

# [Human cytomegalovirus latency and reactivation in allogeneic hematopoietic stem c...](https://assignbuster.com/human-cytomegalovirus-latency-and-reactivation-in-allogeneic-hematopoietic-stem-cell-transplant-recipients/)

[](https://assignbuster.com/)[Health & Medicine](https://assignbuster.com/essay-subjects/health-n-medicine/)

## Introduction

Human cytomegalovirus (HCMV) is a beta-herpesvirus carried by a majority of the global population ( [Cannon et al., 2010](#B18) ; [Zuhair et al., 2019](#B219) ). The seroprevalence of HCMV increases with age and has an estimated global mean of 83% ( [Zuhair et al., 2019](#B219) ). While primary infection is usually asymptomatic in immunocompetent individuals, the virus establishes a lifelong latent infection that is never eliminated by the host immune system. Intermittent subclinical viral reactivation events are thought to be controlled by effective immune surveillance and may drive the high frequencies of HCMV-specific T-cells found in the peripheral blood of healthy seropositive individuals ( [Sester et al., 2002](#B173) ; [Sylwester et al., 2005](#B184) ). By contrast, reactivation from latency is responsible for significant morbidity and mortality in immunocompromised and immunosuppressed populations, including solid-organ transplant and allogeneic hematopoietic stem cell transplant (HSCT) recipients, HIV/AIDS patients and the developing fetus.

HCMV reactivation is the major viral infectious complication after allogeneic HSCT and is associated with an increased risk of non-relapse mortality ( [Takenaka et al., 2015](#B186) ; [Green et al., 2016](#B68) ; [Teira et al., 2016](#B190) ), which is not principally attributable to direct HCMV disease ( [Green et al., 2016](#B68) ). Uncontrolled HCMV replication following reactivation can lead to life-threatening end-organ disease, commonly manifesting as pneumonia and gastrointestinal disease, and less frequently as retinitis, hepatitis and encephalitis. Reactivation may also indirectly contribute to detrimental patient outcomes through antiviral drug toxicities and complex impacts on post-transplant immune reconstitution, including links with graft-versus-host disease (GvHD) ( [Cantoni et al., 2010](#B19) ) and microbial superinfections ( [Nichols et al., 2002](#B142) ; [Yong et al., 2017a](#B210) ). There is no licensed HCMV vaccine and current antiviral agents are limited by their toxic side-effects and the risk of antiviral drug resistance.

The cellular sites and mechanisms associated with HCMV latency and reactivation are incompletely understood, in part due to the high human-specificity of HCMV which precludes the use of animal models to directly study HCMV infection. Clinical evidence indicates that the risk of reactivation post-HSCT is strongly connected to the pre-transplant HCMV serostatus of the donor and recipient ( [Boeckh and Nichols, 2004](#B10) ; [George et al., 2010](#B57) ) and the pace of post-transplant HCMV-specific T-cell recovery. However, the lack of well-validated biomarkers for reactivation makes it challenging to predict the incidence and outcome of infection in individual patients, and greater knowledge of the influence of HCMV on post-transplant immune reconstitution is required.

## HCMV Reactivation in Allogeneic Hematopoietic Stem Cell Transplantation (HSCT)

Allogeneic HSCT is the only curative option for many hematological malignancies and diseases ( [Copelan, 2006](#B30) ). GvHD, opportunistic infections and relapse are the leading causes of mortality in the first 2 years post-transplant ( [Gratwohl et al., 2005](#B66) ; [D’Souza and Fretham, 2018](#B37) ). The reactivation of latent double-stranded DNA viruses is common in the early post-engraftment period ( [Hill et al., 2017](#B79) ) and HCMV reactivation is the most frequent opportunistic viral infection after HSCT. Virological surveillance for HCMV replication is routinely performed in the first 100 days post-transplant through quantitative PCR monitoring for HCMV genomes in blood plasma ( [Emery et al., 2000](#B43) ), with HCMV DNAemia being an independent risk factor for disease ( [Zaia et al., 1997](#B214) ) and non-relapse mortality ( [Hiwarkar et al., 2013](#B80) ; [Green et al., 2016](#B68) ; [Ramanathan et al., 2016](#B158) ; [Teira et al., 2016](#B190) ).

Reactivation develops in over 60% of HCMV seropositive recipients (R+), and in approximately 10% of seronegative recipients (R-) transplanted from seropositive donors (D+) ( [George et al., 2010](#B57) ). In R+/D+ patients, reactivation may derive from endogenous latent HCMV in the seropositive recipient ( [Winston et al., 1985](#B207) ; [Kawasaki et al., 1999](#B89) ) and/or from latently infected cells transferred within the seropositive donor stem cell allograft. Recipient seropositivity alone is an adverse prognostic factor for overall survival ( [Broers et al., 2000](#B15) ; [Craddock et al., 2001](#B31) ). Seropositive recipients who receive grafts from HCMV-naïve donors (R+/D-) experience the highest incidence of HCMV reactivation and disease ( [Ljungman et al., 2006](#B118) ; [Webb et al., 2018](#B202) ), a likely consequence of delayed HCMV-specific immune recovery owing to the lack of pre-existing HCMV-specific memory lymphocytes in the graft ( [Cwynarski et al., 2001](#B33) ; [Zhou et al., 2009](#B217) ). As the recipient’s existing cellular immune system is eradicated by transplant conditioning regimens, R+/D- patients rely on *de novo* T-cell reconstitution via the thymus from donated pluripotent hematopoietic stem cells to generate a primary T-cell response to HCMV reactivation. By contrast, HCMV-specific memory T-cells contained in D+ grafts can undergo more rapid antigen-driven expansion within the recipient in the early post-transplant period and contribute to early control of reactivation ( [Cwynarski et al., 2001](#B33) ; [Gandhi et al., 2003](#B54) ; [Scheinberg et al., 2009](#B169) ). For a seropositive recipient, the choice of a seropositive over seronegative donor offers a survival advantage in the setting of myeloablative unrelated donor transplantation, but the effect on survival with matched sibling donors is less strong ( [Ljungman et al., 2003](#B114) , [2014](#B115) ). Nonetheless, due to the high incidence of HCMV-related complications in R+/D- patients, where possible, attempts are made to match serostatus in donors and recipients.

Advances in transplant and antiviral treatment practices over the last 25 years have reduced the incidence of HCMV disease to ∼10% in the first year post-transplant ( [Boeckh and Ljungman, 2009](#B9) ; [Green et al., 2016](#B68) ). However, the use of prophylactic or pre-emptive antiviral therapy delays HCMV-specific T-cell recovery ( [Li et al., 1994](#B103) ) and has led to increasing rates of late HCMV reactivation and disease ( [Einsele et al., 2000](#B40) ). Additionally, HCMV pneumonia remains associated with high (up to 70%) mortality ( [Erard et al., 2015](#B44) ). Gastrointestinal HCMV disease often develops without detection of HCMV DNAemia ( [Cho et al., 2013](#B25) ; [Gabanti et al., 2015](#B53) ) and can be difficult to distinguish from gastrointestinal GvHD, often occurring in the same patients ( [Cho et al., 2013](#B25) ; [Bhutani et al., 2015](#B5) ).

## Cellular Sites of HCMV Latency and Reactivation

The transition from viral latency to reactivation underpins the pathogenesis of HCMV in HSCT. HCMV latency is characterized by maintenance of the viral genome as an intranuclear episome ( [Bolovan-Fritts et al., 1999](#B11) ) without replication, but with the potential to reactivate to a productive infection. A wide range of cell types support productive infection ( [Ibanez et al., 1991](#B82) ; [Sinzger et al., 2008](#B176) ), but latency appears to be restricted to primitive bone-marrow-resident CD34 + cells and CD33 + myeloid progenitor cells ( [Mendelson et al., 1996](#B130) ; [Hahn et al., 1998](#B71) ; [Reeves et al., 2005b](#B163) ), which retain the latent viral genome as they differentiate into peripheral blood CD14 + monocytes and myeloid dendritic cells (mDCs) ( [Taylor-Wiedeman et al., 1991](#B188) , [1994](#B189) ; [Hahn et al., 1998](#B71) ; [Khaiboullina et al., 2004](#B90) ; [Reeves et al., 2005b](#B163) ). A recent study found that CD14 + monocytes expressing the surface marker B7-H4 were a predominant site of latency in peripheral blood of healthy donors ( [Zhu et al., 2018](#B218) ). It may be that HCMV preferentially infects early myeloid progenitors or promotes the differentiation of infected pluripotent CD34 + cells to myeloid-lineage subsets that support latency ( [Zhu et al., 2018](#B218) ).

Latently infected cells contain HCMV DNA ( [Minton et al., 1994](#B133) ) but do not support infectious virus production. The terminal differentiation to mature mDCs and macrophages is accompanied by chromatin remodeling of the HCMV major immediate-early promoter ( [Reeves et al., 2005a](#B162) , [b](#B163) ), which facilitates reactivation of the lytic gene cascade and the production of infectious virus ( [Taylor-Wiedeman et al., 1994](#B189) ; [Reeves et al., 2005b](#B163) ; [Reeves and Sinclair, 2013](#B164) ; [Poole et al., 2015](#B152) ). Allogeneic stimulation ( [Soderberg-Naucler et al., 1997](#B180) ) and pro-inflammatory cytokines such as IFN-γ, TNF, and IL-6 are implicated in driving myeloid cell maturation and reactivation ( [Fietze et al., 1994](#B46) ; [Söderberg-Nauclér et al., 2001](#B181) ; [Hargett and Shenk, 2010](#B76) ; [Reeves and Compton, 2011](#B161) ; [Huang et al., 2012](#B81) ; [Reeves and Sinclair, 2013](#B164) ; [Forte et al., 2018](#B50) ).

Latently infected cells are present at very low frequencies (0. 004–0. 01% of mononuclear cells) in GCSF-mobilized peripheral blood or bone-marrow from healthy seropositive donors ( [Slobedman and Mocarski, 1999](#B178) ), but underlie the capacity for iatrogenic transmission of latent HCMV through D+ HSCT allografts. Additionally, the high risk of reactivation in R+/D- patients suggests that pre-transplant conditioning regimens incompletely eradicate latent HCMV reservoirs in the recipient ( [Wills et al., 2015](#B206) ). It also remains possible there are additional sites of HCMV latency, with conflicting evidence regarding possible latency in aortic endothelial cells ( [Fish et al., 1998](#B47) ; [Pampou et al., 2000](#B145) ; [Reeves et al., 2004](#B160) ). Whether HCMV establishes a low-level productive infection in bone-marrow stromal cells ( [Taichman et al., 1997](#B185) ; [Smirnov et al., 2007](#B179) ; [Soland et al., 2014](#B182) ) or in a self-renewing CD34 + cell subset ( [Goodrum et al., 2004](#B61) ) also remains unclear, yet HCMV DNA has been detected in diverse tissue sites ( [Hendrix et al., 1997](#B78) ; [Chen and Hudnall, 2006](#B23) ; [Gordon et al., 2017](#B62) ) and recent RNA-seq uncovered HCMV transcripts at multiple locations, including the ovaries, blood, adipose tissue, and lung ( [Shnayder et al., 2018](#B175) ). The specific cell types harboring HCMV in these studies and whether they represent productive, abortive, or latent infection is unknown. The widespread prevalence of HCMV within asymptomatic individuals nonetheless highlights the importance of host immune control in preventing unchecked HCMV replication leading to life-threatening disease.

## Risk Factors for HCMV Reactivation After HSCT

In addition to recipient and donor HCMV serostatus, independent risk factors for reactivation include increasing recipient age ( [Tong et al., 2013](#B193) ; [Takenaka et al., 2015](#B186) ), use of unrelated or HLA-mismatched donors ( [Qayed et al., 2014](#B154) ; [Takenaka et al., 2015](#B186) ), T-cell depletion ( [Walker et al., 2007](#B200) ; [Yoon et al., 2009](#B212) ), GvHD ( [Walker et al., 2007](#B200) ; [George et al., 2010](#B57) ; [Qayed et al., 2014](#B154) ; [Cohen et al., 2015](#B28) ), and high-dose corticosteroids for GvHD ( [Yanada et al., 2003](#B209) ; [Tong et al., 2013](#B193) ; [Melendez-Munoz et al., 2019](#B129) ). T-cell depletion and prolonged steroid therapy mitigate GvHD but delay antiviral T-cell reconstitution ( [Aubert et al., 2001](#B2) ; [Craddock et al., 2001](#B31) ; [Wagner et al., 2005](#B199) ; [Lilleri et al., 2009](#B105) ; [Tormo et al., 2011](#B195) ). A high incidence of HCMV reactivation is also observed after T-cell replete haploidentical HSCT with post-transplant cyclophosphamide ( [Di Stasi et al., 2014](#B35) ; [Crocchiolo et al., 2015](#B32) ; [Goldsmith et al., 2016](#B59) ; [Slade et al., 2017](#B177) ).

The reconstitution kinetics of HCMV-specific T-cells post-HSCT have a close relationship with the risk and prognosis of reactivation ( [Lilleri et al., 2006](#B106) ; [Gratama et al., 2010](#B63) ; [Espigado et al., 2014](#B45) ). HCMV-specific CD4 + and CD8 + T-cells expand with reactivation and are likely both required for control and/or protection ( [Foster et al., 2002](#B51) ; [Sacre et al., 2008](#B168) ; [Widmann et al., 2008](#B204) ; [Pourgheysari et al., 2009](#B153) ; [Lilleri et al., 2012](#B107) ; [Gabanti et al., 2015](#B53) ; [Raeiszadeh et al., 2015](#B157) ; [Ciaurriz et al., 2017](#B26) ). Quantitative thresholds of CD8 + and CD4 + HCMV-specific T-cells associated with protection from, or control of, reactivation or disease post-HSCT have been defined using HLA tetramers or *ex vivo* viral stimulation assays ( [Aubert et al., 2001](#B2) ; [Cwynarski et al., 2001](#B33) ; [Gratama et al., 2001](#B65) , [2010](#B63) ; [Lilleri et al., 2008](#B104) ; [Moins-Teisserenc et al., 2008](#B134) ; [Borchers et al., 2011](#B13) , [2012](#B12) ; [Tormo et al., 2011](#B195) ; [Lilleri et al., 2012](#B107) ; [Liu et al., 2016](#B111) ). Threshold numbers have not been well-validated for routine clinical use and are less informative of protection from reactivation and disease in patients under steroid therapy or with prior GvHD ( [Lilleri et al., 2012](#B107) ; [Gabanti et al., 2015](#B53) ).

Control of reactivation may depend more heavily on the functional recovery of HCMV-specific T-cell immunity ( [Quinnan et al., 1982](#B155) ; [Reusser et al., 1991](#B166) ; [Ozdemir et al., 2002](#B144) ; [Nakamura et al., 2004](#B138) ; [Gratama et al., 2008](#B64) ; [Zhou et al., 2009](#B217) ; [Tormo et al., 2010](#B194) ; [Krol et al., 2011](#B99) ; [Tey et al., 2013](#B192) ; [Espigado et al., 2014](#B45) ; [Ciaurriz et al., 2017](#B26) ). Polyfunctional HCMV-specific T-cell responses post-HSCT are associated with lower viral loads, protection from subsequent episodes of reactivation and lower antiviral therapy requirements ( [Zhou et al., 2009](#B217) ; [Munoz-Cobo et al., 2012](#B137) ; [Gimenez et al., 2015](#B58) ; [Pelak et al., 2017](#B149) ). Delayed or undetectable HCMV-specific cytotoxic T-cell responses are prominent risk factors for HCMV disease ( [Reusser et al., 1991](#B166) ; [Gratama et al., 2001](#B65) ; [Ganepola et al., 2007](#B55) ). [Camargo et al. (2019)](#B16) recently described a composite biomarker comprising a protective (IL-2+IFN-γ+TNF-α+MIP-1β+) and non-protective (IL-2-IFN-γ+TNF-α-MIP-1β+) CD8 + T-cell cytokine signature in response to *in vitro* HCMV pp65 peptide stimulation that independently predicted the risk of clinically significant reactivation. Assessment of HCMV-specific immunity through measurement of whole blood *ex vivo* IFN-γ secretion responses to HCMV peptides has also emerged as a promising prognostic approach for HCMV reactivation post-HSCT ( [Tey et al., 2013](#B192) ; [Yong et al., 2017b](#B211) ). However, it is argued that the selective recovery of HCMV-specific T-cell immunity ahead of global T-cell reconstitution carries a higher risk of subsequent reactivation ( [Tey et al., 2014](#B191) ).

The detection of reactivation prior to 100 days post-transplant ( [Boeckh et al., 2003](#B8) ; [Kim et al., 2004](#B94) ; [Liu et al., 2015](#B112) ), plasma viral load ( [Zaia et al., 1997](#B214) ), leukopenia ( [Jang et al., 2012](#B86) ), lymphopenia ( [Einsele et al., 1993](#B39) ), and GvHD ( [Boeckh et al., 2003](#B8) ; [Ljungman et al., 2006](#B118) ; [Green et al., 2012](#B67) ) represent additional risk factors for HCMV disease. Donor grafts with ≥5 activating killer-cell immunoglobulin-like receptor (KIR) genes or with both KIR2DS2 and KIR2DS4 predict a lower risk of reactivation ( [Zaia et al., 2009](#B215) ), and the use of donors with multiple or additional activating KIRs is associated with a lower incidence of reactivation ( [Chen et al., 2006](#B22) ; [Cook et al., 2006](#B29) ).

## Impact of HCMV Reactivation on Post-HSCT Immune Recovery, Relapse and GvHD

The immune system crucially regulates the risk of HCMV reactivation and disease, but HCMV itself also has a profound influence in shaping immune profiles in healthy seropositive individuals ( [Chidrawar et al., 2009](#B24) ; [Brodin et al., 2015](#B14) ; [Patin et al., 2018](#B146) ) and HSCT patients ( [Itzykson et al., 2015](#B84) ; [Lakshmikanth et al., 2017](#B101) ), although the functional implications of this immune modulation are not yet clear. In some HSCT recipients, reactivation might be an epiphenomenon of poor immune reconstitution, but it is also possible that the immunomodulatory effects of HCMV infection may contribute to poor post-transplant outcomes ( [Nichols et al., 2002](#B142) ). Indeed, while HCMV DNAemia-guided pre-emptive antiviral therapy has reduced the incidence of HCMV disease post-HSCT, the survival disadvantage associated with HCMV infection has not been eliminated ( [Broers et al., 2000](#B15) ; [Schmidt-Hieber et al., 2013](#B171) ; [Green et al., 2016](#B68) ). HCMV encodes a range of immunomodulatory gene products that are expressed during both productive infection and latency, including a homolog of the immunosuppressive cytokine IL-10 ( [Jenkins et al., 2004](#B88) ; [McSharry et al., 2012](#B128) ; [Avdic et al., 2014](#B3) ; [Young et al., 2017](#B213) ). HCMV infection in HSCT recipients increases the risk of bacterial and fungal superinfections ( [Nichols et al., 2002](#B142) ; [Yong et al., 2017a](#B210) ) and GvHD ( [Lonnqvist et al., 1984](#B120) ; [Broers et al., 2000](#B15) ; [Cantoni et al., 2010](#B19) ), which might be connected to complex impacts of HCMV reactivation and/or its treatment on post-transplant immune recovery.

### T Cell Reconstitution

Reactivation stimulates the recovery of HCMV-specific T-cells after HSCT (see section “ Risk Factors for HCMV Reactivation After HSCT”) ( [Hakki et al., 2003](#B72) ; [Tormo et al., 2010](#B194) ; [Ciaurriz et al., 2017](#B26) ), but is also accompanied by broader changes in the T-cell compartment. Patients with reactivation display accelerated CD8 + T-cell reconstitution in the first year post-transplant ( [Lugthart et al., 2014](#B121) ; [Drylewicz et al., 2016](#B36) ), which is likely to be driven by clonal expansions of HCMV-specific effector-memory αβ CD8 + T-cells ( [Suessmuth et al., 2015](#B183) ; [Link et al., 2016](#B109) ), leading to an inverted CD4: CD8 ratio. Deep sequencing of the TCR-β repertoire at 1 year post-HSCT uncovered a contraction in effector-memory CD8 + TCR diversity and holes in the underlying effector-memory CD8 + T-cell repertoire in patients who had experienced reactivation ( [Suessmuth et al., 2015](#B183) ). The selective expansion of HCMV-reactive Vδ2 neg γδ T-cells ( [Knight et al., 2010](#B95) ; [Scheper et al., 2013](#B170) ), and clonal (Vγ9 neg and Vδ2 neg ) γδ T-cell proliferations suggestive of adaptive responses ( [Ravens et al., 2017](#B159) ), are also observed following reactivation. Reactivation also triggers the expansion of large granular lymphocytes ( [Nann-Rütti et al., 2012](#B139) ). [Lugthart et al. (2014)](#B121) found the reconstitution of naïve and central memory T-cells up to 2 years post-transplant was not compromised by reactivation, but [Suessmuth et al. (2015)](#B183) observed lower numbers of naïve T-cells in the first year post-HSCT in patients with reactivation. Many of the immunological features associated with HCMV reactivation after HSCT, including oligoclonal expansions of terminally differentiated HCMV-specific T-cells, are also found with aging in seropositive individuals ( [Khan et al., 2002](#B91) ; [Hadrup et al., 2006](#B70) ), although recently it was reported that these HCMV-induced clonal T-cell expansions may not compromise CD8 + T-cell repertoire diversity in the elderly ( [Lindau et al., 2019](#B108) ). The prominent influence of HCMV seropositivity and reactivation in shaping global immune reconstitution signatures after HSCT is apparent ( [Itzykson et al., 2015](#B84) ), but the impact of reactivation on immune recovery beyond 2 years post-transplant is not well-characterized.

### NK Cell Reconstitution

HCMV reactivation drives a rapid expansion of IFN-γ-producing NKG2C + NK cells ( [Foley et al., 2012b](#B49) ), which likely contribute to early control of reactivation ( [Kheav et al., 2014](#B93) ; [Davis et al., 2015](#B34) ; [Muccio et al., 2016](#B136) ). Expanded proportions of mature (CD56 dim CD57 + NKG2A - CD158b + ) NKG2C + NK cells persist after viral clearance ( [Foley et al., 2012b](#B49) ) and memory-like expansions of NKG2C + CD57 + NK cells are also observed in R+/D+ patients with subclinical HCMV infection ( [Foley et al., 2012a](#B48) ). Specific recognition by NKG2C + NK cells of HCMV UL40 peptides presented in the context of HLA-E was recently identified to be the mechanism that drives the expansion and differentiation of NKG2C + NK cells during HCMV infection ( [Hammer et al., 2018](#B74) ).

### Relapse

An association between early HCMV reactivation and reduced myeloid leukemia relapse has been reported ( [Lonnqvist et al., 1986](#B119) ; [Elmaagacli et al., 2011](#B42) ; [Green et al., 2013](#B69) ; [Ito et al., 2013](#B83) ; [Takenaka et al., 2015](#B186) ; [Peric et al., 2018](#B150) ). This putative protective effect might be mediated through the anti-leukemic activities of CD56 dim CD57 + NKG2C + NK cell and Vδ2 neg γδ T-cell subsets which expand with reactivation ( [Scheper et al., 2013](#B170) ; [Cichocki et al., 2016](#B27) ), or via enhancement of donor alloimmune responses in the presence of infection and HCMV-specific CD8 + T-cells ( [Ogonek et al., 2017](#B143) ; [Varanasi et al., 2019](#B197) ). However, the role of reactivation in protection from malignancy relapse post-HSCT is controversial, as others have not found evidence of this association in patients with acute myeloid leukemia, chronic myeloid leukemia, acute lymphoid leukemia, lymphoma, or myelodysplastic syndrome ( [Nakamura et al., 2004](#B138) ; [Green et al., 2013](#B69) ; [Jeljeli et al., 2014](#B87) ; [Mariotti et al., 2014](#B125) ; [Takenaka et al., 2015](#B186) ; [Teira et al., 2016](#B190) ; [Ramanathan et al., 2016](#B158) ; [Admiraal et al., 2017](#B1) ). Further studies are thus required to better define the patient subgroups and immunological features associated with possible relapse protection in HSCT patients with HCMV reactivation.

### Graft-Versus-Host Disease

Graft-versus-host disease and its steroid therapy increase the risk of reactivation after HSCT ( [Miller et al., 1986](#B132) ; [Yanada et al., 2003](#B209) ; [Ljungman et al., 2006](#B118) ; [George et al., 2012](#B56) ; [Liu et al., 2015](#B112) ; [Valadkhani et al., 2016](#B196) ). The alloimmune responses mediating GvHD impair thymopoiesis ( [Weinberg et al., 2001](#B203) ; [Castermans et al., 2011](#B20) ) and delay HCMV-specific T-cell reconstitution, and high-dose steroids impair the recovery of HCMV-specific T-cells in a dose-dependent manner ( [Hakki et al., 2003](#B72) ; [Widmann et al., 2008](#B204) ). Further, it has been speculated that the proinflammatory immune environment associated with GvHD may promote reactivation, as has been demonstrated following allogeneic stimulation of latently infected cells *ex vivo* ( [Soderberg-Naucler et al., 1997](#B180) ). Conversely, patients with reactivation more frequently develop GvHD ( [Lonnqvist et al., 1984](#B120) ; [Janeczko et al., 2016](#B85) ) and the risk of extensive chronic GvHD was reduced with the use of HCMV DNAemia-guided pre-emptive antiviral therapy ( [Larsson et al., 2004](#B102) ). An increased risk of acute GvHD was observed during episodes of active HCMV replication after HSCT, supporting a bidirectional relationship between reactivation and GvHD ( [Cantoni et al., 2010](#B19) ). Further research is required to delineate the mechanisms underlying this phenomenon, but an inflammatory response to reactivation or the potential cross-reactivity of HCMV-specific T-cells with human alloantigens ( [Hall et al., 2017](#B73) ) might play a role.

## Prevention and Treatment Strategies

Standard antiviral drugs for reactivation after HSCT are ganciclovir, valganciclovir and foscarnet. Prophylactic use is reserved for high-risk patients due to their significant toxic side effects. Ganciclovir causes neutropenia which increases the risk of bacterial and fungal superinfections ( [Goodrich et al., 1993](#B60) ; [Boeckh et al., 1996](#B7) ; [Broers et al., 2000](#B15) ; [Einsele et al., 2000](#B40) ; [Yanada et al., 2003](#B209) ), while foscarnet and cidofovir (used as a second- or third- line therapy) ( [Ljungman et al., 2008](#B116) ) are nephrotoxic ( [Ljungman et al., 2001](#B117) ; [Reusser et al., 2002](#B165) ). Additional concerns relate to the development of antiviral drug resistance ( [Campos et al., 2016](#B17) ; [Servais et al., 2016](#B172) ; [Chemaly et al., 2018](#B21) ) and breakthrough reactivation or disease ( [Green et al., 2012](#B67) ). HCMV drug resistance has been reported in up to 14. 5% of HSCT recipients receiving pre-emptive therapy ( [Shmueli et al., 2014](#B174) ). Prolonged antiviral exposure ( [Boeckh and Ljungman, 2009](#B9) ), suboptimal prophylactic dosing ( [Lischka et al., 2016](#B110) ), corticosteroid therapy ( [Frietsch et al., 2019](#B52) ) and delayed immune reconstitution foster the selection of drug resistant HCMV mutants. Mutations in the HCMV UL97 (viral protein kinase) gene confer resistance to (val)ganciclovir and maribavir ( [Marfori et al., 2007](#B124) ; [Piret and Boivin, 2019](#B151) ), while HCMV UL54 (viral DNA polymerase) gene mutations are associated with resistance to foscarnet, cidofovir and (val)ganciclovir ( [El Chaer et al., 2016](#B41) ). Infection with multiple HCMV genotypes is associated with reduced efficacy of antiviral treatment ( [Zawilinska et al., 2016](#B216) ; [Vinuesa et al., 2017](#B198) ). Importantly, current drugs do not target HCMV during latency, as these drugs target the viral replication machinery, and latency is typified by maintenance of the viral genome without replication. This highlights the potential for clinically relevant recurrence of reactivation following therapy cessation.

