Nutritional therapy during bone marrow transplantation. An overview

By Lena Normén, Ingvar Bosaeus and Tor Ekman

Summary

Bone marrow transplantation (BMT) is a treatment which often results in nutritional complications. Common conditions affecting dietary intake are mucosal membrane injuries, nausea, vomiting and anorexia. Dietary advice is therefore a necessary part of treatment.

The diet situation is complicated by the absence of international dietary guidelines for BMT. The dietary approach varies between hospitals. Most commonly patients receive sterile, low-microbial, modified or normal diet. In Sweden all hospitals use different diets. Based on the current literature the authors propose that a modified diet is preferable in the BMT-patients. Today there are no Nordic dietary recommendations for BMT patients. Dietitians in the Nordic countries have begun a co-operative effort to establish guidelines to standardize and improve the nutrition treatment of BMT-patients.

Sammanfattning

Näringsterapi vid benmärgstransplantation – en översikt

Benmärgstransplantation (BMT) är en behandling som ofta ger nutritionella problem. Vanliga tillstånd är slemhinneskador, illamående, kräkningar och anorexia. Kostrådgivning är nödvändig för de flesta BMT-patienter.

Situationen kompliceras av frånvaron av internationella riktlinjer för kostråd. Typen av näringsterapi varierar vid transplantationsenheter runt om i världen. Vanligtvis får patienterna en steril, låg-mikrobisk, modifierad eller normal kost. I Sverige används olika kosten vid olika sjukhus. Baserat på aktuell litteratur föreslår författarna en modifierad diet som mest lämplig i BMT-patienten. Idag finns inga nordiska kostrekommendationer för BMT-patienter. Dietister i de nordiska länderna har därför påbörjat ett samarbete för att sammanställa riktlinjer för att standardisera och förbättra näringsterapi vid BMT.

Introduction

Bone marrow transplantation (BMT) is a part of the treatment of haematological disorders as lymphoma, leukaemia, aplastic anaemia and thalassaemia. It is also used in the treatment of breast and testicular cancer. High dose chemotherapy, sometimes in combination with total body irradiation (TBI), eradicates tumour cells and suppresses the patients own haematopoiesis before transplantation where haematopoietic stem cells are infused. The cells are obtained from a sibling or matched unrelated donor (allogeneic transplantation), an identical twin (syngenic transplantation) or the patient himself (autologous transplantation). In an autologous transplantation the patient receives his own stem cells harvested and cryopreserved prior to the transplantation procedure. Complications include *graft-versus-host-disease* (GVHD), infections and relapse (1,2).

On admittance to hospital the BMT-patient receives a central venous catheter. The cytotoxic therapy (TBI and/or chemotherapy) is given daily for four or five days. One or two days later the patient is transplanted. The marrow transplant procedure is technically simple. Bone marrow is infused via the central venous catheter. Marrow cells pass through the lungs and then lodge almost exclusively in the marrow cavities. Within 2-4 weeks the donor marrow graft becomes functional, and platelets, leukocytes and red cells increase in peripheral blood. Intensive supportive care is required until marrow recovery. Patients receive prophylactics against gram negative, fungal and viral infection. The transplantation day is traditionally

called day 0 (3). The entrance day at hospital is subsequently called day -7 while the day of discharge usually is day 15-20 (Figure 1).

Nutritional complications are very common due to the use of cytotoxic therapy, drugs and GVHD. The conditions which directly cause these complications are mucosal membrane injuries (mucositis), nausea, vomiting and anorexia. Initially well-nourished patients may require total parenteral nutrition (TPN) during the whole period in hospital (2).

At present there are no Nordic dietary recommendations for BMT-patients. In Sweden allogeneic BMT is performed at four hospitals; Sahlgrenska University Hospital in Göteborg, Huddinge Hospital in

Figure 1. Treatment plan of BMT-patients.

