

## Invited review

# Bortezomib in plasmablastic lymphoma: A glimpse of hope for a hard-to-treat disease



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## ABSTRACT

Plasmablastic lymphoma (PBL) is a rare and hard to treat disease. With current standard chemotherapeutic regimens, PBL is associated with a median overall survival of 12–15 months. We performed a systematic review of the literature through March 31, 2017 looking for patients with a diagnosis of PBL who were treated with bortezomib, alone or in combination. We identified 21 patients, of which 11 received bortezomib in the frontline setting and 10 received bortezomib in the relapsed setting. Eleven patients were HIV-positive and 10 were HIV-negative. The overall response rate to bortezomib-containing regimens was 100% in the frontline setting and 90% in the relapsed setting. Furthermore, the 2-year overall survival of patients treated upfront was 55%, and the median OS in relapsed patients was 14 months. Although the sample size is small, we believe our results are encouraging and should serve as rationale to investigate bortezomib-based regimens in patients with PBL.

## 1. Introduction

Plasmablastic lymphoma (PBL) is a rare B-cell lymphoma with morphological, immunophenotypical and genomic features between aggressive large B-cell lymphomas and plasma cell neoplasms [1]. The vast majority of cases will express CD138, CD38, and IRF4/MUM1—plasma cell markers – and lack expression of typical B-cell markers such as CD19 or CD20. Given these distinct features, the WHO has categorized PBL as an aggressive subtype of diffuse large B-cell lymphoma (DLBCL) [2].

This rare subtype of DLBCL was originally found to be associated with HIV-infected patients [3,4]. However, cases of PBL have also been reported in patients with other immunodeficiencies and even in apparently immunocompetent patients [5]. Treating PBL represents a challenge given there is no standard regimen of treatment established for these patients. Currently, the National Comprehensive Cancer Network (NCCN) recommends against the use of standard cyclophosphamide, doxorubicin, vincristine and prednisone (CHOP), in favor of more intensive regimens [6]. We also need to have in mind that several patients with PBL are elderly and/or are immunosuppressed and might not benefit from intensive therapies [7]. However, the outcome of PBL patients remains poor, and novel approaches are warranted.

Amongst the therapeutic agents used to treat PBL, the proteasome inhibitor bortezomib alone or in combination has been associated with

promising results [8,9]. In this article, we present a systematic review of PBL cases treated with bortezomib-containing regimens, and describe response and survival outcomes on these patients.

## 2. Methods

### 2.1. Literature search

Two authors performed a literature search independently using PubMed through March 31, 2017. The key terms used in the search were: “plasmablastic lymphoma AND bortezomib”. The titles and abstracts were reviewed and full-text articles were selected based on our inclusion criteria. The reference list of each selected study was reviewed to search for additional studies.

### 2.2. Inclusion and exclusion criteria

An article was considered relevant if it contained original data from patient(s) older than 18 years of age with a pathological diagnosis of PBL treated with bortezomib alone or in combination. Case reports and retrospective and prospective case series were included in this review. Cases with ALK1 or HHV8 Latent Nuclear Antigen expression were excluded, as these markers are consistent with ALK-positive DLBCL and primary effusion lymphoma, respectively. Any discrepancies on

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inclusion or exclusion of a study were resolved through consensus in all cases. If there were multiple publications from the same study, only the most recent was selected, using the older publications only to clarify methodology or characteristics of the population.

### 2.3. Data gathering

The data extraction was performed independently by two authors, and included pertinent clinical (e.g. age, sex, stage, HIV status, etc.), pathological (e.g. CD20, CD38, EBER, etc.), treatment, response and overall survival (OS) data. For response assessment, we used the 2007 Cheson response criteria, whenever possible [10]. OS was defined as the time from PBL diagnosis and death or last follow-up, and was estimated using the Kaplan-Meier method for incomplete observations. Comparisons between groups were performed using the log-rank test. All calculations and graphs were obtained using STATA/SE 13.1 (StataCorp, College Station, TX).

