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Collection of Hematopoietic Stem Cells after Previous Radioimmunotherapy is Feasible and Does Not Impair Engraftment after Autologous Stem Cell Transplantation in Follicular Lymphoma

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Major concerns about radioimmunotherapy (RIT) administration early in the course of follicular lymphoma (FL) are long-term toxicity and the theoretical impairment of hematopoietic stem cell (HSC) harvest, but few data are available about mobilization rates after RIT. This study evaluates the impact of prior therapy with RIT (yttrium-90 ibritumomab tiuxetan) and different chemotherapy regimens in all FL patients (N = 103) attempting HSC mobilization at our institution over the last 7 years. Sixty-nine patients received R-CHOP (rituximab-cyclophosphamide-doxorubicin-vincristine-prednisone) or CHOP-like regimens, 21 patients received R-FM (rituximab-fludarabine-mitoxantrone), and 13 patients received RIT before HSC mobilization. Median CD34+ cell yield at first mobilization was 7.2 × 10^6/kg in the R-CHOP group versus 4.3 in the R-FM group versus 1.7 in the RIT group ($P = .02$ R-CHOP versus R-FM; $P < .0001$ R-CHOP versus RIT; $P < .02$ R-FM versus RIT). Although 8 of 13 patients initially failed to collect enough HSC after RIT, a second and/or salvage harvest was successfully performed in 7 patients, with 10 of 13 patients (77%) finally undergoing autologous stem cell transplantation (ASCT). No differences in engraftment kinetics were observed between the three groups (R-CHOP versus R-FM versus RIT). Although mobilization was significantly impaired in patients previously treated with RIT, a salvage HSC harvest and ASCT after RIT were safe and feasible in most patients.
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INTRODUCTION

Follicular lymphoma (FL), the most common form of indolent B cell lymphoma in Western countries [1,2], is characterized by a long natural history with multiple relapses and remains incurable with current standard therapeutic approaches [3,4]. Whereas the anti-CD20 antibody rituximab has been broadly accepted as part of first-line therapy [5-9] or as maintenance therapy [10], there is no standard first-line chemotherapy, because an overall survival advantage of one regimen over another has not been demonstrated [11]. Because some reports underline the potential of bone marrow damage [12,13] of fludarabine-containing regimens, with impairment in subsequent hematopoietic stem cell (HSC) collection and increased risk of secondary acute myeloid leukemias/myelodysplastic syndromes [13], the R-CHOP (rituximab-cyclophosphamide-doxorubicin-vincristine-prednisone) is widely used as induction therapy.

In the relapsed/refractory setting, radioimmunotherapy (RIT) is an effective and manageable treatment option, and yttrium-90 ibritumomab tiuxetan and iodine I-131 tositumomab are currently approved in, respectively, Europe and the United States for the treatment of relapsed/refractory or transformed FL [14,15]. These radioimmunoconjugates showed the most potent single-agent activity against FL [16,17] with high and durable response rates if used as first-line therapy. The results of RIT with yttrium-90 ibritumomab tiuxetan in the setting of first-line therapy consolidation are also very promising, demonstrating a significant progression-free survival advantage over observation [18]. Also, several phase II trials confirmed the feasibility and efficacy of RIT as consolidation treatment after first-line therapy [19-22]. On the other hand, autologous stem cell transplantation (ASCT) is a suitable option for relapsed FL patients [23-25]. Whereas front-line ASCT results in durable remissions and superior progression-free survival compared with standard therapy, to date available data do not support the use of ASCT as first-line consolidation, given the lack of overall survival advantage [26-28].

Considering the natural history of FL, the importance of appropriate drug choice and the placement of RIT and ASCT in the disease course remains an issue, and to date the best way to sequence available treatment strategies is still undefined. Major concerns about the widespread use of RIT early in the disease course (as first-line consolidation) are long-term hematologic toxicity and the theoretically possible irreparable damage to bone marrow function with impairment of peripheral stem cell harvest and thus ASCT. Although RIT administration after ASCT has been demonstrated to be safe and feasible [29], no data are available about peripheral blood stem cell (PBSC) mobilization rates after RIT exposure, and the available reports are anecdotal [30]. The aim of this monocentric study is to analyze the impact of prior RIT administration on PBSC mobilization and harvest and on the outcome of subsequent ASCT. The impact of the type of prior

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regimens and number of previous lines of therapy were evaluated in all FL patients (N = 103) who underwent PBSC mobilization at our institution from January 2005 to December 2012.

