Nutrition of the critically ill patient and effects of implementing a nutritional support algorithm in ICU

Hilde Wøien CNS, MNSc
Doctoral Candidate, Department of Anaesthesia, Rikshospitalet-Radiumhospitalet HF National Hospital, Oslo, Norway

Ida Torunn Bjørk MNSc, DPol
Center for Shared Decision Making & Nursing Research, Rikshospitalet-Radiumhospitalet HF National Hospital, Oslo, Norway

Submitted for publication: 27 January 2005
Accepted for publication: 17 May 2005

Correspondence:
Hilde Wøien
Department of Anaesthesia
Rikshospitalet-Radiumhospitalet HF National Hospital
0027 Oslo
Norway
Telephone: 23072142
E-mail: hilde.woien@rikshospitalet.no

WØIEN H & BJØRK IT (2006) *Journal of Clinical Nursing* **15**, 168–177

Nutrition of the critically ill patient and effects of implementing a nutritional support algorithm in ICU

Aim. To test whether a feeding algorithm could improve the nutritional support of intensive care patients.

Background. Numerous factors may impede delivery of both enteral and parenteral nutrition to patients in the intensive care unit. Often there is a discrepancy between what is prescribed and actual delivery of nutrients. The purpose of this study was to test the effect of a nutritional support algorithm in an intensive care unit mainly by using the enteral route and if necessary by combining enteral and parenteral nutrition.

Methods. In this prospective study, nutritional data were collected from routinely fed critically ill patients (controls, $n = 21$) during the first three days following admission to the intensive care unit. A nutritional support algorithm was then implemented and nutritional data were collected from critically ill patients who participated in this intervention (intervention group, $n = 21$). Data collected included the total amount of calories prescribed vs. received, onset of delivery of enteral nutrition, enteral vs. parenteral nutrition, and the use and size of enteral feeding tubes.

Results. Patients in the intervention group were both prescribed and actually received significantly larger amounts of nutrients than patients in the control group. They also received a larger proportion of their nutrients in the form of enteral nutrition. In addition, the nutritional support algorithm led to greater consistency in nursing practices with respect to aspiration of gastric content and rate of increment in enteral feeding.

Conclusion. The study confirms that a nutritional support algorithm improved the delivery of nutrients to critically ill patients. The algorithm was most effective with respect to the delivery of enteral nutrition. The effect was primarily because of early and more rapid increment in the delivery of enteral nutrition administered by nurses based on improved physician orders. The combination of enteral and parenteral nutrition may contribute to meeting adequate nutritional requirements.

Relevance to clinical practice. By using a nutritional algorithm focused on enteral nutrition, but including parenteral nutrition as a supplement, it is possible to improve the delivery of clinical nutrition in the intensive care unit patients.

Key words: critical care, guidelines, nurses, nursing, nutritional protocols, quasi-experiment

Introduction

Adequate nutrition of intensive care unit (ICU) patients improves outcome, while malnutrition is strongly associated with increased morbidity and mortality rates among critically ill patients (Dempsey *et al.* 1988, Martin *et al.* 2004). This is due to a number of causes, including problematic weaning from ventilatory support (Pingleton 2001) and impaired immunological function (Stratton *et al.* 2002). ICU patients, whose nutritional requirements are properly met, are more likely to achieve reduced time on a ventilator, fewer complications and shorter time in rehabilitation (Galanos *et al.* 1997).

Malnutrition, while in intensive care, may be because of delayed onset of nutritional support and a lack of individually adapted nutritional prescriptions with regard to the patient's weight, recent nutritional history and actual caloric needs (McClave *et al.* 1999, Spain *et al.* 1999). In practice it is also difficult to deliver the patient's otherwise correctly prescribed nutrient. Causes may include interruption of nutritional support because of medical examinations and interventions, as well as uncertainty as to what constitutes an acceptable amount of gastric aspirate.

Thus, the purpose of this study was to test whether a feeding algorithm could improve the nutritional support of intensive care patients. The aim of the study was to answer the following questions:

1. Is there a difference in the nutritional volume delivered to intensive care patients who are fed according to a nutritional support algorithm compared with patients who receive routine care?
2. What effect does a nutritional support algorithm have on timing of nutritional intervention and increment to a desired nutritional volume?
3. How will a nutritional support algorithm influence the nurses' practice concerning use of enteral nutrition (EN)?
4. Will a combination of enteral nutrition (EN) and parenteral nutrition (PEN) better meet patients' nutritional requirements?

Literature review

Cinahl, Medline and Cochrane were databases primarily used for the literature review. Key terms were critical care, nutritional protocols, guidelines, quasi-experiment.

