

Retrobulbar Hemodynamics During Healthy and Preeclamptic Pregnancy

Sağlıklı ve Preeklamptik Gebelikte Retrobulber Hemodinamikler

Zafer Onaran¹ Yasemin Karadeniz Bilgili² Pelin Yılmazbaş¹

¹Department of Ophthalmology, Faculty of Medicine, Kırıkkale University, Kırıkkale, Turkey

²Department of Radiology, Faculty of Medicine, Kırıkkale University, Kırıkkale, Turkey

ABSTRACT

Objective: We aimed to evaluate retrobulbar hemodynamics during healthy and preeclamptic pregnancy.

Methods: We studied retrobulbar hemodynamics in 21 healthy pregnant, 20 preeclamptic and 21 non-pregnant fertile women. The peak systolic velocity, end-diastolic velocity and resistivity index (RI) of the ophthalmic artery (OA), central retinal artery (CRA) and posterior ciliary artery (PCA) were measured by color Doppler imaging.

Results: The systolic and diastolic blood pressures of the preeclamptic women (155±8.5 and 105±7.5 mmHg, respectively) were significantly higher than those of healthy pregnant women (110±5.5 and 70±7.5 mmHg, respectively, p=0.008). The RI values of OA, CRA and PCA in healthy pregnant women were significantly lower than those of the non-pregnant women. The RI of the CRA and PCA in preeclamptic women were significantly higher than those of healthy pregnant women. Although there was no statistical significant difference, the RI of the OA was lower in preeclamptic women than healthy pregnant women.

Conclusion: Resistance of all retrobulbar arteries decreased during healthy pregnancy. On the other hand, increased resistance was detected in PCA and CRA, besides the nonsignificant decrease in OA during preeclamptic pregnancy. Different auto regulator control mechanisms in response to hypertension seem to be responsible for the different conducts of different sized arteries of orbita during preeclamptic pregnancy. (*Gazi Med J 2012; 23: 55-8*)

Key Words: Color Doppler imaging, retrobulbar arteries, pregnancy, preeclampsia

Received: 15.03.2012

Accepted: 17.05.2012

ÖZET

Amaç: Sağlıklı ve preeklamptik gebelik sürecinde retrobulber hemodinamiklerin değerlendirilmesi amaçlanmıştır.

Yöntemler: Yirmi bir sağlıklı gebe, 20 preeklamptik gebe ve 21 gebe olmayan doğurgan yaşta kadın üzerinde retrobulber hemodinamikler çalışıldı. Oftalmik arter (OA), santral retinal arter (SRA) ve posterior siliyer arterin (PSA) tepe sistolik hızı, diastol sonu hızı ve rezistivite indeksleri (RI) renkli Doppler ile ölçüldü.

Bulgular: Sistolik ve diastolik kan basınçları preeklamptik gebelerde (155±8.5 ve 105±7.5 mmHg, sırasıyla) sağlıklı gebelerdekine göre (110±5.5 ve 70±7.5 mmHg, sırasıyla, p=0.008) anlamlı düzeyde yüksek idi. OA, SRA ve PSA'da ölçülen RI değerleri sağlıklı gebelerde gebe olmayanlara göre belirgin şekilde düşük idi. Preeklamptik kadınlarda SRA ve PSA'nın RI değerleri sağlıklı gebe kadınlara göre anlamlı derecede yüksekti. Aradaki fark anlamlı olmasa da OA'nın RI'nın preklamptiklerdeki değeri sağlıklı gebe kadınlardan daha düşük idi.

Sonuç: Gebelik süresince tüm retrobulber arterlerde akıma karşı direnç azalmaktadır. Öte yandan preeklamptik gebelikte PSA ve SRA'da direncin artmasına karşın OA'da anlamlı olmayan bir düşüş saptanmıştır. Preeklamptik gebelikte hipertansiyona cevap olarak geliştirilen farklı otoregülasyon kontrol mekanizmaları orbitanın farklı boyuttaki arterlerinin farklı iletiminden sorumlu olabilir. (*Gazi Med J 2012; 23: 55-8*)

Anahtar Sözcükler: Renkli Doppler görüntüleme, retrobulber arterler, gebelik, preeklampsia

Geliş Tarihi: 15.03.2012

Kabul Tarihi: 17.05.2012

Address for Correspondence / Yazışma Adresi: Dr. Zafer Onaran, Department of Ophthalmology, Faculty of Medicine, Kırıkkale University, Kırıkkale, Turkey Phone: +90 533 359 30 75 E-mail: drzaferonaran@yahoo.com

©Telif Hakkı 2012 Gazi Üniversitesi Tıp Fakültesi - Makale metnine www.gazimedicaljournal.org web sayfasından ulaşılabilir.

