epigastric area while injecting 50 ml of air or abdominal X-ray.
3. Begin with standard formula (isotonic, 1 kcal/ml) full-strength at 30 ml/h continuous infusion unless otherwise specified.
4. Advance by 20 ml/h per 24 h to goal.
5. Check residual volume per 6 h and document in chart. Follow the flow chart (Fig. 1) if residual volume is more than 100 ml.
6. Record stool frequency, consistency, and volume.
7. Flush tube with 30 ml water per 6 h or before and after medications.
8. Change bag and tubing per 24 h.
9. Keep backrest elevated 30−45° unless contraindicated by a medical condition.
10. Do not stop tube feeding for diagnostic tests, nursing care, or routine bedside procedures unless ordered by the physician.

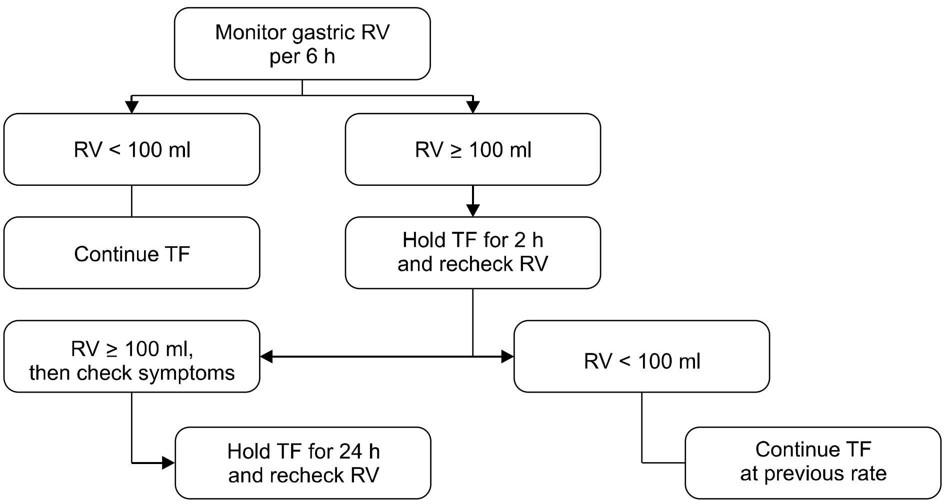


**Fig. 1.** Protocol for monitoring gastric residual volume. RV: residual volume; TF: tube feeding.

primary physicians acceded and changed the diet order in 2 days according to the advice of the dietitian. Patients were prospectively evaluated and monitored after continuous enteral TF was initiated and followed to the study end point, which was defined as advancement to oral diet, death, or discharge from the ICU. The delivery of enteral and parenteral calories was recorded daily. Additionally, the cause and frequency of TF interruption and non-feeding day were monitored daily. We assessed nitrogen balance weekly and serum prealbumin level at admission and discharge from the ICU. Nitrogen balance was calculated as the difference between total dietary nitrogen and total urine nitrogen:

Nitrogen balance = total protein intake/6.25 − (24 hours urine urea nitrogen + 4 g of obligatory nitrogen loss)

Nutritional outcome also included the time to reach calorie goal, incidence of TF interruption, ratio of delivered calories divided by recommended calories on the $4^{th}$ and $7^{th}$ day after initiation of TF. Clinical parameters included the duration of MV, arterial pH, partial pressure of oxygen ($PaO_2$) and carbon dioxide ($PaCO_2$), $PaO_2$/inspired oxygen fraction ratio (P/F ratio), length of stay (LOS), and ICU and hospital mortality.

Statistical analysis was performed using Student t-test for continuous data and $\chi^2$ test for categorical data. Paired t-test was used to compare values at admission and discharge. Repeated measures ANOVA with Bonferroni correction was used to evaluate serial changes in respiratory parameters. $p < 0.05$ was considered to be significant. All analyses were conducted with SPSS for Windows version 12.0.