Lena Normén, clinical nutritionist, Ingvar Bosaeus, MD, PhD, Department of Clinical Nutrition, Sahlgrenska University Hospital, Gothenburg.

Tor Ekman, MD, PhD, Department of Oncology, Sahlgrenska University Hospital, Gothenburg.

Correspondence: Lena Normén, Annedalskliniken, Sahlgrenska University Hospital, S-413 45 Gothenburg.

Stockholm, Lund University Hospital and Uppsala University Hospital. Dietary advice differs at all BMT-units in Swedish hospitals. Transplantations are expected to increase in the future. This is not only due to an improved donor register which increases the supply of matching donors but also an increased number of diagnoses where BMT is a possible treatment, for example in breast cancer.

There are limited data in the literature on nutrient intake and needs in BMT-patients. The aim of this paper is to describe the importance of a proper nutritional assessment in BMT-patients and reasons of using a modified diet in BMT-patients.

Complications and diet

Graft-versus-host-disease

The type of marrow transplantation is important in terms of intestinal and liver complications. The closer the genetic match between patient and marrow donor, the less likely is a reaction against the new marrow from the patient. This reaction is called *graft-versus-host-disease* and only occurs in allogeneic transplantation. Signs and symptoms usually appear between days 20-60 but can appear as early as day 7. Signs of chronic GVHD appear from 3 to 15 months after transplant (3).

In acute GVHD voluminous diarrhoea is a major sign which corresponds to the extent of intestinal mucosal damage and can vary from 0.5 L up to 10-15 L daily. The mortality in patients with moderate or severe GVHD is high (1). Adequate nutrition support is a vital adjunct to immuno suppressive drug therapy in the treatment of acute GVHD. In severe skin GVHD, energy and protein requirements may be greatly enhanced if total body surface involvement is greater than 50%. Fluid losses may be substantial and adequate fluid replacement is important. Patients with severe gastrointestinal GVHD require TPN and total gut rest until abdominal pain subsides and stool volume diminishes (1). Limiting oral intake is the only way to diminish diarrhoea (3). Total gut rest is defined as restriction of all foods and fluids, including free water and ice chips. After improvement different beverages can be introduced. Provided the patient remains symptom free, food items can gradually be introduced and TPN reduced. (1)

Chronic GVHD develops in 25 to 50% of patients with allogeneic transplantation. The symptoms include intestinal mucositis, oesophageal strictures, chronic liver disease and general wasting. Oral involvement occurs in most of these patients and includes reduced saliva flow and dental caries (1). A study by Lenssen et al in 1990 showed that in patients with chronic GVHD an energy intake of less than 85% of needs was reported in 40% (4). Today, in Sweden, there is seldom nutritional follow-up after discharge.

Diet as a preventive action on infectious complications

Viral, fungal and parasitic infections can produce diarrhoea similar to GVHD. Infectious complications such as septicæmia is a common cause of mortality. During the posttransplant period the patient's immune system is very compromised. The BMT-patient is vulnerable and needs protection from possible contamination. The most common ways are a sterile environment, isolation and prophylactic antibiotics. (1,2,3) Most BMT-units also have special dietary recommendations to keep the food as "safe as possible". The traditional dietary approaches used are a sterile diet, a low-microbial diet or a modified diet. Sometimes a normal diet without any restrictions is used.

A sterile diet means canned, irradiated or oven-baked food. All food items used have been microbiologically examined and prepared under very hygienic conditions (5).

Low microbial diet includes well-cooked food and elimination of food items which could contain pathogens. The food usually comes from the central kitchen of the hospital (6,7,8). The low-microbial diet is based on a survey performed by Pizzo et al in 1982 - a microbiological evaluation of food items where the method was bacterial counts. Food products were considered safe when microbiological cultures yielded less than 500 *Bacillus* species per gram or cubic centimetre after five days of incubation (6).