Prophylactic administration of Letermovir, a new anti-HCMV agent which inhibits the viral terminase complex, recently demonstrated the capacity to reduce the risk of HCMV disease and all-cause mortality at 24 weeks post-transplant, in a Phase 3 trial ( [Marty et al., 2017](#B127) ). There are, however, reports emerging of breakthrough viraemia and disease associated with HCMV UL56 terminase mutations conferring Letermovir resistance in HSCT recipients ( [Lischka et al., 2016](#B110) ; [Knoll et al., 2018](#B96) ; [Frietsch et al., 2019](#B52) ). Letermovir has now been licensed for HCMV prophylaxis after HSCT and its efficacy in treating refractory or resistant HCMV infection and disease will be evaluated in an upcoming Phase 2 trial (NCT03728426). Given its unique mechanism of action, combination therapy of Letermovir with other currently licensed antivirals ( [Wildum et al., 2015](#B205) ) may represent a means to more effectively control HCMV and limit the emergence of antiviral drug resistance in HSCT patients, although this area remains to be explored.

Pre-emptive treatment based on viral DNAemia surveillance ( [Emery et al., 2000](#B43) ) minimizes toxic drug exposure and reduces rates of HCMV disease and mortality ( [Einsele et al., 1995](#B38) ; [Ljungman et al., 1998](#B113) ; [Reusser et al., 2002](#B165) ), but there is no consensus on the appropriate plasma viral load threshold for initiating such therapy ( [Green et al., 2012](#B67) ; [Tan et al., 2015](#B187) ; [Green et al., 2016](#B68) ; [Hanna et al., 2017](#B75) ). Inter-laboratory assays for HCMV DNA quantitation vary and the WHO reference standard for HCMV DNA lacks commutability in many assays ( [Hayden et al., 2015](#B77) ). Lower viral load thresholds may be required in settings of corticosteroid treatment and T-cell depletion ( [Green et al., 2012](#B67) ; [Melendez-Munoz et al., 2019](#B129) ). Monitoring both HCMV-specific T-cell immunity and viral load has recently been successfully applied to guide the withholding or early discontinuation of antiviral treatment ( [Avetisyan et al., 2007](#B4) ; [Navarro et al., 2016](#B140) ; [Kumar et al., 2017](#B100) ). Further to characterizing immune reconstitution profiles in patients who spontaneously resolve reactivation without antiviral treatment ( [Camargo et al., 2019](#B16) ), more detailed investigation of the immune environment prior to the detection of HCMV DNAemia should be a focus of future studies to optimize the identification of high-risk patients and timing of pre-emptive therapy.

Pooled HCMV-specific or polyclonal intravenous immunoglobulin is not effective at preventing reactivation or reducing mortality when used in the treatment of HCMV pneumonia post-HSCT ( [Raanani et al., 2009](#B156) ; [Erard et al., 2015](#B44) ), although strain-specific antibody therapy was recently shown to potently inhibit murine cytomegalovirus (MCMV) reactivation after bone-marrow transplantation in a preclinical murine model ( [Martins et al., 2019](#B126) ). Adoptive HCMV-specific T-cell therapies to prevent and treat reactivation after HSCT have been developed since the early 1990s ( [Riddell et al., 1992](#B167) ; [Walter et al., 1995](#B201) ; [Mackinnon et al., 2008](#B123) ). Third-party- or stem cell donor-derived HCMV-specific T-cells expanded *ex vivo* or isolated directly with HCMV-specific tetramers and infused in the post-transplant period can accelerate HCMV-specific immune recovery and contribute to long-term control of reactivation and protection from HCMV disease ( [Peggs et al., 2009](#B148) ; [Peggs et al., 2011](#B147) ; [Neuenhahn et al., 2017](#B141) ; [Withers et al., 2017](#B208) ). The post-transplant infusion of donor-derived HCMV-specific cytotoxic T-cells was shown to reduce the requirement for antiviral drug therapy in a Phase 2 trial ( [Blyth et al., 2013](#B6) ). Further studies are needed to determine the optimal timing of adoptive cell infusion and understand its impact on post-transplant immune reconstitution.

## Conclusion

HCMV is a highly prevalent, opportunistic pathogen that continues to cause substantial morbidity and mortality after HSCT. Improved knowledge of the cellular sites of HCMV latency and the conditions which enable its reactivation to clinically significant infection will be needed to better predict, prevent and control reactivation post-HSCT. Future strategies might involve the selective depletion of latently infected cells from the graft ( [Krishna et al., 2016](#B97) , [2017](#B98) ), plasma metabolomics profiling to predict the emergence of reactivation ( [Monleon et al., 2018](#B135) ), the vaccination of transplant recipients and donors to enhance HCMV-specific immune reconstitution ( [Kharfan-Dabaja et al., 2012](#B92) ; [Ma et al., 2018](#B122) ), or the engineering of corticosteroid-resistant HCMV-specific T-cells to improve adoptive cell therapies ( [Menger et al., 2015](#B131) ). The marked impact of HCMV on post-transplant immune reconstitution warrants continued research to understand its relationship with patient outcomes. New therapeutic approaches for reactivation are actively being pursued and it is hoped these will lessen the clinical impact of reactivation after HSCT in the near future.

## Author Contributions

LS and BW generated the initial draft of the manuscript. All authors contributed to the subsequent writing and review of the manuscript.

## Funding

This work was funded by a Biomed Connect Grant (University of Sydney) awarded to BS and EB and an Australian Government Research Training Program Scholarship awarded to LS. EB is a NSW Cancer Institute Research Fellow.

## Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Acknowledgments

The authors wish to acknowledge the many research groups who have contributed to a better understanding of HCMV latency and reactivation in HSCT patients, and apologize to those whose work has not been cited due to space constraints.

## References

Admiraal, R., de Koning, C. C. H., Lindemans, C. A., Bierings, M. B., Wensing, A. M. J., Versluys, A. B., et al. (2017). Viral reactivations and associated outcomes in the context of immune reconstitution after pediatric hematopoietic cell transplantation. *J. Allergy Clin. Immunol.* 140, 1643–1650. e9. doi: 10. 1016/j. jaci. 2016. 12. 992

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=28392330) | [CrossRef Full Text](https://doi.org/10.1016/j.jaci.2016.12.992) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Viral+reactivations+and+associated+outcomes+in+the+context+of+immune+reconstitution+after+pediatric+hematopoietic+cell+transplantation.&journal=J.+Allergy+Clin.+Immunol.&author=Admiraal+R.&author=de+Koning+C.++C.++H.&author=Lindemans+C.++A.&author=Bierings+M.++B.&author=Wensing+A.++M.++J.&author=Versluys+A.++B.&publication_year=2017&volume=140&pages=1643-1650)

Aubert, G., Hassan-Walker, A. F., Madrigal, J. A., Emery, V. C., Morte, C., Grace, S., et al. (2001). Cytomegalovirus-specific cellular immune responses and viremia in recipients of allogeneic stem cell transplants. *J. Infect. Dis.* 184, 955–963. doi: 10. 1086/323354

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=11574909) | [CrossRef Full Text](https://doi.org/10.1086/323354) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus-specific+cellular+immune+responses++and+viremia+in+recipients+of+allogeneic+stem+cell+transplants.&journal=J.+Infect.+Dis.&author=Aubert+G.&author=Hassan-Walker+A.+F.&author=Madrigal+J.+A.&author=Emery+V.+C.&author=Morte+C.&author=Grace+S.&publication_year=2001&volume=184&pages=955-963)

Avdic, S., McSharry, B. P., and Slobedman, B. (2014). Modulation of dendritic cell functions by viral IL-10 encoded by human cytomegalovirus. *Front. Microbiol.* 5: 337. doi: 10. 3389/fmicb. 2014. 00337

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=25071749) | [CrossRef Full Text](https://doi.org/10.3389/fmicb.2014.00337) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Modulation+of+dendritic+cell+functions+by+viral+IL-10+encoded+by+human+cytomegalovirus.&journal=Front.+Microbiol.&author=Avdic+S.&author=McSharry+B.++P.&author=and+Slobedman+B.&publication_year=2014)

Avetisyan, G., Aschan, J., Hägglund, H., Ringdén, O., and Ljungman, P. (2007). Evaluation of intervention strategy based on CMV-specific immune responses after allogeneic SCT. *Bone Marrow Transplant.* 40, 865–869. doi: 10. 1038/sj. bmt. 1705825

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=17724444) | [CrossRef Full Text](https://doi.org/10.1038/sj.bmt.1705825) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Evaluation+of+intervention+strategy+based+on+CMV-specific+immune+responses+after+allogeneic+SCT.&journal=Bone+Marrow+Transplant.&author=Avetisyan+G.&author=Aschan+J.&author=Hägglund+H.&author=Ringdén+O.&author=and+Ljungman+P.&publication_year=2007&volume=40&pages=865-869)

Bhutani, D., Dyson, G., Manasa, R., Deol, A., Ratanatharathorn, V., Ayash, L., et al. (2015). Incidence, risk factors, and outcome of cytomegalovirus viremia and gastroenteritis in patients with gastrointestinal graft-versus-host disease. *Biol. Blood Marrow Transplant.* 21, 159–164. doi: 10. 1016/j. bbmt. 2014. 10. 004

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=25445637) | [CrossRef Full Text](https://doi.org/10.1016/j.bbmt.2014.10.004) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Incidence%2C+risk+factors%2C+and+outcome+of+cytomegalovirus+viremia+and+gastroenteritis+in+patients+with+gastrointestinal+graft-versus-host+disease.&journal=Biol.+Blood+Marrow+Transplant.&author=Bhutani+D.&author=Dyson+G.&author=Manasa+R.&author=Deol+A.&author=Ratanatharathorn+V.&author=Ayash+L.&publication_year=2015&volume=21&pages=159-164)

Blyth, E., Clancy, L., Simms, R., Ma, C. K. K., Burgess, J., Deo, S., et al. (2013). Donor-derived CMV-specific T cells reduce the requirement for CMV-directed pharmacotherapy after allogeneic stem cell transplantation. *Blood* 121, 3745–3758. doi: 10. 1182/blood-2012-08-448977

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=23435462) | [CrossRef Full Text](https://doi.org/10.1182/blood-2012-08-448977) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Donor-derived+CMV-specific+T+cells+reduce+the+requirement+for+CMV-directed+pharmacotherapy+after+allogeneic+stem+cell+transplantation.&journal=Blood&author=Blyth+E.&author=Clancy+L.&author=Simms+R.&author=Ma+C.+K.+K.&author=Burgess+J.&author=Deo+S.&publication_year=2013&volume=121&pages=3745-3758)

Boeckh, M., Gooley, T. A., Myerson, D., Cunningham, T., Schoch, G., and Bowden, R. A. (1996). Cytomegalovirus pp65 antigenemia-guided early treatment with ganciclovir versus ganciclovir at engraftment after allogeneic marrow transplantation: a randomized double-blind study. *Blood* 88, 4063–4071.

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=8916975) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+pp65+antigenemia-guided+early+treatment+with+ganciclovir+versus+ganciclovir+at+engraftment+after+allogeneic+marrow+transplantation%3A+a+randomized+double-blind+study.&journal=Blood&author=Boeckh+M.&author=Gooley+T.++A.&author=Myerson+D.&author=Cunningham+T.&author=Schoch+G.&author=and+Bowden+R.++A.&publication_year=1996&volume=88&pages=4063-4071)

Boeckh, M., Leisenring, W., Riddell, S. R., Bowden, R. A., Huang, M. L., Myerson, D., et al. (2003). Late cytomegalovirus disease and mortality in recipients of allogeneic hematopoietic stem cell transplants: importance of viral load and T-cell immunity. *Blood* 101, 407–414. doi: 10. 1182/blood-2002-03-0993

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=12393659) | [CrossRef Full Text](https://doi.org/10.1182/blood-2002-03-0993) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Late+cytomegalovirus+disease+and+mortality+in+recipients+of+allogeneic+hematopoietic+stem+cell+transplants%3A+importance+of+viral+load+and+T-cell+immunity.&journal=Blood&author=Boeckh+M.&author=Leisenring+W.&author=Riddell+S.+R.&author=Bowden+R.+A.&author=Huang+M.+L.&author=Myerson+D.&publication_year=2003&volume=101&pages=407-414)

Boeckh, M., and Ljungman, P. (2009). How we treat cytomegalovirus in hematopoietic cell transplant recipients. *Blood* 113, 5711–5719. doi: 10. 1182/blood-2008-10-143560

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=19299333) | [CrossRef Full Text](https://doi.org/10.1182/blood-2008-10-143560) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=How+we+treat+cytomegalovirus+in+hematopoietic+cell+transplant+recipients.&journal=Blood&author=Boeckh+M.&author=and+Ljungman+P.&publication_year=2009&volume=113&pages=5711-5719)

Boeckh, M., and Nichols, W. G. (2004). The impact of cytomegalovirus serostatus of donor and recipient before hematopoietic stem cell transplantation in the era of antiviral prophylaxis and preemptive therapy. *Blood* 103, 2003–2008. doi: 10. 1182/blood-2003-10-3616

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=14644993) | [CrossRef Full Text](https://doi.org/10.1182/blood-2003-10-3616) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=The+impact+of+cytomegalovirus+serostatus+of+donor+and+recipient+before+hematopoietic+stem+cell+transplantation+in+the+era+of+antiviral+prophylaxis+and+preemptive+therapy.&journal=Blood&author=Boeckh+M.&author=and+Nichols+W.++G.&publication_year=2004&volume=103&pages=2003-2008)

Bolovan-Fritts, C. A., Mocarski, E. S., and Wiedeman, J. A. (1999). Peripheral blood CD14(+) cells from healthy subjects carry a circular conformation of latent cytomegalovirus genome. *Blood* 93, 394–398.

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=9864186) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Peripheral+blood+CD14(%2B)+cells+from+healthy+subjects+carry+a+circular+conformation+of+latent+cytomegalovirus+genome.&journal=Blood&author=Bolovan-Fritts+C.++A.&author=Mocarski+E.++S.&author=and+Wiedeman+J.++A.&publication_year=1999&volume=93&pages=394-398)

Borchers, S., Bremm, M., Lehrnbecher, T., Dammann, E., Pabst, B., Wölk, B., et al. (2012). Sequential anti-cytomegalovirus response monitoring may allow prediction of cytomegalovirus reactivation after allogeneic stem cell transplantation. *PLoS One* 7: e50248. doi: 10. 1371/journal. pone. 0050248

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=23272059) | [CrossRef Full Text](https://doi.org/10.1371/journal.pone.0050248) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Sequential+anti-cytomegalovirus+response+monitoring+may+allow+prediction+of+cytomegalovirus+reactivation+after+allogeneic+stem+cell+transplantation.&journal=PLoS+One&author=Borchers+S.&author=Bremm+M.&author=Lehrnbecher+T.&author=Dammann+E.&author=Pabst+B.&author=Wölk+B.&publication_year=2012)

Borchers, S., Luther, S., Lips, U., Hahn, N., Kontsendorn, J., Stadler, M., et al. (2011). Tetramer monitoring to assess risk factors for recurrent cytomegalovirus reactivation and reconstitution of antiviral immunity post allogeneic hematopoietic stem cell transplantation. *Transpl. Infect. Dis.* 13, 222–236. doi: 10. 1111/j. 1399-3062. 2011. 00626. x

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=21585633) | [CrossRef Full Text](https://doi.org/10.1111/j.1399-3062.2011.00626.x) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Tetramer+monitoring+to+assess+risk+factors+for+recurrent+cytomegalovirus+reactivation+and+reconstitution+of+antiviral+immunity+post+allogeneic+hematopoietic+stem+cell+transplantation.&journal=Transpl.+Infect.+Dis.&author=Borchers+S.&author=Luther+S.&author=Lips+U.&author=Hahn+N.&author=Kontsendorn+J.&author=Stadler+M.&publication_year=2011&volume=13&pages=222-236)

Brodin, P., Jojic, V., Gao, T., Bhattacharya, S., Angel, C. J., Furman, D., et al. (2015). Variation in the human immune system is largely driven by non-heritable influences. *Cell* 160, 37–47. doi: 10. 1016/j. cell. 2014. 12. 020

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=25594173) | [CrossRef Full Text](https://doi.org/10.1016/j.cell.2014.12.020) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Variation+in+the+human+immune+system+is+largely+driven+by+non-heritable+influences.&journal=Cell&author=Brodin+P.&author=Jojic+V.&author=Gao+T.&author=Bhattacharya+S.&author=Angel+C.+J.&author=Furman+D.&publication_year=2015&volume=160&pages=37-47)

Broers, A. E., van Der Holt, R., van Esser, J. W., Gratama, J. W., Henzen-Logmans, S., Kuenen-Boumeester, V., et al. (2000). Increased transplant-related morbidity and mortality in CMV-seropositive patients despite highly effective prevention of CMV disease after allogeneic T-cell-depleted stem cell transplantation. *Blood* 95, 2240–2245.

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=10733491) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Increased+transplant-related+morbidity+and+mortality+in+CMV-seropositive+patients+despite+highly+effective+prevention+of+CMV+disease+after+allogeneic+T-cell-depleted+stem+cell+transplantation.&journal=Blood&author=Broers+A.++E.&author=van+Der+Holt+R.&author=van+Esser+J.++W.&author=Gratama+J.++W.&author=Henzen-Logmans+S.&author=Kuenen-Boumeester+V.&publication_year=2000&volume=95&pages=2240-2245)

Camargo, J. F., Wieder, E. D., Kimble, E., Benjamin, C. L., Kolonias, D. S., Kwon, D., et al. (2019). Deep functional immunophenotyping predicts risk of cytomegalovirus reactivation after hematopoietic cell transplantation. *Blood* 133, 867–877. doi: 10. 1182/blood-2018-10-878918

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=30573634) | [CrossRef Full Text](https://doi.org/10.1182/blood-2018-10-878918) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Deep+functional+immunophenotyping+predicts+risk+of+cytomegalovirus+reactivation+after+hematopoietic+cell+transplantation.&journal=Blood&author=Camargo+J.+F.&author=Wieder+E.+D.&author=Kimble+E.&author=Benjamin+C.+L.&author=Kolonias+D.++S.&author=Kwon+D.&publication_year=2019&volume=133&pages=867-877)

Campos, A. B., Ribeiro, J., Boutolleau, D., and Sousa, H. (2016). Human cytomegalovirus antiviral drug resistance in hematopoietic stem cell transplantation: current state of the art. *Rev. Med. Virol.* 26, 161–182. doi: 10. 1002/rmv. 1873

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=26990717) | [CrossRef Full Text](https://doi.org/10.1002/rmv.1873) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Human+cytomegalovirus+antiviral+drug+resistance+in+hematopoietic+stem+cell+transplantation%3A+current+state+of+the+art.&journal=Rev.+Med.+Virol.&author=Campos+A.++B.&author=Ribeiro+J.&author=Boutolleau+D.&author=and+Sousa+H.&publication_year=2016&volume=26&pages=161-182)

Cannon, M. J., Schmid, D. S., and Hyde, T. B. (2010). Review of cytomegalovirus seroprevalence and demographic characteristics associated with infection. *Rev. Med. Virol.* 20, 202–213. doi: 10. 1002/rmv. 655

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=20564615) | [CrossRef Full Text](https://doi.org/10.1002/rmv.655) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Review+of+cytomegalovirus+seroprevalence+and+demographic+characteristics+associated+with+infection.&journal=Rev.+Med.+Virol.&author=Cannon+M.++J.&author=Schmid+D.++S.&author=and+Hyde+T.++B.&publication_year=2010&volume=20&pages=202-213)

Cantoni, N., Hirsch, H. H., Khanna, N., Gerull, S., Buser, A., Bucher, C., et al. (2010). Evidence for a bidirectional relationship between cytomegalovirus replication and acute graft-versus-host disease. *Biol. Blood Marrow Transplant.* 16, 1309–1314. doi: 10. 1016/j. bbmt. 2010. 03. 020

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=20353832) | [CrossRef Full Text](https://doi.org/10.1016/j.bbmt.2010.03.020) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Evidence+for+a+bidirectional+relationship+between+cytomegalovirus+replication+and+acute+graft-versus-host+disease.&journal=Biol.+Blood+Marrow+Transplant.&author=Cantoni+N.&author=Hirsch+H.+H.&author=Khanna+N.&author=Gerull+S.&author=Buser+A.&author=Bucher+C.&publication_year=2010&volume=16&pages=1309-1314)

Castermans, E., Hannon, M., Dutrieux, J., Humblet-Baron, S., Seidel, L., Cheynier, R., et al. (2011). Thymic recovery after allogeneic hematopoietic cell transplantation with non-myeloablative conditioning is limited to patients younger than 60 years of age. *Haematologica* 96, 298–306. doi: 10. 3324/haematol. 2010. 029702

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=20934996) | [CrossRef Full Text](https://doi.org/10.3324/haematol.2010.029702) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Thymic+recovery+after+allogeneic+hematopoietic+cell+transplantation+with+non-myeloablative+conditioning+is+limited+to+patients+younger+than+60+years+of+age.&journal=Haematologica&author=Castermans+E.&author=Hannon+M.&author=Dutrieux+J.&author=Humblet-Baron+S.&author=Seidel+L.&author=Cheynier+R.&publication_year=2011&volume=96&pages=298-306)

Chemaly, R. F., Chou, S., Einsele, H., Griffiths, P., Avery, R., Razonable, R. R., et al. (2018). Definitions of resistant and refractory cytomegalovirus infection and disease in transplant recipients for use in clinical trials. *Clin. Infect. Dis.* 68, 1420–1426. doi: 10. 1093/cid/ciy696

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=30137245) | [CrossRef Full Text](https://doi.org/10.1093/cid/ciy696) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Definitions+of+resistant+and+refractory+cytomegalovirus+infection+and+disease+in+transplant+recipients+for+use+in+clinical+trials.&journal=Clin.++Infect.+Dis.&author=Chemaly+R.+F.&author=Chou+S.&author=Einsele+H.&author=Griffiths+P.&author=Avery+R.&author=Razonable+R.+R.&publication_year=2018&volume=68&pages=1420-1426)

Chen, C., Busson, M., Rocha, V., Appert, M. L., Lepage, V., Dulphy, N., et al. (2006). Activating KIR genes are associated with CMV reactivation and survival after non-T-cell depleted HLA-identical sibling bone marrow transplantation for malignant disorders. *Bone Marrow Transplant.* 38, 437–444. doi: 10. 1038/sj. bmt. 1705468

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=16892071) | [CrossRef Full Text](https://doi.org/10.1038/sj.bmt.1705468) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Activating+KIR+genes+are+associated+with+CMV+reactivation+and+survival+after+non-T-cell+depleted+HLA-identical+sibling+bone+marrow+transplantation+for+malignant+disorders.&journal=Bone+Marrow+Transplant.&author=Chen+C.&author=Busson+M.&author=Rocha+V.&author=Appert+M.+L.&author=Lepage+V.&author=Dulphy+N.&publication_year=2006&volume=38&pages=437-444)

Chen, T., and Hudnall, S. D. (2006). Anatomical mapping of human herpesvirus reservoirs of infection. *Mod. Pathol.* 19, 726–737. doi: 10. 1038/modpathol. 3800584

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=16528368) | [CrossRef Full Text](https://doi.org/10.1038/modpathol.3800584) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Anatomical+mapping+of+human+herpesvirus+reservoirs+of+infection.&journal=Mod.++Pathol.&author=Chen+T.&author=and+Hudnall+S.++D.&publication_year=2006&volume=19&pages=726-737)

Chidrawar, S., Khan, N., Wei, W., McLarnon, A., Smith, N., Nayak, L., et al. (2009). Cytomegalovirus-seropositivity has a profound influence on the magnitude of major lymphoid subsets within healthy individuals. *Clin. Exp. Immunol.* 155, 423–432. doi: 10. 1111/j. 1365-2249. 2008. 03785. x

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=19220832) | [CrossRef Full Text](https://doi.org/10.1111/j.1365-2249.2008.03785.x) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus-seropositivity+has+a+profound+influence+on+the+magnitude+of+major+lymphoid+subsets+within+healthy+individuals.&journal=Clin.+Exp.++Immunol.&author=Chidrawar+S.&author=Khan+N.&author=Wei+W.&author=McLarnon+A.&author=Smith+N.&author=Nayak+L.&publication_year=2009&volume=155&pages=423-432)

Cho, B. S., Yahng, S. A., Kim, J. H., Yoon, J. H., Shin, S. H., Lee, S. E., et al. (2013). Impact of cytomegalovirus gastrointestinal disease on the clinical outcomes in patients with gastrointestinal graft-versus-host disease in the era of preemptive therapy. *Ann. Hematol.* 92, 497–504. doi: 10. 1007/s00277-012-1632-x

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=23180439) | [CrossRef Full Text](https://doi.org/10.1007/s00277-012-1632-x) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Impact+of+cytomegalovirus+gastrointestinal+disease+on+the+clinical+outcomes+in+patients+with+gastrointestinal+graft-versus-host+disease+in+the+era+of+preemptive+therapy.&journal=Ann.+Hematol.&author=Cho+B.++S.&author=Yahng+S.++A.&author=Kim+J.++H.&author=Yoon+J.++H.&author=Shin+S.++H.&author=Lee+S.++E.&publication_year=2013&volume=92&pages=497-504)

Ciaurriz, M., Beloki, L., Zabalza, A., Bandres, E., Mansilla, C., Perez-Valderrama, E., et al. (2017). Functional specific-T-cell expansion after first cytomegalovirus reactivation predicts viremia control in allogeneic hematopoietic stem cell transplant recipients. *Transpl. Infect. Dis.* 19: e12778. doi: 10. 1111/tid. 12778

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=28921749) | [CrossRef Full Text](https://doi.org/10.1111/tid.12778) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Functional+specific-T-cell+expansion+after+first+cytomegalovirus+reactivation+predicts+viremia+control+in+allogeneic++hematopoietic+stem+cell+transplant+recipients.&journal=Transpl.+Infect.+Dis.&author=Ciaurriz+M.&author=Beloki+L.&author=Zabalza+A.&author=Bandres+E.&author=Mansilla+C.&author=Perez-Valderrama+E.&publication_year=2017)

Cichocki, F., Cooley, S., Davis, Z., DeFor, T. E., Schlums, H., Zhang, B., et al. (2016). CD56dimCD57+NKG2C+ NK cell expansion is associated with reduced leukemia relapse after reduced intensity HCT. *Leukemia* 30, 456–463. doi: 10. 1038/leu. 2015. 260

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=26416461) | [CrossRef Full Text](https://doi.org/10.1038/leu.2015.260) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=CD56dimCD57%2BNKG2C%2B+NK+cell+expansion+is+associated+with+reduced+leukemia+relapse+after+reduced+intensity+HCT.&journal=Leukemia&author=Cichocki+F.&author=Cooley+S.&author=Davis+Z.&author=DeFor+T.+E.&author=Schlums+H.&author=Zhang+B.&publication_year=2016&volume=30&pages=456-463)

Cohen, L., Yeshurun, M., Shpilberg, O., and Ram, R. (2015). Risk factors and prognostic scale for cytomegalovirus (CMV) infection in CMV-seropositive patients after allogeneic hematopoietic cell transplantation. *Transpl. Infect. Dis.* 17, 510–517. doi: 10. 1111/tid. 12398

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=25940504) | [CrossRef Full Text](https://doi.org/10.1111/tid.12398) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Risk+factors+and+prognostic+scale+for+cytomegalovirus+(CMV)+infection+in+CMV-seropositive+patients+after+allogeneic+hematopoietic+cell+transplantation.&journal=Transpl.+Infect.++Dis.&author=Cohen+L.&author=Yeshurun+M.&author=Shpilberg+O.&author=and+Ram+R.&publication_year=2015&volume=17&pages=510-517)

Cook, M., Briggs, D., Craddock, C., Mahendra, P., Milligan, D., Fegan, C., et al. (2006). Donor KIR genotype has a major influence on the rate of cytomegalovirus reactivation following T-cell replete stem cell transplantation. *Blood* 107, 1230–1232. doi: 10. 1182/blood-2005-03-1039

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=16239436) | [CrossRef Full Text](https://doi.org/10.1182/blood-2005-03-1039) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Donor+KIR+genotype+has+a+major+influence+on+the+rate+of+cytomegalovirus+reactivation+following+T-cell+replete+stem+cell+transplantation.&journal=Blood&author=Cook+M.&author=Briggs+D.&author=Craddock+C.&author=Mahendra+P.&author=Milligan+D.&author=Fegan+C.&publication_year=2006&volume=107&pages=1230-1232)

Copelan, E. A. (2006). Hematopoietic stem-cell transplantation. *N. Engl. J. Med.* 354, 1813–1826.

