Review Article

Pregnancy-related retinal disorders: clinical features, systemic associations, and management insights

Pegah Rashidian [1] , Sepide Ahmadi [1] , Kyana Jafarabady [1] , Arman Shafiee [2] , Mohammadamin Noorafrooz [1], Ehsan Amini-Salehi [3] and Sedigheh Hantoushzadeh [1]

[1] *Vali-e-Asr Reproductive Health Research Center, Family Health Research Institute, Tehran University of Medical Sciences, Tehran, Iran*
[2] *Student research committee, Alborz university of medical sciences, Karaj, Iran*
[3] *School of Medicine, Guilan University of Medical Science, Rasht, Iran*

ABSTRACT

Background: Pregnancy induces profound hormonal, hemodynamic, and metabolic changes that can trigger or exacerbate retinal disorders, some of which may signal systemic complications. This narrative review summarizes current knowledge on retinal diseases specifically induced or worsened during pregnancy.

Methods: A comprehensive literature search was conducted in PubMed/MEDLINE, Embase, Web of Science, and Google Scholar up to 31 September 2025, supplemented by manual screening of reference lists of included records. Search terms included "pregnancy", "preeclampsia", "eclampsia", "HELLP syndrome", "hemolysis, elevated liver enzyme levels, and low platelets syndrome", "retinal disease", "retinopathy", "hypertensive retinopathy", "serous retinal detachment", "central serous chorioretinopathy", "diabetic retinopathy", "Valsalva retinopathy", "retinal vein occlusion", "retinal artery occlusion", "idiopathic intracranial hypertension", and "artificial intelligence". Eligible articles included case reports, case series, observational studies, reviews, and meta-analyses describing retinal conditions specifically induced or worsened during pregnancy. Data were synthesized narratively.

Results: Pregnancy can precipitate sight-threatening retinal pathology or accelerate pre-existing disease. Hypertensive retinopathy associated with preeclampsia and eclampsia is among the most clinically significant conditions, presenting with arteriolar narrowing, retinal hemorrhages, cotton-wool spots, and, in severe cases, serous retinal detachment. Metabolic adaptations, particularly in women with pregestational diabetes, may accelerate the progression of diabetic retinopathy, with some patients advancing from nonproliferative to proliferative stages over short intervals. Pregnancy has also been implicated in serous retinal detachment, central serous chorioretinopathy, Valsalva retinopathy, retinal vascular occlusions, and, less commonly, papilledema secondary to idiopathic intracranial hypertension. These disorders range from transient, self-limited entities to sight-threatening events and often reflect systemic pathology, including preeclampsia, eclampsia, or hypercoagulable states. Optical coherence tomography, optical coherence tomography angiography, and fundus photography provide safe, noninvasive diagnostic and monitoring modalities. Artificial intelligence (AI)-based retinal imaging offers accurate, noninvasive assessment of diabetic and hypertensive retinopathy and demonstrates expert-level performance across clinical settings. Management emphasizes stabilization of maternal systemic disease, optimization of glycemic and blood pressure control, and multidisciplinary care. Most conditions improve postpartum, but prompt recognition is essential to prevent permanent visual loss.

Conclusions: Pregnancy can precipitate or exacerbate a range of retinal disorders, reflecting the complex vascular, hormonal, and metabolic changes of gestation. Noninvasive imaging, interdisciplinary collaboration, and vigilant monitoring are essential to optimizing maternal and fetal outcomes. Awareness and early detection of pregnancy-associated retinal disorders, together with emerging AI-based tools, may further improve outcomes. Longitudinal studies are needed to establish evidence-based screening and management protocols.

KEYWORDS

pregnancies, gestation, preeclampsia, eclampsias, hellp syndrome, retina, hypertensive retinopathies, diabetic retinopathies, central serous chorioretinopathies, retinal vein occlusions, retinal artery occlusions, idiopathic intracranial hypertension, computer vision system, machine intelligence

Correspondences: Pegah Rashidian, Vali-e-Asr Reproductive Health Research Center, Family Health Research Institute, Tehran University of Medical Sciences, Imam Khomeini Hospital, Tehran, Iran. Email: pegah.rashidian@rocketmail.com. ORCID iD: https://orcid.org/0000-0002-9167-9172.

How to cite this article: Rashidian P, Ahmadi S, Jafarabady K, Shafiee A, Noorafrooz MA, Amini-Salehi E, Hantoushzadeh S. Pregnancy-related retinal disorders: clinical features, systemic associations, and management insights. Med Hypothesis Discov Innov Optom. 2025 Fall; 6(3): 129-143. DOI: https://doi.org/10.51329/mehdioptometry232.

Received: 22 August 2025; Accepted: 30 October 2025

INTRODUCTION

Pregnancy represents a unique physiological state characterized by profound systemic adaptations that support fetal development and prepare the maternal body for childbirth [1]. These changes encompass significant hemodynamic alterations, endocrine fluctuations, metabolic modifications, and immunologic adaptations. Although generally advantageous or clinically insignificant, such changes can unmask preexisting disorders, aggravate underlying conditions, or initiate new pathologies, including those involving the ocular system; this in turn affects visual health in both the mother and the neonate [2, 3]. The retina, with its high metabolic demand, intricate microvascular architecture, and sensitivity to vascular and inflammatory insults, is particularly susceptible to such pregnancy-related changes [4].

