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Evaluation of Total Parenteral Nutrition in the Autologous Transplantation Setting in Patients with AML: A Retrospective Exploratory Analysis

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Abstract

Malnutrition remains a clinical challenge in AML patients undergoing autologous hematopoietic stem cell transplantation (ASCT), leading to physical deconditioning and prolonged hospitalization. Prospective data are mainly lacking to identify those patients who may particularly benefit from parenteral nutrition in this setting. This observational, non-randomized, retrospective, exploratory cohort study assessed the nutritional development in patients following high-dose chemotherapy (HDCT) with ASCT and explored their survival

outcomes. The study included all consecutive AML patients who underwent HDCT with ASCT at a single academic center between January 2000 and January 2019. Patients were divided into two primary cohorts: those who received TPN following high-dose chemotherapy and ASCT and those who did not. We identified 126 patients with AML in first complete remission undergoing ASCT consolidation, including 75 patients receiving TPN after HDCT and ASCT and 51 patients without TPN. Neither group differed in gender, age, or subgroups of AML. The nutritional condition at first diagnosis and after induction chemotherapy was equal in both groups, as were median weight changes throughout the induction chemotherapy cycles. Finally, progression-free and overall survival rates were comparable in both groups. Our data suggest that the need to provide TPN for an average of 11 days following HDCT with ASCT for consolidation of first remission in AML patients does not affect the clinical outcome of these patients.

Keywords
Parenteral nutrition; acute myeloid leukemia (AML); autologous stem cell transplantation

1. Introduction

Malnutrition can occur in most cancer patients [1, 2]. Consequently, it may also represent a challenge in patients undergoing autologous hematopoietic stem cell transplantation (ASCT), such as for myeloma, lymphomas, or leukemias. Malnutrition can be defined as a state resulting from a lack of intake or assimilation of nutrition that leads to altered body composition with reduced fat and fat-free body cell mass, resulting in diminished physical and mental function and impaired clinical outcome from the disease [2-4]. Malnutrition associated with diseases can arise from systemic inflammation and/or catabolic factors, resulting in metabolic changes. Additionally, diminished food consumption may be induced by suppressed appetite signals, thereby triggering primary anorexia [1, 2, 5, 6]. In addition, chemotherapy - such as preceding ASCT - can induce a systemic inflammatory response associated with reduced appetite, mucositis, gastrointestinal symptoms including vomiting, nausea, diarrhea, abdominal pain, and physical effects that reduce food intake such as mouth ulcers or xerostomia [7, 8].

Previous reports suggested that the nutritional condition in patients with acute myeloid leukemia (AML) can affect clinical outcomes [7-12]. As in other cancer types, low body mass index (BMI) at first diagnosis or pronounced weight loss during treatment can emerge as risk factors for infectious complications [9, 13, 14], poor treatment tolerance [15], prolonged duration of hospitalization [9, 16], reduced quality of life [17], reduced overall [9, 18-21] and disease-free survival, [21] and higher relapse rate [19]. In addition, inflammatory markers such as CRP and CRP/Albumin ratio are essential prognostic markers and reflect the inflammatory activity as an important factor for catabolism and malnutrition [4]. Still, physicians and nursing staff underestimate malnutrition in cancer patients [10]. Regarding AML patients, there is an apparent lack of data on factors that trigger the initiation of TPN after ASCT, and no studies have investigated its effects in patients with AML.

To identify patients at risk for malnutrition, healthcare professionals have reported using screening tools such as the "Nutrition Risk Screening" issued by the European Society for Clinical

Nutrition and Metabolism (ESPEN) [22] and the American Society for Parenteral and Enteral Nutrition (ASPEN) [23], along with recommendations for nutritional management in these patients. ESPEN proposes medical nutrition is indicated (i) in cancer patients who suffer from "severe mucositis, ileus, or intractable vomiting," (ii) in undernourished patients, (iii) in patients anticipated not to be able to eat for more than seven days, or if (iv) "an inadequate food intake (<60% of estimated energy expenditure) is anticipated for more than ten days" [1]. Healthcare professionals recommend parenteral nutrition only if enteral nutrition is not sufficient or feasible in those patients [24]. A TPN withdrawal is recommended when patients can take at least 50% of the presumed nutrition enterally [1].

