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Autologous stem cell transplantation as frontline strategy for peripheral T-cell lymphoma: A single-centre experience

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Abstract

Objective: To determine the efficacy and prognosis of autologous hematopoietic stem cell transplantation (ASCT) as frontline treatment for peripheral T cell lymphoma (PTCL).

Methods: Clinical data from 46 PTCL patients who achieved complete (CR) or partial remission (PR) after ASCT from October 1996 to July 2014 were analysed retrospectively.

Results: Median patient age was 32 (range: 15–68) years. Disease types included PTCL, unspecified type, in 23 patients, anaplastic large cell lymphoma in eight, angioimmunoblastic lymphoma in eight, extranodal NK/T-cell lymphoma in five, and hepatosplenic T-cell lymphoma and enteropathy associated T-cell lymphoma in one each. Of these patients, 80% had Prognostic Index for Peripheral T-cell Lymphoma scores $\geq$1. Thirty-four patients had pre-transplantation CR and 12 had PR. Median follow up was 37 (6–176) months. The 5-year overall survival (OS) and progression-free survival (PFS) rates were 77.1% and 61.9%, respectively. Multivariate analysis showed that pre-transplantation CR was an independent risk factor for survival, and CR was more common than PR (OS 81% vs 59.3%; PFS 71.8% vs 17.8%).

Conclusion: Frontline consolidation treatment with ASCT was associated with favourable outcomes in patients with PTCL. Pre-transplantation CR was a prognostic factor for survival, suggesting that ASCT may be favoured as front-line consolidation therapy after first complete remission.

Keywords

Autologous stem-cell transplantation, complete response, consolidation, frontline, peripheral T-cell lymphoma

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Introduction

Peripheral T-cell lymphoma (PTCL) is a rare and highly heterogeneous tumour with a higher incidence in Asia compared with Europe and North America (30%–40% vs 15%).[1] PTCLs, apart from anaplastic lymphoma kinase (ALK)-positive anaplastic large T-cell lymphoma (ALCL), respond poorly to traditional chemotherapy. PTCL is more common than B-cell lymphoma, and has poorer long-term survival.[1,2] The International T-Cell Lymphoma Study confirmed 10–15-year overall survival (OS) and progression-free survival (PFS) rates of only about 10%.[3] Despite the development of new oncological treatments, an effective treatment for T-cell lymphoma is still lacking, and the search for more effective treatments has become a primary focus for oncologists worldwide. Autologous hematopoietic stem cell transplantation (ASCT) is currently the chief consolidation treatment for T-cell lymphoma following conventional chemotherapy.[1] However, the heterogeneous nature of PTCL in terms of its presentation and response has led to a lack of randomized controlled clinical trials of ASCT for PTCL. In the current study, we retrospectively analysed the response rates and survival outcomes in patients with PTCL treated with ASCT.

Methods

Patients

Fifty-two patients diagnosed with PTCL who received first-line ASCT in our centre between January 1997 and December 2014 were included in this study. Our institutional criteria for proceeding to ASCT included age <70 years, Eastern Cooperative Oncology Group performance status ≤ 2 points, no active infection, no vital organ impairment (total bilirubin ≤ 1.5 mg/dl, left ventricular ejection fraction $\geq 50\%$, lung function and diffusion lung capacity $\geq 50\%$ of expected value), and peripheral T-cell lymphoma diagnosis confirmed by immunohistochemistry according to the World Health Organization classification criteria.[4] We excluded six human immunodeficiency virus-positive cases, leaving 46 cases for subsequent analysis.

All histopathologic diagnoses were completed by trained pathologists. Rare or unusual pathologies were submitted to another clinical pathology department for further assessment. Data collected included the results of physical examinations, laboratory haematology, computed tomography (CT) or positron emission tomography/computed tomography (PET/CT) scans of the neck, chest, abdomen and pelvic cavities, and bone marrow aspiration and biopsy. Disease stage was determined using the Ann Arbor staging system. The International Prognostic Index (IPI) and Prognostic Index for T-cell lymphoma (PIT)[5] were also assessed for each patient.