Ocular alterations during pregnancy are often transient and physiological—such as a reduction in intraocular pressure or changes in corneal sensitivity. However, in certain circumstances pregnancy can trigger sight-threatening retinal pathology or accelerate pre-existing disease [5]. Among the most clinically significant entities are hypertensive retinopathy associated with preeclampsia and eclampsia, which may present with arteriolar narrowing, retinal hemorrhages, cotton-wool spots, and, in severe cases, serous retinal detachment (SRD) [6]. Metabolic adaptations, particularly in women with pregestational diabetes, may lead to rapid progression of diabetic retinopathy (DR), sometimes advancing from nonproliferative to proliferative stages within a few months [7]. Pregnancy has also been implicated in the development of central serous chorioretinopathy (CSCR), retinal vascular occlusions, and less common inflammatory or autoimmune-mediated retinal disorders [8].

The pathophysiological mechanisms underlying these conditions are multifactorial. Hemodynamic expansion can increase retinal perfusion pressure, hormonal changes may alter vascular permeability and choroidal circulation, and pregnancy-induced immune modulation can influence the activity of inflammatory retinal diseases. Additionally, the hypercoagulable state inherent to pregnancy predisposes affected individuals to retinal vein or artery occlusions (RVO or RAO) [9].

Management of retinal disease during pregnancy requires a careful balance between preserving maternal visual function and ensuring fetal safety. Diagnostic imaging modalities and pharmacologic interventions may be restricted due to potential teratogenic or fetotoxic risks, limiting therapeutic options. Consequently, optimal care often necessitates close, multidisciplinary collaboration between ophthalmologists, obstetricians, and other relevant specialists [10].

Despite the clinical importance of this topic, the existing literature remains fragmented, largely comprising isolated case reports, small case series, and disease-specific reviews. A comprehensive synthesis is therefore warranted. This review consolidates current evidence on retinal diseases induced or exacerbated by pregnancy, examining their epidemiology, pathophysiology, clinical manifestations, diagnostic considerations, and management strategies. By integrating ophthalmological and obstetric perspectives, it aims to provide a practical, evidence-based resource to guide clinical decision-making and improve maternal and fetal outcomes.

METHODS

A comprehensive literature search was conducted to identify studies reporting retinal diseases induced or aggravated by pregnancy from database inception through 31 September 2025. The databases PubMed/MEDLINE, Embase, Web of Science, and Google Scholar were systematically searched. Additional relevant studies were identified through manual screening of the reference lists of included articles.

Search terms included combinations of keywords and Medical Subject Headings (MeSH) related to pregnancy and retinal pathology, including “pregnancy”, “preeclampsia”, “eclampsia”, “HELLP syndrome”, “hemolysis, elevated liver enzyme levels, and low platelets syndrome”, “retinal disease“, “retinopathy”, “hypertensive retinopathy”, “serous retinal detachment”, “central serous chorioretinopathy”, “diabetic retinopathy”, “Valsalva retinopathy”, “retinal vein occlusion”, “retinal artery occlusion”, “idiopathic intracranial hypertension”, and “artificial intelligence”. Eligible articles comprised case reports, case series, observational studies, reviews, and meta-analyses describing retinal conditions specifically induced by or worsened during pregnancy. Data from included studies were synthesized narratively.

RESULTS and DISCUSSION

Retinal Diseases Induced or Aggravated by Pregnancy

Hypertensive Retinopathy

Hypertensive retinopathy is a common and clinically important ocular manifestation of hypertensive disorders during pregnancy, including preeclampsia, eclampsia, and hemolysis, elevated liver enzymes, and low platelets (HELLP) syndrome [11-13]. These conditions are associated with widespread endothelial damage and vascular constriction, and ocular changes often serve as early indicators of disease severity [11]. Visual complaints such as blurred vision, photopsias, scotomas, and diplopia are frequent and may result from either retinal abnormalities or disruptions in the cortical visual pathways [14].

In pregnancy-induced hypertension, retinal changes typically progress through three phases [15, 16]. The first phase, termed the *spastic phase*, involves transient constriction of retinal arterioles, which may cause reversible vision loss such as amaurosis fugax. The second phase, or *sclerotic phase*, occurs when hypertensive changes are superimposed on existing vascular sclerosis, leading to signs like vascular narrowing, arteriovenous crossing changes (Gunn’s and Salus’s signs), and alterations in light reflex, such as copper- or silver-wiring of the vessels. The final phase, known as the *retinopathy phase*, includes the

appearance of cotton-wool spots, microaneurysms, hemorrhages (flame-shaped or blot), hard exudates, and swelling of the optic disc, reflecting underlying ischemia and vascular leakage [15, 17].