METHODS

Data Source, Assessments, and Study Endpoints

Data from all FL patients who attempted PBSC mobilization from 2005 to 2012 were prospectively collected, and the impact of previous RIT and other chemotherapy regimens given earlier in the disease course on HSC collection was retrospectively evaluated. In our clinical practice, stem cell collection and ASCT was attempted in patients younger than 65 years of age with adequate performance status (Eastern Cooperative Oncology Group ≥ 2) at disease relapse or in those patients who did not achieve a complete response after first-line chemoimmunotherapy. Thirteen patients included in a phase II study received ASCT as consolidation in first complete response. RIT with yttrium-90 ibritumomab tiuxetan was largely used preferentially in elderly patients (≥65 years) with relapsed/refractory disease or in those patients who refused or were unfit for ASCT. RIT was given as consolidation after first-line treatment to 47 patients enrolled in 2 phase II studies and 1 phase III randomized trial [1-3].

The study algorithm is shown in Figure 1. The primary endpoint was to describe the impact of previous RIT compared with different prior treatment regimens (R-CHOP/CHOP-like regimens and R-FM [rituximab-fludarabine-mitoxantrone]) on PBSC mobilization and on the safety and efficacy of subsequent remobilization/collection procedures in FL patients. The secondary endpoint was to evaluate differences in neutrophil and platelet (PLT) engraftment kinetics after ASCT across the 3 groups. Neutrophil engraftment was defined as the first day with an absolute neutrophil count (ANC) > .5 × 10^3/μL. PLT engraftment was defined as the first day with a PLT count > 20 × 10^3/μL.

Treatment Protocols

Patients were treated with the following chemoimmunotherapy regimens either at disease onset or at relapse, according to our institutional guidelines: R-CHOP, R-MACOP-B (rituximab, cyclophosphamide, doxorubicin, methotrexate, vincristine, bleomycin, prednisone), R-FM, and R-CVP (rituximab, cyclophosphamide, vincristine, prednisone) were given as previously described [11,31,32]. The RIT treatment plan consisted of an initial infusion of rituximab at a dose of 250 mg/m^2 on day 1, repeated on day 7. The second infusion of rituximab was followed by a weight-based dose of yttrium 90-ibritumomab tiuxetan as previously described [21,22]. Patients with a pretreatment PLT count < 100,000/μL or bone marrow lymphoma infiltration > 25% were not eligible for RIT. The mobilization protocols were chemotherapy (ifosfamide, etoposide, epirubicin regimen [33] or cyclophosphamide 7 g/m^2, day 1) + granulocyte colony-stimulating factor (G-CSF; 5 μg/kg daily) given from day 6 after chemotherapy or G-CSF alone (10 μg/kg daily) beginning 4 days before stem cell harvest.

Before 2008, all patients who failed the first mobilization attempt underwent bone marrow harvest. After 2008, the CXCR4 inhibitor plerixafor was given at the dose of 240 μg/kg on the evening of the days before leukoapheresis, which was initiated approximately 10 hours later. Before being approved in Europe, plerixafor was slated only as compassionate use from 2008 to 2010.

All patients were treated with the BEAM (BCNU, etoposide, cytosine arabinoside, melphalan) conditioning regimen before stem cell infusion, as previously reported [34]. G-CSF was administered to all patients to accelerate neutrophil recovery beginning 6 days after stem cell infusion.

Inclusion Criteria and Stem Cell Collection Procedure

Patients were considered suitable for PBSC mobilization if aged ≥ 18 years and ≤65 years and potentially eligible for ASCT with Eastern Cooperative Oncology Group ≤ 2. Additional criteria included adequate white blood cell counts, neutrophil, PLT count, serum creatinine, and normal liver function. In addition, all patients were assessed for cardiac and respiratory function tests, and patients with impaired left ventricular ejection fraction or abnormal respiratory tests were excluded. All patients signed a written informed consent, and the protocol was carried out according to the Declaration of Helsinki and approved by the institutional review board.

