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ΕΡΕΥΝΗΤΙΚΗ ΕΡΓΑΣΙΑ

Hepatic influence on vision
A meta-analysis uncovering the link between liver disease and intraocular pressure

OBJECTIVE **To assess the association between liver disease and intraocular pressure (IOP).** METHOD **From December 2023 to January 2024 we conducted a meta-analysis (PROSPERO: CRD42024505202). As of December 15, 2023, a thorough search was carried out to obtain relevant studies from PubMed, Embase, and Scopus. The Newcastle-Ottawa Scale was employed to assess the quality of the articles, and the data collection was extracted using pilot form. The association between liver disease and IOP was determined using the Z-test with the inverse variance method.** RESULTS **In our analysis, we meticulously analyzed data from a compilation of five studies, involving 8,856 patients diagnosed with liver disease and 16,280 controls. We found a notable difference in IOP between patients with liver disease and the control group, where patients with liver disease exhibited higher IOP compared to those without liver disease (mean difference [MD]: 0.98; 95% confidence interval [CI]: 0.64–1.32; p<0.0001). However, we did not include potential confounding factors, such as corticosteroids use, anticholinergic use, blood pressure, and body mass index which could influence the results.** CONCLUSIONS **The findings of our study indicate that liver disease serves as a significant predictor for increased IOP. Our study provides additional information on factors contributing to the increase of IOP.**

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ΑΡΧΕΙΑ ΕΛΛΗΝΙΚΗΣ ΙΑΤΡΙΚΗΣ 2025, 42(3):384–389

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Η επίδραση του ήπατος στην όραση: Μια μετα-ανάλυση που αποκαλύπτει τη σχέση μεταξύ της ηπατικής νόσου και της ενδοφθάλμιας πίεσης

Περίληψη στο τέλος του άρθρου

Key words

Hepatitis
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Non-alcoholic fatty liver disease

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Elevated intraocular pressure (IOP) poses a significant risk for glaucoma, subjecting the optic nerve head to mechanical stress and potentially causing irreversible damage, leading to vision loss.[1] As of 2020, glaucoma emerged as the second most prevalent cause of blindness and the primary source of irreversible vision impairment.[2] The intricate dynamics of elevated IOP involve complex interactions with factors such as aqueous flow, uveoscleral outflow, outflow facility, and episcleral venous pressure (EVP) as determinants of steady-state IOP. EVP, which influences the resistance fluid encounters when leaving the eye through the trabecular outflow pathway, plays a pivotal role.[3] Conversely, various multifactorial elements such as body fat percentage, body mass index (BMI), alcohol, drugs, and liver disease contribute to elevated IOP.[4,5] Notably, the role of liver disease remains a contentious issue, with limited reports and ongoing discussions about its impact.

Hepatic disorders encompass a spectrum of pathological conditions affecting the anatomical and physiological integrity of the liver, including lipid infiltration leading to fatty liver, alcoholic liver disease, liver cirrhosis, and malignancies. Non-alcoholic fatty liver disease (NAFLD), characterized by the aberrant accumulation of lipids within hepatic tissues, is frequently concomitant with metabolic

syndrome.[6] This syndrome, identified as a predisposing factor for heightened IOP, exhibits a robust correlation with IOP in empirical investigations.[7] Additionally, the hepatovisual interconnection extends to hepatitis C, where the viral infection demonstrates a significant association with elevated IOP and presents additional association with idiopathic retinopathy and varied ocular manifestations.[8] However, the intricate mechanisms underlying the impact of metabolic syndrome and hepatitis C infection on IOP remain inadequately elucidated. Presently, the evidentiary landscape regarding the contributory role of liver disease in elevated IOP remains inconclusive. Studies posited a causative association between liver disease and increased IOP,[7–10] whereas other failed to provide conclusive substantiation.[11]

Therefore, the primary aim of the present study was to assess the association between IOP and liver disease. By elucidating the association between liver disease and IOP, it is possible to discern specific risk factors contributing to elevated IOP in the context of hepatic disorders. This comprehension might offer avenues for preventive interventions, targeting the progression of glaucoma –a condition intricately linked to heightened IOP– and thereby mitigating the risk of irreversible blindness.

