

ORIGINAL ARTICLE

Analysis of ocular pulse amplitude values in different pregnancy stages as measured by dynamic contour tonometry

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Key words:

Dynamic contour tonometry, ocular pulse amplitude, pregnancy

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doi: ***

**Abstract**

Background: Orbital circulation is influenced by systemic hormonal status. Ocular pulse amplitude (OPA) is a surrogate measurement of choroidal blood flow. We investigated the OPA profile during different stages of pregnancy.

Design: The study design was a cross-sectional study.

Participants: We enrolled 24 pregnant and 25 non-pregnant women (age-matched controls).

Methods: Data were collected included age, pregnancy period, intraocular pressure (IOP), and central corneal thickness (CCT). Pascal dynamic contour tonometry was used to measure OPA values. The mean of three good quality measurements was used for the analysis. Whenever both eyes were eligible, the right eye was arbitrarily selected.

Main Outcome Measures: There were differences in OPA values between pregnant women (at each trimester) and non-pregnant controls.

Results: Mean age and CCT were similar between pregnant women (27.8 ± 6 years, $547 \pm 25 \mu\text{m}$) and controls (28.9 ± 3.4 years, $546 \pm 28 \mu\text{m}$; $P > 0.25$). Pregnant women (mean gestation period, 20.4 ± 9 weeks) had a lower mean IOP than controls (11.4 ± 2.4 vs. 13 ± 2.1 mmHg; $P = 0.02$). Analysis of covariance (adjusting for IOP difference) revealed that OPA values in women in the 1st (3 ± 0.6 mmHg) and 2nd trimesters (2.5 ± 0.7 mmHg) of pregnancy were increased compared to those in the last trimester (1.8 ± 0.6 mmHg) and controls (2.1 ± 0.7 ; $P < 0.05$). Multivariate analysis showed that gestation period was the only variable associated with OPA values during pregnancy ($r^2 = 0.30$, $P < 0.01$). Age, CCT, and IOP were not statistically significant in this model ($P > 0.5$).

Conclusions: Our results suggest that OPA values are increased in the first two trimesters of pregnancy, returning to normal in the last 3 months. These changes in OPA values seem not to be influenced by age, CCT, or IOP.

Introduction

Pascal dynamic contour tonometry (DCT) is a relatively new technology that claims to measure intraocular pressure (IOP) independently of corneal properties.^[1] The DCT uses a contact tonometer tip with a convex contour radius of 10.5 mm, which is theoretically similar in contour to the cornea, to take up the shape of the cornea and not to deform it. Thus, the resulting IOP measurement is less affected by the thickness of the cornea.

A more detailed description of the DCT has been previously published elsewhere.^[2] Besides measuring IOP, the DCT also provides a reading of ocular pulse amplitude (OPA). It is calculated as the difference between the minimum (diastolic) and maximum (systolic) values of pulsatile IOP within the eye. OPA has been suggested as an indicator of choroidal perfusion.^[3,4]

Several changes in both systemic and ocular parameters occur during pregnancy. The most profound physiological changes occur in the cardiovascular system. There is an increase in heart

rate and a decrease in arterial blood pressure, which could be explained by the reduced systemic vascular resistance observed in these pregnant women. Ocular changes in pregnancy are common, including an increase in corneal thickness, alteration in corneal topography, and a decreased IOP.^[5,6]

To investigate the influence of pregnancy on the ocular blood flow, we evaluated the OPA profile during different phases of pregnancy and compared it to non-pregnant women.

Methods

This cross-sectional protocol adhered to the tenets of the Declaration of Helsinki and was approved by the Ethics Committee of The Federal University of São Paulo. In addition, written informed consent was obtained from all subjects.

