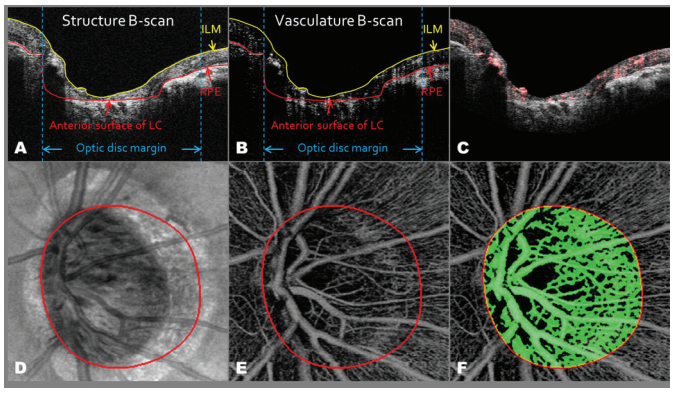
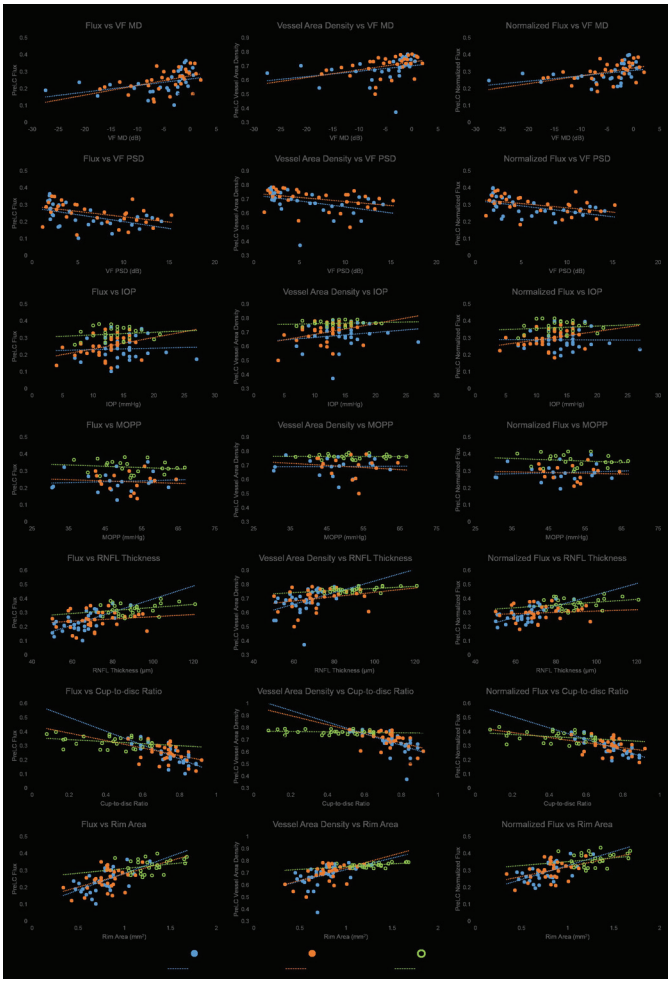
313 Glaucoma Blood Flow
Tuesday, May 03, 2016 8:30 AM–10:15 AM
Exhibit/Poster Hall Poster Session
Program #/Board # Range: 2957–3002/A0306–A0351
Organizing Section: Glaucoma

Program Number: 2957 **Poster Board Number:** A0306
Presentation Time: 8:30 AM–10:15 AM
Optic disc perfusion in eyes with primary open angle glaucoma and normal tension glaucoma using optical coherence tomography-based microangiography
Karine D. Bojikian[1], Chieh-Li Chen[2], Joanne C. Wen[1], Qinqin Zhang[2], Chen Xin[2], Divakar Gupta[1], Raghu C. Mudumbai[1], Murray A. Johnstone[1], Ruikang K. Wang[2, 1], Philip P. Chen[1].
[1]Ophthalmology, University of Washington, KIRKLAND, WA; [2]Bioengineering, University of Washington, Seattle, WA.
Purpose: To investigate optic disc perfusion differences in normal, primary open-angle glaucoma (POAG), and normal tension glaucoma (NTG) eyes using optical microangiography (OMAG) based optical coherence tomography (OCT) angiography technique.
Methods: One eye from each subject was scanned with a 68 kHz Cirrus HD-OCT 5000-based OMAG prototype system centered at the optic nerve head (ONH) (Carl Zeiss Meditec Inc, Dublin, CA). Microvascular images were generated from the OMAG dataset by detecting the differences in OCT signal between consecutive B-scans. The pre-laminar layer (preLC) was isolated by a semi-automatic segmentation program (Figure 1).
Results: Glaucomatous eyes had significantly lower optic disc perfusion in preLC in all three perfusion metrics ($p<0.0001$) compared to normal eyes, but no differences were observed between POAG and NTG eyes. Univariate analysis revealed significant correlation between optic disc perfusion, visual field (VF) mean deviation (MD), VF pattern standard deviation (PSD), and rim area in both POAG and NTG groups ($p\leq0.0288$) (Figure 2).
Conclusions: Optic disc perfusion detected by OMAG showed similar reduction between POAG and NTG groups compared to normal controls. Disc perfusion was significantly correlated with VF MD, VF PSD, and rim area in glaucomatous eyes. Vascular changes at the optic disc as measured using OMAG may provide useful information for diagnosis and monitoring of glaucoma.





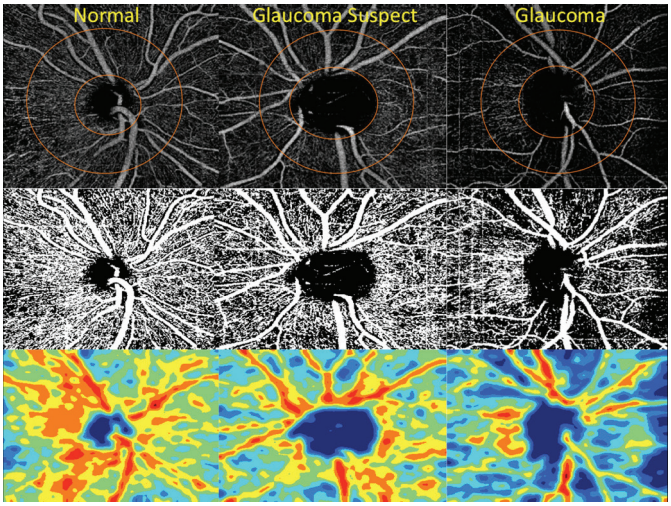
Commercial Relationships: Karine D. Bojikian, None; **Chieh-Li Chen**; **Joanne C. Wen**, None; **Qinqin Zhang**, None; **Chen Xin**, None; **Divakar Gupta**, None; **Raghu C. Mudumbai**, None; **Murray A. Johnstone**, Sensimed (C), Healonics (C), Cascade Ophthalmics (C), Allergan (P), Ivantis (C); **Ruikang K. Wang**, Carl Zeiss Meditec (F), Carl Zeiss Meditec (P); **Philip P. Chen**, None
Support: Unrestricted departmental grant from Research to Prevent Blindness

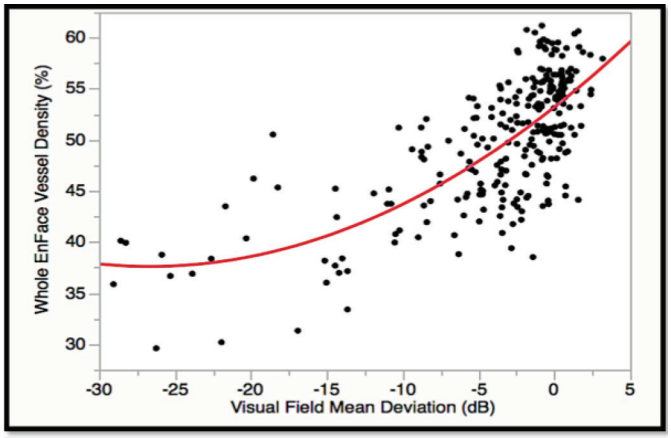
Program Number: 2958 **Poster Board Number:** A0307
Presentation Time: 8:30 AM–10:15 AM
OCT Angiography Vessel Density in Normal, Glaucoma Suspects and Glaucoma Eyes: Structural and Functional Associations in the Diagnostic Innovations in Glaucoma Study (DIGS)
Adeleh Yarmohammadi[1], Linda M. Zangwill[1], Alberto Diniz-Filho[1], Min Hee Suh[1, 2], Patricia Isabel C. Manalastas[1], Naeem Fatehee[1], Akram Belghith[1], Siamak Yousefi[1], Felipe A. Medeiros[1], Robert N. Weinreb[1]. [1]Hamilton Glaucoma Center, Shiley Eye institute, Department of Ophthalmology, University of California San Diego, La Jolla, CA; [2]Inje University, college of medicine, Haeunda Paik Hospital, Busan, Korea (the Republic of).
Purpose: To assess vessel density measurements using optical coherence tomography angiography (OCTA) in normal, glaucoma suspects, and primary open angle (POAG) eyes and to characterize the relationship between vessel density and other quantitative structural and functional measurements.

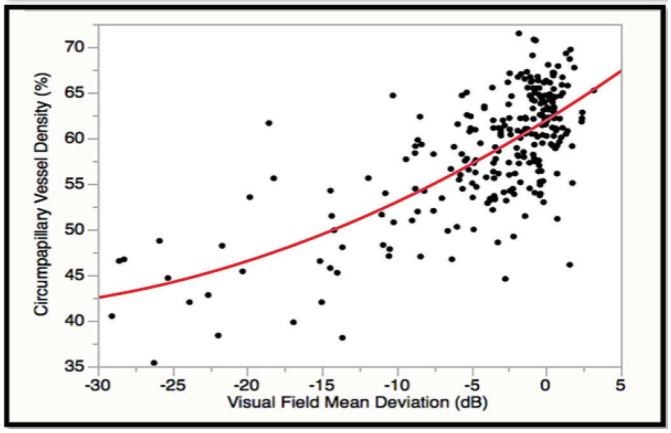
Methods: 261 eyes of 164 DIGS participants with good quality OCTA images according to the Shiley Eye Institute Imaging Data Evaluation and Analysis (IDEA) Reading Center protocol were included. Using the Optovue AngioVue imaging system optic nerve head images (4.5 x 4.5 mm scan field size) were obtained in 124 POAG eyes, 87 glaucoma suspects, and 50 normal eyes. OCTA retinal vasculature information was characterized as a vessel density map, and as vessel density (%), calculated as the percentage area occupied by flowing blood vessels in the measured region. For this report, we analyzed two vessel density measurements in two regions extracted from the retinal nerve fiber layer (RNFL): 1) circumpapillary vessel density (cPVD) measured in a 750-µm-wide elliptical annulus around the disc; and 2) enface vessel density (EVD) measured over the entire image. Linear regression with generalized estimating equation (GEE) models were used to assess the relationship between vessel density, visual field mean deviation (VF MD) and spectral domain optical coherence tomographic (SD-OCT) RNFL thickness and adjusting for within-patient inter-eye correlations.

Results: Compared to POAG eyes, normal eyes demonstrated a denser microvascular network within the RNFL (Figure 1). Vessel density was higher in normal eyes followed by glaucoma suspect and POAG eyes for EVD (56.5%, 51.4% and 46.1%, respectively) and for cPVD (64.2%, 60.7%, 55.1%, respectively) ($p<0.0001$ for both). The association between OCTA measured cPVD and EVD and severity of VF damage measured as MD was stronger ($R^2 = 0.49$, and 0.47 respectively) than the association between RNFL thickness and VF MD ($R^2=0.30$) ($p<0.0001$ for all) (Figure 2). cPVD and EVD also were correlated with RNFL thickness ($R^2=0.55$, and 0.68 respectively) ($p <0.0001$ for both).

Conclusions: OCTA imaging provides quantitative assessment of the RNFL vasculature that is correlated with both structural and functional measurements. Longitudinal studies are needed to determine its value for diagnosing, staging, and monitoring glaucoma.







Commercial Relationships: Adeleh Yarmohammadi, None; **Linda M. Zangwill**; **Alberto Diniz-Filho**, None; **Min Hee Suh**, None; **Patricia Isabel C. Manalastas**, None; **Naeem Fatehee**, None; **Akram Belghith**, None; **Siamak Yousefi**, None; **Felipe A. Medeiros**, Carl Zeiss Metitec Inc (R), Heidelberg Engineering (F), Ametek (F), Ametek (C), Bausch+Lomb (F), Heidelberg Engineering (C), Carl Ziess Meditec (C), Sensimed (F), Alcon (C), Allergan (F), Topcon (F), Carl Ziess Meditec (F), Allergan (C); **Robert N. Weinreb**, carl Zeiss Meditec Inc (C), Heidelberg Engineering (F), Alcon (C), carl zeiss meditec inc (R), carl Zeiss Meditec Inc (F), Topcon (F), Optovue (F), Bausch+Lomb (C), Genentech (F), Allergan (C)
Support: NIH Grants P30EY022589, EY11008, EY019869, EY021818, and participant retention incentive grants in the form of glaucoma medication at no cost from Alcon Laboratories Inc, Allergan, Pfizer Inc, and Santen Inc. Unrestricted grant from Research to Prevent Blindness, New York, New York
Clinical Trial: NCT00221897

Program Number: 2959 **Poster Board Number:** A0308
Presentation Time: 8:30 AM–10:15 AM

OCT Angiography of the Optic Nerve Head to differentiate normal from glaucoma eyes

Manuele Michelessi[1], Gianluca Manni[2], Lucia Tanga[1], Manuela Ferrazza[1], Francesca Berardo[1], Gloria Roberti[1], Ester Elmo[2], Francesco Oddone[1]. [1]IRCCS - Fondazione GB Bietti, Rome, Italy; [2]University of Rome Tor Vergata, Rome, Italy.

Purpose: To evaluate the ability of optic nerve head (ONH) perfusion parameters as assessed by AngioVue OCT in discriminating normal from manifest glaucoma eyes. To also explore the linear relationship between the AngioOCT derived perfusion parameters with structural and functional retinal conventional measurements

Methods: Eighty two eyes from 41 healthy subjects and 41 glaucomatous patients were enrolled. All patients underwent a full eye examination, standard achromatic perimetry (SAP) we Humprey field analyzer and were imaged with SD-OCT RTVue-XR Avanti. Two scanning protocols, Angio 3D OCT and ONH were acquired in sequence. Angio3D disc analysis measures flow density (%) at two level, nerve head (NH) and radial peripapillary capillary (RPC). Glaucoma was defined on the basis of SITA-24-2 visual field loss (PSD and MD p<5% and Glaucoma Hemifield Test outside normal limits) on two consecutive visual fields. T-test was used to explore differences in angioOCt parameters between normal and glaucoma. Areas under receiver operating characteristic curve (AUC) were calculated as measure of discriminating ability. Sensitivity at 90% fixed specificity were also evaluated for all the parameters. To evaluate the relationship betweeen perfusion parameters and structural-functional variables, we performed a linear regression analysis. A p value below 0.05 was considered statistical significantly.
Results: Several ONH OCT derived perfusion parameters have shown statistically significant differences between normal and glaucoma. At NH level the Insidedisc parameter offered the higher AUC: 0.957 (CI, 0.920-0.994) with a sensitivity of 80% at 90% fixed specificity. At RPC level the insidedisc parameter still showed the best AUC, 0.968 (CI 9.37-0.998) with a sensitivity of 87% at 90% fixed specificity. Among glaucoma patients the Insidedisc at NH level have shown the higher coefficient of determination with MD (r^2:0.45), whereas the Wholedisc parameter at RPC level have shown the best correlation with RNFL average parameter (r^2:0.67)
Conclusions: AngioVue OCT derived perfusion parameter have shown a good ability in discriminating healthy from glaucomatous eye and a good linear correlation with structural-functional conventional measurements.
Commercial Relationships: Manuele Michelessi; **Gianluca Manni**, None; **Lucia Tanga**, None; **Manuela Ferrazza**, None; **Francesca Berardo**, None; **Gloria Roberti**, None; **Ester Elmo**, None; **Francesco Oddone**, None

Program Number: 2960 **Poster Board Number:** A0309
Presentation Time: 8:30 AM–10:15 AM
Comparison of the Optic Disc Microvascular and Structure in Open Angle Glaucoma Patients and Related Factors
Kimikazu Sakaguchi, Tomomi Higashide, Sachiko Udagawa, Shinji Ohkubo, Kazuhisa Sugiyama. Dept of Ophthalmology, Kanazawa University, Kanazawa, Japan.
Purpose: In glaucomatous eyes, not only structural changes but reduction of blood flow is observed around the optic disc. Recently, the split-spectrum amplitude-decorrelation angiography (SSADA) algorithm have made it possible to observe the microvasculature around the optic disc nerve head, which is said to associate with the blood flow. In this study, we compared the optic disc microvascular density and structure in subjects with open angle glaucoma using optical coherence tomography angiography (OCTA), and analyzed related factors.
Methods: Observational, cross-sectional study was performed from February to October 2015. We measured two types of OCT; OCTA with RTVue®XR™Avanti™ (OptoVue, California), and circumpapillary retinal nerve fiver layer thickness (cpRNFLT) with RS-3000 Advance®(Nidek, Japan). The scans size was 4.5mm×4.5mm in the OCTA, and 6.0mm×6.0mm in the cpRNFLT. According to Garway-Heath classification, the whole measurement value of OCT was divided into 6 sectors; nasal, inferior nasal (IN), inferior temporal (IT), superior nasal (SN), superior temporal (ST), and temporal. Patients with reliable Humphrey visual field SITA™Standard 24-2 (Carl Zeiss Meditec AG, Germany) within 3 month were included. Patients with fundus, optic nerve and visual tract disease, a history of glaucoma or intraocular surgery were excluded. By using the generalized linear mixed model, RPC density, cpRNFLT, Mean Deviation (MD), age, sex, axial length, logMAR visual acuity, diabetes, high blood pressure, smoking history, were investigated. Statistical analysis was performed using SPSS software (IBM SPSS Statistics 18, IBM Corp., New York).
Results: Sixty-six eyes of 45 patients (male: female = 25:20) were analyzed. The RPC density and the cpRNFLT were significantly correlated with the MD value (R = 0.734, R = 0.744, p <0.05). Age, axial length, logMAR visual acuity, diabetes, high blood pressure, smoking history did not significantly related to the MD value. The OCT measurements of Nasal, IN, and ST showed the best values of Akaike's Information Criterion (AIC) for the visual field sensitivity of each sector,. AIC showed the best value in the adjacent sector in IT and temporal. The RPC density was the better model for the MD value as compared to the cpRNFLT.
Conclusions: The RPC density and the cpRNFLT were associated with the MD value. The RPC density was the better model for the MD value.
Commercial Relationships: Kimikazu Sakaguchi, None; **Tomomi Higashide**, None; **Sachiko Udagawa**, None; **Shinji Ohkubo**, None; **Kazuhisa Sugiyama**, None
Support: CHUO SANGIO CO. : providing the OCT
Clinical Trial: http://www.med.kanazawa-u.ac.jp/staff/ethics/index.html, 824

Program Number: 2961 **Poster Board Number:** A0310
Presentation Time: 8:30 AM–10:15 AM
Optical coherence tomography angiography in glaucoma
Jens Ulrich Werner, Christian Enders, Gerhard K. Lang, Gabriele E. Lang. Department of Ophthalmology, University of Ulm, Ulm, Germany.
Purpose: Glaucoma is characterized by the loss of retinal ganglion cells (RGC). There is evidence that glaucoma is also associated with vascular dysfunction. We hypothesize that there is a correlation between retinal thickness and capillary network perfusion measured by the novel optical coherence tomography angiography (OCTA) technique in glaucoma patients.
Methods: We examined 10 eyes from male and female patients aged from 61 to 85 years with open angle glaucoma and ten matched normal eyes using the Carl Zeiss Meditec Inc. Cirrus 5000 with the AngioPlex module at present allowing qualitative analysis in a prospective study. Capillary network was analyzed in the retinal superficial (SCL) and deep capillary layer (DCL) as well as the retinal thickness (RT). All measurements were performed in a 6x6 mm quadrat around the optic disc and the macula. Images were composed to a panorama showing optic disc and macula. A qualitative analysis of the overlay of RT/SCL and RT/DCL was performed relating to RT and capillary network in the SCL and DCL.
Results: A correlation was found between peripapillary and macular capillary network perfusion and RT. In areas with thinned RT compared to non-glaucomatous patients the density of capillary network was reduced. In 2 of 10 patients this is more evident in the SCL and in 3 of 10 patients the capillary perfusion disorder was more pronounced in the DCL.
Conclusions: Glaucoma seems to be associated with a thinning in the capillary network of the retina. It is unclear whether the capillary bed diminishes due to the loss of RGC or the impaired perfusion induces cell death of the RGC. This study encourages to further analyze the retinal capillary network in glaucoma patients. This novel OCTA technique allows 3-dimensional non-invasive microvascular visualization and enables new insights into the pathology of

glaucoma. OCTA might be a novel tool for glaucoma diagnosis and progression analysis.
Commercial Relationships: Jens Ulrich Werner, Carl Zeiss Meditec (F); **Christian Enders**, Bayer Vital GmbH (R), Carl Zeiss Meditec (F); **Gerhard K. Lang**, Carl Zeiss Meditec (F); **Gabriele E. Lang**, Carl Zeiss Meditec (F), Boehringer Ingelheim Pharma GmbH (R), Bayer Vital GmbH (F), Novartis GmbH (R), Novartis GmbH (F), Boehringer Ingelheim Pharma GmbH (F), Alcon Pharma GmbH (F)

