Published in final edited form as:

Cytotherapy. 2015 December ; 17(12): 1785–1792. doi:10.1016/j.jcyt.2015.09.002.

Hematopoietic Progenitor Cell Mobilization with “Just-in-Time” Plerixafor Approach is a Cost Effective Alternative to Routine Plerixafor Use

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Abstract

Hematopoietic progenitor cell (HPC) mobilization with granulocyte-colony stimulating factor (G-CSF) and plerixafor results in superior CD34⁺ cell yield, when compared to mobilization with G-CSF alone in patients with myeloma and lymphoma. However, plerixafor-based approaches are associated with high costs. To circumvent this, several institutions use a so-called “just-in-time” plerixafor (JIT-P) approach, where plerixafor is only administered to patients likely to fail mobilization with G-CSF alone. Whether such a JIT-P approach is cost effective has not been confirmed to date. We present here, results of 136 patients with myeloma or lymphoma who underwent mobilization with two different approaches of plerixafor utilization. Between Jan 2010-Oct 2012 (n=76) patients uniformly received mobilization with G-CSF and plerixafor (routine G+P cohort). To reduce mobilization costs, between Nov 2012-Jun 2014 (n=60) patients were mobilized with JIT-P where plerixafor was only administered to patients likely to fail mobilization with G-CSF alone. Patients in routine G+P group had a higher median peak peripheral blood CD34⁺ cell count (62 vs. 29 cells/ μ L, $p<0.001$) and a higher median day 1 CD34⁺ cell yield (2.9×10^6 CD34⁺ cells/kg vs. 2.1×10^6 CD34⁺ cells/kg, $p=0.001$). The median total CD34⁺ cell collection was also higher in routine G+P group (5.8×10^6 CD34⁺ cells/kg vs. 4.5×10^6 CD34⁺ cells/kg, $p=0.007$). In the JIT-P group 40% (n=24) completed adequate HPC collection without plerixafor. There was no difference in mobilization failure rates. The mean number of plerixafor doses utilized in JIT-P was lower (1.3 vs. 2.1, $p=0.0002$). The mean estimated cost in the routine G+P group was higher than that in the JIT-P group (USD 27,513 vs. USD 23,597, $p=0.01$). Our

analysis demonstrates that mobilization with a JIT-P approach is a safe, effective and cost efficient strategy for HPC collection.

INTRODUCTION

High dose therapy (HDT) and autologous hematopoietic cell transplantation (auto-HCT) is a standard therapeutic option in eligible patients with multiple myeloma (MM) and Hodgkin and non-Hodgkin lymphoma (1–3). Hematopoietic progenitor cells (HPCs) are frequently mobilized with cytokines, most commonly granulocyte-colony stimulating factor (G-CSF) either alone or in combination with chemotherapy or plerixafor (4–7). The infused CD34+ cell dose is a vital part of auto-HCT success, as optimal cell dose results in improved hematopoietic recovery and decreased transfusion requirements (8–10). Clinical risk factors for suboptimal mobilization have been identified including prior exposure to lenalidomide, fludarabine or melphalan exposure, bone marrow involvement and thrombocytopenia prior to mobilization (11–13).

Plerixafor, a small molecule that reversibly inhibits chemokine stromal cell-derived factor-1 α (SDF-1 α) from binding to CXC chemokine receptor 4 (CXCR4), promotes increased migration of hematopoietic stem cells into the peripheral blood (14, 15). Plerixafor combined with G-CSF provides superior mobilization outcomes in MM and lymphoma compared to G-CSF alone (6, 16). It has also been shown to be an effective salvage option for patients failing to collect adequate CD34+ cells with G-CSF alone or chemomobilization (17, 18). However, the high cost of plerixafor has limited its routine use in HPC mobilization. Risk-adapted algorithms have been developed in several institutions (19–22) to rescue patients at high-risk for mobilization failure and restrict plerixafor use to curtail mobilization costs. However, whether such just-in-time plerixafor (JIT-P) approach is cost effective remains to be proven. We report here, a single institution comparative analysis of patients with MM and lymphoma who underwent G-CSF mobilization, with plerixafor used either routinely or as needed in patients at risk for mobilization failure.