©Copyright 2012 by Gazi University Medical Faculty - Available on-line at www.gazimedicaljournal.org

doi:10.5152/gmj.2012.14

INTRODUCTION

Preeclampsia is a common disorder of pregnancy and a significant cause of maternal and fetal morbidity and mortality. It is a multi organ disease characterized by regional vasospasm with hypertension arising in pregnancy (pregnancy-induced hypertension) in association with significant amounts of protein in the urine (1). The studies on preeclampsia are of fundamental importance in obstetrics due to its high incidence, ranging from 5% to 10%, mortality rate and maternal and perinatal morbidity (2-4).

There has been a continuing interest in the evaluation of intracranial circulation and retrolubar hemodynamics in preeclamptic patients (5-7). Color Doppler imaging (CDI), which has been increasingly used in the assessment of orbital hemodynamics, provides a reliable noninvasive diagnostic method for analyzing velocity of blood flow. The impact of ocular, orbital and systemic diseases on retrolubar circulation has been investigated with the aid of CDI.

The ophthalmic artery (OA) has embryologic, anatomic, and functional similarities to central nervous system arteriolar vessels; it is therefore possible to analyze the hemodynamic behavior of intracranial arteries by evaluating retrolubar hemodynamics (8, 9).

On the other hand, to the best of our knowledge, hemodynamic changes in the posterior ciliary artery (PCA) have not been investigated during healthy and preeclamptic pregnancy.

This study was designed to prospectively evaluate retrolubar hemodynamics including not only OA and CRA but also PCA in normotensive and preeclamptic women by CDI and aimed to highlight the retrolubar hemodynamics during preeclamptic pregnancy.

METHODS

Twenty preeclamptic women, 21 age-matched healthy pregnant women and 21 age-matched non-pregnant fertile women were enrolled in the study. All participants gave informed consent to the study and the tenets of the Declaration of Helsinki were followed. Preeclampsia was defined as the development of hypertension (systolic blood pressure exceeding 140 mmHg and diastolic blood pressure exceeding 90 mmHg) and proteinuria >30 mg/dL, with no history of hypertension or renal disease. All subjects underwent a complete ophthalmologic examination including best-corrected visual acuity, intraocular pressure measurement, slit lamp examination and fundus examination. No subjects had smoking habits.

Subjects with multiple pregnancies, fetal anomalies, diabetes, chronic hypertension (defined as elevation of blood pressure before pregnancy or before 20 weeks gestation) and ocular pathologies, except mild refractive errors, were excluded from the study.

Gestational weeks was estimated from the first day of the last menstrual period and confirmed by first trimester and early second-trimester ultrasonographic examinations (crown-rump length, biparietal diameter and femur length measurements). All preeclamptic women were newly diagnosed and assessed before the antihypertensive treatment.

Assessment of CDI

Retrolubar hemodynamics was assessed using CDI. All measurements were performed by the same experienced radiologist with a 7.5-MHz matrix linear transducer (Logic 400, GE Medical Sys-

tems, Milwaukee, USA). The eye was insulated from the front with the long axis of the transducer approximately horizontal to the eye. The transducer was applied over the eyelid using an ultrasound coupling gel and care was taken to avoid any pressure on the eye. The shadow of the optic nerve was localized, which provides the most useful landmark for the determination of retrolubar vessels. The OA is found either above or below the optic nerve in the posterior orbit. This vessel was examined approximately 25 mm behind the globe. The CRA was examined within 10 mm of the retrolubar portion of the optic nerve. The PCA begin as trunks approximately 10-20 mm behind the globe, before they form multiple branches surrounding the optic nerve in its retrolubar portion. The PCA was measured temporal to the optic nerve head.