Despite these recommendations, routine use of nutritional support in AML patients undergoing ASCT can vary widely, and there is an overall trend towards providing parenteral nutrition support [25]. Parenteral nutrition, however, can contribute to the development of adverse side effects, including infections [26, 27], tumor-feeding [1], and increased treatment costs [26]. For patients with AML undergoing consolidation treatment with ASCT in first complete remission, prospective data are lacking to identify patients who would benefit most from parenteral nutrition. Randomized studies are missing, acknowledging that it is ethically unacceptable to withhold nutritional support from aphagic patients for a control arm of non-TPN [1]. Alternatively, this study explored whether specific parameters at the initial diagnosis, such as age, gender, weight, or nutritional condition, trigger clinical routine decisions to initiate parenteral nutrition following HDCT with ASCT. We also aimed to monitor the nutritional development after ASCT and assess the outcomes of patients receiving (or not) TPN after ASCT.

2. Methods

2.1 Patient Population and Study Design

This research is an observational, non-randomized, retrospective, exploratory, single-center cohort study. All consecutive AML patients undergoing high-dose chemotherapy with ASCT between 01/2000 and 11/2019 at the University Hospital of Berne, Switzerland, were included in this study. Patients lacking information regarding the administration or non-administration of TPN following HDCT were excluded. All clinical data were acquired from the hospital data system "ipdos" and the ASCT data system "Marcell." The local ethics committee in Berne, Switzerland, approved this study through a decision (BE-2020-00182).

2.2 Definitions and Clinical Variables

The patient cohort was stratified into two primary groups: individuals who underwent TPN following high-dose chemotherapy and ASCT and those who did not receive TPN. All patients with TPN received exclusively parenteral nutrition without added oral intake. Inevitably, compounds used for TPN have changed during the study period. However, most patients received the all-in-one formulation and emulsion for infusion SmofKabiven® and NutriFlex®, containing chambers with dextrose, lipids, amino acids, and electrolytes. TPN was tailored to individual energy needs and considering the risk of refeeding (average 25 kcal/kg/day). Regimens were adjusted according to clinical and laboratory monitoring and administered continuously. Water-soluble vitamins (Soluvit®)

and lipid-soluble vitamins (Vitalipid®), along with trace elements (Addaven®) and electrolytes, were blended based on individual needs and following the manufacturer's instructions.

Patients underwent systematic screening utilizing the validated nutritional risk assessment tool NRS-2002 [28]. Supportive measures were applied to all patients at NRS Score ≥3 following local guidelines and individualized nutrition goals defined by specialist dietitians [29-33]. The nutritional status was reassessed daily, employing a low-level step-up strategy to enhance support through parenteral feeding in cases where 75% of the daily caloric intake could not be attained or clinical developments (such as paralytic sub ileus or severe neutropenic colitis/mucositis) impeded oral intake. As soon as engraftment and hematologic recovery led to significant clinical improvement (Mucositis < Grade 2 CTCAE), parenteral nutrition was decreased stepwise and stopped as soon as nutritional goals were met (e.g., oral caloric intake >75%).

To assess the clinical characteristics of the patients at first diagnosis, parameters including BMI, age, gender, blood values, and peripheral/marrow blasts were collected and summarized in Table 1. Alterations in weight (Delta weight) or Body Mass Index (Delta BMI) were recorded for each treatment cycle. They were calculated as the difference in weight from the first day of admission until discharge, as listed in Table S1.

Table 1 Clinical characteristics at diagnosis in AML patients undergoing consolidation with autologous stem cell transplantation (ASCT) at first diagnosis.