[Google Scholar](http://scholar.google.com/scholar_lookup?&title=Hematopoietic+stem-cell+transplantation.&journal=N.+Engl.+J.++Med.&author=Copelan+E.+A.&publication_year=2006&volume=354&pages=1813-1826)

Craddock, C., Szydlo, R. M., Dazzi, F., Olavarria, E., Cwynarski, K., Yong, A., et al. (2001). Cytomegalovirus seropositivity adversely influences outcome after T-depleted unrelated donor transplant in patients with chronic myeloid leukaemia: the case for tailored graft-versus-host disease prophylaxis. *Br. J. Haematol.* 112, 228–236. doi: 10. 1046/j. 1365-2141. 2001. 02519. x

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=11167809) | [CrossRef Full Text](https://doi.org/10.1046/j.1365-2141.2001.02519.x) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+seropositivity+adversely+influences+outcome+after+T-depleted+unrelated+donor+transplant+in+patients+with+chronic+myeloid+leukaemia%3A+the+case+for+tailored+graft-versus-host+disease+prophylaxis.&journal=Br.+J.++Haematol.&author=Craddock+C.&author=Szydlo+R.+M.&author=Dazzi+F.&author=Olavarria+E.&author=Cwynarski+K.&author=Yong+A.&publication_year=2001&volume=112&pages=228-236)

Crocchiolo, R., Bramanti, S., Vai, A., Sarina, B., Mineri, R., Casari, E., et al. (2015). Infections after T-replete haploidentical transplantation and high-dose cyclophosphamide as graft-versus-host disease prophylaxis. *Transpl. Infect. Dis.* 17, 242–249. doi: 10. 1111/tid. 12365

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=25648539) | [CrossRef Full Text](https://doi.org/10.1111/tid.12365) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Infections+after+T-replete+haploidentical+transplantation+and+high-dose+cyclophosphamide+as+graft-versus-host+disease+prophylaxis.&journal=Transpl.++Infect.++Dis.&author=Crocchiolo+R.&author=Bramanti+S.&author=Vai+A.&author=Sarina+B.&author=Mineri+R.&author=Casari+E.&publication_year=2015&volume=17&pages=242-249)

Cwynarski, K., Ainsworth, J., Cobbold, M., Wagner, S., Mahendra, P., Apperley, J., et al. (2001). Direct visualization of cytomegalovirus-specific T-cell reconstitution after allogeneic stem cell transplantation. *Blood* 97, 1232–1240. doi: 10. 1182/blood. v97. 5. 1232

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=11222365) | [CrossRef Full Text](https://doi.org/10.1182/blood.v97.5.1232) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Direct+visualization+of+cytomegalovirus-specific+T-cell+reconstitution+after+allogeneic+stem+cell+transplantation.&journal=Blood&author=Cwynarski+K.&author=Ainsworth+J.&author=Cobbold+M.&author=Wagner+S.&author=Mahendra+P.&author=Apperley+J.&publication_year=2001&volume=97&pages=1232-1240)

Davis, Z. B., Cooley, S. A., Cichocki, F., Felices, M., Wangen, R., Luo, X., et al. (2015). Adaptive natural killer cell and killer cell immunoglobulin-like receptor-expressing T cell responses are induced by cytomegalovirus and are associated with protection against cytomegalovirus reactivation after allogeneic donor hematopoietic cell transplantation. *Biol. Blood Marrow Transplant.* 21, 1653–1662. doi: 10. 1016/j. bbmt. 2015. 05. 025

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=26055301) | [CrossRef Full Text](https://doi.org/10.1016/j.bbmt.2015.05.025) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Adaptive+natural+killer+cell+and+killer+cell+immunoglobulin-like+receptor-expressing+T+cell+responses+are+induced+by+cytomegalovirus+and+are+associated+with+protection+against+cytomegalovirus+reactivation+after+allogeneic++donor+hematopoietic+cell+transplantation.&journal=Biol.+Blood+Marrow+Transplant.&author=Davis+Z.+B.&author=Cooley+S.+A.&author=Cichocki+F.&author=Felices+M.&author=Wangen+R.&author=Luo+X.&publication_year=2015&volume=21&pages=1653-1662)

Di Stasi, A., Milton, D. R., Poon, L. M., Hamdi, A., Rondon, G., Chen, J., et al. (2014). Similar transplantation outcomes for acute myeloid leukemia and myelodysplastic syndrome patients with haploidentical versus 10/10 human leukocyte antigen-matched unrelated and related donors. *Biol. Blood Marrow Transplant.* 20, 1975–1981. doi: 10. 1016/j. bbmt. 2014. 08. 013

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=25263628) | [CrossRef Full Text](https://doi.org/10.1016/j.bbmt.2014.08.013) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Similar+transplantation+outcomes+for+acute+myeloid+leukemia+and+myelodysplastic+syndrome+patients+with+haploidentical+versus+10%2F10+human+leukocyte+antigen-matched+unrelated+and+related+donors.&journal=Biol.+Blood+Marrow+Transplant.&author=Di+Stasi+A.&author=Milton+D.+R.&author=Poon+L.+M.&author=Hamdi+A.&author=Rondon+G.&author=Chen+J.&publication_year=2014&volume=20&pages=1975-1981)

Drylewicz, J., Schellens, I. M., Gaiser, R., Nanlohy, N. M., Quakkelaar, E. D., Otten, H., et al. (2016). Rapid reconstitution of CD4 T cells and NK cells protects against CMV-reactivation after allogeneic stem cell transplantation. *J. Transl. Med.* 14: 230. doi: 10. 1186/s12967-016-0988-4

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=27484705) | [CrossRef Full Text](https://doi.org/10.1186/s12967-016-0988-4) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Rapid+reconstitution+of+CD4+T+cells+and+NK+cells+protects+against+CMV-reactivation+after+allogeneic+stem+cell+transplantation.&journal=J.+Transl.+Med.&author=Drylewicz+J.&author=Schellens+I.+M.&author=Gaiser+R.&author=Nanlohy+N.+M.&author=Quakkelaar+E.++D.&author=Otten+H.&publication_year=2016)

D’Souza, A., and Fretham, C. (2018). *Current Uses and Outcomes of Hematopoietic Cell Transplantation (HCT): CIBMTR Summary Slides, 2018* . Available at: [https://www. cibmtr. org](https://www.cibmtr.org/) (accessed March 30, 2019).

[Google Scholar](http://scholar.google.com/scholar_lookup?&title=Current+Uses+and+Outcomes+of+Hematopoietic+Cell+Transplantation+(HCT)%3A+CIBMTR+Summary+Slides%2C+2018.&author=D’Souza+A.&author=and+Fretham+C.&publication_year=2018&volume=30&issue=2019)

Einsele, H., Ehninger, G., Hebart, H., Wittkowski, K. M., Schuler, U., Jahn, G., et al. (1995). Polymerase chain reaction monitoring reduces the incidence of cytomegalovirus disease and the duration and side effects of antiviral therapy after bone marrow transplantation. *Blood* 86, 2815–2820.

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=7670117) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Polymerase+chain+reaction+monitoring+reduces+the+incidence+of+cytomegalovirus+disease+and+the+duration+and+side+effects+of+antiviral+therapy+after+bone+marrow+transplantation.&journal=Blood&author=Einsele+H.&author=Ehninger+G.&author=Hebart+H.&author=Wittkowski+K.+M.&author=Schuler+U.&author=Jahn+G.&publication_year=1995&volume=86&pages=2815-2820)

Einsele, H., Ehninger, G., Steidle, M., Fischer, I., Bihler, S., Gerneth, F., et al. (1993). Lymphocytopenia as an unfavorable prognostic factor in patients with cytomegalovirus infection after bone marrow transplantation. *Blood* 82, 1672–1678.

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=8395913) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Lymphocytopenia+as+an+unfavorable+prognostic+factor+in+patients+with+cytomegalovirus+infection+after+bone+marrow+transplantation.&journal=Blood&author=Einsele+H.&author=Ehninger+G.&author=Steidle+M.&author=Fischer+I.&author=Bihler+S.&author=Gerneth+F.&publication_year=1993&volume=82&pages=1672-1678)

Einsele, H., Hebart, H., Kauffmann-Schneider, C., Sinzger, C., Jahn, G., Bader, P., et al. (2000). Risk factors for treatment failures in patients receiving PCR-based preemptive therapy for CMV infection. *Bone Marrow Transplant.* 25, 757–763. doi: 10. 1038/sj. bmt. 1702226

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=10745262) | [CrossRef Full Text](https://doi.org/10.1038/sj.bmt.1702226) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Risk+factors+for+treatment+failures+in+patients+receiving+PCR-based+preemptive+therapy+for+CMV+infection.&journal=Bone+Marrow+Transplant.&author=Einsele+H.&author=Hebart+H.&author=Kauffmann-Schneider+C.&author=Sinzger+C.&author=Jahn+G.&author=Bader+P.&publication_year=2000&volume=25&pages=757-763)

El Chaer, F., Shah, D. P., and Chemaly, R. F. (2016). How I treat resistant cytomegalovirus infection in hematopoietic cell transplantation recipients. *Blood* 128, 2624–2636. doi: 10. 1182/blood-2016-06-688432

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=27760756) | [CrossRef Full Text](https://doi.org/10.1182/blood-2016-06-688432) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=How+I+treat+resistant+cytomegalovirus+infection+in+hematopoietic+cell+transplantation+recipients.&journal=Blood&author=El+Chaer+F.&author=Shah+D.+P.&author=and+Chemaly+R.+F.&publication_year=2016&volume=128&pages=2624-2636)

Elmaagacli, A. H., Steckel, N. K., Koldehoff, M., Hegerfeldt, Y., Trenschel, R., Ditschkowski, M., et al. (2011). Early human cytomegalovirus replication after transplantation is associated with a decreased relapse risk: evidence for a putative virus-versus-leukemia effect in acute myeloid leukemia patients. *Blood* 118, 1402–1412. doi: 10. 1182/blood-2010-08-304121

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=21540462) | [CrossRef Full Text](https://doi.org/10.1182/blood-2010-08-304121) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Early+human+cytomegalovirus+replication+after+transplantation+is+associated+with+a+decreased+relapse+risk%3A+evidence+for+a+putative+virus-versus-leukemia+effect+in+acute+myeloid+leukemia+patients.&journal=Blood&author=Elmaagacli+A.+H.&author=Steckel+N.+K.&author=Koldehoff+M.&author=Hegerfeldt+Y.&author=Trenschel+R.&author=Ditschkowski+M.&publication_year=2011&volume=118&pages=1402-1412)

Emery, V. C., Sabin, C. A., Cope, A. V., Gor, D., Hassan-Walker, A. F., and Griffiths, P. D. (2000). Application of viral-load kinetics to identify patients who develop cytomegalovirus disease after transplantation. *Lancet* 355, 2032–2036. doi: 10. 1016/s0140-6736(00)02350-3

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=10885354) | [CrossRef Full Text](https://doi.org/10.1016/s0140-6736(00)02350-3) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Application+of+viral-load+kinetics+to+identify+patients+who+develop+cytomegalovirus+disease+after+transplantation.&journal=Lancet&author=Emery+V.++C.&author=Sabin+C.++A.&author=Cope+A.++V.&author=Gor+D.&author=Hassan-Walker+A.++F.&author=and+Griffiths+P.+D.&publication_year=2000&volume=355&pages=2032-2036)

Erard, V., Guthrie, K. A., Seo, S., Smith, J., Huang, M., Chien, J., et al. (2015). Reduced mortality of cytomegalovirus pneumonia after hematopoietic cell transplantation due to antiviral therapy and changes in transplantation practices. *Clin. Infect. Dis.* 61, 31–39. doi: 10. 1093/cid/civ215

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=25778751) | [CrossRef Full Text](https://doi.org/10.1093/cid/civ215) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Reduced+mortality+of+cytomegalovirus+pneumonia+after+hematopoietic+cell+transplantation+due+to+antiviral+therapy+and+changes+in+transplantation+practices.&journal=Clin.+Infect.+Dis.&author=Erard+V.&author=Guthrie+K.+A.&author=Seo+S.&author=Smith+J.&author=Huang+M.&author=Chien+J.&publication_year=2015&volume=61&pages=31-39)

Espigado, I., de la Cruz-Vicente, F., BenMarzouk-Hidalgo, O. J., Gracia-Ahufinger, I., Garcia-Lozano, J. R., Aguilar-Guisado, M., et al. (2014). Timing of CMV-specific effector memory T cells predicts viral replication and survival after allogeneic hematopoietic stem cell transplantation. *Transpl. Int.* 27, 1253–1262. doi: 10. 1111/tri. 12406

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=25070273) | [CrossRef Full Text](https://doi.org/10.1111/tri.12406) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Timing+of+CMV-specific+effector+memory+T+cells+predicts+viral+replication+and+survival+after+allogeneic+hematopoietic+stem+cell+transplantation.&journal=Transpl.+Int.&author=Espigado+I.&author=de+la+Cruz-Vicente+F.&author=BenMarzouk-Hidalgo+O.++J.&author=Gracia-Ahufinger+I.&author=Garcia-Lozano+J.+R.&author=Aguilar-Guisado+M.&publication_year=2014&volume=27&pages=1253-1262)

Fietze, E., Prosch, S., Reinke, P., Stein, J., Docke, W. D., Staffa, G., et al. (1994). Cytomegalovirus infection in transplant recipients. The role of tumor necrosis factor. *Transplantation* 58, 675–680. doi: 10. 1097/00007890-199409270-00007

[CrossRef Full Text](https://doi.org/10.1097/00007890-199409270-00007) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+infection+in+transplant+recipients.++The+role+of+tumor+necrosis+factor.&journal=Transplantation&author=Fietze+E.&author=Prosch+S.&author=Reinke+P.&author=Stein+J.&author=Docke+W.++D.&author=Staffa+G.&publication_year=1994&volume=58&pages=675-680)

Fish, K. N., Soderberg-Naucler, C., Mills, L. K., Stenglein, S., and Nelson, J. A. (1998). Human cytomegalovirus persistently infects aortic endothelial cells. *J. Virol.* 72, 5661–5668.

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=9621025) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Human+cytomegalovirus+persistently+infects+aortic+endothelial+cells.&journal=J.+Virol.&author=Fish+K.+N.&author=Soderberg-Naucler+C.&author=Mills+L.+K.&author=Stenglein+S.&author=and+Nelson+J.++A.&publication_year=1998&volume=72&pages=5661-5668)

Foley, B., Cooley, S., Verneris, M. R., Curtsinger, J., Luo, X., Waller, E. K., et al. (2012a). Human cytomegalovirus (CMV)-induced memory-like NKG2C(+) NK cells are transplantable and expand in vivo in response to recipient CMV antigen. *J. Immunol.* 189, 5082–5088. doi: 10. 4049/jimmunol. 1201964

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=23077239) | [CrossRef Full Text](https://doi.org/10.4049/jimmunol.1201964) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Human+cytomegalovirus+(CMV)-induced+memory-like+NKG2C(%2B)+NK+cells+are+transplantable+and+expand+in+vivo+in+response+to+recipient+CMV+antigen.&journal=J.+Immunol.&author=Foley+B.&author=Cooley+S.&author=Verneris+M.+R.&author=Curtsinger+J.&author=Luo+X.&author=Waller+E.+K.&publication_year=2012a&volume=189&pages=5082-5088)

Foley, B., Cooley, S., Verneris, M. R., Pitt, M., Curtsinger, J., Luo, X., et al. (2012b). Cytomegalovirus reactivation after allogeneic transplantation promotes a lasting increase in educated NKG2C+ natural killer cells with potent function. *Blood* 119, 2665–2674. doi: 10. 1182/blood-2011-10-386995

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=22180440) | [CrossRef Full Text](https://doi.org/10.1182/blood-2011-10-386995) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+reactivation+after+allogeneic+transplantation+promotes+a+lasting+increase+in+educated+NKG2C%2B+natural+killer+cells+with+potent+function.&journal=Blood&author=Foley+B.&author=Cooley+S.&author=Verneris+M.++R.&author=Pitt+M.&author=Curtsinger+J.&author=Luo+X.&publication_year=2012b&volume=119&pages=2665-2674)

Forte, E., Swaminathan, S., Schroeder, M. W., Kim, J. Y., Terhune, S. S., and Hummel, M. (2018). Tumor necrosis factor alpha induces reactivation of human cytomegalovirus independently of myeloid cell differentiation following posttranscriptional establishment of latency. *mBio* 9: e01560-18. doi: 10. 1128/mBio. 01560-18

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=30206173) | [CrossRef Full Text](https://doi.org/10.1128/mBio.01560-18) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Tumor+necrosis+factor+alpha+induces+reactivation+of+human+cytomegalovirus+independently+of+myeloid+cell+differentiation+following+posttranscriptional+establishment+of+latency.&journal=mBio&author=Forte+E.&author=Swaminathan+S.&author=Schroeder+M.+W.&author=Kim+J.+Y.&author=Terhune+S.+S.&author=and+Hummel+M.&publication_year=2018)

Foster, A. E., Gottlieb, D. J., Sartor, M., Hertzberg, M. S., and Bradstock, K. F. (2002). Cytomegalovirus-specific CD4+ and CD8+ T-cells follow a similar reconstitution pattern after allogeneic stem cell transplantation. *Biol. Blood Marrow Transplant.* 8, 501–511. doi: 10. 1053/bbmt. 2002. v8. pm12374455

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=12374455) | [CrossRef Full Text](https://doi.org/10.1053/bbmt.2002.v8.pm12374455) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus-specific+CD4%2B+and+CD8%2B+T-cells+follow+a+similar+reconstitution+pattern+after+allogeneic+stem+cell+transplantation.&journal=Biol.+Blood+Marrow+Transplant.&author=Foster+A.+E.&author=Gottlieb+D.+J.&author=Sartor+M.&author=Hertzberg+M.+S.&author=and+Bradstock+K.++F.&publication_year=2002&volume=8&pages=501-511)

Frietsch, J. J., Michel, D., Stamminger, T., Hunstig, F., Birndt, S., Schnetzke, U., et al. (2019). In vivo emergence of UL56 C325Y cytomegalovirus resistance to letermovir in a patient with acute myeloid leukemia after hematopoietic cell transplantation. *Mediterr. J. Hematol. Infect. Dis.* 11: e2019001. doi: 10. 4084/MJHID. 2019. 001

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=30671207) | [CrossRef Full Text](https://doi.org/10.4084/MJHID.2019.001) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=In+vivo+emergence+of+UL56+C325Y+cytomegalovirus+resistance+to+letermovir+in+a+patient+with+acute+myeloid+leukemia+after+hematopoietic+cell+transplantation.&journal=Mediterr.++J.++Hematol.++Infect.++Dis.&author=Frietsch+J.+J.&author=Michel+D.&author=Stamminger+T.&author=Hunstig+F.&author=Birndt+S.&author=Schnetzke+U.&publication_year=2019)

Gabanti, E., Lilleri, D., Ripamonti, F., Bruno, F., Zelini, P., Furione, M., et al. (2015). Reconstitution of human cytomegalovirus-specific CD4+ T cells is critical for control of virus reactivation in hematopoietic stem cell transplant recipients but does not prevent organ infection. *Biol. Blood Marrow Transplant.* 21, 2192–2202. doi: 10. 1016/j. bbmt. 2015. 08. 002

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=26260678) | [CrossRef Full Text](https://doi.org/10.1016/j.bbmt.2015.08.002) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Reconstitution+of+human+cytomegalovirus-specific+CD4%2B+T+cells+is+critical+for+control+of+virus+reactivation+in+hematopoietic+stem+cell+transplant+recipients+but+does+not+prevent+organ+infection.&journal=Biol.+Blood+Marrow+Transplant.&author=Gabanti+E.&author=Lilleri+D.&author=Ripamonti+F.&author=Bruno+F.&author=Zelini+P.&author=Furione+M.&publication_year=2015&volume=21&pages=2192-2202)

Gandhi, M. K., Wills, M. R., Okecha, G., Day, E. K., Hicks, R., Marcus, R. E., et al. (2003). Late diversification in the clonal composition of human cytomegalovirus-specific CD8+ T cells following allogeneic hemopoietic stem cell transplantation. *Blood* 102, 3427–3438. doi: 10. 1182/blood-2002-12-3689

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=12869514) | [CrossRef Full Text](https://doi.org/10.1182/blood-2002-12-3689) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Late+diversification+in+the+clonal+composition+of+human+cytomegalovirus-specific+CD8%2B+T+cells+following+allogeneic+hemopoietic+stem+cell+transplantation.&journal=Blood&author=Gandhi+M.+K.&author=Wills+M.+R.&author=Okecha+G.&author=Day+E.+K.&author=Hicks+R.&author=Marcus+R.+E.&publication_year=2003&volume=102&pages=3427-3438)

Ganepola, S., Gentilini, C., Hilbers, U., Lange, T., Rieger, K., Hofmann, J., et al. (2007). Patients at high risk for CMV infection and disease show delayed CD8+ T-cell immune recovery after allogeneic stem cell transplantation. *Bone Marrow Transplant.* 39, 293–299. doi: 10. 1038/sj. bmt. 1705585

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=17262060) | [CrossRef Full Text](https://doi.org/10.1038/sj.bmt.1705585) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Patients+at+high+risk+for+CMV+infection+and+disease+show+delayed+CD8%2B+T-cell+immune+recovery+after+allogeneic+stem+cell+transplantation.&journal=Bone+Marrow+Transplant.&author=Ganepola+S.&author=Gentilini+C.&author=Hilbers+U.&author=Lange+T.&author=Rieger+K.&author=Hofmann+J.&publication_year=2007&volume=39&pages=293-299)

George, B., Kerridge, I. H., Gilroy, N., Huang, G., Hertzberg, M. S., Bradstock, K. F., et al. (2012). A risk score for early cytomegalovirus reactivation after allogeneic stem cell transplantation identifies low-, intermediate-, and high-risk groups: reactivation risk is increased by graft-versus-host disease only in the intermediate-risk group. *Transpl. Infect. Dis.* 14, 141–148. doi: 10. 1111/j. 1399-3062. 2011. 00706. x

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=22283838) | [CrossRef Full Text](https://doi.org/10.1111/j.1399-3062.2011.00706.x) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=A+risk+score+for+early+cytomegalovirus+reactivation+after+allogeneic+stem+cell+transplantation+identifies+low-%2C+intermediate-%2C+and+high-risk+groups%3A+reactivation+risk+is+increased+by+graft-versus-host+disease+only+in+the+intermediate-risk+group.&journal=Transpl.+Infect.++Dis.&author=George+B.&author=Kerridge+I.++H.&author=Gilroy+N.&author=Huang+G.&author=Hertzberg+M.++S.&author=Bradstock+K.++F.&publication_year=2012&volume=14&pages=141-148)

George, B., Pati, N., Gilroy, N., Ratnamohan, M., Huang, G., Kerridge, I., et al. (2010). Pre-transplant cytomegalovirus (CMV) serostatus remains the most important determinant of CMV reactivation after allogeneic hematopoietic stem cell transplantation in the era of surveillance and preemptive therapy. *Transpl. Infect. Dis.* 12, 322–329. doi: 10. 1111/j. 1399-3062. 2010. 00504. x

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=20487414) | [CrossRef Full Text](https://doi.org/10.1111/j.1399-3062.2010.00504.x) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Pre-transplant+cytomegalovirus+(CMV)+serostatus+remains+the+most+important+determinant+of+CMV+reactivation+after+allogeneic+hematopoietic+stem+cell+transplantation+in+the+era+of+surveillance+and+preemptive+therapy.&journal=Transpl.+Infect.+Dis.&author=George+B.&author=Pati+N.&author=Gilroy+N.&author=Ratnamohan+M.&author=Huang+G.&author=Kerridge+I.&publication_year=2010&volume=12&pages=322-329)

Gimenez, E., Blanco-Lobo, P., Munoz-Cobo, B., Solano, C., Amat, P., Perez-Romero, P., et al. (2015). Role of cytomegalovirus (CMV)-specific polyfunctional CD8+ T-cells and antibodies neutralizing virus epithelial infection in the control of CMV infection in an allogeneic stem-cell transplantation setting. *J. Gen. Virol.* 96, 2822–2831. doi: 10. 1099/vir. 0. 000203

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=26025872) | [CrossRef Full Text](https://doi.org/10.1099/vir.0.000203) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Role+of+cytomegalovirus+(CMV)-specific+polyfunctional+CD8%2B+T-cells+and+antibodies+neutralizing+virus+epithelial+infection+in+the+control+of+CMV+infection+in+an+allogeneic+stem-cell+transplantation+setting.&journal=J.+Gen.+Virol.&author=Gimenez+E.&author=Blanco-Lobo+P.&author=Munoz-Cobo+B.&author=Solano+C.&author=Amat+P.&author=Perez-Romero+P.&publication_year=2015&volume=96&pages=2822-2831)

Goldsmith, S. R., Slade, M., DiPersio, J. F., Westervelt, P., Lawrence, S. J., Uy, G. L., et al. (2016). Cytomegalovirus viremia, disease, and impact on relapse in T-cell replete peripheral blood haploidentical hematopoietic cell transplantation with post-transplant cyclophosphamide. *Haematologica* 101, e465–e468. doi: 10. 3324/haematol. 2016. 149880

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=27443287) | [CrossRef Full Text](https://doi.org/10.3324/haematol.2016.149880) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+viremia%2C+disease%2C+and+impact+on+relapse+in+T-cell+replete+peripheral+blood+haploidentical+hematopoietic+cell+transplantation+with+post-transplant+cyclophosphamide.&journal=Haematologica&author=Goldsmith+S.+R.&author=Slade+M.&author=DiPersio+J.+F.&author=Westervelt+P.&author=Lawrence+S.++J.&author=Uy+G.++L.&publication_year=2016&volume=101&pages=e465-e468)

Goodrich, J. M., Bowden, R. A., Fisher, L., Keller, C., Schoch, G., and Meyers, J. D. (1993). Ganciclovir prophylaxis to prevent cytomegalovirus disease after allogeneic marrow transplant. *Ann. Intern. Med.* 118, 173–178.

