

Review Articles

β -HHVs and HHV-8 in Lymphoproliferative Disorders.

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Competing interests: The authors have declared that no competing interests exist.

Published: October 24 , 2011

Received: June 04, 2011

Accepted: September 20 , 2011

Mediterr J Hematol Infect Dis 2011, 3(1): e2011043, DOI 10.4084/MJHID.2011.043

This article is available from: <http://www.mjhid.org/article/view/8348>

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Abstract: Similarly to Epstein-Barr virus (EBV), the human herpesvirus-8 (HHV-8) is a γ -herpesvirus, recently recognized to be associated with the occurrence of rare B cell lymphomas and atypical lymphoproliferations, especially in the human immunodeficiency virus (HIV) infected subjects. Moreover, the human herpesvirus-6 (HHV-6), a β -herpesvirus, has been shown to be implicated in some non-malignant lymph node proliferations, such as the Rosai Dorfman disease, and in a proportion of Hodgkin's lymphoma cases. HHV-6 has a wide cellular tropism and it might play a role in the pathogenesis of a wide variety of human diseases, but given its ubiquity, disease associations are difficult to prove and its role in hematological malignancies is still controversial. The involvement of another β -herpesvirus, the human cytomegalovirus (HCMV), has not yet been proven in human cancer, even though recent findings have suggested its potential role in the development of CD4⁺ large granular lymphocyte (LGL) lymphocytosis. Here, we review the current knowledge on the pathogenetic role of HHV-8 and human β -herpesviruses in human lymphoproliferative disorders.

Introduction. Epstein-Barr virus (EBV) is a γ -herpesvirus well recognized to be involved in the development of human B and NK/T cell lymphomas, either in the general population or in the immunosuppressed individuals. EBV is a lympho- and epitheliotropic γ -herpesvirus apparently carried as an harmless passenger in the immunocompetent host. Alterations in the delicate balance between the virus and the host immune control may result in a wide range of EBV-associated diseases: the simplest scenario is

the outgrowth of EBV-transformed B-lymphoblasts, expressing the full array of EBV latent gene (EBNA1, 2, 3A, 3B, 3C, LP, LMP1 and LMP2) leading to the development of post-transplant lymphoproliferative disease (PTLD) in immunodeficient subjects. EBV is also associated to malignancies in immunocompetent hosts arising from either epithelial, T cell or B cell origin in which is present with a limited pattern of latency genes: latency II (expression of EBNA1, LMP2A) is typical of Nasopharyngeal Carcinoma,

Gastric Carcinoma and Hodgkin's Lymphoma; latency I (expression of EBNA1) is associated to the Burkitt Lymphoma.¹

In addition to EBV, another γ -herpesvirus, Kaposi's sarcoma-associated herpesvirus (KSHV or HHV-8) is oncogenic. Among β -herpesviruses, several investigators have suggested that human herpesvirus-6 (HHV-6) also may be an oncogenic virus. Here, we review the current knowledge on the pathogenetic role of human β -herpesviruses and HHV-8 in human lymphoproliferative disorders.

β HERPESVIRUSES:

HHV-6. *Epidemiology and biology.* HHV-6 was first isolated in 1986 and later two viral variants have been identified, namely HHV-6A and HHV-6B, showing an overall nucleotide sequence identity of 90%. HHV-6 is ubiquitous in human throughout the world, with seroconversion occurring early in life.^{2,3} Salivary contact is likely to be the vehicle for transmission, but intrauterine passage is also possible. HHV-6 can be transmitted by blood products and with bone marrow and solid organ transplantation. Through its cellular receptor CD46, an ubiquitous complement regulatory glycoprotein⁴, HHV-6 can primarily infect either early self-renewing bone marrow precursors or mature blood cells, as well as oropharynx/salivary glands, epithelial mucosa of female genital tract and brain tissue. Following primary infection, HHV-6 can persist lifelong mainly in monocytes and other peripheral blood mononuclear cells.³ Only rare cells remain latently infected in healthy individuals, as shown by PCR testing. Of note, HHV6, unique among all the herpesviruses, exhibits a particular form of persistence in the infected cell, consisting in the integration of the whole viral genome into host chromosomes. The prevalence of the 'chromosomal integration of HHV-6' (CIHHV-6) ranges from 0.2% to 3% among different geographical areas.^{5,6} It has been observed that the main route of acquisition of CIHHV-6 is the vertical transmission, which implies that at least one copy of viral DNA is present in all the nucleated cells of the host. The HHV-6 genome shows human telomere-like repeat sequences at both its ends and this may foster the viral integration in some preferred chromosomal regions (mainly 17p13.3, 22q13, 1q44), which are close to or within the telomeres.⁷⁻¹⁰