Treatment programs

All patients received 6–8 weeks of pretransplant induction chemotherapy. One patient received radiotherapy prior to chemotherapy to alleviate symptoms during the early stages of the disease related to severe bone pain. The initial chemotherapy prior to 2011 was CHOP (cyclophosphamide, epirubicin, vindesine, prednisone) or CHOP-like chemotherapy, and the initial treatment after 2011 was either HyperCVAD (course A: cyclophosphamide, vincristine, doxorubicin, and dexamethasone; course B: methotrexate and cytarabine) or GDP-ML (gemcitabine, dexamethasone, cisplatin, methotrexate, pegaspargase). After 2000, intensity-modulated chemotherapy (IMC) was also used routinely in all PTCL patients. IMC was defined as second-line treatment including MINE (ifosfamide, mesna, mitoxantrone, etoposide) or ESHAP (etoposide, cisplatin, methylprednisolone, cytarabine). Twenty

patients received IMC after being in PR. The source of the stem cells was mobilized peripheral blood in all patients. Stem cells were mobilized with chemotherapy and granulocyte colony-stimulating factor (G-CSF) or granulocyte–macrophage colony-stimulating factor (GM-CSF) in 41 (89%) cases, and with G-CSF alone in five cases. The doses of G-CSF and GM-CSF were 5–10 μg/kg/day and 125–250 μg/day, respectively. The conditioning regimen was mainly BEAM (carmustine 300 mg/m^2, day −7, etoposide 200 mg/m^2, days −6 to −3, cytarabine 400 mg/m^2, days −6 to −3, melphalan 140 mg/m^2, day −2)[6] or CBVC (cyclophosphamide 1.8 g/m^2, day −3 to −2, carmustine, 300 mg/m^2, day −8, etoposide, 300 mg/m^2, day −6 to −4, carboplatin 300 mg/m^2, day −7 to −4). The second regimen, which was the routine conditioning regimen for ASCT in lymphoma patients in our institution, included the addition of carboplatin based on cyclophosphamide, carmustine, and etoposide (CBV).[7,8]

Clinical efficacy and follow-up criteria

The response to therapy was evaluated according to published standards prior to transplantation, 3 and 6 months after transplantation, and every 6 months thereafter. Assessments included a physical examination, complete blood count and biochemistry, bone marrow aspiration and biopsy, and imaging including CT or PET-CT. Complete remission (CR) or undetermined CR, partial remission (PR), stable disease (SD), and progressive disease (PD) were defined according to standard guidelines.[9] If PET-CT was performed, response was assessed according to the rules proposed by the International Harmonization Project in Lymphoma.[10] Post-transplant patients with suspected residual disease were followed up for 6 months or longer. If no changes were noted, this was considered as CR. Transplantation-related death was defined as death within 100 days after high-dosage pre-treatment chemotherapy unrelated to the disease itself, disease recurrence, or progression.

Statistical analysis

The primary endpoints were OS and PFS calculated using the Kaplan–Meier method.[11] OS was defined as the time from diagnosis to patient death or the last follow-up, and PFS was defined as the time from diagnosis to disease progression, death, or last follow-up. Factors affecting OS and PFS were analyzed using Cox's proportional hazards regression analysis, and variables identified as statistically significant using univariate analysis were subsequently assessed by multivariate analysis.[12] Survival was compared using log-rank tests.[13] Statistical significance was set at $a < 0.05$ (two-tailed). SPSS 19.0 software (IBM, Chicago, IL, USA) was used for statistical analysis.

Results

Patient information is shown in Tables 1 and 2. Thirty-four (73.9%) patients achieved CR and 12 (26.1%) achieved PR prior to ASCT. Among the 20 patients who received IMC, 12 (60.0%) achieved CR before transplantation. Six patients achieved PR after four courses of induction chemotherapy without IMC before 2000, among whom two (33.3%) achieved CR before transplantation. Patients who received IMC appeared to be more likely to achieve CR, but the difference was not statistically significant ($P = 0.365$).