A modified diet has not been clearly defined in the literature but seems to consist of a quite normal diet with some high risk foods eliminated. The diet should be kept as normal as possible without foods well known to contain pathogens. Most often dietary restrictions concern fresh fruits and vegetables only. Fruit can be eaten if it is possible to peel. Vegetables and berries must be boiled.

Should a sterile, low microbial, modified or normal diet be used?

Today BMT units in Sweden use different types of diets. At Huddinge Hospital, Stockholm, a modified diet is used.

At the Karolinska Hospital only autologous transplantations are done and no dietary restrictions are imposed.

At the Department of Haematology, Sahlgrenska Hospital in Göteborg, a low-microbial diet according to Pizzo's principles have been used during the last ten years. Restrictions were, however, not based on Pizzo's evaluation of food items - the "forbidden foods" were selected by some of the doctors and the nurses in what they believed were high-microbial foods. The diet approach also differed according to treatment. Dietary recommendations were defined in four different patient categories, based on an

assumed variation in immune defence with treatment; 1) Patients treated only with chemotherapy, not isolated, 2) patients treated only with chemotherapy, isolated, 3) BMT-patients, autologous transplantation, isolated and 4) BMT-patients, allogeneic transplantation, isolated.

A modified diet means less restrictions than a sterile or a low-microbial one. Therefore it gives the patient more of a choice and a greater chance of actually finding tolerable food items. Isolation combined with antibiotic treatment has been proven to reduce the number of infections. Whether a sterile or a low-microbial diet has a greater protective effect than a modified diet has not yet been clarified (6,7). Doctors at Huddinge Hospital using a modified diet, however, claim that their BMT unit does not have a higher incidence of infections than other units.

We propose, based on the current literature, that a modified diet is preferable. BMT-patients are sensitive to infections irrespective of an autologous or allogeneic transplantation and should have the same dietary restrictions even if patients with an allogeneic transplantation have an increased risk of infection. An unrestricted, normal diet should not be recommended until studies have been done to establish safety.

Dietetic approach

Cooked foods are not well tolerated in BMT-patients. A better alternative would be to base the diet on "between-meal-foods" like sandwiches, Swedish thickened fruit juice soup, ice-cream and yoghurt. Addition of energy dense nutrition supplements is also recommended. This diet corresponds to a protein- and energy dense diet referred to as a modified diet with special qualities.

A study of Gavreau-Stern et al. describes the food intake of BMT-patients. The results showed that the food best tolerated can not be based on a normal diet served from the kitchen. The best intakes were reached with an *à la carte* system (2). To meet the special needs of BMT-patients and to get the contamination risk as low as possible the meals should be prepared as much as possible in the ward. The modified diet with special qualities is not an easy alternative but much can be gained by not using the traditional food from the kitchen.

It is however important to remember that most BMT-patients can not meet their dietary needs even with a full-time service of chefs and nutrition staff. The patients with severe complications hardly eat anything at all. The goal of the nutrition team should always be to help, appease and to do a follow-up of nutritional problems. Food has not only a physiological but also a psychological impact. It is an important part of life that should be taken special care of in isolated patients such as BMT-patients.

Table 1. Some characteristics among the patients.

	Sex	Age years	BMI ^a	Diagnosis	Transplantation Type	TBI ^b
Patient A	F	31	23	CML ^c	allogeneic	yes
Patient B	F	25	21	ALL ^d	autologous	no
Patient C	M	65	30	ALL	autologous	yes
Patient D	M	65	24	lymphoma	autologous	no

^a BMI=weight/(length)². ^b TBI=Total Body Irradiation.

^c CML=Chronic myeloid leukemia. ^d ALL=Acute lymphatic leukemia.