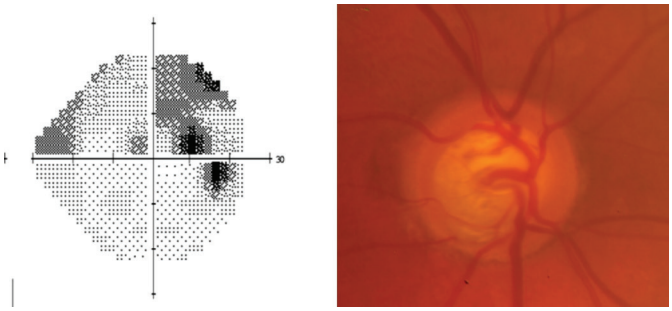
Program Number: 2962 **Poster Board Number:** A0311
Presentation Time: 8:30 AM–10:15 AM
OCT Angiography Macular Vessel Density, Ganglion Cell Complex Thickness and Visual Fields in Healthy, Glaucoma Suspect and Glaucomatous Eyes
Naeem Fatehee[2, 1], Linda M. Zangwill[2, 1], Alberto Diniz-Filho[2, 1], Adeleh Yarmohammadi[2, 1], Min H. Suh[2, 1], Patricia Isabel C. Manalastas[2, 1], Akram Belghith[2, 1], Siamak Yousefi[2, 1], Felipe A. Medeiros[2, 1], Robert N. Weinreb[2, 1]. [1]Shiley Eye Institute, University of California San Diego, La Jolla, CA; [2]Hamilton Glaucoma Center, La Jolla, CA.
Purpose: To compare the utility of macular optical coherence tomography (OCT) angiography vessel density and spectral domain (SD) OCT ganglion cell complex (GCC) and their correlation with functional parameters in normal, glaucoma suspect, and glaucomatous eyes.
Methods: 202 eyes (43 normal, 73 suspect, 86 glaucoma) of 131 patients from the Diagnostic Innovations in Glaucoma Study with OCT angiography and no macular pathology were included in the analysis. Only good quality AngioVue OCT angiography (Optovue) macular (3.0 x 3.0 mm) scans identified according to the Shiley Eye Institute Imaging Data Evaluation and Analysis (IDEA) Reading Center protocol were included. OCT angiography macular vasculature is characterized as a vessel density map, and as vessel density, calculated as the percentage area occupied by vessels in the measured region. SDOCT GCC (7.0 x 7.0 mm) scans were acquired on the same day. Analysis of variance (ANOVA) was used to compare vessel density and GCC average inner retina thickness among the diagnostic groups, while area under receiver operating characteristic (AUROC) curves was used to compare the accuracy for discriminating normal from glaucoma eyes.
Results: Healthy subjects (55.0±11.3 yrs) were significantly younger than both suspect (65.8±12.3 yrs) and glaucoma eyes (70.5±11.7 yrs) (P<0.001). Mean deviations of the visual fields for normal, suspect and glaucoma groups were 0.03±0.9, -0.74±1.3 and -5.25±5.6 dB, respectively (P<0.001). Average macula enface vessel density was higher in normal and suspect eyes compared to glaucoma eyes (52.9±2.8%, 51.2±3.5%, and 48.9±4.0%, respectively (P<0.001)). Average GCC inner retina thickness for normal, suspect and glaucoma eyes was 96.1±7.6, 90.2±8.6 and 79.7±9.3μm, respectively (P<0.001). Both vessel density and GCC values correlated significantly with MD (r2= 0.17 and 0.31, respectively). Age adjusted AUROC curve values for macula enface vessel density was significantly lower than GCC average inner retina thickness (0.70 versus 0.91, respectively, P=0.003).
Conclusions: Average GCC inner retina thickness performed significantly better than macular vessel density in differentiating normal from glaucomatous eyes. Longitudinal studies may elucidate the utility of macular OCTA indices in glaucoma progression. Larger macular OCTA scan areas may yield greater diagnostic utility.
Commercial Relationships: Naeem Fatehee, None; **Linda M. Zangwill**, Optovue Inc., (F), Heidelberg Engineering GmbH, (F), Nidek Inc (F), Carl Zeiss Meditec Inc., (F), Carl Zeiss Meditec Inc (P), Topcon Medical Systems Inc. (F), quark (F); **Alberto Diniz-Filho**, None; **Adeleh Yarmohammadi**, None; **Min H. Suh**, None; **Patricia Isabel C. Manalastas**, None; **Akram Belghith**, None; **Siamak Yousefi**, None; **Felipe A. Medeiros**, Alcon Laboratories Inc (C), NEI (F), Allergan Inc (F), Sensimed (F), Reichert Inc (R), Alcon Laboratories Inc (F), Merck Inc. (F), Allergan Inc (C), Heidelberg Engineering Inc. (F), Topcon Inc. (F), Novartis (C), Carl Zeiss Meditec Inc (C), Carl Zeiss Meditec Inc (F), Reichert Inc (F), Alcon Laboratories Inc (R), Carl Zeiss Meditec Inc (R), Bausch and Lomb (F), Allergan Inc (R); **Robert N. Weinreb**, Alcon (C), Carl Zeiss Meditec (F), Amatek (C), Heidelberg Engineering GmbH (F), Optovue (F), Topcon (C), Nidek (F), Carl Zeiss Meditec (C), Genentec (F), Aquesys (C), Bausch and Lomb (C), Novartis (F), Topcon (F), Aerie (F), Allergan (C), Valeant (C)

Program Number: 2963 **Poster Board Number:** A0312
Presentation Time: 8:30 AM–10:15 AM
Normalization of Retinal Vessel Density profile in healthy subjects
Ivania Pereira[1, 2], Hemma Resch[2], Stephan Holzer[2], Florian Schwarzhans[1], Jing Wu[3], Georg Fischer[1], Clemens Vass[2]. [1]Center for Medical Statistics Informatics and Intelligent Systems, Section for Medical Information Management and Imaging, Medical University Vienna, Vienna, Austria; [2]Department of Ophthalmology, Medical University of Vienna, Vienna, Austria; [3]Christian Doppler Labor for Ophthalmic Image Analysis (OPTIMA), Department of Ophthalmology, Medical University of Vienna, Vienna, Austria.
Purpose: Having demonstrated the strong correlation between the retinal nerve fiber layer (RNFL) and retinal vessel density (RVD) in a mostly young to middle-aged healthy population, one should not forget that, in clinical routine, ocular or systemic diseases may affect RVD. This in turn may jeopardize the benefits of RVD, which facilitates individualized normal limits. It is, therefore, crucial to analyze different normalization methods of the individual RVD profile to cancel out the potential influence of generalized constriction or dilatation of retinal vessels.
Methods: A sample of 202 healthy subjects who all underwent FD-OCT of the macula and the circumpapillary area was used to test three different linear normalization methods: Average RVD subtraction, min-max and Z-scores normalization. First, the RVD was calculated according to automatic measurement of the circumpapillary retinal vessels using Gaussian convolution. Then for each normalization method, the normalized RVD (n-RVD) was obtained according to each subject's statistical parameters of the RVD (e.g. minimum, maximum, average). Finally, for each sector and each method a multivariate linear regression model was calculated, across all subjects, with RNFL as dependent and n-RVD as well as the respective statistical parameters as independent parameters. Partial and total correlation coefficients (CoCo) were calculated for each method and for all 256 sectors of the RNFL profile and were averaged across the 256 sectors.
Results: All three methods performed similarly, in terms of number of significant sectors and R-values. Min-max normalization presented a mean R-value of 0.47 for the multivariate model, significant in 247 (out of 256) sectors. From these, n-RVD was included in 242 sectors and 211 sectors had either maximum or minimum values of RVD included. Mean partial CoCo of n-RVD was 0.45.
Conclusions: Although most sectors of the RNFL profile presented a significant correlation with statistical parameters (in addition to n-RVD), the close similarity between mean values of partial CoCo of n-RVD and the R-value of the multivariate model shows that it was the normalized RVD profile that contained most of the information. Therefore, we

expect that systemic or generalized ophthalmic influences in vessel thickness will not reduce the utility of normalized RVD.
Commercial Relationships: Ivania Pereira, None; **Hemma Resch**, None; **Stephan Holzer**, None; **Florian Schwarzhans**, None; **Jing Wu**; **Georg Fischer**, None; **Clemens Vass**, Carl Zeiss Meditec (R), Heidelberg Engineering (R)
Support: Wiener Wissenschafts-, Forschungs- und Technologiefonds - WWTF - LS11-046

Program Number: 2964 **Poster Board Number:** A0313
Presentation Time: 8:30 AM–10:15 AM
Evaluation of retinal vessel morphology in Open Angle Glaucoma using a novel Optical Coherence Tomography based method
Robert Kromer[1, 3], Sebastian Boelefahr[1], Armin Bartels[2], Sven C. Beutelspacher[3], Maren Klemm[1]. [1]Department of Ophthalmology, Hamburg Medical Center Hamburg-Eppendorf, Hamburg, Germany; [2]Vision Systems, Hamburg University of Technology, Hamburg, Germany; [3]Department of Ophthalmology, Ruprecht-Karls-University Heidelberg, Medical Faculty Mannheim, Mannheim, Germany.
Purpose: Open angle glaucoma (OAG) is one of the main causes of impaired vision worldwide. While several pathogenetic mechanisms have been proposed, it remains poorly understood. Alterations in ocular blood flow and an abnormal vascular circulation configuration seem to be major components in OAG. We use a novel method for facilitating the analysis of retinal vessel morphology: The intensity of the distal shadow of vessels caused by the reflected signal of spectral domain optical coherence tomography (SD-OCT) is analyzed and compared between healthy patients and OAG patients. We evaluate diagnostic technology in a prospective cross-sectional study.
Methods: Sample sizes were chosen using power analysis with 90% power based on preliminary results. Patients were divided into two cohorts (age-and sex-matched): 180 patients with diagnosed OAG (mean age 62.9 years, standard deviation 14.9 years) and 180 healthy control patients (mean age 61.5 years, standard deviation 13.8 years). All patients underwent extensive ophthalmic diagnostics including SD-OCT. The vessel shadow intensity (VSI) is based on peripapillary SD-OCT scans and automatically analyzes the intensity of the distal vessel shadow compared to its surroundings in three segmented layers. Segmentation used a mean filter and curve fitting-based regularization. One eye of each participant was randomly selected and used for statistical analysis (phenotype).
Results: VSI was significantly altered in patients with diagnosed OAG in all three segmented layers (VSI Layer 1: difference between means 0.067 ± 0.073, $p < 0.0001$; VSI Layer 2: difference between means -0.037 ± 0.051, $p < 0.0001$, VSI Layer 3: difference between means -0.033 ± 0.1144, $p = 0.0077$). The retinal vessel morphology seemed to remain unaffected by disease progression, which was determined using visual field parameters (mean deviation and pattern standard deviation), Heidelberg Retina Tomograph and SD-OCT retinal nerve fibre layer thickness ($p > 0.05$).
Conclusions: We conclude that retinal vessel morphology is changed in patients with OAG. Furthermore, it seems that this change is independent from disease progression. Further prospective studies are needed to evaluate the prognostic value in early detection of the disease before other morphological or functional degeneration is observable.
Commercial Relationships: Robert Kromer, None; **Sebastian Boelefahr**, None; **Armin Bartels**, None; **Sven C. Beutelspacher**, None; **Maren Klemm**, None
Support: German Federal Ministry for Economics and Technology; European Social Fund

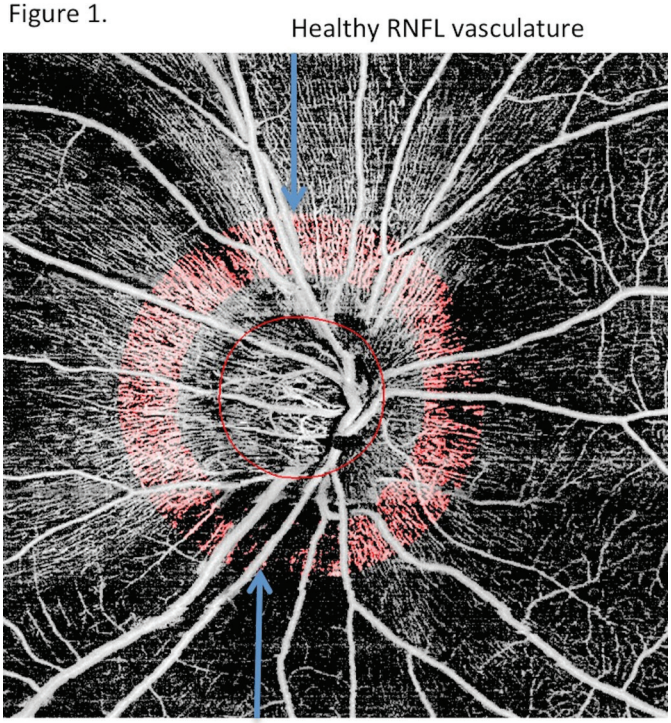
Program Number: 2965 **Poster Board Number:** A0314
Presentation Time: 8:30 AM–10:15 AM
Phenotype of a Subgroup of Primary Open Angle Glaucoma Patients with Optic Nerve Susceptibility
Reza Alizadeh, Pradtana Hirunpatravong, Pablo Romero, Joseph Caprioli. Glaucoma, Jules Stein Eye Institute, University of California, Los angeles, CA.
Purpose: Acquired pit of optic nerve (APON) is a pattern of glaucomatous optic nerve damage defined as a deep, localized excavation of the neural rim with focal disruption of the lamina cribrosa. We describe a phenotype of primary open angle glaucomca (POAG) patients with APON.
Methods: The medical records of Jules Stein Eye Institute glaucoma patients were reviewed. Any patient with a recorded APON was selected. Three experienced, masked, independent observers examined the stereophotographs and decision for presence of a pit was made by the agreement of at least two observers(Figure 1). POAG patients with at least one of these additional criteria were included :systolic blood pressure consistently≤ 100 mmHg, migraine or migraine variant, Raynaud's syndrome.
The type of glaucoma, age, gender, ethnicity, family history, history of intraocular surgeries, systemic conditions, spherical equivalent, central corneal thickness, place of the APON, disc hemorrhage, visual acuity, number of antiglaucoma drops and intraocular pressure (IOP) at each visit were recorded.
Results: Twenty-two patients and 35 eyes met the criteria of the study; 21 patients were female (95.45%). The average age at the time of glaucoma diagnosis (±SD) was 53± 15 years and the mean duration of follow-up was 11.8 ± 5.2 years. A history of low blood pressure was present in 59.1 % of the patients (13 patients). Five patients had a history of using beta-blocker drops for IOP control. Mean IOP, mean number of drops and mean visual acuity (in Log MAR) is 13.2 ± 4.3, 1.35 ± 1.2 and 0.2± 0.4 respectively. Bilateral APON was observed in 13 patients (59.1 %). An inferior APON was observed in 27 eyes (77%); the remainder were located superiorly. The mean central corneal thickness was 559±41 (range 479-648 microns).
Conclusions: Migraine headache, Raynaud's phenomenon and low blood pressure may be signs of a vasospastic component of glaucomatous optic nerve damage. Middle-aged female patients with clinical evidence of an underlying vascular insufficiency are at risk for focal optic nerve damage at low IOPs, in this group manifested as APON.



24-2 SITA-standard visual field shows a superior paracentral scotoma close to fixation with corresponding standard fundus stereophotograph with an inferior Acquired pit of the optic nerve
Commercial Relationships: Reza Alizadeh, None; **Pradtana Hirunpatravong**, None; **Pablo Romero**, None; **Joseph Caprioli**, None

Program Number: 2966 **Poster Board Number:** A0315
Presentation Time: 8:30 AM–10:15 AM
Correlation between isolated hemifield defects, OCT-based microangiography (OMAG) and the macular vulnerability zone (MZV)
Yungtai Kung[1], Chieh-Li Chen[1, 2], Philip P. Chen[1], Qinqin Zhang[1, 2], Ruikang K. Wang[1, 2], Raghu C. Mudumbai[1]. [1]Ophthalmology, University of Washington, Seattle, WA; [2]Bioengineering, University of Washington, Seattle, WA.
Purpose: 1) Correlate peripapillary retinal nerve fiber layer (RNFL) blood flow, as measured by normalized flux (NF) and vessel density (VD), using OMAG in eyes with glaucomatous defects in only one hemifield. 2) Determine whether isolated superior hemifield visual field defects (ISHD) correlate with decreased perfusion in the purported MVZ in the inferotemporal quadrant (IT) of the optic nerve. 3) Compare OMAG blood flow parameters in the affected IT with the superotemporal quadrant (ST) of the same eye.
Methods: Subjects were scanned using a 68 kHz Cirrus HD-OCT 5000 based OMAG prototype system (Zeiss, Dublin, CA) covering a 6.7x6.7 mm2 area centered at the optic nerve head (ONH) (9.8 µm sampling resolution). Blood flow signals were extracted using an OCT signal based OMAG method. Peripapillary RNFL was segmented by a proprietary program. RNFL vascular en face images were generated along the axial direction. RNFL vascular microcirculation (RNFLVM) was measured by calculating the normalized overall blood flux (NF) and vessel density (VD), which is the percent of detected vessels within an annulus region excluding large retinal vessels centered at the ONH. Glaucomatous eyes with the following criteria were included: 1) an isolated hemifield defect on reliable 24-2 SITA-Standard VF (no points in opposite hemifield with P<5% or worse). 2) OCT of RNFL showing focal thinning that was correlated to the visual field deficit. RNFL perfusion in areas of thinning were studied using OMAG where NF and VD of the IT were compared to the ST of the same eye.
Results: Four eyes (4 patients) were included (mean age 53.4 ± 9 years; mean 24-2 MD -4.65 ± 0.82 dB; mean C/D 0.7 ± 0.15; OCT RNFL thickness 75.25 ± 9.29 µm). Anatomic and functional correlation of the visual field, OCT RNFL and OMAG was noted. All 4 eyes had ISHD and showed decreased RNFLVM in the MVZ (Figure 1). There was a significantly decreased VD (P=0.037) in the IT compared to the ST and NF was lower in the IT compared to the ST (P=0.06).
Conclusions: In glaucoma patients with an ISHD, OMAG demonstrates decreased RNFL perfusion in the IT. This finding is consistent with the purported MVZ susceptibility theory of vasculopathic damage.

Figure 1.



Commercial Relationships: Yungtai Kung, None; **Chieh-Li Chen**, None; **Philip P. Chen**, None; **Qinqin Zhang**, None; **Ruikang K. Wang**, National Eye Institute (F), Carl Zeiss Meditec, Inc. (F); **Raghu C. Mudumbai**
Support: R01EY024158

Program Number: 2967 **Poster Board Number:** A0316
Presentation Time: 8:30 AM–10:15 AM
Association between retinal microcirculation perfusion and retinal thickness at macula region in glaucoma patients: An Optical Coherence Tomography Angiography study
Huan Xu, Xiangmei Kong. Ophthalmology and Vision Science, Eye and ENT hospital,Fudan University,Shanghai,China, Shanghai, China.
Purpose: Increasing evidence revealed that abnormalities in ocular blood flow and autoregulation ability of vessels played a crucial role in the etiology and progression of primary open-angle glaucoma (POAG). However, there are controversial opinions regarding the correlation between the alteration of retinal perfusion and the retinal structure changes in POAG patients. Our aim was to explore and evaluate the relationships among retinal microcirculation alteration and structure damage at macular region in POAG eyes using optic coherence tomography (OCT) angiography.
Methods: 35 eyes of 35 early-stage POAG (EG) patients and 33 eyes of 33 advanced-stage POAG (AG) patients were enrolled in this prospective cross-section study. The macular perfusion parameters (flow index & vessel density) and the average value of hemimacular retina thickness were derived from the 3D angio-retina and retina map procedures in the single OCT system with split-spectrum amplitude decorrelation angiography (SSADA) algorithm, respectively. The perfusion-structure correlation was analyzed after adjusting confounding factors with multivariable linear regression

model. And Pearson partial regression analysis model was used to compare the strength of correlations.