The median time to neutrophil engraftment was 10 (range: 8–22) days and the median time to platelet engraftment was 10 (range: 7–24) days. The median duration of growth factor support after transplantation was 11 (range: 8–24) days. Thirty-two (69.6%) patients had neutropenic fever

Table 1. Clinical characteristics of patients at diagnosis (*In the seventh page, the second line*).

Variable	At diagnosis
Age (range)	32 (15–68)
>60 years	1 (2%)
Male	26 (57%)
Histological subtype	
PTCL-NOS	23 (50%)
ALK-negative ALCL	6 (13%)
ALK-positive ALCL	2 (4%)
AITL	8 (17%)
EN-NKTCL	5 (11%)
HSTCL	1 (2%)
EATL	1 (2%)
Ann Arbor stage	
I/II	4 (9%)
III/IV	42 (91%)
B symptoms	32 (70%)
Extranodal sites involvement	
0–1	41 (89%)
≥2	5 (11%)
BM involvement	6 (13%)
Bulky disease	3 (7%)
High LDH	35 (76%)
IPI	
<3	26 (57%)
≥3	20 (43%)
PIT	
0,1	41 (89%)
≥2	5 (11%)
Pre-transplant state	
CR	34 (74%)
PR	12 (26%)
Pre-transplant regimens	
CHOP	20 (43%)
ECHOP	7 (15%)
HyperCVAD	8 (17%)
GDP-ML	11 (24%)
Intensity modulated chemotherapy	
MINE	12 (26%)
ESHAP	8 (17%)

PTCL-NOS: peripheral T cell lymphoma unspecified; ALK: anaplastic lymphoma kinase; ALCL: anaplastic large T-cell lymphoma; AITL: angioimmunoblastic T-cell lymphoma; EN-NKTCL: extranodal natural killer/T-cell lymphoma; HSTCL: hepatosplenic gamma/delta T-cell lymphoma; EATL: enteropathy-associated T-cell lymphoma; BM: bone marrow; LDH: lactate dehydrogenase; IPI: International Prognostic Index; PIT: Prognostic Index for Peripheral (Continued.)

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T-cell Lymphoma; CR: complete remission; PR: partial remission; CHOP: combination chemotherapy with cyclophosphamide, doxorubicin, vincristine, and prednisone; ECHOP: etoposide, cyclophosphamide, doxorubicin, vincristine, and prednisone. HyperCVAD: including courses A (cyclophosphamide, vindesine, epirubicin, and prednisone) and B (methotrexate and cytarabine); GDP-ML: gemcitabine, dexamethasone, cisplatin, methotrexate, and pegaspargase; MINE: mesna/ifosfamide, mitoxantrone, and etoposide; ESHAP: etoposide, methylprednisolone, cytarabine, and cisplatin.

Table 2. Transplant-related factors.

Variable	At transplant
Months from diagnosis to transplant, median (range)	8 (5–24)
Conditioning regimen	
BEAM	20 (43%)
CBVC	26 (57%)
CD34+ dose, median (range)	2.8 (1.6–10.3)/kg
Mobilization growth factor	46 (100%)
Cytokines post-transplant	46 (100%)
G-CSF	45 (98%)
GM-CSF	1 (2%)

BEAM: BCNU, etoposide, cytosine arabinoside and melphalan; CBVC: cyclophosphamide, bleomycin, etoposide, BCNU, and carboplatin; G-CSF: granulocyte colony-stimulating factor; GM-CSF: granulocyte–macrophage colony-stimulating factor.

and 13 (28.3%) experienced infectious complications. All patients had non-tunnelled central venous catheters inserted into internal jugular or subclavian veins, and only one (2.2%) patient developed a catheter-related infection. All patients remained in hospital until successful neutrophil and platelet engraftment. The median hospital stay was 22 (range: 17–34) days.