Nutrient requirements

Energy and protein

Energy and protein needs are generally estimated in BMT-patients. To estimate the energy need the *basal metabolic rate* (BMR) is multiplied with an activity factor and an injury factor. The activity factor is estimated as 1.2 as the patients are slightly mobile. The injury factor was used because of the metabolic stress induced by the disease and the BMT treatment. An injury factor of 1.2 for slighter surgery was estimated by *Jeejeebhoy* (9). This was considered to correspond to the lower range of increased metabolism for a BMT-patient (9,10). *Sandra Aker* of the Fred Hutchinson Cancer Research Centre states that the BMR can increase with as much as 80% (1). This corresponds to the higher range of energy need with an injury factor of 1.8 and depends on factors such as total body irradiation (TBI), fever, infection and GVHD.

Case studies of four patients (Patient A-D in Table 1) were performed during six weeks in March and April, 1995 at the Department of Haematology, Sahlgrenska University Hospital in Göteborg. Patient A, B and D participated in a partly weighed food registration during their hospital stay. Table 2 shows the average nutrient intake during each patient's stay (patient A: 20 days, patient B: 15 days, patient D: 15 days) and the estimated needs of energy and protein.

According to the two injury factors the range of energy need for patient A-D was 10.6-15.5 MJ/day (2400-3700 kcal/day). The registered energy intakes were 5.9-7.9 MJ/

day (1420-1900 kcal) per day. The food records showed that the major contributions to energy intake were sweetened beverages, 11%, bread products, 10%, milk products, 10%, parenteral nutrition, 27%, blood transfusions, 8% and glucose solutions, 10%. The energy balance was negative in all patients. There were some individual differences in energy distribution, but average values were 19 energy% from protein, 31% from fat and 50% from carbohydrates.

The recommended protein intake was 1.5-2.0 g/kg body weight/day, corresponding to 100-140 g/day for the investigated group (1). Average protein intake was 75 g/day.

BMT-patients experience metabolic stress which leads to hypercatabolism, e.g. protein breakdown (11). *Geibig* et al. showed an effect of an increased nitrogen intake in a group of BMT-patients with TPN. The study was a case-control study and the nitrogen doses were high in both groups; 19 g/day and 24 g/day. There was a positive nitrogen balance during almost the whole period of the study (the last five days it was slightly negative). The patients in the control group had a negative nitrogen balance during the whole period (11).

Too high nitrogen intake is not recommended as it entails discomfort, nausea and an increased serum-urea. Higher amounts than 0.25 g N/kg body weight/day does not give a higher retention according to Swedish recommendations of TPN (12). Today a higher input than 18 g/day is seldom used (13).

Ziegler et al. have suggested that nitrogen balance improves in BMT-patients with a

glutamine supplemented TPN. They observed that a glutamine supply improved nitrogen utilisation. Patients in the experimental group acquired less infections and had a shorter hospital stay (14). A glutamine supply could indeed be favourable by improving the access of energy for the intestinal mucosa and thereby decreasing the risk of an impaired gastrointestinal barrier function.

In most of the studies on glutamine support the supplemented groups tended to have a higher total nitrogen intake. It has not been thoroughly investigated whether it is the glutamine supplementation or the higher nitrogen dose by itself which improves nitrogen utilisation. Other aspects are improved fluid balance with glutamine supplemented TPN which could be related to fewer incidents of infections and less mucositis (15). In a pilot study of *Jebb* et al. the use of oral glutamine supplementation has been assessed. There was no significant difference in oral mucositis which was the measured parameter (16). Despite the results, oral glutamine supplementation might offer a protection against gastrointestinal mucositis. More studies are needed to establish the role of glutamine supplementation in nutrition support of BMT patients.

Nitrogen balance is also a question of energy intake. *Mulder* et al. showed that BMT-patients needed approximate 14.2 MJ/day (3400 kcal/day) to achieve nitrogen balance (17). If there is insufficient energy intakes protein will be utilised as an energy substrate instead. If the energy intake is improved the protein supply from food and blood transfusions should be adequate.