Two similar consecutive tracings were recorded in the spectral analysis mode and then peak systolic velocity (PSV) and end diastolic velocity (EDV) were averaged. Then, the resistivity index (RI) was calculated automatically by the scanner.

The repeatability of the measurements was detected by calculation of the coefficient of variation. The coefficient of variation was <10% for PSV and EDV, in all orbital arteries. Since variability was small, our measurements were considered within repeatability limits.

The data were compared with the SPSS 15.0 for Windows (SPSS Inc., Chicago, IL) statistical package, statistical analyses. The Shapiro-Wilk test was used to test the normality of distribution. Data were not normally distributed. Thus, the Kruskal-Wallis test was used to determine the differences in the blood flow velocities of the retrolubar arteries among the groups. The basic level of significance was chosen as $p < 0.05$.

RESULTS

The mean age of the 21 preeclamptic women was 26.9 ± 4.2 years (21-32 years) compared with 26.1 ± 5.9 years (20-33 years) for the 20 healthy pregnant women. There was no significant difference in gestational age between the healthy pregnant women (30.6 ± 3.5 weeks) and the women with preeclampsia (31.5 ± 2.5 weeks) ($p > 0.05$).

Ophthalmic examinations results, including best-corrected visual acuity and intraocular pressure readings, did not show significant changes among three groups ($p > 0.05$).

The blood pressures of the preeclamptic women were significantly higher than those of both healthy pregnant and non-pregnant women ($p < 0.001$). Although not significant, the blood pressure readings of the healthy pregnant were lower than the non-pregnant women ($p > 0.05$). Blood pressures of the study groups are given in Table 1.

Hemodynamic parameters of the OA, CRA and PCA in non-pregnant, healthy pregnant and preeclamptic women are demonstrated in Table 2.

Healthy pregnant and non-pregnant cases showed comparable PSV values ($p > 0.05$), while EDV values were found to be increased in the healthy pregnant group compared to non-pregnant group ($p = 0.01$) in all retrolubar arteries. The EDV value of the PCA was significantly lower in preeclamptic women when compared to the healthy pregnant women group ($p = 0.006$). Conversely, the EDV of the OA was higher in preeclamptic women than healthy pregnant women ($p = 0.044$).

The RI values of the OA, CRA and PCA in healthy pregnant women were significantly lower than those of the non-pregnant wom-

Table 1. Mean systolic and diastolic blood pressure levels in non-pregnant, healthy pregnant and preeclamptic women

	Systolic	Diastolic
Non-pregnant women	114±5.9 mmHg (96-121)	73±4.8 mmHg (61-80)
Healthy pregnant women	110±5.5 mmHg (92-118)	70±7.5 mmHg (58-81)
Preeclamptic women	155±8.5 mmHg (145-163)	105±7.5 mmHg (96-116)

Table 2. Color Doppler flow velocities of the OA, CRA and PCA in non-pregnant, healthy pregnant and preeclamptic women

		Non pregnant women (n=21)	Healthy pregnant women (n=21)	Women with preeclampsia (n=20)
Ophthalmic artery	PSV	37.14±4.08	36.93±5.36	37.92±2.38
	EDV	7.44±1.26	7.76±1.31	7.87±1.22
	RI	0.81±0.03	0.77±0.02	0.76±0.02
Central retinal artery	PSV	10.53±1.52	10.11±1.97	9.90±1.40
	EDV	3.55±0.50	3.71±0.84	3.69±0.51
	RI	0.67±0.02	0.60±0.04	0.68±0.02
Posterior ciliary artery	PSV	13.22±1.92	13.33±2.63	12.05±1.61
	EDV	4.47±0.88	4.74±0.82	3.78±0.88
	RI	0.69±0.03	0.63±0.02	0.70±0.03

(OA: Ophthalmic artery; CRA: Central retinal artery; PCA: Posterior ciliary artery, PSV: Peak systolic flow velocity (cm/sec); EDV: End-Diastolic flow velocity (cm/sec); RI: resistive index)

en (p=0.04, p=0.005, p=0.007, respectively). The RI of the CRA and PCA in preeclamptic women were significantly higher than those of healthy pregnant women (p=0.003, p<0.0001, respectively). Although it is not statistically significant, the RI of the OA was lower in preeclamptic women than in healthy pregnant women (p=0.06).