[Google Scholar](http://scholar.google.com/scholar_lookup?&title=Ganciclovir+prophylaxis+to+prevent+cytomegalovirus+disease+after+allogeneic+marrow+transplant.&journal=Ann.+Intern.+Med.&author=Goodrich+J.+M.&author=Bowden+R.+A.&author=Fisher+L.&author=Keller+C.&author=Schoch+G.&author=and+Meyers+J.++D.&publication_year=1993&volume=118&pages=173-178)

Goodrum, F., Jordan, C. T., Terhune, S. S., High, K., and Shenk, T. (2004). Differential outcomes of human cytomegalovirus infection in primitive hematopoietic cell subpopulations. *Blood* 104, 687–695. doi: 10. 1182/blood-2003-12-4344

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=15090458) | [CrossRef Full Text](https://doi.org/10.1182/blood-2003-12-4344) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Differential+outcomes+of+human+cytomegalovirus+infection+in+primitive+hematopoietic+cell+subpopulations.&journal=Blood&author=Goodrum+F.&author=Jordan+C.++T.&author=Terhune+S.++S.&author=High+K.&author=and+Shenk+T.&publication_year=2004&volume=104&pages=687-695)

Gordon, C. L., Miron, M., Thome, J. J., Matsuoka, N., Weiner, J., Rak, M. A., et al. (2017). Tissue reservoirs of antiviral T cell immunity in persistent human CMV infection. *J. Exp. Med.* 214, 651–667. doi: 10. 1084/jem. 20160758

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=28130404) | [CrossRef Full Text](https://doi.org/10.1084/jem.20160758) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Tissue+reservoirs+of+antiviral+T+cell+immunity+in+persistent+human+CMV+infection.&journal=J.+Exp.+Med.&author=Gordon+C.+L.&author=Miron+M.&author=Thome+J.+J.&author=Matsuoka+N.&author=Weiner+J.&author=Rak+M.++A.&publication_year=2017&volume=214&pages=651-667)

Gratama, J. W., Boeckh, M., Nakamura, R., Cornelissen, J. J., Brooimans, R. A., Zaia, J. A., et al. (2010). Immune monitoring with iTAg MHC Tetramers for prediction of recurrent or persistent cytomegalovirus infection or disease in allogeneic hematopoietic stem cell transplant recipients: a prospective multicenter study. *Blood* 116, 1655–1662. doi: 10. 1182/blood-2010-03-273508

[CrossRef Full Text](https://doi.org/10.1182/blood-2010-03-273508) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Immune+monitoring+with+iTAg+MHC+Tetramers+for+prediction+of+recurrent+or+persistent+cytomegalovirus+infection+or+disease+in+allogeneic+hematopoietic+stem+cell+transplant+recipients%3A+a+prospective+multicenter+study.&journal=Blood&author=Gratama+J.+W.&author=Boeckh+M.&author=Nakamura+R.&author=Cornelissen+J.+J.&author=Brooimans+R.++A.&author=Zaia+J.+A.&publication_year=2010&volume=116&pages=1655-1662)

Gratama, J. W., Brooimans, R. A., van der Holt, B., Sintnicolaas, K., van Doornum, G., Niesters, H. G., et al. (2008). Monitoring cytomegalovirus IE-1 and pp65-specific CD4+ and CD8+ T-cell responses after allogeneic stem cell transplantation may identify patients at risk for recurrent CMV reactivations. *Cytometry B Clin. Cytom.* 74B, 211–220. doi: 10. 1002/cyto. b. 20420

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=18454493) | [CrossRef Full Text](https://doi.org/10.1002/cyto.b.20420) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Monitoring+cytomegalovirus+IE-1+and+pp65-specific+CD4%2B+and+CD8%2B+T-cell+responses+after+allogeneic+stem+cell+transplantation+may+identify+patients+at+risk+for+recurrent+CMV+reactivations.&journal=Cytometry+B+Clin.++Cytom.&author=Gratama+J.+W.&author=Brooimans+R.+A.&author=van+der+Holt+B.&author=Sintnicolaas+K.&author=van+Doornum+G.&author=Niesters+H.+G.&publication_year=2008&pages=211-220)

Gratama, J. W., van Esser, J. W., Lamers, C. H., Tournay, C., Lowenberg, B., Bolhuis, R. L., et al. (2001). Tetramer-based quantification of cytomegalovirus (CMV)-specific CD8+ T lymphocytes in T-cell-depleted stem cell grafts and after transplantation may identify patients at risk for progressive CMV infection. *Blood* 98, 1358–1364. doi: 10. 1182/blood. v98. 5. 1358

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=11520783) | [CrossRef Full Text](https://doi.org/10.1182/blood.v98.5.1358) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Tetramer-based+quantification+of+cytomegalovirus+(CMV)-specific+CD8%2B+T+lymphocytes+in+T-cell-depleted+stem+cell+grafts+and+after+transplantation+may+identify+patients+at+risk+for+progressive+CMV+infection.&journal=Blood&author=Gratama+J.+W.&author=van+Esser+J.+W.&author=Lamers+C.+H.&author=Tournay+C.&author=Lowenberg+B.&author=Bolhuis+R.+L.&publication_year=2001&volume=98&pages=1358-1364)

Gratwohl, A., Brand, R., Frassoni, F., Rocha, V., Niederwieser, D., Reusser, P., et al. (2005). Cause of death after allogeneic haematopoietic stem cell transplantation (HSCT) in early leukaemias: an EBMT analysis of lethal infectious complications and changes over calendar time. *Bone Marrow Transplant.* 36, 757–769. doi: 10. 1038/sj. bmt. 1705140

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=16151426) | [CrossRef Full Text](https://doi.org/10.1038/sj.bmt.1705140) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cause+of+death+after+allogeneic+haematopoietic+stem+cell+transplantation+(HSCT)+in+early+leukaemias%3A+an+EBMT+analysis+of+lethal+infectious+complications+and+changes+over+calendar+time.&journal=Bone+Marrow+Transplant.&author=Gratwohl+A.&author=Brand+R.&author=Frassoni+F.&author=Rocha+V.&author=Niederwieser+D.&author=Reusser+P.&publication_year=2005&volume=36&pages=757-769)

Green, M. L., Leisenring, W., Stachel, D., Pergam, S. A., Sandmaier, B. M., Wald, A., et al. (2012). Efficacy of a viral load-based, risk-adapted, preemptive treatment strategy for prevention of cytomegalovirus disease after hematopoietic cell transplantation. *Biol. Blood Marrow Transplant.* 18, 1687–1699. doi: 10. 1016/j. bbmt. 2012. 05. 015

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=22683614) | [CrossRef Full Text](https://doi.org/10.1016/j.bbmt.2012.05.015) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Efficacy+of+a+viral+load-based%2C+risk-adapted%2C+preemptive+treatment+strategy+for+prevention+of+cytomegalovirus+disease+after+hematopoietic+cell+transplantation.&journal=Biol.+Blood+Marrow+Transplant.&author=Green+M.+L.&author=Leisenring+W.&author=Stachel+D.&author=Pergam+S.+A.&author=Sandmaier+B.++M.&author=Wald+A.&publication_year=2012&volume=18&pages=1687-1699)

Green, M. L., Leisenring, W., Xie, H., Mast, T. C., Cui, Y., Sandmaier, B. M., et al. (2016). Cytomegalovirus viral load and mortality after haemopoietic stem cell transplantation in the era of pre-emptive therapy: a retrospective cohort study. *Lancet Haematol.* 3, e119–e127. doi: 10. 1016/S2352-3026(15)00289-6

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=26947200) | [CrossRef Full Text](https://doi.org/10.1016/S2352-3026(15)00289-6) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+viral+load+and+mortality+after+haemopoietic+stem+cell+transplantation+in+the+era+of+pre-emptive+therapy%3A+a+retrospective+cohort+study.&journal=Lancet+Haematol.&author=Green+M.+L.&author=Leisenring+W.&author=Xie+H.&author=Mast+T.+C.&author=Cui+Y.&author=Sandmaier+B.+M.&publication_year=2016&volume=3&pages=e119-e127)

Green, M. L., Leisenring, W. M., Xie, H., Walter, R. B., Mielcarek, M., Sandmaier, B. M., et al. (2013). CMV reactivation after allogeneic HCT and relapse risk: evidence for early protection in acute myeloid leukemia. *Blood* 122, 1316–1324. doi: 10. 1182/blood-2013-02-487074

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=23744585) | [CrossRef Full Text](https://doi.org/10.1182/blood-2013-02-487074) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=CMV+reactivation+after+allogeneic+HCT+and+relapse+risk%3A+evidence+for+early+protection+in+acute+myeloid+leukemia.&journal=Blood&author=Green+M.+L.&author=Leisenring+W.+M.&author=Xie+H.&author=Walter+R.+B.&author=Mielcarek+M.&author=Sandmaier+B.+M.&publication_year=2013&volume=122&pages=1316-1324)

Hadrup, S. R., Strindhall, J., Kollgaard, T., Seremet, T., Johansson, B., Pawelec, G., et al. (2006). Longitudinal studies of clonally expanded CD8 T cells reveal a repertoire shrinkage predicting mortality and an increased number of dysfunctional cytomegalovirus-specific T cells in the very elderly. *J. Immunol.* 176, 2645–2653. doi: 10. 4049/jimmunol. 176. 4. 2645

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=16456027) | [CrossRef Full Text](https://doi.org/10.4049/jimmunol.176.4.2645) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Longitudinal+studies+of+clonally+expanded+CD8+T+cells+reveal+a+repertoire+shrinkage+predicting+mortality+and+an+increased+number+of+dysfunctional+cytomegalovirus-specific+T+cells+in+the+very+elderly.&journal=J.++Immunol.&author=Hadrup+S.+R.&author=Strindhall+J.&author=Kollgaard+T.&author=Seremet+T.&author=Johansson+B.&author=Pawelec+G.&publication_year=2006&volume=176&pages=2645-2653)

Hahn, G., Jores, R., and Mocarski, E. S. (1998). Cytomegalovirus remains latent in a common precursor of dendritic and myeloid cells. *Proc. Natl. Acad. Sci. U. S. A.* 95, 3937–3942. doi: 10. 1073/pnas. 95. 7. 3937

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=9520471) | [CrossRef Full Text](https://doi.org/10.1073/pnas.95.7.3937) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+remains+latent+in+a+common+precursor+of+dendritic+and+myeloid+cells.&journal=Proc.+Natl.+Acad.++Sci.+U.S.A.&author=Hahn+G.&author=Jores+R.&author=and+Mocarski+E.+S.&publication_year=1998&volume=95&pages=3937-3942)

Hakki, M., Riddell, S. R., Storek, J., Carter, R. A., Stevens-Ayers, T., Sudour, P., et al. (2003). Immune reconstitution to cytomegalovirus after allogeneic hematopoietic stem cell transplantation: impact of host factors, drug therapy, and subclinical reactivation. *Blood* 102, 3060–3067. doi: 10. 1182/blood-2002-11-3472

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=12843000) | [CrossRef Full Text](https://doi.org/10.1182/blood-2002-11-3472) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Immune+reconstitution+to+cytomegalovirus+after+allogeneic+hematopoietic+stem+cell+transplantation%3A+impact+of+host+factors%2C+drug+therapy%2C+and+subclinical+reactivation.&journal=Blood&author=Hakki+M.&author=Riddell+S.++R.&author=Storek+J.&author=Carter+R.++A.&author=Stevens-Ayers+T.&author=Sudour+P.&publication_year=2003&volume=102&pages=3060-3067)

Hall, C. E., Koparde, V. N., Jameson-Lee, M., Elnasseh, A. G., Scalora, A. F., Kobulnicky, D. J., et al. (2017). Sequence homology between HLA-bound cytomegalovirus and human peptides: a potential trigger for alloreactivity. *PLoS One* 12: e0178763. doi: 10. 1371/journal. pone. 0178763

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=28800601) | [CrossRef Full Text](https://doi.org/10.1371/journal.pone.0178763) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Sequence+homology+between+HLA-bound+cytomegalovirus+and+human+peptides%3A+a+potential+trigger+for+alloreactivity.&journal=PLoS+One&author=Hall+C.+E.&author=Koparde+V.+N.&author=Jameson-Lee+M.&author=Elnasseh+A.+G.&author=Scalora+A.++F.&author=Kobulnicky+D.+J.&publication_year=2017)

Hammer, Q., Ruckert, T., Borst, E. M., Dunst, J., Haubner, A., Durek, P., et al. (2018). Peptide-specific recognition of human cytomegalovirus strains controls adaptive natural killer cells. *Nat. Immunol.* 19, 453–463. doi: 10. 1038/s41590-018-0082-6

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=29632329) | [CrossRef Full Text](https://doi.org/10.1038/s41590-018-0082-6) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Peptide-specific+recognition+of+human+cytomegalovirus+strains+controls+adaptive+natural+killer+cells.&journal=Nat.+Immunol.&author=Hammer+Q.&author=Ruckert+T.&author=Borst+E.+M.&author=Dunst+J.&author=Haubner+A.&author=Durek+P.&publication_year=2018&volume=19&pages=453-463)

Hanna, Z., Karrick, M., Jayaprakash, R., Morgan, W., Lutfi, S., Gunasekaran, K., et al. (2017). Establishing the optimal viral load threshold for initiation of therapy for cytomegalovirus infection in hematopoietic stem cell transplant recipients: a prospective derivation cohort study using the international standardized CMV quantitative nucleic acid testing. *Open Forum Infect. Dis.* 4(Suppl. \_1), S713–S714.

[Google Scholar](http://scholar.google.com/scholar_lookup?&title=Establishing+the+optimal+viral+load+threshold+for+initiation+of+therapy+for+cytomegalovirus+infection+in+hematopoietic+stem+cell+transplant+recipients%3A+a+prospective+derivation+cohort+study+using+the+international+standardized+CMV+quantitative+nucleic+acid+testing.&journal=Open+Forum+Infect.+Dis.&author=Hanna+Z.&author=Karrick+M.&author=Jayaprakash+R.&author=Morgan+W.&author=Lutfi+S.&author=Gunasekaran+K.&publication_year=2017&pages=S713-S714)

Hargett, D., and Shenk, T. E. (2010). Experimental human cytomegalovirus latency in CD14+ monocytes. *Proc. Natl. Acad. Sci. U. S. A.* 107, 20039–20044. doi: 10. 1073/pnas. 1014509107

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=21041645) | [CrossRef Full Text](https://doi.org/10.1073/pnas.1014509107) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Experimental+human+cytomegalovirus+latency+in+CD14%2B+monocytes.&journal=Proc.+Natl.+Acad.+Sci.+U.S.A.&author=Hargett+D.&author=and+Shenk+T.+E.&publication_year=2010&volume=107&pages=20039-20044)

Hayden, R. T., Preiksaitis, J., Tong, Y., Pang, X., Sun, Y., Tang, L., et al. (2015). Commutability of the first world health organization international standard for human cytomegalovirus. *J. Clin. Microbiol.* 53, 3325–3333. doi: 10. 1128/JCM. 01495-15

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=26269622) | [CrossRef Full Text](https://doi.org/10.1128/JCM.01495-15) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Commutability+of+the+first+world+health+organization+international+standard+for+human+cytomegalovirus.&journal=J.+Clin.+Microbiol.&author=Hayden+R.+T.&author=Preiksaitis+J.&author=Tong+Y.&author=Pang+X.&author=Sun+Y.&author=Tang+L.&publication_year=2015&volume=53&pages=3325-3333)

Hendrix, R. M., Wagenaar, M., Slobbe, R. L., and Bruggeman, C. A. (1997). Widespread presence of cytomegalovirus DNA in tissues of healthy trauma victims. *J. Clin. Pathol.* 50, 59–63. doi: 10. 1136/jcp. 50. 1. 59

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=9059359) | [CrossRef Full Text](https://doi.org/10.1136/jcp.50.1.59) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Widespread+presence+of+cytomegalovirus+DNA+in+tissues+of+healthy+trauma+victims.&journal=J.+Clin.+Pathol.&author=Hendrix+R.+M.&author=Wagenaar+M.&author=Slobbe+R.+L.&author=and+Bruggeman+C.+A.&publication_year=1997&volume=50&pages=59-63)

Hill, J. A., Mayer, B. T., Xie, H., Leisenring, W. M., Huang, M. L., Stevens-Ayers, T., et al. (2017). The cumulative burden of double-stranded DNA virus detection after allogeneic HCT is associated with increased mortality. *Blood* 129, 2316–2325. doi: 10. 1182/blood-2016-10-748426

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=28209721) | [CrossRef Full Text](https://doi.org/10.1182/blood-2016-10-748426) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=The+cumulative+burden+of+double-stranded+DNA+virus+detection+after+allogeneic+HCT+is+associated+with+increased+mortality.&journal=Blood&author=Hill+J.++A.&author=Mayer+B.++T.&author=Xie+H.&author=Leisenring+W.++M.&author=Huang+M.++L.&author=Stevens-Ayers+T.&publication_year=2017&volume=129&pages=2316-2325)

Hiwarkar, P., Gaspar, H. B., Gilmour, K., Jagani, M., Chiesa, R., Bennett-Rees, N., et al. (2013). Impact of viral reactivations in the era of pre-emptive antiviral drug therapy following allogeneic haematopoietic SCT in paediatric recipients. *Bone Marrow Transplant.* 48, 803–808. doi: 10. 1038/bmt. 2012. 221

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=23178547) | [CrossRef Full Text](https://doi.org/10.1038/bmt.2012.221) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Impact+of+viral+reactivations+in+the+era+of+pre-emptive+antiviral+drug+therapy+following+allogeneic+haematopoietic+SCT+in+paediatric+recipients.&journal=Bone+Marrow+Transplant.&author=Hiwarkar+P.&author=Gaspar+H.++B.&author=Gilmour+K.&author=Jagani+M.&author=Chiesa+R.&author=Bennett-Rees+N.&publication_year=2013&volume=48&pages=803-808)

Huang, M. M., Kew, V. G., Jestice, K., Wills, M. R., and Reeves, M. B. (2012). Efficient human cytomegalovirus reactivation is maturation dependent in the Langerhans dendritic cell lineage and can be studied using a CD14+ experimental latency model. *J. Virol.* 86, 8507–8515. doi: 10. 1128/JVI. 00598-12

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=22647696) | [CrossRef Full Text](https://doi.org/10.1128/JVI.00598-12) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Efficient+human+cytomegalovirus+reactivation+is+maturation+dependent+in+the+Langerhans+dendritic+cell+lineage+and+can+be+studied+using+a+CD14%2B+experimental+latency+model.&journal=J.+Virol.&author=Huang+M.++M.&author=Kew+V.++G.&author=Jestice+K.&author=Wills+M.++R.&author=and+Reeves+M.++B.&publication_year=2012&volume=86&pages=8507-8515)

Ibanez, C. E., Schrier, R., Ghazal, P., Wiley, C., and Nelson, J. A. (1991). Human cytomegalovirus productively infects primary differentiated macrophages. *J. Virol.* 65, 6581–6588.

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=1658363) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Human+cytomegalovirus+productively+infects+primary+differentiated+macrophages.&journal=J.+Virol.&author=Ibanez+C.++E.&author=Schrier+R.&author=Ghazal+P.&author=Wiley+C.&author=and+Nelson+J.++A.&publication_year=1991&volume=65&pages=6581-6588)

Ito, S., Pophali, P., Co, W., Koklanaris, E. K., Superata, J., Fahle, G. A., et al. (2013). CMV reactivation is associated with a lower incidence of relapse after allo-SCT for CML. *Bone Marrow Transplant.* 48, 1313–1316. doi: 10. 1038/bmt. 2013. 49

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=23562969) | [CrossRef Full Text](https://doi.org/10.1038/bmt.2013.49) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=CMV+reactivation+is+associated+with+a+lower+incidence+of+relapse+after+allo-SCT+for+CML.&journal=Bone+Marrow+Transplant.&author=Ito+S.&author=Pophali+P.&author=Co+W.&author=Koklanaris+E.++K.&author=Superata+J.&author=Fahle+G.++A.&publication_year=2013&volume=48&pages=1313-1316)

Itzykson, R., Robin, M., Moins-Teisserenc, H., Delord, M., Busson, M., Xhaard, A., et al. (2015). Cytomegalovirus shapes long-term immune reconstitution after allogeneic stem cell transplantation. *Haematologica* 100, 114–123. doi: 10. 3324/haematol. 2014. 113415

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=25261095) | [CrossRef Full Text](https://doi.org/10.3324/haematol.2014.113415) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+shapes+long-term+immune+reconstitution+after+allogeneic+stem+cell+transplantation.&journal=Haematologica&author=Itzykson+R.&author=Robin+M.&author=Moins-Teisserenc+H.&author=Delord+M.&author=Busson+M.&author=Xhaard+A.&publication_year=2015&volume=100&pages=114-123)

Janeczko, M., Mielcarek, M., Rybka, B., Ryczan-Krawczyk, R., Noworolska-Sauren, D., and Kalwak, K. (2016). Immune recovery and the risk of CMV/ EBV reactivation in children post allogeneic haematopoietic stem cell transplantation. *Cent. Eur. J. Immunol.* 41, 287–296. doi: 10. 5114/ceji. 2016. 63129

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=27833447) | [CrossRef Full Text](https://doi.org/10.5114/ceji.2016.63129) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Immune+recovery+and+the+risk+of+CMV%2F+EBV+reactivation+in+children+post+allogeneic+haematopoietic+stem+cell+transplantation.&journal=Cent.++Eur.++J.++Immunol.&author=Janeczko+M.&author=Mielcarek+M.&author=Rybka+B.&author=Ryczan-Krawczyk+R.&author=Noworolska-Sauren+D.&author=and+Kalwak+K.&publication_year=2016&volume=41&pages=287-296)

Jang, J. E., Hyun, S. Y., Kim, Y. D., Yoon, S. H., Hwang, D. Y., Kim, S. J., et al. (2012). Risk factors for progression from cytomegalovirus viremia to cytomegalovirus disease after allogeneic hematopoietic stem cell transplantation. *Biol. Blood Marrow Transplant.* 18, 881–886. doi: 10. 1016/j. bbmt. 2011. 10. 037

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=22062802) | [CrossRef Full Text](https://doi.org/10.1016/j.bbmt.2011.10.037) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Risk+factors+for+progression+from+cytomegalovirus+viremia+to+cytomegalovirus+disease+after+allogeneic+hematopoietic+stem+cell+transplantation.&journal=Biol.++Blood+Marrow+Transplant.&author=Jang+J.++E.&author=Hyun+S.++Y.&author=Kim+Y.++D.&author=Yoon+S.++H.&author=Hwang+D.++Y.&author=Kim+S.+J.&publication_year=2012&volume=18&pages=881-886)

Jeljeli, M., Guerin-El Khourouj, V., Porcher, R., Fahd, M., Leveille, S., Yakouben, K., et al. (2014). Relationship between cytomegalovirus (CMV) reactivation, CMV-driven immunity, overall immune recovery and graft-versus-leukaemia effect in children. *Br. J. Haematol.* 166, 229–239. doi: 10. 1111/bjh. 12875

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=24702221) | [CrossRef Full Text](https://doi.org/10.1111/bjh.12875) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Relationship+between+cytomegalovirus+(CMV)+reactivation%2C+CMV-driven+immunity%2C+overall+immune+recovery+and+graft-versus-leukaemia+effect+in+children.&journal=Br.+J.+Haematol.&author=Jeljeli+M.&author=Guerin-El+Khourouj+V.&author=Porcher+R.&author=Fahd+M.&author=Leveille+S.&author=Yakouben+K.&publication_year=2014&volume=166&pages=229-239)

Jenkins, C., Abendroth, A., and Slobedman, B. (2004). A novel viral transcript with homology to human interleukin-10 is expressed during latent human cytomegalovirus infection. *J. Virol.* 78, 1440–1447. doi: 10. 1128/jvi. 78. 3. 1440-1447. 2004

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=14722299) | [CrossRef Full Text](https://doi.org/10.1128/jvi.78.3.1440-1447.2004) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=A+novel+viral+transcript+with+homology+to+human+interleukin-10+is+expressed+during++latent+human+cytomegalovirus+infection.&journal=J.++Virol.&author=Jenkins+C.&author=Abendroth+A.&author=and+Slobedman+B.&publication_year=2004&volume=78&pages=1440-1447)

Kawasaki, S., Oshitani, H., Suzuki, H., Arakawa, M., Mizuta, K., Imaizumi, M., et al. (1999). PCR-RFLP analysis of cytomegalovirus infections associated with bone marrow transplantation in Japanese children. *Microbiol. Immunol.* 43, 359–364. doi: 10. 1111/j. 1348-0421. 1999. tb02416. x

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=10385202) | [CrossRef Full Text](https://doi.org/10.1111/j.1348-0421.1999.tb02416.x) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=PCR-RFLP+analysis+of+cytomegalovirus+infections+associated+with+bone+marrow+transplantation+in+Japanese+children.&journal=Microbiol.+Immunol.&author=Kawasaki+S.&author=Oshitani+H.&author=Suzuki+H.&author=Arakawa+M.&author=Mizuta+K.&author=Imaizumi+M.&publication_year=1999&volume=43&pages=359-364)

Khaiboullina, S. F., Maciejewski, J. P., Crapnell, K., Spallone, P. A., Dean Stock, A., Pari, G. S., et al. (2004). Human cytomegalovirus persists in myeloid progenitors and is passed to the myeloid progeny in a latent form. *Br. J. Haematol.* 126, 410–417. doi: 10. 1111/j. 1365-2141. 2004. 05056. x

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=15257715) | [CrossRef Full Text](https://doi.org/10.1111/j.1365-2141.2004.05056.x) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Human+cytomegalovirus+persists+in+myeloid+progenitors+and+is+passed+to+the+myeloid+progeny+in+a+latent+form.&journal=Br.+J.++Haematol.&author=Khaiboullina+S.+F.&author=Maciejewski+J.+P.&author=Crapnell+K.&author=Spallone+P.+A.&author=Dean+Stock+A.&author=Pari+G.+S.&publication_year=2004&volume=126&pages=410-417)

Khan, N., Shariff, N., Cobbold, M., Bruton, R., Ainsworth, J. A., Sinclair, A. J., et al. (2002). Cytomegalovirus seropositivity drives the CD8 T cell repertoire toward greater clonality in healthy elderly individuals. *J. Immunol.* 169, 1984–1992. doi: 10. 4049/jimmunol. 169. 4. 1984