Prognosis

As shown in Figure 1, the median follow-up period after diagnosis was 34 (range: 6–176) months, and 35 of 46 patients remained

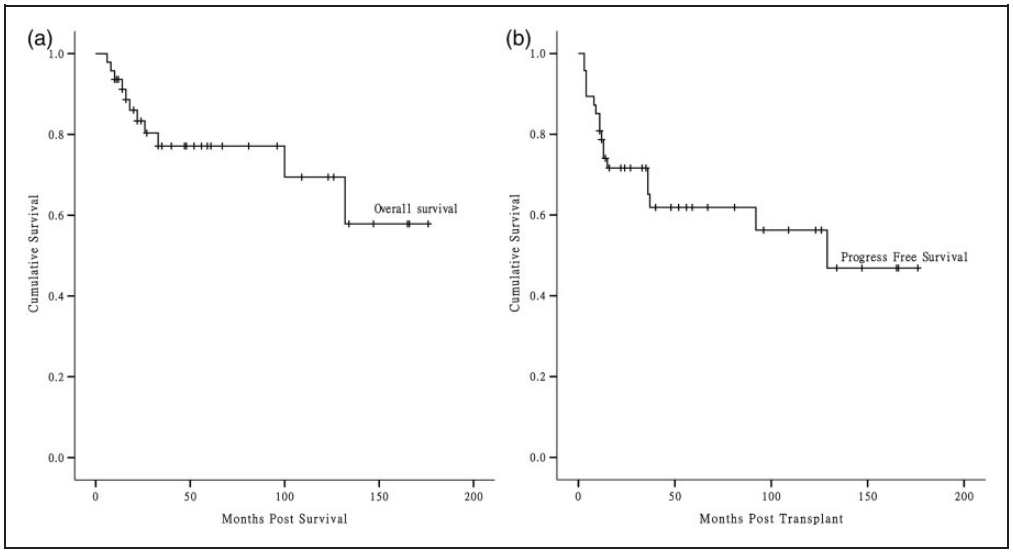

Figure 1. Overall and progression-free survival from diagnosis in peripheral T cell lymphoma patients who achieved complete (CR) or partial remission (PR) after autologous stem cell transplantation (ASCT).

alive. The estimated 5-year OS rate was 71.1% (range: 63.8–%90.4%) and the PFS rate was 61.9% (range: 46.6%–77.2%). Overall, 11 patients died, of whom nine died of disease progression and two of salvage-treatment-related complications. Transplant-related mortality was zero, similar to prior reports in patients with diffuse large B-cell lymphoma.[6]

Prognostic risk factors

We assessed possible prognostic factors that might be associated with OS and PFS (Tables 3 and 4; Figure 2). There was no significant difference in OS between patients with different subtypes of PTCL, though this lack of an association may have been due to the limited number of cases. Disease status and sex were both related to outcome in univariate analysis, while CR before transplantation was the only risk factor associated with OS in multivariate analysis; patients who achieved CR after induction chemotherapy had a 5-year OS rate of 81%, compared with an OS of 59.3% in patients with PR ($P = 0.006$). CR before transplantation was also identified as the only risk factor for 5-year PFS, and the PFS rates in patients with and without CR were 71.8% and 17.8%, respectively ($P = 0.007$). The prognosis of ALK-positive ALCL patients was better than that of other patients with PTCL,[14] which may have interfered with the overall prognosis. However, ALK-positive ALCL patients only accounted for 2% of patients in the current study, and any such effect would therefore have been minimal.

Discussion

In contrast to invasive B-cell lymphoma, there is currently no effective treatment for PTCL.[15,16] A meta-analysis of 2912 cases of PTCL concluded that the 5-year survival following conventional chemotherapy (CHOP or CHOP-like) was only 37%.[17] We reported the response rates and survival of PTCL patients in our centre after front-line ASCT, which represents the largest

Table 3. Univariate analysis of prognostic factors influencing outcome.