HHV-6 has been demonstrated to efficiently replicate in vitro and cause a cytopathic effect either in CD4+ T lymphocytes or in thymocytes, inducing a suppression of T-cell functions. Cells transfected with HHV-6 can cause tumors in nude mice.¹¹ However, the evidence linking HHV-6 to human hematological malignancies is circumstantial, and far from definitive.¹² HHV-6 DNA can transform human

epidermal keratinocytes and NIH 3T3 cells in vitro.¹³⁻¹⁴ HHV-6 has a number of unique genes that are plausible causes of oncogenesis. Its ORF-1 gene encodes a protein that is capable of transforming NIH 3T3 cells in vitro, and cells expressing ORF-1 protein produce fibrosarcomas when injected into nude mice.¹⁵ The ORF-1 protein appears to maintain the transformed state of tumor cells by binding p53 and thereby inhibiting its tumor suppressor properties.¹⁶ HHV-6 also has a unique immediate early gene called U95 that has binding sites for nuclear factor-kappa B (NF-kB).¹⁷ Dysregulation of NF-kB has been postulated to contribute to cancer, through its effects on both the proliferative and apoptotic pathways.¹⁸ (**Table 1**)

Hodgkin's disease. Reports differ as to the possible role of HHV-6 in Hodgkin's disease (HD). Torelli et al.¹⁹ reported finding HHV-6 sequences by PCR in 3 of 25 cases of HD, all nodular sclerosis type, and in none of 41 cases of non-Hodgkin's lymphoma. Krueger et al.²⁰ performed immunohistochemical studies of tumors from 103 patients with HD, and found tissue sections to be infected frequently by both EBV and HHV-6; lymphocytes and histiocytes were infected preferentially. Lacroix et al.²¹ found HHV-6 DNA more frequently in the nodular sclerosis form of HD: of 73 patients with nodular sclerosis, 39 (49%) had both HHV-6 and EBV DNA, 25 (34%) had only HHV-6, and 8 (11%) had only EBV. In contrast, of 10 cases of the mixed cellularity form of HD, 4 (40%) had both viruses, 1 had HHV-6 only, 4 had EBV only, and 1 had neither. HHV-6⁺/EBV⁻ patients were younger than the EBV⁺/HHV-6⁻ patients and 92% of the HHV-6⁺ lymph nodes contained variant B. However, Luppi et al.²² examined a large series of patients with HD in which HHV-6 DNA was found by both PCR and Southern blot analysis, did not detect either latent or lytic HHV-6 antigens in neoplastic cells, and detected only limited expression in Reed-Sternberg cells. Thus, the role of HHV-6 in any form of HD remains unclear. Recently, Lacroix et al.²³ showed the transforming, transactivating and oncogenic properties of HHV-6B and localized the transforming activity into DR7 gene. Cells expressing viral DR7 protein revealed tumorigenic properties when injected into nude mice. The expression of DR7B protein in Reed-Sternberg cells from HD patients causes molecular alterations into the cells typical of the lymphoproliferative disorder. In particular, the oncoprotein protects infected cells from apoptosis by retaining human p53 within the cytoplasm and by increasing NF-kB cellular transcription factor. The action on NF-kB is mainly exerted through two mechanisms: the transactivation of the expression of its subunits p65 and p50-p105 and the direct interaction of DR7B with the assembled

protein. Lastly, DR7B promotes the overexpression of Id2, inhibitor of E2A transcription factor, that negatively regulates cell differentiation.²³ Further studies are needed to confirm a plausible pathogenetic role of HHV-6 infection in HD.

