Bone Marrow Transplantation (2003) 32, 715–721

www.nature.com/bmt

Parenteral Nutrition

Total parenteral nutrition *vs* oral diet in autologous hematopoietic cell transplant recipients

S Roberts[1], J Miller[2], L Pineiro[1] and L Jennings[1]

[1]*Baylor University Medical Center, Dallas, TX, USA; and* [2]*Meredith Corporation, Des Moines, Iowa, USA*

Summary:

Autologous HCT patients often have poor oral intake for 2–4 weeks post transplant. To compare outcomes between patients provided prophylactic total parenteral nutrition (TPN) or an oral diet (OD), 55 well nourished breast cancer/ hematopoietic cell transplantation (HCT) patients were randomized to TPN ($n = 27$), beginning day −1, or OD ($n = 28$). Parameters studied include length of stay (LOS), engraftment, infections, survival, weight, anthropometrics, handgrip strength, and quality of life (QOL) In all, 50% of OD patients were given TPN due to poor oral intake for 10 consecutive days. No significant differences were found between the groups for any of the above parameters except weight and anthropometrics, which were better maintained in the TPN group than the OD group. Trends were seen for increased infections, more stable handgrip strength, and improved QOL in the TPN group *vs* the OD group. Prophylactic TPN did result in a more intact nutritional status and preservation of lean body mass post transplant but did not impact LOS or survival when compared to OD. For this reason, TPN should be reserved for autologous HCT patients with pretransplant nutritional depletion, complications post transplant, or prolonged poor oral intake. These results should not be extrapolated to allogeneic HCT patients but are likely applicable to other well nourished autologous HCT patients.

Bone Marrow Transplantation (2003) **32,** 715–721. doi:10.1038/sj.bmt.1704204

Keywords: total parenteral nutrition; autologous; breast cancer; nutritional status

The nutrition problems associated with high-dose chemotherapy and hematopoietic cell transplantation (HCT) are well known.[1–3] Most patients' oral intake is minimal for at least 2–3 weeks post transplant (posttx) and use of total parenteral nutrition (TPN) during this period is common. The preparative regimens utilized at our center typically result in significant pancytopenia and gastrointestinal (GI) toxicities, including mucositis, leading to the intuitive conclusion that TPN is necessary. Weisdorf *et al*[4] showed that provision of prophylactic TPN was beneficial to marrow transplant recipients. At the time our study was initiated, TPN was a standard of care posttx at our center. However, since HCT for breast cancer (CA) is relatively new, no breast CA patients were included in the aforementioned trial. Also, several advances have been made since that trial was conducted (cytokine growth factors and peripheral blood stem cell transplants), which have shortened the neutropenic period in this patient population, which, in turn, may lead to more rapid return to normal GI function. While currently the use of autologous HCT in breast CA is controversial and not currently carried out at our center, interest in HCT for breast CA still exists.[5–8] This study was carried out to compare clinical, and nutritional outcomes, as well as sense of well-being and survival, in breast CA patients undergoing HCT randomized to an oral diet *vs* prophylactic TPN.

Patients and methods

A total of 55 females with stage II–IV breast CA undergoing high-dose chemotherapy and HCT were prospectively randomized to an oral diet (OD) ($n = 28$) or TPN ($n = 27$). Institutional Review Board approval was obtained for conducting this study and informed consent was obtained from all patients. All study patients were hospitalized during the chemotherapy, HCT, and neutropenic phases of treatment. The patients with stage II–III breast CA received cyclophosphamide (60 mg/kg × 3 doses) and thiotepa (300 mg/m^2 × 3 doses). Patients with stage IV disease received cyclophosphamide (60 mg/kg × 3 doses), thiotepa (300 mg/m^2 × 3 doses), and carboplatin (300 mg/m^2 × 2 doses). All patients were well nourished upon admission for HCT. Patients' admission nutritional status was assessed using a combination of diet and weight history, current weight, ideal body weight (IBW) as assessed using the Hamwi formula[9] and serum albumin levels.[1] Patients were considered adequately nourished if their body weight was $\geqslant 90\%$ of ideal body weight and/or usual body weight with absence of recent weight loss or poor oral intake, and serum albumin level $\geqslant 30$ g/dl. This albumin level was chosen because often the first albumin level obtained is on the second hospital day, after intravenous (i.v.) hydration has started, and decreased

Correspondence: Dr S Roberts, 3911 Kramar Court, Arlington, TX 76016, USA. E-mail: susanro@baylorhealth.edu
Received 13 October 2002; accepted 6 April 2003

albumin levels are seen secondary to hemodilution. Patients who did not meet this critieria for being well nourished were considered undernourished and excluded from the study. Nutrient needs were assessed at 1.3–1.5 times basal energy expenditure (using the Harris–Benedict equation[10]) and 1.5–1.75 g of protein per kilogram body weight.[2] Adjusted body weight was used for calculating nutrient needs of patients significantly over ideal body weight. The following formula was used for adjusted body weight: ((actual weight−ideal weight) × 0.25) + ideal weight = adjusted body weight.[11]

The OD group was given standard i.v. fluids of either 5% dextrose or normal saline, whichever was appropriate. Patients in the OD group were given TPN if one of the following occurred: oral intake below 40% of nutrient needs for 10 consecutive days, weight loss of 10% of admit body weight, or need for mechanical ventilation.