Results: There was a significantly positive correlation between macular perfusion (flow index/vessel density) and the macular retina thickness (full/inner thickness) (All P-values<0.001). Using Pearson partial regression analysis model, vessel density showed a stronger association with any independent variables than flow index. In the hemimacular analysis, the strongest correlation was observed between the macular perfusion and the inferior hemimacular thickness. Furthermore, the correlations between inner macular thickness and perfusion parameters were stronger than that of full macular thickness and same dependent variables (full-infer > full > full-super; inner-infer > inner > inner-super).

Conclusions: For POAG eyes, the thinning of full/inner retinal layer thickness was significantly associated with the attenuated retinal microcirculation perfusion at macular region.

Table 4 Pearson partial correlation coefficients between macular perfusion and macular structural measurements.

Variable	Full		Full-super		Full-infer		Inner		Inner-super		Inner-infer	
	|r|	P	|r|	P	|r|	P	|r|	P	|r|	P	|r|	P
Flow index	0.457	0.0003	0.328	0.0111*	0.549	<0.0001**	0.614	<0.0001**	0.490	<0.0001**	0.659	<0.0001**
Vessel density	0.536	<0.0001**	0.405	0.0015**	0.623	<0.0001**	0.692	<0.0001**	0.573	<0.0001**	0.724	<0.0001**

Full: full macular retina thickness; **Full-super**: full retina thickness of superior hemimacula; **Full-infer**: full retina thickness of inferior hemimacula; **Inner**: inner retina thickness; **Inner-super**: inner retina thickness of superior hemimacula; **Inner-infer**: inner retina thickness of inferior hemimacula; **|r|**: Pearson partial correlation coefficients; **P**: statistical significance calculated from the Pearson correlation analysis, *P<0.05, **P<0.01.

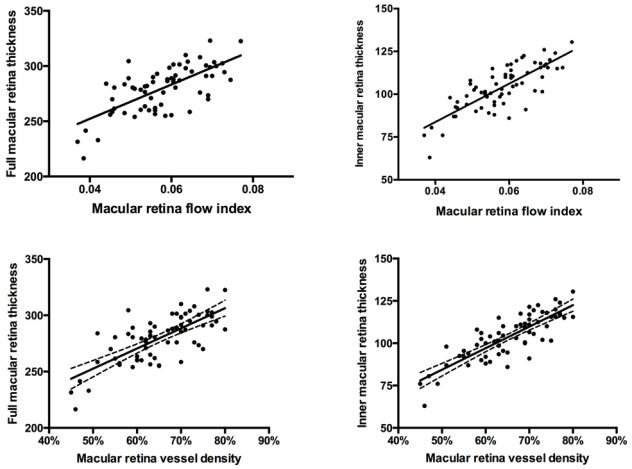


Figure 2 Correlation between macular retina flow index and retinal thickness or visual field parameters. (A) macular retina flow index & full macular retina thickness; (B) macular retina flow index & inner macular retina thickness; (C) macular retina vessel density & full macular retina thickness;(D) macular retina vessel density & inner macular retina thickness. 95% confidence interval were presented as the dashed lines.

Commercial Relationships: Huan Xu; **Xiangmei Kong**, None

Program Number: 2968 **Poster Board Number:** A0317
Presentation Time: 8:30 AM–10:15 AM
Retinal vascular caliber in normal-tension glaucoma patients according to visual field severity

Kojiro Imai[2], Kazuhiko Mori[1], Yoko Ikeda[1, 3], Morio Ueno[1], Haruna Yoshikawa[1], Yuko Maruyama[1], Yuji Yamamoto[1], Shigeru Kinoshita[4], Chie Sotozono[1]. [1]Department of Ophthalmology, Kyoto Prefectural Univ of Med, Kyoto, Japan; [2]Department for Medical Innovation and Translational Medical Science, Kyoto Prefectural Univ. of Med., Kyoto, Japan; [3]Oike-Ikeda Eye Clinic, Kyoto, Japan; [4]Department of Frontier Medical Science and Technology for Ophthalmology, Kyoto Prefectural Univ. of Med., Kyoto, Japan.

Purpose: Glaucoma is known to be a multifactorial disease comprised of intraocular pressure (IOP) and ocular hemodynamics. According to previous reports and our ARVO 2015 report, the retinal vascular caliber related with ocular hemodynamics is narrow in normal-tension glaucoma (NTG) patients. The purpose of this present study was to examine the retinal vascular caliber and ocular perfusion pressure in regard to the Anderson's grade of glaucoma severity in NTG patients.

Methods: This observational study involved 45 untreated NTG patients (22 males and 23 females; mean age: 51.1±13.5 years) and 45 healthy controls (22 males and 23 females; mean age: 53.8±9.5 years), comparable in regard to age and sex who were seen at the Kyoto Prefectural University of Medicine Hospital and the Oike-Ikeda Eye Clinic, Kyoto, Japan. Both patients and control with all kinds of treatment history including internal remedy, except for dry-eye disease or allergic conjunctivitis, were excluded from the study. Based on the width data of the 6 largest venules and arterioles in a digital retinal image, we calculated the central retinal artery equivalent (CRAE), the central retinal vein equivalent (CRVE), and the arterioles-to-venules ratio (AVR) by IVAN software (kindly provided by the University of Wisconsin-Madison) using the Parr-Hubbard-Knudtson formula. Ocular perfusion pressure (OPP) was estimated using blood pressure and IOP measurements. NTG patients were categorized into three groups (mild, moderate, and severe stage) according to the Anderson's grade. The non-paired *t* test and Dunnett's test were used as statistics analyses.

Results: CRAE, CRVE, AVR, and OPP were 128.0μm, 186.1μm, 0.69, and 44.2mmHg, respectively, in the NTG group, and 135.4μm, 198.4μm, 0.69, and 50.0mmHg, respectively, in the control group. CRAE, CRVE, and OPP were significantly lower in the NTG group than in the control group (p<0.01, respectively). The NTG group consisted of 13 mild, 18 moderate, and 14 severe stage patients. CRAE and CRVE were significantly narrower in the moderate and severe stage, and OPP was significantly lower in the mild stage, compared with the control group (p<0.05, respectively).

Conclusions: Ocular hemodynamics may vary among NTG patients from the aspect of the classification of severity.

Commercial Relationships: Kojiro Imai, None; **Kazuhiko Mori**, None; **Yoko Ikeda**, None; **Morio Ueno**, None; **Haruna Yoshikawa**, None; **Yuko Maruyama**, None; **Yuji Yamamoto**, None; **Shigeru Kinoshita**, None; **Chie Sotozono**, None

Program Number: 2969 **Poster Board Number:** A0318
Presentation Time: 8:30 AM–10:15 AM
Total retinal blood flow in healthy and glaucomatous human eyes measured with 3 beam Doppler optical coherence tomography

Richard Haindl[1], Andreas Wartak[1], Wolfgang Trasischker[1, 2], Bernhard Baumann[1], Michael Pircher[1], Christoph K. Hitzenberger[1]. [1]Medical University of Vienna, Vienna, Austria; [2]Harvard Medical School and Wellman Center for Photomedicine, Massachusetts General Hospital, Boston, MA.

Purpose: Two principal theories, a mechanical and a vascular, have been described for glaucomatous optic neuropathy (GON) development. To evaluate the vascular theory, exact and quantitative total retinal blood flow (RBF) measurements are still necessary. Therefore we evaluate the potential and repeatability of 3 beam Doppler optical coherence tomography (D-OCT) with regard to RBF measurements in healthy and glaucomatous human eyes to learn about alterations in RBF and velocity.

Methods: The 3 beam D-OCT consists of 3 independent spectral domain OCT subsystems operating at 50 kA-scans/s each. A well-defined beam geometry enables the full reconstruction of the 3 dimensional velocity vector without prior knowledge on the vessel geometry, which is normally required for D-OCT systems with less than 3 beams.

Twenty healthy and 5 glaucomatous eyes were imaged, employing a circular scan pattern around the optic nerve head (ONH). The mean RBF was measured for arteries and veins in both groups. The reproducibility of the method was evaluated for the mean RBF flow in 6 healthy eyes. Furthermore the RBF between healthy and glaucomatous eyes was compared.
Results: Averaged over 20 healthy eyes, the total venous and arterial mean blood flow was measured to be 47.1 ± 2.7 µl/min and 47.1 ± 2.4 µl/min respectively. The average coefficient of variation was ~ 6% (6 eyes, total flow). In the glaucomatous eyes the total venous and arterial mean flow averaged over 5 eyes was found to be reduced and measured with 36.1 ± 2.3 µl/min and 35.9 ± 1.7 µl/min respectively. A two-sample t-test between healthy and glaucomatous eyes yielded a highly significant difference in RBF between the two groups ($p < 0.001$). Fig. 1 shows a comparison between healthy and glaucomatous eyes.
Conclusions: Three beam D-OCT allows the direct measurement of total retinal blood flow and velocity independent from any a-priory knowledge on the vessel geometry. The average variance for total flow measurements is sufficiently small to measure the reduced blood flow in glaucomatous eyes. In the future 3 beam D-OCT may aid in the early diagnosis of glaucoma, evaluate the relevance of targeting ocular blood flow in treatment modalities and might be the proper tool to evaluate the vascular theory behind GON development.

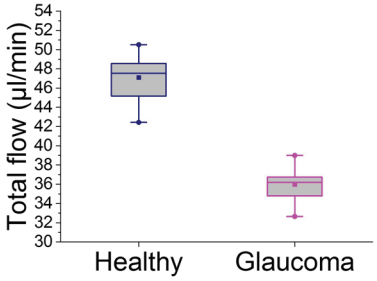


Fig. 1. Box-Whiskers plot of the total retinal mean blood flow in healthy and glaucomatous eyes (20 and 5 eyes respectively). Filled square: Average. Horizontal line: Median. Filled circles: Maximum and minimum measured flow. Box: 25th and 75th percentile. Whiskers: 1.5 times the interquartile distance – (+) the 25th (75th) percentile. If this value is smaller (greater) or equal to the smallest (largest) value in the dataset, the whisker is drawn at this position.

Commercial Relationships: Richard Haindl, None; **Andreas Wartak**, None; **Wolfgang Trasischker**, None; **Bernhard Baumann**, None; **Michael Pircher**, None; **Christoph K. Hitzenberger**, None
Support: FWF Grant P26553-N20

Program Number: 2970 **Poster Board Number:** A0319
Presentation Time: 8:30 AM–10:15 AM
Primary angle-closure glaucoma causes significant decrease in both retinal ganglion cell complex thickness and optic nerve blood flow
Hideki Fukuoka, Robert N. Weinreb, Natalie A. Afshari. Shiley Eye Institute, University of California, San Diego, La Jolla, CA.
Purpose: Acute angle-closure glaucoma (AACG) is an ocular emergency that without treatment may lead to blindness. Intraocular pressure may be controlled by immediate surgical treatment to prevent visual fields loss. However, even when there is no visual field loss, some patients have unexplained symptoms such as pain, blurriness or notice a difference between their two eyes. Therefore we investigated retinal ganglion cell complex (GCC) thickness and optic nerve blood flow of the affected eye and included patients with or without any visual field loss following AACG.
Methods: Ten eyes of nine patients (average age 81±7.6 years) who were being followed up for AACG were evaluated. Laser speckle blood flowgraphy imaging (LSFG-NAVI; Softcare Ltd, Fukuoka Japan) and optical coherence tomography (RS-3000, NIDEK, Gamagori Japan) were performed to measure optic nerve blood flow and GCC thickness when intraocular pressure had been stabilized at 20 mm Hg or less for at least 1 year after surgical treatment was performed at the time of glaucomatous attack and/or after topical glaucoma therapy. These values for the affected eye were compared with those of the fellow eye or average value of three age-gender matched normal subjects as control. We also considered the correlation of GCC thickness and optic nerve blood flow.
Results: Average GCC thickness of the affected eye was significantly thinner (76.1%, $p<0.001$) than that of the control eye especially in nasal inferior outside area. Optic nerve blood flow of the affected eye was significantly lower (MBR: 57%, $p=0.002$) than that of the control eye. There was a strong significantl correlation between GCC thickness and optic nerve flow ($r=0.63$, $p<0.01$). (Percentage of values for the control eye)
Conclusions: The retinal GCC thickness and the optic nerve flow of the affected eye were significantly lower in patients with AACG compared to that of the control eye. We also found a strong relationship between GCC thickness and optic nerve flow. These facts indicate that decreasing consumption of oxygen associated with thinning of GCC thickness may lead to decrease optic nerve blood flow and lead to patient's symptoms.
Commercial Relationships: Hideki Fukuoka, None; **Robert N. Weinreb**, None; **Natalie A. Afshari**

Program Number: 2971 **Poster Board Number:** A0320
Presentation Time: 8:30 AM–10:15 AM
Preperimetric glaucoma study 2: The relationship between optic nerve head blood flow and visual field progression in preperimetric glaucoma
Yukihiro Shiga[1], Naoko Aizawa[1], Satoru Tsuda[1], Kazuko Omodaka[1], Yu Yokoyama[1], Tomoki Yasui[2], Keiichi Kato[3], Toru Nakazawa[1]. [1]Ophthalmology, Tohoku University, Sendai, Japan; [2]Yasui Eye Clinic, Sendai, Japan; [3]Kato Eye Center, Sendai, Japan.
Purpose: We previously reported that optic nerve head blood (ONH) flow, as measured with laser speckle flowgraphy (LSFG), is significantly reduced in preperimetric glaucoma (PPG) (Shiga et al. 2015 in press). The purpose of this study was to investigate the relationship between LSFG-measured ONH hemodynamics and visual field progression in eyes with PPG that were undergoing treatment with topical prostaglandin analogues.
Methods: This prospective study comprised 93 eyes of 93 PPG patients (53.6 ± 1.9 years old). All patients were followed for at least 16 months and underwent at least 5 visual field examinations. ONH blood flow was assessed according to tissue-area mean blur rate (MBR_T), an index of capillary blood flow derived from LSFG. Circumpapillary retinal nerve fiber layer thickness (cpRNFLT) was measured with spectral-domain OCT. Visual field parameters were measured with the 24-2 SITA standard program of the Humphrey Field Analyzer. Total deviation (TD) slope was measured in each sector of the Garway-Heath map, which relates the anatomy of the ONH to the visual field. Finally, we classified subjects whose TD slope was in the first quartile as progressive and other subjects as non-progressive. We then compared baseline clinical characteristics in the two groups.

Results: We found that the TD slope in the upper temporal peripheral sector was significantly reduced in the subjects overall (-0.38 ± 1.43 dB/y, p = 0.001). Furthermore, MBR_T was significantly lower in this sector in the progressive group (10.23 ± 1.77 AU; 24 eyes of 24 subjects) than in the non-progressive group (12.02 ± 2.26 AU, p = 0.001; 69 eyes of 69 subjects). Otherwise, there were no significant differences in age, refractive error, untreated intraocular pressure, vertical cup/disc ratio, or cpRNFLT between the groups.
Conclusions: These data suggest that reduced ONH blood flow is associated with upper visual field loss progression in PPG eyes.
Commercial Relationships: Yukihiro Shiga, None; **Naoko Aizawa**, None; **Satoru Tsuda**, None; **Kazuko Omodaka**, None; **Yu Yokoyama**, None; **Tomoki Yasui**, None; **Keiichi Kato**, None; **Toru Nakazawa**, Santen Pharmaceutical Co. Ltd (F)
Clinical Trial: UMIN000013733

Program Number: 2972 **Poster Board Number:** A0321
Presentation Time: 8:30 AM–10:15 AM
Baseline retrobulbar blood flow velocities correlate more strongly with changes in retinal capillary density over 4 years in open angle glaucoma patients with diabetes mellitus
Casey Seizys[1], Alon Harris[1], Alice Chandra Verticchio Vercellin[2], Nicholas Moore[1], Amelia Huang[1], Darrell WuDunn[1], George Eckert[3], Brent A. Siesky[1]. [1]Ophthalmology, Indiana University School of Medicine, Indianapolis, IN; [2]University Eye Clinic, IRCCS Policlinico San Matteo, Pavia, Italy; [3]Biostatistics, Indiana University School of Medicine, Indianapolis, IN.
Purpose: To examine the relationship between baseline retrobulbar blood flow velocities and longitudinal changes in capillary blood flow in open angle glaucoma (OAG) patients with and without diabetes mellitus (DM)
Methods: 78 patients with OAG (16 with DM, 62 without DM) were assessed for peak systolic (PSV) and end diastolic (EDV) velocities in the nasal and temporal posterior ciliary arteries (NPCA, TPCA) by color Doppler imaging and for capillary blood flow by Heidelberg retinal flowmetry in superior and inferior temporal retinal quadrants at baseline and every 6 months for a 4-year period. Pearson correlations were used to test for associations between measurements, with $p<0.05$ considered statistically significant.
Results: In OAG patients with DM, baseline NPCA and TPCA EDV were 2.42 (95% CI: 2.11, 2.79) and 2.32 (2.02, 2.67) in patients with DM, and 2.41 (2.23, 2.60) and 2.45 (2.27, 2.65) in patients without DM. In OAG patients with DM, baseline NPCA and TPCA EDV were positively and significantly correlated with changes in inferior retinal capillary density (% zero pixels) (NPCA EDV: r=0.63, p=0.0069; TPCA EDV: r=0.65, p=0.0052), leading to a significant difference compared to patients without DM (NPCA EDV: p=0.0344; TPCA EDV: p=0.0121). There were no significant findings for PSV or superior temporal quadrants of blood flow in the retina for either group.
Conclusions: In OAG patients with DM, baseline retrobulbar blood flow exhibited a significantly stronger relationship to changes in retinal capillary density after 4 years compared to non-diabetic glaucoma patients. This data suggests that the presence of DM may affect ocular blood vessels over time in OAG patients.
Commercial Relationships: Casey Seizys, None; **Alon Harris**, Isama therapeutics (C), Stemnion Inc. (C), Nano Retina (C), Oxymap (I), AdOM (C), Biolight (C), Ono (C), Science Based Health (C), AdOM (I); **Alice Chandra Verticchio Vercellin**, None; **Nicholas Moore**, None; **Amelia Huang**, None; **Darrell WuDunn**; **George Eckert**, None; **Brent A. Siesky**, None
Support: Research to Prevent Blindness NY, NY, and American Diabetes Association Grant 1-12-IN-20