We estimated that we would need a sample size of 27 in each group to reliably detect the significant change in serum prealbumin level of 45 mg/dl with $\alpha$ = 0.05 and $\beta$ = 0.20, based on a previously observed data of 120 ± 50 mg/L.[13)]

## RESULTS

A total of 176 patients were followed up but 105 were ruled out because of short-duration MV (n = 69) or patient refusal (n = 36). Data were collected for 1417 days of enteral feeding in 71 patients. Forty patients (56.3%) were classified as the compliant group. Three pulmonologists and 5 neurologists were the primary physicians involved in this study and the number of compliant/noncompliant patients were as follows: pulmonologist 1: 11/12, pulmonologist 2: 8/3, pulmonologist 3: 0/6, neurologist 1: 7/1, neurologist 2: 3/1, neurologist 3: 5/4, neurologist 4: 2/2, and neurologist 5: 4/2. The number of compliant/noncompliant patients according to physician specialty was 19/21 (pulmonology) and 21/10 (neurology).

**Table 2.** Demographic and Clinical Data

| | Compliant (n = 40) | Noncompliant (n = 31) | p value |
|---|---|---|---|
| Age (yr) | 61 ± 18 | 61 ± 18 | 0.900 |
| Gender (M/F) | 22/18 | 18/13 | 0.494 |
| APACHE II score | 16 ± 8 | 17 ± 7 | 0.593 |
| Height (cm) | 162.5 ± 7.8 | 161.6 ± 8.4 | 0.659 |
| Ideal body weight (kg) | 57.1 ± 6.3 | 56.6 ± 6.8 | 0.796 |
| Admission diagnosis | | | |
| Respiratory | 15/40 | 20/31 | |
| Gastrointestinal | 2/40 | 0/31 | |
| Endocrine | 1/40 | 4/31 | |
| Oncology | 2/40 | 0/31 | |
| Neurological | 20/40 | 7/31 | |
| Duration of MV (days) | 21.6 ± 16.1 | 22.5 ± 16.0 | 0.927 |
| ICU LOS (days) | 25.0 ± 12.3 | 23.4 ± 13.0 | 0.603 |
| ICU mortality | 3/40 (7.5%) | 4/31 (12.9%) | 0.691 |
| Hospital LOS (days) | 35 ± 28 | 56 ± 43 | 0.023 |
| Hospital mortality | 4/40 (10.0%) | 7/31 (22.6%) | 0.192 |

Data are mean ± SD or number of patients. Compliant: patients whose physician complied with the TF protocol; Noncompliant: patients whose physicians did not comply with the TF protocol; APACHE: Acute Physiology and Chronic Health Evaluation; MV: mechanical ventilation; ICU: intensive care unit; LOS: length of stay.

**Table 3.** Patterns of Nutritional Delivery and Interruption of Tube Feeding

| | Compliant (n = 40) | Noncompliant (n = 31) | p value |
|---|---|---|---|
| Time to TF start (days) | 3 ± 2 | 4 ± 4 | 0.310 |
| Time to 1,000 kcal (days) | 5 ± 5 | 7 ± 6 | 0.246 |
| Time to calorie goal (days) | 8 ± 5 | 12 ± 6 | 0.037 |
| NS days | 24.8 ± 15.1 | 21.5 ± 13.2 | 0.335 |
| TF days/NS days (%) | 88.7 ± 17.6 | 81.5 ± 22.9 | 0.142 |
| PN days/NS days (%) | 38.5 ± 34.5 | 60.0 ± 41.2 | 0.020 |
| Provided/recommended calories | | | |
| $4^{th}$ day from TF start (%) | 74.3 ± 22.2 | 49.2 ± 19.4 | <0.001 |
| $7^{th}$ day from TF start (%) | 89.4 ± 20.1 | 54.4 ± 30.4 | <0.001 |
| Interruption of TF per patient | 1.3 ± 1.7 | 2.3 ± 2.7 | 0.067 |
| Cause of TF interruption | | | |
| GI dysfunction | 23/40 | 20/31 | 0.628 |
| Duration (days) | 1.5 ± 1.8 | 3.1 ± 3.4 | 0.026 |
| Elective procedures | 11/40 | 9/31 | 1.000 |
| Duration (days) | 0.5 ± 1.0 | 1.6 ± 3.7 | 0.041 |
| Total | 28/40 | 20/31 | 0.799 |
| Duration (days) | 2.9 ± 3.9 | 4.9 ± 5.7 | 0.034 |

Data are mean ± SD or number of patients. Compliant: patients whose physicians complied to the TF protocol; Noncompliant: patients whose physicians did not comply to the TF protocol; TF: tube feeding; GI: gastrointestinal; NS: nutrition support; PN: parenteral nutrition.