TPN was initiated in the TPN group on the day prior to HCT (day −1). The TPN group also was provided i.v. fluids. The patients received a standard 3-in-1 admixture formula (17.5% dextrose, 5% amino acids, 10% lipids – final concentration) three times per week. The other 4 days, the patients received a standard 2-in-1 formula (25% dextrose, 5% amino acids – final concentration). Electrolytes were adjusted daily based on serum chemistries. Vitamins and trace elements were added daily in recommended amounts. TPN was provided as a continuous infusion until the patients were close to discharge; then it was changed to a nocturnal infusion. Both groups were allowed to eat *ad libitum*. TPN was discontinued when the patients' oral intake met ⩾50% of nutrient needs for two consecutive days. Discharge criteria included absolute neutrophil count (ANC) >1000, afebrile off antibiotics, and able to tolerate ⩾50% of nutrient needs via oral intake. Data were collected on the following parameters:

1. *Patient characteristics*: Age, stage of disease, source of HCT (marrow or peripheral blood), and number of patients given TPN.
2. *Clinical outcomes*: Length of stay (LOS) for initial hospitalization, days to engraftment, incidence of infection (determined by positive blood culture), days on antibiotics, days of fever, and changes in total bilirubin and liver function tests (LFTs).
3. *Nutrition outcomes (from admission to day +30 post tx)*: Calorie and protein intake via oral and parenteral routes, number of days until oral intake met 66% of nutrient needs, body weight, handgrip strength (HGS), triceps skinfold, midarm muscle circumference, serum albumin level, and days on TPN.
4. *Sense of well-being*: A total mood disturbance was measured at admission, discharge, and day +30 posttx using the Profile of Mood States (POMS) self-questionnaire (EdITS/Educational and Industrial Testing Service, San Diego, CA, USA).
5. *Survival*: Overall survival until ⩾1 year posttx.

Data Analysis

All patients were analyzed in the group to which they had been randomized (intent-to-treat principle), even when nutrition support route was changed due to study criteria. A *t*-test was used to evaluate differences in age, days to engraftment, length of stay, days on antibiotics, days of fever, body weight changes, days on TPN, number of days until oral intake met >66% of nutrient needs, and nutrient intake. Repeated measures analysis of variance was used to evaluate changes in triceps skinfold, midarm muscle circumference, serum albumin levels, total bilirubin, LFTs, HGS, and sense of well-being. The Bonferroni multiple comparisons procedure was used to compare groups at each time point. Fisher's exact two-tail test was used to compare disease stage, source of HCT, and incidence of infection. Results are reported as the mean ± s.d. Survival analysis was made using Kaplan–Meier plots. A separate three-group analysis was also carried out, comparing the TPN group, the OD group, and the delayed TPN (DTPN) group, which included the patients randomized to the OD group who were ultimately placed on TPN. Statistical analysis was performed using version 6.12 of SAS software (SAS Institute Inc., Cary, NC, USA).

Results

Patient characteristics

Table 1 summarizes the patient characteristics, which were similar for the two treatment groups. One patient randomized to the TPN group consumed ⩾90% of her nutrient needs via oral diet throughout the study period and was never placed on TPN, but was analyzed with the TPN group. The investigators decided that TPN could not be justified medically or ethically in this patient. The three-group analysis also revealed characteristics to be comparable for all groups.

Clinical outcomes

Clinical outcomes for the three-group analysis were either not different (LOS, days to engraftment, infection) or were similar (total bilirubin and LFTs) to results found with the two-group analysis. LOS and days to engraftment were not different for the TPN and OD groups. LOS was 25.4 ± 4.3 days for the OD group and 28.7 ± 8.8 days for the TPN group (NS). Both groups engrafted (ANC >500) by 12.4

Table 1 Patient characteristics

Characteristics	*TPN group*	*OD group*
Number of patients	27	28
Mean age	41.6 ± 6.6 years	45.6 ± 7.3 years
Breast cancer disease stage	13 stage II–III 14 stage IV	10 stage II–III 18 stage IV
Source of transplant	3 peripheral blood 24 marrow	4 peripheral blood 24 marrow
Number of patients given TPN	26[a]	14
Number of days on TPN	17.5 ± 7.4	5.3 ± 5.9