Non-Hodgkin's lymphomas. Luppi et al.²⁴ reported a higher frequency of HHV-6 DNA in a well-characterized series of patients with angioimmunoblastic T-cell lymphoma (AITL), a subtype of T-cell non-Hodgkin's lymphoma (NHL), compared with other lymphoma subtypes and controls. These findings have been confirmed by Zhou et al.²⁵ showing a clear association between histological progression of AITL and the detectable copy number of both EBV and HHV-6B in the AITL lesional tissue. While this increased viral load could reflect a role for HHV-6 in the pathogenesis and progression of AITL, it could also be the consequence of increasing dysfunction of the immune system during lymphoma progression. Immunohistochemical studies have so far failed to demonstrate HHV-6 antigens in the CD4+ T cells (the likely proliferating elements) within AITL lesions.

Leukemias. Persistent IL-2-regulated HHV-6 infection of adult T-cell leukemia cells causes T-cell leukemia to progress more rapidly,²⁶ but in vivo studies have not yet confirmed a pathogenetic role for HHV-6 in this disease. Few other studies aiming to investigate the association of HHV-6 with acute leukemia have been reported. The largest study showed significant higher titres of HHV-6 antibodies in patients with acute myeloid leukemia, but not with acute lymphoblastic leukemia.²⁷ Salonen et al.²⁸ found that 40% of children with leukemia had IgM antibodies to HHV-6 compared to 7.7% of age- and sex-matched children with various neurological diseases. However, molecular studies have so far failed to show a higher rate of HHV-6 DNA in peripheral blasts from children with acute lymphoblastic leukemia compared with healthy subjects.²⁹ A recent report found higher rates of seropositivity to human cytomegalovirus (HCMV) among patients with B-cell chronic lymphocytic leukemia than among healthy control subjects, although restricted only to some geographical areas, but the same was not true for seropositivity to HHV-6 (or EBV and HHV-7).³⁰ In conclusion, with the possible exception of adult T-cell leukemia, available data do not lend support to a role for HHV-6 in human acute leukemias.

Non-malignant lymphatic tissue proliferation. Of interest, HHV-6 late antigens have so far been detected only in non-malignant lymph node proliferations,

namely in cases of reactive lymphadenitis,^{31,32} in which HHV-6 antigens appear to be restricted to CD4+T cells. HHV-6 late antigens have also been identified in cases of Rosai Dorfman disease, otherwise known as sinus histiocytosis with massive lymphadenopathy, a benign chronic disease, mainly affecting children and young adults and with no progression to lymphoma. HHV-6 infection appears to be restricted to follicular dendritic cells and, more significantly, to the abnormal histiocytes that represent the proliferating elements and the hallmark of this disease.³³ (**Table 1**)

HCMV. Epidemiology and biology. HCMV was simultaneously isolated from salivary glands by Rowe and Smith in 1956. This virus was designated 'cytomegalovirus' and the associated clinical syndrome was referred to as 'cytomegalovirus inclusion disease' because viral cytopathic effects typically result in cell swelling and intranuclear inclusions.

HCMV infection is widespread in the entire human population, with prevalence increasing with age. In Western Countries, seropositivity rates range 40-70%, while in developing countries are much higher.³⁴ Using PCR, CMV viremia has been detected in about 98% of healthy individuals over 50 years of age. HCMV can be transmitted orally, sexually, and parenterally; primary infection may be subclinical in healthy subjects. Even asymptomatic carriers may at times shed HCMV in urine and saliva.³⁵⁻³⁶

HCMV productive infection (lytic cycle) is restricted to endothelial cells and fibroblasts, typically causing cell death and tissue damage in lung, liver, colon, brain and retina. Similarly to other herpesviruses, HCMV can establish lifelong latent infection in the host, mainly in macrophages and hematopoietic stem cells/progenitors (then passively transmitted to the mature myeloid progenies), and is a recognized cause of mononucleosis-like syndromes.³⁶ (**Table 1**)