Nutritional status of ICU patients

In a follow-up study of 346 patients after intensive care more than 40% of the patients had experienced considerable (> 10 kg) weight loss during and after the ICU stay (Kvale *et al.* 2003). This indicates the importance of adequate nutritional support during hospitalization.

Patients who are malnourished before the onset of their illness and/or malnourished before acute complications set in should receive nutrition as quickly as possible. Patients who are unable to eat or drink by themselves for more than five to seven days should also receive nutritional support. The benefits encompass less time spent on respiratory support, shorter hospital stay, lower risk of infection, improved healing of wounds and decreased morbidity (Jolliet *et al.* 1998, Kompan *et al.* 1999, ASPEN Guidelines 2002).

Parenteral feeding vs. enteral feeding

When patients require nutritional support EN is preferred over PEN (Jolliet *et al.* 1998, ASPEN Guidelines 2002, Stratton *et al.* 2002). Early initiation is recommended within the first 24–48 hours when a patient has serious trauma, burn wounds or other high catabolic conditions. Early enteral nutritional support is crucial in order to maintain intestinal function and integrity (Heyland *et al.* 1993, Kompan *et al.* 1999, McClave *et al.* 1999). Marik and Zaloga (2001) also showed that early initiated nutrition significantly reduced the number of days in hospital and frequency of complications. Because of various reasons it is difficult to meet ICU patients' nutritional needs by means of enteral feeding alone (Adam & Batson 1997, Griffiths 1997, 2000, McClave *et al.* 1999). It is therefore recommended that a combination of enteral and parenteral feeding should be used in order to meet the patient's nutritional needs as well as to maintain the positive effects enteral feeding have on intestinal function (Davis & Taylor-Vasey 1997, McFie 2000, Griffiths 2001).

Practical problems in nutritional support

De Jonghe *et al.* (2001) documented three main practical reasons why the nutritional requirements of intensive care patients were not met. Firstly, gastrointestinal complications (diarrhoea, nausea, tense abdomen). Secondly, practical and diagnostic procedures interrupted feeding routines as, for example, with patient extubation/intubation or repositioning of the tracheal tube. Thirdly, failure of delivery systems, such as problems with infusion equipment, lack of intravenous access, blocked lines and wrongly placed tubes.

The amount of residual volume is an important measurement of gastrointestinal function. In McClave *et al.* (1999) study, high residual volume was the most common reason for lapses in enteral feeding. It is difficult to indicate the right amount of aspirate for protecting a patient against aspiration. There are other implications of large amounts of gastric aspirate, for example ventilated associated pneumonia (Metheny & Clouse 1997, Griffiths 2000, 2001). Until now there are no studies that conclude what is the maximum amount of residual volume for patients to prevent aspiration. Nurses' lack of methods of handling these problems often lead to reduced nutritional support (Swanson & Winkelman 2002).

Use of standardized nutritional support routines for intensive care patients

Studies reveal that the use of guidelines leads to better nutrition than when no guidelines are used (Dark & Pingleton 1993, Adam & Batson 1997, Griffiths 1997, Kennedy 1997, Spain *et al.* 1999, Adam 2000). A nutritional support plan delineates systematic and practical steps in delivering prescribed nutritional amounts that can be measured and evaluated. This in turn will benefit patients by producing better outcomes.

Summary

Extensive documentation reveals the importance of starting nutritional support in intensive care patients as early as possible. Enteral feeding should be prioritized but it is often necessary and correct to supplement this with parenteral feeding. Most intensive care patients are at risk of malnutrition and it is difficult to achieve the correct measurements of protein and caloric support. Various forms of standardized feeding schedules can help an ICU patient receive proper nutritional support.

Today many ICUs are familiar with several different nutritional protocols, but the ICU patients still do not receive adequate nutritional support. Firstly, this study focused primarily on the effect of implementing a nutritional support algorithm prescribing early EN. Secondly, the focus was on the use of the combination of both EN and PEN in order to meet the nutritional requirement adequately.

Methods

The study was a clinical experiment with one control and one intervention group. There was no additional teaching or special emphasis provided to the staff during the entire data collection period except the author's information concerning the use of the nutritional support algorithm. This information was given after data collection in the control group.

Subjects

Forty-two patients ($n = 42$) of both sexes admitted to a general ICU with mixed medical and surgical diagnoses were consecutively admitted for inclusion. Inclusion criteria: 20–70 years of age and duration of intensive care stay longer than four days. Exclusion criteria: patients were excluded when they moved from the ICU within four days or died.

Setting

An ICU unit staffed for caring for seven patients.

