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Cytomegalovirus retinitis in the highly active anti-retroviral therapy era

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Abstract

Cytomegalovirus (CMV) retinitis is an opportunistic infection that has traditionally affected those who have HIV/AIDS or immunosuppressed individuals. CMV retinitis previously infected one-third of AIDS patients in the pre-highly active antiretroviral therapy (HAART) era, but since HAART, Western countries have seen an 80% decrease in the incidence of the disease. More recently, CMV retinitis has been reported in patients who are immunosuppressed, often due to chemotherapy or immunomodulatory medications. The diagnosis of CMV retinitis is often suspected based on clinical findings, with polymerase chain reaction for confirmation of CMV, especially in atypical cases. Highly active antiretroviral therapy and anti-CMV medications (systemic or local) remain the mainstay of treatment. However, for those who are not responsive to HAART, CMV retinitis remains a challenge, and can still lead to significant vision loss. Moreover, a regimen of anti-CMV medications can sometimes lead to viral resistance or organ toxicity. Complications such as immune recovery retinitis and rhegmatogenous retinal detachments continue to threaten the vision of patients who develop CMV retinitis. These complications can arise following initiation of treatment or if patients show disease progression. Proper vision screening for CMV retinitis in immunosuppressed patients at-risk is necessary for early detection and treatment.

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Keywords

Cytomegalovirus (CMV); retinitis; highly active antiretroviral therapy (HAART)

Introduction

Cytomegalovirus (CMV) is a member of the herpesvirus family and is a well-known opportunistic infection in patients who are immunosuppressed (1). Specifically, for patients with late-stage AIDS, ocular involvement of the virus was the leading cause of blindness in developed countries (2). CMV retinitis previously affected one-third of patients with AIDS, with most vision loss due to macula-involving retinitis or retinal detachment (1,3). Risk factors for CMV infection include CD4 T-lymphocyte counts less than 50 cells/mL and among patients with this CD4 count, the rate of infection of the retina was 20 cases/100 person-years (PY) (3). Since the advent of highly active antiretroviral therapy (HAART), Western countries have seen an 80% reduction in the incidence of CMV retinitis, with an estimated rate of CMV retinitis of 5.6 cases/100 PY (4). However, CMV retinitis has not completely disappeared. Specifically, patients can still develop CMV retinitis if they are either HAART unresponsive or HAART naïve, and may be faced with serious complications of the disease and treatment (4–6). HAART failure is defined as having high HIV viral load and or low CD4 count despite treatment. CMV retinitis can also present in patients that have been immunosuppressed for other reasons including transplantation and systemic immunosuppressive therapy.

Clinical diagnosis and characteristics

Diagnosis of CMV retinitis is made by indirect ophthalmoscopy with a dilated pupillary exam (1). Patients can present symptomatically with decreased visual acuity, floaters, blurred vision, or a visual field defect/scotoma. The fulminant type of CMV retinitis is characterized by yellow-white, fluffy, or granular retinal lesions, usually located near retinal vessels and associated with hemorrhage (Figure 1), while the indolent form of the disease presents as peripheral granular opacities with occasional hemorrhage (7–10). Rarely, CMV presents as a frosted branch angiitis described as retinal sheathing predominantly around the veins but also involves the arteries (11). Histologically, full-thickness necrosis is observed that progresses towards the posterior pole (12). The areas of the eye effected by the retinitis is categorized into zones of involvement. Zone 1 involves the area within 500 micrometers of the optic nerve or within 3,000 micrometers of the center of the macula. Zone 2 extends from zone one to the clinical equator of the eye, and zone 3 extends from zone 2 to the ora serrata (9,13,14). All of these exam findings in the setting of immunocompromise are suggestive of CMV retinitis (9,12).

It has been suggested that the clinical characteristics of CMV retinitis may have changed since the development and use of HAART in patients with HIV/AIDS (15). In those who have failed HAART, studies have shown that patients frequently present with less lesion opacification, which correlates with less viral activity (3). Because these patients have lower levels of viral replication, their lesions are of lesser severity (3). Additionally, individuals

categorized as HAART failure patients are usually asymptomatic, have bilateral retinitis, better visual acuity, and less zone 1 disease (3,9,10). In a more recent report, it was noted in HAART failure patients when compared to HAART responsive patients with CMV retinitis, that the failure group had a higher chance of developing a relapse and more commonly had a three-line loss of vision (16). These differing studies stress the importance of follow-up and close monitoring, especially in at-risk populations.