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=12165524) | [CrossRef Full Text](https://doi.org/10.4049/jimmunol.169.4.1984) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+seropositivity+drives+the+CD8+T+cell+repertoire+toward+greater+clonality+in+healthy+elderly+individuals.&journal=J.+Immunol.&author=Khan+N.&author=Shariff+N.&author=Cobbold+M.&author=Bruton+R.&author=Ainsworth+J.+A.&author=Sinclair+A.++J.&publication_year=2002&volume=169&pages=1984-1992)

Kharfan-Dabaja, M. A., Boeckh, M., Wilck, M. B., Langston, A. A., Chu, A. H., Wloch, M. K., et al. (2012). A novel therapeutic cytomegalovirus DNA vaccine in allogeneic haemopoietic stem-cell transplantation: a randomised, double-blind, placebo-controlled, phase 2 trial. *Lancet Infect. Dis.* 12, 290–299. doi: 10. 1016/S1473-3099(11)70344-9

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=22237175) | [CrossRef Full Text](https://doi.org/10.1016/S1473-3099(11)70344-9) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=A+novel+therapeutic+cytomegalovirus+DNA+vaccine+in+allogeneic+haemopoietic+stem-cell+transplantation%3A+a+randomised%2C+double-blind%2C+placebo-controlled%2C+phase+2+trial.&journal=Lancet+Infect.+Dis.&author=Kharfan-Dabaja+M.+A.&author=Boeckh+M.&author=Wilck+M.+B.&author=Langston+A.+A.&author=Chu+A.+H.&author=Wloch+M.+K.&publication_year=2012&volume=12&pages=290-299)

Kheav, V. D., Busson, M., Scieux, C., Peffault de Latour, R., Maki, G., Haas, P., et al. (2014). Favorable impact of natural killer cell reconstitution on chronic graft-versus-host disease and cytomegalovirus reactivation after allogeneic hematopoietic stem cell transplantation. *Haematologica* 99, 1860–1867. doi: 10. 3324/haematol. 2014. 108407

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=25085354) | [CrossRef Full Text](https://doi.org/10.3324/haematol.2014.108407) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Favorable+impact+of+natural+killer+cell+reconstitution+on+chronic+graft-versus-host+disease+and+cytomegalovirus+reactivation+after+allogeneic+hematopoietic+stem+cell+transplantation.&journal=Haematologica&author=Kheav+V.+D.&author=Busson+M.&author=Scieux+C.&author=Peffault+de+Latour+R.&author=Maki+G.&author=Haas+P.&publication_year=2014&volume=99&pages=1860-1867)

Kim, D. H., Kim, J. G., Lee, N. Y., Sung, W. J., Sohn, S. K., Suh, J. S., et al. (2004). Risk factors for late cytomegalovirus infection after allogeneic stem cell transplantation using HLA-matched sibling donor: donor lymphocyte infusion and previous history of early CMV infection. *Bone Marrow Transplant.* 34, 21–27. doi: 10. 1038/sj. bmt. 1704528

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=15133483) | [CrossRef Full Text](https://doi.org/10.1038/sj.bmt.1704528) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Risk+factors+for+late+cytomegalovirus+infection+after+allogeneic+stem+cell+transplantation+using+HLA-matched+sibling+donor%3A+donor+lymphocyte+infusion+and+previous+history+of+early+CMV+infection.&journal=Bone+Marrow+Transplant.&author=Kim+D.+H.&author=Kim+J.+G.&author=Lee+N.+Y.&author=Sung+W.+J.&author=Sohn+S.+K.&author=Suh+J.+S.&publication_year=2004&volume=34&pages=21-27)

Knight, A., Madrigal, A. J., Grace, S., Sivakumaran, J., Kottaridis, P., Mackinnon, S., et al. (2010). The role of Vdelta2-negative gamma delta T cells during cytomegalovirus reactivation in recipients of allogeneic stem cell transplantation. *Blood* 116, 2164–2172. doi: 10. 1182/blood-2010-01-255166

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=20576814) | [CrossRef Full Text](https://doi.org/10.1182/blood-2010-01-255166) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=The+role+of+Vdelta2-negative+gamma+delta+T+cells+during+cytomegalovirus+reactivation+in+recipients+of+allogeneic+stem+cell+transplantation.&journal=Blood&author=Knight+A.&author=Madrigal+A.++J.&author=Grace+S.&author=Sivakumaran+J.&author=Kottaridis+P.&author=Mackinnon+S.&publication_year=2010&volume=116&pages=2164-2172)

Knoll, B. M., Seiter, K., Phillips, A., and Soave, R. (2018). Breakthrough cytomegalovirus pneumonia in hematopoietic stem cell transplant recipient on letermovir prophylaxis. *Bone Marrow Transplant.* .

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=30401966) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Breakthrough+cytomegalovirus+pneumonia+in+hematopoietic+stem+cell+transplant+recipient+on+letermovir+prophylaxis.&journal=Bone+Marrow+Transplant.&author=Knoll+B.+M.&author=Seiter+K.&author=Phillips+A.&author=and+Soave+R.&publication_year=2018)

Krishna, B. A., Lau, B., Jackson, S. E., Wills, M. R., Sinclair, J. H., and Poole, E. (2016). Transient activation of human cytomegalovirus lytic gene expression during latency allows cytotoxic T cell killing of latently infected cells. *Sci. Rep.* 6: 24674. doi: 10. 1038/srep24674

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=27091512) | [CrossRef Full Text](https://doi.org/10.1038/srep24674) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Transient+activation+of+human+cytomegalovirus+lytic+gene+expression+during+latency+allows+cytotoxic+T+cell+killing+of+latently+infected+cells.&journal=Sci.+Rep.&author=Krishna+B.+A.&author=Lau+B.&author=Jackson+S.+E.&author=Wills+M.+R.&author=Sinclair+J.+H.&author=and+Poole+E.&publication_year=2016)

Krishna, B. A., Spiess, K., Poole, E. L., Lau, B., Voigt, S., Kledal, T. N., et al. (2017). Targeting the latent cytomegalovirus reservoir with an antiviral fusion toxin protein. *Nat. Commun.* 8: 14321. doi: 10. 1038/ncomms14321

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=28148951) | [CrossRef Full Text](https://doi.org/10.1038/ncomms14321) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Targeting+the+latent+cytomegalovirus+reservoir+with+an+antiviral+fusion+toxin+protein.&journal=Nat.+Commun.&author=Krishna+B.+A.&author=Spiess+K.&author=Poole+E.+L.&author=Lau+B.&author=Voigt+S.&author=Kledal+T.+N.&publication_year=2017)

Krol, L., Stuchly, J., Hubacek, P., Keslova, P., Sedlacek, P., Stary, J., et al. (2011). Signature profiles of CMV-specific T-cells in patients with CMV reactivation after hematopoietic SCT. *Bone Marrow Transplant.* 46, 1089–1098. doi: 10. 1038/bmt. 2010. 261

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=21057553) | [CrossRef Full Text](https://doi.org/10.1038/bmt.2010.261) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Signature+profiles+of+CMV-specific+T-cells+in+patients+with+CMV+reactivation+after+hematopoietic+SCT.&journal=Bone+Marrow+Transplant.&author=Krol+L.&author=Stuchly+J.&author=Hubacek+P.&author=Keslova+P.&author=Sedlacek+P.&author=Stary+J.&publication_year=2011&volume=46&pages=1089-1098)

Kumar, D., Mian, M., Singer, L., and Humar, A. (2017). An interventional study using cell-mediated immunity to personalize therapy for cytomegalovirus infection after transplantation. *Am. J. Transplant.* 17, 2468–2473. doi: 10. 1111/ajt. 14347

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=28500691) | [CrossRef Full Text](https://doi.org/10.1111/ajt.14347) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=An+interventional+study+using+cell-mediated+immunity+to+personalize+therapy+for+cytomegalovirus+infection+after+transplantation.&journal=Am.++J.++Transplant.&author=Kumar+D.&author=Mian+M.&author=Singer+L.&author=and+Humar+A.&publication_year=2017&volume=17&pages=2468-2473)

Lakshmikanth, T., Olin, A., Chen, Y., Mikes, J., Fredlund, E., Remberger, M., et al. (2017). Mass cytometry and topological data analysis reveal immune parameters associated with complications after allogeneic stem cell transplantation. *Cell Rep.* 20, 2238–2250. doi: 10. 1016/j. celrep. 2017. 08. 021

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=28854371) | [CrossRef Full Text](https://doi.org/10.1016/j.celrep.2017.08.021) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Mass+cytometry+and+topological+data+analysis+reveal+immune+parameters+associated+with+complications+after+allogeneic+stem+cell+transplantation.&journal=Cell+Rep.&author=Lakshmikanth+T.&author=Olin+A.&author=Chen+Y.&author=Mikes+J.&author=Fredlund+E.&author=Remberger+M.&publication_year=2017&volume=20&pages=2238-2250)

Larsson, K., Aschan, J., Remberger, M., Ringden, O., Winiarski, J., and Ljungman, P. (2004). Reduced risk for extensive chronic graft-versus-host disease in patients receiving transplants with human leukocyte antigen-identical sibling donors given polymerase chain reaction-based preemptive therapy against cytomegalovirus. *Transplantation* 77, 526–531. doi: 10. 1097/01. tp. 0000109778. 39235. f4

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=15084929) | [CrossRef Full Text](https://doi.org/10.1097/01.tp.0000109778.39235.f4) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Reduced+risk+for+extensive+chronic+graft-versus-host+disease+in+patients+receiving+transplants+with+human+leukocyte+antigen-identical+sibling+donors+given+polymerase+chain+reaction-based+preemptive+therapy+against+cytomegalovirus.&journal=Transplantation&author=Larsson+K.&author=Aschan+J.&author=Remberger+M.&author=Ringden+O.&author=Winiarski+J.&author=and+Ljungman+P.&publication_year=2004&volume=77&pages=526-531)

Li, C. R., Greenberg, P. D., Gilbert, M. J., Goodrich, J. M., and Riddell, S. R. (1994). Recovery of HLA-restricted cytomegalovirus (CMV)-specific T-cell responses after allogeneic bone marrow transplant: correlation with CMV disease and effect of ganciclovir prophylaxis. *Blood* 83, 1971–1979.

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=8142663) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Recovery+of+HLA-restricted+cytomegalovirus+(CMV)-specific+T-cell+responses+after+allogeneic+bone+marrow+transplant%3A+correlation+with+CMV+disease+and+effect+of+ganciclovir+prophylaxis.&journal=Blood&author=Li+C.+R.&author=Greenberg+P.+D.&author=Gilbert+M.+J.&author=Goodrich+J.+M.&author=and+Riddell+S.++R.&publication_year=1994&volume=83&pages=1971-1979)

Lilleri, D., Fornara, C., Chiesa, A., Caldera, D., Alessandrino, E. P., and Gerna, G. (2008). Human cytomegalovirus-specific CD4+ and CD8+ T-cell reconstitution in adult allogeneic hematopoietic stem cell transplant recipients and immune control of viral infection. *Haematologica* 93, 248–256. doi: 10. 3324/haematol. 11912

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=18245650) | [CrossRef Full Text](https://doi.org/10.3324/haematol.11912) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Human+cytomegalovirus-specific+CD4%2B+and+CD8%2B+T-cell+reconstitution+in+adult+allogeneic+hematopoietic+stem+cell+transplant+recipients+and+immune+control+of+viral+infection.&journal=Haematologica&author=Lilleri+D.&author=Fornara+C.&author=Chiesa+A.&author=Caldera+D.&author=Alessandrino+E.++P.&author=and+Gerna+G.&publication_year=2008&volume=93&pages=248-256)

Lilleri, D., Gerna, G., Fornara, C., Chiesa, A., Comolli, G., Zecca, M., et al. (2009). Human cytomegalovirus-specific T cell reconstitution in young patients receiving T cell-depleted, allogeneic hematopoietic stem cell transplantation. *J. Infect. Dis.* 199, 829–836. doi: 10. 1086/597123

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=19239337) | [CrossRef Full Text](https://doi.org/10.1086/597123) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Human+cytomegalovirus-specific+T+cell+reconstitution+in+young+patients+receiving+T+cell-depleted%2C+allogeneic+hematopoietic+stem+cell+transplantation.&journal=J.+Infect.+Dis.&author=Lilleri+D.&author=Gerna+G.&author=Fornara+C.&author=Chiesa+A.&author=Comolli+G.&author=Zecca+M.&publication_year=2009&volume=199&pages=829-836)

Lilleri, D., Gerna, G., Fornara, C., Lozza, L., Maccario, R., and Locatelli, F. (2006). Prospective simultaneous quantification of human cytomegalovirus-specific CD4+ and CD8+ T-cell reconstitution in young recipients of allogeneic hematopoietic stem cell transplants. *Blood* 108, 1406–1412. doi: 10. 1182/blood-2005-11-012864

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=16614242) | [CrossRef Full Text](https://doi.org/10.1182/blood-2005-11-012864) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Prospective+simultaneous+quantification+of+human+cytomegalovirus-specific+CD4%2B+and+CD8%2B+T-cell+reconstitution+in+young+recipients+of+allogeneic+hematopoietic+stem+cell+transplants.&journal=Blood&author=Lilleri+D.&author=Gerna+G.&author=Fornara+C.&author=Lozza+L.&author=Maccario+R.&author=and+Locatelli+F.&publication_year=2006&volume=108&pages=1406-1412)

Lilleri, D., Gerna, G., Zelini, P., Chiesa, A., Rognoni, V., Mastronuzzi, A., et al. (2012). Monitoring of human cytomegalovirus and virus-specific T-cell response in young patients receiving allogeneic hematopoietic stem cell transplantation. *PLoS One* 7: e41648. doi: 10. 1371/journal. pone. 0041648

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=22848556) | [CrossRef Full Text](https://doi.org/10.1371/journal.pone.0041648) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Monitoring+of+human+cytomegalovirus+and+virus-specific+T-cell+response+in+young+patients+receiving+allogeneic+hematopoietic+stem+cell+transplantation.&journal=PLoS+One&author=Lilleri+D.&author=Gerna+G.&author=Zelini+P.&author=Chiesa+A.&author=Rognoni+V.&author=Mastronuzzi+A.&publication_year=2012)

Lindau, P., Mukherjee, R., Gutschow, M. V., Vignali, M., Warren, E. H., Riddell, S. R., et al. (2019). Cytomegalovirus exposure in the elderly does not reduce CD8 T cell repertoire diversity. *J. Immunol.* 202, 476–483. doi: 10. 4049/jimmunol. 1800217

[CrossRef Full Text](https://doi.org/10.4049/jimmunol.1800217) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+exposure+in+the+elderly+does+not+reduce+CD8+T+cell+repertoire+diversity.&journal=J.+Immunol.&author=Lindau+P.&author=Mukherjee+R.&author=Gutschow+M.+V.&author=Vignali+M.&author=Warren+E.+H.&author=Riddell+S.+R.&publication_year=2019&volume=202&pages=476-483)

Link, C. S., Eugster, A., Heidenreich, F., Rucker-Braun, E., Schmiedgen, M., Oelschlagel, U., et al. (2016). Abundant cytomegalovirus (CMV) reactive clonotypes in the CD8(+) T cell receptor alpha repertoire following allogeneic transplantation. *Clin. Exp. Immunol.* 184, 389–402. doi: 10. 1111/cei. 12770

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=26800118) | [CrossRef Full Text](https://doi.org/10.1111/cei.12770) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Abundant+cytomegalovirus+(CMV)+reactive+clonotypes+in+the+CD8(%2B)+T+cell+receptor+alpha+repertoire+following+allogeneic+transplantation.&journal=Clin.+Exp.+Immunol.&author=Link+C.+S.&author=Eugster+A.&author=Heidenreich+F.&author=Rucker-Braun+E.&author=Schmiedgen+M.&author=Oelschlagel+U.&publication_year=2016&volume=184&pages=389-402)

Lischka, P., Michel, D., and Zimmermann, H. (2016). Characterization of cytomegalovirus breakthrough events in a phase 2 prophylaxis trial of letermovir (AIC246, MK 8228). *J. Infect. Dis.* 213, 23–30. doi: 10. 1093/infdis/jiv352

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=26113373) | [CrossRef Full Text](https://doi.org/10.1093/infdis/jiv352) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Characterization+of+cytomegalovirus+breakthrough+events+in+a+phase+2+prophylaxis+trial+of+letermovir+(AIC246%2C+MK+8228).&journal=J.++Infect.++Dis.&author=Lischka+P.&author=Michel+D.&author=and+Zimmermann+H.&publication_year=2016&volume=213&pages=23-30)

Liu, J., Chang, Y. J., Yan, C. H., Xu, L. P., Jiang, Z. F., Zhang, X. H., et al. (2016). Poor CMV-specific CD8+ T central memory subset recovery at early stage post-HSCT associates with refractory and recurrent CMV reactivation. *J. Infect.* 73, 261–270. doi: 10. 1016/j. jinf. 2016. 04. 033

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=27311748) | [CrossRef Full Text](https://doi.org/10.1016/j.jinf.2016.04.033) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Poor+CMV-specific+CD8%2B+T+central+memory+subset+recovery+at+early+stage+post-HSCT+associates+with+refractory+and+recurrent+CMV+reactivation.&journal=J.+Infect.&author=Liu+J.&author=Chang+Y.+J.&author=Yan+C.+H.&author=Xu+L.+P.&author=Jiang+Z.+F.&author=Zhang+X.+H.&publication_year=2016&volume=73&pages=261-270)

Liu, J., Kong, J., Chang, Y. J., Chen, H., Chen, Y. H., Han, W., et al. (2015). Patients with refractory cytomegalovirus (CMV) infection following allogeneic haematopoietic stem cell transplantation are at high risk for CMV disease and non-relapse mortality. *Clin. Microbiol. Infect.* 21, 1121. e9–1121. e15. doi: 10. 1016/j. cmi. 2015. 06. 009

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=26093077) | [CrossRef Full Text](https://doi.org/10.1016/j.cmi.2015.06.009) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Patients+with+refractory+cytomegalovirus+(CMV)+infection+following+allogeneic+haematopoietic+stem+cell+transplantation+are+at+high+risk+for+CMV+disease+and+non-relapse+mortality.&journal=Clin.+Microbiol.+Infect.&author=Liu+J.&author=Kong+J.&author=Chang+Y.+J.&author=Chen+H.&author=Chen+Y.+H.&author=Han+W.&publication_year=2015&volume=21&issue=1121&pages=e9-1121)

Ljungman, P., Aschan, J., Lewensohn-Fuchs, I., Carlens, S., Larsson, K., Lonnqvist, B., et al. (1998). Results of different strategies for reducing: cytomegalovirus-associated mortality in allogeneic stem cell transplant recipients. *Transplantation* 66, 1330–1334. doi: 10. 1097/00007890-199811270-00012

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=9846518) | [CrossRef Full Text](https://doi.org/10.1097/00007890-199811270-00012) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Results+of+different+strategies+for+reducing%3A+cytomegalovirus-associated+mortality+in+allogeneic+stem+cell+transplant+recipients.&journal=Transplantation&author=Ljungman+P.&author=Aschan+J.&author=Lewensohn-Fuchs+I.&author=Carlens+S.&author=Larsson+K.&author=Lonnqvist+B.&publication_year=1998&volume=66&pages=1330-1334)

Ljungman, P., Brand, R., Einsele, H., Frassoni, F., Niederwieser, D., and Cordonnier, C. (2003). Donor CMV serologic status and outcome of CMV-seropositive recipients after unrelated donor stem cell transplantation: an EBMT megafile analysis. *Blood* 102, 4255–4260. doi: 10. 1182/blood-2002-10-3263

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=12933590) | [CrossRef Full Text](https://doi.org/10.1182/blood-2002-10-3263) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Donor+CMV+serologic+status+and+outcome+of+CMV-seropositive+recipients+after+unrelated+donor+stem+cell+transplantation%3A+an+EBMT+megafile+analysis.&journal=Blood&author=Ljungman+P.&author=Brand+R.&author=Einsele+H.&author=Frassoni+F.&author=Niederwieser+D.&author=and+Cordonnier+C.&publication_year=2003&volume=102&pages=4255-4260)

Ljungman, P., Brand, R., Hoek, J., de la Camara, R., Cordonnier, C., Einsele, H., et al. (2014). Donor cytomegalovirus status influences the outcome of allogeneic stem cell transplant: a study by the European group for blood and marrow transplantation. *Clin. Infect. Dis.* 59, 473–481. doi: 10. 1093/cid/ciu364

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=24850801) | [CrossRef Full Text](https://doi.org/10.1093/cid/ciu364) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Donor+cytomegalovirus+status+influences+the+outcome+of+allogeneic+stem+cell+transplant%3A+a+study+by+the+European+group+for+blood+and+marrow+transplantation.&journal=Clin.+Infect.+Dis.&author=Ljungman+P.&author=Brand+R.&author=Hoek+J.&author=de+la+Camara+R.&author=Cordonnier+C.&author=Einsele+H.&publication_year=2014&volume=59&pages=473-481)

Ljungman, P., de la Camara, R., Cordonnier, C., Einsele, H., Engelhard, D., Reusser, P., et al. (2008). Management of CMV, HHV-6, HHV-7 and Kaposi-sarcoma herpesvirus (HHV-8) infections in patients with hematological malignancies and after SCT. *Bone Marrow Transplant.* 42, 227–240. doi: 10. 1038/bmt. 2008. 162

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=18587440) | [CrossRef Full Text](https://doi.org/10.1038/bmt.2008.162) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Management+of+CMV%2C+HHV-6%2C+HHV-7+and+Kaposi-sarcoma+herpesvirus+(HHV-8)+infections+in+patients+with+hematological+malignancies+and+after+SCT.&journal=Bone+Marrow+Transplant.&author=Ljungman+P.&author=de+la+Camara+R.&author=Cordonnier+C.&author=Einsele+H.&author=Engelhard+D.&author=Reusser+P.&publication_year=2008&volume=42&pages=227-240)

Ljungman, P., Deliliers, G. L., Platzbecker, U., Matthes-Martin, S., Bacigalupo, A., Einsele, H., et al. (2001). Cidofovir for cytomegalovirus infection and disease in allogeneic stem cell transplant recipients. The infectious diseases working party of the European group for blood and marrow transplantation. *Blood* 97, 388–392. doi: 10. 1182/blood. v97. 2. 388

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=11154213) | [CrossRef Full Text](https://doi.org/10.1182/blood.v97.2.388) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cidofovir+for+cytomegalovirus+infection+and+disease+in+allogeneic+stem+cell+transplant+recipients.++The+infectious+diseases+working+party+of+the+European+group+for+blood+and+marrow+transplantation.&journal=Blood&author=Ljungman+P.&author=Deliliers+G.++L.&author=Platzbecker+U.&author=Matthes-Martin+S.&author=Bacigalupo+A.&author=Einsele+H.&publication_year=2001&volume=97&pages=388-392)

Ljungman, P., Perez-Bercoff, L., Jonsson, J., Avetisyan, G., Sparrelid, E., Aschan, J., et al. (2006). Risk factors for the development of cytomegalovirus disease after allogeneic stem cell transplantation. *Haematologica* 91, 78–83.

[Google Scholar](http://scholar.google.com/scholar_lookup?&title=Risk+factors+for+the+development+of+cytomegalovirus+disease+after+allogeneic+stem+cell+transplantation.&journal=Haematologica&author=Ljungman+P.&author=Perez-Bercoff+L.&author=Jonsson+J.&author=Avetisyan+G.&author=Sparrelid+E.&author=Aschan+J.&publication_year=2006&volume=91&pages=78-83)

Lonnqvist, B., Ringden, O., Ljungman, P., Wahren, B., and Gahrton, G. (1986). Reduced risk of recurrent leukaemia in bone marrow transplant recipients after cytomegalovirus infection. *Br. J. Haematol.* 63, 671–679. doi: 10. 1111/j. 1365-2141. 1986. tb07551. x

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=3015193) | [CrossRef Full Text](https://doi.org/10.1111/j.1365-2141.1986.tb07551.x) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Reduced+risk+of+recurrent+leukaemia+in+bone+marrow+transplant+recipients+after+cytomegalovirus+infection.&journal=Br.+J.+Haematol.&author=Lonnqvist+B.&author=Ringden+O.&author=Ljungman+P.&author=Wahren+B.&author=and+Gahrton+G.&publication_year=1986&volume=63&pages=671-679)

Lonnqvist, B., Ringden, O., Wahren, B., Gahrton, G., and Lundgren, G. (1984). Cytomegalovirus infection associated with and preceding chronic graft-versus-host disease. *Transplantation* 38, 465–468. doi: 10. 1097/00007890-198411000-00004

[CrossRef Full Text](https://doi.org/10.1097/00007890-198411000-00004) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+infection+associated+with+and+preceding+chronic+graft-versus-host+disease.&journal=Transplantation&author=Lonnqvist+B.&author=Ringden+O.&author=Wahren+B.&author=Gahrton+G.&author=and+Lundgren+G.&publication_year=1984&volume=38&pages=465-468)

Lugthart, G., van Ostaijen-Ten Dam, M. M., Jol-van der Zijde, C. M., van Holten, T. C., Kester, M. G., Heemskerk, M. H., et al. (2014). Early cytomegalovirus reactivation leaves a specific and dynamic imprint on the reconstituting T cell compartment long-term after hematopoietic stem cell transplantation. *Biol. Blood Marrow Transplant.* 20, 655–661. doi: 10. 1016/j. bbmt. 2014. 01. 018

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=24462981) | [CrossRef Full Text](https://doi.org/10.1016/j.bbmt.2014.01.018) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Early+cytomegalovirus+reactivation+leaves+a+specific+and+dynamic+imprint+on+the+reconstituting+T+cell+compartment+long-term+after+hematopoietic+stem+cell+transplantation.&journal=Biol.+Blood+Marrow+Transplant.&author=Lugthart+G.&author=van+Ostaijen-Ten+Dam+M.++M.&author=Jol-van+der+Zijde+C.++M.&author=van+Holten+T.++C.&author=Kester+M.++G.&author=Heemskerk+M.++H.&publication_year=2014&volume=20&pages=655-661)

Ma, C. K. K., Clancy, L., Simms, R., Burgess, J., Deo, S., Blyth, E., et al. (2018). Adjuvant peptide pulsed dendritic cell vaccination in addition to T cell adoptive immunotherapy for cytomegalovirus infection in allogeneic hematopoietic stem cell transplantation recipients. *Biol. Blood Marrow Transplant.* 24, 71–77. doi: 10. 1016/j. bbmt. 2017. 08. 028

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=28864137) | [CrossRef Full Text](https://doi.org/10.1016/j.bbmt.2017.08.028) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Adjuvant+peptide+pulsed+dendritic+cell+vaccination+in+addition+to+T+cell+adoptive+immunotherapy+for+cytomegalovirus+infection+in+allogeneic+hematopoietic+stem+cell+transplantation+recipients.&journal=Biol.+Blood+Marrow+Transplant.&author=Ma+C.++K.++K.&author=Clancy+L.&author=Simms+R.&author=Burgess+J.&author=Deo+S.&author=Blyth+E.&publication_year=2018&volume=24&pages=71-77)