Large granular lymphocyte proliferation. In contrast to HHV-6, HCMV has not been proven to be involved in human cancer. However, Rodriguez-Caballero and colleagues³⁷ suggested a role of HCMV in the pathogenesis of a specific subtype of large granular lymphocyte (LGL) proliferation involving CD4⁺CD8⁺dim T cells. In particular, they used microarray gene expression profile (GEP) to show that CD4⁺ T cells in patients with CD4⁺ LGL expansions, differ significantly from HCMV-specific memory CD4⁺ lymphocytes derived from healthy control individuals. The chronic antigenic stimulation of T cells by HCMV can lead to persistent monoclonal expansion of vβ13.1/CD4⁺ NKA⁺ CD8dim⁺ lymphocytes presenting a deregulation of genes involved in cell cycle

progression, resistance to apoptosis and genetic instability. The observed deregulation of key genes allows these cells to accumulate in excess to what is required to control HCMV infection and to abnormally proliferate. (**Table 1**)

γ HERPESVIRUSES

HHV-8. *Epidemiology and biology.* Human herpesvirus-8 (HHV-8) was identified by Moore & Chang in 1994, from the Kaposi's sarcoma (KS) tissues of patients with AIDS. HHV-8 is not ubiquitous in the general population: the infectious rates are low in the United Kingdom, United States and Asia, intermediate in Mediterranean countries and high in Central Africa. The seroprevalence of HHV-8 among blood donors ranges from 0.2% in Japan, to up to 10% in the United States, and to more than 50% in Africa,³⁸ with rates in Italy and other Mediterranean countries falling between these percentages.^{39,40} HHV-8 is mainly spread by sexual route in non-endemic areas, while non-sexual transmission may be important in endemic areas where infection is usually acquired early in the childhood.

HHV-8 is classified as a γ -herpesvirus, related to EBV and Herpesvirus Saimiri. Like other herpesviruses, HHV-8 is a large, double-stranded DNA virus that replicates in the nucleus as a closer circular episome during latency, but linearizes during virion packaging and replication. The HHV-8 genome typically contains genes that are homologous to cellular genes involved in the control of cell cycle and apoptosis. Similarly to other herpesviruses, HHV-8 has evolved to persist within the lymphoid system and has shown an oncogenic potential. HHV-8 infection has been described in association with rare lymphoproliferative disorders, including primary effusion lymphoma (PEL), multicentric Castleman's disease (MCD), and MCD-associated plasmablastic lymphoma, often occurring in AIDS patients. A subset of viral proteins is expressed in HHV-8-associated lymphoproliferative disorders and are involved in the viral lymphomagenesis. The viral proteins expressed in most PEL cells are the following: latency-associated nuclear antigen 1 (LANA -1), v-Cyclin, v-FLICE inhibitory protein (v-FLIP), v-interferon regulatory factor/LANA-2, Kaposin, v-Interleukin-6 (v-IL-6). LANA-1, v-Cyclin, v-FLIP and v-IL-6 are also expressed in most of the MCD cases. Two additional proteins, namely the K1 and the v-G-protein-coupled receptor (v-GPCR) are expressed in few cases of PEL and MCD.⁴¹ (**Table 1**)

Primary Effusion Lymphoma. PEL has been included in the WHO classification as a distinct entity among AIDS-associated NHLs, representing about 3-4% of all AIDS-NHLs.⁴²⁻⁴⁴ The lymphoma grows predominantly