TPN = total parenteral nutrition, OD = oral diet. Age is reported as mean ± s.d.
[a]One patient randomized to the TPN group never received TPN due to excellent oral intake.

days posttx. Table 2 contains the infection data. There were three *vs* no positive blood cultures in the TPN and OD groups, respectively. This did not reach statistical significance, but represents a trend toward more infections in the TPN group. Total bilirubin and LFTs were evaluated at admission, day −1, day +7, discharge, and day +30 (see Table 3). Both groups demonstrated a significant change over time in total bilirubin and LFTs ($P< 0.0004$ for total bilirubin and SGPT, $P<0.0002$ for alkaline phosphatase, GGT, and SGOT). Alkaline phosphatase ($P<0.05$), GGT ($P<0.005$), and SGPT ($P<0.05$) were significantly higher at day +7 in the TPN group. However, by day +30, there was no difference between the groups. Two patients in the TPN group and no patients in the OD group developed veno-occlusive disease (VOD) during the posttx period.

Nutrition outcomes

Tables 4 and 5 provide data on nutritional outcome data for the two- and three-group analyses. Unless stated, this section focuses on the two-group analysis since very similar results were found in the two-group and three-group analyses. Both groups had significant decreases in anthropometrics over time (weight $P=0.0001$, TSF $P=0.0003$, MAMC $P=0.017$). Additionally, there was a significantly higher weight loss and MAMC decrease in the OD group compared with the TPN group. The three-group analysis revealed a similar pattern, with all three groups having a significant decrease in weight ($P=0.0001$), TSF ($P=0.0004$), and MAMC ($P=0.0001$) over time. When comparing the three groups, weight and MAMC also decreased significantly more in the DTPN and OD groups compared to the TPN group. The TPN and OD groups each experienced a statistically significant decrease in right ($P<0.003$) and left ($P<0.02$) HGS from admission to day +30. Albumin levels were similar for both groups. A significant change over time in the albumin levels was seen for both groups ($P=0.0001$), but the change was not different between the groups. Based on the percent of body weight lost and loss of lean body mass from admission to day +30, the TPN group maintained their intact nutritional status while the OD and DTPN groups became depleted. The number of days patients received TPN was significantly higher ($P<0.0001$) in the TPN group compared to the OD group (17.5±7.4 *vs* 5.3±5.9 days). Of the OD group, 14 (50%) received TPN due to 10 consecutive days of oral intake at <40% of nutrient needs. The inadequate oral intake was usually due to severe mucositis. No difference was noted between the groups for the number of days posttx until oral intake met >66% of nutrient needs (OD – 19.9±6.0 days, TPN – 20.2±7.4 days, $P=0.89$). Nutrient intake was calculated for the entire study period (day of admission until 30 days posttx) by averaging the calorie and protein intake. Therefore, the nutrient intake reported includes the days with and without

Table 2 Infection data for TPN *vs* OD groups

Parameter	*TPN group (n=27)*	*OD group (n=28)*	*P-value*
Number of positive blood cultures	3	0	0.051
Number of days on antibiotics	20.8±6.6	17.7±4.5	0.045
Number of days with fever (temperature ⩾100.5°F)	10.2±6.4	8.0±6.0	0.19

TPN = total parenteral nutrition, OD = oral diet. Values are means±s.d.

Table 4 Nutritional outcomes for TPN and OD groups

Study group	*TPN (n=27)*	*OD (n=28)*
Weight (kg)	Admit: 67.5±13.4	Admit: 76.2±18.6
$P=0.0001$	Day +30: 66.4±13.8	Day +30: 71.3±17.7
	Decrease: 2%	Decrease: 6.5%
TSF (mm)	Admit: 28.6±6.8	Admit: 31.9±8.4
$P=0.79$	Day +30: 26.8±7.7	Day +30: 29.8±10.0
	Decrease: 6%	Decrease: 7%
MAMC (cm)	Admit: 20.9±3.2	Admit: 23.5±3.8
$P=0.02$	Day +30: 20.6±2.6	Day +30: 21.9±3.5
	Decrease: 2%	Decrease: 7%
Right HGS (pounds of force)	Admit: 58±13.7	Admit: 65.6±18.0
$P=0.28$	Day +30: 56.8±12.5	Day +30: 60.1±13.4
	Decrease: 2%	Decrease: 9%
Albumin (g/l)	Admit: 31±3	Admit: 32±4
$P=0.24$	Day +30: 35±6	Day +30: 37±4
Nutritional status	Admit: Intact	Admit: Intact
	Day +30: Intact	Day +30: Depleted

TPN = total parenteral nutrition, OD = oral diet, TSF = triceps skinfold, MAMC = midarm muscle circumference, HGS = handgrip strength. Values are means±s.d. *P*-values reported for differences between the groups in change over time.