Parameter	**all patients**	**with TPN**	**without TPN**	**p**
Patients, n	126	75	51	
Demographic data				
Age, median, years (range)	54 (19-71)	57 (22-70)	50 (19-71)	0.089
Males/females, n/n (%/%)	68/58 (54/46)	41/34 (55/45)	27/24 (53/47)	0.857
Body weight, median, kg (range), n	74.8 (42.5-119.9)	76 (42.5-117.2)	72.5 (46-119.9)	0.697
Size, median, cm (range), n	170 (147-196)	170.5 (152-190)	170 (147-196)	0.994
BMI, median, kg/cm^2 (range), n	25.1 (17-45.7)	25.1 (17-43)	25.1 (17.8-45.7)	0.682
Laboratory parameters				
Hemoglobin, median, g/L (range), n	90 (8.1-515)	92 (8.1-151)	86 (38-515)	0.483
WBC, median, G/L (range), n	7.1 (0.6-303)	7.2 (0.6-240)	6.2 (0.6-303)	0.123
Platelets, median, G/L (range), n	76 (4-714)	81.5 (6-714)	63 (4-608)	0.406
LDH, median, IU/L (range), n	704 (105-9134)	706 (105-9134)	696 (235-2737)	0.227
Uric acid, median, µmol/L (range), n	284 (12-788)	279 (12-788)	295 (91-560)	0.936
CRP, median, mg/L (range), n	21 (3-630)	20 (3-265)	24 (3-630)	0.241

Albumin, median, g/l (range), n	34 (21-46)	33 (21-46)	34 (22-46)	0.842
CRP/Albumin ratio, (range), n	0.6 (0.07-71)	0.7 (0.07-71)	0.2 (0.07-8.3)	0.415
Peripheral blasts, median, % (range) n	38 (0-99)	43 (0-99)	32 (0-95)	0.835
Marrow blasts, median, % (range), n	80 (0-95)	73 (0-95)	80 (15-95)	0.348
European Leukemia Network (ELN) risk classification of the AML				0.132
favorable risk, n (%)	50 (40)	35 (47)	15 (29)	0.132
intermediate risk, n (%)	65 (51)	33 (44)	32 (63)	0.132
adverse risk, n (%)	11 (9)	7 (9)	4 (8)	0.132

TPN, Total parenteral nutrition; WBC, White blood cells.

The variations in weight or BMI during the recovery period between two chemotherapy cycles were computed as the disparity in weight or BMI from the day of discharge after the preceding cycle to the day of admission for the subsequent chemotherapy cycle. The disparities in weight or BMI from the initial diagnosis until the day of discharge following the second chemotherapy cycle are documented as Delta BMI or Delta weight.

The cut-off for follow-up was November 30, 2019, or death, whichever occurred first. Survival outcomes are summarized, comprising overall survival (OS), disease-free survival (DFS), and progression-free survival (PFS). OS was computed from the initial diagnosis until death or the last follow-up, whichever transpired first. PFS was defined from the initial diagnosis until relapse, death, or the last follow-up, whichever took place first. DFS was calculated from the first day of high-dose chemotherapy until relapse, death, or the last follow-up, whichever occurred first. The median follow-up duration was determined from the initial diagnosis until death or the last follow-up. All values are presented as median.

2.3 Statistical Analysis

Statistical analysis was conducted using the "GraphPad PRISM" software program. All quantitative data are presented as the median of the listed values and the respective range of values. Qualitative data are expressed as numbers. The comparison of the median values from the two groups, the two-tailed, unpaired t-test was used. The chi-square test for trend or Fisher's exact test was employed to compare parameters with absolute numbers in both groups. Survival analysis utilized the Kaplan-Meier test. The predetermined level of statistical significance was set at $p < 0.05$.