## 3. Results

### 3.1. Patient characteristics

The literature search rendered 22 articles of which 9 articles were excluded; 4 were reviews, 3 reported on plasmablastic myeloma and 2 were pre-clinical. From the remaining 13 articles, a total of 21 patients met inclusion criteria and were included in this study [8,9,11–21]. Eleven patients received bortezomib-containing regimens in the frontline setting, and ten patients received bortezomib-containing regimens in the relapsed and/or refractory setting.

The patients' clinical characteristics are summarized in Table 1. The median age for the patients with frontline use of bortezomib was 42 years (range 34–80 years) and 50 years (range 19–66 years) in the relapsed group. There was a male predominance in both groups, 10 (91%) in the frontline, and 9 (90%) in the relapsed group. Eleven patients (52%) were HIV-positive. Sixteen patients (76%) had advance disease by Lugano staging criteria. All cases had extranodal involvement, and the lower GI tract was the most common site of extranodal involvement (43% of the cases).

Pathologically, all cases demonstrated plasmacytic differentiation by CD38/CD138 expression. Except for one HIV-positive patient, all cases tested lacked CD20 expression. A Ki67 expression > 80% was found in eleven (52%) of the 21 patients. EBER expression was detected in 5 of the 7 (71%) HIV-positive patients tested, as opposed to 1 of 6

**Table 1**

Selected clinical characteristics of patients with plasmablastic lymphoma treated with bortezomib alone or in combination.

	Frontline (n = 11)	Relapsed (n = 10)
Clinical features		
Median age (range)	42 (34–80)	49.5 (19–66)
Male sex	10 (91%)	9 (90%)
IPI score > 2	6 (60%)	4 (44%)
Lugano stage III/IV	7 (70%)	9 (90%)
Extranodal involvement	11 (100%)	10 (100%)
Lower GI tract	5 (45%)	4 (40%)
Head/neck	3 (27%)	2 (20%)
Lung/pleura	3 (27%)	1 (10%)
Bone marrow	3 (27%)	2 (20%)
Skeletal bone	2 (18%)	3 (30%)
Other	4 (36%) <sup>a</sup>	3 (30%) <sup>b</sup>
HIV-positive status	6 (55%)	5 (50%)
On HAART	6 (100%)	2 (40%)

IPI: International Prognostic Index; GI: gastrointestinal; HAART: highly active anti-retroviral therapy.

<sup>a</sup>Other sites include central nervous system (n = 1), testicle (n = 1), liver (n = 1), skin (n = 1)

<sup>b</sup>Other sites include skin (n = 1), spleen (n = 1), muscle (n = 1)

**Table 2**

Selected pathological characteristics of patients with plasmablastic lymphoma treated with bortezomib alone or in combination.

Pathological features	Frontline (n = 11)	Relapsed (n = 10)
CD20	0/11 (0%)	1/10 (10%)
CD38/CD138	11/11 (100%)	10/10 (100%)
Ki67 expression > 80%	7/11 (78%)	4/5 (80%)
MYC rearrangement	6/7 (86%)	NR
EBER positive	6/9 (67%)	0/4 (0%)
HHV-8 LANA	0/6 (0%)	0/3 (0%)
ALK1	0/4 (0%)	0/1 (0%)

EBER: EBV-encoded RNA; LANA: latent nuclear antigen; ALK1: anaplastic lymphoma kinase 1.

(16%) HIV-negative patients tested. HHV8 LANA and ALK1 expression was not identified in any of the tested cases. Selected pathological characteristics are shown in Table 2.

