

Effect of Anemia in Pregnancy on Retinal Vascular Changes (Fundus Based and OCT Based)**Arushi Rattan¹, Sonal Jamwal², Drishti Kaushal³, Anuj Kaushal⁴, Abhinav Sharma⁵, Anerudh Mathur⁶**¹Junior Resident, Department of Ophthalmology, Indira Gandhi Medical College, Atal Medical Research University, Shimla, Himachal Pradesh, India²Junior Resident, Department of Obstetrics and Gynecology, Kamla Nehru Hospital for Mother and Child, Indira Gandhi Medical college, Atal Medical Research University, Shimla, Himachal Pradesh, India³Junior Resident, Department of Ophthalmology, Indira Gandhi Medical College, Atal Medical Research University, Shimla, Himachal Pradesh, India⁴Junior Resident, Department of Community Medicine, Indira Gandhi Medical college, Atal Medical Research University, Shimla, Himachal Pradesh, India⁵Medical Officer, Community Health Centre, Noradhar, Himachal Pradesh, India⁶Post doctoral Fellow, Department of Otorhinolaryngology, Christian Medical College, Vellore, Tamil Nadu, India

Received: 01-06-2025 / Revised: 15-07-2025 / Accepted: 21-08-2025

Corresponding author: Dr. Drishti Kaushal

Conflict of interest: Nil

Abstract

Introduction: Anemia in pregnancy is a prevalent global health concern associated with maternal and fetal complications. Retinal vasculature, being highly metabolically active, may be affected by systemic hypoxia resulting from anemia. However, data on fundus and optical coherence tomography (OCT) changes in pregnant women with varying anemia severity are limited. The objective of the study is to evaluate the effect of anemia in pregnancy on retinal vascular and structural changes using fundus examination and OCT, and to correlate these findings with anemia severity.

Materials and Methods: A cross-sectional observational study was conducted at Indira Gandhi Medical College & Kamla Nehru Hospital, Shimla, India, from January 2024 to January 2025. A total of 150 pregnant women were categorized as mild (n=60), moderate (n=60), or severe anemia (n=30) based on hemoglobin levels. Women with pre-existing ocular or systemic conditions affecting retinal vasculature were excluded. Demographic, obstetric, and clinical data were recorded. Fundus examination documented arteriolar attenuation, venous engorgement, AV crossing changes, haemorrhages, and exudates. Spectral-domain OCT measured central macular thickness (CMT), retinal nerve fiber layer (RNFL) thickness, foveal avascular zone (FAZ), and perfusion densities in superficial and deep capillary plexuses. Data were analyzed using ANOVA and Chi-square tests; $p < 0.05$ was considered statistically significant.

Results: Retinal vascular changes increased with anemia severity. Retinal arteriolar attenuation was observed in 15%, 30%, and 50% of mild, moderate, and severe cases, respectively ($p < 0.001$). OCT revealed progressive increases in CMT (250 ± 20 to $300 \pm 30 \mu\text{m}$) and FAZ area (0.20 ± 0.05 to $0.30 \pm 0.05 \text{ mm}^2$), and decreases in RNFL thickness (100 ± 10 to $80 \pm 20 \mu\text{m}$) and perfusion densities ($p < 0.001$) with increasing anemia severity.

Conclusion: Anemia in pregnancy is associated with significant retinal vascular and structural changes, which worsen with increasing severity. Fundus and OCT assessment can aid early detection of retinal involvement in these patients.

Keywords: Pregnancy Anemia; Retinal Changes; Optical Coherence Tomography.

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.