Importance of including transfusions in nutrient calculations

There is no tradition of including transfusion products in nutrient calculations. It might be argued that transfusion products are no real food, but is there really a major difference between the protein in TPN and erythrocyte concentrates? The protein in transfusion products improves the protein balance in two ways;

- 1) Erythrocytes and platelets decrease the protein requirements from food, TPN or enteral nutrition (EN). By replacing red cells and platelets the endogenous production of blood cells does not require as much protein as it otherwise would have done.
- 2) Breakdown of the transfusion products provides amino acids which can build up new protein or serve as an energy fuel.

In a study of surgical patients by *Sandström* et al. concentrates of erythrocytes were included when protein balance was measured in postoperative surgical patients. By doing

Table 2. Energy and protein intakes compared with requirements.

	Energy intake kcal/day	Energy requirements kcal/day ^a	Protein intake g/day	Protein requirement g/day ^b
Patient A	1860	2300-3500	85	100-130
Patient B	1900	2300-3500	90	100-130
Patient D	1420	2300-3500	70	110-140

^a The lower value is calculated according to the assumptions of *Jeejeebhoy*.

The higher value is calculated according to the assumptions of *Aker*.

^b The values are based on the recommendation 1.5-2.0 g/kg body weight/day

this they showed that the patients were in a slightly positive protein balance. Excluding the transfusions made the balance negative (18). This illustrates the importance of including transfusion products.

To investigate the importance of blood products as a protein source the erythrocyte and thrombocyte concentrates used at the Department of Haematology at the Sahl-grenska Hospital were analysed. The nitrogen content of erythrocyte concentrates was ≈ 36 g/L and in platelet concentrates 3.5 g/L, corresponding to 220 g protein/L and 20 g protein/L. An interesting finding was that the content of protein in the erythrocyte concentrates was 10 times higher than in the platelets. Nutrient calculations showed that patient A, B and D in the earlier mentioned case studies received a major part of their protein from the concentrates of red cells and platelets. Patient A's intake was 36 g/day which corresponds to 41% of her total protein intake. Patient B's intake was 24 g/day or 26%. Patient D had a high intake, 40 g/day and because of his low nutrient intake the protein from the blood products corresponded to 57%.

The transfusion samples were taken from five donors after preparation of concentrates. The figures should not be considered as very exact but give us an idea of the content. As patients A-D received 100 ml erythrocytes/day and 500 ml platelets/day during their active treatment the platelets also contributed with protein despite the relative low concentration.

Vitamins and minerals

Treatment of many haematological diseases last for a very long time, sometimes several years. During active treatment it is almost impossible to cover vitamin and mineral needs with hospital food because of the many side effects which the patients experience. There is also a possibility of an increased requirement of certain vitamins and minerals depending on the aggressiveness type of treatment. Of special interest are vitamins C, D, E and calcium.

Animal studies have shown that there is an impaired function of the cytochrome P450-system in animals on a diet low in vitamin C content (19). Cytochrome P450-system converts toxic substances into more water soluble ones and thereby promotes excretion. Vitamin C and E have antioxidative properties and it can be assumed that total body irradiation can increase the need of protection against free radicals. The requirements of vitamin C and E in BMT-patients should be investigated further before any new recommendations can be made.

Intakes of vitamin D and calcium should be evaluated together as they both have an important effect on bone mineralisation. Cortisone therapy is sometimes used to avoid

Table 3. Vitamin and mineral intake in patient A, B and D.

	Retinol equivalents μg	Vitamin C mg	Vitamin E μg	Vitamin D μg	Calcium mg
Average intakes	500	77	4.5	3.6	580
Recommended intakes, NNR*	800-1000	60	5-10	5-10	800-1000

*NNR-Nordic Nutrition Recommendations (20)

morbidity and mortality associated with chronic GVHD. Cortisone therapy is known to increase calcium excretion. Intake of vitamin D and calcium should at least meet national recommendations. This is to prevent an unnecessary large decrease in bone mass as lost bone mass is very difficult to regain (1). Again, this hypothesis is built on logical assumptions and further investigations are needed to clarify the connection between low intakes of vitamin D, calcium, cortisone therapy and loss of bone mass.