Intervention, data collection and allocation of treatment

The organizational plan for nurses made it difficult to randomize patients to the study. To avoid bias, nutritional data were therefore collected over a two-month period from 21 routinely fed ICU patients (controls), i.e. there were no existing protocols or written goals for clinical nutrition in the ICU unit. PEN and EN were prescribed by the doctors one to three days after admission. The staff was familiar with EN, but there was no written consensus that gave directions for advancement or stop in delivery of EN. The prescription of EN was ordered in millilitres per hour often as an interval, e.g. 20–30 ml/hour. There was no standard regime in the unit for using anti-emetics or pro-kinetics. To avoid bias we did not introduce these medications during the study. Then a nutritional support algorithm (Fig. 1) was subsequently implemented, and data were collected over the next two-month period from another 21 patients (intervention group).

Nutritional support algorithm

A nutritional support algorithm (Fig. 1) was formulated based upon an Australian study (Anderson & Jennings 2001) as well as two UK nutritional support algorithms published in 1990 (Adam *et al.* 1990). The algorithm was developed as a simple flow chart focusing on the advancement of EN because it was thought that this was where there was potential for improvement in practice (see textbox Fig. 1).

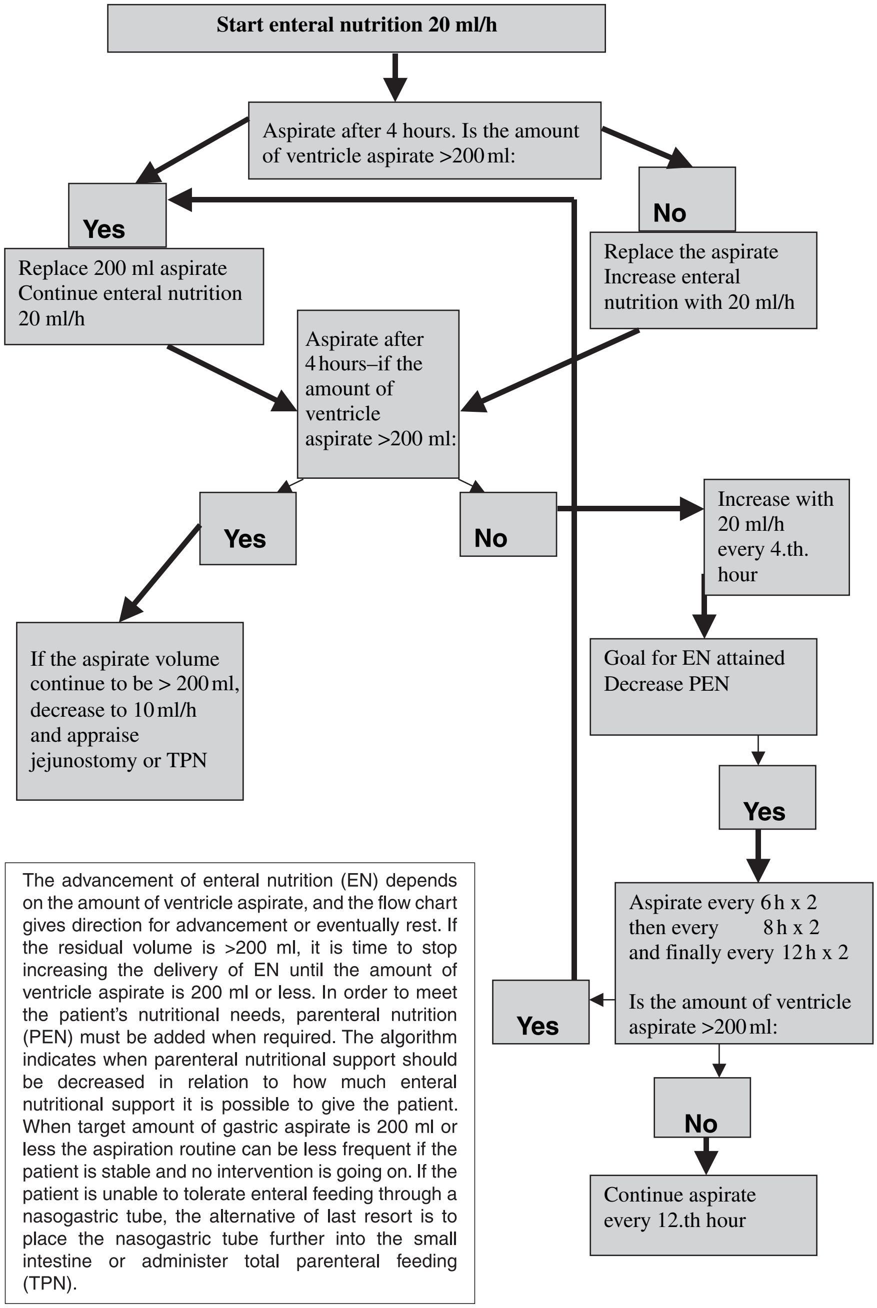

Figure 1 Nutrition support algorithm.