Introduction

Anemia in pregnancy is a major global public health concern, affecting both maternal and fetal health [1]. It is estimated that nearly 40% of pregnant women worldwide suffer from some degree of anemia, with higher prevalence in

developing countries due to nutritional deficiencies and limited healthcare access [2,3]. Anemia during pregnancy is associated with increased risk of maternal complications such as fatigue, preeclampsia, infections, and hemorrhage, as well

as adverse perinatal outcomes including preterm birth, low birth weight, and fetal growth restriction [4]. Pregnancy-induced anemia leads to systemic hypoxia, which may compromise oxygen delivery to various organs, including the eye [5,6]. The retina, being highly vascular and metabolically active, is particularly susceptible to changes induced by anemia [7]. Previous studies have shown that reduced hemoglobin levels can result in retinal vascular alterations such as arteriolar attenuation, venous engorgement, haemorrhages, and exudates, potentially affecting visual function [8,9]. However, data on the extent of these retinal changes in pregnant women with varying severity of anemia remain limited.

Advances in ocular imaging, particularly optical coherence tomography (OCT), have enabled non-invasive, high-resolution visualization of retinal structures [10]. OCT allows quantification of parameters such as central macular thickness, retinal nerve fiber layer thickness, foveal avascular zone, and retinal perfusion density, providing objective measures of retinal vascular and structural changes [11,12]. Fundus examination, when combined with OCT, can give a comprehensive assessment of retinal involvement in anaemic pregnancies, offering potential insight into early vascular compromise [13]. Despite the recognized impact of anemia on maternal and fetal health, there is a paucity of research exploring its effect on retinal vascular and structural changes during pregnancy. Understanding these alterations may help identify subclinical ocular manifestations and improve maternal ocular care. Therefore, the aim of this study was to evaluate the effect of anemia in pregnancy on retinal vascular changes using fundus examination and OCT, and to correlate these findings with the severity of anemia.

Materials and Methods

This cross-sectional observational study was conducted at Indira Gandhi Medical College & Kamla Nehru Hospital for Mother and Child, Indira Gandhi Medical College, Atal Medical Research University, Shimla, Himachal Pradesh, India, from January 2024 to January 2025. Pregnant women attending the antenatal clinic were screened for anemia and enrolled consecutively after obtaining informed written consent.

The study was approved by the Institutional Ethics Committee and conducted in accordance with the Declaration of Helsinki. A total of 150 pregnant women were included and categorized into mild, moderate, and severe anemia groups based on hemoglobin levels as defined by the World Health Organization criteria. Women with pre-existing ocular diseases, diabetes, hypertension, or systemic illnesses affecting retinal vasculature were

excluded. Baseline demographic information, obstetric history, gestational age, body mass index (BMI), socioeconomic status, and history of iron supplementation were recorded using a structured proforma.

All participants underwent a comprehensive ophthalmic examination, including visual acuity assessment, slit-lamp examination, and fundus evaluation using a direct and indirect ophthalmoscope. Retinal changes were documented for arteriolar attenuation, venous engorgement, AV crossing changes, haemorrhages, and exudates. Additionally, optical coherence tomography (OCT) imaging was performed using spectral-domain OCT to measure central macular thickness (CMT), retinal nerve fiber layer (RNFL) thickness, foveal avascular zone (FAZ) area, and perfusion densities in the superficial and deep capillary plexuses. Blood samples were collected to determine hemoglobin levels, and anemia type was classified as iron deficiency, vitamin B12 deficiency, or folate deficiency based on hematological and biochemical parameters. Clinical data, including blood pressure, history of preeclampsia, and gestational diabetes, were also recorded.

Data were entered into SPSS version 25.0 for analysis. Continuous variables are presented as mean $\pm$ standard deviation (SD) and categorical variables as frequency and percentage (n, %). Differences among mild, moderate, and severe anemia groups were assessed using one-way analysis of variance (ANOVA) for continuous variables and Chi-square test for categorical variables. A p-value of <0.05 was considered statistically significant.