PATIENTS AND METHODS

Patient population

One-hundred and thirty-six consecutive, adult patients with MM and lymphoma scheduled for HDT and auto-HCT who underwent mobilization with two different approaches of plerixafor utilization at our institution were included. Seventy-six patients who received mobilization between January 2010 and October 2012 was in the routine G-CSF + plerixafor group (routine G+P). In order to circumvent higher costs, the JIT-P algorithm was adopted in November 2012 and thus from November 2012-January 2014 sixty patients who underwent mobilization in the JIT-P group were analyzed. All patients underwent a planned, single autograft. This study was approved by the Institutional Review Board and the Protocol Review and Monitoring Committee.

PBPC Mobilization and Collection

In the routine G+P group, patients received G-CSF (10 μ g/kg/day subcutaneously) daily for 5 days and plerixafor (0.24 mg/kg subcutaneously) on the evening of day four, ~11 hours prior to the initiation of apheresis the following day. Plerixafor, G-CSF and apheresis were repeated daily, for up to 3 additional apheresis sessions.

A JIT risk-adapted algorithm, shown in Figure 1, was applied in patients mobilized from November 2012 to April 2014 (JIT-P). In this algorithm, all patients received G-CSF (10 μ g/kg/day subcutaneously) daily for 5 days. Plerixafor was administered only to patients at high-risk for mobilization failures, defined as: (1) patients with a day 4 peripheral blood (PB) CD34+ count of <10/ μ L, (2) patients with a day 1 collection yield of <1.0 $\times$ 10⁶ CD34+ cells/kg or (3) day 1+2 yield of <1.5 $\times$ 10⁶ CD34+ cells/kg recipient body weight (21–22).

Collections were performed using the MNC (mononuclear cell) program on the COBE Spectra apheresis system (Caridian BCT, Lakewood, CO) (COBE Spectra software version 5.1), by processing a goal of 4 blood volumes. Two patients underwent 3 blood volume collections, one due to a calculation error and the other due to being near goal after 3 collections. Typical leukapheresis instrument settings included: inlet/anticoagulant ratio of 15:1, collect flow rate of 0.5–1.5 mL/min and blood flow rate of 60–70 mL/minute. During apheresis, the operator used the COBE Spectra Colorgram to determine the optimal red blood cell/plasma interface position by changing the plasma pump flow rate in response to the color of the product in the collection line. The target hematocrit of the product was 2–3%. Acid citrate dextrose-A was used as the anticoagulant. In November 2012 we began using the MNC program on the Optia apheresis system (Terumo BCT, Lakewood CO) (Software Version 9, Protocol Version 3.4), which operates through an automated system using pre-collection blood indices to determine the cellular interface and a camera to determine adequate collection. Typical leukapheresis instrument settings included: inlet/anticoagulant ratio of 12:1, collect flow rate of 0.5–1.5 mL/min and blood flow rate of 60–70 mL/minute. Validation of the Optia apheresis machine was performed and demonstrated that CD34 collection efficiencies, viability and sterility testing results were comparable to those collected with the COBE Spectra in 2012. It is our institutional policy to routinely target collection of a sufficient number of CD34+ cells/kg to administer two rounds of HDT and auto-HCT in MM (i.e. an ideal target yield of 10 $\times$ 10⁶ CD34+ cells/kg, but a minimum of 5 $\times$ 10⁶ CD34+ cells/kg) and one auto-HCT in lymphoma (goal of 5 $\times$ 10⁶ CD34+ cells/kg, but a minimum of 2 $\times$ 10⁶ CD34+ cells/kg with). Determination of peripheral blood CD34+ cell count and CD34+ cell content of the apheresis product were performed in the West Virginia University Hospital Flow Cytometry Laboratory. The BDFACS Canto II flow cytometer, Becton Dickinson, (San Jose, CA) was used for all analysis. Red blood cell lysed and washed samples were used for CD34+ enumeration with PE-labeled, 8G12 clone, immunoglobulin G1 (Becton Dickinson, San Jose, CA) based on International Society of Hematotherapy and Graft Engineering guidelines (23). A dual platform CD34 assay was performed through counting the specimen for WBC on the heme analyzer and performing flow cytometry on the specimen for CD34+ cells. Both numbers are utilized for the final enumeration. The viability was performed via flow cytometry (7AAD). The final products

were cryopreserved in 10% dimethyl sulfoxide using a controlled rate freezer and stored in liquid nitrogen.