The PBSC collection procedure was initiated when CD34+ cell counts reached to 10/μL. Double-volume leukoapheresis (two blood volume) was used, according to the institutional guidelines, until enough stem cells were collected: The minimum stem cell dose needed to proceed to ASCT was ≥2.0 × 10^6/kg. The optimal stem cell dose was considered to be ≥5.0 × 10^6/kg, according to the literature [35-37]. Regarding rescue HST harvest procedures (such as bone marrow harvest or plerixafor salvage), although the optimal stem cell dose was still considered to be ≥2.0 × 10^6/kg, the minimum CD34+ cell dose required to undergo ASCT was lowered to ≥.8 × 10^6/kg for those patients lacking valid alternative therapeutic options.

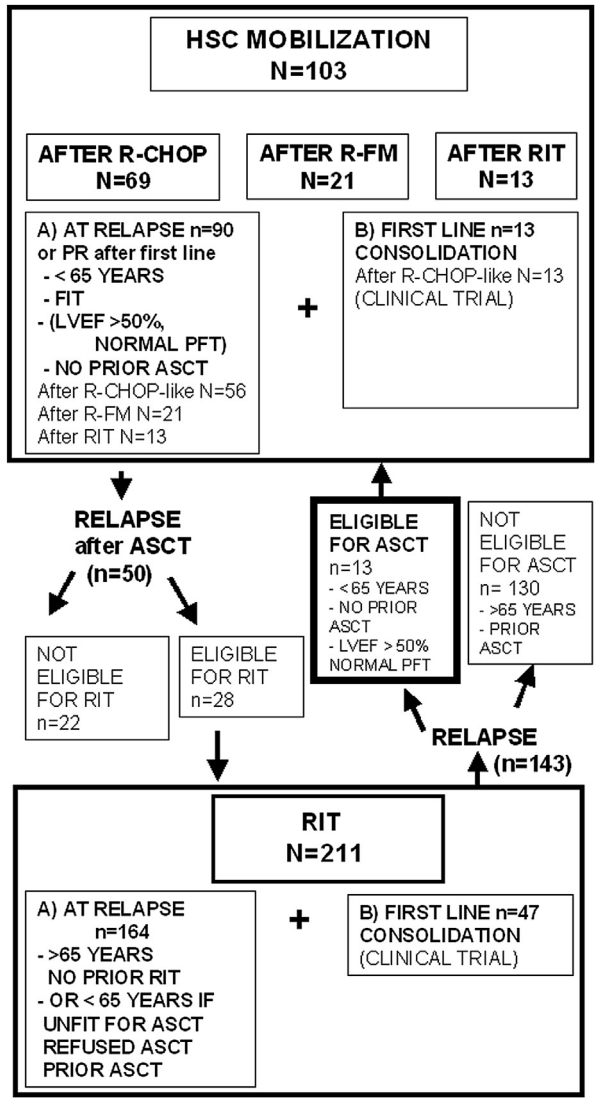

Figure 1. General study design. LVEF, left ventricular ejection fraction; PFT, pulmonary function test; PR, partial response.

Statistical Analysis

Differences in proportions between groups were evaluated by using the chi-square test. Differences of median values of collected and reinfused CD34+ cells between groups were calculated using the Mann-Whitney test. Differences in engraftment kinetics between groups were calculated with the Kaplan-Meier method [38], using the Wilcoxon rank test. Significance was set at $P < .05$.

RESULTS

Impact of RIT and Other Prior Therapies on Stem Cell Mobilization and Collection

From January 2005 to December 2012, 103 patients affected by FL underwent PBSC mobilization in our institution. ASCT was finally performed in 97 patients. Six patients did not undergo ASCT because of disease progression (n = 2), left ventricular ejection fraction < 50% (n = 2), and insufficient stem cell harvest (n = 2). Thirteen patients included in a phase II study received ASCT as consolidation in first complete response. During the same period, 211 patients