Nutrient calculations in the case studies show an example of intakes of the mentioned vitamins and calcium (Table 3). Vitamin D, E and calcium intakes are clearly below the lowest recommended intakes. The only nutrient which meets needs is vitamin C. Nutrient recommendations are made for healthy people. It is highly unlikely that the absorption and metabolism in BMT-patients with different degrees of mucositis receiving between 5-6 L of intravenous fluid support per day corresponds to the situation of a healthy person.

Supply of parenteral and enteral nutrition

Traditionally artificial nutrient supply in this patient group is almost always by the parenteral route. An enteral alternative has not been considered possible as the BMT-patient suffer from nausea, vomiting, oral mucositis and diarrhoea. However potential advantages could be gained using an enteral alternative because the parenteral nutrition also implies clinical problems. One of the major problems is overhydration which can lead to nausea, discomfort and dilution of serum proteins.

Mulder et al. compared a TPN treatment with a partly parenteral, partly enteral nutrition treatment (PPN/EN) in 22 patients. Both regimes were effective in maintaining body composition. There were no differences in number of days with vomiting. Diarrhoea decreased significantly in the PPN/EN group (17). Szeluga et al. compared TPN with an enteral programme (EN) in 57 patients. The enteral alternative was not as effective as the TPN programme in preserving the body composition but it gave less overhydration. The TPN programme gave more days with

diuretics, more frequent hyperglycaemia and more catheter complications. There were no differences in haematopoietic recovery, frequency of positive blood cultures, hospital stay or survival rate but TPN costs were 2.3 times higher than EN (21).

With support of the last two studies the conclusion is drawn that TPN is not the only alternative in nutrition treatment of BMT-patients. EN may be important in protecting the BMT-patient against gut-derived septic-aemia. Chemotherapy induces morphological and functional changes of the intestinal mucosa. Diarrhoea is probably a result of an increasing intestinal flow and electrolyte secretion from the damaged intestine. The presence of nutrients in the intestinal tract increases the motility, blood flow and proliferation of the intestinal cells. Intestinal atrophy impairs barrier function and protection against pathogenic bacteria (17).

EN might be offered as an alternative to TPN in consultation between the patient, physician and dietitian. In the study by Szeluga 10% could not tolerate EN because of vomiting and diarrhoea (21). If even 50% of the BMT-patients could accept an enteral alternative the money saved would make it possible to financially support an improved nutrition service from ward kitchens.

Nutritional status

Nutritional status in BMT-patients can be estimated by weight, height, body composition, haemoglobin, albumin, creatinine and protein in serum. Body composition is most frequently assessed by two different methods; bioelectrical impedance and anthropometry (15,22,23). There are limitations in the number of available methods due to the isolation. This is illustrated by the case studies of the four BMT-patients whose nutrition status also was followed during their hospital stay. Four anthropometric measures of skinfold thickness were performed; triceps skinfold (TSF), biceps skinfold (BSF), suprailiac skinfold and subscapular skinfold. (24). Patient A-D only decreased their body weight by 1.2 kg on average during the examination period. The anthropometric measures were used to calculate the body composition of the four subjects according

to Durnin (25). The patients were all clinically overhydrated with increasing skinfold thickness. According to the four measurements that were done during the hospitalisation period the skinfold sum increased from 42 to 60 mm for patient A, 48 to 59 for patient B and 53 to 60 mm for patient D. Patient C was the only one whose skinfold thickness decreased, from 81 to 71 mm. The suprailiac and subscapular skinfold varied greatly and thereby indicated the overhydration (variation 0-9 mm). TSF was at the same level during the whole study (variation 0-2 mm) while the BSF first decreased and thereafter increased at the end (variation 0-7 mm). One might argue that the energy balance was not clearly negative but considering the fluctuating anthropometric values this indicates a weight loss disguised by the relative overhydration. This is exemplified by patient D who lost more than 4 kg in one of his last days at the hospital. Anthropometry is not a method to recommend in patients who are overhydrated. Patient A-D were actively treated which made them even more overhydrated, indicated by the anthropometric values.