The algorithm in this study was based upon physician orders of a target calorific requirement of 30 kcal/kg/day for the intensive care patient and that nutritional support began within 24 hours after admission to the ICU.

Procedures and data collection

Nurses at another hospital pretested the nutritional support algorithm for two months to evaluate the practical application. The inclusion criteria were identical to the planned study and the results of the pretest did not produce any concern indicating the need to make any changes. Doctors' prescriptions of nutrients were in ml/day. The prescribed feeding for the control group followed routine practice, whereas the intervention group received orders for an increment according to the nutritional support algorithm to an individually defined maximum dose prescribed by the doctor. In Norway there are few dieticians and no tradition for using them in the ICU. The calorie requirement was therefore decided by the doctors.

The control/intervention regime was nurse-led. Every morning during the first three days after admission all variants of nutritional support were measured by the main researcher, i.e. total calories received vs. prescribed, time to nutritional intervention, rate of increment to prescribed amounts, use of nasogastric feeding tube, and use of enteral vs. parenteral nutrients. All nurses and doctors who took part in this experiment received a laminated, pocket-sized nutritional support algorithm card. In cases where the staff did not follow the algorithm, each nurse and/or doctor reported the reason on a deviation chart. Nutritional support was to be given continuously to both the control and intervention group. In the study, the first author registered all forms of nutritional data.

Data analysis

All nutritional solutions, as well as dextrose solutions > 5%, were calculated in kilocalorie and recorded as nutritional support. Some medications include fat. Given in high doses this will affect the prescriptions of nutrients. In this publication the set of data do not include these medications. Student's *t*-test was used in the analysis for continuous variables. To study the distribution of EN days 1, 2 and 3 after admission, Pearson chi-square test was used. The software program, SPSS version 11·0 was used for the analysis (SPSS Inc., Chicago, IL, USA). The significance level was set at 5% ($P = 0.05$).

Ethical issues

The nutritional support algorithm was not a trial of a new treatment but rather an intervention based on well-documented international research. This was defined as quality improvement in practice. According to national rules, it was therefore not necessary to apply for approval from the Regional Ethics Committee. Physicians and nurses in the department where the study took place were informed both verbally and in writing before data was collected for the intervention group. Informed consent was gathered from all the nurses who worked in the unit. Permission to perform the study was obtained from the department manager and hospital administration. All patient information was handled confidentially.

Results

Demographic data

There were 21 patients in each group. No significant differences were observed between the two groups with regard to gender, diagnosis and age (Table 1).

Table 1 Distribution of patients between the two groups

	Intervention	Control	*P*-value
Gender			
Women	10	8	0·533
Men	11	13	
Total	21	21	
Diagnose			
Neurosurgery*	12	12	0·645
Gastrosurgery†	3	5	
Medical diseases‡	6	4	
Total	21	21	
Age Mean (SD)	52·9 (14·3)	53·8 (13·1)	0·832

*Patients treated with neurosurgery.
†Patients treated with gastrointestinal surgery.
‡Non-surgical patients with different medical conditions.

Nutritional support

Nutritional support was delivered in three ways: PEN only, EN only or a combination of PEN and EN (Fig. 2).

Sixteen (76·2%) patients in the intervention group and 14 (66·7%) patients in the control group began nutritional support during the first day after admission. Of these, 12 (57·1%) in the intervention group and seven (33·3%) in the control group received enteral feeding either alone or in combination with PEN feeding. After two days, all patients in the intervention group and 14 (66·7%) in the control group received EN feeding. In the control group, seven (33·3%) of the patients were given PEN support alone for the first three days after admission. The intervention group was more likely to receive either EN feeding alone or in combination with PEN feeding than the control group ($P < 0{\cdot}001$). This difference persisted on day 3 ($P < 0{\cdot}032$).

Relationship between prescribed and received total amount of nutritional support during the first three days after admission

The average nutritional amount that was prescribed and received for the two groups was calculated in kcal/kg/day for the first three days combined and for the third day specifically. The third day was seen as a reasonable time to review the intensive care patient's nutritional support schedule. We were therefore interested in studying the nutritional amount given at day 3 after admission.