Mackinnon, S., Thomson, K., Verfuerth, S., Peggs, K., and Lowdell, M. (2008). Adoptive cellular therapy for cytomegalovirus infection following allogeneic stem cell transplantation using virus-specific T cells. *Blood Cells Mol. Dis.* 40, 63–67. doi: 10. 1016/j. bcmd. 2007. 07. 003

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=17869548) | [CrossRef Full Text](https://doi.org/10.1016/j.bcmd.2007.07.003) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Adoptive+cellular+therapy+for+cytomegalovirus+infection+following+allogeneic+stem+cell+transplantation+using+virus-specific+T+cells.&journal=Blood+Cells+Mol.+Dis.&author=Mackinnon+S.&author=Thomson+K.&author=Verfuerth+S.&author=Peggs+K.&author=and+Lowdell+M.&publication_year=2008&volume=40&pages=63-67)

Marfori, J. E., Exner, M. M., Marousek, G. I., Chou, S., and Drew, W. L. (2007). Development of new cytomegalovirus UL97 and DNA polymerase mutations conferring drug resistance after valganciclovir therapy in allogeneic stem cell recipients. *J. Clin. Virol.* 38, 120–125. doi: 10. 1016/j. jcv. 2006. 11. 005

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=17157554) | [CrossRef Full Text](https://doi.org/10.1016/j.jcv.2006.11.005) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Development+of+new+cytomegalovirus+UL97+and+DNA+polymerase+mutations+conferring+drug+resistance+after+valganciclovir+therapy+in+allogeneic+stem+cell+recipients.&journal=J.+Clin.+Virol.&author=Marfori+J.+E.&author=Exner+M.+M.&author=Marousek+G.+I.&author=Chou+S.&author=and+Drew+W.++L.&publication_year=2007&volume=38&pages=120-125)

Mariotti, J., Maura, F., Spina, F., Roncari, L., Dodero, A., Farina, L., et al. (2014). Impact of cytomegalovirus replication and cytomegalovirus serostatus on the outcome of patients with B cell lymphoma after allogeneic stem cell transplantation. *Biol. Blood Marrow Transplantat.* 20, 885–890. doi: 10. 1016/j. bbmt. 2014. 02. 015

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=24583412) | [CrossRef Full Text](https://doi.org/10.1016/j.bbmt.2014.02.015) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Impact+of+cytomegalovirus+replication+and+cytomegalovirus+serostatus+on+the+outcome+of+patients+with+B+cell+lymphoma+after+allogeneic+stem+cell+transplantation.&journal=Biol.+Blood+Marrow+Transplantat.&author=Mariotti+J.&author=Maura+F.&author=Spina+F.&author=Roncari+L.&author=Dodero+A.&author=Farina+L.&publication_year=2014&volume=20&pages=885-890)

Martins, J. P., Andoniou, C. E., Fleming, P., Kuns, R. D., Schuster, I. S., Voigt, V., et al. (2019). Strain-specific antibody therapy prevents cytomegalovirus reactivation after transplantation. *Science* 363, 288–293. doi: 10. 1126/science. aat0066

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=30655443) | [CrossRef Full Text](https://doi.org/10.1126/science.aat0066) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Strain-specific+antibody+therapy+prevents+cytomegalovirus+reactivation+after+transplantation.&journal=Science&author=Martins+J.++P.&author=Andoniou+C.++E.&author=Fleming+P.&author=Kuns+R.++D.&author=Schuster+I.++S.&author=Voigt+V.&publication_year=2019&volume=363&pages=288-293)

Marty, F. M., Ljungman, P., Chemaly, R. F., Maertens, J., Dadwal, S. S., Duarte, R. F., et al. (2017). Letermovir prophylaxis for cytomegalovirus in hematopoietic-cell transplantation. *N. Engl. J. Med.* 377, 2433–2444. doi: 10. 1056/NEJMoa1706640

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=29211658) | [CrossRef Full Text](https://doi.org/10.1056/NEJMoa1706640) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Letermovir+prophylaxis+for+cytomegalovirus+in+hematopoietic-cell+transplantation.&journal=N.+Engl.+J.+Med.&author=Marty+F.++M.&author=Ljungman+P.&author=Chemaly+R.++F.&author=Maertens+J.&author=Dadwal+S.++S.&author=Duarte+R.+F.&publication_year=2017&volume=377&pages=2433-2444)

McSharry, B. P., Avdic, S., and Slobedman, B. (2012). Human cytomegalovirus encoded homologs of cytokines, chemokines and their receptors: roles in immunomodulation. *Viruses* 4, 2448–2470. doi: 10. 3390/v411—2448 doi: 10. 3390/v4112448

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=23202490) | [CrossRef Full Text](https://doi.org/10.3390/v411—2448 doi: 10.3390/v4112448) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Human+cytomegalovirus+encoded+homologs+of+cytokines%2C+chemokines+and+their+receptors%3A+roles+in+immunomodulation.&journal=Viruses&author=McSharry+B.++P.&author=Avdic+S.&author=and+Slobedman+B.&publication_year=2012&volume=4&pages=2448-2470)

Melendez-Munoz, R., Marchalik, R., Jerussi, T., Dimitrova, D., Nussenblatt, V., Beri, A., et al. (2019). Cytomegalovirus infection incidence and risk factors across diverse hematopoietic cell transplantation platforms using a standardized monitoring and treatment approach: a comprehensive evaluation from a single institution. *Biol. Blood Marrow Transplant.* 25, 577–586. doi: 10. 1016/j. bbmt. 2018. 10. 011

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=30342913) | [CrossRef Full Text](https://doi.org/10.1016/j.bbmt.2018.10.011) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+infection+incidence+and+risk+factors+across+diverse+hematopoietic+cell+transplantation+platforms+using+a+standardized+monitoring+and+treatment+approach%3A+a+comprehensive+evaluation+from+a+single+institution.&journal=Biol.+Blood+Marrow+Transplant.&author=Melendez-Munoz+R.&author=Marchalik+R.&author=Jerussi+T.&author=Dimitrova+D.&author=Nussenblatt+V.&author=Beri+A.&publication_year=2019&volume=25&pages=577-586)

Mendelson, M., Monard, S., Sissons, P., and Sinclair, J. (1996). Detection of endogenous human cytomegalovirus in CD34+ bone marrow progenitors. *J. Gen. Virol.* 77(Pt 12), 3099–3102. doi: 10. 1099/0022-1317-77-12-3099

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=9000102) | [CrossRef Full Text](https://doi.org/10.1099/0022-1317-77-12-3099) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Detection+of+endogenous+human+cytomegalovirus+in+CD34%2B+bone+marrow+progenitors.&journal=J.++Gen.+Virol.&author=Mendelson+M.&author=Monard+S.&author=Sissons+P.&author=and+Sinclair+J.&publication_year=1996&pages=3099-3102)

Menger, L., Gouble, A., Marzolini, M. A., Pachnio, A., Bergerhoff, K., Henry, J. Y., et al. (2015). TALEN-mediated genetic inactivation of the glucocorticoid receptor in cytomegalovirus-specific T cells. *Blood* 126, 2781–2789. doi: 10. 1182/blood-2015-08-664755

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=26508783) | [CrossRef Full Text](https://doi.org/10.1182/blood-2015-08-664755) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=TALEN-mediated+genetic+inactivation+of+the+glucocorticoid+receptor+in+cytomegalovirus-specific+T+cells.&journal=Blood&author=Menger+L.&author=Gouble+A.&author=Marzolini+M.+A.&author=Pachnio+A.&author=Bergerhoff+K.&author=Henry+J.+Y.&publication_year=2015&volume=126&pages=2781-2789)

Miller, W., Flynn, P., McCullough, J., Balfour, H. J., Goldman, A., Haake, R., et al. (1986). Cytomegalovirus infection after bone marrow transplantation: an association with acute graft-v-host disease. *Blood* 67, 1162–1167.

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=3006831) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+infection+after+bone+marrow+transplantation%3A+an+association+with+acute+graft-v-host+disease.&journal=Blood&author=Miller+W.&author=Flynn+P.&author=McCullough+J.&author=Balfour+H.+J.&author=Goldman+A.&author=Haake+R.&publication_year=1986&volume=67&pages=1162-1167)

Minton, E. J., Tysoe, C., Sinclair, J. H., and Sissons, J. G. (1994). Human cytomegalovirus infection of the monocyte/macrophage lineage in bone marrow. *J. Virol.* 68, 4017–4021.

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=8189535) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Human+cytomegalovirus+infection+of+the+monocyte%2Fmacrophage+lineage+in+bone+marrow.&journal=J.+Virol.&author=Minton+E.++J.&author=Tysoe+C.&author=Sinclair+J.++H.&author=and+Sissons+J.++G.&publication_year=1994&volume=68&pages=4017-4021)

Moins-Teisserenc, H., Busson, M., Scieux, C., Bajzik, V., Cayuela, J. M., Clave, E., et al. (2008). Patterns of cytomegalovirus reactivation are associated with distinct evolutive profiles of immune reconstitution after allogeneic hematopoietic stem cell transplantation. *J. Infect. Dis.* 198, 818–826. doi: 10. 1086/591185

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=18666855) | [CrossRef Full Text](https://doi.org/10.1086/591185) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Patterns+of+cytomegalovirus+reactivation+are+associated+with+distinct+evolutive+profiles+of+immune+reconstitution+after+allogeneic+hematopoietic+stem+cell+transplantation.&journal=J.++Infect.++Dis.&author=Moins-Teisserenc+H.&author=Busson+M.&author=Scieux+C.&author=Bajzik+V.&author=Cayuela+J.+M.&author=Clave+E.&publication_year=2008&volume=198&pages=818-826)

Monleon, D., Talaya, A., Gimenez, E., Vinuesa, V., Morales, J. M., Hernandez-Boluda, J. C., et al. (2018). Validation of a plasma metabolomics model that allows anticipation of the occurrence of cytomegalovirus DNAaemia in allogeneic stem cell transplant recipients. *J. Med. Microbiol.* .

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=29724268) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Validation+of+a+plasma+metabolomics+model+that+allows+anticipation+of+the+occurrence+of+cytomegalovirus+DNAaemia+in+allogeneic+stem+cell+transplant+recipients.&journal=J.+Med.+Microbiol.&author=Monleon+D.&author=Talaya+A.&author=Gimenez+E.&author=Vinuesa+V.&author=Morales+J.++M.&author=Hernandez-Boluda+J.+C.&publication_year=2018)

Muccio, L., Bertaina, A., Falco, M., Pende, D., Meazza, R., Lopez-Botet, M., et al. (2016). Analysis of memory-like natural killer cells in human cytomegalovirus-infected children undergoing αβ+T and B cell-depleted hematopoietic stem cell transplantation for hematological malignancies. *Haematologica* 101, 371–381. doi: 10. 3324/haematol. 2015. 134155

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=26659918) | [CrossRef Full Text](https://doi.org/10.3324/haematol.2015.134155) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Analysis+of+memory-like+natural+killer+cells+in+human+cytomegalovirus-infected+children+undergoing+αβ%2BT+and+B+cell-depleted+hematopoietic+stem+cell+transplantation+for+hematological+malignancies.&journal=Haematologica&author=Muccio+L.&author=Bertaina+A.&author=Falco+M.&author=Pende+D.&author=Meazza+R.&author=Lopez-Botet+M.&publication_year=2016&volume=101&pages=371-381)

Munoz-Cobo, B., Solano, C., Benet, I., Costa, E., Remigia, M. J., de la Camara, R., et al. (2012). Functional profile of cytomegalovirus (CMV)-specific CD8+ T cells and kinetics of NKG2C+ NK cells associated with the resolution of CMV DNAemia in allogeneic stem cell transplant recipients. *J. Med. Virol.* 84, 259–267. doi: 10. 1002/jmv. 22254

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=22170546) | [CrossRef Full Text](https://doi.org/10.1002/jmv.22254) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Functional+profile+of+cytomegalovirus+(CMV)-specific+CD8%2B+T+cells+and+kinetics+of+NKG2C%2B+NK+cells+associated+with+the+resolution+of+CMV+DNAemia+in+allogeneic+stem+cell+transplant+recipients.&journal=J.+Med.+Virol.&author=Munoz-Cobo+B.&author=Solano+C.&author=Benet+I.&author=Costa+E.&author=Remigia+M.+J.&author=de+la+Camara+R.&publication_year=2012&volume=84&pages=259-267)

Nakamura, R., Battiwalla, M., Solomon, S., Follmann, D., Chakrabarti, S., Cortez, K., et al. (2004). Persisting posttransplantation cytomegalovirus antigenemia correlates with poor lymphocyte proliferation to cytomegalovirus antigen and predicts for increased late relapse and treatment failure. *Biol. Blood Marrow Transplantat.* 10, 49–57. doi: 10. 1016/j. bbmt. 2003. 08. 011

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=14752779) | [CrossRef Full Text](https://doi.org/10.1016/j.bbmt.2003.08.011) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Persisting+posttransplantation+cytomegalovirus+antigenemia+correlates+with+poor+lymphocyte+proliferation+to+cytomegalovirus+antigen+and+predicts+for+increased+late+relapse+and+treatment+failure.&journal=Biol.++Blood+Marrow+Transplantat.&author=Nakamura+R.&author=Battiwalla+M.&author=Solomon+S.&author=Follmann+D.&author=Chakrabarti+S.&author=Cortez+K.&publication_year=2004&volume=10&pages=49-57)

Nann-Rütti, S., Tzankov, A., Cantoni, N., Halter, J., Heim, D., Tsakiris, D., et al. (2012). Large granular lymphocyte expansion after allogeneic hematopoietic stem cell transplant is associated with a cytomegalovirus reactivation and shows an indolent outcome. *Biol. Blood Marrow Transplant.* 18, 1765–1770. doi: 10. 1016/j. bbmt. 2012. 07. 007

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=22796340) | [CrossRef Full Text](https://doi.org/10.1016/j.bbmt.2012.07.007) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Large+granular+lymphocyte+expansion+after+allogeneic+hematopoietic+stem+cell+transplant+is+associated+with+a+cytomegalovirus+reactivation+and+shows+an+indolent+outcome.&journal=Biol.+Blood+Marrow+Transplant.&author=Nann-Rütti+S.&author=Tzankov+A.&author=Cantoni+N.&author=Halter+J.&author=Heim+D.&author=Tsakiris+D.&publication_year=2012&volume=18&pages=1765-1770)

Navarro, D., Amat, P., de la Camara, R., Lopez, J., Vazquez, L., Serrano, D., et al. (2016). Efficacy and safety of a preemptive antiviral therapy strategy based on combined virological and immunological monitoring for active cytomegalovirus infection in allogeneic stem cell transplant recipients. *Open Forum Infect. Dis.* 3: ofw107. doi: 10. 1093/ofid/ofw107

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=27419179) | [CrossRef Full Text](https://doi.org/10.1093/ofid/ofw107) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Efficacy+and+safety+of+a+preemptive+antiviral+therapy+strategy+based+on+combined+virological+and+immunological+monitoring+for+active+cytomegalovirus+infection+in+allogeneic+stem+cell+transplant+recipients.&journal=Open+Forum+Infect.+Dis.&author=Navarro+D.&author=Amat+P.&author=de+la+Camara+R.&author=Lopez+J.&author=Vazquez+L.&author=Serrano+D.&publication_year=2016)

Neuenhahn, M., Albrecht, J., Odendahl, M., Schlott, F., Dossinger, G., Schiemann, M., et al. (2017). Transfer of minimally manipulated CMV-specific T cells from stem cell or third-party donors to treat CMV infection after allo-HSCT. *Leukemia* 31, 2161–2171. doi: 10. 1038/leu. 2017. 16

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=28090089) | [CrossRef Full Text](https://doi.org/10.1038/leu.2017.16) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Transfer+of+minimally+manipulated+CMV-specific+T+cells+from+stem+cell+or+third-party+donors+to+treat+CMV+infection+after+allo-HSCT.&journal=Leukemia&author=Neuenhahn+M.&author=Albrecht+J.&author=Odendahl+M.&author=Schlott+F.&author=Dossinger+G.&author=Schiemann+M.&publication_year=2017&volume=31&pages=2161-2171)

Nichols, W. G., Corey, L., Gooley, T., Davis, C., and Boeckh, M. (2002). High risk of death due to bacterial and fungal infection among cytomegalovirus (CMV)-seronegative recipients of stem cell transplants from seropositive donors: evidence for indirect effects of primary CMV infection. *J. Infect. Dis.* 185, 273–282. doi: 10. 1086/338624

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=11807708) | [CrossRef Full Text](https://doi.org/10.1086/338624) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=High+risk+of+death+due+to+bacterial+and+fungal+infection+among+cytomegalovirus+(CMV)-seronegative+recipients+of+stem+cell+transplants+from+seropositive+donors%3A+evidence+for+indirect+effects+of+primary+CMV+infection.&journal=J.+Infect.+Dis.&author=Nichols+W.+G.&author=Corey+L.&author=Gooley+T.&author=Davis+C.&author=and+Boeckh+M.&publication_year=2002&volume=185&pages=273-282)

Ogonek, J., Varanasi, P., Luther, S., Schweier, P., Kuhnau, W., Gohring, G., et al. (2017). Possible impact of cytomegalovirus-specific CD8(+) T cells on immune reconstitution and conversion to complete donor chimerism after allogeneic stem cell transplantation. *Biol. Blood Marrow Transplant.* 23, 1046–1053. doi: 10. 1016/j. bbmt. 2017. 03. 027

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=28344058) | [CrossRef Full Text](https://doi.org/10.1016/j.bbmt.2017.03.027) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Possible+impact+of+cytomegalovirus-specific+CD8(%2B)+T+cells+on+immune+reconstitution+and+conversion+to+complete+donor+chimerism+after+allogeneic+stem+cell+transplantation.&journal=Biol.+Blood+Marrow+Transplant.&author=Ogonek+J.&author=Varanasi+P.&author=Luther+S.&author=Schweier+P.&author=Kuhnau+W.&author=Gohring+G.&publication_year=2017&volume=23&pages=1046-1053)

Ozdemir, E., St John, L. S., Gillespie, G., Rowland-Jones, S., Champlin, R. E., Molldrem, J. J., et al. (2002). Cytomegalovirus reactivation following allogeneic stem cell transplantation is associated with the presence of dysfunctional antigen-specific CD8+ T cells. *Blood* 100, 3690–3697. doi: 10. 1182/blood-2002-05-1387

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=12393402) | [CrossRef Full Text](https://doi.org/10.1182/blood-2002-05-1387) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+reactivation+following+allogeneic+stem+cell+transplantation+is+associated+with+the+presence+of+dysfunctional+antigen-specific+CD8%2B+T+cells.&journal=Blood&author=Ozdemir+E.&author=St+John+L.+S.&author=Gillespie+G.&author=Rowland-Jones+S.&author=Champlin+R.+E.&author=Molldrem+J.+J.&publication_year=2002&volume=100&pages=3690-3697)

Pampou, S., Gnedoy, S. N., Bystrevskaya, V. B., Smirnov, V. N., Chazov, E. I., Melnick, J. L., et al. (2000). Cytomegalovirus genome and the immediate-early antigen in cells of different layers of human aorta. *Virchows Arch.* 436, 539–552. doi: 10. 1007/s004289900173

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=10917167) | [CrossRef Full Text](https://doi.org/10.1007/s004289900173) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+genome+and+the+immediate-early+antigen+in+cells+of+different+layers+of+human+aorta.&journal=Virchows+Arch.&author=Pampou+S.&author=Gnedoy+S.+N.&author=Bystrevskaya+V.+B.&author=Smirnov+V.+N.&author=Chazov+E.++I.&author=Melnick+J.++L.&publication_year=2000&volume=436&pages=539-552)

Patin, E., Hasan, M., Bergstedt, J., Rouilly, V., Libri, V., Urrutia, A., et al. (2018). Natural variation in the parameters of innate immune cells is preferentially driven by genetic factors. *Nat. Immunol.* 19, 302–314. doi: 10. 1038/s41590-018-0049-7

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=29476184) | [CrossRef Full Text](https://doi.org/10.1038/s41590-018-0049-7) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Natural+variation+in+the+parameters+of+innate+immune+cells+is+preferentially+driven+by+genetic+factors.&journal=Nat.+Immunol.&author=Patin+E.&author=Hasan+M.&author=Bergstedt+J.&author=Rouilly+V.&author=Libri+V.&author=Urrutia+A.&publication_year=2018&volume=19&pages=302-314)

Peggs, K. S., Thomson, K., Samuel, E., Dyer, G., Armoogum, J., Chakraverty, R., et al. (2011). Directly selected cytomegalovirus-reactive donor T cells confer rapid and safe systemic reconstitution of virus-specific immunity following stem cell transplantation. *Clin. Infect. Dis.* 52, 49–57. doi: 10. 1093/cid/ciq042

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=21148519) | [CrossRef Full Text](https://doi.org/10.1093/cid/ciq042) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Directly+selected+cytomegalovirus-reactive+donor+T+cells+confer+rapid+and+safe+systemic+reconstitution+of+virus-specific+immunity+following+stem+cell+transplantation.&journal=Clin.+Infect.+Dis.&author=Peggs+K.+S.&author=Thomson+K.&author=Samuel+E.&author=Dyer+G.&author=Armoogum+J.&author=Chakraverty+R.&publication_year=2011&volume=52&pages=49-57)

Peggs, K. S., Verfuerth, S., Pizzey, A., Chow, S. L., Thomson, K., and Mackinnon, S. (2009). Cytomegalovirus-specific T cell immunotherapy promotes restoration of durable functional antiviral immunity following allogeneic stem cell transplantation. *Clin. Infect. Dis.* 49, 1851–1860. doi: 10. 1086/648422

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=19911966) | [CrossRef Full Text](https://doi.org/10.1086/648422) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus-specific+T+cell+immunotherapy+promotes+restoration+of+durable+functional+antiviral+immunity+following+allogeneic+stem+cell+transplantation.&journal=Clin.++Infect.++Dis.&author=Peggs+K.++S.&author=Verfuerth+S.&author=Pizzey+A.&author=Chow+S.++L.&author=Thomson+K.&author=and+Mackinnon+S.&publication_year=2009&volume=49&pages=1851-1860)

Pelak, O., Stuchly, J., Krol, L., Hubacek, P., Keslova, P., Sedlacek, P., et al. (2017). Appearance of cytomegalovirus-specific T-cells predicts fast resolution of viremia post hematopoietic stem cell transplantation. *Cytometry B Clin. Cytom.* 92, 380–388. doi: 10. 1002/cyto. b. 21348

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=26647177) | [CrossRef Full Text](https://doi.org/10.1002/cyto.b.21348) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Appearance+of+cytomegalovirus-specific+T-cells+predicts+fast+resolution+of+viremia+post+hematopoietic+stem+cell+transplantation.&journal=Cytometry+B+Clin.++Cytom.&author=Pelak+O.&author=Stuchly+J.&author=Krol+L.&author=Hubacek+P.&author=Keslova+P.&author=Sedlacek+P.&publication_year=2017&volume=92&pages=380-388)

Peric, Z., Wilson, J., Durakovic, N., Ostojic, A., Desnica, L., Vranjes, V. R., et al. (2018). Early human cytomegalovirus reactivation is associated with lower incidence of relapse of myeloproliferative disorders after allogeneic hematopoietic stem cell transplantation. *Bone Marrow Transplant.* 53, 1450–1456. doi: 10. 1038/s41409-018-0172-y

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=29662245) | [CrossRef Full Text](https://doi.org/10.1038/s41409-018-0172-y) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Early+human+cytomegalovirus+reactivation+is+associated+with+lower+incidence+of+relapse+of+myeloproliferative+disorders+after+allogeneic+hematopoietic+stem+cell+transplantation.&journal=Bone+Marrow+Transplant.&author=Peric+Z.&author=Wilson+J.&author=Durakovic+N.&author=Ostojic+A.&author=Desnica+L.&author=Vranjes+V.++R.&publication_year=2018&volume=53&pages=1450-1456)

Piret, J., and Boivin, G. (2019). Clinical development of letermovir and maribavir: overview of human cytomegalovirus drug resistance. *Antiviral Res.* 163, 91–105. doi: 10. 1016/j. antiviral. 2019. 01. 011

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=30690043) | [CrossRef Full Text](https://doi.org/10.1016/j.antiviral.2019.01.011) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Clinical+development+of+letermovir+and+maribavir%3A+overview+of+human+cytomegalovirus+drug+resistance.&journal=Antiviral+Res.&author=Piret+J.&author=and+Boivin+G.&publication_year=2019&volume=163&pages=91-105)

Poole, E., Juss, J. K., Krishna, B., Herre, J., Chilvers, E. R., and Sinclair, J. (2015). Alveolar macrophages isolated directly from human cytomegalovirus (HCMV)-seropositive individuals are sites of HCMV reactivation in vivo. *J. Infect. Dis.* 211, 1936–1942. doi: 10. 1093/infdis/jiu837

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=25552371) | [CrossRef Full Text](https://doi.org/10.1093/infdis/jiu837) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Alveolar+macrophages+isolated+directly+from+human+cytomegalovirus+(HCMV)-seropositive+individuals+are+sites+of+HCMV+reactivation+in+vivo.&journal=J.++Infect.+Dis.&author=Poole+E.&author=Juss+J.+K.&author=Krishna+B.&author=Herre+J.&author=Chilvers+E.+R.&author=and+Sinclair+J.&publication_year=2015&volume=211&pages=1936-1942)

Pourgheysari, B., Piper, K. P., McLarnon, A., Arrazi, J., Bruton, R., Clark, F., et al. (2009). Early reconstitution of effector memory CD4+ CMV-specific T cells protects against CMV reactivation following allogeneic SCT. *Bone Marrow Transplant.* 43, 853–861. doi: 10. 1038/bmt. 2008. 403

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=19104497) | [CrossRef Full Text](https://doi.org/10.1038/bmt.2008.403) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Early+reconstitution+of+effector+memory+CD4%2B+CMV-specific+T+cells+protects+against+CMV+reactivation+following+allogeneic+SCT.&journal=Bone+Marrow+Transplant.&author=Pourgheysari+B.&author=Piper+K.+P.&author=McLarnon+A.&author=Arrazi+J.&author=Bruton+R.&author=Clark+F.&publication_year=2009&volume=43&pages=853-861)

Qayed, M., Khurana, M., Hilinski, J., Gillespie, S., McCracken, C., Applegate, K., et al. (2014). Risk for CMV reactivation in children undergoing allogeneic hematopoietic stem cell transplantation. *Pediatr. Blood Cancer* 62, 364–366. doi: 10. 1002/pbc. 25237

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=25264150) | [CrossRef Full Text](https://doi.org/10.1002/pbc.25237) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Risk+for+CMV+reactivation+in+children+undergoing+allogeneic+hematopoietic+stem+cell+transplantation.&journal=Pediatr.+Blood+Cancer&author=Qayed+M.&author=Khurana+M.&author=Hilinski+J.&author=Gillespie+S.&author=McCracken+C.&author=Applegate+K.&publication_year=2014&volume=62&pages=364-366)

Quinnan, G. V., Kirmani, N., Rook, A. H., Manischewitz, J. F., Jackson, L., Moreschi, G., et al. (1982). Cytotoxic t cells in cytomegalovirus infection: HLA-restricted T-lymphocyte and non-T-lymphocyte cytotoxic responses correlate with recovery from cytomegalovirus infection in bone-marrow-transplant recipients. *N. Engl. J. Med.* 307, 7–13. doi: 10. 1056/nejm198207013070102

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=6281647) | [CrossRef Full Text](https://doi.org/10.1056/nejm198207013070102) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytotoxic+t+cells+in+cytomegalovirus+infection%3A+HLA-restricted+T-lymphocyte+and+non-T-lymphocyte+cytotoxic+responses+correlate+with+recovery+from+cytomegalovirus+infection+in+bone-marrow-transplant+recipients.&journal=N.++Engl.++J.++Med.&author=Quinnan+G.+V.&author=Kirmani+N.&author=Rook+A.+H.&author=Manischewitz+J.+F.&author=Jackson+L.&author=Moreschi+G.&publication_year=1982&volume=307&pages=7-13)

Raanani, P., Gafter-Gvili, A., Paul, M., Ben-Bassat, I., Leibovici, L., and Shpilberg, O. (2009). Immunoglobulin prophylaxis in hematopoietic stem cell transplantation: systematic review and meta-analysis. *J. Clin. Oncol.* 27, 770–781. doi: 10. 1200/jco. 2008. 16. 8450

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=19114702) | [CrossRef Full Text](https://doi.org/10.1200/jco.2008.16.8450) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Immunoglobulin+prophylaxis+in+hematopoietic+stem+cell+transplantation%3A+systematic+review+and+meta-analysis.&journal=J.++Clin.++Oncol.&author=Raanani+P.&author=Gafter-Gvili+A.&author=Paul+M.&author=Ben-Bassat+I.&author=Leibovici+L.&author=and+Shpilberg+O.&publication_year=2009&volume=27&pages=770-781)

Raeiszadeh, M., Pachnio, A., Begum, J., Craddock, C., Moss, P., and Chen, F. E. (2015). Characterization of CMV-specific CD4+ T-cell reconstitution following stem cell transplantation through the use of HLA Class II-peptide tetramers identifies patients at high risk of recurrent CMV reactivation. *Haematologica* 100, e318–e322.