Table 3 Total bilirubin and liver function tests for admit, day +7, and day +30

Liver function parameter	*Study group*	*Admit*	*Day +7*	*Day +30*	*P-value*
Total bilirubin (μmol/l)	TPN	6.8±3.4	22.2±20.5	18.8±29	NS
	OD	6.8±3.4	13.7±8.6	11.9±6.8	
Alkaline phosphataste (μkat/l)	TPN	1.1±0.3	1.6±0.6*	2.4±1.3	<0.05*
	OD	1.2±0.5	1.3±0.4	1.9±1.3	
SGOT (μkat/l)	TPN	0.52±0.22	0.43±0.27	0.65±0.39	NS
	OD	0.53±0.17	0.40±0.42	0.62±0.35	
SGPT (μkat/l)	TPN	0.65±0.35	0.68±0.49**	0.58±0.29	<0.05**
	OD	0.63±0.30	0.45±0.23	0.62±0.47	
GGT (μkat/l)	TPN	0.58±0.46	2.50±1.02***	2.40±1.75	<0.005***
	OD	0.68±0.39	1.63±0.94	2.17±3.91	

TPN = total parenteral nutrition, OD = oral diet, SGOT = serum glutamic-oxaloacetic transaminase, SGPT = serum glutamic-pyruvic transaminase, GGT = γ-glutamyltransferase, NS = nonsiginificant. Values are mean±s.d. *P*-values reported for differences between the groups.

Table 5 Nutritional outcomes for TPN, DTPN, and OD groups

Study group (P-value)	*TPN (n=27)*	*DTPN (n=14)*	*OD (n=14)*
Weight (kg)	Admit: 67.5±13.4	Admit: 71.7±12.9	Admit: 80.7±22.5
(*P*=0.0001)	Day +30: 66.4±13.8	Day +30: 67.7±12.0	Day +30: 75.0±21.9
	Decrease: 2%	Decrease: 6%	Decrease: 7%
TSF (mm)	Admit: 28.6±6.8	Admit: 29.9±7.4	Admit: 33.9±9.1
(*P*=0.82)	Day +30: 26.8±7.7	Day +30: 27.4±9.2	Day +30: 32.2±10.6
	Decrease: 6%	Decrease: 8%	Decrease: 5%
MAMC (cm)	Admit: 20.9±3.2	Admit: 22.9±3.7	Admit: 24.0±3.9
(*P*=0.05)	Day +30: 20.6±2.6	Day +30: 21.6±2.9	Day +30: 22.2±4.1
	Decrease: 2%	Decrease: 6%	Decrease: 7%
Right HGS (pounds of force)	Admit: 58±13.7	Admit: 65.0±18.9	Admit: 66.2±17.7
(*P*=0.32)	Day +30: 56.8±12.5	Day +30: 57.7±14.0	Day +30: 62.5±12.7
	Decrease: 2%	Decrease: 11%	Decrease: 6%
Albumin (g/l)	Admit: 31±3	Admit: 31±4	Admit: 33±4
(*P*=0.55)	Day +30: 35±6	Day +30: 36±3	Day +30: 38±5
Nutritional status	Admit: Intact	Admit: Intact	Admit: Intact
	Day +30: Intact	Day +30: Depleted	Day +30: Depleted

TPN=total parenteral nutrition, DTPN=delayed total parenteral nutrition, OD=oral diet, TSF=triceps skinfold, MAMC=midarm muscle circumference, HGS=handgrip strength. Values are means±s.d. *P*-values reported for differences between the groups in change over time.

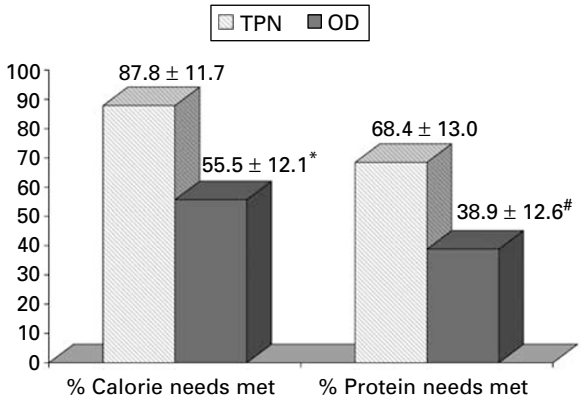

Figure 1 Percent of calorie and protein needs met by TPN and OD groups from admit to day +30. *$P<0.001$, $P<0.0001$.