Transplantation Procedure and Supportive Care

All patients with MM received uniform conditioning with melphalan 200 mg/m² (reduced to 140 mg/m² in patients with renal insufficiency) on day-2, followed by infusion of autologous HPC on day 0. Patients with underlying lymphoid malignancies received CBV (cyclophosphamide, carmustine, and etoposide) conditioning followed by infusion of autologous HPC on day 0. All patients received post-transplant growth factor support (G-CSF 5 µg/kg starting at day +5), fungal (fluconazole), herpes zoster/herpes simplex (acyclovir or valacyclovir) and bacterial prophylaxis (levofloxacin) per institutional guidelines. The time to neutrophil engraftment was considered the first of 3 successive days with absolute neutrophil count (ANC) $0.5 \times 10^9/L$ after post-transplantation nadir (24). The time of platelet engraftment was considered the first of three consecutive days with platelet count $20 \times 10^9/L$ or higher, in the absence of platelet transfusion for the preceding seven days (24).

Cost Determination

Cost of first HPC mobilization attempt (including cost of all medications, laboratory assessments, intravenous access, apheresis, cryopreservation, etc.) was estimated using the method previously described by Shaughnessy et al (25). Costs were calculated per patient in both groups (including all reimbursable procedures and costs of all medications during mobilization). A subset analysis was performed to estimate the cost of mobilization for patients completing HPC collection in a total of 1, 2, 3, or 4 apheresis sessions. The costs related to mobilization and apheresis procedures are shown in Table 1 and are adjusted to reflect 2014 US dollars (USD). Median Centers for Medicare and Medicaid Services (CMS) reimbursement rates were used to determine the mobilization, apheresis, and cryopreservation costs, as indicated in Table 1. Medication prices were based on the average sale price (ASP) for each product and was estimated from the average wholesale price (25).

Statistical Analysis

Baseline categorical variables were compared using chi-square test, while continuous variables were compared by Wilcoxon rank-sum test or a two sample t-test as appropriate. Successful mobilization was defined as a total of 2×10^6 CD34+ cells/kg of patient's body weight in the final product. To account for differences in number of collection days across patients, data were analyzed regarding peak peripheral blood CD34+ cell count and CD34+ stem cell collection on day one only. All p-values are two-sided. All analysis were carried out in SAS version 9.3 (SAS Institute, Cary, NC) and R statistical software (Foundation for Statistical Computing, Vienna Austria).

RESULTS

Patient Characteristics

The baseline characteristics of 136 consecutive patients included in this analysis are shown in Table 2. Seventy-six patients underwent mobilization with routine G+P and 60 patients

received the JIT-P approach. The two groups did not differ significantly at baseline for gender, age, race, prior radiotherapy, number of lines of chemotherapy, Karnofsky performance score or HCT-comorbidity index ($p>0.1$).