In preeclampsia, these retinal findings may occur anew or worsen pre-existing ocular conditions. Research indicates that 40%–100% of individuals with preeclampsia develop retinal vascular changes, including arteriolar narrowing, tortuosity, vasospasm, and vascular occlusion [18]. The extent of these changes is closely linked to diastolic blood pressure levels, making them useful as noninvasive markers of disease severity. Advanced imaging techniques, such as fundus photography, optical coherence tomography (OCT), and OCT angiography have identified complications like SRD, subretinal drusenoid deposits, and choroidal vascular changes, all of which are also observed in malignant hypertension [19-21].

Both retina and choroid are implicated in the disease process. The choroid, which has the highest blood flow per unit area in the body and is sensitive to vascular endothelial growth factor (VEGF), is particularly vulnerable to sudden spikes in blood pressure. Choroidal ischemia may result in dysfunction of the retinal pigment epithelium (RPE), leading to retinal damage and potential long-term visual impairment. OCT studies show increased choroidal thickness in patients with preeclampsia, usually subsiding after childbirth [6, 22-24].

Neurological visual disturbances can also accompany these ocular findings. Posterior reversible encephalopathy syndrome, a condition involving vasogenic edema mainly in the occipital lobes, affects up to one-third of patients with preeclampsia with neurological symptoms and may lead to temporary or lasting vision loss. Other complications such as cortical blindness, visual field loss, and sixth cranial nerve palsy—leading to diplopia—have also been described [25-27].

In summary, hypertensive retinopathy is not only a key ocular finding in hypertensive pregnancy disorders but also a valuable prognostic tool. Its recognition should prompt vigilant monitoring and may necessitate timely delivery. Routine eye examinations are crucial for detecting and managing ocular and neurologic complications to optimize outcomes for both mother and fetus [28].

Serous Retinal Detachment

SRD is an uncommon but serious ocular complication occurring in hypertensive disorders of pregnancy, particularly in cases of severe preeclampsia, eclampsia, and HELLP syndrome [29, 30]. It affects approximately 0.1%–2% of individuals with severe preeclampsia and up to 0.9% of those with HELLP syndrome, with a higher incidence reported in primiparous women, typically during the third trimester or shortly after delivery [31, 32].

SRD presents clinically with visual symptoms such as scotomas, blurred vision, visual obscurations, and occasionally cortical blindness [33]. Fundoscopic findings in these cases may include retinal edema and detachment, typically bilateral and bullous in configuration [33]. In contrast to CSCR or Vogt-Koyanagi-Harada disease, SRD in preeclampsia lacks intraocular inflammation and often involves the macula bilaterally [32].

The underlying pathophysiology of SRD is multifactorial. A central mechanism is choroidal ischemia, thought to result from intense arteriolar vasospasm. The RPE, which relies on choroidal circulation, becomes dysfunctional under ischemic conditions. This impairs the ability of RPE to maintain the outer blood-retinal barrier, leading to fluid leakage into the subretinal space and resultant detachment. In HELLP syndrome the situation may be exacerbated by microthrombi formation and hypoalbuminemia, which increase vascular permeability and reduce oncotic pressure, further promoting fluid accumulation [31, 33].

OCT is the preferred imaging modality in pregnant women as it is noninvasive and safe throughout gestation. OCT provides detailed visualization of retinal layers and can confirm SRD, reveal RPE irregularities, and measure choroidal thickness—which has been found to be significantly increased in patients with SRD. Fluorescein angiography (FA), while informative, is typically reserved for postpartum evaluation due to concerns about teratogenicity [31, 32].

Management of SRD in the context of preeclampsia is generally conservative, focused on stabilizing blood pressure and timely delivery, usually via cesarean section. Most cases resolve spontaneously postpartum, with minimal anatomical or functional sequelae. Persistent visual loss due to cortical damage or retinal vascular occlusion is rare [31, 32].

Central Serous Chorioretinopathy

CSCR is an uncommon retinal disorder in pregnancy characterized by the accumulation of fluid beneath the central retina [34]. It results from a dysfunction in the outer blood-retinal barrier, specifically at the level of the RPE, leading to detachment of the neurosensory retina. Though CSCR is more frequently observed in men between ages 20 and 50, it may occur in pregnant women, typically during the third trimester [34].

CSCR in pregnancy is believed to be triggered by hormonal fluctuations—particularly elevated levels of endogenous corticosteroids like cortisol—and increased emotional or physiological stress [35]. These factors can contribute to changes in choroidal circulation, leading to capillary congestion and increased choroidal vascular permeability. The disruption of the RPE barrier allows fluid from the choroid to accumulate in the subretinal space, causing localized retinal elevation [35].

Clinically, CSCR presents with unilateral visual symptoms such as decreased central vision and metamorphopsia [35]. On fundus examination a well-defined elevation of the macula may be visible, sometimes associated with subretinal fibrin or subtle

exudates. Unlike other causes of SRD in pregnancy, such as those linked to preeclampsia, CSCR typically occurs in normotensive women without systemic findings like proteinuria or edema [32].

OCT and OCT angiography are the preferred imaging modalities during pregnancy due to their safety and high resolution. They can confirm the presence of subretinal fluid and pigment epithelial detachment [36]. While FA is useful in CSCR diagnosis, it is usually avoided in pregnant patients due to potential fetal risks [10].