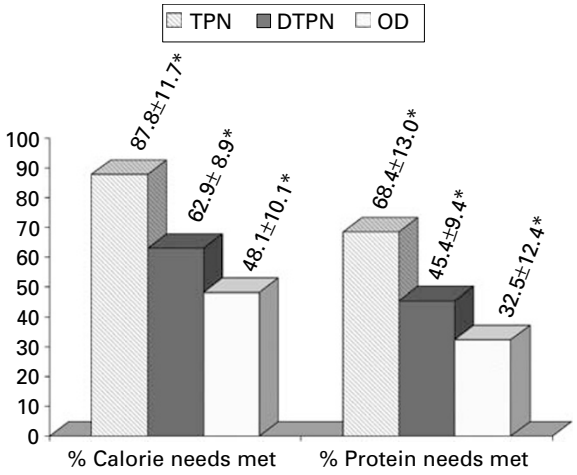

Figure 2 Percent of calorie and protein needs met by TPN, DTPN, and OD groups from admit to day +30. *$P<0.0001$.

TPN for both groups. The TPN group averaged 1494±197 total calories and 60±11 total grams of protein per day, while the OD group averaged 951±191 total calories and 36±10 total grams of protein per day. The three-group analysis found the following total nutrient intake levels: TPN – 1494±197 calories and 60±11 grams of protein per day, DTPN – 1069±125 calories and 41±5.9 grams of protein per day, and OD – 833±173 calories and 30±11 grams of protein per day. Percent of nutrient needs met is presented in Figures 1 and 2.

Sense of well-being

The POMS questionnaire, which has been utilized in other studies to measure mood disturbance in cancer patients,[12,13] provides a total mood disturbance (TMD) score. Figure 3 provides data on the TDM scores at admission, discharge, and day +30 posttx for the two-group analysis. The three-group analysis did not reveal any significant differences between the groups. Mean TMD scores in normal adults, for comparison purposes, are as follows: females – 48.4±33.6, males – 43.5±28.8.[14]

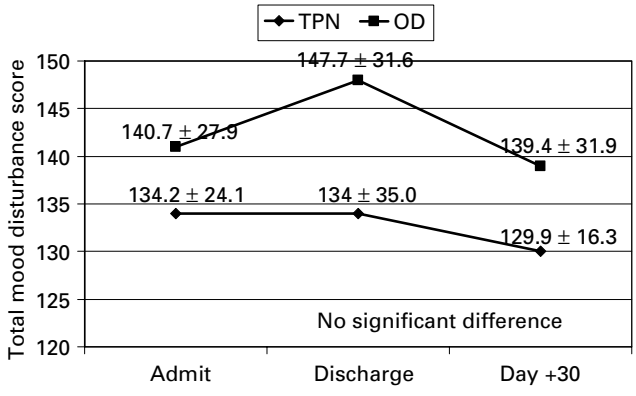

Figure 3 Total mood disturbance score for TPN and OD groups.

Survival data

Probability of survival at 2 years posttx was 57% for the OD group and 74% for the TPN group. Probability of

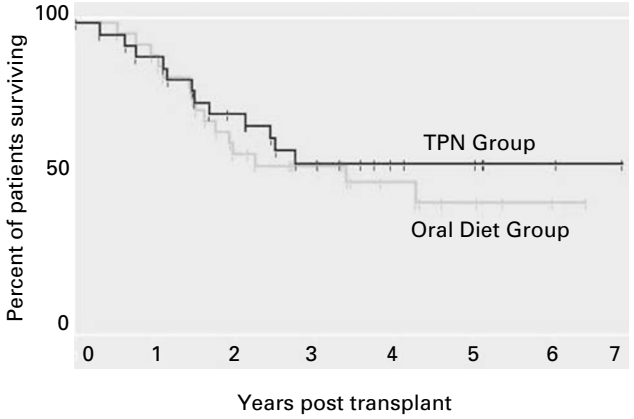

Figure 4 Overall survival in TPN and oral diet groups (Kaplan–Meier plot).

survival at 5 years posttx was 38% for both groups. There was no significant difference between the groups' survival curves ($P = 0.73$) (see Figure 4 for Kaplan–Meier plot). Survival analysis was not performed for the three-group analysis.