3. Results

3.1 Patient Characteristics

One hundred sixty-three patients were identified with a first diagnosis of AML and effectively undergoing HDCT/ASCT. The final analysis included 126 patients, fulfilling all criteria. Thirty-seven patients were excluded due to incomplete information regarding the administration of TPN. Finally, the two groups comprised 75 patients with TPN after HDCT and ASCT and 51 patients not receiving

TPN after HDCT. This analysis was independent of whether patients have received (or not) TPN during the first or second induction chemotherapy cycle. The study comprised 68 men and 58 women, equally distributed in both groups (+/- TPN after ASCT; p = 0.857). The median age of all patients was 54 years, and there was no difference in age between the two groups (+/- TPN after ASCT; p = 0.089).

3.2 Nutritional Condition and Biochemical Markers at First Diagnosis of AML

The nutritional condition at first diagnosis of AML was similar for weight, BMI, and albumin levels in both groups (+/- TPN after ASCT). Also, there were no significant differences in CRP or blood counts at first diagnosis. The distribution of molecular and cytogenetic findings and the ELN risk group and AML-FAB classified groups were comparable in both study groups. Table 1 displays the clinical characteristics at the initial diagnosis. Cytogenetics, molecular diagnostics, and AML-FAB classification are presented in Table S2.

3.3 Evolution of Nutritional Parameters during Chemotherapy

The median change in weight during the first chemotherapy cycle in patients with TPN (+TPN-ASCT) was -3.5 kg ranging from -12 kg to +4 kg and in patients without TPN -2.1 kg ranging from -20.9 kg to +5 kg (p = 0.956). During the second chemotherapy cycle, the median weight change was -1 kg (-7 kg, +3.8 kg) in +TPN-ASCT patients and -1.9 kg (-7 kg, +3.8 kg) in patients without TPN (p = 0.338). During the recovery phase between the first and second chemotherapy cycle, the median weight change was -0.2 kg in patients with TPN-ASCT (-8 kg, +7.7 kg) and +0.7 kg in patients without TPN-ASCT (-8 kg, +10.7 kg) (p = 0.212).

From first diagnosis until stem cell apheresis planned at hematologic recovery after cycle 2, a median change in weight in patients with TPN-ASCT of -4.5 kg was observed (-16.1 kg, +3 kg), and in patients without TPN-ASCT -4.4 kg (-20.5 kg, +3.4 kg; p = 0.450).

In the recovery phase between the second cycle and the High-Dose Chemotherapy (HDCT) cycle, patients with TPN-ASCT exhibited a median weight change of +1.3 kg (-4.8 kg, +13.5 kg). In comparison, those without TPN-ASCT showed a median change of +3 kg (-3.5 kg, +11 kg) (p = 0.439). Finally, following HDCT with ASCT until discharge, patients with TPN-ASCT had a median change in weight of -2.2 kg (-8.4 kg, +1.1 kg), while patients without TPN-ASCT had a median change in weight of -2.5 kg (-8.6 kg, +1.2 kg; p = 0.415; Table S1).

3.4 Survival Outcome

The median follow-up of the entire cohort was 27.5 months. The median overall survival in patients with TPN was 25 months (4 months, 195 months), and in patients without TPN, 29 months (3 months, 186 months; p = 0.922). The median disease-free survival was 13.5 months (0 months, 191 months) in patients with TPN and 12 months (0 months, 148 months; p = 0.196) in patients without TPN. The median progression-free survival was 16 months (3 months, 195 months) in patients with TPN, and in patients without TPN, 15 months (3 months, 186 months; p = 0.423) (Figure 1a-1c).