Table 1
General Patient Characteristics

Factor	R-CHOP(-like)	R-FM	RIT	*P*
No. of patients (%)	69 (67)	21 (20.4)	13 (12.6)	
Age, median (range)	48 (27-67)	47 (35-65)	51 (36-66)	.7*
Gender, M/F (%)	35/34 (50.7/49.3)	10/11 (47.6/52.4)	7/6 (53.8/46.2)	.9†
Weight, median (range)	77 (50-98)	75 (47-88)	80 (52-110)	.5*
Stage at diagnosis				
I-II (%)	13 (18.8)	3 (14.3)	2 (15.3)	.9†
III-IV (%)	56 (81.2)	18 (85.7)	11 (84.7)	
Bone marrow involvement				
Yes (%)	7 (10.1)	3 (23)	1 (7.7)	.5†
No (%)	62 (89.9)	13 (77)	12 (92.3)	
Lines of therapies before mobilization, median (range)	1 (1-3)	2 (1-3)	2 (2-3)	<.001*,‡ <.001*,§ .09*,‖
First line (median no. of cycles)				NE
R-CHOP	51 (6)	2 (6)	7 (6)	
R-MACOP-B	18 (12)	1	0	
R-CVP	0	0	2 (6)	
R-FM	0	17 (6)	4 (6)	
RT	3	1	0	
First mobilization regimen				
IEV+G-CSF (%)	48 (69.5)	12 (57.1)	9 (69.2)	.4†
CTX + G-CSF (%)	18 (26.1)	6 (28.6)	2 (15.4)	
G-CSF (%)	3 (4.4)	3 (14.3)	2 (15.4)	
Preemptive Plerixafor	0	1 (4.8)	1 (7.7)	

R-MACOP-B indicates rituximab, cyclophosphamide, doxorubicin, vincristine, methotrexate, bleomycin, prednisone; IEV, ifosfamide, etoposide, epirubicin; RT, radiotherapy; CTX, high-dose cyclophosphamide; NE, not evaluated; M, male; F, female.
* Mann-Whitney test.
† Chi-square test.
‡ (R)-CHOP vs. (R)-FM.
§ (R)-CHOP vs. RIT.
‖ (R)-FM vs. RIT.

were treated with RIT using yttrium-90 ibritumomab tiuxetan. RIT was given at disease relapse in 164 cases and as first-line consolidation in 47 patients enrolled in 3 phase II studies and 1 phase III randomized trial [18,21,22,39]. Forty-one patients had both RIT and the PBSC mobilization procedure during their disease course, and in 13 patients the PBSC mobilization was attempted after RIT exposure. The study design is depicted in Figure 1.

At the time of mobilization, 69 patients had received R-CHOP (or CHOP-like regimens), 21 patients R-FM, and 13 patients RIT with yttrium-90 ibritumomab tiuxetan at least once earlier in the disease course. Characteristics of patients are described in Table 1.

In the RIT group (n = 13), 11 patients met the diagnosis of FL grade I-IIIA, and 2 patients were affected by FL grade IIIB/DLBCL. Seven patients received RIT as first-line consolidation and 6 patients at disease relapse. Eight patients (61%) did not reach the minimum CD34+ cell count to undergo apheresis (10/μL). One of these patients received plerixafor at first mobilization with a "just in time" approach, finally reaching the optimum mobilization target of $>5.0 \times 10^6$ CD34+/kg; thus, 6 patients (46%) finally reached the collection yield of $\geq 2.0 \times 10^6$ CD34+ cells/kg at first mobilization attempt. Considering the remaining patients who failed (n = 7), a bone marrow harvest was attempted in 5, 2 patients had G-CSF + plerixafor as remobilization procedure, and 1 had both. Remarkably, 6 additional patients (5 patients after bone marrow harvest and 1 after G-CSF + plerixafor) were finally able to collect the minimum HSCs required to undergo ASCT.

Considering also the first mobilization attempt, 2 of 3 patients rescued with plerixafor met the mobilization target of $>2.0 \times 10^6$ CD 34 + cells/kg. The median number of CD34+ cells collected in the 7 patients undergoing salvage harvest procedures was .95 CD34+ $\times 10^6$/kg (range, .72 to 3.6). Overall, after the second/third harvest, the median value of CD34+ cells collected increased from 1.7 to 3.3 $\times 10^6$ CD34+ cells/kg (range, .72 to 8.2). Finally, ASCT was successfully performed in 10 patients (77%). Three patients did not