There were no significant differences in patient characteristics between groups (Table 2). Acute Physiology and Chronic Health Evaluation (APACHE) II score and duration of MV were identical between the 2 groups. ICU mortality/stay and hospital mortality were comparable. However, hospital stay was significantly longer in the noncompliant group (35 ± 28 vs 56 ± 43 days, $p = 0.023$).

Patterns of nutrition delivery are presented in Table 3. Duration of nutritional support and time to TF start and reaching 1000 kcal were not different, but more time was taken to reach calorie goal from TF start in the noncompliant group (8 ± 5 vs 12 ± 6 days, $p = 0.037$). Frequency of TF interruption per patient was not different but more patients in the noncompliant group suffered from interruption >= 5 times (2/40 vs 7/31, $p = 0.036$). TF was interrupted due to many causes, with the 2 major being GI problems and procedures. Incidences of those 2 problems did not differ between groups but durations of interruption were significantly longer in the noncompliant group. The number of patients who withheld feeding due to GI problems in the compliant and noncompliant groups are as follows: high gastric residual volume (19 vs 18), abdominal distension (12 vs 8), diarrhea (4 vs 1), and GI bleeding (1 vs 0). Other causes of TF interruption were uncon-

**Table 4.** Nutritional Assessment at Admission and Discharge from ICU

| | | Compliant (n = 40) | Noncompliant (n = 31) | p value |
|---|---|---|---|---|
| Body weight | Admission | 58.5 ± 9.3 | 57.8 ± 13.9 | 0.794 |
| (kg) | Discharge | 58.7 ± 9.4 | 55.8 ± 10.9 | 0.247 |
| Albumin | Admission | 3.3 ± 0.7 | 3.1 ± 0.5 | 0.239 |
| (g/dl) | Discharge | 3.1 ± 0.5 | 2.9 ± 0.5 | 0.359 |
| Prealbumin | Admission | 133 ± 53 | 112 ± 75 | 0.197 |
| (mg/L) | Discharge | 222 ± 81* | 157 ± 77* | 0.025 |
| N balance | Admission | −7.86 ± 5.8 | −6.3 ± 5.1 | 0.271 |
| (g) | Discharge | −3.5 ± 3.8† | −4.6 ± 5.3 | 0.331 |

Data are mean ± SD. Compliant: patients whose physicians complied with the TF protocol; Noncompliant: patients whose physicians did not comply with the TF protocol; N: nitrogen. *$p < 0.05$; †$p < 0.01$ compared with the value at admission using paired t-test.

**Table 5.** Arterial Blood Gas Analysis and Parameters Associated with Mechanical Ventilation

| | | Admission | 4th day | 7th day |
|---|---|---|---|---|
| pH | Compliant | 7.5 ± 0.7 | 7.5 ± 0.06 | 7.5 ± 0.57 |
| | Noncompliant | 7.4 ± 0.1 | 7.4 ± 0.08 | 7.44 ± 0.08 |
| $PaO_2$ (torr) | Compliant | 109 ± 35 | 111 ± 31* | 99 ± 30* |
| | Noncompliant | 116 ± 30 | 94 ± 31† | 89 ± 17† |
| $SaO_2$ (%) | Compliant | 97 ± 2 | 99 ± 2 | 97 ± 2 |
| | Noncompliant | 98 ± 1 | 96 ± 4 | 97 ± 2 |
| $PaCO_2$ (torr) | Compliant | 41 ± 14 | 44 ± 9 | 44 ± 6 |
| | Noncompliant | 43 ± 19 | 50 ± 13 | 53 ± 19 |
| $FiO_2$ | Compliant | 0.50 ± 0.17 | 0.48 ± 0.17 | 0.44 ± 0.17 |
| | Noncompliant | 0.47 ± 0.12 | 0.45 ± 0.10 | 0.49 ± 0.21 |
| P/F ratio (torr) | Compliant | 246 ± 108 | 281 ± 68* | 249 ± 92* |
| | Noncompliant | 233 ± 45 | 212 ± 78 | 177 ± 54† |
| Oxygenation index | Compliant | 9.5 ± 5.5 | 7.8 ± 4.8* | 7.7 ± 4.0* |
| | Noncompliant | 11.1 ± 2.2 | 14.1 ± 5.0 | 17.3 ± 7.0† |
| PS ($cmH_2O$) | Compliant | 10.7 ± 5 | 10.0 ± 4.4 | 8.2 ± 3.2 |
| | Noncompliant | 8.0 ± 0 | 10.0 ± 2.0 | 10.8 ± 3.3 |
| PEEP ($cmH_2O$) | Compliant | 7.2 ± 3.4 | 6.9 ± 3.0 | 6.1 ± 2.2 |
| | Noncompliant | 6.3 ± 2.3 | 5.7 ± 1.4 | 6.1 ± 2.3 |
| Tidal volume (ml) | Compliant | 453 ± 101 | 475 ± 95 | 449 ± 69 |
| | Noncompliant | 455 ± 113 | 495 ± 134 | 491 ± 163 |
| Plateau airway pressure ($cmH_2O$) | Compliant | 22.4 ± 8.2 | 23.0 ± 9.4 | 25.7 ± 10.5 |
| | Noncompliant | 26.9 ± 6.7 | 26.4 ± 7.0 | 26.0 ± 6.4 |
| Static compliance ($ml/cmH_2O$) | Compliant | 23.9 ± 10.8 | 22.9 ± 10.1 | 22.0 ± 11.6 |
| | Noncompliant | 26.9 ± 6.7 | 21.9 ± 6.4 | 22.0 ± 9.5 |