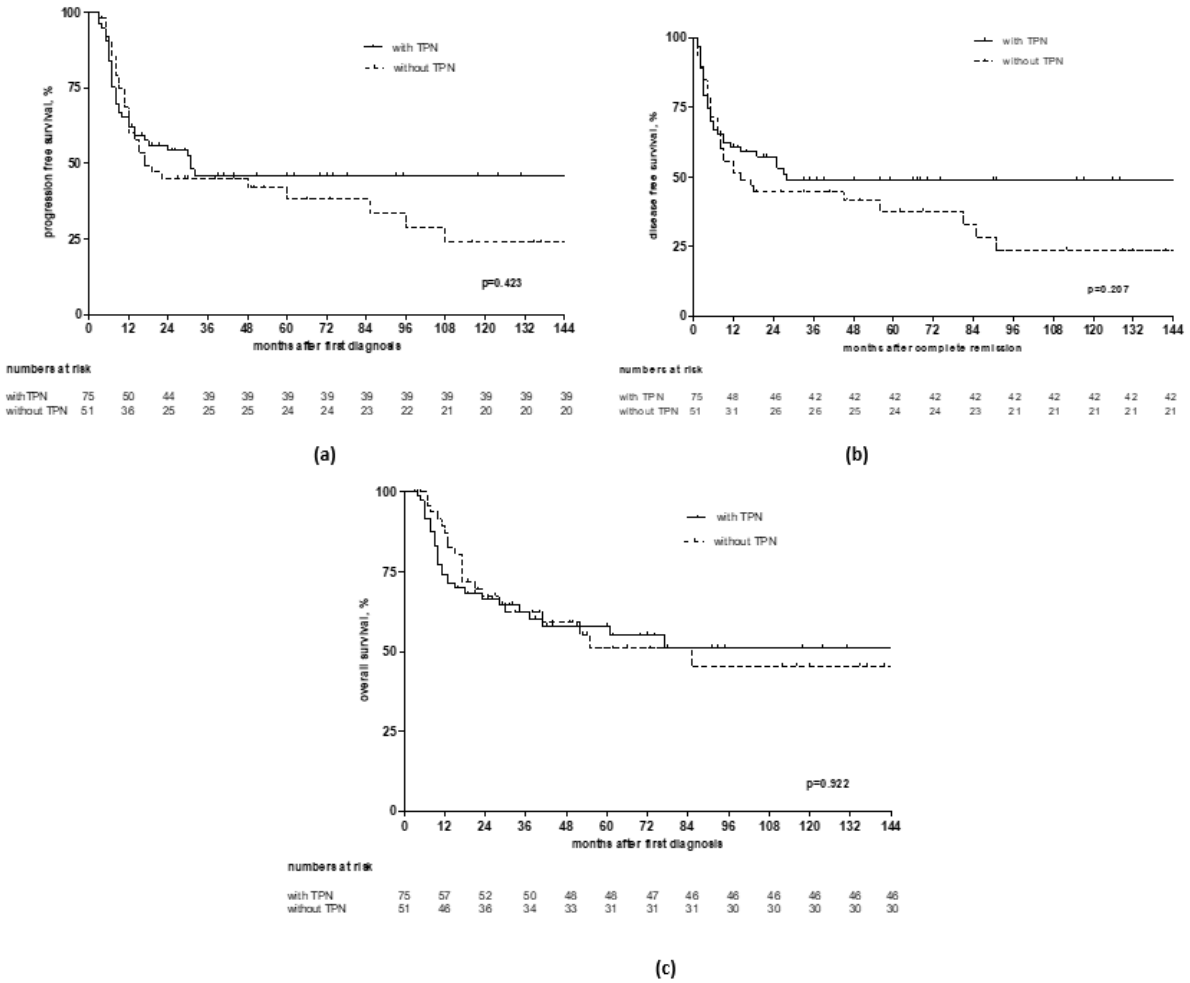

Figure 1 (a) Progression-free survival, (b) Disease-free survival, and (c) Overall survival in AML patients after ASCT consolidation.

The median duration of TPN was 11 days (3 days, 28 days) from the initial diagnosis until the last follow-up or death. All patients were monitored for a median period of 13 months (4 months, 169 months), with no significant difference observed between the two cohorts. Identifying microbiologic pathogens from peripheral blood samples causing febrile episodes was successful in 77.7% of all patients, 80% in patients with TPN, and 74.5% in patients without (p = 1.00). Sepsis occurred in 35.7% of all patients, 38.6% with TPN, and 31.3% without TPN (p = 0.690). Septic shock occurred in 5.8% of all patients, 8% with TPN, and 0% without TPN (p = 0.080).