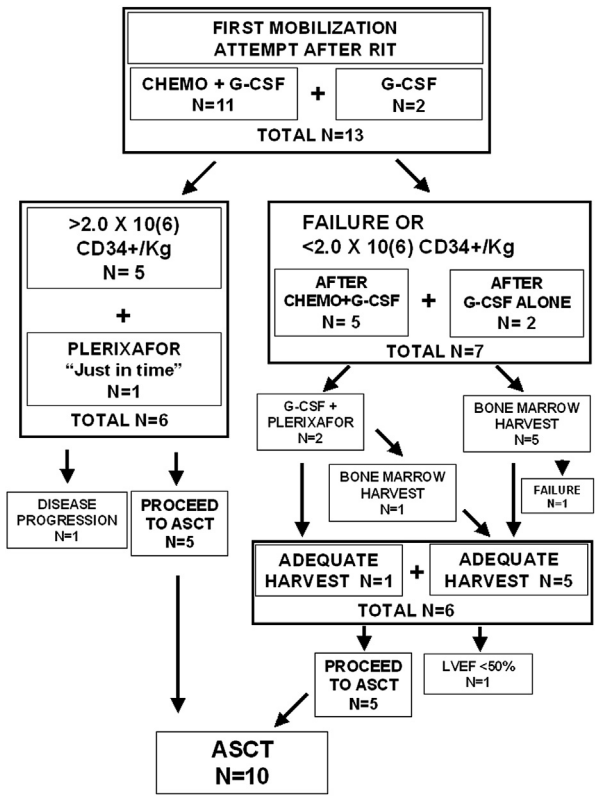

Figure 2. HSC collection algorithm in the RIT group. LVEF, left ventricular ejection fraction; CHEMO, chemotherapy.

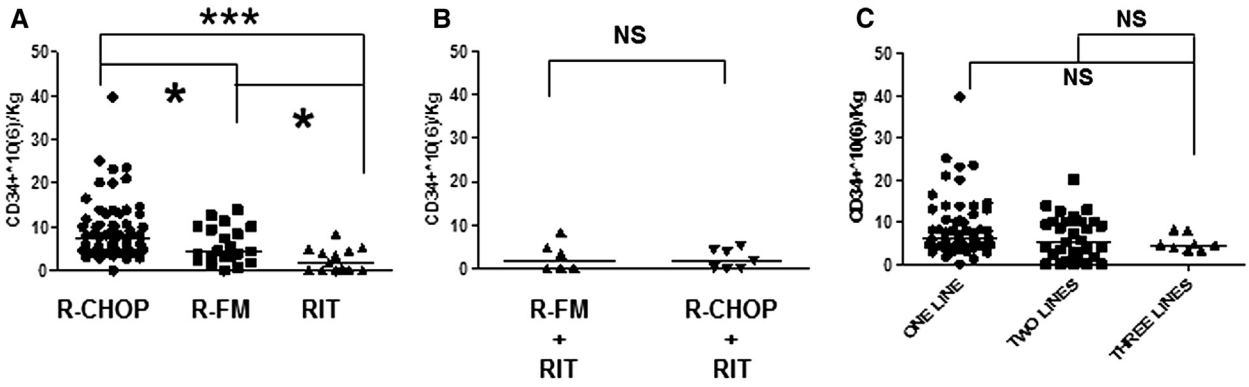

Figure 3. (A) Impact of prior therapies (R-CHOP versus R-FM versus RIT) on the first PBSC mobilization attempt. (B) Impact of prior fludarabine versus R-CHOP exposure on the first PBSC mobilization attempt in the RIT group. (C) Impact of the number of prior therapies on the first PBSC mobilization attempt. *$P < .05$; **$P < .01$; ***$P < .001$.

undergo ASCT, 1 because of insufficient HSC harvest, 1 because of left ventricular ejection fraction < 50%, and 1 because of disease progression. The time from RIT exposure to PBSC mobilization (>/<12 months) did not appear to influence the final outcome of PBSC collection ($P = .14$). The HSC collection algorithm of the RIT group is depicted in Figure 2, and detailed data of patients in the RIT group are shown in Supplemental Table 1.