MATERIAL AND METHOD

Study design

We conducted a meta-analysis study to explore the relationship between liver disease and IOP (PROSPERO: CRD42024505202). The study was carried out from December 2023 to January 2024. To attain our objective, we gathered data from scientific databases such as PubMed, Scopus, and Embase. Cumulative data were analyzed to determine the pooled effect estimate. Our study protocols adhered to the Preferred Reporting Items for Meta-analysis (PRISMA) checklist.[12] The PRISMA checklist for our present study is detailed in supplementary files table 1. The study was conducted in accordance with the Helsinki Declaration principles.

Eligibility criteria

We included studies that met the following criteria: (a) Cross-sectional studies, (b) case-control and cohort studies, (c) reporting any form of liver disease, (d) providing IOP measurement data, and (e) offering data for the evaluation of the Newcastle-Ottawa Scale (NOS). Excluded were articles with irrelevant studies, insufficient data, and duplicate records. Additionally, review, commentary, and letter to the editor articles were excluded. Articles assessed as low quality by the NOS were also excluded.

Quality assessments

The quality of included studies was assessed using the NOS.[13] The scale comprises three items: Sample selection (4 points), group comparability (2 points), and the outcome (3 points). Studies with a total score of ≤3 are considered poor, 4–6 as moderate, and ≥7 as high quality. Only studies with moderate and high quality were included in the analysis. The assessment of studies using a pilot form was conducted by AZ in consultation with JKF.

Search strategy

The potential studies in three databases (PubMed, Scopus, and Embase) were searched as of December 15, 2023. The combination of keywords ([“liver disease” or “liver fibrosis” or “hepatitis” or “steatohepatitis”] and [“intraocular pressure”]) was used. The publication language was restricted to English. Additionally, articles from the reference lists of related articles were reviewed to obtain additional data. The article search was conducted by AZ.

Table 1. Baseline characteristics of studies included in our analysis.

Study	Country	Design	Age (range, years)	Sample size	Sub-type	IOP measurement method	Fibrosis	Lipid profile	Quality assessment (NOS)
Chang et al[9]	Taiwan	Cross-sectional	38–65	1,044	NAFLD	Non-contact tonometry	NA	HDL, LDL, TG	Moderate
Strobbe et al[11]	Italy	Case control	39–56	40	HCV infection	Applanation tonometry	METAVIR	NA	Moderate
Zeni et al[8]	Brazil	Cross-sectional	32–53	149	HCV infection	Applanation tonometry	METAVIR	NA	Moderate
Kwon et al[10]	South Korea	Cross-sectional	32–59	7,681	NAFLD	Applanation tonometry	NA	Total cholesterol, HDL, TG	Moderate
Lee et al[7]	South Korea	Cross-sectional	34–58	16,240	NAFLD	Non-contact tonometry	NA	Total cholesterol	Moderate

NAFLD: Non-alcoholic fatty liver disease, HCV: Hepatitis C virus, IOP: Intraocular pressure, NA: Not available, NOS: Newcastle-Ottawa Scale, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, TG: Triglycerides

Data extraction

During data extraction, the following information was collected from the included studies: (a) First author's name, (b) year of publication, (c) country of origin, (d) study design, (e) age range of the sample, (f) sample size, (g) sub-type of liver disease, (h) IOP measurement method, (i) fibrosis scoring method, and (j) NOS. Data extraction was carried out by AZ in consultation with JKF.

Study covariates

The predictor variable in our study was liver disease, encompassing various liver conditions such as fatty liver, hepatitis, steatohepatitis, cirrhosis, and hepatic malignancy. The outcome variable was IOP, defined as the fluid pressure within the eye, regulated by continuous aqueous formation and drainage. There are several methods to measure IOP, with applanation tonometry being the most widely used. In applanation tonometry, IOP is determined by measuring the applanating force and the area of the cornea flattened. Another common method is non-contact tonometry, which measures the force of air required to indent and flatten the cornea.[14]

Statistical analysis

Data in our study were presented as mean±standard deviation (SD). The association between liver disease and IOP was determined by the Z test with the inverse variance method. Before establishing the association, we evaluated potential publication bias and heterogeneity. The statistic for assessing potential publication bias was Egger's test with a funnel plot. A p-value less than 0.05 in Egger's test indicated the presence of potential publication bias. Furthermore, to assess data heterogeneity, we used the Q test and I^2. A p-value for heterogeneity less than 0.10 or I^2 greater than 50% indicated the presence of heterogeneity, leading to the use of a random-effects model. Otherwise, a fixed-effects model was employed. The effect size in our study was calculated using mean difference (MD) with a 95% confidence interval (95% CI). Statistical analysis in our study was performed using Review Manager, version 5.3 (RevMan Cochrane, London, UK).