### 3.2. Treatment and outcomes

In the frontline setting, the overall response rate (ORR) to bortezomib-based regimens was 100%, with complete response (CR) seen in 89% of patients. The response to bortezomib alone in the frontline setting was also 100% but all cases achieved a partial response (PR). In the relapsed setting, the ORR to bortezomib-based regimens was also 100% but the CR rate was 16%. In relapsed patients, the ORR to bortezomib alone was 75% but no CR was seen, and one patient (25%) had progressive disease. Response results are shown in Table 3. With a median follow-up time of 22 months, the median OS time of PBL patients treated with bortezomib-based regimens upfront was not reached. The 2-year OS rate was 55% (95% CI 23–78%; Fig. 1A). The OS of patients who received bortezomib alone upfront was shorter than patients who received bortezomib in combination (Fig. 2B). Of the five deaths, 3 were due to infections (2 sepsis and 1 progressive multifocal leukoencephalopathy) without evidence disease, and 2 were due to PBL relapse and progression. After a median follow-up time of 24 months, the median OS of PBL patients who received bortezomib-based regimens in the relapsed setting was 14 months with a 2-year OS rate of 27% (Fig. 2A). There was no apparent difference in OS between receiving bortezomib alone or in combination (Fig. 2B). The cause of death in all patients with relapsed PBL was progressive disease.

### 3.3. Analysis per HIV status

Out of the 21 patients with PBL, eleven (52%) had HIV infection. All patients in the bortezomib frontline group were on highly active anti-retroviral therapy. Of the 11 HIV-positive patients, 5 patients (45%) had a complete response (CR), 5 (45%) had a partial response and 1

**Table 3**

Response of plasmablastic lymphoma patients to bortezomib alone or in combination.

<sup>a</sup>THP-COP-bortezomib (n = 1), bortezomib-ESHAP (n = 1), bortezomib-ICE (n = 1), bendamustine-bortezomib (n = 1), bortezomib-rituximab (n = 1), VDT-PACE (n = 1).

Treatment	Frontline (n = 11)	Relapsed (n = 10)
Bortezomib-chemo	9 (82%) <sup>a</sup>	6 (60%) <sup>b</sup>
Complete response	8 (89%)	1 (16%)
Partial response	1 (11%)	5 (84%)
Bortezomib alone	2 (18%)	4 (40%)
Complete response	0 (0%)	0 (0%)
Partial response	2 (100%)	3 (75%)
Progressive disease	0 (0%)	1 (25%)

<sup>a</sup>Bortezomib-EPOCH (n = 4), bortezomib-CHOP (n = 3), R-CYBORD (n = 1), PAD (n = 1).

<sup>b</sup>THP-COP-bortezomib (n = 1), bortezomib-ESHAP (n = 1), bortezomib-ICE (n = 1), bendamustine-bortezomib (n = 1), bortezomib-rituximab (n = 1), VDT-PACE (n = 1).

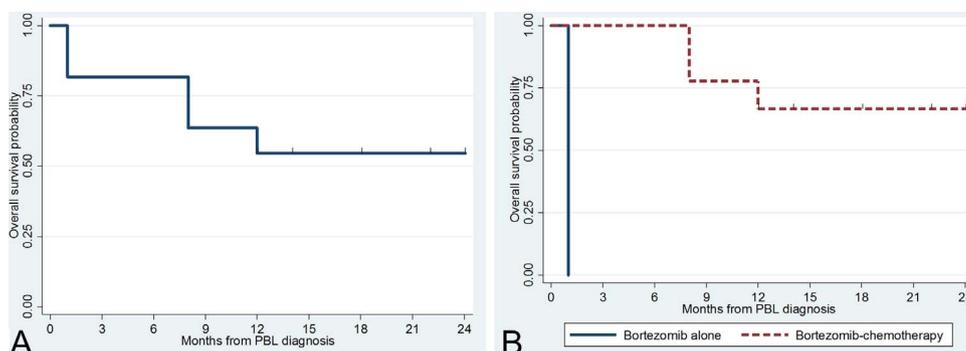


Fig. 1. Median OS curve of PBL patients who received frontline bortezomib-containing regimens (A), and in PBL patients who received upfront bortezomib alone or in combination (B).