Overall, patients in the intervention group received more kcal/kg/day than the patients in the control group (Table 2). By registering nutrition orders, discrepancies between prescribed and received nutritional amounts were made more visible, making it possible to see to what degree the nutritional needs of

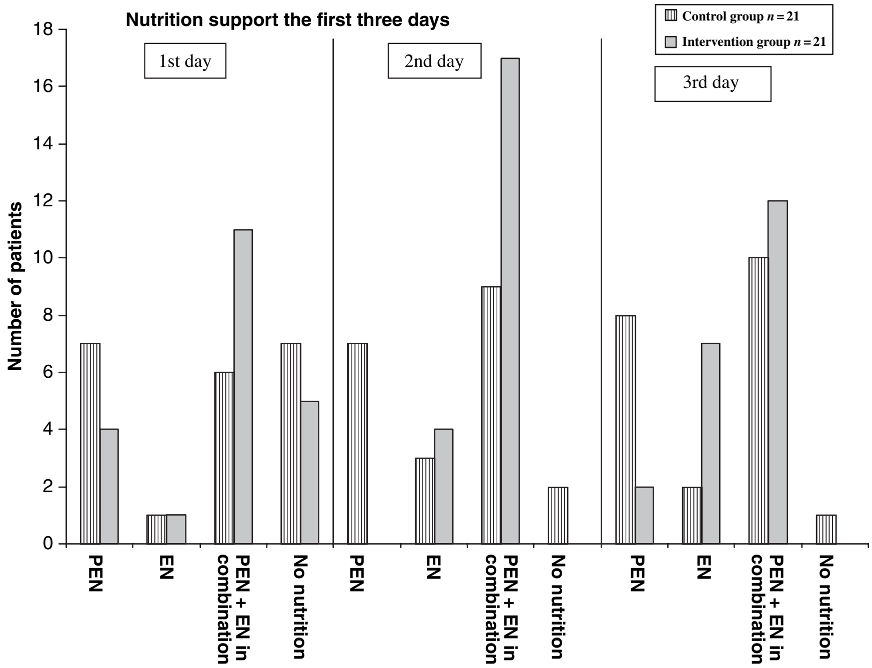

Figure 2 Division of parenteral (PEN) and enteral (EN) delivery of nutritional solutions during the first three days after admission.

the intensive care patient were actually met. Prescribed amounts in the control group were 61·1% of daily nutritional requirements. Received amounts were 84·2% of the prescribed amounts, indicating that patients received 51·7% of their ideal daily intake. Prescribed amounts for the intervention group were 82·2% of their daily caloric needs. Received nutritional amounts were 81·6% of the ordered amount, which corresponds to 69% of the ideal requirements.

On the third day after admission, patients in the intervention group received more kcal/kg/day compared with the control group (Table 3). Both prescribed and received nutritional amounts increased by more than 7 kcal/kg/day per patient in the intervention group and prescribed amounts were close to the ideal amounts. The difference between prescribed and received nutritional amounts was lower in the control group and further away from ideal amounts.

Enteral nutrition

The nutritional support algorithm provided specific guidelines for the advancement of enteral feeding. Two days after admission there was only one patient in the intervention group who had not started EN (Table 4). In the control group there were seven patients. There were significantly more patients who had started EN in the intervention group compared with the control group ($P = 0.018$).

Table 2 Relation between the average prescribed and average total nutritional amount received during the first three days

	Intervention ($n = 21$) Mean kcal/kg/day (SD)	Control ($n = 21$) Mean kcal/kg/day (SD)	Difference	95% CI	*P*-value
Prescribed nutrition	24·2 (6·9)	18·4 (6·8)	−5·8	−10·1 to −1·5	0·009
Delivered nutrition	20·1 (7·2)	15·5 (7·2)	−4·6	−9·1 to −0·1	0·047

Table 3 Relation between average prescribed and average received nutritional amounts for the third day

	Intervention ($n = 21$) Mean kcal/kg/day (SD)	Control ($n = 21$) Mean kcal/kg/day (SD)	Difference	95% CI	*P*-value
Prescribed nutrition	29·1 (9·7)	21·1 (9·3)	−7·9	−13·8 to −2·0	0·010
Delivered nutrition	24·7 (9·2)	17·5 (10·5)	−7·2	−13·4 to −1·0	0·023

Table 4 Number of patients who began with enteral feeding the first, second and third day after admission. (*P*-value = 0.018)

Day after admission	Control ($n = 21$)	Intervention ($n = 21$)
1	7	12
2	5	8
3	2	0
Total	14	20

Prescribed vs. received amounts of enteral feeding on the third day

The nutritional support algorithm aimed at stimulating a rapid increment in the amount of EN received by the patient. This effect was measured by comparing prescribed and delivered amounts of enteral nutrients on the third day after admission.

On the third day after admission, prescribed enteral nutritional support for patients in the control group was less than a quarter of their total daily requirement (Table 5). Of this amount, patients received only 72·4%. In the intervention group, prescribed amounts of EN were nearly three times higher than the control group, and the patients received 80·8% of this amount.

Practical nursing procedures

A prerequisite of the study was that the nurses should follow the nutritional support algorithm for the intervention patients who were included in the study. Of 21 patients who were included, the algorithm was used in 19 patients. One patient was unable to tolerate EN the third day after admission and another patient tolerated a maximum of 50 ml EN per hour.

