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# Quality control of parenteral nutrition in hospitalized patients

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ABSTRACT

*Objective:* For hospitalized patients requiring parenteral nutrition (PN), adequate nutritional support has a profound effect on hospital length of stay, morbidity, mortality, and complication rates. Inappropriate or inadequate nutritional therapy may worsen clinical outcome. The aim of this study was to investigate the compliance with nutritional guidelines for PN in a university hospital setting.

*Methods:* Over a 6-mo period, this monocentric study prospectively recruited 107 (41 women, 66 men) hospitalized medical and surgical patients requiring PN. Data on nutritional support were collected before nutritional counseling. Nutritional requirements were estimated on the basis of the European Society for Clinical Nutrition and Metabolism (ESPEN) Guidelines for Adult Parenteral Nutrition (2009).

*Results:* The mean patient age was 65 ± 1.4 y and the mean body mass index was 23.2 ± 0.5 kg/m$^2$. Only 75% of the caloric requirement was met. Multivitamin supplementation was adequate in only 37%, and for vitamin K in only 6% of cases. Trace element supplementation was adequate in only 35%. PN in complete agreement with the ESPEN guidelines was achieved in none of the patients.

*Conclusions:* In routine hospital practice, PN is generally not provided in compliance with established guidelines. To improve the quality of nutritional therapy, a nutritional support team should be established. Furthermore, there should be periodical training sessions in nutrition for medical and nursing staff, as well as in standard operating procedures.



## Introduction

Parenteral nutrition (PN) is a complex treatment modality providing intravenous nutrition to patients who cannot be fed orally and/or who are unable to meet their caloric requirements via the enteral route. In these patients, malnutrition is a frequent phenomenon with an overall prevalence of 25%, and up to 50% in specific cohorts such as oncology and geriatric patients [1,2]. PN is invasive, costly, and associated with potentially serious and harmful complications. A recent review of nutritional support teams highlighted the risks associated with PN, including infectious complications, fluid overload, hyperglycemia, refeeding syndrome, hyperlipidemia, azotemia, hepatic dysfunction, and respiratory failure [1]. On one hand, caloric overload may worsen underlying diseases and give rise to nutrition-related complications such as acute pancreatitis, liver failure, or refeeding syndrome. On the other hand, hospitalized patients lose weight and undernutrition worsens during hospital admission in the absence of adequate nutritional therapy [3]. PN has been shown to reduce morbidity in severely malnourished surgical patients and significantly decrease mortality in critically ill patients, regardless of its related infectious complications [4,5]. Moreover, there is cumulating evidence that treating malnutrition in these patients is also economically beneficial [6]. In this context, it needs to be stressed that the majority of physicians and surgeons

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have minimal training in clinical nutrition and PN [2], but often are responsible for its management and prescription. Guidelines for the use of PN have been developed by several nutrition societies, such as the German Society of Nutritional Medicine (DGEM) [7], as well as the European Society of Clinical Nutrition and Metabolism (ESPEN) and the American Society of Parenteral and Enteral Nutrition (ASPEN) [8,9]. A reduced dietary intake, together with an increased energy requirement, is the main cause of hospital undernutrition [10–12]. Treating malnutrition should, first of all, be based on the evaluation of the individual causes of malnutrition and should precede nutritional intervention strategies.

The aim of this study was to investigate the appropriateness of PN usage and compliance with nutritional guidelines for PN in a tertiary medical center without prior involvement of, and physician counseling by a nutritional support team (NST).

## Materials and methods

### *Patients and procedures*

We conducted a monocentric study in a university hospital setting after ethics committee approval. Over a period of 6 mo, 107 in-hospital patients aged between 24 and 88 y were prospectively recruited to this study from a tertiary medical center in northeastern Germany (11 units, four different internal and surgery departments). The patients were included consecutively after informed consent was obtained to assess their clinical data to determine whether they received total or supplementary PN. PN was prescribed by the medical staff of the different units without prior involvement of, or counseling by an NST, reflecting clinical routine practice in this setting.