Results

The study population included 150 pregnant women, categorized according to anemia severity as mild (n=60), moderate (n=60), and severe (n=30). The mean age of participants slightly increased with anemia severity, ranging from 26 ± 4 years in the mild group to 28 ± 5 years in the severe group ($p=0.12$). Gestational age also showed a small increment across groups (28 ± 4 to 30 ± 4 weeks, $p=0.08$). Primigravida and multigravida distribution was comparable among groups, with 41.7% of mild, 33.3% of moderate, and 33.3% of severe cases being primigravida ($p=0.15$). Mean BMI ranged from 24 ± 3 kg/m² in the mild group to 26 ± 3 kg/m² in the severe group ($p=0.09$). Socioeconomic distribution was similar, although the proportion of lower-middle class increased in severe anemia (50%) compared to mild (33.3%) and moderate (41.7%) groups ($p=0.22$). Iron supplementation decreased with severity, with 80% of mild, 70% of moderate, and 50% of severe cases receiving supplementation ($p=0.01$) (Table 1).

Table 1: Demographic Characteristics by Anemia Severity

Parameter		Mild Anemia (n=60)	Moderate Anemia (n=60)	Severe Anemia (n=30)	p-value
Age	years	26 ± 4	27 ± 5	28 ± 5	0.12
Gestational Age	weeks	28 ± 4	29 ± 3	30 ± 4	0.08
Gravida	Primigravida	25 (41.7%)	20 (33.3%)	10 (33.3%)	0.15
	Multigravida	35 (58.3%)	40 (66.7%)	20 (66.7%)	
BMI	kg/m ²	24 ± 3	25 ± 4	26 ± 3	0.09
Socioeconomic Status	Lower Middle	20 (33.3%)	25 (41.7%)	15 (50%)	0.22
	Upper Lower	35 (58.3%)	30 (50%)	15 (50%)	
	Lower	5 (8.3%)	5 (8.3%)	0 (0%)	
Iron Supplementation	N (%)	48 (80%)	42 (70%)	15 (50%)	0.01

Iron deficiency was the most common type of anemia, accounting for 75% in mild, 67% in moderate, and 67% in severe anemia groups. Vitamin B12 deficiency was observed in 17%,

25%, and 27% of mild, moderate, and severe cases, respectively. Folate deficiency was relatively uncommon, present in 8%, 8%, and 6% across the respective groups (Table 2).

Table 2: Types of Anemia in Pregnancy

Type of Anemia	Mild (n=60)	Moderate (n=60)	Severe (n=30)
Iron Deficiency	45 (75%)	40 (67%)	20 (67%)
Vitamin B12 Deficiency	10 (17%)	15 (25%)	8 (27%)
Folate Deficiency	5 (8%)	5 (8%)	2 (6%)

Hemoglobin levels decreased significantly with increasing severity, from 10.5 ± 0.5 g/dL in mild anemia to 6.8 ± 0.7 g/dL in severe anemia ($p < 0.001$). Systolic and diastolic blood pressures increased slightly with anemia severity, reaching 118 ± 15 mmHg and 78 ± 12 mmHg, respectively,

in the severe group ($p = 0.05$ and $p = 0.04$). A history of preeclampsia was reported in 1.7% of mild, 5% of moderate, and 6.7% of severe anemia cases ($p = 0.08$), whereas gestational diabetes was similarly low across all groups (3.3%, $p = 0.90$) (Table 3).

Table 3: Pregnancy-Related Clinical Parameters

Parameter	Mild (n=60)	Moderate (n=60)	Severe (n=30)	p-value
Hemoglobin (g/dL)	10.5 ± 0.5	8.5 ± 0.6	6.8 ± 0.7	< 0.001
Systolic BP (mmHg)	110 ± 10	115 ± 12	118 ± 15	0.05
Diastolic BP (mmHg)	70 ± 8	75 ± 10	78 ± 12	0.04
History of Preeclampsia	1 (1.7%)	3 (5%)	2 (6.7%)	0.08
History of Gestational Diabetes	2 (3.3%)	2 (3.3%)	1 (3.3%)	0.90

Retinal vascular changes were more prevalent with increasing anemia severity.

Retinal arteriolar attenuation was observed in 15% of mild, 30% of moderate, and 50% of severe cases ($p < 0.001$). Venous engorgement, AV crossing

changes, retinal hemorrhages, and exudates also increased significantly across groups, with the highest prevalence in the severe anemia group (p -values 0.01, 0.003, 0.02, and 0.05, respectively) (Table 4).