Considering the whole study cohort (N = 103 patients), the type of previous therapy significantly affected PBSC collection because the median CD34+ cell yield was 7.2 × 10^6/kg in the R-CHOP group versus 4.3 × 10^6 CD34+ cells/kg in the R-FM group versus 1.7 × 10^6 CD34+ cells/kg in the RIT group ($P = .02$ R-CHOP versus R-FM; $P < .001$ R-CHOP versus RIT; $P = .02$ R-FM versus RIT; Mann-Whitney test) (Figure 3A). Interestingly, with the limit of small numbers available, no significant differences in PBSC mobilization were observed in patients previously exposed to both R-FM and RIT compared with patients treated with both R-CHOP and RIT (Figure 3B). At first mobilization attempt, the collection yield of 2.0 × 10^6 CD34+ cells/kg was reached in 97% of patients (n = 67) in the R-CHOP group versus 76% (n = 16) in the R-FM group versus 46% (n = 6) in the RIT group. Although the median number of prior therapies was 1 in the R-CHOP group versus 2 in the R-FM and RIT groups, the number of treatments received before HSC mobilization per se did not significantly affect the amount of PBSC collected (1 versus 2 lines: $P = .1$; 1 versus 3 lines: $P = .1$; 2 versus 3 lines: $P = .7$; Mann Whitney test) (Figure 3C). Considering the total number of chemotherapy cycles received before mobilization, 12 patients had ≤6 cycles, 60 patients between 7 and 12 cycles, and 31 patients received 13 to 20 cycles. In addition, the total number of chemotherapy cycles received before mobilization did not affect the PBSC collection rate (0 to 6 cycles versus 7 to 12 cycles, 13 to 20 cycles, $P = .8$, Mann Whitney test, data not shown). Mobilization results according to prior therapies are summarized in Table 2 and Figure 3.

Impact of RIT and Other Prior Therapies on Engraftment after ASCT

Because a concern about PBSC harvest after RIT exposure is the quality of HSCs collected, we evaluated the functionality of the reinfused stem cells by assessing the engraftment parameters. Overall, 97 patients underwent ASCT after HSC collection. Stem cell source were PBSC in 91 patients (94%), bone marrow in 5 (5%), and both in 1 (1%). The median number of reinfused CD34+ cells was 4.4 for the R-CHOP group versus 3.4 for the R-FM group versus 2.6 for the RIT group ($P < .01$ R-CHOP versus RIT; $P = .07$ R-CHOP versus R-FM; $P = .08$ R-FM versus RIT). General data on ASCT and engraftment in the 3 groups are shown in Table 3. Of note 70% of patients (7/10) in the RIT group received >2.0 × 10^6/kg CD34+ cells (Supplemental Table 1).

Median time to ANC > 500/μL and PLT recovery > 20,000/μL was 10 and 11 days, respectively, from stem cell infusion in all groups. Using the Kaplan-Meier method and the Wilcoxon rank test, we did not find a statistically significant difference between the two chemotherapy arms and the RIT arm

Table 2
General Mobilization Outcome According to Prior Therapies

Factor	R-CHOP (n = 69)	R-FM (n = 21)	RIT (n = 13)	*P*
Collected CD34+ cells, median (range)	7.2 (0-39.7)	4.3 (0-13.9)	1.7 (0-8.2)	.02*,‡ <.0001*,‡ .02*,‖
≥2.0 × 10^6 CD34+/kg (%)	67 (97)	16 (76.2)	6 (46)	<.001†
≥5.0 × 10^6 CD34+/kg (%)	45 (65)	9 (42.8)	2 (15)	<.01†
Median days of leucoapheresis (range)	1 (1-3)	1 (1-3)	2 (1-3)	.03*,‡ <.001*,§ .09*,‖
Salvage harvest procedure (%)	1 (1.5)	5 (24)	8 (61.5)	<.001†
Patients proceeding to ASCT (%)	68 (98.5)	19 (90.5)	10 (76.9)	.007†

* Mann-Whitney test.
† Chi-square test.
‡ R-CHOP vs. R-FM.
§ R-CHOP vs. RIT.
‖ R-FM vs. RIT.