Discussion

LOS, engraftment, infection rate, and survival were not different between the groups receiving TPN *vs* those on an OD. The lack of difference in survival contrasts with that found in an earlier randomized study by Weisdorf *et al*,[4] in which both allogeneic and autologous HCT patients were randomized to either prophylactic TPN or hydration containing electrolytes, minerals, trace elements, and vitamins. This difference may reflect the patient population and length of time on nutrition support in our study compared to theirs. While both studies included well nourished patients at the outset, their study did not include breast CA patients undergoing autologous HCT and the TPN was given during the preparative regimen and for 4 weeks after HCT. Many of their patients were allogeneic HCT recipients. The allogeneic patient population experiences more significant GI toxicities and other complications posttx, such as infections, organ failure, and graft-versus-host disease (GVHD), which can lead to more nutritional depletion, as compared to autologous recipients. In agreement with our study, they also found no difference between the TPN group and the i.v. hydration group in engraftment, LOS, and infection rate. A study by Szeluga *et al*[15] compared outcomes in autologous and allogeneic patients randomized to TPN or an enteral feeding program. These researchers found that, as we did, TPN was more effective in maintaining weight or body cell mass compared to the enteral feeding program. But, like our study, this did not translate into improvements in outcomes such as LOS, engraftment, or survival.

Determining the etiology of elevated LFTs can be problematic in the HCT patient. Cholestasis is common and may have multiple etiologies, including sepsis, drug toxicity, VOD, lack of enteral nutrition, and TPN.[16] In this study, LFTs increased more in the TPN group than the OD group, but by day +30 posttx, there was no difference between the groups. In addition, patients with infections while on TPN are more likely to have elevated LFTs.[17] Since there were more positive blood cultures as well as two cases of VOD in the TPN group, it is not surprising to find more elevated LFTs in this group. Based on our findings, short-term TPN in this population may contribute to elevated LFTs but does not lead to significant liver dysfunction.

Several investigators have shown that HCT patients have altered and elevated protein requirements.[18–20] In our study, prophylactic TPN resulted in better preservation of nutritional status and protein stores, while the OD led to depletion in protein stores. This is demonstrated by the greater decreases in weight, MAMC, and HGS seen in the OD group compared to the TPN group. Similar reductions in weight and MAMC were seen with the three-group analysis. Additionally, the DTPN group had the highest drop in HGS, 7.8 pounds of force, suggesting more loss of lean body mass in this group compared to the OD group. HGS has been shown in other studies to be a sensitive marker of nutritional status.[21–23] Serum albumin, not surprisingly, was a poor indicator of nutrient intake during the early posttx period and was not maintained by TPN because it is affected by non-nutritional factors, such as the acute inflammatory response, hydration status, and liver function.[24–26] While a good nutritional status is considered beneficial in HCT patients, in this study, a more intact nutritional status posttx, specifically more adequate calorie and protein intake, less weight loss, and less decrease in MAMC and HGS, did not impact clinical outcomes such as engraftment, LOS, infection, or survival. This may reflect the initial nutritional status of the patients as well, since they were well nourished and, in general, over their IBW. A study assessing the impact of body weight on survival in HCT patients found those with a low body weight (<95% of IBW) had lower survival rates when compared to patients with a body weight at 95–145% of IBW.[27] Studies evaluating TPN in other patient populations have suggested that only those with severe malnutrition benefit from TPN.[28–31]

As TPN has been implicated in delaying the return to adequate oral intake, we evaluated the day posttx when the patient's oral intake was >66% of estimated needs. We found no difference between the groups, suggesting no influence of TPN upon appetite in these patients. This contrasts with a study conducted by Charuhas *et al*,[32] in which HCT outpatients were randomized in a double-blind fashion to TPN or a hydration solution during the first 28 days of outpatient treatment. These investigators found that the group receiving hydration resumed adequate oral intake 6 days sooner than the patients on TPN. The difference in results is likely due to the posttx time period studied (+30 days posttx *vs* post discharge before day +65 posttx). In general, it is our observation that appetite and oral intake, with or without TPN, do not return to a more normal state in HCT patients until they are at least 4–6 weeks posttx, due to the GI toxicities associated with the preparative regimen.

Quality of life (QOL) is an important issue in HCT patients. Treatment side effects can result in severe fatigue, and have been shown to impact daily functioning and QOL.[33,34] The TMD score acquired through the POMS questionnaire is obtained by combining scores of six moods: fatigue, depression, anxiety, anger, confusion, and vigor. We did not find a statistical difference between the groups. However, there was a trend for the TPN group to have a lower TMD score, which indicates a higher QOL. Several factors could explain this trend, including less fatigue due to more adequate nutrient intake. Also, patients randomized to the OD group may have felt more anxiety related to ''pressure'' to eat despite GI toxicities.

