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Risk factors and incidence of mobilization failure in autologous stem cell transplant: 10 years' experience in a specialized bone marrow transplant center, Baghdad Medical City

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Abstract:

BACKGROUND: Successful hematopoietic stem cell mobilization is essential for hematopoietic cell transplantation. However, mobilization failure remains a clinical challenge, particularly in settings with limited access to plerixafor. Understanding its predictors is crucial to improving transplant outcomes in Iraq.

OBJECTIVES: The aims of this study were to determine the incidence and predictors of stem cell mobilization failure in the Hematology and Transplant Center in Baghdad Medical City.

MATERIALS AND METHODS: This retrospective study was conducted at the HBMT Center, Baghdad Medical City, and included 395 adult and pediatric patients with various hematologic malignancies who underwent stem cell mobilization between January 2013 and December 2023. Clinical, disease, and treatment-related factors were analyzed in relation to mobilization outcomes.

RESULTS: Mobilization failure occurred in 11.6% (46/395) of patients. Failure was significantly associated with bone marrow involvement and prior chemotherapy exposure, whereas diagnosis also influenced outcome – being most frequent among multiple myeloma patients. The mean age was 42.1 years, and the mean BMI was 27.4 kg/m^2. Use of Plerixafor was rare during the study period.

CONCLUSION: Despite limited drug availability, the mobilization failure rate in our center was comparable to international data. Expanding access to c and optimizing mobilization protocols could enhance stem cell collection efficiency and reduce hospitalization days in Iraq.

Keywords:

Baghdad HBMT center, failure, lymphoma, multiple myeloma, stem cell mobilization, transplantation

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Introduction

Autologous hematopoietic stem cell transplant (ASCT) remains a standard therapeutic approach for hematologic malignancies, particularly multiple myeloma (MM), non-Hodgkin lymphoma (NHL), and Hodgkin lymphoma (HL).[1,2] Successful transplantation requires adequate mobilization of hematopoietic stem cells (HSCs), most commonly using granulocyte colony-stimulating factor (G-CSF), granulocyte-macrophage colony-stimulating factor, or chemotherapy-based regimens.[3,4] Mobilization failure

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is influenced by several factors, including prior chemotherapy, bone marrow involvement, radiotherapy exposure, and patient-related characteristics.[5-8]

Recent advances, including the use of plerixafor and motixafortide, have demonstrated improved mobilization efficacy and patient outcomes.[9-13] Updated international guidelines, such as the EBMT Handbook (2nd edition, 2024), emphasize risk-adapted mobilization strategies, early identification of poor mobilizers, and equitable access to novel agents.[14,15] However, in resource-limited regions such as Iraq, access to these newer agents remains restricted. To our knowledge, this study represents the first Iraqi cohort to evaluate the incidence and clinical predictors of stem cell mobilization failure over a 10-year period at the Baghdad Medical City Bone Marrow Transplant Center.

Materials and Methods

This retrospective study was conducted at the Hematology and Bone Marrow Transplant (HBMT) Center, Baghdad Medical City, between January 2013 and December 2023. A total of 395 patients with various hematological malignancies who underwent stem cell mobilization for autologous HSC transplantation (HSCT) were included.

Inclusion criteria

Patients scheduled for autologous HSCT who underwent mobilization at the HBMT Center between 2013 and 2023.

Exclusion criteria

Patients undergoing allogeneic HSCT.

The study included all consecutive eligible patients during the 10-year period, which minimized selection bias.

Definition of mobilization failure

Mobilization failure was defined as peripheral blood $CD34^+$ count <10/μL at the expected peak, or total collected $CD34^+$ cells $<2 \times 10^6$/kg after apheresis.

Among the 395 patients, 46 (11.6%) fulfilled these criteria. Of these, 31 did not proceed to apheresis due to persistently low PB $CD34^+$ counts, whereas 13 underwent 1–4 apheresis sessions using the Spectra Optia system but failed to collect sufficient cells.

Mobilization regimen

Most patients received disease-specific chemotherapy followed by G-CSF at 10–15 μg/kg/day. Steady-state G-CSF mobilization was rarely used, and plerixafor was not available during the study period.

Sample size consideration

All eligible patients during the study period were included; therefore, no formal sample size calculation was required.

Laboratory procedures

Peripheral blood $CD34^+$ counts were monitored daily from Day 4 of G-CSF administration until apheresis. Enumeration of $CD34^+$ cells was performed by flow cytometry according to the International Society of Hematotherapy and Graft Engineering single-platform protocol.

Stem cell collection was performed using an automated apheresis system with standard protocols for peripheral blood stem cell and mononuclear cell collection. Each procedure processed approximately three times the patient's blood volume, using acid-citrate-dextrose solution-A as an anticoagulant.

Ethical approval

Ethical approval was obtained from the Scientific Committee of the Hematology and Bone Marrow Transplantation Center under reference number 1603 on December 31, 2023.