During follow-up, we observed death in 40% of all patients, 39% in patients with TPN, and 41% in patients without TPN (p = 0.853). Intriguingly, the relapse rate differed between the two groups. Among patients receiving TPN, 30 cases of relapse were observed (40%), whereas in patients without TPN, 30 instances of relapse were recorded (59%; p = 0.046; see Table 2).

Table 2 Outcome of AML patients after HDCT/ASCT consolidation.

Parameter	**all patients**	**with TPN**	**without TPN**	**p**
Patients, n	126	75	51	
Number of days with TPN, median, days (range)	6 (0-28)	11 (3-28)	0 (0)	

Follow-up, median, months (range)	27.5 (3-195)	25 (4-195)	29 (3-186)	0.829
Total amount of transplanted CD34 + cells $\times 10^6$/kg b.w., median, (range)	4.3 (0.7-408.9)	3.8 (0.7-263.2)	4.6 (0.9-408.9)	0.733
CR after induction cycle, n (%)	97 (77)	57 (76)	40 (78)	0.854
CR after cycle 2, n (%)	116 (92)	69 (92)	47 (92)	0.974
CR after ASCT, n (%)	121 (96)	72 (96)	49 (96)	0.982
Relapse, n (%)	60 (48)	30 (40)	30 (59)	0.046
Number of relapses, median, n (range)	0 (0-4)	0 (0-4)	1 (0-2)	0.098
Duration from FD until relapse, median, months (range)	9 (0-108)	7.5 (3-32)	11.5 (0-108)	0.096
PFS, median, months (range)	17 (0-195)	16 (3-195)	15 (3-186)	0.423
OS, median, months (range)	27.5 (3-195)	25 (4-195)	29 (3-186)	0.922
DFS, median, months (range)	12 (0-191)	13.5 (0-191)	12 (0-148)	0.196
Death, n (%)	50 (40)	29 (39)	21 (41)	0.853
Duration from FD until death in deceased patients, median, months (range)	13 (4-169)	10 (4-169)	17 (7-137)	0.554
Duration of Hospitalization during HDCT/ASCT, median, days (range)	21 (1-51)	21 (1-48)	21 (2-51)	0.731
Intensive care stay, median, days (range)	0 (0-22)	0 (0-22)	0 (0-8)	0.464
Blood sampling with identification of microbiologic pathogen, n (%)	98 (77.7)	60 (80)	38 (74.5)	1.00
Sepsis, n (%)	45 (35.7)	29 (38.6)	16 (31.3)	0.690
Septic Shock, n (%)	6 (5.8)	6 (8)	0 (0)	0.080

HDCT, High-dose chemotherapy; ASCT, Autologous stem cell transplantation; TPN, Total parenteral nutrition; CR, Complete remission; PFS, Progression-free survival; OS, Overall survival; DFS, Disease-free survival; FD, First diagnosis.

4. Discussion

There is growing interest in providing nutrition support to AML patients undergoing ASCT. Despite enteral nutrition being recommended as the primary nutrition support, concerns about poor tolerability, insufficient efficacy, and inconvenience frequently prompt the initiation of parenteral nutrition [34]. Despite the increasing awareness of the importance of nutritional status, there is a lack of interventional data enabling physicians to identify those AML patients who eventually benefit most from nutritional interventions and the optimal route, starting time, and available products to be used [35, 36]. Individual clinical judgment of the treating team - and often not a regularly applied validated screening tool - leads to daily decisions triggering the initiation of

parenteral nutrition. At our center, patients administered for ASCT receive a nutritional screening applying the NRS (nutritional risk screening tool), comprising BMI at first diagnosis, loss of weight during the last 1-3 months, and reduced nutritional intake during the last week, as well as severity of stress metabolism. Defined by a score from 0 to 7 points, this tool allows us to estimate the malnutritional risk of each patient. The NRS score for each patient was consistently assessed throughout the study period, serving as a screening tool to evaluate nutritional status.