Most cases of pregnancy-associated CSCR resolve spontaneously within weeks after delivery [37]. Visual acuity generally returns to normal, although some patients may have residual RPE changes or mild visual disturbances [37, 38]. In rare cases, especially when subretinal fluid persists beyond several months or in the presence of recurrence, treatment may be considered [34, 35, 37]. Options include focal laser therapy or photodynamic therapy, though these are typically postponed until after delivery [37, 39]. Recurrence in subsequent pregnancies has been documented, and some individuals may experience multiple episodes [37, 40].

Worsening of Diabetic Retinopathy

DR, a frequent microvascular fallout of longstanding diabetes, tends to worsen during pregnancy, largely as a result of various intersecting hormonal shifts, metabolic fluctuations, and circulatory adjustments that destabilize retinal vasculature [7, 41, 42]. Approximately 15% of pregnant women with diabetes develop new DR, and about 6% with mild nonproliferative DR (NPDR) and up to 29% with moderate-to-severe NPDR progress to proliferative stages. Progression to advanced DR is uncommon in women who have no DR at baseline [41, 43-45]. This deterioration is driven largely by elevations in placental growth hormone and VEGF levels, a rise in insulin resistance, and the overall increase in maternal blood volume, all of which act together to encourage abnormal new vessel formation and fluid leakage in the retina [7, 42, 46, 47]. DR is the leading cause of blindness in reproductive-age women, and pregnancy itself is a recognized risk factor for its progression [45, 48]. Despite the long-term benefits of improved glycemic control, rapid normalization of blood glucose early in pregnancy can paradoxically worsen DR due to osmotic shifts in the retina [49, 50]. Increased retinal permeability leads to hemorrhages, exudates, and diabetic macular edema (DME), a major cause of vision loss. In DME, fluid leaks into the macula, causing thickening and visual distortion [51].

In terms of symptoms, DR often flies under the radar until it has significantly progressed, at which point patients might report things like blurred vision, new floaters, or loss of central vision, especially when DME develops [50, 52, 53].

Fundus examination can reveal a range of retinal abnormalities, including microaneurysms, cotton-wool spots, and scattered intraretinal hemorrhages, all of which are indicative of mild or moderate NPDR [54]. When neovascularization is present, this generally reflects a shift toward the proliferative phase [55].

OCT remains a key imaging modality for assessing retinal architecture, especially when it comes to identifying macular thickening, and is widely regarded as the standard approach for confirming DME [43, 56]. Although FA can provide valuable insight into the retinal vasculature, its use in pregnant patients is usually limited due to potential risks to the fetus [7]. Noninvasive imaging approaches like color fundus photography, along with deep learning CNN-based systems, have shown promise in early flagging and grading of DR, which may be useful in pregnancy care. These artificial intelligence (AI) platforms haven't yet been specifically validated for use in pregnant populations though [7, 57].

Recent advances have led to the development of novel treatment options for DR [58]. The primary aim of treatment is to maintain tight control over blood glucose levels and blood pressure, both of which play central roles in slowing or stopping the progression of DR [59]. Laser photocoagulation is considered safe and remains the first-line treatment for proliferative DR during pregnancy; it can regress neovascular vessels and prevent vision-threatening hemorrhages [50, 60-63]. Anti-VEGF agents are typically avoided owing to insufficient safety data in this population, though in situations where vision is clearly threatened, ranibizumab with shorter systemic half-life may be considered with caution, usually later in gestation [7, 64, 65]. When it comes to treating DME, focal or grid laser therapy is generally favored, particularly in cases where the fovea remains uninvolved. Intravitreal injections, on the other hand, are typically held back for situations where the edema is either more advanced or not responding to initial treatments [66, 67].

The outlook depends heavily on how severe the retinopathy is at the outset, the level of glycemic control maintained throughout, and whether the patient adheres reliably to follow-up care [60, 68]. DR often regresses postpartum, and if stable after delivery it typically does not worsen in future pregnancies. Still, individuals who enter pregnancy with advanced DR face a greater risk of persistent visual impairment [48].

A thorough ophthalmologic assessment should be performed in the first trimester for all pregnant patients with diabetes, with follow-up intervals ranging from 3 to 12 months based on how advanced the disease is [43]. Monthly evaluations may be needed for more serious cases. Labor and delivery planning ought to include ophthalmologic consultation, especially in cases of proliferative DR, where the exertional strain of labor could raise the risk of Valsalva-induced issues, occasionally tipping the balance in favor of cesarean section as a precautionary measure [42]. Close collaboration among eye specialists, endocrinologists, ophthalmic nurses, and obstetricians is key to managing these patients effectively [7, 69].

Emerging AI tools may support early detection and management planning. Newer AI tools like IDx-DR and EyeArt have demonstrated solid accuracy in spotting referable DR and could be useful additions to routine screening protocols [70, 71].