(10%) had progression of disease (PD) while undergoing therapy. In the frontline setting, the 5 patients who received bortezomib in combination (CHOP or EPOCH) had a CR rate of 100%. The one patient treated with bortezomib alone experienced a PR. For the 10 HIV negative patients, 3 patients (30%) achieved a CR and 7 (70%) had a PR. In the frontline setting, the 3 patients (60%) who achieved a CR received bortezomib in combination (CYBORD or EPOCH).

### 3.4. Toxicity

Grade 3 neuropathy was reported in 20% of patients. The combination of bortezomib-chemotherapy resulted in grade 2–4 anemia, neutropenia and thrombocytopenia. Grade 2–3 urinary and respiratory infections and zoster reactivations were also reported. One patient experienced small bowel obstruction needing partial small bowel resection. Febrile neutropenia was not reported as a complication.

## 4. Discussion

In this systematic review, we searched for PBL cases treated with bortezomib-based regimens, and identified a total of 21 cases. Currently, there is no standard treatment regimen for PBL. Current NCCN guidelines recommend regimens like DA-EPOCH, HyperCVAD and CODOX-M/IVAC based on studies largely incorporating other aggressive lymphomas like Burkitt lymphoma, and almost always in the setting of HIV infection [22–24]. However, none of these seem to have changed the survival of patients with PBL, and current data does not support that more intensive regimens improve outcomes in PBL [25,26]. Standard chemotherapy and survival continues to be poor with a median survival that ranges between 9 and 15 months [25,27,28].

In these 21 cases of PBL, treatment with bortezomib exhibited promising results with regard to response and OS rates. ORR rates of almost 100% were reported in both the frontline and relapsed settings. Furthermore, bortezomib-based regimens can induce high rates of CR, which is highly encouraging. Previous studies have shown the importance of inducing deep responses in patients with PBL [25,26]. With regards to survival, a median OS of 14 months was observed in the relapsed group, which is comparable to the survival of patients with

PBL treated upfront with standard chemotherapy regimens. The 2-year OS rate in PBL patients treated upfront with bortezomib-based regimens was 55% with a median OS that was not reached at 24 months of follow-up. As an aggressive lymphoma, most relapses are expected to occur within a 2-year interval. One could speculate that patients alive at 2 years could be cured from the disease.

Given the rarity of PBL, one tends to evaluate patients regardless of HIV status. There is, however, mounting evidence that HIV-positive and HIV-negative patients might have different clinical course and survival. In an initial comparative study, HIV-negative PBL patients were older and were less likely to obtain CR to chemotherapy. Also, HIV-negative patients had a worse OS than HIV-positive patients of 9 months and 15 months, respectively [29]. In this systematic review, HIV-negative PBL patients have lower rates of CR and probably a worse outcome as well. However, the sample size does not permit strong statements. Previous studies have shown that autologous hematopoietic stem cell transplant in first CR might increase survival in PBL patients [30,31].

Recent case series have reported high success rates with the use of bortezomib upfront in combination with commonly used regimens in lymphoma such as EPOCH or CHOP. These results are the most promising results found in the literature in regards to overall length of survival in PBL patients [8,9,17]. If EPOCH is more effective at inducing responses and improve survival in PBL is unclear. A recent patient-level meta-analysis provided higher-level evidence that EPOCH might be a better option than CHOP in patients with HIV-associated lymphomas by inducing higher rates of event-free survival (EFS) as well as OS [32]. More recently, results from the highly anticipated Alliance 50303 showed that, with a median follow-up of 5 years, there was no difference in EFS or OS between R-CHOP and R-EPOCH in patients with DLBCL [33]. However, subset analyses evaluating high-risk patients were not reported.