Bioelectrical impedance measurements gave varying results. The within-patient variation was 9-48% but the associated body weights only varied 2-6%. There was no consistency in the results. Impedance measurement was not satisfactory in the four patients. The method is based on the use of a single frequency current. Scheltinga et al. have reported better results using multi frequency impedance. Studies in healthy individuals show an agreement in results

between anthropometry and impedance (23,27). Catalano et al. did a case-control study on cancer patients undergoing no active antitumoural therapy. Impedance revealed an overhydration in the cancer patients compared to the healthy individuals. Decreasing values of resistance were shown to correlate with an increasing overhydration (26).

In patient A-D there was no logical decrease or increase of the impedance measurements in relation with the weight change which also was considered to indicate the overhydration. Single frequency bioelectric impedance was therefore considered not to be a suitable method for BMT-patients.

The serum parameters haemoglobin, albumin, creatinine and protein were used in the case studies as indicators of nutritional status. Haemoglobin was lower than the reference values during the whole study period. All four patients had a low value of haemoglobin because of their illness.

Serum albumin is a frequently used parameter to estimate malnutrition. It was low in all patients. Concentrates decreased two weeks after transplantation. This finding agrees with the findings of others (17). It could be explained by a transcapillary leakage which follows the cytotoxic therapy or simply reflect an acute phase response. A secondary effect is the toxic effect on the liver which might impair the capacity to produce protein. This theory combined with the relative protein deficiency could explain the low values of serum protein.

None of the methods seemed preferable in estimating changes in body composition of

BMT-patients. There is a need of a new method for effective measurements. The method should be easy to use with patients in isolation. The cost is also very important. The goal is to find a method dietitians can use as routine in examining the patients' nutrition status. Today without such a method problems arise in quality assurance of the nutritional assessment.

Nordic dietary recommendations for BMT-patients

Today there are no Nordic nutritional recommendations for BMT-units. Dietitians who work with BMT in Nordic countries have started a co-operative effort to develop nutritional recommendations for BMT-patients (first meeting was taken place in Göteborg on November 21 and 22, 1996). The goal of the Nordic recommendations is to standardise and improve the nutrition treatment. The guidelines in nutrition treatment should contain dietary advice during hospital stay and after discharge, recommendations of nutrition supplements and how to use them, treatment plans which also contain long term follow-up, suggestions on how to measure nutrition status, a definition of the modified diet with special needs and a motivation of reasons for using it and finally a parenteral/enteral programme. The recommendations should also be easily implemented and insure the quality of nutritional assessment. Thereby the importance of dietary treatment actually could be shown to lower costs and better the food situation for the BMT-patient.