### *Data collection*

Anthropometric data and clinical parameters, underlying disease that required hospitalization and PN, access for PN (peripheral venous or central venous) and supplementation of trace elements and vitamins, as well as calories prescribed and received, were collected when patients were enrolled. We also recorded whether PN was followed up with laboratory testing and clinical assessment to ensure the safety of nutritional therapy.

### *Calculation of the caloric requirement and adequate coverage*

The caloric requirements of each patient were estimated on the basis of the ESPEN guidelines taking into account disease activity and oral nutritional intake [13]. PN was considered to be adequate if the total administration covered 90% to 110% of the energy requirements calculated for each patient.

For calculating the recommended energy requirements, body weight was determined as adapted body weight [14] in obese patients (body mass index [BMI] $\geq$ 30 kg/m$^2$) and actual body weight for all other patients. During the initial visit, the amount of prescribed parenteral calories and total calories required was determined. In case of additional oral nutrition, the amount of calories ingested by mouth (including oral supplements), were registered by a 24-h recall. The nutrient analysis software OPTIDIET Version 4.2.1 (GOE, Linden, Germany) was used to calculate the energy supply of oral nutritional intake, assessed by the 24-h recall. The total amount of energy intake was calculated as sum of calories provided parenterally, as well as ingested orally.

In addition to the aforementioned parameters, we determined whether vitamins and trace elements were supplemented. The multivitamin supplement listed in our hospital does not include vitamin K. Therefore, all patients required additional vitamin K supplementation, the prescription and administration of which was recorded.

Patients on gastric tube feeding were excluded from the study.

### *Statistical analysis*

Statistical analyses were performed using PASW 18 (Predictive Analytics Software, Chicago, IL, USA) and Sigmaplot 11.0 (Systat Software Inc., San Jose, CA, USA). All Data presented as the mean ± SEM for continuous variables and as absolute or relative frequencies for categorical variables. Graphics were generated by Sigmaplot. Overall test's significance was set to a two-tailed *P*-value $< 0.05$. Values with $P < 0.05$ were labeled with one asterisk; $P < 0.01$ with two asterisks, and $P < 0.001$ with three asterisks in tables or graphs.

### *Ethical statement*

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human participants were approved by the hospital human research ethics committee. All included patients gave their informed consent.

## Results

The baseline characteristics of the 41 women and 66 men enrolled in the study are listed in Table 1. Baseline characteristics did not significantly differ between men and women. The mean age was 65 ± 1.4 y and mean BMI was 23.2 ± 0.5 kg/m$^2$ with different underlying diseases. Most of the patients included in the study (64.5%) suffered from malignant disease, predominantly of the gastrointestinal tract. In 13% acute (four patients) or chronic (nine patients) pancreatitis was the underlying cause of hospitalization. Eight patients suffered from liver cirrhosis; five showed acute or chronic renal failure. Other diseases (9.3%) were chronic inflammatory bowel diseases, short bowel syndrome, or gastroenteritis.

In 69% of cases, PN was administered via peripheral veins. In only 31% of cases, a central venous administration via port (24.3%) or central venous catheter (6.5%) was used for delivering PN.

In most cases, administration of PN covered the nutritional requirements only inadequately (Fig. 1). The caloric substitution was adequate in only 8.4% of all patients (11% liver disease, 15% pancreatic disease, 6% tumor disease, and 20% other disease). The mean caloric intake via PN was 942 ± 46.3 kcal/d. Of the patients, 77.6% received less than 90% of caloric needs (range, 34.8–88.3%) (n = 83; 78% with liver disease, 77% with pancreatic disease, 78% with malignancies, 100% with kidney disease, and 60% with other diseases). Hypercaloric nutrition with more than 110% caloric intake (range, 114.4–289.1%) was identified in 10.3% of patients (n = 15; 11% with liver disease, 8% with pancreatic disease, 16% with tumor disease, and 20% with other diseases). In this group of patients, the overnutrition led to a mean excess of 686 ± 119 kcal/d.