in serous effusions, without solid tumor masses in the affected body cavity,⁴⁵⁻⁴⁷ while involvement of lymph nodes,⁴⁸ bone marrow^{49,50} or other tissues⁵¹ is occasionally seen. A number of continuous cell lines has been established from such lymphomatous effusions and peripheral blood of PEL patients.⁵² The PEL cells can include features of large cell immunoblastic and anaplastic lymphoma,⁵³ and also sometimes express a more plasmacytoid cytology.⁴² PEL cells generally lack immunophenotypical expression of differentiated B- or T- cell antigens, but for MUM1 and CD138, reflecting their post-germinal centre B-cell origin. Consistent with this, the gene expression profile analysis suggests a plasmablastic derivation of PEL cells.^{54,55} They express cell activation associated markers, including HLA-DR, CD23, CD25, CD30 and CD38, and the epithelial membrane antigen whereas adhesion markers are variably expressed.^{43,52} The B cell lineage derivation of PEL cells is established on the basis of clonal rearrangements of the heavy immunoglobulin (Ig) genes,^{45,52} and the PCR-based findings of a preferential expression of certain lambda light chain genes in AIDS-related PELs, suggesting clonal proliferation by an antigen selection process.⁵⁶ A few cases of AIDS-related PEL did not demonstrate Ig gene rearrangements, consistent with a polyclonal pattern of lymphoproliferation.⁴⁷ In contrast to other non Hodgkin's B-cell lymphoma types, neither c-MYC nor other proto-oncogene rearrangements were detected in PELs.⁵⁴ Likewise, a wild type of the tumor suppressor p53 gene is expressed by PELs, while mutations of the BCL-6 5' non-coding regions have been documented in most of the cases.⁵² PELs show complex karyotypes, the most frequent chromosomal abnormalities being trisomy 7, 12 and aberrations of chromosomal bands 1q21-q25.⁵² Virtually all reported cases of PEL have a relatively high number of HHV-8 DNA copies (40-150) per cell, most cells being latently infected and relatively few permissive for lytic infection as obtained in cultured PEL lines. Analysis of HHV-8 terminal repeats (TR) by pulsed-field gel electrophoresis has shown monoclonal or oligoclonal fused TR fragments in all examined cases of PEL, suggesting HHV-8 infection of clonogenic cells, supporting an etiologic role of the virus in these lymphoproliferations.⁵⁷ EBV co-infection is detected in many cases of PEL, also with a monoclonal infection pattern and with a restricted antigen expression pattern of latency. Human interleukin-6 (IL-6) and -10 (IL-10), v-IL-6 and vascular endothelial growth factor (VEGF) are the major growth factors released and used by PEL cells for autocrine growth stimulation.^{52,58-60} The occurrence of PEL in a non-AIDS setting appears to be very rare and has been reported in very few cases of solid organ

transplant patients,^{50,61,62} and a few cases have also been described in HIV negative elderly men, most of them originating from HHV-8 endemic areas.^{63,64} The clinical outcome of AIDS-related and post-transplant PEL is very poor, with a median survival from 2 to 6 months, despite chemotherapy.^{50,52,57} Decreasing CD4+ cell counts seem to be the most important indicator of progression of AIDS-related PEL.⁶⁵ In HIV negative patients, PEL may have a more indolent clinical course without specific therapy and may initially respond to drainage procedures.⁶³ Recently, it has been reported that azidothymidine and interferon- α induce apoptosis in PEL cells either in vitro or in vivo,^{66,67} and PEL remission was observed in a patient on anti-retroviral therapy.⁶⁸ We have demonstrated that cidofovir at high doses induces in vitro apoptosis in PEL cell lines and PEL remission in four HIV negative, elderly Italian men treated with intrapleural/intraperitoneal injections of cidofovir, who had recurrent effusions not responding either to pleural/peritoneal drainages or to chemotherapy.^{69,70} Recent in vitro data have shown that glycyrrhizic acid, contained in the licorice root, induces apoptosis of PEL cells, by down-regulating the synthesis of the HHV-8 LANA-1.⁷¹ Other approaches have recently been considered for the treatment of PEL, based on the targeting of viral gene products,^{72,73} providing the basis for new therapeutic options for PEL patients who are generally poor candidates for aggressive chemotherapy.