Reasons for interruptions in nutritional support were lack of feeding pumps, vomiting/distended abdomen, surgery, computed tomography, tracheotomy and waiting for a new feeding tube. In the intervention group, 16 interruptions were registered while in the control group there were 28 interruptions registered. Reasons for interruptions in the control group were poorly documented.

The type of tube used was registered in order to exclude group differences in whether a total absence of tubes hindered enteral feeding or if various tube types could influence aspiration routines (Table 6). Only one of the 42 patients included in the study had no tube. Thus, absence of a feeding tube did not explain the method of delivery of nutritional support. Tube type was also divided evenly between the two groups and it is reasonable to assume that similar aspiration conditions existed in both groups. Eighty-four withdrawals of gastric content were registered in the control group and on eight occasions the amount of aspirate was over 200 ml. In the intervention group, there were 185 aspirations, because the nutrition algorithm directed more frequent checking of gastric content. In 31 cases the amount was more than 200 ml. Examination of the data provides no explanation for why this happened more often in the intervention group.

Table 6 Type of tube

	Intervention	Control
Ventricular tube	15	12
Nasogastric tube	5	7
Nasoduodenal tube	1	1

Discussion

Effects of a nutritional support algorithm on delivery of nutrition

The patients in the intervention group were prescribed and given significantly more calories in relation to their body weight than the control group. This was true for both the first three days after admission and for the third day. These results confirm previous research findings that indicate a positive effect of following a standardized nutritional plan on prescribed and delivered nutrition (Adam & Batson 1997, Griffiths 1997, Spain *et al.* 1999, De Jonghe *et al.* 2001, Stratton *et al.* 2002).

In this study a combination of EN and PEN was used in order to meet the patient's nutritional requirement. PEN was to be added when required and the algorithm indicated a decrease in PEN depending on how much enteral nutritional it was possible to give the patient. This focus on nutritional amount in general may also have contributed to the positive effects in the intervention group.

Table 5 Averages of received and prescribed amounts of enteral nutrition on the third day after admission

	Intervention ($n = 21$) Mean kcal/kg/day (SD)	Control ($n = 21$) Mean kcal/kg/day (SD)	Difference	95% CI	*P*-value
Prescribed	1466·0 (608·3)	512·0 (526·1)	−953·9	−1308·8 to −599·0	< 0·001
Delivered	1185·4 (650·1)	370·9 (456·1)	−814·5	−1164·8 to −464·0	< 0·001

Bauer *et al.* (2000) found that supplementing EN with PEN enhanced intensive care patient energy intake significantly the first week after admission. The aim of both Bauer's and this study was to combine PEN and EN in order to meet the intensive care patients' energy needs at an early stage. The conclusion of the Bauer *et al.* study, however, was that this did not have any clinical effect on the patients' short-term and long-term mortality or length of ICU stay. This contradicts other studies that claim that adequate caloric supplements reduce mortality and hospital stay (Dempsey *et al.* 1988, Heyland *et al.* 1998, Martin *et al.* 2004).

Patients who were fed according to the nutritional support algorithm received more of both prescribed and delivered EN on the third day compared with patients who followed routine practice. In the study of Spain *et al.* (1999), patients following an enteral nutritional algorithm also received significantly more EN on the third day after admission. The authors did not assess possible combinations of parenteral and enteral nutritional support, and the study only focused on the average delivery of EN during the patient's entire intensive care stay. Other studies that measured the effects of implementing a standardized nutritional plan have also excluded all patients who received parenteral nutritional support (Adam & Batson 1997, McClave *et al.* 1999, Pinilla *et al.* 2001). Therefore they are not exactly comparable with the present study.

Effect of a nutritional support algorithm on the timing and increment of nutrition

The results of our study show that nutritional support after the first two days reached target levels in both groups. In the Spain *et al.* (1999) study 57% of the patients in the intervention group began with EN within 72 hours vs. 14% in the control group. These are poorer results than in the present study where 95% of patients in the intervention group began EN within 48 hours compared with 57% in the control group.

The third day was seen as a reasonable time to finish the incremental phase and establish a nutritional regimen that fulfilled the intensive care patient's nutritional requirements. We could demonstrate a rapid increment in the intervention group. This group also received significantly more EN. The importance of intensive care patients quickly receiving adequate nutrition, so as to avoid serious complications from a long-term catabolic state, has been documented (Webb *et al.* 1999, Barendregt & Soeters 2000). Our results demonstrate the effect of our algorithm in obtaining target levels rapidly. To our knowledge there is no similar documentation in the literature.