Efficacy Characteristics

The median total CD34+ cell collection in the routine G+P and JIT-P groups was 5.8×10^6 ($0.2\text{--}22.2 \times 10^6$) CD34+ cells/kg and 4.5×10^6 ($1.7\text{--}9.8 \times 10^6$) CD34+ cells/kg respectively; $p=0.02$. We compared peak PB CD34+ cell count and CD34+ cell collection on day 1 of apheresis only to account for the differences in the number of collection days across patients. Mobilization with routine G+P yielded significantly higher peak median PB CD34+ cell count; 61.5 (range, 5–389) CD34+cells/ μL vs. 29 (range, 7–101) CD34+ cells/ μL ; $p<0.001$. The median day 1 yield of CD34+ cells in the routine G+P and JIT-P groups was 2.9 (range, $0.2\text{--}14.4 \times 10^6$ CD34+ cells/kg vs. 2.1 (range, $0.4\text{--}6.7 \times 10^6$ CD34+ cells/kg, $p=0.001$, respectively. Mean number of plerixafor doses administered in the routine G+P and JIT-P groups were 2.2 and 1.3 respectively; $p=0.0001$. The median number apheresis in the two groups was 2 and the mean was 2.2 and 2.4 in the routine G+P and JIT-P groups respectively, $p=0.06$. Within the JIT-P group, the mean number of apheresis sessions between patients receiving plerixafor vs. those not receiving plerixafor was 2.5 vs. 2.4 respectively ($p=0.6$). In the JIT-P group, 40% ($n=24$) completed adequate HPC collection without plerixafor rescue, which included 15 patients with MM and 9 patients with lymphoma. In the JIT-P group although 63% ($n=19$) of the lymphoma patients had a peak CD34+ cell count of $>20/\mu\text{L}$, thirteen patients (68%) still required plerixafor to meet institutional goals of collection. Among MM patients 63% ($n=19$) had a peak CD34+ count of $>25/\mu\text{L}$, but 9 patients (47%) required plerixafor. A CD34+ cell yield of at least 2×10^6 CD34+ cells/kg on day 1 of collection was seen in 71% ($n=54$) and 56.7% ($n=34$) of subjects in the routine G+P and JIT-P groups respectively, $p=0.09$. Mobilization failure was noted in four patients in the routine G+P group (2 of these patients were salvaged with bone marrow harvest) and 2 patients in the JIT-P. Mobilization outcomes are shown in Table 3. Importantly, there were no documented grades 2–4 adverse events in either treatment group.

Mobilization Cost

Mobilization costs are summarized in Table 4. There was no significant difference in the average (mean) apheresis related costs between the routine G+P and the JIT-P groups (USD 9,292.01 vs. USD 10,336.82, respectively; $p=0.08$). JIT-P approach was associated with a higher cost for G-CSF use ($p=0.01$) and lower well cost for plerixafor use (USD 13,760.77 vs. USD 8,449.26, respectively; $p<0.001$). The mean total mobilization cost in the routine G+P and JIT-P groups was USD 27,513.29 and USD 23,596.64 respectively, $p=0.01$. All mobilization costs, regardless of the number of apheresis sessions were significantly lower in the JIT-P group as noted in Table 4.

Engraftment Outcomes

Patients in the routine G+P group received an average of 4.5 (range, 1.3–10.1) CD34+ cells/kg at transplant and those in JIT-P group received 3.9 (range, 1.4–9.8) CD34+ cells/kg, $p=0.04$. The median time to neutrophil engraftment was 12 days in both groups; $p=0.5$. Median time to platelet engraftment in routine G+P and JIT-P groups was 16 and 18 days

respectively; $p=0.002$. In myeloma patients the median days to neutrophil engraftment in the routine G+P was 12 (range 11–22; mean 13.2) days and in the JIT-P group was 12 (range 11–19; mean 13.1), $p=0.8$. The corresponding median days to platelet engraftment was 19 (range 11–138; mean 24) and 16 (range 10–25; mean 21) respectively, $p=0.06$. In lymphoma patients, the median time to neutrophil recovery in routine G+P was 11 (range 9–22; mean 12.2) versus 11 (range 10–25; mean 12.6) in the JIT-P; p -value 0.6. The corresponding median days to platelet engraftment was 17 (range 11–48; mean 24.8) and 16 (range 8–26; mean 21.3) days, respectively, $p=0.3$.