Data are mean ± SD. Compliant: patients whose physicians complied with the TF protocol; Noncompliant: patients whose physicians did not comply with the TF protocol; $PaO_2$: arterial oxygen tension; $PaCO_2$: arterial carbon dioxide tension; $FiO_2$: inspired oxygen fraction; P/F ratio: $PaO_2/FiO_2$; PS: pressure support; PEEP: positive end-expiratory pressure. Oxygenation index = (mean airway pressure × $FiO_2$(%))/ $PaO_2$. *$p < 0.05$ compared to the other group; †$p < 0.05$ compared to the value at admission.

trolled blood glucose (1 vs 1), tube problems (1 vs 0), and unspecified factors (1 vs 2). The proportion of parenteral nutrition (PN) to nutritional support days was lower in the compliant group (39 ± 35% vs 60 ± 41%, p = 0.020) although the percentage of TF day to nutritional support day failed to show prolongation in the compliant group (p = 0.142). The proportion of actually delivered calories to recommended calories on the $4^{th}$ and $7^{th}$ day from TF start were definitely higher in the compliant group (74.3 ± 22.2 vs 49.2 ± 19.4% and 89.4 ± 20.1 vs 54.4 ± 30.4%, respectively, p < 0.001).

Compared to the initial values, prealbumin was improved significantly in both groups, but nitrogen balance only in the compliant group (Table 4). Comparisons of body weight and albumin at admission and discharge did not demonstrate statistical differences in both groups. The power of this study to detect a 65 mg/L change in prealbumin was 94%, while the power to detect a 69 torr change in P/F ratio was 95%.

Arterial blood gas analysis did not show any significant differences, except P/F ratio and $PaO_2$. They were decreased in the noncompliant group on the $4^{th}$ and $7^{th}$ day of ICU admission but maintained in the compliant group (Table 5). Oxygenation index showed significant increase on $7^{th}$ day in the noncompliant group.

## DISCUSSION

There are many studies about the effect of the implementation of TF protocols on nutritional and clinical outcomes,[3,14,15] but none paid attention to the influence of physician compliance on nutritional and clinical outcomes. We performed this study to examine the influence of physician attitude to a TF protocol on clinical and nutritional outcomes in ALI patients. It was demonstrated that in the group where physician was compliant with the protocol showed improvement in prealbumin and nitrogen balance in nutritional aspects. In clinical view points, hospital stay was reduced and oxygenation was improved in the compliant group.

Prealbumin and nitrogen balance were definitely improved during ICU stay in the compliant group but only prealbumin was increased in the noncompliant group. This result proved our assumption that physicians' reluctance to adopt a feeding protocol could limit critically ill patients' nutritional achievements and consequently, clinical improvements.[16] Prealbumin, also known as transthyretin, has been used as a sensitive nutritional indicator because of its short half-life of 1.9 days.[17] However, its role in critically ill patients has been debated.[18,19] The prealbumin increase shown in this study might imply not only improved nutrition status but also reversed inflammatory reprioritization of hepatic protein synthesis. However, albumin represented a decreasing tendency during ICU stay irrespective of prealbumin increase. This discrepancy could result from its long half-life, reduced synthesis, and/or redistribution. Albumin usually cannot show an acute increase in response to nutritional support. Additionally, hypoalbuminemia in critically ill patient, can occur due to capillary leak syndrome; which means albumin escaping through capillaries into the interstitium.[19]