		OS HR	95%CI	*P*	PFS HR	95%CI	*P*
Pre-transplant response	PR vs CR	3.743	1.048–13.367	*0.042*	3.949	1.495–10.434	*0.006*
BM involvement	yes vs no	1.834	0.380–8.856	0.45	2.178	0.702–6.761	0.178
Sex	male vs female	9.307	1.174–73.780	*0.035*	7.515	1.708–33.061	*0.008*
Ann Arbor stage	III–IV vs I–II	27.077	0.013–56666.633	0.398	2.405	0.314–18.4	0.398
IPI	>2 vs ≤2	1.005	0.293–3.449	0.994	1.056	0.406–2.747	0.911
PIT	≥2 vs <2	1	0.126–7.905	0.998	1.22	0.279–5.334	0.792
B symptoms	yes vs no	1.426	0.375–5.419	0.603	0.997	0.372–2.670	0.997
LDH	high vs normal	0.99	0.258–3.805	0.989	1.275	0.415–3.918	0.672
Bulky disease	yes vs no	0.044	0–1452.313	0.556	1.761	0.401–7.735	0.454
Extranodal sites involvement	>1 vs ≤1	0.885	0.112–7.005	0.908	1.024	0.234–4.484	0.975
Months from diagnosis to transplant	<6 m vs ≥6 m	1.795	0.542–5.940	0.338	1.146	0.427–3.077	0.787
Conditioning regimen	CBVC vs BEAM	0.822	0.181–3.727	0.8	1.068	0.343–3.328	0.909
Intensity-modulated chemotherapy	yes vs no	1.756	0.535–5.768	0.353	1.972	0.748–5.198	0.169

OS: overall survival; HR: hazard ratio; CI: confidence interval; PFS: progression-free survival; PR: partial remission; CR: complete remission; BM: bone marrow; IPI; International Prognostic Index; PIT: Prognostic Index for T-cell Lymphoma; LDH: lactate dehydrogenase; CBVC: cyclophosphamide, bleomycin, etoposide, BCNU, and carboplatin; BEAM: BCNU, etoposide, cytosine arabinoside, and melphalan.
Note: Italics represent significant differences between the two groups were shown.

Table 4. Multivariate analysis of potential prognostic factors for progression-free and overall survival.

		OS HR	95%CI	*P*	PFS HR	95%CI	*P*
Pre-transplant response	PR vs CR	8.127	1.851–35.673	*0.006*	4.978	1.565–15.838	*0.007*
Sex	male vs female	4.924	0.534–45.435	0.16	3.931	0.786–19.668	0.096

OS: overall survival; HR: hazard ratio; PFS; progression-free survival; CI: confidence interval.
Note: Italics represent significant differences between the two groups were shown.

single-institution study of ASCT in PTCL patients in China published to date. We demonstrated a 5-year OS rate of 71.1% and PFS rate of 61.9% in PTCL patients who underwent frontline ASCT as consolidation therapy after experiencing CR or PR to conventional induction chemotherapy. Similar results from a series of retrospective studies suggested that transplantation was an effective frontline consolidation therapy for PTCL (Table 5), though prognoses differed among studies as a result of differences in patient selection, disease subtypes, and conditioning regimens, and 5-year OS rates ranged from 62%–67%, and PFS rates from 60%–63%.[18–20]

Although retrospective studies include selection bias that can artificially inflate survival estimates, some prospective studies have also shown encouraging results (Table 6). The largest studies from northern Europe and Germany reported a 40%–70%