DISCUSSION

We analyzed HPC mobilization outcomes in patients with MM or lymphoma who received routine plerixafor with G-CSF versus plerixafor use in a risk-adapted JIT approach. The goal of the algorithm was to restrict plerixafor use to the patients at risk for mobilization failure, in order to minimize plerixafor doses and reduce overall mobilization costs. In this study we note several important findings in a well-balanced patient cohort. First, while the routine G+P approach was associated with a higher peak PB CD34+ count and higher day 1 and total CD34+ cell collection, there was no difference between the 2 cohorts with regards to the total number apheresis sessions required and mobilization failures. Secondly, the routine G+P group had significantly higher total mobilization costs irrespective of the number of apheresis sessions required. Finally, although patients mobilized with the routine G+P strategy received a higher CD34+ cell dose in the autograft infusate and had early platelet engraftment; no difference was noted in neutrophil engraftment. The cost of plerixafor has limited its widespread use and several centers have adopted treatment algorithms for limiting plerixafor utilization (19–22, 26, 27). These algorithms are designed to identify patients at risk for suboptimal mobilization without plerixafor use. Although some patients are selected based upon risk secondary to prior therapy or mobilization failure, most rely on day four or five PB CD34+ cell count after initiation of cytokines or the daily CD34+ cell yield after the initiation of apheresis (19–21, 28).

Pre-apheresis PB CD34+ cell count can reliably identify potential poor mobilizers (29, 30). The day 4 PB CD34+ count of at least 10 cells/ μ L correlates with a collection $> 2 \times 10^6$ CD34+ cells/kg (21, 22). Another predictor for suboptimal collection is CD34+ yield of $< 0.8 \times 10^6$ CD34/kg on the first apheresis (31). Day 4 PB CD34+ cell count (compared to day 5) leads to early identification of patients at risk for suboptimal mobilization, allowing the JIT application of plerixafor without compromising the total CD34+ cell yield (21). In designing our risk-adapted algorithm, we adopted the day 4 PB CD34+ cell count < 10 CD34+ cells/ μ L as a predictor for mobilization failure. We also included a day one CD34+ cell yield of $< 1.0 \times 10^6$ CD34+ cells/kg or CD34+ cell yield of $< 1.5 \times 10^6$ CD34+ cells/kg after two days of collection.

As expected routine G+P approach led to a higher day 4 peak PB CD34+ cell count as well as total CD34+ cell yield. In the routine G+P group, the day 1 cell yield as well as the likelihood of collection > 2 million CD34+ cells on the first day of apheresis was higher. However, there was neither any difference in the total number of apheresis sessions required to complete HPC collection nor the number of mobilization failures between the 2 groups.

The number of patients requiring >2 apheresis sessions was also similar in the routine G+P (22%) and the JIT-P (27%) groups. It is interesting to note that we had a total of 6 mobilization failures (4 in routine G+P and 2 in JIT-P groups). All 6 patients had lymphoma with a median age of 58, received a median of 2 lines of prior therapy and had a median peak CD34+ cells/ μ L of 6 (range, 3–12). Their median pre-transplant bone marrow cellularity was 30% (range, 15–70) and day 0 platelet count was 167,000/ μ L (range, 62,000–257,000). None of these patients previously received lenalidomide, fludarabine or brentuximab. Two had prior radiation therapy and one had bone marrow involvement at the time of diagnosis. Of these 4 underwent salvage bone marrow harvest, but only 2 patients had enough CD34+ cell yield to proceed to auto-HCT. This is in line with our prior case series demonstrating minimal additional benefit of salvage bone marrow harvest in those patients who failed plerixafor mobilization (32).