Program Number: 2973 **Poster Board Number:** A0322
Presentation Time: 8:30 AM–10:15 AM
Baseline retrobulbar blood flow correlates more strongly with longitudinal changes in macular structure in glaucoma patients of African descent
Alice Chandra Verticchio Vercellin[4], Alon Harris[1], Brent A. Siesky[1], Amelia Huang[1], Colin Ridenour[1], Ingrida Januleviciene[2], Lina Siaudvytyte[2], George Eckert[3], Nicholas Moore[1], Thomas A. Ciulla[1]. [1]Ophthalmology, Indiana University School of Medicine, Indianapolis, IN; [2]Ophthalmology, Lithuanian Univ of Health Sciences, Kaunas, Lithuania; [3]Biostatistics, Indiana University School of Medicine, Indianapolis, IN; [4]University Eye Clinic, IRCCS Policlinico San Matteo, Pavia, Italy.
Purpose: To examine the relationship between baseline retrobulbar blood flow and changes in macular structure in open-angle glaucoma (OAG) patients of African (AD) and European descent (ED) after four years
Methods: 84 patients with OAG (20 AD, 64 ED) were assessed for resistivity index (RI) in the ophthalmic artery (OA) and nasal posterior ciliary artery, and for end diastolic velocity (EDV) in the nasal and temporal posterior ciliary arteries (NPCA and TPCA) by color Doppler imaging. Macular thickness was assessed by optical coherence tomography every six months for a four-year period. Pearson correlations were used to test for associations between measurements, with $p<0.05$ considered statistically significant.
Results: Baseline OA RIs were 0.76 (95% CI: 0.73, 0.78) and 0.75 (0.73, 0.77), baseline NPCA RIs were 0.68 (0.65, 0.71) and 0.66 (0.64, 0.68) in patients of AD and ED, respectively. In patients of AD, baseline OA RI positively correlated with changes in macular volume (r=0.52, p=0.017), macular thickness outer inferior (r=0.53, p=0.015), inner inferior (r=0.55, p=0.011), inner nasal (r=0.57, p=0.008), and outer temporal (r=0.58, p=0.007). Baseline NPCA RI positively correlated with macular thickness inner nasal (r=0.51, p=0.020). These correlations were weak and/or not significant in patients of ED, leading to a significant difference between ED and AD groups (all $p<0.05$). Additionally, baseline NPCA EDV was 2.3 (2.1, 2.6) and 2.4 (2.2, 2.6), and TPCA EDV was 2.3 (2.1, 2.6) and 2.4 (2.2, 2.6) in AD and ED patients, respectively. In OAG patients of AD, baseline NPCA EDV negatively correlated with inner nasal macular thickness (r=-0.44, p=0.0495). NPCA EDV (r=-0.56, p=0.0088) and TPCA EDV (r=-0.54, p=0.0122) negatively correlated with outer inferior macular thickness. These correlations were weak and/or not significant in patients of ED, leading to a significant difference between groups (all $p<0.05$).
Conclusions: In OAG patients of AD, baseline retrobulbar blood flow parameters were more strongly associated with changes in macular thickness after four years, compared to ED patients. These findings suggest that retrobulbar blood flow may have a more prominent role in macular structural changes in OAG patients of AD.
Commercial Relationships: Alice Chandra Verticchio Vercellin, None; **Alon Harris**, Isama therapeutics (C), Stemnion Inc. (C), Nano Retina (C), Oxymap (I), AdOM (C), Biolight (C), Ono (C), Science Based Health (C), AdOM (I); **Brent A. Siesky**, None; **Amelia Huang**, None; **Colin Ridenour**, None; **Ingrida Januleviciene**; **Lina Siaudvytyte**, None; **George Eckert**, None; **Nicholas Moore**, None; **Thomas A. Ciulla**, None
Support: Research to Prevent Blindness NY, NY and NIH Grant 1R21EY022101-01A1

Program Number: 2974 **Poster Board Number:** A0323
Presentation Time: 8:30 AM–10:15 AM
Ophthalmic artery blood flow velocities predict functional and structural glaucoma progression after 5 years
Andrew Huck[1], Alon Harris[1], Alice Chandra Verticchio Vercellin[2], Nicholas Moore[1], Tyler J. Knight[1], Christian C. Frye[1], George Eckert[3], Brent A. Siesky[1]. [1]Ophthalmology, Indiana University School of Medicine, Indianapolis, IN; [2]University Eye Clinic, IRCCS Policlinico San Matteo, Pavia, Italy; [3]Biostatistics, Indiana University School of Medicine, Indianapolis, IN.
Purpose: To examine retrobulbar blood flow parameters and functional and structural progression in patients with open-angle glaucoma (OAG) over a 5-year period
Methods: 76 patients (Mean age 70 ± 10.9 years; 31 male, 45 female) were assessed every 6 months for a 5-year period for retrobulbar blood flow in the ophthalmic (OA), central retinal (CRA), nasal (NPCA) and temporal (TPCA) posterior ciliary arteries as measured by color Doppler imaging at baseline and functional disease progression was monitored with Humphrey visual field (24-2 Swedish Interactive Threshold Algorithm) defined as 2 consecutive visits with mean deviation decrease ≥2 and/or Advanced Glaucoma Intervention Study score increase ≥2 compared to baseline. Structural progression was monitored with optical coherence tomography and Heidelberg retinal tomography and defined as two consecutive visits with retinal nerve fiber layer thickness decrease ≥8% and/or horizontal or vertical cup/disk ratio increase ≥0.2 compared to baseline. Mixed-model ANCOVA was used to test for significant change from baseline to 5-year follow-up. Times to functional and structural progression were analyzed using Cox proportional hazards models.
Results: OA peak systolic velocity (PSV) was 23.0 (95% CI; 20.9, 25.4) at baseline, 21.8 (19.4, 24.4) at 5 years, change of -1.3 (-3.5, 0.7; p= 0.21), OA end diastolic velocity (EDV) significantly decreased from 5.6 (5.1, 6.2) at baseline to 3.9 (3.5, 4.4) at 5 years, change of -2.4 (-3.3, -1.6; p<0.0001). CRA PSV and EDV significantly decreased with changes of -0.6 (-1.1, -0.1; p=0.0126) and -0.8 (-1.1, -0.5; p<0.0001), respectively. NPCA and TPCA EDV significantly decreased with changes of -0.7 (-0.9, -0.4; p<0.0001) and -0.7 (-1.0, -0.5; p<0.0001), respectively, while neither NPCA nor TPCA PSV changed significantly. Resistivity indices (RI) in all retrobulbar vessels significantly increased over 5-years (p<0.0001). Lower OA PSV and OA EDV were associated with shorter time to functional and structural progression (OA PSV: p= 0.0162; OA EDV: p= 0.0065).
Conclusions: Lower OA blood flow velocities were predictive of both functional and structural glaucomatous progression after 5 years.
Commercial Relationships: Andrew Huck, None; **Alon Harris**, Isama therapeutics (C), Stemnion Inc. (C), Nano Retina (C), Oxymap (I), AdOM (C), Biolight (C), Ono (C), Science Based Health (C), AdOM (I); **Alice Chandra Verticchio Vercellin**, None; **Nicholas Moore**, None; **Tyler J. Knight**, None; **Christian C. Frye**, None; **George Eckert**, None; **Brent A. Siesky**, None
Support: Research to Prevent Blindness NY, NY

Program Number: 2975 **Poster Board Number:** A0324
Presentation Time: 8:30 AM–10:15 AM
Association of optic disc haemorrhages in open angle glaucoma with vascular symptoms
Gregor Thomaschewski, Karin R. Pillunat, Eberhard Spoerl, Lutz E. Pillunat. Ophthalmology, Univ Clinic Carl Gustav Carus Dresden, Dresden, Germany.
Purpose: The objective of this study was to investigate a possible association between optic disc haemorrhage (ODH) and blood pressure parameters and the occurrence of vascular symptoms such as vertigo, a tendency to collapse, tinnitus, cold extremities, migraine and headaches in patients with normal tension glaucoma (NTG) and high tension glaucoma (HTG).
Methods: 113 patients with NTG and 148 patients with HTG were investigated. Each participant had a complete glaucoma workup as well as 24-hour blood pressure monitoring. The patients also completed a standardised questionnaire relating to the occurrence of vertigo, a tendency to collapse, tinnitus, cold extremities, migraine and headaches. An association with the occurrence of an ODH was investigated with a contingency analysis and verified with the Chi2 test.
Results: Out of the 113 NTG patients, 32 patients (28.3%) had an ODH in at least one eye, 81 patients (71.7%) had no ODH. In this group, an ODH was statistically significantly associated with symptoms of vertigo (P=0.004) and tinnitus (P=0.032), but not with blood pressure parameters (p=0.336), the tendency to collapse (p=0.528), cold extremities (p=0.952), migraine (p=0.388) and headaches (p=0.343). For HTG patients, ODH occurred in 15 % of cases and showed no statistically significant correlation with blood pressure parameters (p=0.102) nor for the mentioned vascular symptoms (vertigo: P=0.462, tinnitus: P=0.653, the tendency to collapse: p=0.283, cold extremities: p=0.722, migraine: p=0.245 and headaches: p=0.448).
Conclusions: Vertigo and tinnitus seem to be associated with the occurrence of an ODH in NTG patients, but not in HTG patients. While migraine does not show an association with ODH, neither in NTG nor in HTG patients, as well as the blood pressure parameters, the tendency to collapse, cold extremities and headaches.
Commercial Relationships: Gregor Thomaschewski, None; **Karin R. Pillunat**, None; **Eberhard Spoerl**, None; **Lutz E. Pillunat**, None
Clinical Trial: NCT01503996

Program Number: 2976 **Poster Board Number:** A0325
Presentation Time: 8:30 AM–10:15 AM
Systemic and local factors related to optic nerve head blood flow in patients with glaucoma
Yutaro Yamada, Tomomi Higashide, Satoshi Takeshima, Sachiko Udagawa, Kazuhisa Sugiyama. Kanazawa University, Kanazawa, Japan.
Purpose: To evaluate systemic and local factors related to optic nerve head blood flow in patients with glaucoma.
Methods: We examined 163 eyes of 87 patients with glaucoma excluding the eyes with a history of glaucoma surgery and refractive surgery (82 eyes of 45 males; mean age, 62.2±11.9 years old). Optic nerve head (ONH) blood flow was measured with laser speckle flowgraphy (LSFG; Softcare, Japan). Here, we investigated the relationship between clinical parameters and ONH blood flow in all (MA), vessel (MV) and tissue (MT) areas using generalized linear mixed model with independent variables including age, sex, hypertension, diabetes mellitus, mean deviation (MD) in Humphrey visual field analyzer (24-2 SITA standard) (Carl Zeiss Meditec), best-corrected visual acuity, mean and range of the intraocular pressure (IOP) and ocular perfusion pressure (OPP) obtained from 2-day diurnal measurement, glaucoma medication score, axial length (AL) and lens status.
Results: Older age was significantly associated with lower ONH blood flow in MA, MV and MT (p=0.001, p=0.012, p=0.002, respectively). In patients with hypertension, ONH blood flow was significantly lower than patients without hypertension in MA, MV and MT (p<0.001, p<0.001, p<0.001, respectively). Worse MD was significantly associated with lower ONH blood flow in MA, MV

and MT (p<0.001, p<0.001, p<0.001, respectively). Longer AL was significantly associated with lower ONH blood flow in MA, MV and MT (p<0.001, p<0.001, p<0.001, respectively). Higher mean OPP was significantly associated with higher ONH blood flow in MA, MV and MT (p=0.001, p=0.003, p=0.006, respectively). In diabetic patients, ONH blood flow was significantly lower than non-diabetic patients in MA and MT (p=0.011, p=0.021, respectively). In female patients, ONH blood flow was significantly higher than male patients only in MT (p=0.019).
Conclusions: Systemic and local factors such as age, sex, hypertension, diabetes mellitus, MD, AL and OPP were significantly associated with the ONH blood flow in patients with glaucoma.
Commercial Relationships: Yutaro Yamada, None; **Tomomi Higashide**, None; **Satoshi Takeshima**; **Sachiko Udagawa**, None; **Kazuhisa Sugiyama**, None
Clinical Trial: http://www.med.kanazawa-u.ac.jp/staff/ethics/, 2012-016

Program Number: 2977 **Poster Board Number:** A0326
Presentation Time: 8:30 AM–10:15 AM
Alzheimer's disease and primary open angle glaucoma may share nailfold capillary abnormalities
Paul A. Knepper[1, 2], Clara Cousins[3], Kevin Carey[1], Indre Bielskus[1], Mit Patel[1], Nicholas J. Volpe[2], Thomas Patrianakos[4], Michael Giovingo[4], Louis R. Pasquale[5], Robert Stern[3].
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Purpose: Alzheimer's disease (AD) and primary open angle glaucoma (POAG) are common neurodegenerative diseases without known causes. Superactivated platelets which may cause hemorrhages occur in AD (J Neuro 254:545,2007) and in POAG (IOVS 55;531,2014). Recently we observed a significantly elevated number of nailfold (NF) hemorrhages in POAG (IOVS 56:7021,2015). The purpose is to examine the NF capillary in patients with AD and mild cognitive impairment (MCI) as well as POAG and controls.
Methods: Subjects were recruited from five sites after Institutional Review Board approval. Inclusive criteria were 70 to 90 years of age. Exclusion criteria were connective tissue disease and blood diathesis. NF video microscopy was performed on 10 AD/MCI subjects with a global clinical dementia rating ≥0.5, 56 POAG patients and 46 controls. All controls had IOP< 21 mm Hg OU and a cup-disc ratio of ≤0.6. All POAG patients had manifest visual field loss on standard automated perimetric tests. All AD/MCI patients denied a history of glaucoma. Masked observers graded NF capillary videos for the presence of hemorrhages, dilated capillary loops (>50μm), and avascular areas (>200μm). Intraobserver and interobserver agreement was high. ANOVA with post-hoc Tukey's correction was used for statistical analysis.
Results: The mean age was comparable: 78.4±7.7 (AD/MCI), 76.5±4.5 (POAG) vs. 73.9±5.2 (control) years. NF hemorrhages were present in 100% of AD/MCI, 86% of POAG compared to 24% of controls. The mean number of hemorrhages per 100 capillaries in AD/MCI was 2.41±2.3 (p<0.001 compared to control), in POAG was 2.06 ±2.0 (p<0.001 compared to controls) and 0.42 ±0.8 in controls. Dilated capillaries were present in 60% of AD/MCI, 45% of POAG and 35% of control subjects (p=0.2). Avascular zones were observed in 30% AD/MCI, 13% POAG, and 4% controls (p=0.1).
Conclusions: Both AD/MCI and POAG patients had significantly more NF hemorrhages compared to controls, supporting the notion that microvascular abnormalities exist in these patients. Since the NF hemorrhages are transient biomarkers lasting less than 7 days, the outcomes of therapeutic interventions to prevent the NF hemorrhages or treatments geared at AD can be readily determined by video microscopy. The etiology of these peripheral microvascular findings requires further studies, but these findings offer an exciting new lead to microvascular disease in AD/MCI and POAG.
Commercial Relationships: Paul A. Knepper, Testog Inc (P); **Clara Cousins**; **Kevin Carey**, None; **Indre Bielskus**, None; **Mit Patel**, None; **Nicholas J. Volpe**, None; **Thomas Patrianakos**, None; **Michael Giovingo**, None; **Louis R. Pasquale**, None; **Robert Stern**, None
Support: BrightFocus Foundation Grant G2011-047, National Eye Institute Grant p30EY01792

Program Number: 2978 **Poster Board Number:** A0327
Presentation Time: 8:30 AM–10:15 AM
Systemic blood and ocular perfusion pressures influence retrobulbar blood flow in open-angle glaucoma patients with diabetes mellitus
Betul Kaskan[1], Alon Harris[1], Nicholas Moore[1], Alice Chandra Verticchio Vercellin[2], Rachel Frantz[1], Christian Jonescu-Cuypers[1], George Eckert[3], Brent A. Siesky[1]. [1]Ophthalmology, Indiana University School of Medicine, Istanbul, Turkey; [2]University Eye Clinic, IRCCS Policlinico San Matteo, Pavia, Italy; [3]Biostatistics, Indiana University School of Medicine, Indianapolis, IN.
Purpose: To examine the relationship between blood pressure (BP) and ocular perfusion pressure (OPP) and changes in retrobulbar blood flow in open-angle glaucoma (OAG) patients with and without diabetes mellitus (DM)
Methods: 73 patients with OAG (13 DM, 60 without DM) were assessed for BP, OPP, and nasal posterior ciliary artery (NPCA) resistivity index (RI) by color Doppler imaging every six months for a four-year period. Systolic and diastolic blood pressure (SBP, DBP), mean arterial pressure (MAP), systolic and diastolic perfusion pressure (SPP, DPP), and mean perfusion pressure (MPP) were recorded at each visit. Additionally, 78 patients with OAG (12 DM, 66 without DM) were assessed for SBP, DBP, MAP, and ophthalmic artery (OA) peak systolic velocity (PSV) every six months over a four-year period. Pearson correlations were used to test for associations between measurements, with p<0.05 considered statistically significant.
Results: In the group of 73 OAG patients (13 DM, 60 without DM), baseline SBP (r=-0.68, p=0.010), DBP (r=-0.66, p=0.012), MAP (r=-0.76, p=0.002), SPP (r=-0.72, p=0.004), DPP (r=-0.71, p=0.005), OPP (r=-0.82, p<0.001), and MPP (r=-0.81, p<0.001) negatively correlated with changes in NPCA RI in DM patients. In patients without DM, these correlations were weak and non-significant (r=0.06-0.19, all p>0.05); leading to a significant difference between groups (SBP: p=0.008; DBP: p=0.013, MAP: p=0.002; SPP: p=0.002; DPP: p=0.002; OPP: p<0.001; MPP: p<0.001). In DM OAG patients: SBP had a mean change of 2.9 (95% CI: -8.3, 14.1; p=0.604), DBP had a mean change of -1.6 (-8.3, 5.2; p=0.648), and MAP had a mean change of 0.0 (-7.7, 7.7; p=0.995). Changes in SBP (r=0.80, p=0.001), DBP (r=0.71, p=0.008), and MAP (r=0.77, p=0.002) strongly and positively correlated with changes in OA PSV. In OAG patients without DM, changes in SBP, DBP, and MAP weakly correlated with changes in OA PSV (r=0.0 to 0.06, all p>0.05); leading to a significant difference between groups (SBP: p=0.002; DBP: p=0.020; MAP: p=0.006).
Conclusions: In OAG patients with DM, BP and OPP correlated with larger increases in retrobulbar vascular resistance and changes in retrobulbar blood flow after four years, compared to non-DM patients. This data suggests that mechanisms influencing the systemic

vasculature may also affect localized ocular blood vessels more strongly in OAG patients with DM.
Commercial Relationships: Betul Kaskan, None; **Alon Harris**, Isama therapeutics (C), Stemnion Inc. (C), Nano Retina (C), Oxymap (I), AdOM (C), Biolight (C), Ono (C), Science Based Health (C), AdOM (I); **Nicholas Moore**, None; **Alice Chandra Verticchio Vercellin**, None; **Rachel Frantz**, None; **Christian Jonescu-Cuypers**, None; **George Eckert**; **Brent A. Siesky**, None
Support: Research to Prevent Blindness NY, NY and American Diabetes Association Grant 1-12-IN-20

Program Number: 2979 **Poster Board Number:** A0328
Presentation Time: 8:30 AM–10:15 AM
Diabetic status influences retrobulbar blood flow involvement in glaucomatous functional progression over five years
Colin Ridenour[1], Alon Harris[1], Brent A. Siesky[1], Alice Chandra Verticchio Vercellin[2], Tyler J. Knight[1], Amelia Huang[1], Joseph Carr[1], George Eckert[3], Nicholas Moore[1]. [1]Ophthalmology, Indiana University School of Medicine, Avon, IN; [2]University Eye Clinic, IRCCS Policlinico San Matteo, Pavia, Italy; [3]Biostatistics, Indiana University School of Medicine, Indianapolis, IN.
Purpose: To examine retrobulbar blood flow velocities and functional progression in open-angle glaucoma (OAG) patients with and without diabetes mellitus (DM) over a five-year period
Methods: 111 patients with OAG (21 with DM, 90 without DM) were assessed for peak systolic velocity (PSV) and end diastolic velocity (EDV) in the ophthalmic artery (OA) and nasal posterior ciliary artery (NPCA) every six months for five years. Functional progression, evaluated by Humphrey 24-2 visual fields, was defined as two consecutive visits with mean deviation decrease ≥2 compared to baseline and/or Advanced Glaucoma Intervention Study score increase ≥2 compared to baseline. Mixed-model ANCOVA was used to test for statistically significant changes from baseline to five-year follow-up. Time to functional progression was analyzed using Cox proportional hazard survival analysis. Interactions were tested to determine if the effects of the factors on progression time differed by diabetes status.
Results: In OAG patients without DM, OA EDV decreased from baseline 6.0 to 4.4 at five years, mean change of -2.2 (95% CI -3.2, -1.4; p<0.001), NPCA EDV decreased from 2.4 to 1.9, mean change of -0.6 (-0.9, -0.4; p<0.001), while NPCA PSV did not significantly change from 7.5 to 7.4, mean change of 0.0 (-0.6, 0.5; p=0.871). Similarly in patients with DM, OA EDV decreased from 5.4 to 3.2, mean change -3.6 (-6.0, -1.7; p<0.001), NPCA EDV decreased from 2.4 to 1.6, mean change -1.1 (-1.8, -0.6; p<0.001), while NPCA PSV did not significantly change from 7.7 to 7.4, mean change of -0.4 (-1.5, 0.8; p=0.553). In diabetic patients, a smaller decrease in NPCA PSV was associated with shorter time to functional progression, while in patients without diabetes, a larger decrease in OA EDV and NPCA EDV were associated with shorter time to functional progression (p<0.05).
Conclusions: In this study, we found that changes in retrobulbar blood flow velocity have different effects on time to functional glaucoma progression in diabetics and non-diabetics. More research is required to understand how vascular contributions to the glaucoma disease process may be influenced by diabetes.
Commercial Relationships: Colin Ridenour, None; **Alon Harris**, Isama therapeutics (C), Stemnion Inc. (C), Nano Retina (C), Oxymap (I), AdOM (C), Biolight (C), Ono (C), Science Based Health (C), AdOM (I); **Brent A. Siesky**, None; **Alice Chandra Verticchio Vercellin**, None; **Tyler J. Knight**, None; **Amelia Huang**, None; **Joseph Carr**; **George Eckert**, None; **Nicholas Moore**, None
Support: Research to Prevent Blindness NY, NY, and American Diabetes Association Grant 1-12-IN-20