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=25975839) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Characterization+of+CMV-specific+CD4%2B+T-cell+reconstitution+following+stem+cell+transplantation+through+the+use+of+HLA+Class+II-peptide+tetramers+identifies+patients+at+high+risk+of+recurrent+CMV+reactivation.&journal=Haematologica&author=Raeiszadeh+M.&author=Pachnio+A.&author=Begum+J.&author=Craddock+C.&author=Moss+P.&author=and+Chen+F.+E.&publication_year=2015&volume=100&pages=e318-e322)

Ramanathan, M., Teira, P., Battiwalla, M., Barrett, J., Ahn, K. W., Chen, M., et al. (2016). Impact of early CMV reactivation in cord blood stem cell recipients in the current era. *Bone Marrow Transplant.* 51, 1113–1120. doi: 10. 1038/bmt. 2016. 89

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=27042847) | [CrossRef Full Text](https://doi.org/10.1038/bmt.2016.89) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Impact+of+early+CMV+reactivation+in+cord+blood+stem+cell+recipients+in+the+current+era.&journal=Bone+Marrow+Transplant.&author=Ramanathan+M.&author=Teira+P.&author=Battiwalla+M.&author=Barrett+J.&author=Ahn+K.+W.&author=Chen+M.&publication_year=2016&volume=51&pages=1113-1120)

Ravens, S., Schultze-Florey, C., Raha, S., Sandrock, I., Drenker, M., Oberdorfer, L., et al. (2017). Human gammadelta T cells are quickly reconstituted after stem-cell transplantation and show adaptive clonal expansion in response to viral infection. *Nat. Immunol.* 18, 393–401. doi: 10. 1038/ni. 3686

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=28218745) | [CrossRef Full Text](https://doi.org/10.1038/ni.3686) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Human+gammadelta+T+cells+are+quickly+reconstituted+after+stem-cell+transplantation+and+show+adaptive+clonal+expansion+in+response+to+viral+infection.&journal=Nat.++Immunol.&author=Ravens+S.&author=Schultze-Florey+C.&author=Raha+S.&author=Sandrock+I.&author=Drenker+M.&author=Oberdorfer+L.&publication_year=2017&volume=18&pages=393-401)

Reeves, M. B., Coleman, H., Chadderton, J., Goddard, M., Sissons, J. G. P., and Sinclair, J. H. (2004). Vascular endothelial and smooth muscle cells are unlikely to be major sites of latency of human cytomegalovirus in vivo. *J. Gen. Virol.* 85, 3337–3341. doi: 10. 1099/vir. 0. 80285-0

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=15483249) | [CrossRef Full Text](https://doi.org/10.1099/vir.0.80285-0) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Vascular+endothelial+and+smooth+muscle+cells+are+unlikely+to+be+major+sites+of+latency+of+human+cytomegalovirus+in+vivo.&journal=J.+Gen.++Virol.&author=Reeves+M.+B.&author=Coleman+H.&author=Chadderton+J.&author=Goddard+M.&author=Sissons+J.+G.+P.&author=and+Sinclair+J.+H.&publication_year=2004&volume=85&pages=3337-3341)

Reeves, M. B., and Compton, T. (2011). Inhibition of inflammatory interleukin-6 activity via extracellular signal-regulated kinase-mitogen-activated protein kinase signaling antagonizes human cytomegalovirus reactivation from dendritic cells. *J. Virol.* 85, 12750–12758. doi: 10. 1128/JVI. 05878-11

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=21937636) | [CrossRef Full Text](https://doi.org/10.1128/JVI.05878-11) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Inhibition+of+inflammatory+interleukin-6+activity+via+extracellular+signal-regulated+kinase-mitogen-activated+protein+kinase+signaling+antagonizes+human+cytomegalovirus+reactivation+from+dendritic+cells.&journal=J.+Virol.&author=Reeves+M.++B.&author=and+Compton+T.&publication_year=2011&volume=85&pages=12750-12758)

Reeves, M. B., Lehner, P. J., Sissons, J. G., and Sinclair, J. H. (2005a). An in vitro model for the regulation of human cytomegalovirus latency and reactivation in dendritic cells by chromatin remodelling. *J. Gen. Virol.* 86(Pt 11), 2949–2954. doi: 10. 1099/vir. 0. 81161-0

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=16227215) | [CrossRef Full Text](https://doi.org/10.1099/vir.0.81161-0) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=An+in+vitro+model+for+the+regulation+of+human+cytomegalovirus+latency+and+reactivation+in+dendritic+cells+by+chromatin+remodelling.&journal=J.+Gen.+Virol.&author=Reeves+M.+B.&author=Lehner+P.+J.&author=Sissons+J.+G.&author=and+Sinclair+J.+H.&publication_year=2005a&pages=2949-2954)

Reeves, M. B., MacAry, P. A., Lehner, P. J., Sissons, J. G., and Sinclair, J. H. (2005b). Latency, chromatin remodeling, and reactivation of human cytomegalovirus in the dendritic cells of healthy carriers. *Proc. Natl. Acad. Sci. U. S. A.* 102, 4140–4145. doi: 10. 1073/pnas. 0408994102

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=15738399) | [CrossRef Full Text](https://doi.org/10.1073/pnas.0408994102) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Latency%2C+chromatin+remodeling%2C+and+reactivation+of+human+cytomegalovirus+in+the+dendritic+cells+of+healthy+carriers.&journal=Proc.+Natl.+Acad.+Sci.++U.S.A.&author=Reeves+M.+B.&author=MacAry+P.+A.&author=Lehner+P.+J.&author=Sissons+J.+G.&author=and+Sinclair+J.++H.&publication_year=2005b&volume=102&pages=4140-4145)

Reeves, M. B., and Sinclair, J. H. (2013). Circulating dendritic cells isolated from healthy seropositive donors are sites of human cytomegalovirus reactivation in vivo. *J. Virol.* 87, 10660–10667. doi: 10. 1128/JVI. 01539-13

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=23885077) | [CrossRef Full Text](https://doi.org/10.1128/JVI.01539-13) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Circulating+dendritic+cells+isolated+from+healthy+seropositive+donors+are+sites+of+human+cytomegalovirus+reactivation+in+vivo.&journal=J.+Virol.&author=Reeves+M.++B.&author=and+Sinclair+J.++H.&publication_year=2013&volume=87&pages=10660-10667)

Reusser, P., Einsele, H., Lee, J., Volin, L., Rovira, M., Engelhard, D., et al. (2002). Randomized multicenter trial of foscarnet versus ganciclovir for preemptive therapy of cytomegalovirus infection after allogeneic stem cell transplantation. *Blood* 99, 1159–1164. doi: 10. 1182/blood. v99. 4. 1159

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=11830461) | [CrossRef Full Text](https://doi.org/10.1182/blood.v99.4.1159) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Randomized+multicenter+trial+of+foscarnet+versus+ganciclovir+for+preemptive+therapy+of+cytomegalovirus+infection+after+allogeneic+stem+cell+transplantation.&journal=Blood&author=Reusser+P.&author=Einsele+H.&author=Lee+J.&author=Volin+L.&author=Rovira+M.&author=Engelhard+D.&publication_year=2002&volume=99&pages=1159-1164)

Reusser, P., Riddell, S. R., Meyers, J. D., and Greenberg, P. D. (1991). Cytotoxic T-lymphocyte response to cytomegalovirus after human allogeneic bone marrow transplantation: pattern of recovery and correlation with cytomegalovirus infection and disease. *Blood* 78, 1373–1380.

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=1652311) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytotoxic+T-lymphocyte+response+to+cytomegalovirus+after+human+allogeneic+bone+marrow+transplantation%3A+pattern+of+recovery+and+correlation+with+cytomegalovirus+infection+and+disease.&journal=Blood&author=Reusser+P.&author=Riddell+S.+R.&author=Meyers+J.+D.&author=and+Greenberg+P.+D.&publication_year=1991&volume=78&pages=1373-1380)

Riddell, S. R., Watanabe, K. S., Goodrich, J. M., Li, C. R., Agha, M. E., and Greenberg, P. D. (1992). Restoration of viral immunity in immunodeficient humans by the adoptive transfer of T cell clones. *Science* 257, 238–241. doi: 10. 1126/science. 1352912

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=1352912) | [CrossRef Full Text](https://doi.org/10.1126/science.1352912) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Restoration+of+viral+immunity+in+immunodeficient+humans+by+the+adoptive+transfer+of+T+cell+clones.&journal=Science&author=Riddell+S.+R.&author=Watanabe+K.+S.&author=Goodrich+J.+M.&author=Li+C.+R.&author=Agha+M.+E.&author=and+Greenberg+P.+D.&publication_year=1992&volume=257&pages=238-241)

Sacre, K., Nguyen, S., Deback, C., Carcelain, G., Vernant, J. P., Leblond, V., et al. (2008). Expansion of human cytomegalovirus (HCMV) immediate-early 1-specific CD8+ T cells and control of HCMV replication after allogeneic stem cell transplantation. *J. Virol.* 82, 10143–10152. doi: 10. 1128/JVI. 00688-08

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=18684826) | [CrossRef Full Text](https://doi.org/10.1128/JVI.00688-08) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Expansion+of+human+cytomegalovirus+(HCMV)+immediate-early+1-specific+CD8%2B+T+cells+and+control+of+HCMV+replication+after+allogeneic+stem+cell+transplantation.&journal=J.+Virol.&author=Sacre+K.&author=Nguyen+S.&author=Deback+C.&author=Carcelain+G.&author=Vernant+J.+P.&author=Leblond+V.&publication_year=2008&volume=82&pages=10143-10152)

Scheinberg, P., Melenhorst, J. J., Brenchley, J. M., Hill, B. J., Hensel, N. F., Chattopadhyay, P. K., et al. (2009). The transfer of adaptive immunity to CMV during hematopoietic stem cell transplantation is dependent on the specificity and phenotype of CMV-specific T cells in the donor. *Blood* 114, 5071–5080. doi: 10. 1182/blood-2009-04-214684

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=19776383) | [CrossRef Full Text](https://doi.org/10.1182/blood-2009-04-214684) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=The+transfer+of+adaptive+immunity+to+CMV+during+hematopoietic+stem+cell+transplantation+is+dependent+on+the+specificity+and+phenotype+of+CMV-specific+T+cells+in+the+donor.&journal=Blood&author=Scheinberg+P.&author=Melenhorst+J.+J.&author=Brenchley+J.+M.&author=Hill+B.+J.&author=Hensel+N.++F.&author=Chattopadhyay+P.+K.&publication_year=2009&volume=114&pages=5071-5080)

Scheper, W., van Dorp, S., Kersting, S., Pietersma, F., Lindemans, C., Hol, S., et al. (2013). γδT cells elicited by CMV reactivation after allo-SCT cross-recognize CMV and leukemia. *Leukemia* 27, 1328–1338. doi: 10. 1038/leu. 2012. 374

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=23277330) | [CrossRef Full Text](https://doi.org/10.1038/leu.2012.374) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=γδT+cells+elicited+by+CMV+reactivation+after+allo-SCT+cross-recognize+CMV+and+leukemia.&journal=Leukemia&author=Scheper+W.&author=van+Dorp+S.&author=Kersting+S.&author=Pietersma+F.&author=Lindemans+C.&author=Hol+S.&publication_year=2013&volume=27&pages=1328-1338)

Schmidt-Hieber, M., Labopin, M., Beelen, D., Volin, L., Ehninger, G., Finke, J., et al. (2013). CMV serostatus still has an important prognostic impact in de novo acute leukemia patients after allogeneic stem cell transplantation: a report from the Acute Leukemia Working Party of EBMT. *Blood* 122, 3359–3364. doi: 10. 1182/blood-2013-05-499830

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=24037724) | [CrossRef Full Text](https://doi.org/10.1182/blood-2013-05-499830) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=CMV+serostatus+still+has+an+important+prognostic+impact+in+de+novo+acute+leukemia+patients+after+allogeneic+stem+cell+transplantation%3A+a+report+from+the+Acute+Leukemia+Working+Party+of+EBMT.&journal=Blood&author=Schmidt-Hieber+M.&author=Labopin+M.&author=Beelen+D.&author=Volin+L.&author=Ehninger+G.&author=Finke+J.&publication_year=2013&volume=122&pages=3359-3364)

Servais, S., Dumontier, N., Biard, L., Schnepf, N., Resche-Rigon, M., Peffault de Latour, R., et al. (2016). Response to antiviral therapy in haematopoietic stem cell transplant recipients with cytomegalovirus (CMV) reactivation according to the donor CMV serological status. *Clin. Microbiol. Infect.* 22, 289. e1–289. e7. doi: 10. 1016/j. cmi. 2015. 11. 006

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=26627339) | [CrossRef Full Text](https://doi.org/10.1016/j.cmi.2015.11.006) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Response+to+antiviral+therapy+in+haematopoietic+stem+cell+transplant+recipients+with+cytomegalovirus+(CMV)+reactivation++according+to+the+donor+CMV+serological+status.&journal=Clin.+Microbiol.+Infect.&author=Servais+S.&author=Dumontier+N.&author=Biard+L.&author=Schnepf+N.&author=Resche-Rigon+M.&author=Peffault+de+Latour+R.&publication_year=2016&volume=22&issue=289&pages=e1-289)

Sester, M., Sester, U., Gartner, B., Kubuschok, B., Girndt, M., Meyerhans, A., et al. (2002). Sustained high frequencies of specific CD4 T cells restricted to a single persistent virus. *J. Virol.* 76, 3748–3755. doi: 10. 1128/jvi. 76. 8. 3748-3755. 2002

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=11907214) | [CrossRef Full Text](https://doi.org/10.1128/jvi.76.8.3748-3755.2002) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Sustained+high+frequencies+of+specific+CD4+T+cells+restricted+to+a+single+persistent+virus.&journal=J.++Virol.&author=Sester+M.&author=Sester+U.&author=Gartner+B.&author=Kubuschok+B.&author=Girndt+M.&author=Meyerhans+A.&publication_year=2002&volume=76&pages=3748-3755)

Shmueli, E., Or, R., Shapira, M. Y., Resnick, I. B., Caplan, O., Bdolah-Abram, T., et al. (2014). High rate of cytomegalovirus drug resistance among patients receiving preemptive antiviral treatment after haploidentical stem cell transplantation. *J. Infect. Dis.* 209, 557–561. doi: 10. 1093/infdis/jit475

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=23983215) | [CrossRef Full Text](https://doi.org/10.1093/infdis/jit475) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=High+rate+of+cytomegalovirus+drug+resistance+among+patients+receiving+preemptive+antiviral+treatment+after+haploidentical+stem+cell+transplantation.&journal=J.++Infect.++Dis.&author=Shmueli+E.&author=Or+R.&author=Shapira+M.++Y.&author=Resnick+I.++B.&author=Caplan+O.&author=Bdolah-Abram+T.&publication_year=2014&volume=209&pages=557-561)

Shnayder, M., Nachshon, A., Krishna, B., Poole, E., Boshkov, A., Binyamin, A., et al. (2018). Defining the transcriptional landscape during cytomegalovirus latency with single-cell RNA sequencing. *mBio* 9: e00013-18. doi: 10. 1128/mBio. 00013-18

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=29895640) | [CrossRef Full Text](https://doi.org/10.1128/mBio.00013-18) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Defining+the+transcriptional+landscape+during+cytomegalovirus+latency+with+single-cell+RNA+sequencing.&journal=mBio&author=Shnayder+M.&author=Nachshon+A.&author=Krishna+B.&author=Poole+E.&author=Boshkov+A.&author=Binyamin+A.&publication_year=2018)

Sinzger, C., Digel, M., and Jahn, G. (2008). Cytomegalovirus cell tropism. *Curr. Top. Microbiol. Immunol.* 325, 63–83. doi: 10. 1007/978-3-540-77349-8\_4

[CrossRef Full Text](https://doi.org/10.1007/978-3-540-77349-8_4) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+cell+tropism.&journal=Curr.+Top.+Microbiol.+Immunol.&author=Sinzger+C.&author=Digel+M.&author=and+Jahn+G.&publication_year=2008&volume=325&pages=63-83)

Slade, M., Goldsmith, S., Romee, R., DiPersio, J. F., Dubberke, E. R., Westervelt, P., et al. (2017). Epidemiology of infections following haploidentical peripheral blood hematopoietic cell transplantation. *Transpl. Infect. Dis.* 19: e12629.

[Google Scholar](http://scholar.google.com/scholar_lookup?&title=Epidemiology+of+infections+following+haploidentical+peripheral+blood+hematopoietic+cell+transplantation.&journal=Transpl.++Infect.++Dis.&author=Slade+M.&author=Goldsmith+S.&author=Romee+R.&author=DiPersio+J.++F.&author=Dubberke+E.++R.&author=Westervelt+P.&publication_year=2017)

Slobedman, B., and Mocarski, E. S. (1999). Quantitative analysis of latent human cytomegalovirus. *J. Virol.* 73, 4806–4812.

[Google Scholar](http://scholar.google.com/scholar_lookup?&title=Quantitative+analysis+of+latent+human+cytomegalovirus.&journal=J.+Virol.&author=Slobedman+B.&author=and+Mocarski+E.+S.&publication_year=1999&volume=73&pages=4806-4812)

Smirnov, S. V., Harbacheuski, R., Lewis-Antes, A., Zhu, H., Rameshwar, P., and Kotenko, S. V. (2007). Bone-marrow-derived mesenchymal stem cells as a target for cytomegalovirus infection: implications for hematopoiesis, self-renewal and differentiation potential. *Virology* 360, 6–16. doi: 10. 1016/j. virol. 2006. 09. 017

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=17113121) | [CrossRef Full Text](https://doi.org/10.1016/j.virol.2006.09.017) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Bone-marrow-derived+mesenchymal+stem+cells+as+a+target+for+cytomegalovirus+infection%3A+implications+for+hematopoiesis%2C+self-renewal+and+differentiation+potential.&journal=Virology&author=Smirnov+S.+V.&author=Harbacheuski+R.&author=Lewis-Antes+A.&author=Zhu+H.&author=Rameshwar+P.&author=and+Kotenko+S.++V.&publication_year=2007&volume=360&pages=6-16)

Soderberg-Naucler, C., Fish, K. N., and Nelson, J. A. (1997). Reactivation of latent human cytomegalovirus by allogeneic stimulation of blood cells from healthy donors. *Cell* 91, 119–126. doi: 10. 1016/s0092-8674(01)80014-3

[CrossRef Full Text](https://doi.org/10.1016/s0092-8674(01)80014-3) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Reactivation+of+latent+human+cytomegalovirus+by+allogeneic+stimulation+of+blood+cells+from+healthy+donors.&journal=Cell&author=Soderberg-Naucler+C.&author=Fish+K.+N.&author=and+Nelson+J.+A.&publication_year=1997&volume=91&pages=119-126)

Söderberg-Nauclér, C., Streblow, D. N., Fish, K. N., Allan-Yorke, J., Smith, P. P., and Nelson, J. A. (2001). Reactivation of latent human cytomegalovirus in CD14(+) monocytes is differentiation dependent. *J. Virol.* 75, 7543–7554. doi: 10. 1128/jvi. 75. 16. 7543-7554. 2001

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=11462026) | [CrossRef Full Text](https://doi.org/10.1128/jvi.75.16.7543-7554.2001) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Reactivation+of+latent+human+cytomegalovirus+in+CD14(%2B)+monocytes+is+differentiation+dependent.&journal=J.+Virol.&author=Söderberg-Nauclér+C.&author=Streblow+D.+N.&author=Fish+K.+N.&author=Allan-Yorke+J.&author=Smith+P.+P.&author=and+Nelson+J.+A.&publication_year=2001&volume=75&pages=7543-7554)

Soland, M. A., Keyes, L. R., Bayne, R., Moon, J., Porada, C. D., St Jeor, S., et al. (2014). Perivascular stromal cells as a potential reservoir of human cytomegalovirus. *Am. J. Transplant.* 14, 820–830. doi: 10. 1111/ajt. 12642

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=24592822) | [CrossRef Full Text](https://doi.org/10.1111/ajt.12642) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Perivascular+stromal+cells+as+a+potential+reservoir+of+human+cytomegalovirus.&journal=Am.+J.+Transplant.&author=Soland+M.+A.&author=Keyes+L.+R.&author=Bayne+R.&author=Moon+J.&author=Porada+C.+D.&author=St+Jeor+S.&publication_year=2014&volume=14&pages=820-830)

Suessmuth, Y., Mukherjee, R., Watkins, B., Koura, D. T., Finstermeier, K., Desmarais, C., et al. (2015). CMV reactivation drives posttransplant T-cell reconstitution and results in defects in the underlying TCRbeta repertoire. *Blood* 125, 3835–3850. doi: 10. 1182/blood-2015-03-631853

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=25852054) | [CrossRef Full Text](https://doi.org/10.1182/blood-2015-03-631853) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=CMV+reactivation+drives+posttransplant+T-cell+reconstitution+and+results+in+defects+in+the+underlying+TCRbeta+repertoire.&journal=Blood&author=Suessmuth+Y.&author=Mukherjee+R.&author=Watkins+B.&author=Koura+D.+T.&author=Finstermeier+K.&author=Desmarais+C.&publication_year=2015&volume=125&pages=3835-3850)

Sylwester, A. W., Mitchell, B. L., Edgar, J. B., Taormina, C., Pelte, C., Ruchti, F., et al. (2005). Broadly targeted human cytomegalovirus-specific CD4+ and CD8+ T cells dominate the memory compartments of exposed subjects. *J. Exp. Med.* 202, 673–685. doi: 10. 1084/jem. 20050882

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=16147978) | [CrossRef Full Text](https://doi.org/10.1084/jem.20050882) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Broadly+targeted+human+cytomegalovirus-specific+CD4%2B+and+CD8%2B+T+cells+dominate+the+memory+compartments+of+exposed+subjects.&journal=J.+Exp.+Med.&author=Sylwester+A.+W.&author=Mitchell+B.+L.&author=Edgar+J.+B.&author=Taormina+C.&author=Pelte+C.&author=Ruchti+F.&publication_year=2005&volume=202&pages=673-685)

Taichman, R. S., Nassiri, M. R., Reilly, M. J., Ptak, R. G., Emerson, S. G., and Drach, J. C. (1997). Infection and replication of human cytomegalovirus in bone marrow stromal cells: effects on the production of IL-6, MIP-1alpha, and TGF-beta1. *Bone Marrow Transplant.* 19, 471–480. doi: 10. 1038/sj. bmt. 1700685

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=9052914) | [CrossRef Full Text](https://doi.org/10.1038/sj.bmt.1700685) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Infection+and+replication+of+human+cytomegalovirus+in+bone+marrow+stromal+cells%3A+effects+on+the+production+of+IL-6%2C+MIP-1alpha%2C+and+TGF-beta1.&journal=Bone+Marrow+Transplant.&author=Taichman+R.++S.&author=Nassiri+M.++R.&author=Reilly+M.++J.&author=Ptak+R.++G.&author=Emerson+S.++G.&author=and+Drach+J.++C.&publication_year=1997&volume=19&pages=471-480)

Takenaka, K., Nishida, T., Asano-Mori, Y., Oshima, K., Ohashi, K., Mori, T., et al. (2015). Cytomegalovirus reactivation after allogeneic hematopoietic stem cell transplantation is associated with a reduced risk of relapse in patients with acute myeloid leukemia who survived to day 100 after transplantation: the Japan society for hematopoietic cell transplantation transplantation-related complication working group. *Biol. Blood Marrow Transplant.* 21, 2008–2016. doi: 10. 1016/j. bbmt. 2015. 07. 019

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=26211985) | [CrossRef Full Text](https://doi.org/10.1016/j.bbmt.2015.07.019) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+reactivation+after+allogeneic+hematopoietic+stem+cell+transplantation+is+associated+with+a+reduced+risk+of+relapse+in+patients+with+acute+myeloid+leukemia+who+survived+to+day+100+after+transplantation%3A+the+Japan+society+for+hematopoietic+cell+transplantation+transplantation-related+complication+working+group.&journal=Biol.+Blood+Marrow+Transplant.&author=Takenaka+K.&author=Nishida+T.&author=Asano-Mori+Y.&author=Oshima+K.&author=Ohashi+K.&author=Mori+T.&publication_year=2015&volume=21&pages=2008-2016)

Tan, S. K., Waggoner, J. J., and Pinsky, B. A. (2015). Cytomegalovirus load at treatment initiation is predictive of time to resolution of viremia and duration of therapy in hematopoietic cell transplant recipients. *J. Clin. Virol.* 69, 179–183. doi: 10. 1016/j. jcv. 2015. 06. 006

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=26209403) | [CrossRef Full Text](https://doi.org/10.1016/j.jcv.2015.06.006) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+load+at+treatment+initiation+is+predictive+of+time+to+resolution+of+viremia+and+duration+of+therapy+in+hematopoietic+cell+transplant+recipients.&journal=J.+Clin.+Virol.&author=Tan+S.+K.&author=Waggoner+J.+J.&author=and+Pinsky+B.+A.&publication_year=2015&volume=69&pages=179-183)

Taylor-Wiedeman, J., Sissons, J. G., Borysiewicz, L. K., and Sinclair, J. H. (1991). Monocytes are a major site of persistence of human cytomegalovirus in peripheral blood mononuclear cells. *J. Gen. Virol.* 72(Pt 9), 2059–2064. doi: 10. 1099/0022-1317-72-9-2059

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=1654370) | [CrossRef Full Text](https://doi.org/10.1099/0022-1317-72-9-2059) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Monocytes+are+a+major+site+of+persistence+of+human+cytomegalovirus++in+peripheral+blood+mononuclear+cells.&journal=J.+Gen.+Virol.&author=Taylor-Wiedeman+J.&author=Sissons+J.+G.&author=Borysiewicz+L.+K.&author=and+Sinclair+J.+H.&publication_year=1991&pages=2059-2064)

Taylor-Wiedeman, J., Sissons, P., and Sinclair, J. (1994). Induction of endogenous human cytomegalovirus gene expression after differentiation of monocytes from healthy carriers. *J. Virol.* 68, 1597–1604.