Statistical analysis

Data were entered into Microsoft Excel 2010 and analyzed using SPSS version 26 (Spectra Optia Apheresis System [Terumo BCT, Lakewood, Colorado, USA]). Descriptive statistics were used to summarize patients' characteristics. The Student's *t*-test and one-way ANOVA were applied for numerical variables, and the Chi-square test for categorical variables.

Although this study primarily used univariate analysis, multivariate logistic regression was not performed due to the retrospective and descriptive design. $P < 0.05$ was considered statistically significant.

Results

A total of 395 patients underwent stem cell mobilization between 2013 and 2023 at the BMT Center, Baghdad Medical City. Of these, 234 (59.2%) were diagnosed with Hodgkin'slymphoma (HL), 66 (16.7%) with non-Hodgkin's lymphoma (NHL), 74 (18.7%) with MM, 8 (2.0%) with acute myeloid leukemia (AML), one (0.3%) with amyloidosis, three (0.8%) with neuroblastoma, and nine (2.3%) with missing data [Table 1].

Overall mobilization success rate remained consistently high across the 10 years study period, ranging between 83% and 100%, the annual variations were minimal. The overall success rate was 88.4%, whereas mobilization failure occurred in 11.6% of cases, a total of 46 patients

experienced mobilization failure [Table 2]. However, complete clinical and treatment data were available for 44 patients, who were therefore included in the detailed analysis presented in the subsequent tables.

Among patients who failed mobilization, the mean age was 42 years, with an equal sex distribution. The majority were within the 40–59 year range, and most had no significant past medical history (84.1%) [Table 3].

Among patients with failed mobilization, the most frequent adverse predictors were bone-marrow involvement (40.9%), exposure to ≥3 chemotherapy protocols (45.5%), and previous radiotherapy (20.5%). Most patients received chemotherapy-based mobilization (Endoxan or ICE, 63.6%), required prolonged G-CSF support (mean 12 days) and hospitalization (mean 16 days), whereas only 4.5% received plerixafor. Low $CD34^+$ counts before collection and reduced platelet recovery indicate that cumulative treatment burden and

Table 1: Distribution of diagnoses among patients undergoing mobilization (2013–2023)

Diagnosis	Number of patients (%)
Lymphoma (HL)	234 (59.2)
Lymphoma (NHL)	66 (16.7)
MM	74 (18.7)
AML	8 (2)
Amyloidosis	1 (0.3)
Neuroblastoma	3 (0.8)
Missing data	9 (2.3)
Total	395 (100)

MM=Multiple myeloma, AML=Acute myeloid leukemia, NHL=Non HL, HL=Hodgkin lymphoma

Table 2: Overall outcome of stem cell mobilization among patients from 2013 to 2023

Mobilization outcome	Number of patients (%)
Successful mobilization	349 (88.4)
Failed mobilization	46 (11.6)
Total	395 (100)

Table 3: Sociodemographic characteristics of patients with failed mobilization

Sociodemographic data	*n* (%)
Sex	
Male	22 (50.0)
Female	22 (50.0)
Total	44 (100)
Age group/years	
<30	12 (27.3)
30–39	6 (13.6)
40–49	11 (25)
50–59	11 (25)
60–69	4 (9.1)
Total	44 (100)
PMH	
Positive	4 (9.1)
Negative	37 (84.1)
Missed data	3 (6.8)
Total	44 (100.0)

PMH=Past medical history

Table 4: Clinical data of patients with failed mobilization

Clinical data	*n* (%)
BM involvement	
Yes	18 (40.9)
No	22 (50.0)
Missed data	4 (9.1)
Number of protocols	
<3 protocols	20 (45.5)
≥3 protocols	20 (45.5)
Missed data	4 (9.1)
Second transplantation	
Yes	3 (6.8)
No	41 (93.2)
Missed data	0
Radiotherapy	
Yes	9 (20.5)
No	35 (79.5)
Total	44 (100.0)

BM=Bone marrow

Table 5: Treatment data of patients with failed mobilization

Treatment data	*n* (%)
Mobilization protocol	
Endoxan	14 (31.8)
ICE	14 (31.8)
GDP	8 (18.2)
GCSF	2 (4.5)
DHAP	2 (4.5)
R-DHAP	2 (4.5)
HIDAC	1 (2.3)
Missed data	1 (2.3)
Total	44 (100)
Hospitalization during mobilization protocol/ days, mean±SD	16.18±5.12
GCSF days of neuopogen taken, mean±SD	12.16±4.302
Mozobil use	
Yes	2 (4.5)
No	41 (93.2)
Missed data	1 (2.3)
Total	44 (100)
Duration of mozobil/days (number 2), mean±SD	2.00±000
CD34 before collection, mean±SD	9.04±7.19
Number of patients who had collection	
Yes	13 (29.5)
No	30 (68.3)
Missed data	1 (2.2)
Platelets at admission, mean±SD	164.72±88.86
Platelets at first collection, mean±SD	101.15±103.41

SD=Standard deviation, ICE=Ifosfamide, Carboplatin, and Etoposide, GDP=Gemcitabine, dexamethasone, and cisplatin, G-CSF=Granulocyte colony-stimulating factor, DHAP=Dexamethasone high-dose cytarabine cisplatin, R-DHAP=Rituximab-DHAP, HIDAC=High-dose Ara-C

marrow damage are key contributors to mobilization failure [Tables 4 and 5].