Bortezomib is a proteasome inhibitor approved for the treatment of multiple myeloma, and there is emerging evidence of its efficacy in non-germinal DLBCL [34]. Bortezomib has also shown preclinical and clinical activity in other CD20-negative lymphomas such as primary effusion lymphoma [35–37]. Therefore, bortezomib presents itself as a promising alternative for the treatment of PBL. PBL cells are characterized by the expression of plasma cell transcription factors such as

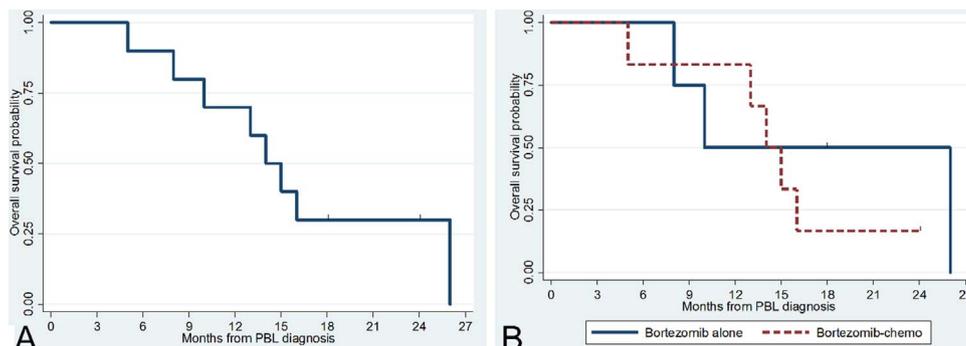


Fig. 2. Median OS curve of PBL patients who received bortezomib-containing regimens in the relapsed setting (A), and in PBL patients who received bortezomib alone or in combination (B).

LRF4, BLIMP1 and XBP1 [1,38]. Expression of XBP1 and BLIMP1 has been associated with the efficacy of bortezomib in myeloma, likely due to driving anti-body production and hence reliance on the unfolded protein response [39–41].

Despite its retrospective design and small number of patients, we provide perhaps the most updated information about response and survival of PBL patients treated with bortezomib-based regimens. PBL will continue being a diagnostic challenge given its features between lymphoma and myeloma. It will also continue being a therapeutic challenge given its aggressiveness and lack of effective treatments. Perhaps in the era of novel agents in the field of multiple myeloma, we can deploy these agents to see whether mechanistically they could have any effect in PBL patients. For example, it would be of interest to evaluate the anti-CD38 monoclonal antibody daratumumab in patients with PBL given the almost universal expression of CD38 by PBL cells. In the small proportion of PBL cases expressing CD30, the antibody-drug conjugate brentuximab vedotin could be of value [42]. Finally, MYC-directed therapies can prove efficacious against PBL cases with MYC gene rearrangements.

## 5. Conclusion

In summary, we have observed higher response and survival rates in PBL patients treated with bortezomib-based regimens in the frontline setting, and impressive transient responses in relapsed cases. Larger multi-institutional studies will need to confirm these observations. We hope the evidence presented here can help inform therapeutic decisions clinicians and patients faced with this rare and aggressive disease.