In conclusion, while prophylactic TPN preserved nutritional status and possibly QOL better than OD, there were no differences found in clinical outcomes or survival. It is vital to note that all patients in the study received some form of nutrition, TPN (early or delayed) or oral nutrition, meeting at the minimum, in the OD group, 48% of calorie needs and 32% of protein needs. This could explain the lack of difference in clinical outcomes between the groups, especially in the light of the well nourished state of the patients at study entrance. Since we did provide TPN to the patients in the OD group who could not eat for an extended period of time, an accepted standard of care in hospitalized patients with nonfunctioning GI tracts, we cannot confirm or assume that no detrimental effects would occur to these patients without TPN. Additionally, since breast CA patients do not always develop nutritional deficiencies while undergoing standard chemotherapy,[35] they may not be representative of other CA patients undergoing autologous HCT. Therefore, caution should be taken in extrapolating these results to all autologous HCT recipients. Additionally, these findings should not be extrapolated to allogeneic HCT recipients, who are much more likely to develop nutritional depletion posttx due to GVHD and infectious complications. It may be reasonable to apply our results to other well nourished autologous HCT patients, if they have a good performance status initially, adequate body weight and no history of nutritional problems with previous therapies or recent unintentional significant weight loss. Well nourished patients undergoing autologous HCT should be followed closely to evaluate nutrient intake and to monitor for nutritional depletion. Those without major complications or prolonged poor oral intake likely will not benefit from TPN. Patients may require nutrition support if they have >10 days of little or no oral intake, to prevent complications associated with malnutrition. Autologous HCT patients who present at the time of transplant with nutritional deficiencies and those who develop serious posttx complications (such as complications leading to mechanical ventilation) are still candidates for nutrition support. Furthermore, other than a trend toward more infections in the TPN group, TPN did not result in adverse outcomes in this study. But because of its expense and potential for complications such as increased risk of infection, it should be utilized in the appropriate patients only. Each HCT center should evaluate the usual GI toxicity associated with its preparative regimens to help guide nutritional assessment, nutritional goals, and decisions regarding nutrition support. Further research is needed to elucidate the benefits of various nutrition support components in HCT patients, as well as to determine the most appropriate and successful route of nutrition support to utilize in HCT recipients.

References

1 Aker SN. Bone marrow transplantation: nutrition support and monitoring. In: Bloch AS (ed.). *Nutrition Management of the Cancer Patient*. Aspen Publishers: Rockville, MD, 1990, pp 199–225.
2 Herrmann VM, Petruska PJ. Nutrition support in bone marrow transplant recipients. *Nutr Clin Pract* 1993; **8**: 19–27.
3 Weisdorf SA, Schwarzenberg SJ. Nutritional support of bone marrow transplant recipients. In: Forman SJ, Blume KG, Thomas ED (eds). *Bone Marrow Transplantation*. Blackwell Scientific Publications: Boston, MA, 1994, pp 327–336.
4 Weisdorf SA, Lysne J, Wind D *et al*. Positive effect of prophylactic total parenteral nutrition on long-term outcome of bone marrow transplantation. *Transplantation* 1987; **43**: 833–838.
5 Dicato M. High-dose chemotherapy in breast cancer: where are we now? *Semin Oncol* 2002; **29**: 16–20.
6 Baynes RD, Dansey RD, Klein JL *et al*. High-dose chemotherapy and hematopoietic stem cell transplantation for breast cancer: past or future? *Semin Oncol* 2001; **28**: 377–388.
7 Carella AM, Beltrami C, Lerma E *et al*. Combined use of autografting and non-myeloablative allografting for the treatment of hematologic malignancies and metastatic breast cancer. *Cancer Treat Res* 2002; **110**: 101–102.
8 Pecora AL, Lazarus HM, Stadtmauer EA *et al*. Effect of induction chemotherapy and tandem cycles of high-dose chemotherapy on outcomes in autologous stem cell transplant for metastatic breast cancer. *Bone Marrow Transplant* 2001; **27**: 1245–1253.
9 Hamwi GJ. Changing dietary concepts. In: Danowski TS (ed.). *Diabetes Mellitus: Diagnosis and Treatment*, American Diabetes Association, Inc.: New York, Vol. 1, 1964, pp 73–78.
10 Harris JA, Benedict FG. A Biometric Study of Basal Metabolism in Man. Publication No. 279. Carnegie Institute: Washington, DC, 1919.
11 Kushner RF, Wall-Alonso E, Alverdy J. Obesity. In: Merritt RJ (ed.). *The A.S.P.E.N. Nutrition Support Practice Manual*. A.S.P.E.N.: Silver Springs, MD, 1998, pp 21/1–21/11.
12 Taylor SE, Lichtman RR, Wood JV *et al*. Illness-related and treatment-related factors in psychological adjustment to breast cancer. *Cancer* 1985; **55**: 2506–2513.
13 Taylor SE, Lichtman RR, Wood JV *et al*. Breast self-examination among diagnosed breast cancer patients. *Cancer* 1984; **54**: 2528–2532.
14 McNair DM, Lorr M, Droppleman LF. *Edits Manual for the Profile of Mood States*. EdITS/Educational and Industrial Testing Service: San Diego, CA, 1992, p 23.
15 Szeluga DJ, Stuart RK, Brookmeyer R *et al*. Nutritional support of bone marrow transplant recipients: randomized clinical trial comparing total parenteral nutrition to an enteral feeding program. *Cancer Res* 1987; **47**: 3309–3316.
16 Strasser SI, Shulman HM, McDonald GB. Cholestasis after hematopoietic cell transplantation. *Clin Liver Dis* 1999; **3**: 651–668.
17 Fleming CR. Hepatobiliary complications in adults receiving nutrition support. *Dig Dis* 1994; **12**: 191–198.
18 Geibig CB, Ponting Owens J, Mirtallo JM *et al*. Parenteral nutrition for marrow transplant recipients: evaluation of an