There is a difference in the coverage of the caloric needs between the peripheral and the central venous administration. Patients with a central venous catheter are more likely to achieve caloric needs than patients with a peripheral venous catheter (central venous, 96.3 ± 8.7% versus peripheral venous, 65.4 ± 3.2% coverage; $P = 0.01$). Furthermore, the proportion of overfeeding is higher in the central venous fed group (central venous catheter,

**Table 1**
Characteristics of the study population

| | All (N = 107) | Women (n = 41) | Men (n = 66) |
|---|---|---|---|
| Age (y) | 65.0 ± 1.37 | 67.58 ± 1.91 | 63.43 ± 1.86 |
| Height (m) | 1.70 ± 0.01 | 1.64 ± 0.01 | 1.74 ± 0.01† |
| Weight (kg) | 67.16 ± 1.37 | 64,71 ± 2.27 | 68.67 ± 1.71 |
| BMI (kg/m$^2$)* | 23.18 ± 0.45 | 24.05 ± 0.79 | 22.65 ± 0.53 |
| Albumin (g/L) | 24.12 ± 0.68 | 24.63 ± 1.06 | 23.78 ± 0.89 |
| Oral caloric intake (kcal/d) | 554.42 ± 39.78 | 484.02 ± 57.41 | 598.11 ± 53.29 |
| Parenteral caloric intake (kcal/d) | 941.50 ± 46.27 | 906.22 ± 79.22 | 963.41 ± 56.93 |
| Caloric requirement (kcal/d) | 2026 ± 42 | 1940.73 ± 74.16 | 2079.64 ± 49.19 |
| Coverage of caloric requirement (%) | 74.91 ± 3.73 | 75.90 ± 7.82 | 74.30 ± 3.65 |

All data presented as the mean ± SEM.
* BMI, body mass index in kg/m$^2$.
† $P < 0.001$ comparison between men and women analyzed by the Mann-Whitney-U-Test.

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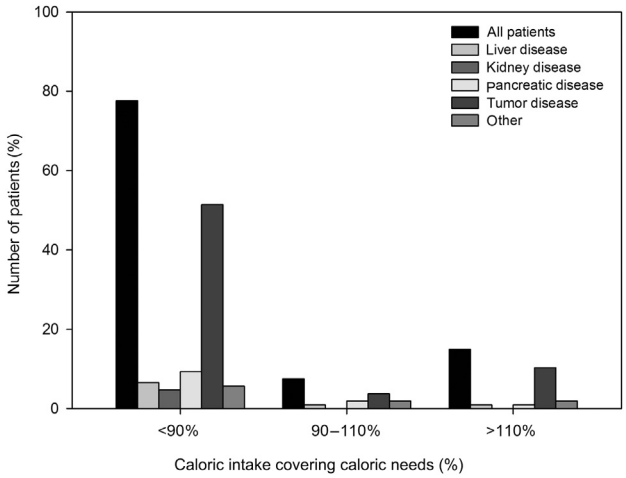


**Fig. 1.** Achieved caloric intake in percent of caloric needs via oral/enteral nutrition plus supplementary parenteral nutrition. Number of patients in percent covering < 90%, 90%–110%, > 110% of the calculated energy needs, according to the ESPEN Guidelines 2009, taking into account oral intake and physical activity level. Liver disease: cirrhosis of the liver; Kidney disease: acute and chronic renal failure; Pancreatic disease: acute and chronic pancreatitis; tumour disease: gastrointestinal malignancies; Others: chronic inflammatory bowel disease, short bowel syndrome, gastroenteritis.

30.3% versus peripheral venous catheter, 6.8%) as shown in Figure 2.