Patients

Study patients were recruited from the Obstetrics and Gynecology Clinic of the Federal University of Sao Paulo. A total of 24 healthy pregnant patients and 25 healthy, age-matched, non-pregnant women were enrolled in the study. All participants underwent a complete ophthalmic evaluation, and those presenting with any significant ocular disease or previous ocular surgery were excluded from the study. Exclusion criteria included age <18 years, Snellen best-corrected visual acuity $\leq 20/20$, spherical equivalent ≥ 4.00 diopters, systemic hypertension, diabetes, and any collagen disease or history of steroids use. Demographic data were obtained, including age, self-identified race, and pregnancy period.

Procedures

Initially, all patients underwent OPA measurement using the DCT (Swiss Microtechnology AG, Bern, Switzerland) after resting for at least 10 min in sitting position. The Pascal DCT is a slit-lamp mounted digital device that uses single-use, disposable caps. It provides a direct transcorneal measurement of IOP and detects OPA. The DCT measures diastolic IOP using the principle of contour matching with the built-in miniature Sensor Tip™ utilizing a solid-state pressure sensor. It displays the average diastolic IOP recorded and the mean OPA through a digital liquid crystal display. Adding the DCT's IOP, reading to the OPA will give the systolic IOP. After a 15-min interval, Goldmann applanation tonometry and ultrasound pachymetry

were performed. The mean of three good quality measurements was used for all tests. Minimum quality score for OPA readings was set at ≥ 3 . Whenever both eyes were eligible, the right eye was arbitrarily selected. All tests were performed by the same examiner (AKSS).

Statistical analysis

Independent sample *t*-test and Chi-square test were used to evaluate differences between groups. Analysis of covariance (adjusting for differences in IOP) was performed to compare OPA values between patients in different trimesters of pregnancy and controls. Multiple regression analysis was used to investigate the effect of age, central corneal thickness (CCT), IOP, and pregnancy period (in weeks) on OPA values. Computerized analysis was performed using MedCalc software (MedCalc Inc., Mariakerke, Belgium), and statistical significance was set at $P < 0.05$.

Results

Baseline characteristics of study patients are given in Table 1. Mean age and CCT were similar between pregnant women (27.8 ± 6 years, 547 ± 25 μm) and controls (28.9 ± 3.4 years, 546 ± 28 μm ; $P > 0.25$). Pregnant women had a mean gestation period of 20.4 ± 9 weeks (range, 9–37 weeks).

As we found a significantly lower mean IOP in pregnant women than controls (11.4 ± 2.4 vs. 13 ± 2.1 mmHg; $P = 0.02$), we used analysis of covariance (adjusting for IOP difference) to compare OPA values between patients in different trimesters of pregnancy and controls. These analyses revealed that OPA values in women in the 1st (3 ± 0.6 mmHg) and 2nd trimester (2.5 ± 0.7 mmHg) of pregnancy were significantly increased compared to those in the last trimester (1.8 ± 0.6 mmHg) and controls (2.1 ± 0.7 ; $P < 0.05$). Finally, multiple regression analysis showed that gestation period was the only variable associated with OPA values in these patients ($r^2 = 0.30$, $P < 0.01$). Age, CCT, and IOP were not significant in this model ($P > 0.5$).

Discussion

The OPA has been described as an indirect measurement of choroidal blood flow, which represents the major part of the ocular perfusion.^[3] It has been suggested that pulsatile

Table 1: Characteristics of pregnant patients and controls[†]

Variable	Pregnant patients (n=24)	Control Group (n=25)	P value
Age (years)	27.8 \pm 6	28.9 \pm 3.4	0.25 [‡]
Race (C/AD/M/A)	15/4/5/0	10/5/5/5	0.10 [§]
Pregnancy period (weeks)	20.4 \pm 9	N/A	N/A
CCT (μm)	547 \pm 25 (537–557)	546 \pm 28 (535–557)	0.47 [‡]
IOP (mmHg)	11.4 \pm 2.4 (10.4–12.4)	13 \pm 2.1 (12.2–13.8)	0.02 [‡]

C: Caucasian, AD: African descent, M: Mixed, A: Asian, N/A: Non-applicable. [†]Data are given as mean \pm standard deviation (95% confidence interval) whenever indicated. [‡]Independent sample *t*-test. [§]Chi-square test. CCT: Central corneal thickness, IOP: Intraocular pressure

ocular blood flow increases in pregnant women in comparison with those non-pregnant.^[7] Comparing OPA values between pregnant patients in different gestation trimesters and controls using DCT, we not only found higher values in the former group but also a trend for OPA reduction toward the last trimester. As far as we know, this is the first study to evaluate the OPA profile along the gestation period using this technology.