CMVR in Non-HIV patients

CMV retinitis can develop in immunocompromised patients who are HIV negative, including patients with solid organ or hematopoietic stem cell transplants, intraocular steroids (Figure 2), and in patients requiring immunosuppressive treatment for other diseases (17). Although rare, it has also been reported in immunocompetent patients; this includes patients with some immune dysfunction, such as diabetics and elderly patients, and those on cytotoxic medications (18). CMV retinitis in non-HIV patients has a non-classical presentation, now termed chronic retinal necrosis. Patients with chronic retinal necrosis, which differs phenotypically from CMV retinitis seen in AIDS patients, may present with a more indolent, granular retinitis, pan-retinal occlusive vasculitis, and is associated with more severe intraocular inflammation in comparison to the limited extent of the retinitis (18–20). In a study by Davis *et al.*, 71% of elderly immunocompetent patients with CMV retinitis also had concomitant retinal arteriolar occlusions, and were more likely to have vascular occlusions compared to HIV-infected patients (21). This atypical presentation is similar to that seen in HSV and VZV infections with features of acute retinal necrosis (ARN) (18). Other studies have also shown that the visual prognosis and complications from CMV retinitis in HIV-positive and HIV-negative patients (e.g., incidence of retinal detachment, zonal involvement and bilateral versus unilateral disease) were comparable (22).

Clinical course

In patients with unilateral CMV retinitis, precautions are taken to reduce the incidence of second eye involvement including early detection and timely treatment. The Longitudinal Studies of the Ocular Complications of AIDS showed that patients treated with HAART were still at risk for developing contralateral eye disease if their CD4⁺ cell count was <50 mL (23). Additionally, previous studies have shown that HAART has been associated with decreased rates of retinitis progression (6,23), and visual acuity loss (6), decreased risk of retinal detachment (15), and overall improved survival in patients with CMV retinitis, without reaching the threshold CD4⁺ cell count that is associated with treatment (above 100 cells/mL) (24).

Typically, the greatest risk of developing CMV retinitis occurs when the CD4⁺ cell count drops below 50 cell/mL (14,24). The goal of treatment for CMV retinitis is to reach a threshold of greater than 100 cells/mL. This is because the risk of progression is 30-fold less compared to the progression of retinitis prior to the HAART era (6). HAART raises the CD4⁺ cell count, leading to less of the population being affected by CMV retinitis (24). It allows for HIV suppression in the blood, leading to immune recovery and specific anti-CMV immunity (6).

In a study by Jabs *et al.*, rates for progression of CMV retinitis were higher in those with newly-diagnosed CMV retinitis compared to those with previously diagnosed CMV retinitis (25). Knowing this, it is important to provide thorough screening of CMV retinitis in at-risk populations, given that patients may have mild visual symptoms and despite ophthalmic disease manifestations (1,13,18,19,26,27). It is suggested that patients with CD4⁺ cell counts <50 cells/ μ L should be screened every two to three months, 51 to 250 cells/ μ L should be screened every three to four months, and 250 to 500 cells/ μ L should be screened every five to six months (18,20,22). A dilated fundus examination performed by an ophthalmologist is highly sensitive and specific for identifying CMV retinitis (1,7,14,28,29).

Treatment

CMV retinitis should be treated promptly due its rapid progression if not managed. It will typically progress towards the posterior pole at an average rate of 24 micrometers per day (30), and the zone of retinitis grows at a rate of 750 microns every three weeks (1). The progressive necrotizing retinitis can cause destruction of the entire retina in three to six months if untreated (1). HAART has been pivotal in the role of immune reconstitution in patients with HIV/AIDS suffering from CMV retinitis. Its administration results in improved CD4⁺ cell counts, reduced HIV replication, and reduced mortality in those with HIV/AIDS (5,28). For this reason, immunocompromised hosts with CMV retinitis should first begin HAART before initiating other treatment (8,9,30). The different modes of therapy include systemic, intravitreal, and combined systemic and intravitreal treatment. The goals of therapy are to stop acute inflammation and delay the time to relapse (10).

Systemic therapy

Systemic antivirals remain the gold standard of treatment for CMV retinitis, given its efficacy and contribution to a reduction in overall morbidity and preventing disease in the contralateral eye if unilateral disease is present (31). First-line treatment for both HIV-positive and HIV-negative patients with CMV retinitis is typically induction therapy with either intravenous (IV) ganciclovir or oral valganciclovir (31–33), followed by maintenance therapy (12,33,34). Oral ganciclovir has poor bioavailability (only 6–9%), and therefore is not the preferred treatment for CMV retinitis induction therapy (35). It is typically reserved for maintenance therapy and primary prophylaxis (3,10).