Valsalva Retinopathy (VR)

VR represents a sudden-onset retinal hemorrhagic event, precipitated by sharp elevations in either intrathoracic or intra-abdominal pressure. This abrupt strain can rupture superficial retinal capillaries, resulting in preretinal hemorrhages, most often situated beneath the internal limiting membrane or within the subhyaloid space [72-74].

Pregnancy increases the chances of developing VR due to several overlapping physiological changes. As the uterus enlarges, venous pressure rises, and hormonal shifts may weaken vascular walls. Added to this, repeated physical strain from actions like persistent coughing, intense vomiting seen in hyperemesis gravidarum, or the effort involved in labor can place further stress on already fragile retinal vessels [75, 76]. Such physiological strain can lead to sudden, short-lived spikes in venous pressure within the eye, enough to rupture the thin-walled capillaries, most commonly in the macular region, where vessels are especially vulnerable [77, 78].

Clinically, patients usually report a sudden and painless drop in vision, central visual field defects, or the presence of floaters—symptoms that in the context of pregnancy may be wrongly dismissed as benign or transient visual disturbances [77, 79, 80]. When examined ophthalmoscopically, the hemorrhages generally appear as sharply outlined, boat-shaped pools of blood layered over the macula, sometimes obscuring the deeper retinal structures beneath them [80]. OCT serves as the preferred imaging technique, allowing precise localization of the hemorrhage and assessment of retinal involvement; characteristic features may include hyperreflective dome-shaped elevations and possible disruption of the ellipsoid zone [81]. In most cases, diagnosis is based on clinical findings, with OCT often used to support the assessment when needed [80].

A watch-and-wait approach is generally sufficient, as the hemorrhage usually clears on its own over the span of a few months. During these recovery phase patients are commonly advised to steer clear of physical strain, especially lifting or bearing down, as added pressure might worsen the bleed [79, 82-84]. In cases where the hemorrhage is particularly dense or slow to resolve, and vision is notably impaired, Nd:YAG laser hyaloidotomy can sometimes speed things along by allowing the blood to drain into the vitreous cavity. If that doesn't work or the hemorrhage continues to linger, a vitrectomy via the pars plana route might be considered, although surgical options are approached with caution during pregnancy because of the inherent risks involved [78].

The prognosis is generally favorable, with most patients recovering near-normal visual acuity (often 20/20 to 20/30) because the neurosensory retina typically remains anatomically intact. Reported outcomes are similar with or without intervention. Recurrence is uncommon but documented, particularly in subsequent pregnancies or the postpartum period. Importantly, cesarean delivery does not appear to reduce recurrence risk, as episodes may also be precipitated by Valsalva-type events such as vomiting or coughing. [77, 85].

Decisions around delivery should be made based on standard obstetric factors, though ophthalmology may have a role when active bleeding or repeat episodes are present. Preventive recommendations typically include controlling emesis, using stool softeners, and avoiding activities that may precipitate a Valsalva response [86].

Although no AI tools have been specifically validated for VR, established imaging modalities such as OCT and fundus photography remain valuable for monitoring structural changes. For patients with limited access or mobility—often the case during pregnancy—smartphone-adapted fundus cameras and teleophthalmology platforms can facilitate remote evaluation. Emerging AI models developed for related retinal hemorrhagic disorders [87-91] may eventually aid in quantifying hemorrhage burden or estimating recurrence risk.

Retinal Vein and Artery Occlusions

RVO and RAO represent serious vascular disturbances of the retina that can be precipitated or exacerbated during pregnancy, largely owing to the prothrombotic milieu, increased vascular permeability, and the complex hormonal and hemodynamic fluctuations characteristic of gestation [92, 93]. RVO tends to occur more often than RAO and includes both central (CRVO) and branch (BRVO) types, while RAO encompasses central (CRAO) and branch (BRAO) types plus cases involving the cilioretinal artery [94, 95].

Pregnancy brings about a physiological tilt toward hypercoagulability, shaped by several interrelated factors: an upsurge in clotting proteins, reduced function of natural anticoagulants like protein S and antithrombin III, and sluggish venous return due to progesterone-induced vascular relaxation. Taken together, these alterations significantly raise the likelihood of thrombus development [47, 92, 96, 97]. In RVO, pregnancy-related physiological alterations, particularly when compounded by conditions such as preeclampsia or underlying thrombophilic disorders, may increase susceptibility to vein occlusion. RAO, in contrast, typically results from emboli originating from cardiac sources or atherosclerotic plaques within larger vessels [9, 97, 98].

Clinically, patients typically present with sudden-onset, usually unilateral vision loss or visual field defects that correspond to the territory of the affected vessel. In the context of pregnancy, such symptoms can be mistaken for benign or transient visual disturbances. When preeclampsia is present, additional systemic signs may indicate a more generalized vascular pathology [99-101].