References

1. Aker SN. Bone Marrow Transplantation: Nutrition Support and Monitoring. In: Bloch AS, ed. Nutrition management of the cancer patient. An ASPEN publication. ASPEN publishers Inc, Rockville, Maryland, USA. 1990;199-225.
2. Gavreau-Stern JM, Cheney CL, Aker SN: Food intake patterns and foodservice requirements on a marrow transplant unit. *J Am Diet Assoc* 1989;89:367-72.
3. Wolford JL, McDonald GB. A problem orientated approach to intestinal and liver disease after marrow transplantation. *J Clin Gastroenterol* 1988;10:419-33.
4. Lenssen P, Sherry ME, Cheney CL et al. Prevalence of nutrition related problems among long term survivors of allogeneic transplantation. *J Am Diet Assoc* 1990;90:835-42.
5. Swain JF, Hargleroad MJ: Minimal-bacteria diets: An assessment for implementation. *J Am Diet Assoc* 1976;69:258-61.
6. Pizzo PA, Purvis DS, Waters C: Microbiological evaluation of food items. *J Am Diet Assoc* 1982;81:72-9.
7. Aker SN, Cheney CL: The use of sterile and low microbial diets in ultraisolation environments. *JPEN* 1983;7:390-7.
8. Dezenhall, Cyrry-Bartley C, Blackburn SA, De Lamerens S, Khan AR: Food and nutrition services in bone marrow transplant centers. *J Am Diet Assoc* 1987;87:1351-3.
9. Nutrition requirements: Nutritional assessment and support. Ed. Grant A, Dehoog S. Seattle, USA. 1991.
10. Harris JA, Benedict FG: A biometric study of basal metabolism in man. Carnegie Institute, Washington DC, Printed by JB Lippincott Company Washington Square Press, Philadelphia, USA. 1919.
11. Geibig C, Ponting J, Mirtallo JM, Bowers D, Nahikian-Nelms M, Tutschka P: Parenteral nutrition for marrow transplant recipients: Evaluation of an increased nitrogen dose. *JPEN* 1991;15:184-8.
12. Mossberg T: Fullständig intravenös nutrition och vätskebehandling. Pharmacia, Sverige AB. 1993.
13. ASPEN Board of directors: Guidelines for use of total parenteral nutrition in the hospitalized adult patient. *JPEN* 1986;10:441-5.
14. Ziegler TR, Young LS, Benfell K et al: Clinical and metabolic efficacy of glutamine-supplemented parenteral nutrition after bone marrow transplantation. *Ann Intern Med* 1992;116:821-8.
15. Scheltinga MR, Young LS, Benfell K et al: Glutamine-enriched intravenous feedings attenuate extracellular fluid expansion after a standard stress. *Ann Surg* 1991;214:385-95.
16. Jebb SA, Marcus R, Elia M: A pilot study of oral glutamine supplementation in patients receiving bone marrow transplants. *Clin Nutr* 1995;14:162-5.
17. Mulder POM, Bouman JG, Gietema JA et al: Hyperalimentation in autologous bone marrow transplantation for solid tumors. Comparison of total parenteral versus partial parenteral plus enteral nutrition. *Cancer* 1989;64:2045-52.
18. Sandström R, Drott C, Hyltander A et al: The effect of postoperative intravenous feeding (TPN) on outcome following major surgery evaluated in a randomized study. *Ann Surg* 1993;217:185-95.
19. Hatchcock JN, Coob J: Ascorbic acid and drug metabolism. In: Nutrition and drug interactions. A monograph series. Academic Press. New York, San Francisco, Paris, London, 1978.
20. Statens livsmedelsverk. Nordiska Näringsrekommendationer. 1989.
21. Szeluga DJ, Stuart RK, Brookmeyer R, Utermohlen V, Santos GW: Nutritional support of bone marrow transplant recipients: A prospective randomized clinical trial comparing total parenteral nutrition to an enteral feeding program. *Cancer Res* 1987;47:3309-16.
22. Jebb SA, Elia M: Techniques for the measurement of body composition: a practical guide. *Int J Obes* 1993;17:611-21.
23. Lukaski HC, Johnsen PE, Bolonchuk WW, Lykken GI: Assessment of fat-free mass using bioelectrical impedance measurements of the human body. *Am J Clin Nutr* 1985;41:810-7.
24. Measuring obesity. Report and recommendations from a consultation on the epidemiology of obesity - classification and description of anthropometric data. Nutrition unit, WHO Regional Office for Europe. Copenhagen, 1987.
25. Durnin JVA, Womersley J: Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. *Br J Nutr* 1974;32:77-97.
26. Catalano G, Scarpato MDV, De Vita F et al: The role of bioelectrical impedance analysis in the evaluation of the nutritional status of cancer patients. *Adv Nutr Cancer* 1993;145-8.
27. Kushner RF, Schoeller DA: Estimation of total body water by bioelectrical impedance analysis. *Am J Clin Nutr* 1986;44:417-24. ■