In our population of patients, 76 had underlying MM and 44% (n=34) had received prior treatment with lenalidomide with a median of 4 doses. Lenalidomide can result in suboptimal HPC mobilization in patients with MM (13, 33). Our data is consistent with previous reports demonstrating that patients with prior lenalidomide exposure can be successfully mobilized with growth factor alone or with plerixafor (34, 35). Similarly, prior fludarabine exposure has also been shown to impair HPC mobilization (36, 37). No patients in either group were exposed to fludarabine or melphalan prior to mobilization. While mobilization costs associated with a JIT-P approach have been reported (19–22), no studies have compared the costs of JIT-P method against that of routine G+P approach, to prove the cost benefit of ‘rationing’ plerixafor use to only patients likely to fail mobilization with G-CSF alone. A small study in relapsed diffuse large B-cell lymphoma undergoing mobilization with routine G+P versus G-CSF alone to assess an incremental cost-utility ratio (ICUR) over the patient’s remaining lifetime, and found that although G+P cost was USD 25,567 more than G-CSF alone, they accumulated 1.74 more quality adjusted life years for an ICUR of USD 14,735/quality of life years (38). Utilizing the risk adapted JIT algorithm ~40% of the patients mobilized HPCs successfully without requiring plerixafor. This in turn decreased the total mobilization costs by approximately USD 4000 in the JIT-P group. Even though the patients in the routine G+P group received more plerixafor doses, this did not decrease the number of apheresis sessions required. In contrast, the cost was significantly lower in the JIT-P group regardless of the number of apheresis required. It may be noted that the average mobilization cost difference between the 2 groups widened even further when 3 or more apheresis sessions were required (Table 4). For those patients requiring 4 apheresis sessions, in the routine G+P (n=6) and JIT-P (n=6) groups the average mobilization costs was USD 47,697.84 and USD 31,087.84, respectively; a difference of USD 16,610 (p=0.0001).

In our study, cost assessments based on length of hospitalization, readmission rates, treatment related complications and requirements for intravenous antimicrobials and blood products were not included. However neutrophil engraftment, which is a clinical marker for discharge planning, was similar in the two groups. The slower platelet engraftment noted in the JIT-P group is likely related to the lower median CD34+ cell dose in the infusate in this group.

Noting the inherent difficulty with cost efficacy studies as results will differ based on variables utilized; comparative evaluation of different mobilization strategies with plerixafor provides clinically relevant and useful information on its impact on HPC mobilization and collection. Acknowledging the sample size and retrospective nature of this study, we conclude that a risk-adapted approach to JIT utilization of plerixafor is useful in identifying potential mobilization failures and is cost effective and safe without negatively impacting mobilization outcomes.

Acknowledgments

SW acknowledges the support from the National Institute of General Medical Sciences grant U54GM104942.

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Figure 1. “Just In Time”: Risk Adapted Algorithm

Abbreviations: G-CSF – granulocyte colony stimulating factor, PB – peripheral blood, kg–kilogram

Table 1

Procedure and Medication Costs During Mobilization

Treatment Component	Associated Cost (in US Dollars, 2014)
G-CSF	
Cost per dose	538.60 (filgrastim)
Immunotherapy injections	12.40
Same day hospital observation	165.70
Total	716.70
Plerixafor	
20mg/mL, 1.2 mL SQ	6,250
Immunotherapy injections	12.40
Total	6262.40
Cost of apheresis	
Apheresis session	2,494.30
Cryopreservation	1,555.50
CD34+ flow cytometry	89.40
CD34+ immunohistochemistry	52.90
Total	4192.10

Cost of apheresis catheter insertion was not included in cost analysis, as it was similar across two groups.

Table 2**Patient Characteristics at the Time of Transplantation**

Baseline Characteristics	Routine G-CSF + Plerixafor (n=76)	Just-in-Time Plerixafor (n=60)	P-value
Disease Histology			0.23
Myeloma	45 (59%)	30 (50%)	
Lymphoma	31 (41%)	30 (50%)	
<i>DLBCL</i>	11(35%)	9 (30%)	
<i>HL</i>	9 (30%)	7 (23%)	
<i>MCL</i>	4 (13%)	9 (30%)	
<i>FL</i>	1 (3%)	4 (13%)	
<i>Others</i> ^ψ	6 (19%)	1 (3%)	
Median age, years (range)	61 (23–75)	59 (22–75)	0.48
Male gender	42 (55.3%)	34 (56.7%)	1.0
Race Caucasian	74 (97.4%)	59 (98.3%)	1.0
Prior radiation	14 (18.4%)	12 (20%)	0.83
Lines of prior therapy Mean/Median (range)	1.6/1 (1–4)	1.8/2 (1–4)	0.23
Bone marrow cellularity Mean/Median (range)	40/41 (10–90)	40/41 (5–95)	0.87
Pre-transplant status*			
<i>Myeloma</i>			
CR+VGPR	28 (61%)	16 (53%)	0.83
PR	18 (39%)	13 (43%)	
SD	0	1 (3 %)	
<i>Lymphoma</i>			
CR	20 (67%)	18 (60%)	0.48
PR	9 (30%)	11 (37%)	
SD/RD	1 (3%)	1 (3%)	
KPS median (range)	80 (70–100)	80 (60–100)	0.64
HCT CI median (range)	2 (0–6)	2 (0–6)	0.39

* Percentages are that of the specific disease subgroup.