Program Number: 2980 **Poster Board Number:** A0329
Presentation Time: 8:30 AM–10:15 AM
Longitudinal changes in macular thickness correlate with changes in retrobulbar vascular resistance in open-angle glaucoma patients with diabetes mellitus
Thai Do[1], Alon Harris[1], Alice Chandra Verticchio Vercellin[2], Nicholas Moore[1], Colin Ridenour[1], Aditya Belamkar[1], George Eckert[3], Brent A. Siesky[1]. [1]Ophthalmology, Indiana University School of Medicine, Indianapolis, IN; [2]University Eye Clinic, iRCCS Policlinico San Matteo, Pavia, Italy; [3]Biostatistics, Indiana University School of Medicine, Indianapolis, IN.
Purpose: To examine the relationship between changes in macular thickness and changes in retrobulbar blood flow in open-angle glaucoma (OAG) patients with and without diabetes mellitus (DM)
Methods: 78 patients with OAG (12 with DM, 66 without DM) were assessed for retrobulbar blood flow in the central retinal artery (CRA) and nasal posterior ciliary artery (NPCA) by color Doppler imaging, and for macular thickness by optical coherence tomography every six months for a four-year period. Pearson correlations were used to determine statistically significant (p<0.05) associations between measurements.
Results: In patients with DM, changes in CRA resistivity index (RI) were positively correlated with changes in macular thickness in the outer inferior segment (r=0.70, p=0.009), and changes in NPCA RI were positively correlated with changes in macular thickness in both the inner superior (r=0.72, p=0.007) and inner nasal segments (r=0.71, p=0.008). In OAG patients without DM, these correlations were weak and not significant (CRA RI and outer inferior segment: r=0.03, p=0.831; NPCA RI and inner superior: r=0.03, p=0.820, and inner nasal segments: r=-0.04, p=0.770); leading to a significant difference between groups (macular thickness: outer inferior p=0.018; inner superior p=0.015; inner nasal p=0.010).
Conclusions: In this group of OAG patients with DM, changes in macular thickness were more strongly correlated to changes in retrobulbar blood flow, compared to non-diabetic subjects. These data suggest that retrobulbar vascular resistance may play a larger role in changes to macular structure in patients with diabetes.
Commercial Relationships: Thai Do, None; **Alon Harris**, Isama Therapeutics (C), Stemnion Inc. (C), Nano Retina (C), Oxymap (I), AdOM (C), Biolight (C), Ono (C), Science Based Health (C), AdOM (I); **Alice Chandra Verticchio Vercellin**, None; **Nicholas Moore**, None; **Colin Ridenour**, None; **Aditya Belamkar**, None; **George Eckert**, None; **Brent A. Siesky**
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Program Number: 2981 **Poster Board Number:** A0330
Presentation Time: 8:30 AM–10:15 AM
Longitudinal changes in retrobulbar blood flow more strongly correlate with changes in optic nerve head structure in open-angle glaucoma patients with diabetes mellitus
Tyler J. Knight[1], Alon Harris[1], Brent A. Siesky[1], Nicholas Moore[1], Colin Ridenour[1], Betul Kaskan[1], George Eckert[3], Alice Chandra Verticchio Vercellin[2]. [1]Ophthalmology, Indiana University School of Medicine, Indianapolis, IN; [2]University Eye Clinic, IRCCS Policlinico San Matteo, Pavia, Italy; [3]Biostatistics, Indiana University School of Medicine, Indianapolis, IN.
Purpose: To examine the relationship between changes in retrobulbar blood flow velocities and changes in optic nerve head (ONH)

structure in open-angle glaucoma (OAG) patients with and without diabetes mellitus (DM)
Methods: 79 patients with OAG (13 with DM, 66 without DM) were assessed for peak systolic velocity (PSV), end diastolic velocity (EDV), and resistivity index (RI) in the ophthalmic artery (OA), central retinal artery (CRA) and temporal posterior ciliary artery (TPCA) by color Doppler imaging and for ONH morphology and retinal nerve fiber layer (RNFL) thickness by Heidelberg retinal tomography 3 every six months for a four-year period. Pearson correlations were used to test for associations between measurements, with $p<0.05$ considered statistically significant.
Results: In OAG patients with DM, changes in OA RI were positively correlated with changes in height variation contour (r=0.70, p=0.009). Changes in CRA RI were negatively correlated with changes in linear cup/disc ratio (r=-0.64, p=0.016). TPCA PSV and EDV negatively correlated with changes in mean RNFL thickness (PSV: r=-0.71, p=0.006, EDV: r=-0.64, p=0.017) and RNFL cross-sectional area (PSV: r=-0.72, p=0.004; EDV: r=-0.67, p=0.010). Additionally, TPCA EDV correlated positively with changes in cup area (r=0.63, p=0.018), and cup/disc area ratio (r=0.56, p=0.046), and negatively with rim area (r=-0.62, p=0.022), and rim volume (r=-0.66, p=0.012). In OAG patients without DM, these correlations were weak and non-significant (r=-0.11 to 0.12, all $p>0.05$); leading to a significant difference compared to patients without DM ($p<0.05$).
Conclusions: These results suggest that vascular factors may play a more prominent role in the structural progression of OAG in patients with DM, compared to those without DM.
Commercial Relationships: Tyler J. Knight, None; **Alon Harris**, Isama therapeutics (C), Stemnion Inc. (C), Nano Retina (C), Oxymap (I), AdOM (C), Biolight (C), Ono (C), Science Based Health (C), AdOM (I); **Brent A. Siesky**, None; **Nicholas Moore**, None; **Colin Ridenour**; **Betul Kaskan**, None; **George Eckert**, None; **Alice Chandra Verticchio Vercellin**, None
Support: Research to Prevent Blindness NY, NY, and American Diabetics Association Grant 1-12-IN-20

Program Number: 2982 **Poster Board Number:** A0331
Presentation Time: 8:30 AM–10:15 AM
Retinal blood flow more strongly correlates with systemic blood pressure and ocular perfusion pressure in open-angle glaucoma patients with diabetes mellitus
Katherine Hutchins[1], Alon Harris[1], Nicholas Moore[1], Alice Chandra Verticchio Vercellin[2], Colin Ridenour[1], Betul Kaskan[1], George Eckert[3], Brent A. Siesky[1]. [1]Ophthalmology, Indiana University School of Medicine, Indianapolis, IN; [2]University Eye Clinic, IRCCS Policlinico San Matteo, Pavia, IN; [3]Biostatistics, Indiana University School of Medicine, Indianapolis, IN.
Purpose: To examine the relationship between retinal volumetric blood flow and both systemic blood pressure (BP) and ocular perfusion pressure (OPP) in open-angle glaucoma (OAG) patients with and without diabetes mellitus (DM)
Methods: 120 patients with OAG (19 with DM, 91 without DM) were assessed for systemic BP and OPP and for volumetric blood flow in the retinal vessels by Doppler Fourier-domain optical coherence tomography. Pearson correlations were used to test for associations between measurements, with $p<0.05$ considered statistically significant.
Results: In OAG patients, the superior hemisphere blood flow (microliters/min) was 16.45 (standard error: 1.38) and 17.68 (0.58) in patients with and without DM, respectively. In OAG patients with DM, superior hemisphere blood flow was positively correlated with diastolic BP (DBP) (r=0.53, p=0.019), mean arterial pressure (MAP) (r=0.50, p=0.027), OPP (r=0.45, p=0.054), diastolic perfusion pressure (DPP) (r=0.49, p=0.032) and mean perfusion pressure (MPP) (r=0.47, p=0.041). In OAG patients without DM, these correlations were weak and non-significant (r=-0.12 to -0.02, all $p>0.05$); leading to a significant difference between groups (DBP: p=0.022; MAP: p=0.031; OPP: p=0.025; DPP: p=0.018; MPP: p=0.024).
Conclusions: In this group of OAG patients, systemic BP and OPP were positively correlated with volumetric blood flow in the superior retinal hemisphere only in diabetics. These results suggest that systemic blood and ocular perfusion pressures have a larger influence on retinal blood flow in diabetic patients compared to those without diabetes, possibly due to a lack of localized autoregulation.
Commercial Relationships: Katherine Hutchins, None; **Alon Harris**, Isama therapeutics (C), Stemnion Inc. (C), Nano Retina (C), Oxymap (I), AdOM (C), Biolight (C), Ono (C), Science Based Health (C), AdOM (I); **Nicholas Moore**, None; **Alice Chandra Verticchio Vercellin**, None; **Colin Ridenour**, None; **Betul Kaskan**, None; **George Eckert**; **Brent A. Siesky**, None
Support: Research to Prevent Blindness NY, NY, and American Diabetes Association Grant 1-12-IN-20

Program Number: 2983 **Poster Board Number:** A0332
Presentation Time: 8:30 AM–10:15 AM
Racial differences in correlations between optic nerve head morphology and ocular blood flow in healthy eyes
Koosha Ramezani, Alon Harris, Brent A. Siesky, Carine Olinde, Darrell WuDunn, Betul Kaskan, Jennifer Eikenberry, Leslie A. Tobe, Lyne Racette. Department of Ophthalmology, Eugene and Marilyn Glick Eye Institute, Indianapolis, IN.
Purpose: To assess differences in the relationship between optic nerve head (ONH) morphology and ocular blood flow between persons of African descent (AD) and European descent (ED) with healthy eyes.
Methods: 46 participants (20 AD, 26 ED) with normal fundoscopic exam and intraocular pressure (IOP) <22mmHg were included. Each participant was assessed for disc area (DA), rim area (RA), linear cup to disc ratio (CDR), mean retinal nerve fiber layer (RNFL) thickness by Heidelberg retina tomograph. Retrobulbar blood flow was assessed by color Doppler imaging in the ophthalmic (OA), central retinal (CRA), nasal short posterior ciliary (NPCA) and temporal short posterior ciliary (TPCA) arteries. Peak systolic velocity (PSV), end diastolic velocity (EDV) and the resistive index (RI) were assessed in each artery. Mean retinal capillary blood flow and % of the area with no blood flow (% zero flow pixels) in both hemifields were measured with Heidelberg retinal flowmeter. Correlations between ONH morphology and ocular blood flow were derived using Pearson correlations. Differences between the correlations in the AD and ED groups were assessed using the Fisher r-to-z transformation method.
Results: No significant differences in age, gender, IOP and blood pressure were observed between groups. Significant differences in correlations were observed between the AD and ED groups in the CRA. In this artery, PSV and DA were positively correlated in AD (r=0.43) and negatively correlated in ED (r=-0.35) ($\Delta r=0.78$; p=0.01). A similar finding was observed for PSV and RA (AD: r=0.39; ED: r=-0.22; $\Delta r=0.61$; p=0.04). Significant negative correlations between RI and CDR were observed in all arteries in the ED group (r coefficients range=-0.48 to -0.39), but not in the AD group (r coefficients range=-0.14 to 0.17). No significant differences were observed in the correlations of ONH morphology and capillary blood flow. However, in the inferior hemifield, a positive correlation was found between zero flow pixel and RNFL thickness (r=0.51, p=0.01) and a negative

correlation between mean retinal flow and RNFL thickness (r=-0.50, p=0.01) in the ED group only.
Conclusions: ONH morphology and ocular blood flow relationship was significantly different in the healthy eyes of AD compared to ED. More research is required to show how these differences may affect glaucomatous risk.
Commercial Relationships: Koosha Ramezani, None; **Alon Harris**, Isama therapeutics (C), Stemnion Inc. (C), Nano Retina (C), Oxymap (I), Biolight (C), AdOM (C), Ono (C), Science Based Health (C), AdOM (I); **Brent A. Siesky**, None; **Carine Olinde**, None; **Darrell WuDunn**; **Betul Kaskan**, None; **Jennifer Eikenberry**, None; **Leslie A. Tobe**, None; **Lyne Racette**, None
Support: Biomedical Research Grant from Indiana University School of Medicine (LR); IUPUI DRIVE (Developing Diverse Researchers with InVestigative Expertise); unrestricted grant from Research to Prevent Blindness

Program Number: 2984 **Poster Board Number:** A0333
Presentation Time: 8:30 AM–10:15 AM
Retinal arterial vessel cross-sectional area more strongly correlates with structural parameters in open-angle glaucoma patients of African descent
Brent A. Siesky[1], Alon Harris[1], Alice Chandra Verticchio Vercellin[2], Amelia Huang[1], Tyler J. Knight[1], Yara Catoira-Boyle[1], George Eckert[3], Darrell WuDunn[1], Nicholas Moore[1]. [1]Ophthalmology, Indiana University School of Medicine, Indianapolis, IN; [2]University Eye Clinic, IRCCS Policlinico San Matteo, Pavia, Italy; [3]Biostatistics, Indiana University School of Medicine, Indianapolis, IN.
Purpose: To examine the relationship between retinal arterial vessel cross-sectional area and ocular structural parameters in open-angle glaucoma (OAG) patients of African (AD) and European descent (ED)
Methods: 122 patients with OAG (35 AD, 87 ED) were assessed for optic nerve head (ONH) morphology and retinal nerve fiber layer (RNFL) thickness by optical coherence tomography (OCT) and for retinal arterial area by Fourier domain Doppler OCT. Pearson correlations were used to test for associations between measurements, with $p<0.05$ considered statistically significant.
Results: The mean arterial area (mm2) was 0.0316 (standard error, SE: 0.0010) and 0.0300 (SE: 0.0008) in patients of AD and ED, respectively. In OAG patients of AD, arterial area (mm2) was positively correlated with rim area (r=0.47, p=0.004), superior RNFL thickness (r=0.39, p=0.021), temporal RNFL thickness (r=0.40, p=0.017), average RNFL thickness (r=0.38, p=0.025), and negatively correlated with cup/disc area ratio (r=-0.38, p=0.025) and cup/disc vertical ratio (r=-0.44, p=0.008). In ED patients, correlations were weak and non-significant (r=-0.17 to 0.07; all $p>0.05$); leading to a significant difference between groups (rim area: p=0.027; superior RNFL thickness: p=0.009; temporal RNFL thickness: p=0.004, average RNFL thickness: p=0.018; cup/disc area ratio: p=0.045; cup/disc vertical ratio: p=0.010).
Conclusions: In OAG patients of AD, retinal arterial vessel cross-sectional area was positively correlated with ONH rim area and RNFL thickness, and negatively correlated with cup/disc ratio. These results suggest that retinal blood supply may have a greater influence on structural markers of OAG disease in patients of AD compared to ED patients.
Commercial Relationships: Brent A. Siesky, None; **Alon Harris**, Isama therapeutics (C), Stemnion Inc. (C), Nano Retina (C), Oxymap (I), AdOM (C), Biolight (C), Ono (C), Science Based Health (C), AdOM (I); **Alice Chandra Verticchio Vercellin**, None; **Amelia Huang**, None; **Tyler J. Knight**, None; **Yara Catoira-Boyle**; **George Eckert**, None; **Darrell WuDunn**, Aerie Pharmaceuticals (F), Mati Therapeutics (F), InnFocus (F), Allergan (F); **Nicholas Moore**, None
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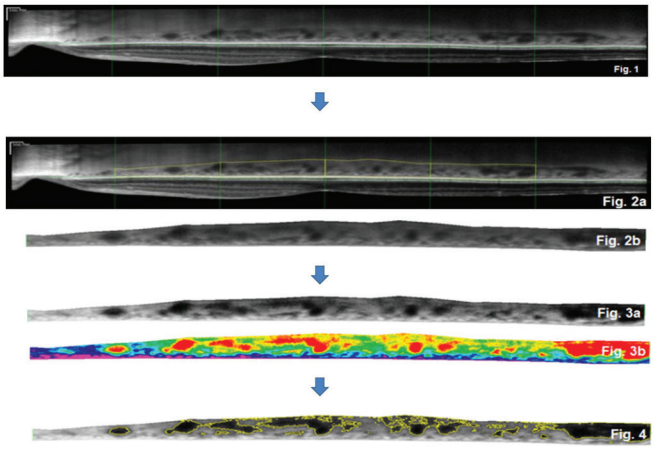
Program Number: 2985 **Poster Board Number:** A0334
Presentation Time: 8:30 AM–10:15 AM
Lower baseline ophthalmic artery blood flow velocities predict glaucomatous functional progression differently according to gender
Amelia Huang[1], Alon Harris[1], Alice Chandra Verticchio Vercellin[2], Nicholas Moore[1], Tyler J. Knight[1], Betul Kaskan[1], Christian Jonescu-Cuypers[1], George Eckert[3], Brent A. Siesky[1]. [1]Ophthalmology, Indiana University School of Medicine, Indianapolis, IN; [2]University Eye Clinic, IRCCS Policlinico San Matteo, Pavia, Italy; [3]Biostatistics, Indiana University School of Medicine, Indianapolis, IN.
Purpose: To examine retrobulbar blood flow parameters as they relate to functional progression in males and females with open-angle glaucoma (OAG) over a five-year period
Methods: 111 OAG patients (mean age 65 ± 10.9 years; 43 male, 68 female) were assessed for retrobulbar blood flow in the ophthalmic artery (OA), which was measured by color Doppler imaging at baseline and every six months for a five-year period. 73 patients (mean age 70 ± 10.9 years; 31 male, 42 female) were assessed at five-year follow-up. Visual field analysis was performed with Humphrey 24-2 and functional disease progression was defined as two consecutive visits with mean deviation decrease ≥2 and/or Advanced Glaucoma Intervention Study score increase ≥2 compared to baseline. Mixed-model ANCOVA was used to test for significant changes from baseline to five-year follow-up. Time to functional progression was analyzed using Cox proportional hazard models. Interactions were tested to determine if the effects of the factors on progression time differed by sex.
Results: OA end diastolic velocity (EDV) in males decreased from 5.7 (95% CI: 5.0, 6.6) at baseline to 4.6 (3.8, 5.5) at five years, mean change -1.4 (-2.7, -0.4; p=0.006). OA EDV in females decreased from 5.5 (4.9, 6.1) at baseline to 3.4 (3.1, 4.0) at five years, mean change -3.2 (-4.3, -2.2; $p<0.001$). Lower baseline OA EDV was associated with shorter time to functional progression in male (p=0.003), but not in female patients, leading to a significant difference between groups (p=0.040).
Conclusions: In this study, lower baseline retrobulbar blood flow was more predictive of functional vision loss after five years in males compared to females. These data suggest that blood flow may have a greater influence on time to disease progression based upon gender in certain patients with OAG.
Commercial Relationships: Amelia Huang, None; **Alon Harris**, Isama Therapeutics (C), Stemnion Inc. (C), Nano Retina (C), Oxymap (I), AdOM (C), Biolight (C), Ono (C), Science Based Health (C), AdOM (I); **Alice Chandra Verticchio Vercellin**, None; **Nicholas Moore**, None; **Tyler J. Knight**, None; **Betul Kaskan**, None; **Christian Jonescu-Cuypers**, None; **George Eckert**; **Brent A. Siesky**, None
Support: Research to Prevent Blindness NY, NY