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## References

- J.J. Castillo, M. Bibas, R.N. Miranda, The biology and treatment of plasmablastic lymphoma, *Blood* 125 (2015) 2323–2330.
- S.H. Swerdlow, E. Campo, S.A. Pileri, N.L. Harris, H. Stein, R. Siebert, et al., The 2016 revision of the World Health Organization classification of lymphoid neoplasms, *Blood* 127 (2016) 2375–2390.
- J. Castillo, L. Pantanowitz, B.J. Dezube, HIV-associated plasmablastic lymphoma: lessons learned from 112 published cases, *Am. J. Hematol.* 83 (2008) 804–809.
- H.J. Delecluse, I. Anagnostopoulos, F. Dallenbach, M. Hummel, T. Marafioti, U. Schneider, et al., Plasmablastic lymphomas of the oral cavity: a new entity associated with the human immunodeficiency virus infection, *Blood* 89 (1997) 1413–1420.
- J.J. Castillo, E.S. Winer, D. Stachurski, K. Perez, M. Jabbour, C. Milani, et al., HIV-negative plasmablastic lymphoma: not in the mouth, *Clin. Lymphoma Myeloma Leuk.* 11 (2011) 185–189.
- NCCN Guidelines Version 3.2017. AIDS-Related B-Cell Lymphomas. AIDS-4. Available at [http://www.nccn.org/professionals/physician\\_gls/pdf/nhl.pdf](http://www.nccn.org/professionals/physician_gls/pdf/nhl.pdf). (Accessed 30 May 2017).
- D.A. Rizzieri, J.L. Johnson, J.C. Byrd, G. Lozanski, K.A. Blum, B.L. Powell, et al., Improved efficacy using rituximab and brief duration, high intensity chemotherapy with filgrastim support for Burkitt or aggressive lymphomas: cancer and Leukemia Group B study 10 002, *Br. J. Haematol.* 165 (2014) 102–111.
- J.J. Castillo, J.L. Reagan, W.M. Sikov, E.S. Winer, Bortezomib in combination with infusional dose-adjusted EPOCH for the treatment of plasmablastic lymphoma, *Br. J. Haematol.* 169 (2015) 352–355.
- R. Fernandez-Alvarez, A.P. Gonzalez-Rodriguez, A. Rubio-Castro, M.E. Gonzalez, A.R. Payer, A. Alonso-Garcia, et al., Bortezomib plus CHOP for the treatment of HIV-associated plasmablastic lymphoma: clinical experience in three patients, *Leuk. Lymphoma* (2015) 1–4.
- B.D. Cheson, B. Pfistner, M.E. Juweid, R.D. Gascoyne, L. Specht, S.J. Horning, et al., Revised response criteria for malignant lymphoma, *J. Clin. Oncol.* 25 (2007) 579–586.
- M. Akce, E. Chang, M. Haeri, M. Perez, C.J. Finch, M.M. Udden, et al., Bortezomib, ifosfamide, carboplatin, and etoposide in a patient with HIV-Negative relapsed plasmablastic lymphoma, *Case Rep. Hematol.* 2016 (2016) 3598547.
- M. Bibas, S. Grisetti, L. Alba, G. Picchi, F. Del Nonno, A. Antinori, Patient with HIV-associated plasmablastic lymphoma responding to bortezomib alone and in combination with dexamethasone, gemcitabine, oxaliplatin, cytarabine, and pegfilgrastim chemotherapy and lenalidomide alone, *J. Clin. Oncol.* 28 (2010) e704–708.
- P. Bose, C. Thompson, D. Gandhi, B. Ghahach, H. Ozer, AIDS-related plasmablastic lymphoma with dramatic, early response to bortezomib, *Eur. J. Haematol.* 82 (2009) 490–492.
- C. Cao, T. Liu, H. Zhu, L. Wang, S. Kai, Xiang B. Bortezomib-Contained Chemotherapy, Thalidomide combined with CHOP (cyclophosphamide, doxorubicin, vincristine, and prednisone) play promising roles in plasmablastic lymphoma: a case report and literature review, *Clin. Lymphoma Myeloma Leuk.* 14 (2014) e145–150.