On fundoscopic examination, RVO typically presents with intraretinal hemorrhages, engorged and tortuous retinal veins, cotton-wool spots, and macular edema. In contrast, RAO is characterized by a blanched retinal appearance due to ischemia; in CRAO the fovea remains visible as a cherry-red spot, whereas BRAO produces localized retinal whitening corresponding to the

affected vascular territory [100, 102-104]. Imaging modalities such as OCT and OCT angiography play a central role in evaluating both anatomical and vascular alterations of the retina. These imaging techniques enable detection of fluid accumulation in the macula, identification of regions with inadequate capillary perfusion, and visualization of broader disruptions in retinal blood flow. Quantitative analysis of the retinal vasculature can be performed using platforms such as the Singapore I Vessel Assessment (SIVA) and the Vessel Assessment and Measurement Platform for Images of the Retina (VAMPIRE). Moreover, AI-based systems such as PROMPT (Preeclampsia Risk factor + Ophthalmic data + Mean arterial pressure Prediction Test) provide individualized predictive models for risk evaluation and longitudinal disease monitoring [92, 105-108].

Diagnostic protocols during pregnancy rely predominantly on noninvasive imaging modalities—namely, fundus photography, OCT, and OCT angiography—given the safety considerations associated with gestation. Although FA provides valuable diagnostic insights, it is generally avoided because of potential fetal risks. OCT-derived biomarkers, including central macular thickness, ellipsoid zone integrity, and the presence of foveal hemorrhage, offer important prognostic information [109-111].

Therapeutic decisions during pregnancy are guided primarily by considerations of maternal and fetal safety. In cases of nonischemic BRVO without macular involvement, a conservative, observational approach is generally appropriate. However, when ischemia is present or the macula is affected, laser photocoagulation is typically indicated. Although anti-VEGF therapy is generally avoided during pregnancy due to safety concerns, its use—particularly with agents such as ranibizumab—may be cautiously considered in the later stages of gestation when vision is acutely threatened [10, 100, 109, 112]. The safety profile of intravitreal corticosteroids remains inadequately defined. In patients with documented thrombophilia, low-molecular-weight heparin represents a safe and effective therapeutic option [113-117].

Visual prognosis is variable and depends on both location and extent of the ischemia. Recovery is more likely in BRVO and BRAO when the macula is spared; however, CRVO and CRAO are associated with a greater risk of permanent vision loss [93]. Pregnancy itself does not inherently worsen retinal prognosis [98], although therapeutic options may be limited due to fetal safety concerns. The occurrence of a vascular occlusion during gestation should prompt a comprehensive systemic evaluation to investigate potential coagulopathies, hypertensive disorders, and cardioembolic sources. Close interdisciplinary coordination is essential; though obstetric management typically remains unchanged unless significant visual deterioration occurs in the later stages of pregnancy [114].

From a technological perspective, AI, particularly models integrating OCT angiography-derived data, continues to evolve rapidly. These platforms are increasingly valuable for detecting ischemic alterations and enhancing risk stratification, providing clinicians with noninvasive, safe, and precise tools for longitudinal monitoring and more nuanced clinical decision-making [109, 118].

Papilledema from Idiopathic Intracranial Hypertension (IIH)

IIH, also known as pseudotumor cerebri, is characterized by elevated intracranial pressure in the absence of a mass lesion or abnormal cerebrospinal fluid (CSF) composition [119]. The condition predominantly affects obese women of reproductive age and may arise de novo during pregnancy or worsen as gestation progresses. Hormonal fluctuations, elevated estrogen levels, fluid retention, and weight gain are believed to contribute to disease onset [97, 120, 121]. Papilledema—the cardinal ocular manifestation—results from impaired axoplasmic flow at the optic nerve head and, if left untreated, can lead to irreversible vision loss [120].

Mechanistically, IIH is associated with impaired CSF reabsorption at the arachnoid granulations and elevated venous sinus pressure, frequently linked to transverse sinus stenosis. Obesity may further increase intra-abdominal pressure, thereby impeding cerebral venous outflow. Additionally, adipokines such as leptin have been implicated in stimulating CSF production [97, 122, 123].

Common presenting symptoms include generalized headache, transient visual obscurations, diplopia secondary to sixth nerve palsy, and pulsatile tinnitus. These manifestations may be mistaken for nonspecific pregnancy-related complaints, potentially delaying diagnosis [123-125].

Fundoscopic examination typically reveals bilateral optic disc swelling. OCT serves as a key diagnostic adjunct by quantifying retinal nerve fiber layer and total retinal thickness, both of which correlate with disease severity [126]. Elevated body mass index, polycystic ovary syndrome, and rapid gestational weight gain are recognized risk factors for IIH. Pregnant patients with newly diagnosed IIH tend to exhibit a more rapid increase in total retinal thickness and more pronounced papilledema compared with those who have a pre-existing diagnosis [122, 123, 127, 128].

Detection of papilledema warrants a comprehensive diagnostic evaluation. IIH should be considered only after exclusion of secondary causes. Magnetic resonance imaging (MRI) with magnetic resonance venography (MRV), performed without gadolinium enhancement, is safe during pregnancy and helps rule out space-occupying lesions or cerebral venous thrombosis. MRI may also demonstrate subtle, nonspecific findings such as an empty sella or dilated optic nerve sheaths. Following neuroimaging, lumbar puncture—preferably performed in the lateral decubitus position—confirms the diagnosis when the CSF opening pressure exceeds 250 mm H_2O with otherwise normal composition. Serial ophthalmic evaluations incorporating the Frisen grading scale and automated perimetry are essential for monitoring papilledema and visual field changes. OCT provides objective and reproducible quantification of optic nerve head swelling and is increasingly applied in conjunction with machine

learning-based analyses. The presence of a relative afferent pupillary defect or impaired color vision indicates optic nerve dysfunction [120, 122, 128].