Program Number: 2986 **Poster Board Number:** A0335
Presentation Time: 8:30 AM–10:15 AM
Retrobulbar blood flow velocities predict functional progression in open-angle glaucoma patients differently according to age
Alexander Snyder[1], Alon Harris[1], Nicholas Moore[1], Alice Chandra Verticchio Vercellin[2], Colin Ridenour[1], George Eckert[3], Scott Wentz[1], Brent A. Siesky[1]. [1]Ophthalmology, Indiana University School of Medicine, Indianapolis, IN; [2]University Eye Clinic, IRCCS Policlinico San Matteo, Pavia, Italy; [3]Biostatistics, Indiana University School of Medicine, Indianapolis, IN.
Purpose: To examine the relationship between retrobulbar blood flow parameters and functional progression in open-angle glaucoma (OAG) patients aged <65 and those ≥65 years old
Methods: 112 OAG patients (50 aged <65 years, 62 aged ≥65 years) were assessed for peak systolic velocity (PSV) and end diastolic velocity (EDV) in the ophthalmic (OA) and temporal posterior ciliary arteries (TPCA) as measured by color Doppler imaging at baseline and every six months for five years. 76 patients (25 aged <65 years, 51 aged ≥65 years) were assessed at five-year follow-up. Visual field analysis was performed with Humphrey 24-2 and functional disease progression was defined as two consecutive visits with mean deviation decrease ≥2 and/or Advanced Glaucoma Intervention Study score increase ≥2 compared to baseline. Mixed model ANCOVA was used to test for statistically significant changes from baseline to five-year follow-up. Time to functional progression was analyzed using Cox proportional hazards survival analysis. Interactions were tested to determine if the effects of factors on progression time differed by age status.
Results: In patients <65 years old, OA EDV decreased from baseline 6.3 (95% CI: 5.5, 7.3) to 4.4 (3.6, 5.3) at five years, mean change -2.8 (-4.5, -1.4; p<0.001). TPCA EDV also decreased from 2.4 (2.2, 2.7) to 1.9 (1.7, 2.1), mean change -0.7 (-1.1, -0.3; p<0.001). However OA PSV did not significantly change from 23.7 (20.8, 27.1) at baseline to 20.9 (17.6, 24.8) at five years, mean change -3.3 (-7.3, 0.3; p=0.072). Similarly in patients >65 years old, OA EDV decreased from 5.5 to 3.8, mean change -2.4, TPCA EDV decreased from 2.4 to 1.8, mean change -0.9, and OA PSV did not significantly change from 23.4 to 20.1, mean change -0.4. Lower OA PSV, lower OA EDV, and higher TPCA EDV were predictive of functional progression in OAG patients aged <65 years after five years only, resulting in a significant difference between age groups (p<0.05).
Conclusions: In this group of OAG patients, retrobulbar blood flow was more predictive of functional vision loss in glaucoma patients younger than 65 years old, compared to OAG patients 65 and older. Therefore, changes in blood flow may play a larger role in functional disease progression in younger patients compared to those age 65 and older.
Commercial Relationships: Alexander Snyder, None; **Alon Harris**, Isama Therapeutics (C), Stemnion Inc. (C), Nano Retina (C), Oxymap (I), AdOM (C), Biolight (C), Ono (C), Science Based Health (C), AdOM (I); **Nicholas Moore**, None; **Alice Chandra Verticchio Vercellin**, None; **Colin Ridenour**, None; **George Eckert**, None; **Scott Wentz**, None; **Brent A. Siesky**
Support: Research to Prevent Blindness NY, NY

Program Number: 2987 **Poster Board Number:** A0336
Presentation Time: 8:30 AM–10:15 AM
Large choroidal vessel thickness drives change in choroidal thickness with IOP following Trabeculectomy
Xuemin Zhang[1], Emily Cole[2], Angelique Pillar[1], Mehreen Adhi[2], Nadia K. Waheed[2], Osamah Saeedi[1]. [1]Ophthalmology, University of Maryland School of Medicine, Burtonsville, MD; [2]Ophthalmology, Tufts Medical Center, Boston, MA.
Purpose: Choroidal thickness (CT) has been shown to increase with intraocular pressure (IOP)-lowering following trabeculectomy. We studied the relationship between IOP and the change in the large choroidal vessels to determine the physiology behind change in CT.
Methods: 21 eyes of 20 patients undergoing trabeculectomy were examined pre-operatively, then post-operatively at 1 week and 1, 3, and 6 months with IOP checks and Enhanced Depth Imaging SD-OCT (Spectralis, Heidelberg Instruments) centered on the posterior 6mm surrounding the fovea. Two techniques were used to measure the choroidal vessel (CV) thickness, one focusing on the large choroidal vessel layer (LCVL), and the other determining the thickness (diameter) of the visible choroidal vessels themselves. Interstitial thickness was defined (1 – CV thickness). The relationship between the change in CV thickness, choroidal interstitial thickness, LCVL, change in IOP, and change in CT after trabeculectomy was analyzed using linear regression model to calculate the coefficient of determination (R^2), at one month and at greatest change.
Results: CV thickness increased with decrease in IOP at one month (p=0.03, 95% CI: -3.1, -0.2) but not at largest change in IOP (P=0.19, 95% CI: -3.3, 0.7). Similarly, interstitial thickness increased with decrease in IOP at one month (P=0.01, 95% CI: -2.8, -0.4), but not at the largest change in IOP (P=0.08, 95% CI: -2.8, 0.2). We found change in LCVL to be linearly correlated with change in CT nasally, temporally, and subfoveally at 1 month (b=1.10-1.49, R^2=0.82-0.94, p<0.05) and largest difference (b=1.21-1.40, R^2=0.40-0.62,p<0.05). In this sample, CV thickness was not linearly correlated with change in IOP (b=-1.6, R^2=0.291).
Conclusions: Our data show that the increase in CT with IOP-lowering following trabeculectomy is due to both changes in intravascular volume and interstitial space. CT increases linearly with the large choroidal vessel layer.

Method #1



Method #2

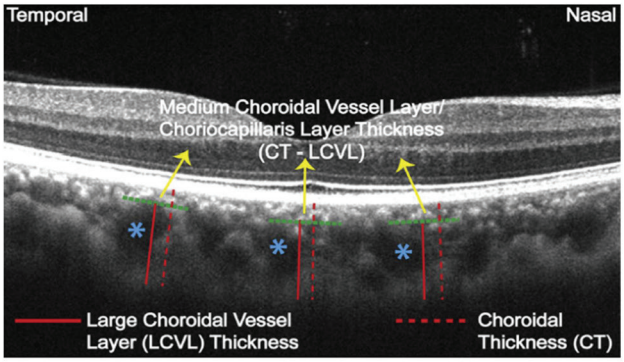


Figure 5 (Branchini 2010)

1. SD-OCT on the posterior 6 mm surrounding the fovea.
2. Using ImageJ, the choroid was manually isolated.
3. Contrast enhancement with histogram equalization.
4. A threshold value was set to outline vessels for area measurement, which was averaged over 6 mm choroid to obtain CT.
5. LCVL and CT were measured as the distance between inner sclera and inner point of the large choroidal vessel, and RPE, respectively, using Heidelberg software.

Commercial Relationships: Xuemin Zhang; **Emily Cole**, None; **Angelique Pillar**, None; **Mehreen Adhi**, None; **Nadia K. Waheed**, None; **Osamah Saeedi**, None

Program Number: 2988 **Poster Board Number:** A0337
Presentation Time: 8:30 AM–10:15 AM
Relationship between oxygen saturation of the retinal vessels and visual field defect in glaucoma patients: comparison with each hemifield

Kazuyuki Hirooka, Takeru Shimazaki, Yuuki Nakano, Eri Nitta, Kaori Ukegawa, Shino Sato, Akitaka Tsujikawa. Ophthalmology, Kagawa Univ Faculty of Medicine, Kita-gun, Japan.

Purpose: To investigate the relationship between visual field defects in the upper and lower hemifields and the corresponding oxygen saturation of the retinal vessels in patients with glaucoma.
Methods: This study enrolled 44 glaucoma patients who had more than a 10 dB difference between the upper and lower total deviation (TD). Retinal vessel oxygen saturation was measured with a non-invasive spectrophotometric retinal oximeter. The hemifields in one eye of each patient were divided into worse (worse TD) and better (better TD) hemifield areas. We also examined an additional 40 glaucoma patients who had less than a 5 dB difference between upper and lower TD. Statistical analysis was performed using a Student's t-test.
Results: Mean venous saturation of oxygen (SaO_2) was higher in the worse (59.0 ± 8.0%) versus the better (55.4 ± 7.2%) hemifield ($P < 0.01$). The mean arteriovenous difference in the SaO_2 was lower in the worse (44.4 ± 9.0%) versus the better (48.6 ± 11.4%) hemifield ($P = 0.02$). However, no statistical difference was found for the retinal SaO_2 in the venous vessels or for the arteriovenous difference between the worse and better hemifield in patients with less than a 5 dB difference in the upper and lower hemifield TD.
Conclusions: Advanced glaucomatous visual field defects are associated with increased SaO_2 in the venous vessels and a decreased arteriovenous difference in the SaO_2. Data suggest that there is a reduced retinal oxygen consumption in eyes with glaucomatous damage due to retinal ganglion cell loss.
Commercial Relationships: Kazuyuki Hirooka, None; **Takeru Shimazaki**, None; **Yuuki Nakano**, None; **Eri Nitta**, None; **Kaori Ukegawa**, None; **Shino Sato**, None; **Akitaka Tsujikawa**, None

Program Number: 2989 **Poster Board Number:** A0338
Presentation Time: 8:30 AM–10:15 AM
Retrobulbar blood flow predicts functional and structural progression in open-angle glaucoma patients with greater body mass indices

Leslie A. Tobe[1], Alon Harris[1], Brent A. Siesky[1], Nicholas Moore[1], Amelia Huang[1], Colin Ridenour[1], Yara Catoira-Boyle[1], George Eckert[2], Alice Chandra Verticchio Vercellin[3]. [1]Ophthalmology, Indiana University School of Medicine, Indianapolis, IN; [2]Biostatistics, Indiana University School of Medicine, Indianapolis, IN; [3]University Eye Clinic, IRCCS Policlinico San Matteo, Pavia, Italy.

Purpose: To examine ocular blood flow as it relates to functional and structural disease progression in normal weight (NW: body mass index (BMI) <25), overweight (OW: BMI 25-30) and obese (OB: BMI >30) patients with open-angle glaucoma (OAG) over five years
Methods: 112 patients with OAG (38 NW; 40 OW; 34 OB) were assessed for retrobulbar blood flow as measured by color Doppler imaging at baseline and every six months for a five-year period. 76 patients (30 NW; 25 OW; 21 OB) were assessed at five-year follow-up. Functional progression was monitored with Humphrey 24-2 visual fields, defined as two consecutive visits with mean deviation decrease ≥2 and/or Advanced Glaucoma Intervention Study score increase ≥2 compared to baseline. Structural progression was monitored with optical coherence tomography and Heidelberg retinal tomography, defined as two consecutive visits with retinal nerve fiber layer decrease ≥8% and/or horizontal or vertical cup/disc ratio increase ≥0.2 compared to baseline. Mixed-model ANCOVA and Cox proportional hazards models were utilized for significance and time to functional progression, respectively.
Results: All results are reported from baseline to five years. Ophthalmic artery (OA) resistivity index (RI) increased in NW from 0.77 to 0.83, change of 0.09 (95% CI: 0.04, 0.13), in OW from 0.76

to 0.81, change of 0.06 (0.02, 0.10), and in OB from 0.75 to 0.81, change of 0.07 (0.03, 0.13) (all p<0.05). Central retinal artery (CRA) RI increased in NW from 0.71 to 0.76, change of 0.04 (0.02, 0.07), in OW from 0.71 to 0.76, change of 0.05 (0.02, 0.09), and in OB from 0.70 to 0.78, change of 0.08 (0.05, 0.12) (all p<0.05). Higher OA RI and CRA RI were predictive of functional progression in OW patients (p<0.05). Lower CRA RI was predictive of functional progression in OB patients. Nasal posterior ciliary artery (NPCA) peak systolic velocity (PSV) did not change significantly within any weight group, however lower NPCA PSV was predictive of structural progression in OB patients (p<0.05).

Conclusions: Retrobulbar blood flow parameters may have a greater influence on functional and structural progression in OAG patients with a higher BMI.

Commercial Relationships: Leslie A. Tobe, None; **Alon Harris**, Isama therapeutics (C), Stemnion Inc. (C), Nano Retina (C), Oxymap (I), AdOM (C), Biolight (C), Ono (C), Science Based Health (C), AdOM (I); **Brent A. Siesky**, None; **Nicholas Moore**, None; **Amelia Huang**, None; **Colin Ridenour**, None; **Yara Catoira-Boyle**, None; **George Eckert**; **Alice Chandra Verticchio Vercellin**, None
Support: Research to Prevent Blindness NY, NY

Program Number: 2990 **Poster Board Number:** A0339
Presentation Time: 8:30 AM–10:15 AM

Ocular perfusion pressure as a surrogate for ocular perfusion: mathematical and statistical methods to interpret clinical data

Giovanna Guidoboni[1], Alon Harris[2], Alessandra Guglielmi[3], Simone Cassani[1], Brent A. Siesky[2]. [1]Mathematical Sciences, Indiana University Purdue University Indianapolis, Indianapolis, IN; [2]Ophthalmology, Indiana University School of Medicine, Indianapolis, IN; [3]Mathematics, Politecnico di Milano, Milano, Italy.

Purpose: Ocular perfusion pressure (OPP), defined as the difference between 2/3 of mean arterial pressure (MAP) and intraocular pressure (IOP), has been proposed as a surrogate for ocular perfusion, which is not measurable directly. Even though low OPP is a recognized risk factor for glaucoma, controversies remain as to what extent OPP is indicative of ocular circulation and whether MAP and IOP are combined risk factors. Here, mathematical and statistical methods are used to address these controversies.

Methods: Two approaches are used to study in silico (Part 1) and clinical data (Part 2).

Part 1: A mathematical model of the retinal circulation (Fig1a) is used as a virtual lab to isolate the contributions of IOP and MAP on retinal blood flow (RBF). IOP acts as external pressure in the intraocular region and on the lamina cribrosa, MAP is the input blood pressure, and autoregulation (AR) is embodied in the resistances R_{2a} and R_{2b}.

Part 2: A statistical method (logistic regression) with variance inflation factors is used to account for the multicollinearity of OPP, MAP and IOP as covariates in predicting glaucoma risk and it is applied to a dataset of 157 individuals (73 healthy, 84 with glaucoma) from the Indianapolis Glaucoma Progression Study.

Results: Fig1b shows the model predicted RBF as a function of OPP when: 1) IOP varies in [5, 45]mmHg and MAP=93.3mmHg (solid line); 2) MAP varies in [48.3, 108.3]mmHg and IOP=15mmHg(dashed line); 3) with functional AR (black lines); and 4) impaired AR (blue lines). Results indicate that, in the range [23,50] mmHg, OPP is a good synthetic index for the influence of MAP and/or IOP variations on RBF. Fig2a shows that the probabilities (p) of having glaucoma (p=1) or not (p=0) as predicted by the statistical model (red circles) and observed in the dataset (black circles) are in good agreement. Fig2b reports the predicted p for a new female (F) or male (M) patient joining the study as a function of OPP, for MAP=93.3mmHg and IOP=12, 16 or 20mmHg, indicating the importance of MAP and IOP as combined risk factors.

Conclusions: Our analysis suggest that: 1) OPP is a good indicator of retinal circulation over a wide range of MAP and IOP; and 2) good estimates of glaucoma risk can be obtained when accounting for the multicollinearity of OPP, MAP and IOP in the statistical analysis of clinical data.

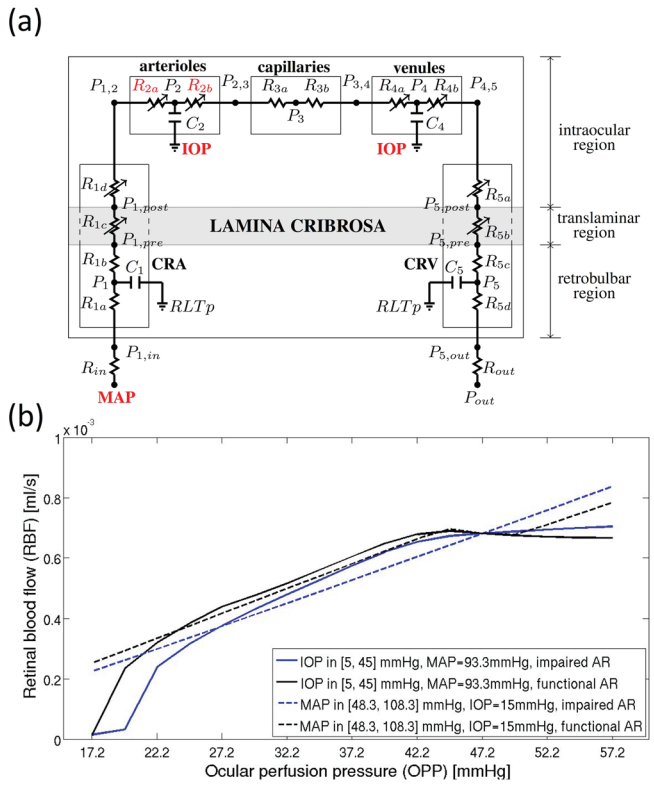


Fig1: Mathematical model

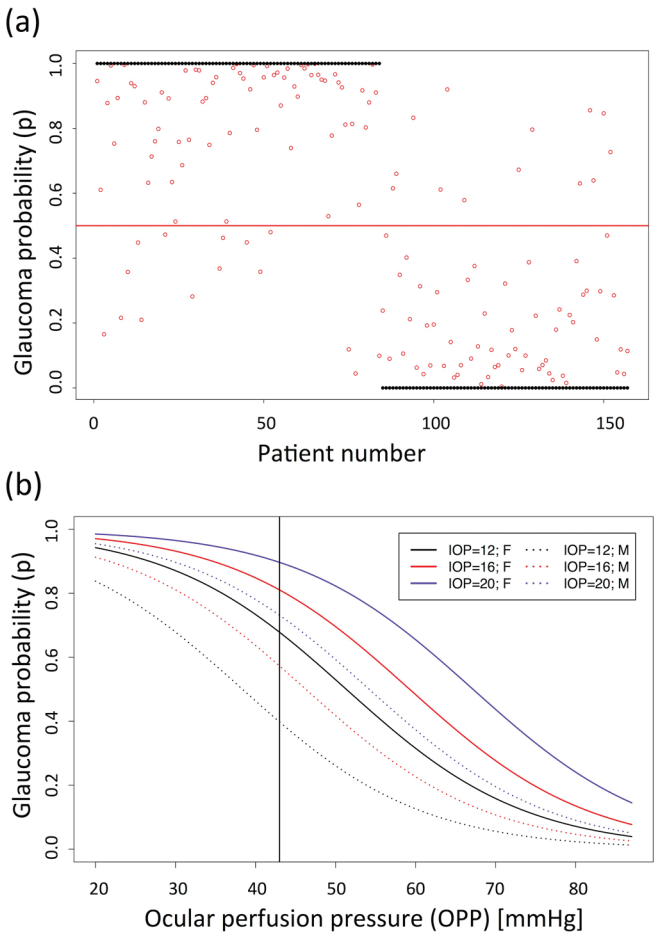


Fig2: Statistical analysis

Commercial Relationships: Giovanna Guidoboni, None; **Alon Harris**, Isama therapeutics (C), Stemnion Inc. (C), Nano Retina (C), Oxymap (I), Biolight (C), AdOM (C), Ono (C), Science Based Health (C), AdOM (I); **Alessandra Guglielmi**, None; **Simone Cassani**, None; **Brent A. Siesky**, None

Support: This work has been partially supported by the NSF DMS-1224195, NIH 1R21EY022101- 01A1, a grant from Research to Prevent Blindness (RPB, NY, USA), an Indiana University Collaborative Research Grant of the Office of the Vice President for Research, the Chair Gutenberg funds of the Cercle Gutenberg (France) and the Labex IRMIA (University of Strasbourg, France).

Program Number: 2991 **Poster Board Number:** A0340
Presentation Time: 8:30 AM–10:15 AM

Computer-aided ophthalmic artery waveform analysis in healthy individuals and glaucoma patients

Lucia Carichino[1], Giovanna Guidoboni[1, 2], Alice Chandra Verticchio Vercellin[4], Giovanni Milano[4], Carlo Alberto Cutolo[3], Carmine Tinelli[5], Annalisa De Silvestri[5], Sergey Lapin[6, 7], Brent A. Siesky[2], Alon Harris[2]. [1]Mathematical Sciences, Indiana University Purdue University Indianapolis, Indianapolis, IN; [2]Ophthalmology, Indiana University School of Medicine, Indianapolis, IN; [3]University Eye Clinic, DiNOGMI, University of Genoa, Genoa, Italy; [4]University Eye Clinic, Foundation IRCCS, Policlinico San Matteo, Pavia, Italy; [5]Clinical Epidemiology and Biometric Unit, Foundation IRCCS, Policlinico San Matteo, Pavia, Italy; [6]Washington State University, Pullman, WA; [7]Kazan Federal University, Kazan, Russian Federation.