Positive conversion of nitrogen balance is associated with improved patient outcome during critical illness.[20] Positive nitrogen balance is widely considered to be the primary goal of nutritional support but it is difficult to achieve in critically ill patients. Adding 20−25% to the resting energy expenditure for critical, mechanically ventilated patients is recommended to calculate total energy requirements.[21,22] In the present study, we could not demonstrate significant differences in nitrogen balance between groups and it remained negative until discharge from the ICU, which indicated that our protocol provided insufficient protein or calories compared to the actual requirements of ALI patients or it was difficult to replenish the initial nutritional deficiency at ICU admission. Some authors advocate permissive underfeeding,[23] considering that hyperalimentation is associated with increased production of carbon dioxide despite little clinical influence in patients under MV.[24] Carbon dioxide production can be detrimental to lung injury patients because it leads to increased minute ventilation, respiratory muscle waste, and fatigue. Hyperglycemia resulting from excessive nutrition is also related to fatty liver and infective complications. Therefore, we think that close monitoring and assessment of nutritional status is required to avoid complications of malnutrition or hyperalimentation, especially in patients with respiratory problems.

In our study, indicators of oxygenation (oxygenation index, P/F ratio, and arterial oxygen tension) showed a significant aggravation along with ICU stay in the noncompliant group. Nutritional deficiency was probably aggravated in the noncompliant group by limited nutritional support due to physicians' reluctance and increased energy expenditure from work of breathing. Additionally, immunonutrients such as eicosapentaenoic and gamma-linolenic acid are known to contribute to improved oxygenation, reduced MV duration, and mortality in patients with severe sepsis or requiring MV.[25] Although immunonutrients were not involved in this study, the combined effect of immunonutrients and physician compliance to a TF protocol deserves investigation.

The effect of nutrition on mortality and LOS has been studied but the results have not been consistent. Barr et al.[14] showed that the risk of death was 56% lower in enterally fed patients. Another study demonstrated feeding protocol increased duration of enteral nutrition and reduced hospital stay although there was only a trend toward reduced mortality and mean stay in the ICU did not differ.[26] These 2 results are very similar to those of this study. We failed to exert an improvement in ICU mortality/stay and hospital mortality but hospital stay was significantly shorter in the compliant group. This could mean that nutrition is more important in chronic care of critically ill patients and short-term clinical responses to nutrition seemed to be difficult to exhibit in a small-sized study. Our data showed that appropriate nutritional support in the acute phase of lung injury could prevent prolonged hospital stay. The frequent occurrence of complication and treatment or rehabilitation of the associated morbidity might prolong hospital stay in undernourished patients. Another positive effect of nutrition lies in prevention of myopathy.[27] We expected a shorter duration of MV in the compliant group but they were identical in both groups.

Although adequate nutritional support is an essential component of critical care,[28] the delivery of enteral feeding used to be delayed or even interrupted in the ICU for several reasons, including GI dysfunction, elective discontinuation for procedures, and physicians' ignorance of nutrition.[4,29] Among these causes, physicians' understanding of feeding is important for appropriate nutritional support because a physician's order is the first step in nutrition delivery and it can be improved by education and standardization, unlike other causes. Many physicians are reluctant to start enteral feeding, especially in critically ill patients, because it is known to be associated with an increased risk of ventilator-associated pneumonia (VAP).[1]

Physicians' reluctance to order TF was shown in many ways in this study. TF interruption only showed a trend toward increase in the noncompliant group but the duration of interruption was definitely longer in the noncompliant group. A longer period of time was taken to reach calorie goal and a significantly larger percentage of nutritional support was provided via parenteral route in the noncompliant group. This difference in ordering pattern is thought to lead to nutritional deficiency. To overcome this problem, implementing a TF protocol is a good method to improve nutritional support in critically ill patients.[14,30] Use of a standard enteral nutrition protocol decreased the time to reach calorie goal[31] and duration of MV,[14] although there were no differences in ICU or hospital LOS. These results might be biased by the Hawthorne effect, which has been defined as "an increase in productivity produced by the psychological stimulus of attention and being observed".[32] This is weakness of the above mentioned studies including the present study. While introducing the TF protocol, a lot of attention and encouragement were given to the medical and nursing staff and the positive effect of TF might be derived from these factors.