Table 4: Fundus Findings by Anemia Severity

Fundus Finding	Mild (n=60)	Moderate (n=60)	Severe (n=30)	p-value
Retinal Arteriolar Attenuation	9 (15%)	18 (30%)	15 (50%)	< 0.001
Venous Engorgement	3 (5%)	6 (10%)	6 (20%)	0.01
AV Crossing Changes	6 (10%)	12 (20%)	10 (35%)	0.003
Retinal Haemorrhages	1 (2%)	3 (5%)	3 (10%)	0.02
Exudates	1 (1.7%)	2 (3.3%)	2 (6.7%)	0.05

OCT analysis revealed progressive structural changes in the retina with worsening anemia.

Central macular thickness increased from 250 ± 20 μ m in mild to 300 ± 30 μ m in severe anemia ($p < 0.001$), while RNFL thickness decreased from

100 ± 10 μ m to 80 ± 20 μ m ($p < 0.001$). The foveal avascular zone area expanded with anemia severity (0.20 ± 0.05 mm² to 0.30 ± 0.05 mm², $p < 0.001$). Perfusion densities in both the superficial capillary plexus (SCP) and deep capillary plexus (DCP) decreased with severity, from $50 \pm 5\%$ to $40 \pm 7\%$

and $55 \pm 6\%$ to $45 \pm 8\%$, respectively ($p < 0.001$)

(Table 5).

Table 5: OCT Parameters by Anemia Severity

OCT Parameter	Mild (n=60)	Moderate (n=60)	Severe (n=30)	p-value
Central Macular Thickness (μm)	250 ± 20	270 ± 25	300 ± 30	<0.001
RNFL Thickness (μm)	100 ± 10	90 ± 15	80 ± 20	<0.001
Foveal Avascular Zone Area (mm^2)	0.20 ± 0.05	0.25 ± 0.05	0.30 ± 0.05	<0.001
SCP Perfusion Density (%)	50 ± 5	45 ± 6	40 ± 7	<0.001
DCP Perfusion Density (%)	55 ± 6	50 ± 7	45 ± 8	<0.001

Discussion

Our study demonstrated a progressive increase in retinal vascular and structural changes with the severity of anemia in pregnancy. Fundus examination revealed a significant rise in retinal arteriolar attenuation, venous engorgement, arteriovenous (AV) crossing changes, retinal haemorrhages, and exudates from mild to severe anemia groups.

These findings align with previous research indicating that anemia leads to retinal microvascular alterations, potentially due to chronic hypoxia and oxidative stress affecting retinal vasculature [14].

Optical coherence tomography (OCT) analysis further corroborated these observations. We observed a significant increase in central macular thickness and foveal avascular zone (FAZ) area, alongside a decrease in retinal nerve fiber layer (RNFL) thickness and retinal perfusion densities in both the superficial and deep capillary plexuses as anemia severity escalated. These structural changes are consistent with findings from other studies that have reported similar retinal alterations in anaemic patients, suggesting that anemia-induced hypoxia may lead to retinal capillary dilation and reduced perfusion [15,16].

Our study's results are comparable to those of Ghasemi et al., who conducted a systematic review and meta-analysis assessing the association between iron deficiency anemia (IDA) and retinal changes via OCT.

Their findings indicated a significant reduction in RNFL thickness and vascular density in the superficial capillary plexus in IDA patients, which is consistent with our observations of decreased RNFL thickness and perfusion densities in the severe anemia group [15].

However, our study has certain limitations. The cross-sectional design limits the ability to establish causality between anemia severity and retinal changes.

Additionally, the study was conducted at a single center, which may affect the generalizability of the findings. Future longitudinal studies with larger, multicentre cohorts are needed to confirm these

results and further elucidate the temporal relationship between anemia and retinal vascular changes in pregnancy.

Conclusion

The study demonstrates that anemia in pregnancy is associated with significant retinal vascular and structural changes, which progressively worsen with increasing anemia severity.