Purpose: Arterial waveform parameters (WPs) are commonly used to monitor and diagnose systemic diseases. Color Doppler Imaging (CDI) is a consolidated technique to measure blood velocity profile in some of the major ocular vessels. This study proposes a computer-aided manipulation process of ophthalmic artery (OA) CDI images to classify and quantify WPs that might be significant in the assessment of glaucoma and ocular vascular diseases.

Methods: The Siemens Antares Stellar Plus™, probe VFX 9-4 MHz vascular linear array, was used to obtain 50 CDI images acquired by 4 different operators on 9 healthy individuals at the IRCCS Policlinico San Matteo of Pavia. The Philips HDI 5000 SonoCT Ultrasound System with the microvascular small parts clinical option (Philips Medical Systems, Bothell, Washington, USA), 7.5 MHz linear probe, was used to obtain CDI images of 22 glaucoma patients within the Indianapolis Glaucoma Progression Study. An ad-hoc semi-automated image processing code was implemented to detect the digitalized OA velocity waveform and to extract the following WPs: peak systolic velocity (PSV), end diastolic velocity (EDV), resistive index (RI), area under the wave (A), period of a cardiac cycle (T), difference between the PSV time and the dicrotic notch time (Dt) and the area ratio (f), Fig 1.

Results: When compared to healthy individuals, glaucoma patients show:
1) significantly lower values of PSV (25.02±11.29 vs 39.50±11.16 cm/s, p=2e-6), EDV (4.56±2.82 vs 6.02±2.33 cm/s, p=0.014), A (11.54±5.29 vs 14.53±4.80 cm, p=0.012) and Dt (0.22±0.04 vs 0.25±0.01 s, p=4e-7);
2) significantly higher values of f (0.77±0.08 vs 0.56±0.06, p=3e-19);
3) no statistical difference in RI (p=0.053) and T (p=0.107).
All comparisons were made with a two-sample t-test with a 5% significance level. When comparing multiple CDI images for the same healthy individual, T, Dt and f resulted to be more consistent than PSV, EDV, RI and A (average coefficient of variation <8% vs >20%), Fig 2.

Conclusions: The proposed computer-aided manipulation of OA-CDI images allowed to identify novel reliable WPs that vary significantly among healthy individuals and glaucoma patients (Dt and f). In future studies, this technique will be used to further assess the clinical relevance of these findings in the assessment of glaucoma and ocular vascular diseases.

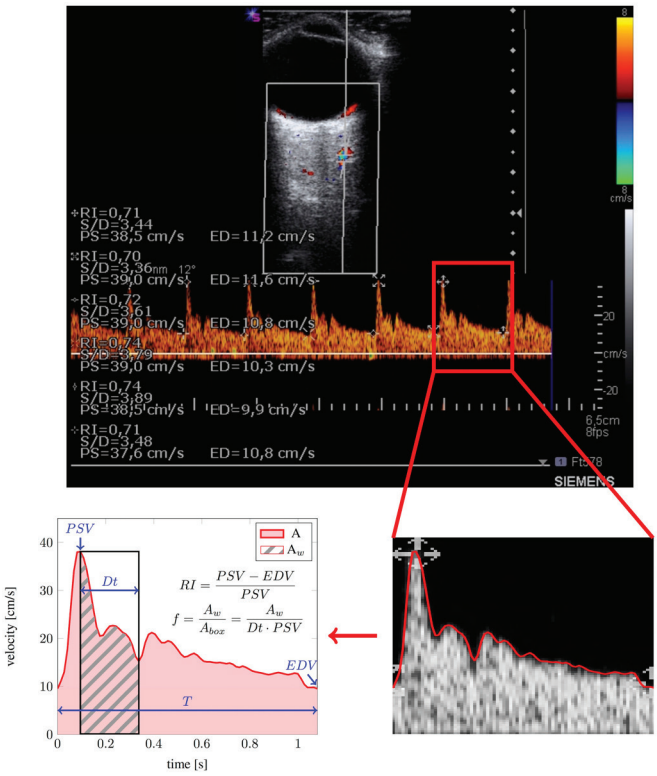


Fig 1. Computer-aided image manipulation process

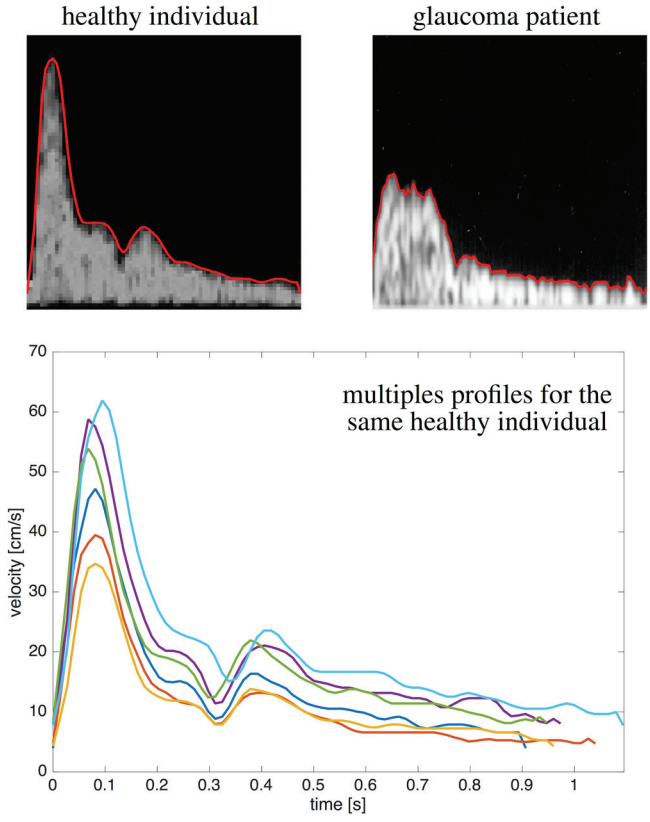


Fig 2. OA-CDI digitalized profiles

Commercial Relationships: Lucia Carichino; **Giovanna Guidoboni**, None; **Alice Chandra Verticchio Vercellin**, None; **Giovanni Milano**, None; **Carlo Alberto Cutolo**, None; **Carmine Tinelli**, None; **Annalisa De Silvestri**, None; **Sergey Lapin**, None; **Brent A. Siesky**, None; **Alon Harris**, Isama therapeutics (C), Stemnion Inc. (C), Nano Retina (C), Oxymap (I), Biolight (C), AdOM (C), Ono (C), Science Based Health (C), AdOM (I)

Support: This work has been partially supported by the NSF DMS-1224195, NIH 1R21EY022101- 01A1, a grant from Research to Prevent Blindness (RPB, NY, USA), an Indiana University Collaborative Research Grant of the Office of the Vice President for Research, the Chair Gutenberg funds of the Cercle Gutenberg (France) and the Labex IRMIA (University of Strasbourg, France).

Program Number: 2992 **Poster Board Number:** A0341
Presentation Time: 8:30 AM–10:15 AM

The Effect of Systemic Hyperoxia on Optic Nerve Head Blood Flow in Glaucoma

Naoki Kiyota, Yukihiro Shiga, Marika Sato, Shigeto Maekwa, Kazuko Omodaka, Kazuichi Maruyama, Hidetoshi Takahashi, Hiroshi Kunikata, Toru Nakazawa. Ophthalmology, Tohoku university school of medicine, Sendai-shi, Japan.

Purpose: It has been suggested that dysfunctional autoregulation of optic nerve head blood flow is associated with the pathology of glaucoma. Thus, methods to evaluate autoregulatory capacity are needed. Previously, we described a laser speckle flowgraphy-based method to quantify autoregulatory capacity during oxygen inhalation in normal subjects (Shiga Y et al. 2014). Here, we evaluate this technique in open-angle glaucoma (OAG) patients.
Methods: This study comprised 12 eyes of 12 OAG patients (age: 54.4 ± 12.7 years, mean deviation: -3.4 ± 4.0 dB) and 12 age-matched eyes of 12 normal subjects (age: 55.2 ± 8.1 years). The testing protocol had three stages: baseline, hyperoxia (12 min of pure oxygen at 6L/min), and recovery (4 min of room air). Before and after oxygen inhalation, we evaluated optic nerve head blood flow according to the mean blur rate (MBR), an LSFG-derived variable. We measured blood pressure (BP), heart rate (HR), and peripheral capillary oxygen saturation (SpO_2) every 5 min.
Ocular perfusion pressure (OPP) was calculated using baseline IOP. We compared the variables at each measured time point in both groups.
Results: No significant changes were seen in BP, HR, or OPP (P = 0.39-0.98) during the testing despite a significant increase in SpO_2 during hyperoxia in both groups (P < 0.0001). MBR was significantly higher during hyperoxia in the OAG patients than in the normal subjects (90.7 ± 8.8% vs. 85.0 ± 4.6%, respectively, P = 0.04; baseline = 100% in both).
Conclusions: The response to hyperoxia was significantly lower in the OAG patients. This result may indicate that autoregulation becomes dysfunctional in glaucoma.

Commercial Relationships: Naoki Kiyota, None; **Yukihiro Shiga**, None; **Marika Sato**; **Shigeto Maekwa**, None; **Kazuko Omodaka**, None; **Kazuichi Maruyama**, None; **Hidetoshi Takahashi**, None; **Hiroshi Kunikata**, None; **Toru Nakazawa**, None

Program Number: 2993 **Poster Board Number:** A0342
Presentation Time: 8:30 AM–10:15 AM

Ocular neurovascular changes during head-down posture predict future retinal nerve fiber layer loss in glaucoma suspects

Giacinto Triolo[1, 2], William J. Feuer[1], Pedro F. Monsalve[1], Luis E. Vazquez[1], John J. McSoley[1], Lori Ventura[1], Vittorio Porciatti[1]. [1]Ophthalmology, Bascom Palmer Eye Institute, University of Miami Miller School of Medicine, Miami, FL; [2]Ophthalmology, University Scientific Institute San Raffaele, Milan, Italy.

Purpose: To investigate posture-induced neuro-vascular changes predictive of optic nerve tissue loss in glaucoma suspects (GS).
Methods: Mean peripapillary retinal fiber layer thickness (RNFLT) was measured with OCT two times/year in 29 GS aged 58 ± 8.9 years over 5.0 ± 0.73 years. GS, together with 11 age-matched controls aged 54.2 ± 10 years, also had a baseline pattern electroretinogram (PERG), IOP and brachial blood pressure measurements in the seated and - 10 degrees head-down-body-tilt position (HDT). An additional group of 17 young, healthy subjects aged 20.4 ± 10 years was used to investigate age-dependent changes in hemodynamic parameters during HDT.
Results: While all GS had baseline RNFLT in the normal range, 10/29 (34%) of them developed significant (P<0.05) thinning over the follow-up period. There was no correlation between initial RNFLT and corresponding change (R2 = 0.008). RNFL-thinners, RNFL-non-thinners, and controls tended to differ in a number of measurements such as HDT-PERG amplitude, seated PERG phase, seated systolic blood pressure (SBP), HDT-diastolic blood pressure (DBP), and calculated HDT-ocular perfusion pressure (OPP). Backward stepwise logistic regression including seated and HDT-induced changes of all variables determined a prediction equation discriminating (P=0.007) thinners from non-thinners with 90% sensitivity and 79% specificity (AUROC=0.91) with 2 false negatives and 1 false positive.
Conclusions: HDT is a non-invasive provocative procedure that can disclose neuro-vascular deficits in glaucoma suspects predictive of future loss of optic nerve tissue. This study provides a proof of concept that the HDT-PERG provocative test may have a role in the clinical management of glaucoma.
Commercial Relationships: Giacinto Triolo, None; **William J. Feuer**, None; **Pedro F. Monsalve**, None; **Luis E. Vazquez**, None; **John J. McSoley**, None; **Lori Ventura**, None; **Vittorio Porciatti**, None
Support: National Institute of Health-National Eye Institute (NIH-NEI) RO1 EY014957, NIH Center Grant P30-EY014801, and an unrestricted grant to Bascom Palmer Eye Institute from Research to Prevent Blindness, Inc.

Program Number: 2994 **Poster Board Number:** A0343
Presentation Time: 8:30 AM–10:15 AM
Choroidal Volume Change with Acute Intraocular Pressure Elevation in Primary Angle-Closure Suspects
Ya Xing Wang[1], Ran Jiang[1], Hong Li Shi[2], Liang Xu[1], Jost B. Jonas[3].
[1]Beijing Institute of Ophthalmology, Beijing Tongren Hospital, Beijing, China; [2]College of Biomedical Engineering, Capital Medical University, Beijin, China; [3]Department of Ophthalmology, Medical Faculty Mannheim of the Ruprecht-Karls-University, Manheim, Germany.
Purpose: To investigate the change of choroidal volume (CV) in the macular region after acute intraocular pressure (IOP) elevation in patients with occludable angles.
Methods: A dark room prone provocative test (DRPPT) for was applied to angle-closure suspects. A swept-source optical coherence tomography was performed in the individuals before the DRPPT was started and within 5 minutes after the 2-hour DRPPT. 3D image data sets of the macular choroid were obtained using a 6×6 mm raster scan protocol. It post-processed using the Amira software. The choroid was manually outlined every 10 images by one experienced ophthalmologist. A cubic spline interpolation was applied to obtain a smooth continuous line in the X-axis, and then in the Y-axis, to get a smooth continuous plane. A 3×3 mm^2 square area centered on the fovea was chosen for analysis, which was further divided to 5 regions (central, superior, inferior, nasal and temporal) (Fig1). CV was computed in a masked manner in each region and as a whole at baseline and after IOP rise using MATLAB software.
Results: The study enrolled 30 eyes of 16 individuals with a mean age of 61.8±8.1 years. IOP increased from 18.1±2.0mmHg at baseline to 27.4±8.7mmHg after the DRPPT. CV showed a significant (P<0.05) decrease after the DRPPT in each sub-region and as a whole (Tab1.) The change of CV was largest in the central region (-5.1±6.7%), followed by the nasal region (-4.6±6.8%), inferior region (-4.1±6.0%), temporal region (-3.7±5.6%), and superior region (-1.8±5.0%). In multivariate analysis, the change in CV was significantly associated with the rise in IOP and / or with the baseline CV at the same location, but not associated with age, gender, axial length, or anterior chamber depth.
Conclusions: CV in the macular region decreased parallel to an acute increase in IOP in individuals 2 hours after the DRPPT, with the changes being most marked in the central and nasal regions of the macula.

Figure 1. Image showing the scan location (within green square, 6×6mm^2), the area that the choroidl volume was measured (within yellow square, 3×3 mm^2), and the divided five sub-regions. The central region was defined within the red square (1×1mm^2). The superior, nasal, inferior, and temporal region was defined as the according area between the read square and the yellow square.

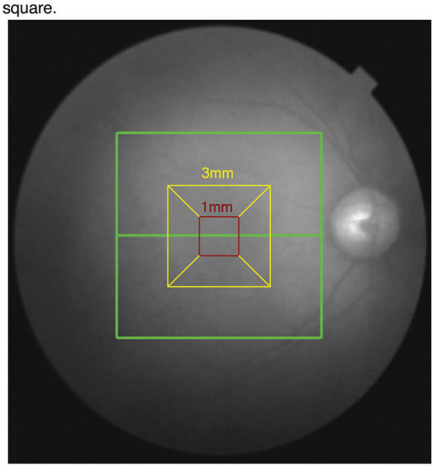


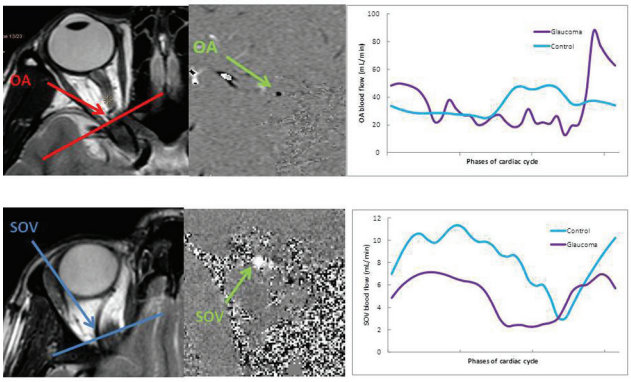
Table 1. Values of the intraocular pressure (IOP) and the choroidal volume (CV) at baseline and afther the dark room prone provocative test (DRPPT), and the comparisons. Data was presented as mean ± standar deviation and range.

Parameters	Baseline	After DRPPT	Change	Proportion of change (%)	t	P
IOP *mmHg*	18.1 ± 2.0 (15, 21)	27.4 ± 8.7 (20, 57)	9.3 ± 8.7 (3.0, 40.3)	52.5± 52.3 (15.0, 241.0)	-5.84	<0.001
Central CV *mm^3*	0.254 ± 0.102 (0.105, 0.462)	0.241 ± 0.096 (0.098, 0.431)	-0.014 ± 0.017 (-0.052, 0.010)	-5.1 ± 6.7 (-18.7, 3.9)	4.09	<0.001
Superior CV *mm^3*	0.474 ± 0.18 (0.219, 0.865)	0.464 ± 0.17 (0.206, 0.803)	-0.011 ± 0.025 (-0.065, 0.026)	-1.8 ± 5.0 (-11.2, 4.7)	2.64	0.013
Nasal CV *mm^3*	0.431 ± 0.182 (0.180, 0.801)	0.411 ± 0.172 (0.149, 0.746)	-0.022 ± 0.026 (-0.081, 0.021)	-4.6 ± 6.8 (-21.8, 10.0)	4.19	<0.001
Inferior CV *mm^3*	0.448 ± 0.196 (0.220, 0.883)	0.428 ± 0.187 (0.213, 0.815)	-0.02 ± 0.029 (-0.092, 0.022)	-4.1 ± 6.0 (-15.0, 7.0)	4.20	<0.001
Temporal CV *mm^3*	0.490 ± 0.188 (0.22, 0.876)	0.473 ± 0.177 (0.228, 0.769)	-0.021 ± 0.034 (-0.106, 0.038)	-3.7 ± 5.6 (-15.6, 5.2)	2.59	0.015
Total CV *mm^3*	2.096 ± 0.833 (1.03, 3.886)	1.995 ± 0.804 (0.976, 3.564)	-0.109 ± 0.137 (-0.507, 0.071)	-5.0 ±7.1 (-30.4, 4.7)	4.18	<0.001

Commercial Relationships: Ya Xing Wang, None; **Ran Jiang**, None; **Hong Li Shi**, None; **Liang Xu**, None; **Jost B. Jonas**, None
Support: Natural Science Foundation of China 81570835

Program Number: 2995 **Poster Board Number:** A0344
Presentation Time: 8:30 AM–10:15 AM
Evaluation of retinal blood flow before and after topical tafluprost treatment in glaucoma patients using adaptive optics scanning laser ophthalmoscopy
Yuto Iida, Tadamichi Akagi, Hideo Nakanishi, Hanako Ikeda, Satoshi Morooka, Kenji Suda, Tomoko Hasegawa, Hiroshi Yamada, Munemitsu Yoshikawa, Akihito Uji, Nagahisa Yoshimura. Department of Ophthalmology and Visual Sciences, Kyoto University, Kyoto City, Japan.
Purpose: Adaptive optics scanning laser ophthalmoscopy (AO-SLO) enables clear visualization of retinal microstructures and detailed analysis of the microcirculatory status non-invasively. Topical tafluprost was previously reported to increase ocular blood flow in animal models of glaucoma, but it remains unclear whether tafluprost increases absolute ocular blood flow in human glaucomatous eyes. In this study, we evaluated the effects of topical tafluprost on the absolute retinal blood flow in glaucoma patients using AO-SLO.
Methods: This prospective observational study included 7 eyes of 7 patients with untreated primary open-angle glaucoma. The participants underwent comprehensive ophthalmic examinations including standard automated perimetry (SAP) at the inclusion. AO-SLO and intraocular pressure (IOP) and blood pressure measurements were performed at baseline and 1 and 4 weeks after the topical tafluprost induction. The AO-SLO videos were obtained from parafoveal areas to cover the innermost capillary ring. To assess the retinal blood flow, we used aggregated erythrocyte velocity (AEV), which was measured at the innermost vessel of the capillary ring and calculated using spatiotemporal images generated from AO-SLO videos. The identical capillary vessel selected at the baseline was used to measure AEV during follow-up examinations in each patient.
Results: At the baseline, the mean age was 53.0±8.9 years and the average mean deviation (MD) value in SAP was -6.90±4.89 dB. The mean axial length was 25.34±1.56 mm. After topical tafluprost induction, the AEV increased significantly (baseline: 1.08±0.15 mm/sec, 1 week: 1.22±0.14 mm/sec, p=0.003, 4 weeks: 1.29±0.20 mm/sec, p=0.001), and the IOP decreased significantly (baseline: 17.4±2.1 mmHg, 1 week: 13.6±1.1 mmHg, p=0.003, 4 weeks: 14.3±2.1 mmHg, p=0.004). The blood pressure was not different between the baseline and after the treatments.
Conclusions: Using AO-SLO, we successfully evaluated the retinal blood flow in patients with glaucoma. Topical tafluprost treatment significantly increased AEV in addition to significantly reducing IOP.
Commercial Relationships: Yuto Iida, None; **Tadamichi Akagi**, None; **Hideo Nakanishi**, None; **Hanako Ikeda**, None; **Satoshi Morooka**, None; **Kenji Suda**, None; **Tomoko Hasegawa**, None; **Hiroshi Yamada**, None; **Munemitsu Yoshikawa**, None; **Akihito Uji**, None; **Nagahisa Yoshimura**, Canon (R), Canon (F), Canon (C)