- E. Cencini, A. Fabbri, S. Guerrini, M.A. Mazzei, V. Rossi, M. Bocchia, Long-term remission in a case of plasmablastic lymphoma treated with COMP (cyclophosphamide, liposomal doxorubicin, vincristine, prednisone) and bortezomib, *Eur. J. Haematol.* 96 (2016) 650–654.
- C.A. Dasanu, F. Bauer, I. Codreanu, P. Padmanabhan, M. Rampurwala, Plasmablastic haemato-lymphoid neoplasm with a complex genetic signature of Burkitt lymphoma responding to bortezomib, *Hematol. Oncol.* 31 (2013) 164–166.
- P.L. Fedele, G.P. Gregory, M. Gilbertson, J. Shortt, B. Kumar, S. Opat, et al., Infusional dose-adjusted epoch plus bortezomib for the treatment of plasmablastic lymphoma, *Ann. Hematol.* 95 (2016) 667–668.
- M. Hirasawa, H. Morimoto, R. Shibuya, S. Shimajiri, J. Tsukada, A striking response of plasmablastic lymphoma of the oral cavity to bortezomib: a case report, *Biomark. Res.* 3 (2015) 28.
- M. Lipstein, O. O'Connor, F. Montanari, L. Paoluzzi, D. Bongero, G. Bhagat, Bortezomib-induced tumor lysis syndrome in a patient with HIV-negative plasmablastic lymphoma, *Clin. Lymphoma Myeloma Leuk.* 10 (2010) E43–E46.
- N.S. Saba, D. Dang, J. Saba, C. Cao, M. Janbin, B. Maalouf, et al., Bortezomib in plasmablastic lymphoma: a case report and review of the literature, *Onkologie* 36 (2013) 287–291.
- M. Yan, Z. Dong, F. Zhao, T. Chauncey, D. Deauna-Limayo, J. Wang-Rodriguez, et al., CD20-positive plasmablastic lymphoma with excellent response to bortezomib combined with rituximab, *Eur. J. Haematol.* 93 (2014) 77–80.
- R.F. Little, S. Pittaluga, N. Grant, S.M. Steinberg, M.F. Kavlick, H. Mitsuya, et al., Highly effective treatment of acquired immunodeficiency syndrome-related lymphoma with dose-adjusted EPOCH: impact of antiretroviral therapy suspension and tumor biology, *Blood* 101 (2003) 4653–4659.
- A. Noy, J.Y. Lee, E. Cesarman, R. Ambinder, R. Baiocchi, E. Reid, et al., AMC 048: modified CODOX-M/IVAC-rituximab is safe and effective for HIV-associated Burkitt lymphoma, *Blood* 126 (2015) 160–166.
- D.A. Thomas, S. Faderl, S. O'Brien, C. Bueso-Ramos, J. Cortes, G. Garcia-Manero, et al., Chemoimmunotherapy with hyper-CVAD plus rituximab for the treatment of adult Burkitt and Burkitt-type lymphoma or acute lymphoblastic leukemia, *Cancer* 106 (2006) 1569–1580.
- J.J. Castillo, M. Furman, B.E. Beltran, M. Bibas, M. Bower, W. Chen, et al., Human immunodeficiency virus-associated plasmablastic lymphoma: poor prognosis in the era of highly active antiretroviral therapy, *Cancer* 118 (2012) 5270–5277.
- J.J. Castillo, E.S. Winer, D. Stachurski, K. Perez, M. Jabbour, C. Milani, et al., Prognostic factors in chemotherapy-treated patients with HIV-associated Plasmablastic lymphoma, *Oncologist* 15 (2010) 293–299.
- J. Morscio, D. Dierickx, J. Nijs, G. Verhoef, E. Bittoun, X. Vanoeteren, et al., Clinicopathologic comparison of plasmablastic lymphoma in HIV-positive, immunocompetent, and posttransplant patients: single-center series of 25 cases and meta-analysis of 277 reported cases, *Am. J. Surg. Pathol.* 38 (2014) 875–886.
- P. Schommers, C. Wyen, M. Hentrich, D. Gillor, A. Zoufaly, B. Jensen, et al., Poor outcome of HIV-infected patients with plasmablastic lymphoma: results from the German. AIDS-related lymphoma cohort study, *AIDS* 27 (2013) 842–845.