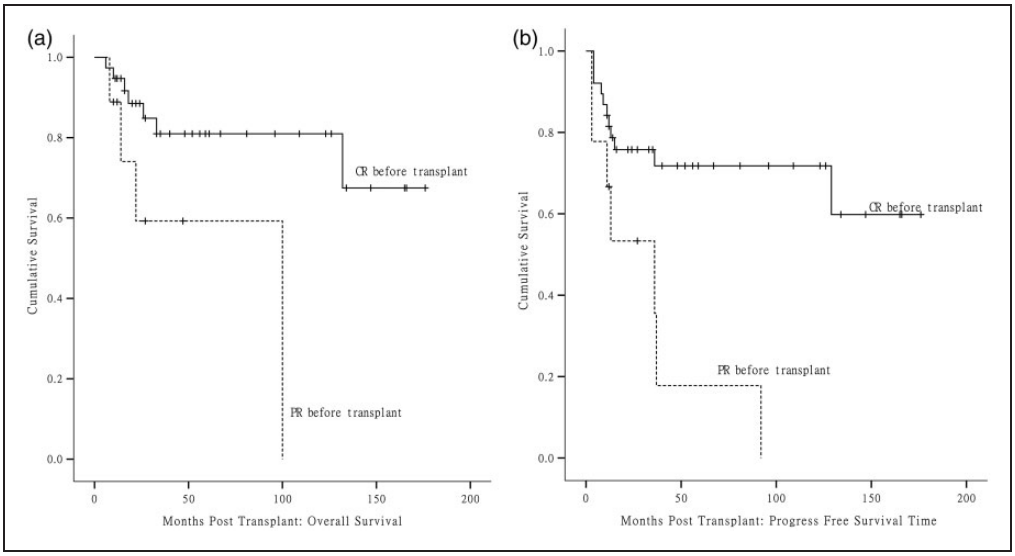

Figure 2. Survival according to pre-transplant response for the 46 peripheral T cell lymphoma patients. Pre-transplant CR achievement was associated with significantly better OS and PFS than pre-transplant PR. CR: complete remission; PR: partial remission; OS: overall survival; PFS: progression free survival.

Table 5. Retrospective studies of HDT + ASCT as first-line treatment in patients with peripheral T cell lymphoma (PTCL).

Year	Author	*n*	Histologic subtype	High-dose regimen	Response pre-ASCT	DFS/PFS	OS	Follow-up (months)
2007	Rodriguez[39]	19	100% AITL	BEAM/ BEAC	42% CR1 26% PR1	55% (3 y)	25% (5 y)	25
2007	Rodriguez[40]	74	50% PTCL-NOS 31% ALCL 11% AITL	BEAM/ BEAC	No data	63% (5 y)	67% (5 y)	67
2007	Feyler[41]	64	47% PTCL-NOS 31% ALCL 8% AITL 3% CTCL 3% NK/T	TBI BEAM BEC Flu/Mel	48% CR1 23% PR1	50% (3 y)	53% (3 y)	48
2008	Kyriakou[18]	146	100% AITL	BEAM (74%)	33%CR1 36%PR1	49% (4 y)	59% (4 y)	31
2010	Numata[42]	39	31% PTCL-NOS 23% ALCL 28% AITL 18% NK/T	MCEC TBI-based	69%CR1	61% (5 y)	62% (5 y)	78
2011	Beitinjaneh[43]	126	33% PTCL-NOS 37% ALCL (7% ALK +)	BEAM BEAM-like conditioning	33% CR1 51% chemo sensitive	30% (4 y)	39% (4 y)	39

(continued)

Table 5. Continued.