increased nitrogen dose. *J Parenter Enteral Nutr* 1991; **15**: 184–188.
19 Keller U, Kraenzlin ME, Gratwohl A *et al*. Protein metabolism assessed by 1-^{13}C leucine infusions in patients undergoing bone marrow transplantation. *J Parenter Enteral Nutr* 1990; **14**: 480–484.
20 Cheney CL, Abson KG, Aker SN *et al*. Body composition changes in marrow transplant recipients receiving TPN. *Cancer* 1987; **59**: 1515–1519.
21 Figueiredo FA, Dickson ER, Pasha TM *et al*. Utility of standard nutritional parameters in detecting body cell mass depletion in patients with end-stage liver disease. *Liver Transplant* 2000; **6**: 575–581.
22 Vaz M, Thangam S, Prabhu A *et al*. Maximal voluntary contraction as a functional indicator of adult chronic undernutrition. *Br J Nutr* 1996; **76**: 9–15.
23 Efthimiou J, Fleming J, Gomes C *et al*. The effect of supplementary oral nutrition in poorly nourished patients with chronic obstructive pulmonary disease. *Am Rev Respir Dis* 1988; **137**: 1075–1082.
24 Johnson AM. Low levels of plasma proteins: malnutrition or inflammation? *Clin Chem Lab Med* 1999; **37**: 91–96.
25 Vanek VW. The use of serum albumin as a prognostic or nutritional marker and the pros and cons of IV albumin therapy. *Nutr Clin Pract* 1998; **13**: 110–122.
26 Boosalis MG, Ott L, Levine AS *et al*. Relationship of visceral proteins to nutritional status in chronic and acute stress. *Crit Care Med* 1989; **17**: 741–747.
27 Deeg HJ, Seidel K, Bruemmer B *et al*. Impact of patient weight on non-relapse mortality after marrow transplantation. *Bone Marrow Transplant* 1995; **15**: 461–468.
28 Perioperative total parenteral nutrition in surgical patients. The Veterans Affairs Total Parenteral Nutrition Cooperative Study Group. *N Engl J Med* 1991; **325**: 525–532.
29 Buzby GP. Overview of randomized clinical trials of total parenteral nutrition for malnourished surgical patients. *World J Surg* 1993; **17**: 173–177.
30 Bozzetti F, Gavazzi C, Miceli R *et al*. Perioperative total parenteral nutrition in malnourished, gastrointestinal cancer patients: a randomized, clinical trial. *J Parenter Enteral Nutr* 2000; **24**: 7–14.
31 De Cicco M, Panarello G, Fantin D *et al*. Parenteral nutrition in cancer patients receiving chemotherapy: effects on toxicity and nutritional status. *J Parenter Enteral Nutr* 1993; **17**: 513–518.
32 Charuhas PM, Fosberg KL, Bruemmer B *et al*. A double-blind randomized trial comparing outpatient parenteral nutrition with intravenous hydration: effect on resumption of oral intake after marrow transplantation. *J Parenter Enteral Nutr* 1997; **21**: 157–161.
33 Carlson LE, Koski T, Glück S. Longitudinal effects of high-dose chemotherapy and autologous stem cell transplantation on quality of life in the treatment of metastatic breast cancer. *Bone Marrow Transplant* 2001; **27**: 989–998.
34 Hann DM, Garovoy N, Finkelstein B *et al*. Fatigue and quality of life in breast cancer patients undergoing autologous stem cell transplantation: a longitudinal comparative study. *J Pain Symptom Manage* 1999; **17**: 311–319.
35 Rock CL, Flatt SW, Newman V *et al*. Factors associated with weight gain in women after diagnosis of breast cancer. Women's Healthy Eating and Living Study Group. *J Am Diet Assoc* 1999; **99**: 1212–1221.