^ψothers included primary CNS lymphoma (2), T-cell rich B-cell lymphoma (1), angioimmunoblastic T-cell lymphoma (1) and T-cell lymphoma-NOS (2) and DLBCL skin type (1).

Abbreviations: G-CSF, granulocyte colony-stimulating factor; HL, Hodgkin lymphoma; DLBCL, diffuse large B-cell lymphoma; MCL, mantle cell lymphoma; FL, follicular lymphoma; CR, complete remission; VGPR, very good partial response; PR, partial response; SD, stable disease; RD, refractory disease; KPS, Karnofsky performance score; HCT-CI, hematopoietic cell transplantation-specific comorbidity index.

Table 3**Mobilization and Apheresis Results**

Mobilization and Apheresis Results	Routine G+P (n=76)	JIT-P (n=60)	P-value
Peak peripheral blood CD34+ cell count (μL), mean/median (range)	77.5/61.5 (5–389)	33.1/29 (7–101)	<0.001
CD34+ cells × 10 ⁶ cells/kg collected on day 1, mean/median (range)	4.3/2.9 (0.2–14.4)	2.4/2.1 (0.4–6.7)	0.001
Total CD34+ cells × 10 ⁶ /kg collected, mean/median (range)	6.7/5.8 (0.2–22.2)	4.8/4.5 (1.7–9.8)	0.02
Total number of apheresis sessions, mean/median (range)	2.2/2.0	2.4/2	0.06
Mobilization failures, N (%)	4 (5.3%)	2 (3.3%)	0.69
Patients collecting 2 × 10 ⁶ CD34+ cells/kg on day 1 N (%)	54 (71%)	34 (56.7%)	0.09
Patients collecting 5 × 10 ⁶ CD34+ cells/kg on day 1 N (%)	49 (66.2%)	21 (36.2%)	<0.001
Patients collecting 10 × 10 ⁶ CD34+ cells/kg on day 1 N (%)	4 (5.3%)	0 (0%)	<0.001
Number of patients requiring > 1 apheresis sessions (%)	61 (80.2%)	54 (90%)	0.34
Number of patients requiring >2 apheresis sessions (%)	22 (28.9%)	27(45%)	0.53

Abbreviations: G+P, Granulocyte-colony stimulating factor with plerixafor; JIT-P, Just-intime-plerixafor, kg, kilogram.

Table 4**Mobilization Costs**

	Routine G+P (US Dollars, 2014)	JIT-P (US Dollars 2014)	P-value
Average apheresis cost	9,292.01	10,336.82	0.08
Day 4 CD34+ flow cytometry, mean	Not performed	89.44	NA
Average G-CSF costs	4,460.51	4,686.11	0.01
Average plerixafor costs	13,760.77	8,449.26	<0.0001
Average total mobilization costs	27,513.29	23,596.64	0.01
Average mobilization cost of patients requiring 1 session of apheresis	14,074.59	10,406.60	0.0002
Average mobilization cost of patients requiring 2 sessions of apheresis	25,302.30	21,516.52	0.0002
Average mobilization cost of patients requiring 3 sessions of apheresis	36,532.33	27,667.47	0.0002
Average mobilization cost of patients requiring 4 sessions of apheresis	47,697.84	31,087.69	0.0001

Abbreviations: G+P-Granulocyte-colony stimulating factor with plerixafor; JIT-P-Just-in-time-plerixafor; G-CSF-granulocyte-colony stimulating factor, kg-kilogram.