Year	Author	*n*	Histologic subtype	High-dose regimen	Response pre-ASCT	DFS/PFS	OS	Follow-up (months)
			12% AILT 5% NK/T 5%HSTCL 8% others		relapse 16% RD			
2011	Prochazka[44]	29 (19 ASCT)	45% PTCL-NOS 38% ALCL (10% ALK +) 3%AITL 3%HSTCL 7%EATL 3% Sezary s.	BEAM	66% CR 10% PR	52% (2 y)	65% (2 y)	55.1
2011	Hwang[45]	35 (25 ASCT)	4% Panniculitis like 8% ALCL 56% PTCL-NOS 4% ATLl 4% γ/δ T-cell	BEAM BEC Flu-RIC TBI-C based	84% CR/PR (median prior treatment 1–4)	No data	70% (3 y)	39
2013	Ahn[46]	31	42% PTCL-NOS 19% ALCL 29% NK/T (nasal) 7% AITL 3% HS-TL	BEC	74% CR 26% PR	64.5 (3 y)	64.5 (3 y)	32.4
2013	Smith[19]	115	54% PTCL-NOS 53% ALCL 13% AITL	TBI BEAM/BEAM- like conditioning C BMel/BC Other	35% CR1 21% CR2 14% PIF sensitive	47% (3 y)	59% (3 y)	71
2013	Mehta[47]	34	35% PTCL-NOS 47%AITL 18% ALK-ALCL	NA	97%CR1 3%PR	54.9% (4 y)	67.4% (4 y)	48
2014	Cairoli[48]	43	44%PTCL-NOS 26%ALCL 11.5%AICL 11.5%EATL 7%others	BEAM CVB Mito/Mel	83.7%CR1/PR1 16.3%CR2/PR2	34% (12 y)	40% (12 y)	63
2014	Gui[31]	45	66%PTCL-NOS 11%ALK + ALCL 13%ALK unknown	BEAM BEAC CBV TBI-based	40%CR1 18%PR1 29%CR2 + 13%PR2+	60% (5 y)	64% (5 y)	113.5
2015	Zou[49]	25	64%PTCL-NOS 16%AITL 12%ALCL 8%HSTL	BEAM BEAC TBI-based	76%CR1 24%CR2	63.1% (3 y)	71.8 (3 y)	38

Table 6. Prospective studies on HDT + ASCT as first-line treatment in patients with peripheral T cell lymphoma (PTCL).

Year	Author	*n*	Histologic subtype	High-dose regimen	Response pre-ASCT	DFS/PFS	OS	Follow-p (months)
2006	Corradini[23]	62	45% PTCL-NOS 30% ALK + ALCL 16% AITL	Mito/Mel or BEAM	56%CR 16% PR	30% (12 y)	34 (12 y)	76
2007	Rodriguez[50]	26	42% PTCL-NOS 31%ALK + ALCL 27% AITL	BEAM	65% CR 8% PR	53% (3 y)	73% (3 y)	35
2008	Mercadal[51]	41	49% PTCL-NOS 29% AITL 5% HSTL 5% NK/T	BEAM/BEAC	49% CR 10% PR	30% (4 y)	39% (4 y)	38
2009	Reimer[22]	83	39% PTCL-NOS 16% ALK-ALCL 33% AITL	TBI-C	47% CR 24% PR	36% (3 y)	48% (3 y)	33
2009	Nickelsen[52]	33	33% PTCL-NOS 39% ALK-ALCL 12% AITL	Mega-CHOEP	49% CR 6% PR	26% (3 y)	45% (3 y)	53
2012	D'Amore[21]	115	39% PTCL-NOS 19% ALK-ALCL 19% AITL 13% EATL 4%pannicultis like 3% T/NK nasal 3% HSTC	BEAM/BEAC (at Finnish centres)	83% CR/Cru 31% PR (130 pts. response assessable)	44% (5 y)	51% (5 y)	60.5

transplant rate based on intent-to-treat analysis. A study in northern Europe[21] reported on 115 PTCL patients who received CHOEP-14 followed by frontline autologous transplantation consolidation. Patients were pretreated with BEAM, and the 5-year OS was 51% and PFS was 44% after a median follow-up of 60.5 months. A German research group[22] reported on 83 patients who received four to six courses of CHOP, pretreated with total-body irradiation and high-dose cyclophosphamide, and demonstrated OS and PFS rates of 48% and 36%, respectively, after a median follow-up of 33 months. In addition, Corradini's group[23] prospectively studied 62 PTCL patients (including 19 cases of ALK-positive ALCL), and reported a 12-year OS of 34% and a PFS of 30%. Thus outcomes in patients who receive ASCT seem to be superior to those in patients receiving conventional chemotherapy alone. The results of the current, albeit retrospective study, confirm this conclusion. However, conventional chemotherapy was only effective in 30% of patients who therefore received ASCT in our center, while 60% of patients did not undergo transplantation because of disease progression during first-line chemotherapy, and the remaining 10% of patients missed the opportunity for ASCT because of poor general health or treatment-related complications, such as severe infections.