Subgroup analysis

Subgroup analyses were performed to explore potential associations between patients' sociodemographic and clinical variables and mobilization outcomes. Bone marrow involvement was significantly more common among MM patients compared to lymphoma cases ($P < 0.001$). Patients with lymphoma had longer hospitalization and G-CSF administration periods than those with MM ($P = 0.001$ and $P < 0.001$, respectively).

Regarding lymphoma subtypes, Hodgkin's lymphoma was significantly more frequent among patients aged below 30 years, whereas non-Hodgkin's lymphoma predominated in the 60–69 age group ($P = 0.009$).

In addition, complete remission before mobilization was significantly more frequent among male patients and those without bone marrow involvement ($P = 0.008$ and $P = 0.045$, respectively).

Other subgroup comparisons did not show statistically significant associations and were therefore summarized narratively rather than displayed in tables.

Discussion

The present study demonstrated that the overall success rate of stem cell mobilization for autologous transplantation at the Baghdad BMT Center between 2013 and 2023 was 88.4%, with a mobilization failure rate of 11.6%. This rate falls within the range reported in international series (5%–46%) and aligns with findings from large European cohorts.[16]

Disease patterns and predictors

Mobilization failure occurred most frequently in patients with MM (20.5%), followed by AML (12.5%) and NHL (12.1%), whereas HL patients had the lowest rate (8.5%). Similar trends have been observed in recent Turkish and European reports.[14,17,18] Studies from Hacettepe University (2003–2018) and others showed lower failure rates in MM (≈10%) but confirmed that poor mobilization remains associated with heavy prior chemotherapy and marrow involvement.

Role of plerixafor

The introduction of plerixafor, a CXCR4 antagonist approved for NHL and MM mobilization, has substantially reduced failure rates to <5% in most centers.[19,20] However, plerixafor was largely unavailable in Iraq during the study period. The limited access to this drug likely contributed to the observed failure rate, underscoring a need for policy support to improve drug accessibility in resource-limited settings.

Predictive laboratory and clinical factors

Consistent with prior studies, a low peripheral-blood $CD34^+$ count before apheresis was the strongest indicator of mobilization failure.[21] In our cohort, all patients who failed collection had PB-$CD34^+$ <20/μL. Additional predictors identified in the literature – low platelet count, prior radiotherapy, and advanced age – were also seen in our failed mobilizers, highlighting the multifactorial nature of poor mobilization.

Bone-marrow involvement and biological context

Bone-marrow infiltration was documented in 40.9% of failed cases and was significantly higher in MM than in lymphoma. This can be explained by age-related decline in marrow reserve and disease-related replacement of hematopoietic niches, both of which limit progenitor-cell egress during G-CSF mobilization.[22]

Sociodemographic and chemotherapy factors

Age, sex, and BMI did not significantly correlate with mobilization outcomes. However, repeated or intensive chemotherapy – particularly regimens containing alkylating or platinum compounds – negatively affects $CD34^+$ yields by damaging hematopoietic niches. Our findings confirm prior reports that three or more prior chemotherapy lines increase failure risk, independent of diagnosis.[23]

Mobilization regimens and hospitalization

Endoxan, ICE, and GDP were the most commonly used protocols, with no significant difference in outcomes among them. Hospitalization duration averaged 16 days, slightly longer in lymphoma than MM patients, likely reflecting disease-specific mobilization schedules. In contrast to international data, our analysis found no significant correlation between hospitalization length or G-CSF duration and mobilization success, possibly due to the uniform clinical protocols used across the study period.

Future directions

The recent introduction of daratumumab-based induction in MM patients has been associated with a higher need for plerixafor rescue during mobilization.[24] Future work in our center will focus on evaluating mobilization strategies in this new treatment era and on developing predictive scoring models to optimize resource utilization.

Conclusion

Mobilization failure occurred in 11.6% of patients undergoing autologous stem cell transplantation at

the BMT Center in Baghdad, a rate comparable to that reported in international studies.

The highest incidence of mobilization failure was observed among patients with MM, followed by AML and NHL, whereas HL showed the lowest rate.

Bone marrow involvement and heavy prior chemotherapy exposure appeared to contribute to poor mobilization, whereas most sociodemographic factors showed no significant correlation.

Importantly, all mobilizations were performed without plerixafor due to its unavailability during the study period, underscoring the need to improve access to this agent to optimize outcomes in resource-limited settings.

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Conflicts of interest

There are no conflicts of interest.

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