Supplementation with multivitamin preparations, which lack vitamin K, was prescribed in only 37% of patients on total parenteral nutrition (TPN). The missing vitamin K was substituted in only 6%, and trace elements in only 35% of cases (Fig. 3). Interestingly, in patients with peripheral venous nutrition, compliance with guidelines regarding micronutrients was greater (39% multivitamin preparation and trace elements, 6.8% vitamin K) and lower for central venous nutrition (27.3% multivitamin preparation, 33.3% trace elements, and 3% vitamin K), but the effect of application is not significant.

When the study population was divided into two groups with a cutoff value of 18.5 kg/m$^2$, a BMI of < 18.5 kg/m$^2$ was associated with a significant higher coverage of the energy supply than a

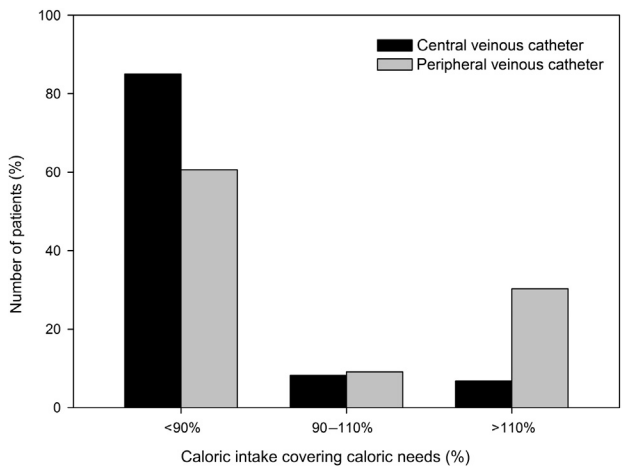


**Fig. 2.** Difference in covering the caloric needs according to application methods. Number of patients in percent covering < 90%, 90%–110%, > 110% of the calculated energy needs, according to the ESPEN Guidelines 2009, in regard to physical activity.

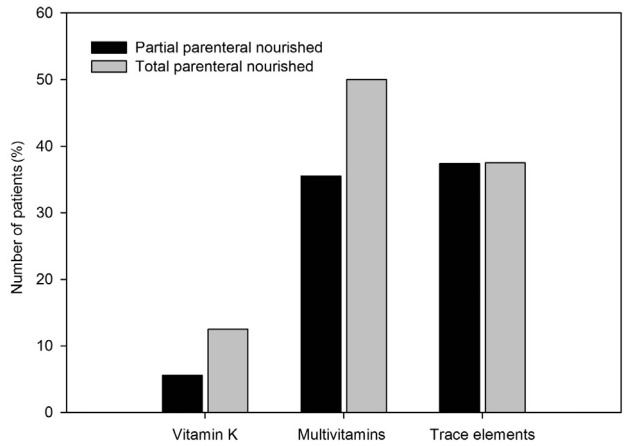


**Fig. 3.** Administration of vitamins and trace elements in patients with parenteral nutrition. Administration of trace elements and vitamins in percent of patients on total or additive parenteral nutrition.

BMI ≥ 18.5 kg/m$^2$ (101.8 ± 53.6 versus 69.1 ± 32; $P < 0.001$), indicating that obviously malnourished patients received more adequate nutritional therapy.

Of all participants, 15 received TPN. The energy supply of those was below the calculated energy requirements in 87% and in the remaining 13% above the required caloric need (Fig. 4).

Laboratory data that should be used to monitor PN according to the nutritional guidelines were assessed for magnesium in 5%, phosphate in 15.9%, triglycerides in 17.8%, calcium in 100%, albumin in 82.2%, glucose in 71%, and lactate in 26.2%.