Influence of the nutritional support algorithm on nurses' practice

In the control group, practice varied with respect to the nurses' personal consideration of supplying incremental amounts of EN. Nurses interpreted orders differently, and the rate of increase in enteral nutritional support was often connected to the amount of gastric aspirate and they did not have any aspiration routines. Practice was based on the nurses' evaluation of what was considered to be acceptable gastric content, and how enteral nutritional support should be supplied in relation to this. Interruptions in enteral nutritional support were closely connected to the lack of aspiration routines, which in turn were a direct reason that prescribed nutritional amounts were not delivered to the patient. This also help explain why there were several more interruptions in nutritional support in the control group than in the intervention group and why the control patients received less nutritional support. Five studies confirm this relationship. All conclude that some of the interruptions were unnecessary and that improved nutritional routines would resolve the problem (Adam & Batson 1997, McClave *et al.* 1999, Spain *et al.* 1999, De Jonghe *et al.* 2001, Pinilla *et al.* 2001).

In the intervention group there were several large amounts of aspirate over 200 ml. One explanation of why this did not lead to reduced nutritional support can be attributed to the nutritional support algorithm's specific guidelines about both reducing and increasing nutritional amounts. In the study of McClave *et al.* (1999), there were significantly fewer patients who had residual volumes >200 ml, but nevertheless enteral feeding was stopped in 45% of the cases with less than 200 ml to aspirate. Adam and Batson (1997) did not record the number of aspiration attempts in their study but their results indicate that intensive care patients have the largest amounts of aspirate, about 200 ml per procedure, on the second and third day after admission and thereafter drop to a stable level of around 100 ml per procedure.

The medical orders for EN in the control group were given as an interval, for example 20–60 ml/hour, leading to imprecise and vague nutrition orders. One finding of this study seems to be that nutrition is not seen as a medical intervention along the same lines as other delegated orders. In the intervention group, nutrition orders were three times higher compared with the control group. By following a nutritional support algorithm, it appears that the nurses and doctors had a useful tool to work with in prescribing intensive care patients' nutritional requirements.

Limitations of the study

The control and intervention groups were not treated simultaneously because of fear that nurses might confuse feeding protocols in patients belonging to the control and intervention groups respectively. This type of bias could have hindered a true measurement of the effect of the nutritional support algorithm. The sizes of the groups are small and they were followed for only four days. Another limitation is that implementation of the nutrition support algorithm may have focused on the topic of nutrition in critical care in general. This may have biased the study in favour of the intervention group.

Conclusion

The nutritional support algorithm appears to have resulted in meaningful improvements in the care of intensive care patients' nutrition in several areas. Firstly, the results indicate that the prescribed and delivered nutrition amounts were significantly higher in the intervention group than in the control group. Secondly, the algorithm encourages early initiation and rapid increment of nutritional support in general and in EN specifically. Finally, the results show that the nurses practiced less arbitrarily concerning the execution of nutrition orders and aspiration routines for the intervention group.

Future studies should examine the effects of nutrition orders for intensive care patients to be specified as number of kcal/kg/day for each patient, so that nurses can deliver nutrition with a clearly defined goal and by the route (PEN and/or EN) best suited for the patient according to relevant guidelines. There is a need for more studies that combine PEN and EN. A lack of responsibility for nutritional therapy or a lack of teamwork might cause inadequate nutrition in the ICU. Increased focus on education is important in order to improve nutritional care for patients and should also be the focus for future studies.

Contributions

Study design: HW; data analysis: HW; manuscript preparation: HW, ITB.

References

ASPEN Guidelines (2002) Guidelines for the use of Parenteral and Enteral Nutrition in adult and pediatric patients. *Journal of Parenteral and Enteral Nutrition* **26**, Supplement January–February 2002.

Adam S (2000) Standardization of nutritional support: are protocols useful? *Intensive and Critical Care Nursing* **16**, 283–289.

Adam S & Batson S (1997) A study of problems associated with the delivery of enteral feed in critically ill patients in five ICUs in the UK. *Intensive Care Medicine* **23**, 261–266.

Adam S, Armstrong RF, Bullen C, Cohen SL, Scott AL, Singer M & Webb AR (1990) Critical Care Algorithm. Enteral and parenteral nutrition. *Clinical Intensive Care* **2**, 252–255.

Anderson A & Jennings CE (2001). ICU enteral nutrition algorithm. In *Proceedings 23rd ESPEN Congress*, Münich, 2001.

Barendregt K & Soeters P (2000) Stress starvation. In *Basics in Clinical Nutrition*, 2nd edn (Sobotka L ed.). Edited for ESPEN Courses. Publishing House Galén, Czech Republic.

Bauer P, Charpentier C, Bouchet C, Nace L & Gaconnet N (2000) Parenteral with enteral nutrition in the critically ill. *Intensive Care Medicine* **26**, 893–900.

Dark DS & Pingleton SK (1993) Nutrition and nutritional support in critically ill patients. *Journal of Intensive Care Medicine* **8**, 16–33.