Table 3
Characteristics of ASCT and Engraftment According to Prior Therapies

ASCT	R-CHOP (n = 68)	R-FM (n = 19)	RIT (n = 10)	*P*
Reinfused CD34+ cells, median (range)	4.4 (1.2-12.2)	3.4 (1.2-8.3)	2.6 (0.7-4.2)	.07*,§ <.01*,‖ .08*,¶
Stem cell source (%)				
PBSC	68 (100)	18 (94.8)	6 (60)	
Bone marrow	0 (0)	1 (5.2)	4 (40)	<.001†
Both	0 (0)	0 (0)	1 (10)	
Days to neutrophil recovery > 500/μL, median (range)	10 (7-18)	10 (8-13)	10 (8-24)	.1‡
Days to PLT recovery > 20,000/μL, median (range)	11 (9-19)	11 (9-25)	11 (10-180)	.1‡

* Mann-Whitney test.
† Chi-square test.
‡ Wilcoxon rank test.
§ (R)-CHOP vs. (R)-FM.
‖ (R)-CHOP vs. RIT.
¶ (R)-FM vs. RIT.

regarding both ANC and PLT recovery (Figure 4A, Table 3). Only the absolute number of reinfused CD34+ cells significantly affected ANC and PLT engraftment (Figure 4B). Of note, considering the RIT group, in 6 of 7 patients (86%) who were reinfused with more than 2.0 × 10^6 CD34+ cells/kg, the hematologic recovery was fast and complete (Figure 4C). These findings indicate that RIT exposure per se does not impair PLT and ANC engraftment and thus the quality of collected stem cells. No differences in the incidence of febrile neutropenia were noted across the 3 groups (42% in the R-CHOP group, 33% in the R-FM group, 38% in the RIT group, *P* = NS).

Late Hematologic Toxicity and Secondary Neoplasms

All patients had a complete neutrophil recovery after ASCT. PLT recovery was complete (≥150,000/μL) in 93 of 97 patients. One patient in the R-CHOP, 1 in the R-FM, and 2 in the RIT group had an incomplete PLT recovery.

We observed only 1 case of secondary acute myeloid leukemia developing in a patient exposed in sequence to