Ganciclovir is a nucleoside analog that acts against human CMV (HCMV) by preferentially phosphorylating HCMV-infected cells by the virus-encoded UL97 kinase, which essentially inhibits DNA synthesis (36). Induction therapy is given at a dose of 5 mg/kg every 12 hours for 14–21 days, and can also be used as maintenance therapy at a dose of 5 mg/kg/day (10,30). Limiting factors of long-term treatment with IV ganciclovir include side effects such as myelosuppression (neutropenia, anemia, and thrombocytopenia), catheter-related sepsis, as well as the development of resistance (3,10,37,38).

Valganciclovir is an oral prodrug that is rapidly converted to ganciclovir in the body (30,39). It has been shown to be as effective as IV ganciclovir, and because of its high bioavailability, it can be used as both an induction and maintenance therapy. Martin *et al.* compared the effects of induction therapy using oral valganciclovir with IV ganciclovir, and

found that using twice daily 900 mg of oral valganciclovir was similar to IV ganciclovir (39). Additionally, oral valganciclovir can avoid catheter-related sepsis related to parenteral antiviral administration (3,30,39,40). Boivin and colleagues found that the rate of emergence of ganciclovir-resistant viruses is no greater with the use of valganciclovir versus IV ganciclovir, although valganciclovir is commonly associated with a low incidence of viral resistance (3,41).

Foscarnet is typically used as a second-line therapy for CMV retinitis, particularly for CMV retinitis that is resistant to ganciclovir or valganciclovir, or for patients who cannot be treated with ganciclovir due to dose-limiting neutropenia or leukopenia (3,37). Jab *et al.* found that of patients of the 44 foscarnet-treated patients in their prospective observational study, about one-third developed resistance to foscarnet, and possibly at similar rates to those of ganciclovir resistance (42). Nonetheless, the choice of therapy continues to rely on clinical decision-making and monitoring of treatment response. The Studies of Ocular Complications of AIDS research trial revealed that foscarnet is equivalent to IV ganciclovir for induction and maintenance therapy for HIV-associated CMV retinitis (10,43,44). Induction therapy consists of 180 mg/kg total daily and 90 mg/kg/day for maintenance, ranging from weeks to months, given intravenously (3). It has been shown that in patients with HIV/AIDS and CMV retinitis, foscarnet offers a survival benefit over treatment with IV ganciclovir (45). However, a potential risk of foscarnet is related to nephrotoxicity and electrolyte abnormalities (46).

Cidofovir is another antiviral medication administered intravenously that has activity against CMV. A randomized control trial compared cidofovir to oral and intravitreal ganciclovir, and found that both groups had similar efficacy in treating CMV retinitis (30,47). The administration of cidofovir is also limited by its adverse effects, such as nephrotoxicity, neutropenia, ocular inflammation, and ocular hypotony (47,48). For this reason, probenecid is given before and after infusion of cidofovir, as well as IV fluids, in order to decrease renal toxicity (10,31,33).

The use of systemic therapy with ganciclovir, foscarnet, and cidofovir, have been related to resistance involving the viral genome and viral DNA polymerase mutations, UL97 and UL54 respectively (49,50). Ganciclovir resistance mutations have been identified in both the UL97 and UL54 genes, whereas foscarnet and cidofovir have only been associated with UL54 mutations (51,52). Resistance remains a challenge for immunocompromised patients who require long-term anti-CMV therapy. However, due to the immunological benefits of HAART in HIV/AIDS patients, the incidence of HCMV drug resistance has decreased significantly (53,54). Studies have shown that CMV viral load can help identify patients who are unlikely to develop resistance to ganciclovir or those who are at increased risk of developing resistance (high negative predictive value) (53,55). Consequently, management of CMV retinitis has evolved to include treatment that targets viral genome sites different from UL97 and UL54. Letermovir, a drug that targets UL56 (CMV viral terminase complex), is currently only FDA approved as a prophylactic drug for CMV retinitis, but has been studied as a potential antiviral treatment in patients with resistance to other therapies (56).

Intravitreal therapy

Ganciclovir and foscarnet can be administered via intravitreal injection and have been used for the treatment of CMV retinitis. The intraocular ganciclovir implant demonstrated efficacy for the treatment of CMV retinitis but is no longer manufactured for clinical use. The rationale for intravitreal therapy is that administration of these medications to the location of the infectious process can inhibit viral concentrations in the vitreous, while avoiding complications that may accompany systemic therapy. Studies have shown that weekly injections of intravitreal ganciclovir are effective in treating the acute infectious stage of the disease (57,58). However, use of any of these medications as a sole therapy is uncommon; it is often used in conjunction with systemic treatment or as short-term management (35). In one study, 17 (70.8%) eyes of non-HIV patients had a negative DNA viral load one month after treatment with high-dose intravitreal ganciclovir, and the mean CMV DNA load in aqueous humor had decreased from about 2.6×10^5 copies/mL at baseline to about 1×10^4 copies/mL (59). Additionally, Jabs and colleagues found that generally, patients who are treated with intravitreal injections alone fared more poorly than patients treated with regimens where systemic antiviral was employed (60). However, monotherapy with intravitreal injections is associated with a 22–35% incidence of new CMV retinitis occurring in the contralateral eye (1,12).