Management aims to preserve maternal vision while minimizing fetal exposure. Nutritional counseling and weight optimization constitute the first-line approach [129]. Acetazolamide, which decreases CSF production, is generally effective and considered relatively safe during pregnancy; although early animal studies raised concerns regarding teratogenicity, subsequent human data have not evidenced clear adverse effects [130–132]. In contrast, topiramate is contraindicated due to its association with cleft lip and other congenital malformations [133, 134]. Headache symptoms often improve with reduction in intracranial pressure, although this response can be variable [135]. Nonsteroidal anti-inflammatory drugs are generally regarded as safe until the third trimester, after which their use may increase the risk of premature ductus arteriosus closure or oligohydramnios. Opioid analgesics should be avoided because of the potential for neonatal withdrawal [136, 137]. Serial lumbar punctures performed every 10 to 14 days may provide temporary relief when other measures fail, though the procedure is technically challenging and often poorly tolerated during pregnancy [120]. Surgical options, including optic nerve sheath fenestration [138] and ventriculoperitoneal shunting [120, 139, 140], are reserved for severe or refractory cases.

The prognosis for IIH during pregnancy is generally favorable with timely diagnosis and appropriate management. Patients with pre-existing IIH typically remain stable, whereas new-onset cases arising during pregnancy are more likely to experience disease progression. Postpartum improvement is common [120, 122, 123, 130, 141]. Long-term visual outcomes largely depend on baseline optic nerve status and pre-pregnancy body mass index [122]. Close interdisciplinary coordination among neurology, ophthalmology, obstetrics, and anesthesiology is essential for optimal care. Ongoing surveillance with OCT, visual field testing, and weight monitoring assist in disease monitoring and therapeutic decision-making. Epidural anesthesia is preferred during labor to minimize intracranial pressure fluctuations, while cesarean delivery is reserved for patients with severe papilledema or specific obstetric indications [123, 132, 142, 143].

Emerging AI applications, particularly deep learning models utilizing OCT and fundus imaging, signal considerable promise for the detection and longitudinal monitoring of papilledema. These platforms provide safe, noninvasive diagnostic support, which is especially valuable during pregnancy. However, further validation in pregnant populations remains necessary to establish their reliability and clinical utility [144–146]. A comprehensive overview of the etiology, pathophysiology, retinal manifestations, clinical features, diagnostic approaches, management strategies, and pregnancy-specific considerations, including prognosis of each pregnancy-associated retinal disorder, is summarized in Table 1.

Emerging Role of AI in Pregnancy-Related Retinal Diseases

Recent advances in AI show substantial potential in the diagnosis of retinal diseases, particularly in remote or resource-limited settings where access to specialist care is limited [151]. Specific retinal abnormalities—including macular edema [152,153], exudates [153], cotton-wool spots [154], microaneurysms [155], and optic disc neovascularization [156]—can be effectively identified using conventional machine-learning techniques. AI-based diagnostic systems represent a significant step forward in the early detection and management of hypertensive retinopathy, offering considerable benefits for both clinicians and patients [157].

AI algorithms applied to retinal fundus photographs evidence promising utility in predicting preeclampsia [158]. In parallel, AI-based systems exhibit robust diagnostic performance in detecting DR, with sensitivity and specificity values comparable to—and, in some cases, exceeding—those of human experts [159]. For instance, a systematic review and meta-analysis of 21 studies reported pooled sensitivity and specificity values of 0.880 (95% CI, 0.875–0.884) and 0.912 (95% CI, 0.909–0.913), respectively, for AI-based DR detection [160]. To enhance clinical applicability, AI systems must integrate multimodal imaging modalities—such as fundus photography, OCT, and OCT angiography—and leverage large, diverse, and high-quality datasets that capture real-world variations in disease phenotypes, patient populations, and imaging conditions [151,161].

This review provides a broad and integrative overview of retinal diseases induced or aggravated by pregnancy, synthesizing evidence from diverse study designs and highlighting emerging diagnostic and AI-based approaches. Its strength lies in the comprehensive synthesis of the literature and the detailed clinical and pathophysiologic insights that enhance clinical relevance. However, as a narrative rather than a systematic review it may not encompass all pertinent studies, introducing potential selection bias. The heterogeneity of available evidence and the predominance of case-based reports further limit generalizability. Overall, pregnancy can trigger or exacerbate a spectrum of retinal disorders, including hypertensive retinopathy, SRD, and CSCR—particularly in preeclampsia or eclampsia, where ocular findings may serve as early indicators of disease severity. Pre-existing DR often worsens, necessitating stringent metabolic and blood pressure control, while less common conditions such as retinal vascular occlusions and papilledema secondary to IIH may pose substantial visual and systemic risks. Diagnosis relies on safe, noninvasive imaging modalities such as fundus photography, OCT, and OCT angiography, and most conditions improve postpartum with timely, multidisciplinary management. Emerging AI-based tools show promise for screening and risk prediction but require validation in pregnant populations. Future systematic reviews, meta-analyses, and longitudinal studies are warranted to develop evidence-based screening and management protocols that integrate ocular findings into comprehensive maternal care and improve both visual and systemic outcomes.