Multicentric Castlemann's Disease (MCD) and MCD-associated plasmablastic lymphoma. MCD of plasma cell type is an atypical lymphoproliferative disorder, which is histologically characterized by abundance and prominent alterations of the germinal centers, marked plasmacytic infiltration, and vascular hyperplasia.⁷⁴ Two types of malignancies, lymphoma and KS, have been reported to occur during the course of MCD in 18% and 13% of cases respectively.⁷⁴ HHV-8 DNA sequences have been detected in most of MCD cases occurring in HIV positive patients, but only in few HIV negative cases.⁷⁵⁻⁷⁸ HHV-8 infection is also found in most MCD patients with associated POEMS (polyneuropathy, organomegaly, endocrinopathy, M protein, skin changes) syndrome.⁷⁹ One case of HHV-8 positive MCD has also been reported in a renal transplant patient with KS.⁸⁰ HHV-8 positive MCD cells, expressing LANA-1, morphologically resemble plasmablasts and are localized in the mantle zone of the follicles.⁸¹ These plasmablasts show λ light-chain restriction and coalesce to form microscopic lymphomas in some MCD cases, which could herald the development of frank HHV-8 positive plasmablastic lymphoma.⁸²⁻⁸⁴ A role in the pathogenesis of MCD for an over-expression of IL-6, a

cytokine which promotes B cell survival and proliferation, has been proposed.⁷⁴ The expression of v-IL-6 in a proportion of HHV-8 infected MCD cells⁸⁵⁻⁸⁸ thus appears to support such a pathogenic mechanism. This is consistent with findings that exacerbations of systemic symptoms in MCD correlate with an increase in HHV-8 viral load together with IL-6 and IL-10, which thus represent markers of disease activity.^{89,90} Recent studies suggest that HHV-8 positive MCD cases have a more aggressive clinical course and a poorer prognosis.⁸² With regard to therapy, single agent chemotherapy with vinblastine is the most effective therapeutic option and may prolong survival.⁹¹ A patient with MCD has successfully been treated with retinoic acid and prednisone.⁹² Ganciclovir has also been effective in attenuating the constitutional symptoms in some cases of HIV-associated HHV-8 positive MCD cases.⁹³ Recently, treatment of MCD with humanized anti-IL-6 receptor antibody has been reported to be safe and to alleviate chronic inflammatory symptoms and wasting in a series of 28 patients, followed-up for 60 weeks.⁹⁴

Other diseases. The pathogenetic association between HHV-8 infection and the development of multiple myeloma, proposed by Rettig and colleagues,⁹⁵ has not been confirmed.⁹⁶⁻⁹⁸ HHV-8 infection is certainly rare in lymphoproliferative diseases other than PEL or MCD, both in HIV positive and HIV negative subjects. Moreover, the occurrence of HHV-8 positive solid lymphomas, usually extranodal and extracavitary, but with pathobiological features mimicking those of PEL, has been described in AIDS as well as in HIV negative patients.⁹⁹ HHV-8 infection was documented in association with hepatitis C virus infection in one case of plasma cell leukemia,¹⁰⁰ and three HIV negative cases of a germinotropic lymphoproliferative disorder characterized by plasmablasts coinfecting by HHV-8 and EBV have also been described.¹⁰¹ HHV-8 DNA and LANA-1 antigens have been detected in liver, lung and bone marrow tissues from patients affected with common variable immunodeficiency and granulomatous/lymphocytic interstitial lung disease, suggesting a pathogenetic viral role in this disorder.¹⁰² HHV-8 DNA was also found in a single case of primary cerebral lymphoma, in a woman who had received long-term steroid therapy for uveitis, suggesting that HHV-8 infection may be occasionally involved in a lymphoproliferation process associated with iatrogenic immunosuppression.¹⁰³ Consistent with this, the occurrence of an EBV negative, HHV-8 positive, monoclonal, lymphoproliferative disease of polymorphic type has recently been reported in a HHV-8 seronegative Jewish man, nine months after receiving a kidney from his HHV-8 seropositive

Table 1. Main biological, epidemiological and hematologic features of human β -herpesviruses and HHV-8 infections.