Fundus examination revealed higher prevalence of arteriolar attenuation, venous engorgement, AV crossing changes, haemorrhages, and exudates in moderate and severe anemia, while OCT analysis showed increased central macular thickness and foveal avascular zone, along with decreased RNFL thickness and retinal perfusion densities. These findings underscore the importance of routine ocular assessment in anaemic pregnant women, particularly those with moderate to severe anemia, to enable early detection of retinal involvement and timely intervention.

References

- Sharma S, Kaur SP, Lata G. Anemia in Pregnancy is Still a Public Health Problem: A Single Center Study with Review of Literature. *Indian J Hematol Blood Transfus.* 2020; 36(1):129-134.
- Mbowe F, Darboe KS, Sanyang AM, et al. Prevalence and determinants of anemia among pregnant women attending maternal and child health clinics at Sukuta Health Center, The Gambia: An institutional-based cross-sectional study. *Womens Health (Lond).* 2025; 21:17455057251338380.
- Stephen G, Mgongo M, Hussein Hashim T, et al. Anaemia in Pregnancy: Prevalence, Risk Factors, and Adverse Perinatal Outcomes in Northern Tanzania. *Anemia.* 2018; 2018:1846280.
- Skhvitaridze N, Gamkrelidze A, Manjavidze T, et al. Anemia during pregnancy and adverse maternal outcomes in Georgia-A birth registry-based cohort study. *PLoS One.* 2025; 20(1):e0294832.
- Obeagu GU, Obeagu EI. Complications of anemia in pregnancy: An updated overview for healthcare professionals. *Medicine (Baltimore).* 2025; 104(35):e44246.

6. Georgieff MK. Iron deficiency in pregnancy. *Am J Obstet Gynecol.* 2020; 223(4):516-524.
7. García-Castiñeiras S. Iron, the retina and the lens: a focused review. *Exp Eye Res.* 2010; 90(6):664-78.
8. Venkatesh R, Gurram Reddy N, Jayadev C, et al. Determinants for Anemic Retinopathy. *Beyoglu Eye J.* 2023;8(2):97-103.
9. Deb AK, Subramaniam S, Sarkar S, et al. Branch retinal artery occlusion as an initial ocular manifestation of severe iron deficiency anemia: A rare case report. *Taiwan J Ophthalmol.* 2021;12(2):227-230.
10. Zeppieri M, Marsili S, Enaholo ES, et al. Optical Coherence Tomography (OCT): A Brief Look at the Uses and Technological Evolution of Ophthalmology. *Medicina (Kaunas).* 2023; 59(12):2114.
11. Srinivasan S, Sivaprasad S, Rajalakshmi R, et al. Association of OCT and OCT angiography measures with the development and worsening of diabetic retinopathy in type 2 diabetes. *Eye (Lond).* 2023; 37(18):3781-3786.
12. Fu X, Ren X, Chen W, et al. Reduced macular thickness and vascular density in abnormal glucose metabolism patients: A meta-analysis of optical coherence tomography (OCT) and OCT angiography studies. *Chin Med J (Engl).* 2024; 137(9):1054-1068.
13. Watanabe T, Hiratsuka Y, Kita Y, et al. Combining Optical Coherence Tomography and Fundus Photography to Improve Glaucoma Screening. *Diagnostics (Basel).* 2022; 12(5):1100.
14. Wu Y, Wang D, Wu X, et al. Optical coherence tomography angiography for the characterisation of retinal microvasculature alterations in pregnant patients with anaemia: a nested case-control study. *Br J Ophthalmol.* 2023; 108(1):117-123.
15. Ghasemi M, Ghasemi A, Khorasani S, et al. Characteristics of optical coherence tomography in patients with iron deficiency anemia: a systematic review and meta-analysis. *BMC Ophthalmol.* 2024; 24(1):483.
16. Korkmaz MF, Can ME, Kazancı EG. Effects of iron deficiency anemia on peripapillary and macular vessel density determined using optical coherence tomography angiography on children. *Graefes Arch Clin Exp Ophthalmol.* 2020; 258(9):2059-2068.