Davis DA & Taylor-Vasey A (1997) Translating guidelines into practice. A systematic review of theoretic concepts, practical experience and research evidence in the adoption of clinical practice guidelines. *CMAJ* **157**, 408–416.

De Jonghe B, Appere-De-Vechi C, Fournier M, Tran B, Merrer J, Melchior J.P & Outin H (2001) A prospective survey of nutritional support practices in intensive care unit patients: What is prescribed? What is delivered? *Critical Care Medicine* **29**, 8–12.

Dempsey DT, Mullen JL & Buzby GP (1988) The link between nutritional status and clinical outcome: can nutritional intervention modify it? *American Journal of Clinical Nutrition* **47**, 352–356.

Galanos AN, Pieper CF, Kussin PS, Winchell MT, Fulkerson WJ, Harrell FE, Teno JM, Layde P, Connors AF, Phillips RS & Wenger NS (1997) Relationship of body mass index to subsequent mortality among seriously ill hospitalized patients. *Critical Care Medicine* **25**, 1962–1968.

Griffiths RD (1997) Feeding the critically ill – should we do better? *Intensive Care Medicine* **23**, 246–247.

Griffiths RD (2000) Supplemental nutrition, how much is enough? *Intensive Care Medicine* **26**, 838–840.

Griffiths RD (2001) Nutrition in intensive care: give enough but choose the route wisely? *Nutrition* **17**, 53–55.

Heyland DK, Cook DJ & Guyatt GH (1993) Enteral nutrition in the critically ill patient: a critical review of the evidence. *Intensive Care Medicine* **19**, 435–442.

Heyland DK, MacDonald S & Keefe L (1998) Total parenteral nutrition in the critically ill patient: a meta analysis. *JAMA* **280**, 2013–2019.

Jolliet P, Pichard C, Biolo G, Ciolèro R, Grimble G, Leverve X, Nitenberg G, Novak I, Planas M, Preiser J-C, Roth E, Schols A-M & Wernerman J (1998) Enteral nutrition in intensive care patients: a practical approach. *Intensive Care Medicine* **24**, 848–849.

Kennedy J (1997) Enteral feeding for the critically ill patient. *Nursing standard* **11**, 33–43.

Kompan L, Kremzar B, Gadzijev E & Prosek M (1999) Effects of early enteral nutrition on intestinal permeability and the development of multiple organ failure after multiple injury. *Intensive Care Medicine* **25**, 157–161.

Kvale R, Ulvik A & Flaaten H (2003) Follow-up after intensive care: a single center study. *Intensive Care Medicine* **29**, 2149–2156.

Marik PE & Zaloga GP (2001) Early enteral nutrition in acutely ill patients: a systematic review. *Critical Care Medicine* **29**, 2264–2270.

Martin CM, Doig GS, Heyland DK, Morrison T & Sibbald W (2004) Multicentre, cluster-randomized clinical trial of algorithms for critical-care enteral and parenteral therapy (ACCEPT). *CMAJ* **170**, 197–204.

McClave SA, Sexton LK, Spain D, Adams BA, Owens NA, Sullins MB, Blandford BS & Snider H (1999) Enteral tube feeding in the intensive care unit: factors impeding adequate delivery. *Critical Care Medicine* **27**, 1252–1256.

McFie J (2000) Enteral versus parenteral nutrition. *British Journal of Surgery* **87**, 1121–1122.

Metheny N & Clouse R (1997) Bedside methods for detecting aspiration in tube fed patients. *Chest* **111**, 724–731.

Pingleton SK (2001) Nutrition in chronic critical illness. *Clinics in Chest Medicine* **22**, 149–163.

Pinilla JC, Samphire J, Arnold C, Liu L & Thiessen B (2001) Comparison of gastrointstinal tolerance to two enteral feeding protocols in critically ill patients: a prospective, randomized trial. *Journal of Parenteral and Enteral Nutrition* **25**, 81–86.

Spain D, McClave S, Sexton L, Adams J, Blanford B, Sullins M, Owens N & Snider H (1999) Infusion protocol improves delivery of enteral tube feeding in the critical care unit. *Journal of Parenteral and Enteral Nutrition* **23**, 288–292.

Stratton RJ, Green CJ & Elia M (2002) *Disease-Related Malnutrition: An Evidence-Based Approach to Treatment*, Ch. 2. CAB International, Wallingford, UK.

Swanson RS & Winkelman C (2002) Special feature: exploring the benefits and myths of enteral feeding in the critically ill. *Critical Care Nursing Quarterly* **24**, 67–74.

Webb A, Shapiro M, Singer M & Surter P (1999). *The Oxford Textbook of Critical Care*. Oxford Medical, Oxford.