We also analysed the prognostic factors that might be associated with OS and PFS. Patients with pre-transplant CR had a better

prognosis for ASCT than those who had not achieved CR. Similarly, a previous retrospective study[24] showed that frontline consolidation with ASCT in PTCL patients was associated with a 4-year OS of 76% and PFS of 56%, while the 4-year OS was as high as 84% and PFS was up to 61% in patients with pre-transplant CR. Corradini et al.[23] also reported strong correlations between CR before transplantation and 10-year OS and event-free survival (EFS), with 10-year EFS rates of 62% in patients who achieved pre-transplant CR, compared with only 10% in those who did not. PTCL patients who achieve CR after induction chemotherapy may thus be more suitable candidates for frontline ASCT.

IMC may be administered to improve survival and the CR rate of induction chemotherapy. Hodgkin's lymphoma patients with advanced disease and positive PET assessment after two courses of chemotherapy who were given the bleomycin, etoposide, doxorubicin, cyclophosphamide, vincristine, procarbazine and prednisone (BEACOPP) regimen demonstrated better survival than those who received doxorubicin, bleomycin, vinblastine and dacarbazine (ABVD).[25] In addition, intensified immunochemotherapy or rituximab, doxorubicin, cyclophosphamide, vindesine, bleomycin, and prednisone (RACVBP) has been used in low-risk 18–59-year-old patients with diffuse large B-cell lymphoma (according to IPI score), with survival rates exceeding those for the standard RCHOP program.[26] Although no previous studies have supported a similar approach for improving survival in PTCL patients, our results indicated that 60% of patients with PR after four courses of induction chemotherapy achieved CR after IMC, with a higher CR rate in the IMC compared with the non-IMC group (60% vs 33%, $P = 0.365$). However, the difference in survival between the groups was not significant, possibly because of the small number of cases involved.

New drug applications in China are generally slow to be approved, and improvements in existing pre-transplant therapies are therefore needed. Various aspects of PTCL remain incompletely understood, though a limited number of retrospective and prospective studies of ASCT in PTCL have indicated that disease progression occurs early during traditional chemotherapy, and about 30% of patients miss the opportunity for transplantation. In our centre, 231 patients younger than 70 years were diagnosed with PTCL, and although 173 of them received chemotherapy between January 1997 and December 2014, only 52 met the criteria for ASCT in our center. Moreover, ASCT was associated with limited improvements in survival of patients with PR, suggesting that new drug regimens with histone deacetylase inhibitors,[27–30] new nucleotide analogues,[31] bortezomib,[20,32] and anti-CD30 monoclonal antibody[33–35] should be investigated in these patients. Genomics and proteomics are currently providing new therapeutic targets and biomarkers that may offer potential therapies for this type of lymphoma. PTCL classification is based not only on clinical and morphological features, but also on genetic and epigenetic factors. Different subclasses of PTCL may thus require specific treatments, and ALK inhibitors may be an appropriate option in ALK-positive anaplastic large cell lymphoma (ALCL) patients.[36–38]

This study had some limitations. Although we studied ASCT over an 18-year period, 96% of patients received their transplants after 2000. This was a retrospective study and was therefore subject to recall bias, and precise relapse data for some patients after transplantation could not be located. In addition, our subjects were younger than those in Western reports, possibly because of earlier onset of PTCL in China, which may be based on socioeconomic and ethnic differences.

In conclusion, frontline ASCT as consolidation therapy is associated with a good

prognosis in patients with PTCL. Patients who achieve CR prior to ASCT may have a significantly better prognosis than those who achieve PR, but further randomized prospective studies are needed to confirm this conclusion.

Declaration of conflicting interests

The authors declare that there is no conflict of interest.

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