Combination therapy

In cases of resistant CMV retinitis, a combination of IV ganciclovir and foscarnet, or oral valganciclovir and IV foscarnet, has been found to be more effective than monotherapy (31,57). In one study, patients with unilateral cytomegalovirus retinitis were randomly assigned to either a ganciclovir implant plus oral ganciclovir, a ganciclovir implant plus oral placebo, or IV ganciclovir alone. Results showed that after one year, patients on oral ganciclovir or IV ganciclovir took a longer time to develop new CMV disease than those receiving the placebo (61). Patients who have had previous treatment for CMV retinitis, have relapsed and can tolerate the medications, can try a combination of foscarnet and ganciclovir, or any combination of systemic and intraocular therapy for controlling CMV retinitis.

Prophylaxis

Valganciclovir, oral ganciclovir, and letermovir are medications that have been used for CMV prophylaxis. However, since the introduction of HAART, anti-CMV prophylactic treatment for opportunistic infections in patients with HIV has decreased. Before HAART, patients with CMV retinitis were advised to remain on anti-CMV treatment as a lifelong therapy (62). Now, maintenance therapy (or secondary prophylaxis) is recommended to be continued until adequate immune recovery due to the effectiveness of HAART (63). A prospective study by Berenguer *et al.* supports this. They found that in the 35 patients who were on HAART for 75 weeks (median) and had a median CD4⁺ count of 287 cells/mL, there was no progression of CMV retinitis after cessation of secondary prophylaxis (62). In most patients, immune recovery from HAART can allow for the discontinuation of anti-CMV medications without rebound activation, and in some patients, HAART alone is sufficient in suppressing CMV retinitis (3).

Immune reconstitution usually occurs 3 to 6 months after initiation of HAART (33,64). Patients who are considered for discontinuation of anti-CMV medications are those whose non-sight threatening retinitis has been quiescent for six months and who have immune reconstitution with a CD4⁺ cell count above 100 cells/mL (3). A study by Jabs *et al.* showed that following immune recovery, patients may remain off anti-CMV therapy. However, longer follow-up is needed to determine at what CD4⁺ count treatment should be reinitiated to prevent disease relapse (65). Therefore, it is important to be vigilant with routine follow-up examinations in order to catch recurring disease in those who have discontinued treatment. In general, treatment and prophylaxis should be individualized based on the location and size of the retinitis, adverse effects of the medications, and the patient's experience with HAART (3).

Complications

Treatment for CMV retinitis is also dependent on the timing of the commencement of HAART. Studies have suggested that patients with preexisting CMV retinitis who are treated with HAART can experience immune recovery uveitis (12). The incidence is estimated to be 5 to 30 percent of patients with preexisting CMV retinitis starting HAART (5). Specifically, immune recovery uveitis is likely the result of previously exposed antigens from CMV retinitis that are now recognized by the improved immune response (5,30,64). This manifests as an anterior or intermediate uveitis and vitritis, and is associated with structural ocular complications such as cystoid macular edema, cataracts, and epiretinal membrane formation (6,9,30,64). Because this phenomenon can cause significant vision loss, treatment with oral or periocular steroids may be needed for the further improvement of visual acuity via reduction of cystoid macular edema (5,30).

Rhegmatogenous retinal detachments occur in about 20 to 30 percent of patients with CMV retinitis (31). Retinal detachments occur due to necrotic breaks in the retina, but can also result from peripheral anterior lesions on the retina (this location is particularly thin and is prone to breaks and tears) (9,66). The anterior retina also underlies the vitreous base, making a lesion in this area more likely to cause vitreoretinal traction (2). Studies have shown that the major risk factors associated with retinal detachments in CMV retinitis are an increased area of retinal involvement, the size of the lesion (at diagnosis and at the visit before detachment), a low CD4⁺ cell count, and bilateral disease (1,2,23,66). Additionally, studies have shown that the use of HAART has the greatest effect on the risk of retinal detachment, by decreasing the risk by 60%, an effect that is enhanced in patients that exhibit immune recovery (15).