- J.J. Castillo, E.S. Winer, D. Stachurski, K. Perez, M. Jabbour, C. Milani, et al., Clinical and pathological differences between human immunodeficiency virus-positive and human immunodeficiency virus-negative patients with plasmablastic lymphoma, *Leuk. Lymphoma* 51 (2010) 2047–2053.
- J.J. Liu, L. Zhang, E. Ayala, T. Field, J.L. Ochoa-Bayona, L. Perez, et al., Human immunodeficiency virus (HIV)-negative plasmablastic lymphoma: a single institutional experience and literature review, *Leuk. Res.* 35 (2011) 1571–1577.
- M.M. Al-Malki, J.J. Castillo, J.M. Sloan, A. Re, Hematopoietic cell transplantation for plasmablastic lymphoma: a review, *Biol. Blood Marrow Transplant.* 20 (2014) 1877–1884.
- S.K. Barta, J.Y. Lee, L.D. Kaplan, A. Noy, J.A. Sparano, Pooled analysis of AIDS malignancy consortium trials evaluating rituximab plus CHOP or infusional EPOCH chemotherapy in HIV-associated non-Hodgkin lymphoma, *Cancer* 118 (2012) 3977–3983.
- W.H. Wilson, J. sin-Ho, B.N. Pitcher, E.D. Hsi, J. Friedberg, B. Cheson, et al., Phase III randomized study of R-CHOP versus DA-EPOCH-R and molecular analysis of untreated diffuse large B-Cell lymphoma: CALGB/Alliance 50303, *Blood* 128 (2016) 469.
- K. Dunleavy, S. Pittaluga, M.S. Czuczman, S.S. Dave, G. Wright, N. Grant, et al., Differential efficacy of bortezomib plus chemotherapy within molecular subtypes of diffuse large B-cell lymphoma, *Blood* 113 (2009) 6069–6076.
- J. An, Y. Sun, M. Fisher, M.B. Rettig, Antitumor effects of bortezomib (PS-341) on primary effusion lymphomas, *Leukemia* 18 (2004) 1699–1704.
- E. Boulanger, V. Meignin, E. Oksenhendler, Bortezomib (PS-341) in patients with human herpesvirus 8-associated primary effusion lymphoma, *Br. J. Haematol.* 141 (2008) 559–561.
- K.A. Sarosiek, L.E. Cavallin, S. Bhatt, N.L. Toomey, Y. Natkunam, W. Blasini, et al., Efficacy of bortezomib in a direct xenograft model of primary effusion lymphoma, *Proc. Natl. Acad. Sci. U. S. A.* 107 (2010) 13069–13074.
- S. Montes-Moreno, A.R. Gonzalez-Medina, S.M. Rodriguez-Pinilla, L. Maestre, L. Sanchez-Verde, G. Roncador, et al., Aggressive large B-cell lymphoma with plasma cell differentiation: immunohistochemical characterization of plasmablastic lymphoma and diffuse large B-cell lymphoma with partial plasmablastic phenotype, *Haematologica* 95 (2010) 1342–1349.

- [39] C. Leung-Hagesteijn, N. Erdmann, G. Cheung, J.J. Keats, A.K. Stewart, D.E. Reece, et al., Xbp1s-negative tumor B cells and pre-plasmablasts mediate therapeutic proteasome inhibitor resistance in multiple myeloma, *Cancer Cell* 24 (2013) 289–304.
- [40] S.C. Ling, E.K. Lau, A. Al-Shabeeb, A. Nikolic, A. Catalano, H. Iland, et al., Response of myeloma to the proteasome inhibitor bortezomib is correlated with the unfolded protein response regulator XBP-1, *Haematologica* 97 (2012) 64–72.
- [41] N. Taubenheim, D.M. Tarlinton, S. Crawford, L.M. Corcoran, P.D. Hodgkin, S.L. Nutt, High rate of antibody secretion is not integral to plasma cell differentiation as revealed by XBP-1 deficiency, *J. Immunol.* 189 (2012) 3328–3338.
- [42] B.M. Holderness, S. Malhotra, N.B. Levy, A.V. Danilov, Brentuximab vedotin demonstrates activity in a patient with plasmablastic lymphoma arising from a background of chronic lymphocytic leukemia, *J. Clin. Oncol.* 31 (2013) e197–e199.