Herpes Virus	Tropism	Epidemiology	Non-neoplastic hematologic manifestations	Associations with neoplastic diseases
HHV-6	Peripheral blood mononuclear cells (mainly T lymphocytes and monocytes); hematopoietic progenitor cells; neuroglial cells; salivary gland epithelial cells. Lifelong persistence also as chromosomal genome integration.	Worldwide diffusion (variants A and B, with 90% nucleotide identity), infection early in life. Transmission: saliva, in utero, blood, organ transplant.	Mononucleosis-like syndrome, reactive lymphadenopathies, hemophagocytic syndrome, pancytopenias. Possible role in Rosai Dorfman Disease.	Possible role in Angioimmunoblastic T-cell Lymphoma and in Hodgkin's disease.
HCMV	Hematopoietic progenitor cells (mainly monocyte-macrophages); peripheral blood mononuclear cells; endothelial cells and fibroblasts.	Worldwide diffusion, seropositivity increasing with age (98% over 50 years old). Transmission: saliva, in utero, sexual route, blood, organ transplant.	Mononucleosis-like syndrome, hemophagocytic syndrome, pancytopenias.	Possible role in Large Granular Lymphocyte lymphocytosis.
HHV-8	B-lymphocytes; hematopoietic progenitors cells; microvascular endothelial cells (lymphatic and blood vascular cells).	Not ubiquitous diffusion: seroprevalence 30-70% in endemic African areas, 10-25% in Mediterranean areas. Transmission: vertical in endemic areas, sexual in non-endemic areas; organ transplant, blood?	Reactive lymphadenopathies, hemophagocytic syndrome, pancytopenias, bone marrow aplasia in organ transplant patients.	Kaposi's Sarcoma, Primary Effusion Lymphoma, Multicentric Castleman's Disease/plasmablastic lymphoma.

father.¹⁰⁴ Non malignant plasmacytic proliferations have also been reported in two solid organ transplant patients¹⁰⁵ as well as in a few Italian cases of HIV negative angioimmunoblastic lymphadenopathy.¹⁰⁶ Interestingly, a few cases of benign lymphadenopathy with germinal center hyperplasia and increased vascularity in which HHV-8 DNA sequences were detected, have been reported in HIV negative^{75,106} and HIV positive^{106,107} young adults. The only one case of well documented HHV-8 primary infection in HIV positive subjects has been reported to be associated with the development of fever, splenomegaly and a cervical lymphadenopathy, characterized by angiolymphoid hyperplasia.¹⁰⁸ Thus, the above mentioned histologic features of florid follicular hyperplasia and increased vascularity, which are observed also in MCD, are likely to represent the distinct histologic pattern of lymphoid response induced by HHV-8. Interestingly, a lymphoproliferative disease characterized by persistent angiofollicular lymphadenopathy is induced in simian immunodeficiency-virus infected Rhesus Macaques, following infection with the simian homologue of HHV-8.¹⁰⁹

It is also likely that, as with other human herpesviruses, a HHV-8 primary infection or reactivation, is manifested by non neoplastic pathological changes. Thus, HHV-8 DNA has been detected in the pathologic lung tissue of HIV negative

and positive patients with interstitial pneumonitis.^{110,111} Fever, cutaneous rash and hepatitis have also been reported in an Italian patient with NHL, who received autologous peripheral blood stem cell (PBSC) transplantation and showed HHV-8 reactivation.¹¹² Recently, we had also the possibility to study primary HHV-8 infection in two patients four months after kidney transplantation from the same HHV-8-seropositive cadaveric donor. Seroconversion and viremia coincided with development of a disseminated KS in one patient and with an acute syndrome of fever, splenomegaly, cytopenia, and marrow failure with plasmacytosis in the other patient.¹¹³ We also reported a further case of HHV-8 reactivation associated with fever and marrow aplasia with plasmacytosis in a patient with NHL, after autologous PBSC transplantation. HHV-8 transcripts and latency associated nuclear antigen were expressed in the immature myeloid progenitors of the aplastic marrow of these patients.¹¹³ In recent studies we and others have observed that HHV-8 may also exert a myelosuppressive effect in vitro,^{114,115} suggesting that HHV-8 could also be implicated in the complex pathophysiology of cytopenias often occurring in HIV infected patients.¹¹⁶ (Table 1)

Acknowledgments. This study was supported by the Associazione Italiana per la Ricerca sul Cancro (AIRC), Milan, Italy; the European Commission's FP6

Life-Science-Health Programme (INCA project; LSHC-CT-2005-018704); the Associazione Italiana Lotta alle Leucemie, Linfoma e Mieloma (AIL)-

Modena ONLUS; and the Programma di ricerca Regione-Università PRU 2007-2009 (M.L.).

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