Our study has two limitations. First, there might be a selection bias by grouping patients retrospectively. The clinical effect of stable enteral nutrition could be biased by placing healthier patients in the compliant group. Although the severity score were not significantly different between the two groups, there was a difference in the distribution of admission diagnosis which might make differences in the baseline medical and nutritional conditions. The most frequent admission diagnoses were neurological disease, followed by pulmonary disease in the compliant group but pulmonary disease were the most frequent admission diagnosis in the noncompliant group. However, it is difficult to design a randomized prospective study to consider physician's attitude to a TF protocol as a factor to influence on clinical and nutritional outcomes. If we had prospectively design the study, we could have planned to obtain detailed information regarding the reason why the primary physicians in the noncompliant group didn't follow the feeding protocol. This is the second limitation of our study which precluded further investigation. A physician survey[33] showed a substantial discordance in physician perceptions and practice patterns regarding initiation and management of nutrition in ICU patients. Although physicians believed that nutrition is important in the ICU, they didn't feel confident in their knowledge of the role of nutrition support in the critically ill because of a deficiency in awareness and familiarity with current guidelines and difficulty integrating previous dogma with recent clinical practice guidelines. In our ICU, the resident physicians assigned after implementing the protocol might not be familiar with the background and purpose of the TF protocol despite education session in every rotation term. Although we might not generalize our results to other ICU patients, we would like to conclude that good compliance of primary physicians with a continuous TF protocol improved nutritional indicators such as prealbumin and time to calorie goal in patients with ALI who require prolonged MV. Physicians' compliance with the TF protocol was also beneficial in maintaining oxygenation and reduced hospital stay. Further studies should investigate strategies to improve physician compliance with TF protocols.