DISCUSSION

The ocular effects of pregnancy may be both physiological and pathological. Pregnancy is often associated with ocular changes which may be more commonly transient but, occasionally, permanent. Preeclampsia and eclampsia may complicate the pregnancy and could result in hypertensive retinopathy, exudative retinal detachment and cortical blindness.

Preeclampsia is defined as systemic endothelial dysfunction and vasospasm that occurs after 20 weeks of gestation, manifesting with hypertension and proteinuria. Central nervous system complaints including headache, visual disturbances (blurred, scintillating scotomata), altered mental status and cortical blindness are not infrequently encountered in patients with severe preeclampsia. Thus, intracranial and orbital circulation still remains to be a concern in preeclamptic patients (5).

Embryological, anatomical and functional similarities between orbital and intracranial vasculature enabled the investigators to evaluate the intracranial circulation by examining orbital vessels with CDI (10). The OA originates from the internal carotid artery and enters the orbital cavity through the optic canal. It is a medium-sized

muscular artery about 1.33±0.33 mm in size and the CRA and PCA are the ocular branches of the OA. Since retinal and choroidal changes have long been associated with preeclampsia, the orbital circulatory effects of preeclampsia have not been clarified yet (11).

The changes in the orbital circulation in preeclamptic women have been evaluated by measuring various indexes with CDI (12), and pulsatility index (PI) and RI values are the most popular ones that reflect resistance to flow distal to the artery under investigation (5).

However, conflicting results have been reported regarding the pathologic ocular circulatory changes in preeclampsia. Some authors confirmed the presence of vasodilatory signs in the OA related to orbital hyperperfusion in preeclamptic women by identifying lower PI and RI values in the preeclamptic group compared with healthy pregnant women (13, 14); whereas others have registered a vascular impedance elevation in severe preeclampsia (5, 15). The differences between the studies may be explained by small sample numbers, differences in populations, equipment, technique and methods of analysis.

In the present study, consistent with the literature, we demonstrated a decrease in the RI of the OA, PCA and CRA during healthy pregnancy (7). Lowered RI values mean vasodilatation of all orbital arteries and orbital hyperperfusion in healthy pregnancies.

While we observed an additional, but not significant, decrease in the RI of the OA in the preeclamptic group, the RI of the CRA and PCA was found to be increased in contrast to OA during preeclamptic pregnancy compared with healthy pregnant cases. This finding would be more meaningful when interpreted together with the fluorescein angiographic study that has reported delayed filling of choriocapillaries and choroidal nonfilling in hypertensive pregnancies (16). This presumed choroidal hypoperfusion in preeclamptic patients could be attributed to an increased RI of PCA which mainly supplies the choroid. To the best of our knowledge, hemodynamic changes in PCA, related to choroidal circulation, in preeclamptic women has not been investigated.

Moreover, we also demonstrated a decrease in EDV values of the PCA but not in CRA during preeclamptic pregnancy. This may reflect that hypoperfusion and ischemia were more prominent in the choroidal circulation than the retinal circulation. According to our results, different responses to preeclampsia might be explained with the different vascular caliber and different auto regulatory mechanisms (17, 18).

Our study results suggest that preeclampsia led to increased resistance in small caliber orbital vasculature such as the PCA and CRA. Thus, to increase arterial blood supply to the distal capillary beds, vasodilatation resulting from auto regulatory control mechanisms may occur in the OA, which has a larger lumen diameter.

Establishment of the increased resistance of the PCA, which has not been stated previously, could highlight the choroidal circulation and hemodynamics of preeclampsia. However, conflicting results even among healthy pregnancy concerning PI and RI makes it necessary for our results to be confirmed from different centers (7, 12, 19). Further studies are also required to elucidate whether these pathologic blood flow changes of the retrolbulbar arteries reflect the cerebral circulation in preeclampsia.

Conflict of Interest

No conflict of interest was declared by the authors.