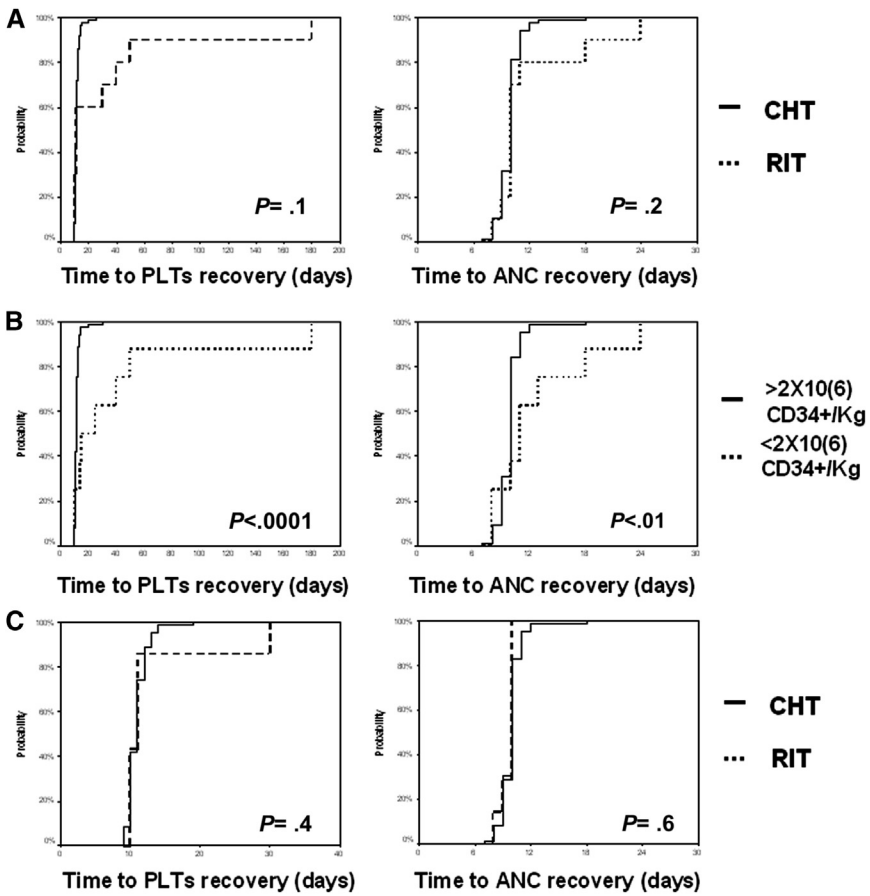

Figure 4. (A) Time to ANC (≥500/μL) and PLT recovery (≥20,000/μL) in the chemotherapy (CHT) group (n = 87) compared with the RIT group (n = 10). (B) Time to ANC (≥500/μL) and PLT recovery (≥20,000/μL) in patients reinfused with <2.0 × 10^6/kg CD34+ cells (n = 9) compared with patients reinfused with >2.0 × 10^6/kg CD34+ cells (total n = 88). (C) Time to ANC (≥500/μL) and PLT recovery (≥20,000/μL) in the chemotherapy (CHT) group (n = 81) compared with the RIT group (n = 7) for patients reinfused with >2.0 × 10^6/kg CD34+ cells (total n = 88).

R-CHOP, R-FM, RIT, and ASCT during the disease course 48 months after ASCT. In this patient PBSCs were collected before RIT and fludarabine exposure. Median follow-up was 61 months in the R-CHOP group versus 64 months in the R-FM group versus 58 months in the RIT group (P = NS). No myelodysplastic syndromes were documented in any treatment group.

DISCUSSION

This is the first study investigating the effect of RIT on HSC mobilization with respect to other therapies in FL. These data show that although prior RIT significantly impairs PBSC mobilization compared with other chemotherapy regimens, HSC harvest after RIT exposure is feasible, allowing most patients to undergo ASCT with a salvage harvest/remobilization procedure. In this light, the activity of the CXCR4 inhibitor plerixafor, which was used with G-CSF in 3 cases, was particularly promising, allowing 2 patients to collect $\geq 2 \times 10^6$ CD34+ cells/kg without the need of performing a bone marrow harvest. Although the proportion of patients undergoing ASCT was slightly higher in the CHOP and fludarabine groups, notably 77% of patients (10/13) in the RIT group could finally undergo ASCT, and 2 of 3 patients were not able to proceed to ASCT for causes unrelated to HSC collection. The time from RIT exposure to PBSC mobilization did not appear to influence the final outcome of PBSC collection, and, interestingly, patients previously treated with both fludarabine and RIT retained the possibility to mobilize PBSC.

Although there was a significant reduction in PBSC collection in patients previously treated with fludarabine compared with CHOP, in this study 76% of patients previously exposed to fludarabine reached the collection yield of $\geq 2 \times 10^6$ CD34+ cells/kg. Interestingly, all patients in the R-FM group received a cumulative fludarabine dose higher than 150 mg/m^2, which was recently reported to be the threshold for a detrimental effect on PBSC mobilization and long-term toxicity in FL patients undergoing ASCT [13]. The higher rate of mobilization success reported in the present study after fludarabine treatment with respect to other reports could be explained by the fact that the vast majority of patients were mobilized with chemotherapy plus G-CSF, suggesting that the mobilization schedule (chemotherapy + G-CSF versus G-CSF alone) could overcome the adverse effects of prior fludarabine exposure. Although patients in the RIT and R-FM groups received more therapy at the time of mobilization (median of 2 lines in the RIT and in R-FM arms versus 1 line in the R-CHOP arm), the amount of lines and cycles of therapy received before mobilization per se did not significantly affect the PBSC mobilization rate. Regarding engraftment after ASCT, the CD34+ cell dose was the most important factor affecting engraftment kinetics, and most RIT-exposed patients who were reinfused with $\geq 2 \times 10^6$ CD34+ cells/kg had a fast and complete hematologic recovery after ASCT. Taken together, these findings indicate that the quality of collected HSCs is not affected by previous RIT exposure. Notably, we observed only 1 case of secondary acute myeloid leukemia (.9%) in a heavily pretreated patient.

In conclusion, these data suggest that with current mobilization regimens most patients previously exposed to RIT retain the possibility to collect enough HSC to undergo ASCT, without significant increases in short- and long-term hematologic toxicities. Plerixafor should be recommended for HSC mobilization in all post-RIT patients due to the high rate of initial mobilization failure.

This is the first study addressing the effect of prior RIT on HSC mobilization and ASCT. Here we show that although the mobilization rate is significantly impaired in patients previously treated with RIT, most patients retain the possibility of undergoing ASCT after a salvage HSC harvest.

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SUPPLEMENTARY DATA

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.bbmt.2013.09.004.

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