This retrospective analysis included all patients diagnosed with AML and underwent HDCT/ASCT from January 2000 to November 2019. Throughout this relatively extended study period, our department incorporated a restricted number of targeted therapies into treating AML patients, concurrently benefiting from enhanced genomic profiling options. However, we retained cytotoxic chemotherapy as the primary cornerstone of treatment and administered it to all patients in this study.

A relatively high proportion of 59.5% of all patients from our cohort received TPN during a high-dose chemotherapy cycle for a median duration of 11 days (3 days to 28 days). The compounds used for TPN in most patients were SmofKabiven® and NutriFlex®. At our center, a patient's clinical presentation at admission and throughout hospitalization, above all the general condition and nutritional intake, helped the attending physicians in their decision-making. We could not extract a defined and persistent approach concerning initiating TPN at our center, presuming the individual assessment of each attending physician resulted in an individual approach. To clarify this process, we explored whether specific parameters at the initial diagnosis or throughout therapy trigger clinical routine decisions to initiate TPN following HDCT with ASCT. In addition, we aimed to monitor the nutritional development and assess the survival outcome after ASCT, comparing patients with or without TPN.

Regarding the age and sex distribution at first diagnosis, we observed no significant difference comparing patients with or without TPN following HDCT. The importance of age at first diagnosis is reflected by its inclusion within the nutritional risk assessment, given that higher age increases the risk for malnutrition. In contrast, the role of sex for nutritional evolution during induction chemotherapy cycles and following ASCT remains unclear. Ongoing research is necessary to elucidate the significance of sex as a significant factor affecting the use of parenteral nutrition.

Also, we observed no differences in the nutritional condition at first diagnosis, comparing patients with and without TPN during the HDCT cycle. In particular, albumin, BMI, and weight at first diagnosis showed comparable nutritional status in patients in both groups. With our manuscript, we hope to increase physicians' awareness of the nutritional needs of AML patients undergoing HDCT/ASCT. This result is justified as low initial BMI, malnutrition at first diagnosis, and more pronounced weight loss during chemotherapy cycles are associated with poorer survival [8, 9, 12]. Low BMI at first diagnosis is an independent risk factor for nosocomial infections [13]. The C-reactive protein is not part of malnutrition screening - although it reflects the inflammatory activity as an essential factor for catabolism and, therefore, malnutrition [4] - since it remains more an etiologic than a diagnostic factor for malnutrition [4]. Another study showed an association of elevated pre-treatment levels of acute phase proteins in AML patients with adverse outcomes [37], which means acute phase proteins at first diagnosis of AML represent an important prognostic factor. In our study, we assessed C-reactive protein as an inflammatory marker and calculated the CRP/Albumin ratio for each patient at the initial diagnosis of AML. However, we found no significant difference in CRP level and CRP/Albumin ratio at this early time-point comparing the two cohorts (TPN versus no TPN).

Therefore, based on these laboratory parameters, we found no clear evidence of a worse nutritional state or enhanced inflammatory activity at first diagnosis in patients who later received TPN. Still, it remains to be clarified in future studies if a more detailed evaluation of the inflammatory status before and throughout treatment would better identify patients at risk for or with malnutrition. We could not identify a significant difference in specific parameters at the initial diagnosis when comparing the two cohorts.

As previously reported by others, more pronounced weight loss is associated with a longer duration of hospitalization, and such patients are at high risk for infectious complications and have higher mortality during hospitalization [9]. Comparing patients with and without TPN during the HDCT cycle, we observed no significant difference in weight changes during the first and second chemotherapy cycles and during the recovery phase. Thus, one can speculate that timely TPN may prevent excessive weight loss in the respective patients. It is essential to emphasize that despite meticulous Total Parenteral Nutrition (TPN) support, we noted a consistent weight loss in both groups, beginning from the initial diagnosis and continuing until the last follow-up, in line with findings from previous studies [35, 36, 38]. We observed no significant difference in sepsis or septic shock incidence in patients with or without TPN. This is an important finding because total parenteral nutrition (TPN) poses a higher risk for infectious complications [26, 27], and more pronounced weight loss is also identified as a risk factor for infectious complications [9, 13, 14]. Still, the development of septic shock was documented only in patients who received TPN. Given our study's limited number of patients, further and more extensive clinical trials would be necessary to elucidate this point.