REFERENCES

1. Riskin-Mashiah S, Belfort MA, Saade GR, Herd AJ. Side-to-side differences in transcranial Doppler parameters in normotensive and preeclamptic pregnant women. *Am J Obstet Gynecol* 2004; 190: 194-8. **[CossRef]**
2. Cunningham FG, Twickler D. Cerebral edema complicating eclampsia. *Am J Obstet Gynecol* 2000; 182: 94-100. **[CossRef]**
3. Sass N, Mattar R, Rocha NSC, Camano L. Coeficientes de mortalidade materna geral e decorrentes de hipertensão arterial na Escola Paulista de Medicina na UNIFESP no período de 1983 a 1993. *RBGO* 1996; 10: 989-98.
4. Diniz AL, Moron AF, dos Santos MC, Sass N, Pires CR, Debs CL. Ophthalmic artery Doppler as a measure of severe pre-eclampsia. *Int J Gynaecol Obstet* 2008; 100: 216-20. **[CossRef]**
5. Ayaz T, Akansel G, Hayirlioglu A, Arslan A, Suer N, Kuru I. Ophthalmic artery color Doppler ultrasonography in mild-to-moderate preeclampsia. *Eur J Radiol* 2003; 46: 244-9. **[CossRef]**
6. Guthoff RF, Berger RW, Winkler P, Helmke K, Chumbley LC. Doppler ultrasonography of the ophthalmic and central vessels. *Arch Ophthalmol* 1991; 109: 532-6. **[CossRef]**
7. MacKenzie F, De Vermette R, Nimrod C, Boisvert D, Jackson B. Doppler sonographic studies on the ophthalmic and central retinal arteries in the gravid woman. *J Ultrasound Med* 1995; 14: 643-7.
8. Belfort MA, Saade G. Retinal vasospasm associated with visual disturbance in preeclampsia: color flow Doppler findings. *Am J Obstet Gynecol* 1993; 169: 523-5.
9. Ozdikici M, Baykal O, Çelenk C, Levent A, Eren S. Ultrasonography and color Doppler imaging in the diagnosis of ocular and orbital lesions. *T Klin J Med Sci* 1998; 18: 59-63.
10. Baxter GM, Williamson TH. Color Doppler imaging of the eye: normal ranges, reproducibility, and observer variation. *J Ultrasound Med* 1995; 14: 91-6.
11. Laffe G, Schatz H. Ocular manifestations of preeclampsia. *Am J Ophthalmol* 1987; 103: 309-15.
12. Carneiro RS, Sass N, Diniz AL, Souza EV, Torloni MR, Moron AF. Ophthalmic artery Doppler velocimetry in healthy pregnancy. *Int J Gynaecol Obstet* 2008; 100: 211-5. **[CossRef]**
13. Hata T, Hata K, Moritake K. Maternal ophthalmic artery Doppler velocimetry in normotensive pregnancies and pregnancies complicated by hypertensive disorders. *Am J Obstet Gynecol* 1997; 177: 174-8. **[CossRef]**
14. Takata M, Nakatsuka M, Kudo T. Differential blood flow in uterine, ophthalmic, and brachial arteries of preeclamptic women. *Obstet Gynecol* 2002; 100: 931-8. **[CossRef]**
15. Hata T, Hashimoto M, Senoh D, Hata K, Kitao M, Masumura S. Effect of dehydroepiandrosterone sulfate on ophthalmic artery flow velocity waveforms in full-term pregnant women. *Am J Perinatol* 1995; 12: 135-7. **[CossRef]**
16. Schereyer P, Tzadok J, Sherman DJ, Herman A, Bar-Itzak, Caspi E. Fluorescein angiography in hypertensive pregnancies. *Int J Gynecol Obstet* 1990; 34: 127-32. **[CossRef]**
17. Mancia G, Giannatasio C. Arterial distensibility and pulse pressure. Measurements and clinical significance in hypertension. *Clin Exp Hypertens* 1999; 21: 615-33. **[CossRef]**
18. Tso MO, Abrams GW, Jampol LM. Hypertensive retinopathy, choroidopathy and optic neuropathy. A clinical and pathophysiological approach to classification. In: Singerman LJ, Jampol LM, eds. *Retinal and Choroidal Manifestations of Systemic Disease*, Baltimore: Williams & Wilkins, 1991; 79-127.
19. Ohno Y, Kawai M, Wakahara Y, Kitagawa T, Kakirara M, Arii Y. Ophthalmic artery velocimetry in normotensive and preeclamptic women with or without photophobia. *Obstet Gynecol* 1999; 94: 361-3. **[CossRef]**