Table 1. Summary of key features of retinal diseases associated with pregnancy

Condition	Etiology	Pathophysiology	Retinal manifestations	Clinical features	Diagnostic approaches	Management strategies	Pregnancy-specific considerations and prognosis
Hypertensive retinopathy [14-21, 28]	Pregnancy-related hypertension	Systemic hypertension causes vascular changes and endothelial damage	- Arteriolar narrowing - Retinal hemorrhages - Cotton-wool spots - Hard exudates. - Optic disc swelling	- Blurring of vision - Photopsia - Scotomas - Diplopia	- Fundoscopy. - OCT - OCT angiography	- Close monitoring - Treat hypertension.	- Requires frequent monitoring of blood pressure - Can resolve postpartum in some cases
SRD [29-33, 147, 148]	Severe preeclampsia or Eclampsia	Choroidal ischemia and retinal pigment epithelium dysfunction	- Subretinal fluid - Retinal detachment	- Blurring of vision -Metamorphopsia - Loss of central vision	- Fundoscopy - OCT	- Monitor for resolution postpartum. - Possible need for interventions in severe cases	- Requires management of preeclampsia - Close follow-up after delivery
CSCR [35-40, 149, 150]	Hormonal and hemodynamic changes	Alterations in choroidal circulation and fluid retention in the retina	- SRD - RPE abnormalities	- Blurring of central vision - Metamorphopsia	- Fundoscopy - OCT - OCT angiography	- Often resolves postpartum. - Sometimes requires focal laser therapy or photodynamic therapy	- Hormonal changes may exacerbate CSCR during pregnancy - Resolution after delivery is common
Worsening of DR [7, 41-43, 50-56, 60-63]	Pregnancy-related hormonal changes	Pregnancy exacerbates preexisting DR	- Diabetic macular edema - Microaneurysms - Cotton-wool spots - Retinal neovascularization	- Blurring of vision - Difficulty seeing at night	- Fundoscopy - OCT	- Tight glycemic control - Frequent ophthalmic monitoring -Laser photocoagulation	- Requires strict control of blood glucose - Increased monitoring during pregnancy
Valsalva retinopathy [72-84]	Increased intrathoracic pressure	Raised pressure ruptures retinal capillaries	- Preretinal hemorrhage	- Sudden vision loss. - Blurring of vision in one eye	- Fundoscopy - OCT	- Observation. - Treatment of underlying cause (e.g., vomiting)	- Often triggered during labor or vomiting - Spontaneous resolution in many cases
Retinal vein and artery occlusions [92, 93, 96-111]	Hypercoagulability of pregnancy	Pregnancy-induced changes in coagulation lead to vascular occlusion	- Retinal hemorrhages - Retinal ischemia - Cotton-wool spots	- Sudden vision loss. - Blurring of vision	- Fundoscopy - OCT - OCT angiography	- Immediate management to reduce risk of vision loss - Possible need for anticoagulation therapy	- Hypercoagulability during pregnancy increases risk - Requires prompt anticoagulation if needed
Papilledema from IIH [97, 119-130, 141-143]	Increased ICP	Raised ICP leads to optic disc swelling	- Optic disc edema - Peripapillary hemorrhages - Enlarged blind spot	- Headaches - Transient visual obscurations - Diplopia - Nausea	- Fundoscopy - OCT - MRI of the brain	- Manage weight - Manage ICP - Ophthalmologic monitoring - Often resolves postpartum	- May require close monitoring of both ICP and vision

Abbreviations: OCT, optical coherence tomography; SRD, serous retinal detachment; CSCR, central serous chorioretinopathy; RPE, retinal pigment epithelium; DR, diabetic retinopathy; IIH, idiopathic intracranial hypertension; ICP, intracranial pressure; MRI, magnetic resonance imaging.

CONCLUSIONS

Pregnancy can precipitate or exacerbate a range of retinal disorders, reflecting the complex vascular, hormonal, and metabolic changes of gestation. Early recognition of ocular manifestations is critical, as they often parallel systemic disease severity and may inform timely obstetric management. Noninvasive imaging, interdisciplinary collaboration, and vigilant monitoring are essential to optimizing maternal and fetal outcomes. Although most retinal changes resolve postpartum, continued awareness and prompt management remain necessary. Future research should prioritize longitudinal studies and AI-driven tools to refine screening, diagnosis, and personalized care in pregnant populations.

ETHICAL DECLARATIONS

Ethical approval: Not required.

Conflict of interests: None.

FUNDING

None.

ACKNOWLEDGMENTS

None.

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