Conflicting data regarding the impact of TPN on survival and disease outcomes have been reported. Weisdorf et al. reported that prophylactic TPN in patients with normal weight at first diagnosis improves overall survival, disease-free survival, and the time to relapse [39]. In contrast, other studies reported opposite findings, meaning TPN did not improve survival outcomes in those patients [36, 38-40]. It is crucial to consider that these studies are not specific to AML, so any comparisons must be cautiously approached. Our study found no differences in survival outcomes, including overall survival, disease-free survival, and progression-free survival, when comparing patients with or without TPN following HDCT/ASCT. This suggests that the use of TPN is not a prognostic factor in AML patients with ASCT.

Intriguingly, we found a significantly lower relapse rate in patients receiving TPN. We would avoid proposing TPN as a protective factor, as this single-center retrospective study contains a low case number. Conclusively, evaluating TPN as a protective factor against relapse rate requires further investigation through more extensive, prospective studies with independent cohorts.

The limited sample size, the retrospective observational design, missing data in some patients, and the time bias associated with the long study period are apparent limiting factors of our study. Clearly, adequately powered comparative studies are needed to clarify TPN's role in AML patients undergoing HDCT with ASCT; however, ethical considerations to withhold TPN in a control arm will prevent such trials. In the absence of such data, our study may contribute to recognizing the importance of timely administration of TPN in those patients needing it, preventing patients needing TPN support from having inferior outcomes compared to patients without TPN administration.

Above all, we could show that a relatively high proportion of 59.5% of AML patients with HDCT/ASCT received TPN for a median duration of 11 days based on routine clinical practice. This

highlights the importance of this issue and emphasizes the need for further investigations to eventually establish a standardized approach regarding the indication and application of TPN in these patients.

5. Conclusions

Our retrospective study demonstrates that a relatively high proportion of 59.5% of AML patients with HDCT/ASCT received TPN - based on routine clinical practice. The median duration of TPN was 11 days (3 days to 28 days). Investigations concerning TPN indication and application seem to be significant regarding this high proportion of patients receiving TPN and the relatively long duration of TPN application. Our data suggest that receiving TPN following HDCT and ASCT does not affect survival rates or duration of hospitalization. There is no significant difference in the evolution of nutritional parameters throughout chemotherapy in patients with TPN compared to patients without TPN. In addition, our data suggest that applying TPN for an average of 11 days following HDCT with ASCT prevents AML patients with inadequate food intake from having worse nutritional and survival outcomes than patients without TPN. Finally, this study should help clinicians become more aware of the importance of dealing with the adequate nutritional needs of AML patients after ASCT.

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Author Contributions

Conceptualization, Thomas Pabst; Data curation, Lia Bally and Thomas Pabst; Investigation, Sarah Willi and Ulrike Bacher; Methodology, Sarah Willi, Michael Daskalakis, Lia Bally and Thomas Pabst; Resources, Marie-Noelle Kronig, Michael Daskalakis and Thomas Pabst; Validation, Ulrike Bacher, Marie-Noelle Kronig and Thomas Pabst; Writing - original draft, Sarah Willi, Ulrike Bacher, Lia Bally and Thomas Pabst; Writing - review & editing, Ulrike Bacher, Marie-Noelle Kronig, Michael Daskalakis, Lia Bally and Thomas Pabst.

Competing Interests

The authors declare no conflict of interest.

Additional Materials

1. Table S1: Body weight changes during AML treatment cycles.
2. Table S2: Characteristics of the disease in patients of this study.

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