## REFERENCES


1) Artinian V, Krayem H, DiGiovine B: Effects of early enteral feeding on the outcome of critically ill mechanically ventilated medical patients. Chest 2006; 129: 960-7.
2) Mizock BA, DeMichele SJ: The acute respiratory distress syndrome: role of nutritional modulation of inflammation through dietary lipids. Nutr Clin Pract 2004; 19: 563-74.
3) Heyland D, Cook DJ, Winder B, Brylowski L, Van deMark H, Guyatt G: Enteral nutrition in the critically ill patient: a prospective survey. Crit Care Med 1995; 23: 1055-60.
4) McClave SA, Sexton LK, Spain DA, Adams JL, Owens NA, Sullins MB, et al: Enteral tube feeding in the intensive care unit: factors impeding adequate delivery. Crit Care Med 1999; 27: 1252-6.
5) Adam S, Batson S: A study of problems associated with the delivery of enteral feed in critically ill patients in five ICUs in the UK. Intensive Care Med 1997; 23: 261-6.
6) Moon SS, Lim H, Choi JW, Kim DK, Lee JW, Ko S, et al: Analysis of nutrition support status in the intensive care unit. Korean J Crit Care Med 2009; 24: 129-33.
7) Mackenzie SL, Zygun DA, Whitmore BL, Doig CJ, Hameed SM: Implementation of a nutrition support protocol increases the proportion of mechanically ventilated patients reaching enteral nutrition targets in the adult intensive care unit. JPEN J Parenter Enteral Nutr 2005; 29: 74-80.
8) Mentec H, Dupont H, Bocchetti M, Cani P, Ponche F, Bleichner G: Upper digestive intolerance during enteral nutrition in critically ill patients: frequency, risk factors, and complications. Crit Care Med 2001; 29: 1955-61.
9) American Gastroenterological Association Medical Position Statement: guidelines for the use of enteral nutrition. Gastroenterology 1995; 108: 1280-1.
10) Reid WD, Clarke TJ, Wallace AM: Respiratory muscle injury: evidence to date and potential mechanisms. Can J Appl Physiol 2001; 26: 356-87.
11) Hart DW, Wolf SE, Zhang XJ, Chinkes DL, Buffalo MC, Matin SI, et al: Efficacy of a high-carbohydrate diet in catabolic illness. Crit Care Med 2001; 29: 1318-24.
12) Ware LB, Matthay MA: The acute respiratory distress syndrome. N Engl J Med 2000; 342: 1334-49.
13) Bauer P, Charpentier C, Bouchet C, Nace L, Raffy F, Gaconnet N: Parenteral with enteral nutrition in the critically ill. Intensive Care Med 2000; 26: 893-900.
14) Barr J, Hecht M, Flavin KE, Khorana A, Gould MK: Outcomes in critically ill patients before and after the implementation of an evidence-based nutritional management protocol. Chest 2004; 125: 1446-57.
15) Rice TW, Swope T, Bozeman S, Wheeler AP: Variation in enteral nutrition delivery in mechanically ventilated patients. Nutrition 2005; 21: 786-92.
16) Ferrie S, McWilliam D: Failure of a quality improvement process to increase nutrition delivery to intensive care patients. Anaesth Intensive Care 2006; 34: 191-6.
17) Bernstein LH, Ingenbleek Y: Transthyretin: its response to malnutrition and stress injury. Clinical usefulness and economic implications. Clin Chem Lab Med 2002; 40: 1344-8.
18) Lim SH, Lee JS, Chae SH, Ahn BS, Chang DJ, Shin CS: Prealbumin is not sensitive indicator of nutrition and prognosis in critical ill patients. Yonsei Med J 2005; 46: 21-6.
19) Raguso CA, Dupertuis YM, Pichard C: The role of visceral proteins in the nutritional assessment of intensive care unit patients. Curr Opin Clin Nutr Metab Care 2003; 6: 211-6.
20) Manning EM, Shenkin A: Nutritional assessment in the critically ill. Crit Care Clin 1995; 11: 603-34.
21) Swinamer DL, Phang PT, Jones RL, Grace M, King EG: Twenty-four hour energy expenditure in critically ill patients. Crit Care Med 1987; 15: 637-43.
22) Kan MN, Chang HH, Sheu WF, Cheng CH, Lee BJ, Huang YC: Estimation of energy requirements for mechanically ventilated, critically ill patients using nutritional status. Crit Care 2003; 7: R108-15.
23) Jeejeebhoy KN: Permissive underfeeding of the critically ill patient. Nutr Clin Pract 2004; 19: 477-80.
24) Lo HC, Lin CH, Tsai LJ: Effects of hypercaloric feeding on nutrition status and carbon dioxide production in patients with long-term mechanical ventilation. JPEN J Parenter Enteral Nutr 2005; 29: 380-7.
25) Pontes-Arruda A, Aragão AM, Albuquerque JD: Effects of enteral feeding with eicosapentaenoic acid, gamma-linolenic acid, and antioxidants in mechanically ventilated patients with severe sepsis and septic shock. Crit Care Med 2006; 34: 2325-33.
26) Martin CM, Doig GS, Heyland DK, Morrison T, Sibbald WJ; Southwestern Ontario Critical Care Research Network: Multicentre, cluster-randomized clinical trial of algorithms for critical-care enteral and parenteral therapy (ACCEPT). CMAJ 2004; 170: 197-204.
27) Burnham EL, Moss M, Ziegler TR: Myopathies in critical illness: characterization and nutritional aspects. J Nutr 2005; 135: 1818S-23S.
28) Heyland DK: Nutritional support in the critically ill patients. A critical review of the evidence. Crit Care Clin 1998; 14: 423-40.
29) De Beaux, Chapman M, Fraser R, Finnis M, De Keulenaer B, Liberalli D, et al: Enteral nutrition in the critically ill: a prospective survey in an Australian intensive care unit. Anaesth Intensive Care 2001; 29: 619-22.
30) Arabi Y, Haddad S, Sakkijha M, Al Shimemeri A: The impact of implementing an enteral tube feeding protocol on caloric and protein delivery in intensive care unit patients. Nutr Clin Pract 2004; 19: 523-30.
31) Chapman G, Curtas S, Meguid MM: Standardized enteral or-

ders attain caloric goals sooner: a prospective study. JPEN J Parenter Enteral Nutr 1992; 16: 149-51.
32) De Amici D, Klersy C, Ramajoli F, Brustia L, Politi P: Impact of the Hawthorne effect in a longitudinal clinical study: the case of anesthesia. Control Clin Trials 2000; 21: 103-14.
33) Behara AS, Peterson SJ, Chen Y, Butsch J, Lateef O, Komanduri S: Nutrition support in the critically ill: a physician survey. JPEN J Parenter Enteral Nutr 2008; 32: 113-9.