Program Number: 2996 **Poster Board Number:** A0345
Presentation Time: 8:30 AM–10:15 AM
Assessment of the ophthalmic artery and the superior ophtalmic vein blood flow in glaucoma patients with Phase contrast MRI, preliminary results
Veronique Promelle[2, 1], Solange Milazzo[2, 1], Gwenael Pagé[3, 1], Joel Daouk[3, 1], Roger Bouzerar[3, 1], Olivier Balédent[3, 1]. [1]Université de Picardie Jules Verne, Amiens, France; [2]Ophthalmology, University Hospital of Amiens, Amiens, France; [3]Medical Image Processing Unit, University Hospital of Amiens, Amiens, France.
Purpose: Glaucoma has been proved to be an optic neuropathy with blood flow impairment. Phase contrast magnetic resonance imaging (PC MRI) is an imaging modality able to quantify blood flow in the large orbital vessels. Purpose : Evaluate with PC MRI the potential impairment of the ophthalmic artery (OA) and the superior ophthalmic vein (SOV) blood flow in glaucoma.
Methods: A PC MRI was performed for 6 glaucoma patients and 3 controls on a 3 Tesla MRI. First, a morphological T2-weighed sequence was acquired in order to place a measurement plan perpendicularly to the orbital part of the OA and SOV. The duration of acquisition was less than 2 minutes, allowing to obtain 20 images per cardiac cycle for each vessel. Segmentations of vascular structures were obtained by a dedicated software to calculate blood flow curves. The OA mean, systolic and diastolic flow and the SOV mean flow were automatically calculated.
Results: Glaucoma patients and controls did not show any difference in the mean OA blood flow (23 ± 13 and 19 ± 9 mL/min respectively). The OA systolic flow was increased in patients (48 ± 25 versus 29 ± 11 mL/min for controls) as well as the difference between systolic and diastolic flow during cardiac cycle (37 ± 21 mL/min for patients, 18 ± 4 mL/min for controls). Conversely, the mean venous flow seemed decreased (7 ± 4 mL/min for patients, 11 ± 8 mL/min for controls).
Conclusions: These preliminary results indicate no significant difference in our glaucoma population in OA or SOV mean flows. Glaucoma seems to impact more the pulsatility of the flow during cardiac cycle than the mean blood supply. Numerous factors seem to be involved in glaucoma, including ocular perfusion pressure and translaminar pressure difference. Quantification of the global arterio-venous blood flow of the eye by mean of phase contrast MRI could open new insights on the glaucoma pathology.



Thanks to a plane of acquisition placed perpendicularly to the direction of the ophthalmic artery (OA) or the superior ophthalmic vein (SOV), phase contrast sequence is obtained : 20 images corresponding to 20 phases of a cardiac cycle. The blood flow is calculated for each image and the software provides the curve of the evolution of the flow during an average cardiac cycle for glaucoma and for controls.
Commercial Relationships: Veronique Promelle, None; **Solange Milazzo**, None; **Gwenael Pagé**, None; **Joel Daouk**, None; **Roger Bouzerar**, None; **Olivier Balédent**, None

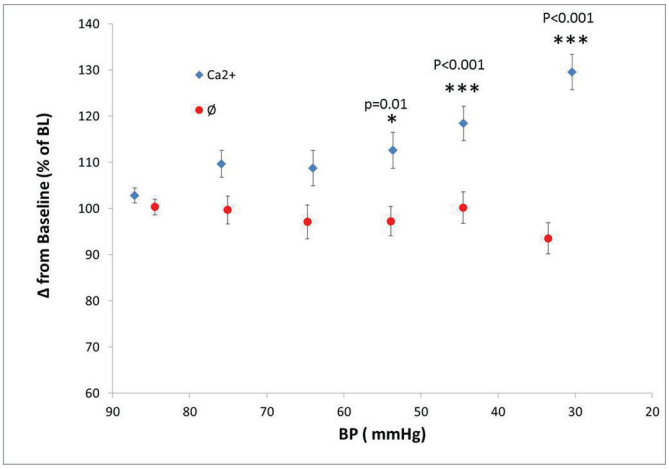
Program Number: 2997 **Poster Board Number:** A0346
Presentation Time: 8:30 AM–10:15 AM
The effect of low cerebrospinal fluid pressure on optic disc and macula perfusion in monkey model using optical coherence tomography angiography
Ningli Wang. Dept of Ophthalmology, Beijing Tongren Eye Center, Beijing, China.
Purpose: To investigate the influence of experimentally reduced cerebrospinal fluid pressure (CSFP) on optic disc and macular perfusion.
Methods: The experimental study included 2 monkeys which underwent cerebrospinal fluid drainage for 3 years, 2 monkeys in a sham group with only implant drainage catheter but no CSF drainage and 3 monkeys in a normal group with changes neither in IOP nor CSFP. Four years after baseline, both eyes of each subject were scanned by a high-speed 840-nm ewavelength OCT instrument. The split-spectrum amplitude-decorrelation angiography (SSADA) algorithm was used to compute 3-dimensional optic disc angiography. Flow index of both optic disc and macula were computed from 4 registered scans.
Results: In the low CSFP group as compared to the sham group and normal group, flow index of radial peripapillar capillaries layer were markedly decreased. And, flow index of the superficial and deep retina were both lower than the sham group and normal group; CSFP and TLCPD were both significantly correlated with flow index of PRC layer, superficial and deep retina separately. IOP was only significantly correlated with flow index of RPC layer. Flow index of choroid layer was also significantly correlated with RNFL, GCC, C/D area, C/D volumn, C/D height, rim area, disc area and cup volumn.
Conclusions: The results suggest that experimental models with an chronic CSFP reduction showed blood flow changes in optic disc which mainly affect the radial peripapillar capillaries superficial and deep retina. It supports the hypothesis that an experimental model with an chronic reduction in CSFP may be different in the process of optic nerve damage.
Commercial Relationships: Ningli Wang

Program Number: 2998 **Poster Board Number:** A0347
Presentation Time: 8:30 AM–10:15 AM
Vasodilating effect of Ripasudil Hydrochloride Hydrate on isolated rabbit posterior ciliary arteries
Takako Sugimoto, Hideki Chuman, Nobuhisa Nao-i. Opthalmology, Miyazaki University, Miyazaki, Japan.
Purpose: Ripasudil (K-115) is a Rho-kinase inhibitor and is an ocular hypotensive agent. Ripasudil also has a vasodilating effect. The optic disc blood flow is supplied by posterior ciliary arteries (PCAs). This study aimed to clarify the vasodilatory effect of exogenous Ripasudil on isolated PCAs.
Methods: Vascular ring segments were mounted on a double myograph system. After obtaining the maximal contraction following the administration of a high-K solution, different concentrations of Ripasudil (100 nM to 100 μM) were administrated. When a vasodilatory effect was observed, carboxy-2-phenyl-4,4,5,5,-tetramethyl-imidazoline-1-oxyl-3-oxide (carboxy-PTIO), a nitric oxide scavenger, or NG-nitro-L-arginine methyl ester (L-NAME), a nitric oxide synthase inhibitor, were administered. All isometric force measurements are given as relative values compared with high-K–induced maximal contractions.
Results: Ripasudil significantly relaxed high-K solution-induced contracted rabbit PCAs in a concentration dependent manner (100 nM [34.8%±3.5]; 1 μM [78.5±17.3]; 10 μM [91.68±9.0]; 100 μM [94.41±8.3]). Carboxy-PTIO (1 mM) or L-NAME (300 mM) did not inhibit Ripasudil-induced relaxation in rabbit PCAs.
Conclusions: Ripasudil has a nitric oxide independent vasodilatory effect on high K-induced contractions in isolated rabbit PCAs.
Commercial Relationships: Takako Sugimoto; **Hideki Chuman**, None; **Nobuhisa Nao-i**, None

Program Number: 2999 **Poster Board Number:** A0348
Presentation Time: 8:30 AM–10:15 AM
The effect of chronic hypertension on retinal autoregulation in rats
Anna K. van Koeverden, Zheng He, Christine T. Nguyen, Algis J. Vingrys, Bang V. Bui. Optometry and Vision Sciences, The University of Melbourne, Parkville, VIC, Australia.
Purpose: Systemic hypertension engenders high ocular perfusion pressure (OPP); however extended periods of hypertension may compromise retinal autoregulation such that blood flow may not be adequately maintained during fluctuations in blood pressure (BP) and intraocular pressure (IOP). We considered the effect of an experimental model of chronic hypertension on retinal autoregulation in response to an acute BP challenge in rats.
Methods: Anaesthetised (60:5mg/kg ketamine:xylazine) adult (24 weeks old) Long Evans rats were implanted with Alzet osmotic minipumps (2ML4) for 12 weeks to induce chronic hypertension. The hypertensive group (n = 10) received a subcutaneous Angiotensin II infusion (150ng/kg/min) and the normotensive group received the saline vehicle only (n = 8). Systolic BP was measured weekly in awake rats (tail cuff sphygmomanometry). After 12 weeks of hypertension, retinal arteriole diameter was assayed (Andor sCMOS camera) during acute BP manipulation induced with intravenous infusion of Sodium Nitroprusside) (0.6mg/mL, 0.003-0.008mL/min, BP reduced to approximately 50mmHg over 15 minutes). The vasodilatory capacity of retinal arterioles during low BP was used as an index of autoregulatory capacity. Ophthalmic artery and aorta tissues were sectioned (Gomori Aldehyde Fuchsin staining) to assess the effect of 12 weeks of chronic hypertension on arterial wall:lumen ratio (WLR). Data are presented as mean±SEM.
Results: Systolic BP was significantly increased in hypertensive (164.8±4.6mmHg) compared to normotensive rats (122.6±2.3mmHg) ($p<0.001$, RM two-way ANOVA). Aorta (0.4±0.006 vs 0.3±0.005, $p<0.001$, t-test) and ophthalmic artery (2.1±0.2 vs 1.4±0.2, $p = 0.024$, t-test) WLR were significantly increased in hypertensive rats. During acute low BP (-32.50 to -62.50mmHg below baseline), significant vasodilation of retinal arterioles was observed in normotensive rats ($p<0.001$, restricted maximum likelihood analysis). No significant vasodilation was observed in hypertensive rats ($p>0.05$). A moderate correlation was found between peak vasodilatory capacity and aorta WLR ($r_s = -0.6$, $p = 0.009$) and vasodilatory capacity and chronic BP integral over 12 weeks ($r_s = -0.65$, $p = 0.003$).
Conclusions: Chronic hypertension impairs the retinal vascular response to autoregulation challenge. It would therefore render the eye more susceptible to blood flow compromise during OPP fluctuations which occur during BP and IOP fluctuations.
Commercial Relationships: Anna K. van Koeverden, None; **Zheng He**, None; **Christine T. Nguyen**, None; **Algis J. Vingrys**, None; **Bang V. Bui**, None
Support: NHMRC: 1046203

Program Number: 3000 **Poster Board Number:** A0349
Presentation Time: 8:30 AM–10:15 AM
The longitudinal changes of optic nerve head blood flow of the normal rats using laser speckle flowgraphy
Yasushi Wada[1, 2]. [1]Ophthalmology, Ophthalmology and Visual Science, Kanazawa University Graduate School of Medical Science, Kanazawa, Japan., Kanazawa city, Japan; [2]Ophthalmology, Ophthalmology, National Hospital Organization Kanazawa Medical Center, Kanazawa, Japan., Kanazawa, Japan., Japan.
Purpose: There is evidence to suggest that a disturbance of ocular blood flow may be one of the risk factors unrelated to the intraocular pressure (IOP) for the onset and progression of glaucoma. Laser speckle flowgraphy (LSFG) allows in vivo quantitative evaluation of blood flow in the optic nerve head (ONH), choroid and retina. A literature search did not find any reports on LSFG measurement in the ONH of rodent eyes. In this study, we investigated the longitudinal changes of ONH blood flow of normal rats using LSFG, and the reproducibility of LSFG measurement.
Methods: Brown-Norway rats (N = 9), 10 weeks of age, were used. Rats were kept under general anesthesia, and their right eyes were dilated with 0.4% tropicamide. IOP, blood pressure, ocular perfusion pressure (OPP), heart rate, and LSFG (LSFG-Micro, Softcare Co., Ltd., Japan) were measured 30 minutes after the start of anesthesia. Three parameters of mean blur rate (MBR) in the ONH was derived from LSFG; MBR in all area (MA), MBR in vessel area (MV), and MBR in tissue area (MT). These parameters were evaluated in each quadrant: superior, inferior, temporal, and nasal quadrants. The coefficient of variation (COV) was calculated from MBR data in three consecutive examinations on the same day. MBR measurements were repeated at 10, 11, 13, 19, 20 weeks of age, and every 5 week until 60 weeks of age thereafter.
Results: The COV of MBR was less than 6.4% in all ONH quadrants. MBR (MA, MV, and MT) in all ONH quadrants increased until 19 weeks of age (MT in the superior quadrant, $P = 0.019$; MT in the nasal quadrant, $P = 0.004$; MT in other quadrants, and MV and MA in all quadrants, $P < 0.001$), but was stable thereafter until 60 weeks of age. MBR (MA) in the inferior quadrant was significantly higher than the temporal quadrant from 19 to 55 weeks of age. There were no significant changes in IOP, blood pressure and OPP during the experimental period.
Conclusions: The ONH blood flow in rats may change overtime; increase from 10 to 19 weeks of age, and then become stable until 60 weeks of age. The ONH blood flow may exhibit regional differences; higher blood flow in the inferior quadrant than the temporal quadrant. LSFG is a reliable and useful method for longitudinal evaluation of ONH blood flow in rats.
Commercial Relationships: yasushi wada, None

Program Number: 3001 **Poster Board Number:** A0350
Presentation Time: 8:30 AM–10:15 AM
The effect of ocular perfusion pressure lowering on vessel diameter and astrocyte calcium in the rat retina
Grant Cull[1], *Lin Wang*[1], *Hui Li*[3], *Bang V. Bui*[2]. [1]Ophthalmology, Devers Eye Institute, Portland, OR; [2]Department of Optometry and Vision Sciences, The University of Melbourne, Melbourne, VIC, Australia; [3]Department of Ophthalmology, Shanghai Tenth People's Hospital, Shanghai, China.
Purpose: To test that lowering ocular perfusion pressure (OPP) by reducing blood pressure (BP) causes parallel changes in arterial astrocyte calcium levels (Ca2+) and vessel diameter (Ø) within the rat retina.
Methods: In 17 rats, femoral vein and arteries were surgically cannulated. In the Ca2+ group (n=8), 5 µl Fluo-4 AM solution was injected intravitreally in both eyes. To establish Ca2+ baseline (BL), three 30-second cSLO image sequences, in fluorescein mode were acquired. In the Ø group (n=9), BL diameter was acquired with the cSLO in infrared reflection mode. A syringe pump withdrew blood (1ml/min) via a femoral artery to induce a slow constant decrease in BP. One minute image sequences were acquired for both groups every 1.7 minutes until BP was < 30 mmHg. Ca2+ level and Ø were analyzed offline using ImageJ. The images for each test were combined into one stack, registered and analyzed across all time points. The Ca2+ intensity and Ø were measured one disc diameter from the optic nerve. Change in Ca2+ and Ø for each artery was expressed relative to its own BL (%). Statistical analysis was performed using repeated measures ANOVA, with a post hoc comparison (Dunnetts test). Analysis of covariance compared the differences of BP change over time between the Ca2+ and Ø groups.
Results: : Baseline BP and its change over time was not significantly different between the 2 groups (p=0.56). The average BL BP was 84.1 ± 7.6 mmHg (n=17). With blood withdrawal BP decreased at a rate of 4.6 ± 0.8 mmHg/min (SD) to reach 30 mmHg in 13.2 ± 2.9 minutes. In the Ca2+ group a significant increase (p=0.01) in Ca2+ from BL was observed for BP reductions of 54 mmHg or more (p<0.001). There was no significant change in Ø from baseline as BP declined. However once BP was < 34 mmHg the arteries were constricted.
Conclusions: Lowering BP caused an increase in periarterial astrocytes Ca2+ with no equivalent change in arterial Ø. This suggests that astrocyte may be involved in maintaining the arterial Ø as BP declines and play a role in blood flow regulation in the rat retina. Further studies are required to correlate the function of astrocytes with blood flow regulation.



The change in Ca2+ intensity and the Ø of arteries in the rat retina expressed as a % change relative to it's the baseline (mean ± SEM) as blood pressure (BP) decreases.

Commercial Relationships: Grant Cull; **Lin Wang**, None; **Hui Li**, None; **Bang V. Bui**, None
Support: R21EY024432, BrightFocus Foundation

Program Number: 3002 **Poster Board Number:** A0351
Presentation Time: 8:30 AM–10:15 AM
Localization of AT1 and MAS receptors on porcine retinal arteries
Arnar Ossur Hardarson[1], *Saevar Ingthorsson*[2], *Thor Eysteinsson*[1]. [1]Physiology, University of Iceland, Reykjavik, Iceland; [2]Stem Cell Research Unit, University of Iceland, Reykjavik, Iceland.
Purpose: Inhibition of the renin-angiotensin system (RAS) is a promising way of reducing the progression of glaucoma, diabetic

retinopathy and age-related macular degeneration. Both AT1 and MAS receptors play key roles in RAS. As porcine retinas are used to study retinal vascular functions, the purpose of this work was to determine whether AT1 and MAS receptors are present in the porcine retinal vasculature, and if so where they are located.
Methods: Freshly slaughtered porcine eyes were obtained from a local abattoir. Retinal vascular segments (2-12mm in length) were fixed with 3.7 % phosphate-buffered paraformaldehyde and incubated with primary antibodies against AT1 and MAS. To determine their location in/on the vascular segments primary antibodies against alpha smooth muscle actin and glial fibrillary acidic protein were used for reference. After wash the rings were incubated with secondary antibodies and 4'6-diamidino-2-phenylindole (DAPI) prior to examination. Immunofluorescent signals were viewed using a confocal laser scanning microscope.
Results: AT1 receptors were identified in all samples tested (N=13), as were MAS receptors in separate samples (N=13). Both AT1 and MAS receptors were present in all samples outside the vascular smooth muscle layer and within the astrocyte layer (tunica media) (N=26). In < 10% of the samples were AT1 (N=1) and MAS (N=2) found present within the smooth muscle cell layer, i.e. the endothelium. Control experiments (N=12) were done to eliminate autofluorescence, and ensure the secondary antibodies were specific to only the primary antibodies. When whole retinal arteries were examined from the optic disk to the retinal periphery we found that the distribution and density of both AT1 (n=1) and MAS (n=1) varied along the vessels.
Conclusions: The study demonstrates for the first time the presence of AT1 and MAS in porcine retinal arteries, and that these receptors are colocalized on the same cellular layers of the retinal vasculature. In most cases the receptors are found outside the vascular smooth muscle layer and are rarely seen on the endothelium. This is in contrast to prior studies, where AT1 has mainly been found on the smooth muscle layer and endothelium.
Commercial Relationships: Arnar Ossur Hardarson, None; **Saevar Ingthorsson**, None; **Thor Eysteinsson**, None
Support: National University Hospital Research Fund, Iceland; The Helga Jónsdóttir and Sigurlidi Kristjánsson Memorial Fund, Iceland.