In the present study, we found OPA values of approximately 2 mmHg in healthy women, which is in agreement with previous reports using DCT in healthy controls.^[8] When it comes to OPA measurements in pregnant participants, there are scant data in the literature. However, looking at previous reports on ocular blood flow during pregnancy using other technologies, our findings seem to corroborate those previously published. For instance, Centofanti *et al.*, using a pneumotonometer, found that pulsatile ocular blood flow, measured in millimeters per minute, increased gradually during pregnancy until the second trimester. On the other hand, lower IOP values were documented in this period. Even though the authors did not provide data on the third trimester, our results regarding both OPA and IOP seem similar to their study.^[9] Considering studies that included blood flow measurements until the last trimester, Hörven *et al.* found an increase in the corneal indentation pulse amplitude during the first half of pregnancy, with values coming to about one-third of a non-pregnant woman at term.^[10,11]

Some of the previously reported hemodynamic changes that take place with pregnancy could explain, in part, our findings on OPA and IOP measurements in these patients. During gestation, estrogen and progesterone lead to hemodynamic changes to facilitate venous return.^[12] Both hormones elevate the levels of renin-angiotensin-aldosterone system. Around the 5th week of pregnancy begins a retention of sodium and an increase in blood volume, but not in the same level for all constituents (blood cells and leukocytes), which results in hemodilution and, consequently, augmented cardiac frequency and systolic volume.^[13] Such changes could be responsible for the higher OPA values observed in pregnant patients. Regarding the lower IOP values during pregnancy, there seems to exist a resistance to angiotensin LL effect, added to an increased nitric oxide action,^[14-16] causing peripheral vasodilatation. Moreover, prostacyclin promotes generalized vasodilatation,^[13] resulting in lower blood pressure values, reaching its nadir in the second trimester, and returning to normality after delivery. Those changes in venous return have repercussions in the episcleral venous pressure as well, which could contribute to IOP reduction.^[17] Estrogen and progesterone also influence IOP by decreasing the production of aqueous humor. Another hormone, relaxin, produced during pregnancy, regulates the collagenase enzymes and promotes relaxation of collagen structures, including the trabecular meshwork, easing the aqueous humor outflow venous return.^[18]

We believe that it is important to stress some specific characteristics of the present study. First, it is limited in part by its small sample size. Even though it was adequately powered to reveal significant differences, we believe a larger

sample would be desirable. Second, blood pressure was not investigated. However, a lack of correlation between OPA and blood pressure parameters in healthy controls has been shown in previous studies.^[7,19] Finally, one should not extrapolate these cross-sectional data to an evolving situation such as pregnancy. A prospective study is warranted.

In conclusion, our results add information on the ocular hemodynamics profile during pregnancy. It suggests that OPA values are increased in the first two trimesters, returning to normal values in the last 3 months. These results give basis to a more detailed and longitudinal analysis. In addition, as pregnancy and glaucoma may coexist, it would be interesting to evaluate whether and how these OPA changes could influence a glaucomatous pregnant patient.

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How to cite this article: Fernandez LA, Sousa AKS, Doi LM, Dorairaj S, Filho CAG, Paranhos A, Prata TS. Analysis of ocular pulse amplitude values in different pregnancy stages as measured by dynamic contour tonometry. *Clin Exp Vis Eye Res J* 2018;1(1):1-4.

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