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=8107221) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Induction+of+endogenous+human+cytomegalovirus+gene+expression+after+differentiation+of+monocytes+from+healthy+carriers.&journal=J.+Virol.&author=Taylor-Wiedeman+J.&author=Sissons+P.&author=and+Sinclair+J.&publication_year=1994&volume=68&pages=1597-1604)

Teira, P., Battiwalla, M., Ramanathan, M., Barrett, A. J., Ahn, K. W., Chen, M., et al. (2016). Early cytomegalovirus reactivation remains associated with increased transplant-related mortality in the current era: a CIBMTR analysis. *Blood* 127, 2427–2438. doi: 10. 1182/blood-2015-11-679639

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=26884374) | [CrossRef Full Text](https://doi.org/10.1182/blood-2015-11-679639) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Early+cytomegalovirus+reactivation+remains+associated+with+increased+transplant-related+mortality+in+the+current+era%3A+a+CIBMTR+analysis.&journal=Blood&author=Teira+P.&author=Battiwalla+M.&author=Ramanathan+M.&author=Barrett+A.+J.&author=Ahn+K.+W.&author=Chen+M.&publication_year=2016&volume=127&pages=2427-2438)

Tey, S. K., Davenport, M. P., Hill, G. R., Kennedy, G. A., Durrant, S. T., Khanna, R., et al. (2014). Post transplant CMV-specific T-cell immune reconstitution in the absence of global T-cell immunity is associated with a high risk of subsequent virus reactivation. *Bone Marrow Transplant.* 50, 315–316. doi: 10. 1038/bmt. 2014. 265

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=25402417) | [CrossRef Full Text](https://doi.org/10.1038/bmt.2014.265) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Post+transplant+CMV-specific+T-cell+immune+reconstitution+in+the+absence+of+global+T-cell+immunity+is+associated+with+a+high+risk+of+subsequent+virus+reactivation.&journal=Bone+Marrow+Transplant.&author=Tey+S.++K.&author=Davenport+M.++P.&author=Hill+G.++R.&author=Kennedy+G.++A.&author=Durrant+S.++T.&author=Khanna+R.&publication_year=2014&volume=50&pages=315-316)

Tey, S. K., Kennedy, G. A., Cromer, D., Davenport, M. P., Walker, S., Jones, L. I., et al. (2013). Clinical assessment of anti-viral CD8+ T cell immune monitoring using QuantiFERON-CMV(R) assay to identify high risk allogeneic hematopoietic stem cell transplant patients with CMV infection complications. *PLoS One* 8: e74744. doi: 10. 1371/journal. pone. 0074744

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=24146744) | [CrossRef Full Text](https://doi.org/10.1371/journal.pone.0074744) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Clinical+assessment+of+anti-viral+CD8%2B+T+cell+immune+monitoring+using+QuantiFERON-CMV(R)+assay+to+identify+high+risk+allogeneic+hematopoietic+stem+cell+transplant+patients+with+CMV+infection+complications.&journal=PLoS+One&author=Tey+S.+K.&author=Kennedy+G.+A.&author=Cromer+D.&author=Davenport+M.+P.&author=Walker+S.&author=Jones+L.+I.&publication_year=2013)

Tong, J., Sun, Z., Liu, H., Geng, L., Zheng, C., Tang, B., et al. (2013). Risk factors of CMV infection in patients after umbilical cord blood transplantation: a multicenter study in China. *Chin. J. Cancer Res.* 25, 695–703. doi: 10. 3978/j. issn. 1000-9604. 2013. 11. 08

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=24385697) | [CrossRef Full Text](https://doi.org/10.3978/j.issn.1000-9604.2013.11.08) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Risk+factors+of+CMV+infection+in+patients+after+umbilical+cord+blood+transplantation%3A+a+multicenter+study+in+China.&journal=Chin.++J.++Cancer+Res.&author=Tong+J.&author=Sun+Z.&author=Liu+H.&author=Geng+L.&author=Zheng+C.&author=Tang+B.&publication_year=2013&volume=25&pages=695-703)

Tormo, N., Solano, C., Benet, I., Clari, M. A., Nieto, J., de la Camara, R., et al. (2010). Lack of prompt expansion of cytomegalovirus pp65 and IE-1-specific IFNgamma CD8+ and CD4+ T cells is associated with rising levels of pp65 antigenemia and DNAemia during pre-emptive therapy in allogeneic hematopoietic stem cell transplant recipients. *Bone Marrow Transplant.* 45, 543–549. doi: 10. 1038/bmt. 2009. 172

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=19617905) | [CrossRef Full Text](https://doi.org/10.1038/bmt.2009.172) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Lack+of+prompt+expansion+of+cytomegalovirus+pp65+and+IE-1-specific+IFNgamma+CD8%2B+and+CD4%2B+T+cells+is+associated+with+rising+levels+of+pp65+antigenemia+and+DNAemia+during+pre-emptive+therapy+in+allogeneic+hematopoietic+stem+cell+transplant+recipients.&journal=Bone+Marrow+Transplant.&author=Tormo+N.&author=Solano+C.&author=Benet+I.&author=Clari+M.+A.&author=Nieto+J.&author=de+la+Camara+R.&publication_year=2010&volume=45&pages=543-549)

Tormo, N., Solano, C., Benet, I., Nieto, J., de la Camara, R., Lopez, J., et al. (2011). Reconstitution of CMV pp65 and IE-1-specific IFN-gamma CD8(+) and CD4(+) T-cell responses affording protection from CMV DNAemia following allogeneic hematopoietic SCT. *Bone Marrow Transplant.* 46, 1437–1443. doi: 10. 1038/bmt. 2010. 330

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=21243030) | [CrossRef Full Text](https://doi.org/10.1038/bmt.2010.330) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Reconstitution+of+CMV+pp65+and+IE-1-specific+IFN-gamma+CD8(%2B)+and+CD4(%2B)+T-cell+responses+affording+protection+from+CMV+DNAemia+following+allogeneic+hematopoietic+SCT.&journal=Bone+Marrow+Transplant.&author=Tormo+N.&author=Solano+C.&author=Benet+I.&author=Nieto+J.&author=de+la+Camara+R.&author=Lopez+J.&publication_year=2011&volume=46&pages=1437-1443)

Valadkhani, B., Kargar, M., Ashouri, A., Hadjibabaie, M., Gholami, K., and Ghavamzadeh, A. (2016). The risk factors for cytomegalovirus reactivation following stem cell transplantation. *J. Res. Pharm. Pract.* 5, 63–69. doi: 10. 4103/2279-042X. 176554

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=26985438) | [CrossRef Full Text](https://doi.org/10.4103/2279-042X.176554) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=The+risk+factors+for+cytomegalovirus+reactivation+following+stem+cell+transplantation.&journal=J.++Res.++Pharm.++Pract.&author=Valadkhani+B.&author=Kargar+M.&author=Ashouri+A.&author=Hadjibabaie+M.&author=Gholami+K.&author=and+Ghavamzadeh+A.&publication_year=2016&volume=5&pages=63-69)

Varanasi, P. R., Ogonek, J., Luther, S., Dammann, E., Stadler, M., Ganser, A., et al. (2019). Cytomegalovirus-specific CD8+ T-cells are associated with a reduced incidence of early relapse after allogeneic stem cell transplantation. *PLoS One* 14: e0213739. doi: 10. 1371/journal. pone. 0213739

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=30889204) | [CrossRef Full Text](https://doi.org/10.1371/journal.pone.0213739) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus-specific+CD8%2B+T-cells+are+associated+with+a+reduced+incidence+of+early+relapse+after+allogeneic+stem+cell+transplantation.&journal=PLoS+One&author=Varanasi+P.+R.&author=Ogonek+J.&author=Luther+S.&author=Dammann+E.&author=Stadler+M.&author=Ganser+A.&publication_year=2019)

Vinuesa, V., Bracho, M. A., Albert, E., Solano, C., Torres-Puente, M., Gimenez, E., et al. (2017). The impact of virus population diversity on the dynamics of cytomegalovirus DNAemia in allogeneic stem cell transplant recipients. *J. Gen. Virol.* 98, 2530–2542. doi: 10. 1099/jgv. 0. 000916

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=28874227) | [CrossRef Full Text](https://doi.org/10.1099/jgv.0.000916) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=The+impact+of+virus+population+diversity+on+the+dynamics+of+cytomegalovirus+DNAemia+in+allogeneic+stem+cell+transplant+recipients.&journal=J.+Gen.+Virol.&author=Vinuesa+V.&author=Bracho+M.++A.&author=Albert+E.&author=Solano+C.&author=Torres-Puente+M.&author=Gimenez+E.&publication_year=2017&volume=98&pages=2530-2542)

Wagner, J. E., Thompson, J. S., Carter, S. L., Kernan, N. A., and Unrelated Donor Marrow Transplantation Trial. (2005). Effect of graft-versus-host disease prophylaxis on 3-year disease-free survival in recipients of unrelated donor bone marrow (T-cell Depletion Trial): a multi-centre, randomised phase II-III trial. *Lancet* 366, 733–741. doi: 10. 1016/s0140-6736(05)66996-6

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=16125590) | [CrossRef Full Text](https://doi.org/10.1016/s0140-6736(05)66996-6) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Effect+of+graft-versus-host+disease+prophylaxis+on+3-year+disease-free+survival+in+recipients+of+unrelated+donor+bone+marrow+(T-cell+Depletion+Trial)%3A+a+multi-centre%2C+randomised+phase+II-III+trial.&journal=Lancet&author=Wagner+J.+E.&author=Thompson+J.+S.&author=Carter+S.+L.&author=Kernan+N.+A.&publication_year=2005&volume=366&pages=733-741)

Walker, C. M., van Burik, J. A., De For, T. E., and Weisdorf, D. J. (2007). Cytomegalovirus infection after allogeneic transplantation: comparison of cord blood with peripheral blood and marrow graft sources. *Biol. Blood Marrow Transplant.* 13, 1106–1115. doi: 10. 1016/j. bbmt. 2007. 06. 006

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=17697973) | [CrossRef Full Text](https://doi.org/10.1016/j.bbmt.2007.06.006) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+infection+after+allogeneic+transplantation%3A+comparison+of+cord+blood+with+peripheral+blood+and+marrow+graft+sources.&journal=Biol.+Blood+Marrow+Transplant.&author=Walker+C.+M.&author=van+Burik+J.+A.&author=De+For+T.+E.&author=and+Weisdorf+D.+J.&publication_year=2007&volume=13&pages=1106-1115)

Walter, E. A., Greenberg, P. D., Gilbert, M. J., Finch, R. J., Watanabe, K. S., Thomas, E. D., et al. (1995). Reconstitution of cellular immunity against cytomegalovirus in recipients of allogeneic bone marrow by transfer of T-cell clones from the donor. *N. Engl. J. Med.* 333, 1038–1044. doi: 10. 1056/nejm199510193331603

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=7675046) | [CrossRef Full Text](https://doi.org/10.1056/nejm199510193331603) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Reconstitution+of+cellular+immunity+against+cytomegalovirus+in+recipients+of+allogeneic+bone+marrow+by+transfer+of+T-cell+clones+from+the+donor.&journal=N.++Engl.++J.++Med.&author=Walter+E.+A.&author=Greenberg+P.+D.&author=Gilbert+M.+J.&author=Finch+R.+J.&author=Watanabe+K.++S.&author=Thomas+E.++D.&publication_year=1995&volume=333&pages=1038-1044)

Webb, B. J., Harrington, R., Schwartz, J., Kammerer, J., Spalding, J., Lee, E., et al. (2018). The clinical and economic impact of cytomegalovirus infection in recipients of hematopoietic stem cell transplantation. *Transpl. Infect. Dis.* 20: e12961. doi: 10. 1111/tid. 12961

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=29975816) | [CrossRef Full Text](https://doi.org/10.1111/tid.12961) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=The+clinical+and+economic+impact+of+cytomegalovirus+infection+in+recipients+of+hematopoietic+stem+cell+transplantation.&journal=Transpl.+Infect.+Dis.&author=Webb+B.+J.&author=Harrington+R.&author=Schwartz+J.&author=Kammerer+J.&author=Spalding+J.&author=Lee+E.&publication_year=2018)

Weinberg, K., Blazar, B. R., Wagner, J. E., Agura, E., Hill, B. J., Smogorzewska, M., et al. (2001). Factors affecting thymic function after allogeneic hematopoietic stem cell transplantation. *Blood* 97, 1458–1466. doi: 10. 1182/blood. v97. 5. 1458

[CrossRef Full Text](https://doi.org/10.1182/blood.v97.5.1458) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Factors+affecting+thymic+function+after+allogeneic+hematopoietic+stem+cell+transplantation.&journal=Blood&author=Weinberg+K.&author=Blazar+B.++R.&author=Wagner+J.++E.&author=Agura+E.&author=Hill+B.++J.&author=Smogorzewska+M.&publication_year=2001&volume=97&pages=1458-1466)

Widmann, T., Sester, U., Gartner, B. C., Schubert, J., Pfreundschuh, M., Kohler, H., et al. (2008). Levels of CMV specific CD4 T cells are dynamic and correlate with CMV viremia after allogeneic stem cell transplantation. *PLoS One* 3: e3634. doi: 10. 1371/journal. pone. 0003634

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=18982061) | [CrossRef Full Text](https://doi.org/10.1371/journal.pone.0003634) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Levels+of+CMV+specific+CD4+T+cells+are+dynamic+and+correlate+with+CMV+viremia+after+allogeneic+stem+cell+transplantation.&journal=PLoS+One&author=Widmann+T.&author=Sester+U.&author=Gartner+B.+C.&author=Schubert+J.&author=Pfreundschuh+M.&author=Kohler+H.&publication_year=2008)

Wildum, S., Zimmermann, H., and Lischka, P. (2015). In vitro drug combination studies of Letermovir (AIC246, MK-8228) with approved anti-human cytomegalovirus (HCMV) and anti-HIV compounds in inhibition of HCMV and HIV replication. *Antimicrob. Agents Chemother.* 59, 3140–3148. doi: 10. 1128/AAC. 00114-15

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=25779572) | [CrossRef Full Text](https://doi.org/10.1128/AAC.00114-15) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=In+vitro+drug+combination+studies+of+Letermovir+(AIC246%2C+MK-8228)+with+approved+anti-human+cytomegalovirus+(HCMV)+and+anti-HIV+compounds+in+inhibition+of+HCMV+and+HIV+replication.&journal=Antimicrob.+Agents+Chemother.&author=Wildum+S.&author=Zimmermann+H.&author=and+Lischka+P.&publication_year=2015&volume=59&pages=3140-3148)

Wills, M. R., Poole, E., Lau, B., Krishna, B., and Sinclair, J. H. (2015). The immunology of human cytomegalovirus latency: could latent infection be cleared by novel immunotherapeutic strategies? *Cell. Mol. Immunol.* 12, 128–138. doi: 10. 1038/cmi. 2014. 75

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=25132454) | [CrossRef Full Text](https://doi.org/10.1038/cmi.2014.75) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=The+immunology+of+human+cytomegalovirus+latency%3A+could+latent+infection+be+cleared+by+novel+immunotherapeutic+strategies%B4&journal=Cell.+Mol.+Immunol.&author=Wills+M.+R.&author=Poole+E.&author=Lau+B.&author=Krishna+B.&author=and+Sinclair+J.+H.&publication_year=2015&volume=12&pages=128-138)

Winston, D. J., Huang, E. S., Miller, M. J., Lin, C. H., Ho, W. G., Gale, R. P., et al. (1985). Molecular epidemiology of cytomegalovirus infections associated with bone marrow transplantation. *Ann. Intern. Med.* 102, 16–20.

[Google Scholar](http://scholar.google.com/scholar_lookup?&title=Molecular+epidemiology+of+cytomegalovirus+infections+associated+with+bone+marrow+transplantation.&journal=Ann.+Intern.+Med.&author=Winston+D.+J.&author=Huang+E.+S.&author=Miller+M.+J.&author=Lin+C.+H.&author=Ho+W.+G.&author=Gale+R.+P.&publication_year=1985&volume=102&pages=16-20)

Withers, B., Blyth, E., Clancy, L. E., Yong, A., Fraser, C., Burgess, J., et al. (2017). Long-term control of recurrent or refractory viral infections after allogeneic HSCT with third-party virus-specific T cells. *Blood Adv.* 1, 2193–2205. doi: 10. 1182/bloodadvances. 2017010223

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=29296867) | [CrossRef Full Text](https://doi.org/10.1182/bloodadvances.2017010223) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Long-term+control+of+recurrent+or+refractory+viral+infections+after+allogeneic+HSCT+with+third-party+virus-specific+T+cells.&journal=Blood+Adv.&author=Withers+B.&author=Blyth+E.&author=Clancy+L.++E.&author=Yong+A.&author=Fraser+C.&author=Burgess+J.&publication_year=2017&volume=1&pages=2193-2205)

Yanada, M., Yamamoto, K., Emi, N., Naoe, T., Suzuki, R., Taji, H., et al. (2003). Cytomegalovirus antigenemia and outcome of patients treated with pre-emptive ganciclovir: retrospective analysis of 241 consecutive patients undergoing allogeneic hematopoietic stem cell transplantation. *Bone Marrow Transplant.* 32, 801–807. doi: 10. 1038/sj. bmt. 1704232

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=14520425) | [CrossRef Full Text](https://doi.org/10.1038/sj.bmt.1704232) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+antigenemia+and+outcome+of+patients+treated+with+pre-emptive+ganciclovir%3A+retrospective+analysis+of+241+consecutive+patients+undergoing+allogeneic+hematopoietic+stem+cell+transplantation.&journal=Bone+Marrow+Transplant.&author=Yanada+M.&author=Yamamoto+K.&author=Emi+N.&author=Naoe+T.&author=Suzuki+R.&author=Taji+H.&publication_year=2003&volume=32&pages=801-807)

Yong, M. K., Ananda-Rajah, M., Cameron, P. U., Morrissey, C. O., Spencer, A., Ritchie, D., et al. (2017a). Cytomegalovirus reactivation is associated with increased risk of late-onset invasive fungal disease after allogeneic hematopoietic stem cell transplantation: a multicenter study in the current era of viral load monitoring. *Biol. Blood Marrow Transplant.* 23, 1961–1967. doi: 10. 1016/j. bbmt. 2017. 07. 025

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=28797778) | [CrossRef Full Text](https://doi.org/10.1016/j.bbmt.2017.07.025) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+reactivation+is+associated+with+increased+risk+of+late-onset+invasive+fungal+disease+after+allogeneic+hematopoietic+stem+cell+transplantation%3A+a+multicenter+study+in+the+current+era+of+viral+load+monitoring.&journal=Biol.+Blood+Marrow+Transplant.&author=Yong+M.+K.&author=Ananda-Rajah+M.&author=Cameron+P.+U.&author=Morrissey+C.+O.&author=Spencer+A.&author=Ritchie+D.&publication_year=2017a&volume=23&pages=1961-1967)

Yong, M. K., Cameron, P. U., Slavin, M., Morrissey, C. O., Bergin, K., Spencer, A., et al. (2017b). Identifying cytomegalovirus complications using the quantiferon-CMV assay after allogeneic hematopoietic stem cell transplantation. *J. Infect. Dis.* 215, 1684–1694. doi: 10. 1093/infdis/jix192

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=28431019) | [CrossRef Full Text](https://doi.org/10.1093/infdis/jix192) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Identifying+cytomegalovirus+complications++using+the+quantiferon-CMV+assay+after+allogeneic+hematopoietic+stem+cell+transplantation.&journal=J.+Infect.+Dis.&author=Yong+M.++K.&author=Cameron+P.++U.&author=Slavin+M.&author=Morrissey+C.++O.&author=Bergin+K.&author=Spencer+A.&publication_year=2017b&volume=215&pages=1684-1694)

Yoon, H. S., Lee, J. H., Choi, E. S., Seo, J. J., Moon, H. N., Kim, M. N., et al. (2009). Cytomegalovirus infection in children who underwent hematopoietic stem cell transplantation at a single center: a retrospective study of the risk factors. *Pediatr. Transplant.* 13, 898–905. doi: 10. 1111/j. 1399-3046. 2008. 01084. x

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=19032414) | [CrossRef Full Text](https://doi.org/10.1111/j.1399-3046.2008.01084.x) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Cytomegalovirus+infection+in+children+who+underwent+hematopoietic+stem+cell+transplantation+at+a+single+center%3A+a+retrospective+study+of+the+risk+factors.&journal=Pediatr.+Transplant.&author=Yoon+H.++S.&author=Lee+J.++H.&author=Choi+E.++S.&author=Seo+J.++J.&author=Moon+H.++N.&author=Kim+M.++N.&publication_year=2009&volume=13&pages=898-905)

Young, V. P., Mariano, M. C., Tu, C. C., Allaire, K. M., Avdic, S., Slobedman, B., et al. (2017). Modulation of the host environment by human cytomegalovirus with viral interleukin 10 in peripheral blood. *J. Infect. Dis.* 215, 874–882. doi: 10. 1093/infdis/jix043

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=28453840) | [CrossRef Full Text](https://doi.org/10.1093/infdis/jix043) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Modulation+of+the+host+environment+by+human+cytomegalovirus+with+viral+interleukin+10+in+peripheral+blood.&journal=J.+Infect.+Dis.&author=Young+V.++P.&author=Mariano+M.++C.&author=Tu+C.++C.&author=Allaire+K.++M.&author=Avdic+S.&author=Slobedman+B.&publication_year=2017&volume=215&pages=874-882)

Zaia, J. A., Gallez-Hawkins, G. M., Tegtmeier, B. R., ter Veer, A., Li, X., Niland, J. C., et al. (1997). Late cytomegalovirus disease in marrow transplantation is predicted by virus load in plasma. *J. Infect. Dis.* 176, 782–785. doi: 10. 1086/517301

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=9291333) | [CrossRef Full Text](https://doi.org/10.1086/517301) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Late+cytomegalovirus+disease+in+marrow+transplantation+is+predicted+by+virus+load+in+plasma.&journal=J.++Infect.++Dis.&author=Zaia+J.++A.&author=Gallez-Hawkins+G.++M.&author=Tegtmeier+B.++R.&author=ter+Veer+A.&author=Li+X.&author=Niland+J.++C.&publication_year=1997&volume=176&pages=782-785)

Zaia, J. A., Sun, J. Y., Gallez-Hawkins, G. M., Thao, L., Oki, A., Lacey, S. F., et al. (2009). The effect of single and combined activating killer immunoglobulin-like receptor genotypes on cytomegalovirus infection and immunity after hematopoietic cell transplantation. *Biol. Blood Marrow Transplant.* 15, 315–325. doi: 10. 1016/j. bbmt. 2008. 11. 030

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=19203722) | [CrossRef Full Text](https://doi.org/10.1016/j.bbmt.2008.11.030) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=The+effect+of+single+and+combined+activating+killer+immunoglobulin-like+receptor+genotypes+on+cytomegalovirus+infection+and+immunity+after+hematopoietic+cell+transplantation.&journal=Biol.+Blood+Marrow+Transplant.&author=Zaia+J.++A.&author=Sun+J.++Y.&author=Gallez-Hawkins+G.++M.&author=Thao+L.&author=Oki+A.&author=Lacey+S.++F.&publication_year=2009&volume=15&pages=315-325)

Zawilinska, B., Szostek, S., Kopec, J., Piatkowska-Jakubas, B., and Kosz-Vnenchak, M. (2016). Multiplex real-time PCR to identify a possible reinfection with different strains of human cytomegalovirus in allogeneic hematopoietic stem cell transplant recipients. *Acta Biochim. Pol.* 63, 161–166. doi: 10. 18388/abp. 2015\_1162

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=26885773) | [CrossRef Full Text](https://doi.org/10.18388/abp.2015_1162) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Multiplex+real-time+PCR+to+identify+a+possible+reinfection+with+different+strains+of+human+cytomegalovirus+in+allogeneic+hematopoietic+stem+cell+transplant+recipients.&journal=Acta+Biochim.+Pol.&author=Zawilinska+B.&author=Szostek+S.&author=Kopec+J.&author=Piatkowska-Jakubas+B.&author=and+Kosz-Vnenchak+M.&publication_year=2016&volume=63&pages=161-166)

Zhou, W., Longmate, J., Lacey, S. F., Palmer, J. M., Gallez-Hawkins, G., Thao, L., et al. (2009). Impact of donor CMV status on viral infection and reconstitution of multifunction CMV-specific T cells in CMV-positive transplant recipients. *Blood* 113, 6465–6476. doi: 10. 1182/blood-2009-02-203307

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=19369230) | [CrossRef Full Text](https://doi.org/10.1182/blood-2009-02-203307) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Impact+of+donor+CMV+status+on+viral+infection+and+reconstitution+of+multifunction+CMV-specific+T+cells+in+CMV-positive+transplant+recipients.&journal=Blood&author=Zhou+W.&author=Longmate+J.&author=Lacey+S.+F.&author=Palmer+J.+M.&author=Gallez-Hawkins+G.&author=Thao+L.&publication_year=2009&volume=113&pages=6465-6476)

Zhu, D., Pan, C., Sheng, J., Liang, H., Bian, Z., Liu, Y., et al. (2018). Human cytomegalovirus reprogrammes haematopoietic progenitor cells into immunosuppressive monocytes to achieve latency. *Nat. Microbiol.* 3, 503–513. doi: 10. 1038/s41564-018-0131-9

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=29588542) | [CrossRef Full Text](https://doi.org/10.1038/s41564-018-0131-9) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Human+cytomegalovirus+reprogrammes+haematopoietic+progenitor+cells+into+immunosuppressive+monocytes+to+achieve+latency.&journal=Nat.+Microbiol.&author=Zhu+D.&author=Pan+C.&author=Sheng+J.&author=Liang+H.&author=Bian+Z.&author=Liu+Y.&publication_year=2018&volume=3&pages=503-513)

Zuhair, M., Smit, G. S. A., Wallis, G., Jabbar, F., Smith, C., Devleesschauwer, B., et al. (2019). Estimation of the worldwide seroprevalence of cytomegalovirus: a systematic review and meta-analysis. *Rev. Med. Virol.* 29: e2034. doi: 10. 1002/rmv. 2034

[PubMed Abstract](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=ShowDetailView&TermToSearch=30706584) | [CrossRef Full Text](https://doi.org/10.1002/rmv.2034) | [Google Scholar](http://scholar.google.com/scholar_lookup?&title=Estimation+of+the+worldwide+seroprevalence+of+cytomegalovirus%3A+a+systematic+review+and+meta-analysis.&journal=Rev.+Med.+Virol.&author=Zuhair+M.&author=Smit+G.++S.++A.&author=Wallis+G.&author=Jabbar+F.&author=Smith+C.&author=Devleesschauwer+B.&publication_year=2019)