## Discussion

The aim of this study was to determine PN practice in a tertiary referral hospital in northeastern Germany. Although an NST has been established at this hospital, our data demonstrate that in cases where the NST was not consulted, routinely

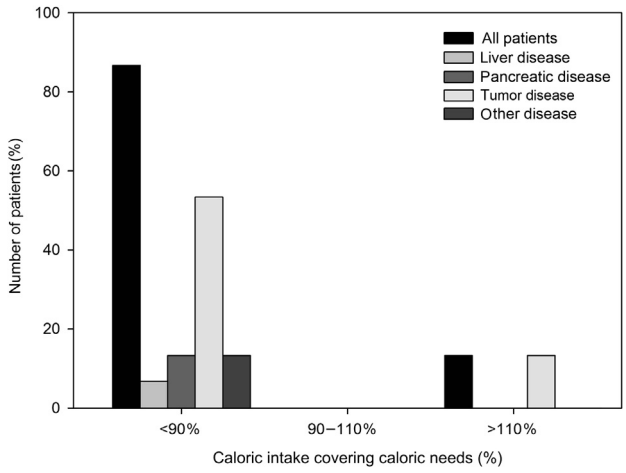


**Fig. 4.** Achieved caloric intake in percent of caloric needs of total parenteral nourished patients. Number of total parenteral nourished patients in percent covering < 90%, 90%–110%, > 110% of the calculated energy needs, according to the ESPEN Guidelines 2009, in regard to physical activity. Liver disease: cirrhosis of the liver; Kidney disease: acute and chronic renal failure; Pancreatic disease: acute and chronic pancreatitis; tumour disease: gastrointestinal malignancies; Others: chronic inflammatory bowel disease, short bowel syndrome, gastroenteritis.

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prescribed PN by the medical or surgical staff does not meet the caloric requirements in most cases. Given the fact that PN may potentially lead to serious side effects and over- as well as undernutrition carries significant risks, our data demonstrate an unmet clinical need and may be representative for other hospitals [15]. According to our data, the subgroup of patients with clinically evident cachexia receives more adequate nutritional therapy and is more likely to have its energy requirement met. In patients without clinically evident undernutrition or protein energy malnutrition, even though a significant weight loss and reduced oral caloric uptake were present, the caloric needs usually were not covered. This can have deleterious effects, especially in patients with uncontrolled malignancies [16,17]. Moreover, our data indicate that the route of PN determines the amount of prescribed caloric energy. A significant proportion of patients received intravenous nutrition as an additive peripheral infusion because oral/enteral nutrition could not cover caloric requirements. Still, in most patients with intravenous nutrition via a peripheral venous catheter, caloric requirements were not met. This was mainly because this route of PN requires application of high fluid volumes to cover nutritional needs, which seems to have raised concerns for prescribing physicians. Furthermore, it is much more time-consuming regarding repeated changes of infusion bags compared with TPN via a central venous line. It therefore must be stressed that nutritional management seems to be, at least in part, driven by factors that are unrelated to nutritional needs. Nevertheless, the difference in undernutrition between the peripheral and central venous group is only marginal. The amount of overnutrition therefore is slightly higher in the central venous group. This entails a higher risk for complications caused by overnutrition, especially when a monitoring of laboratory parameters is not undertaken. Another striking finding of this study was that in patients on PN, neither trace elements nor multivitamin preparations were routinely added to the PN regime.

Even when multivitamin preparations were prescribed, vitamin K was not added. This may lead to potentially serious side effects, such as deranged coagulation, especially in cases with concomitant liver disease and prolonged PN therapy.

## Conclusions

NSTs are used by some institutions to manage PN and control costs associated with this therapy [18]. These teams consist of clinicians or nutritionists with advanced training in nutritional support, and are assigned the responsibility of ensuring the safety and quality of nutritional therapy. Our data would support the employment of NSTs, as inadequate PN is not cost-effective and may impair clinical outcome. In routine hospital practice, PN is generally not provided in compliance with established guidelines. To improve the quality of nutritional therapy, an NST should be established, as it has the potential to reduce cost of care by minimizing inappropriate use, decreasing the mean duration of PN, and reducing the number of laboratory tests needed to monitor PN [19–21]. Furthermore, there should be periodical training sessions in nutrition for medical and nursing staff, as well as standard operating procedures.

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