Conclusions

CMV retinitis is a vision-threatening opportunistic infection that may still affect patients living with HIV and AIDS in the post-HAART era. Following HIV and anti-CMV therapy, immune recovery may result in adverse complications such as immune recovery uveitis, and treatment with anti-CMV medications may lead to side effects that require laboratory and health monitoring. CMV retinitis in the post-HAART era carries a much better prognosis, and incidence has significantly declined. However, because these patients still

have increased mortality rates than the rest of the population, immunosuppressed patients should be properly screened, with guidance dependent on the CD4⁺ counts. Moreover, CMV retinitis may complicate the clinical course of other patients with systemic and local immunosuppressed status.

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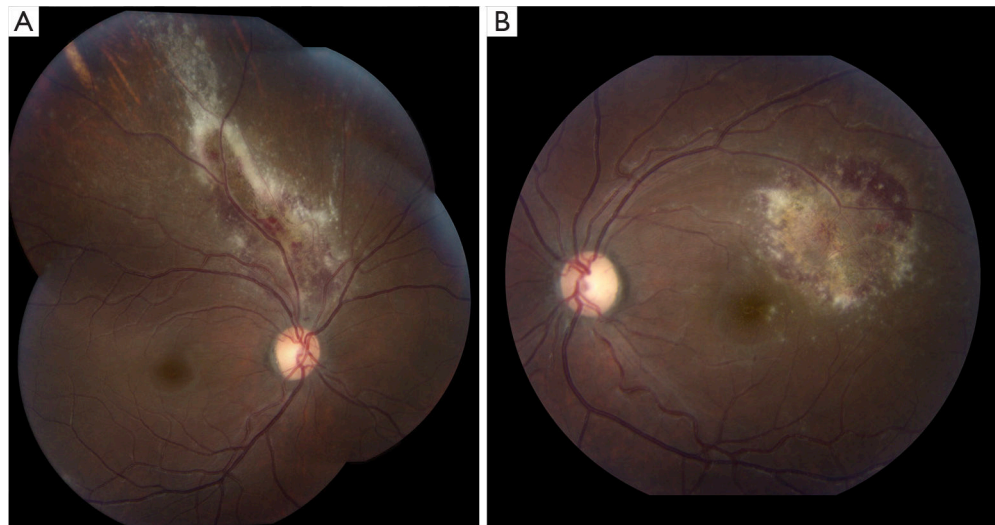


Figure 1. Fundus photo montage of a HIV+ patient, not on highly active anti-retroviral therapy (HAART) shows bilateral cytomegalovirus retinitis with retinal whitening and associated hemorrhage (A). In the left eye, there is vascular tortuosity as well as a patch of retinitis with hemorrhage and granular white opacities within the superotemporal macula (B).

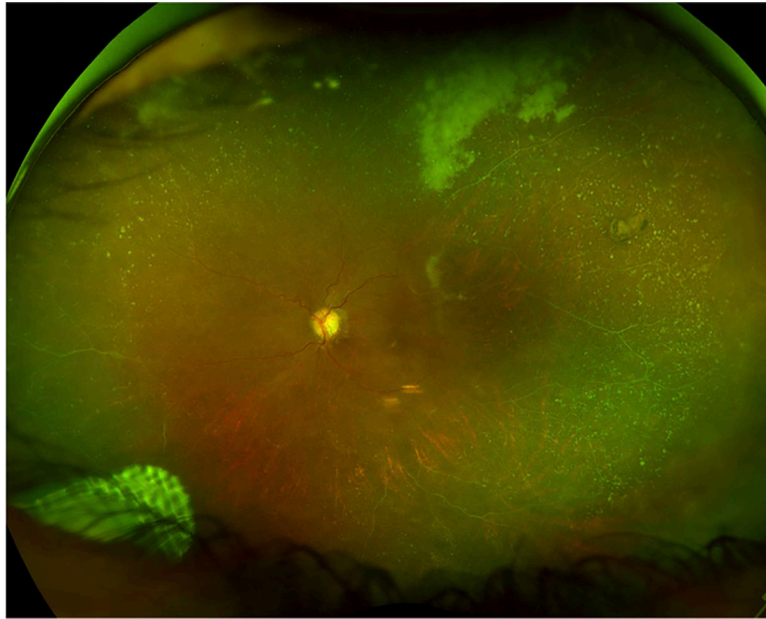


Figure 2. A wide-field photograph of a patient with sarcoidosis status post fluocinolone acetonide (Retisert™, Bausch and Lomb) shows focal retinitis superior to the superotemporal arcade. There is vascular sheathing involving the superotemporal and inferotemporal vascular arcades).