RESULTS

Article selection

In our search strategy, 8,859 articles were retrieved from the databases, and 17 articles were assessed from the reference list of related papers. Subsequently, 8,820 studies were excluded as they were irrelevant, and 22 records were excluded as duplicates. A total of 34 records were screened and retrieved. After eligibility assessment, four studies were excluded due to insufficient data, and 25 studies were excluded as they were review articles. The final screening resulted in five studies, which were included in our meta-analysis (fig. 1). All articles had moderate quality based on the assessment of NOS, with the main source of bias is the outcomes, as the length of follow up was not described at any included articles (Supp tab. 2).[15] Baseline characteristics of the articles included in our study are outlined in table 1, consisting of country of origin, study design, patients' age range, sample sizes, subtype of liver disease, IOP measurement methods, liver fibrosis staging, lipid profile and quality assessment score.

Association between liver disease and intraocular pressure

We analyzed five studies, accumulating a total of 8,856 cases of patients with liver disease and 16,280 controls, to determine the association between liver disease and IOP. We found a significant association between liver disease and IOP. Our calculation revealed that IOP was higher in patients with liver disease compared to controls (MD: 0.98; 95% CI: 0.64, 1.32; p<0.0001) (fig 2).

Heterogeneity among studies and potential publication bias

Our analysis detected evidence of heterogeneity in our study (p heterogeneity <0.0001; I^2: 90%). Therefore, we applied a random-effects model to analyze the data. We used Egger's test and a Funnel Plot to assess potential publication bias. Our analysis using Egger's test found no

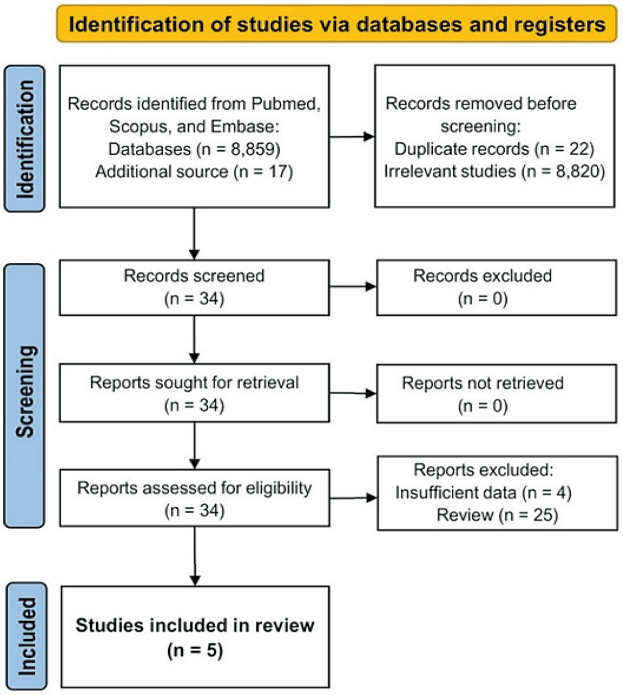

Figure 1. A flowchart of article selection in our study.

Table 2. Newcastle-Ottawa Scale of studies included in our analysis.

Author and year	Newcastle – Ottawa scale								
	Selection				Comparability	Outcomes			Total
	Re-pre-exposed cohort	Select non-exposed cohort	Asc exposure	Outcomes not present at the start of study		Ass outcomes	Length of follow up	Adequacy follow up	
Chang et al[9]	1	1	1	–	1	1	–	1	6
Strobbe et al[11]	1	–	1	–	1	1	–	1	5
Zeni et al[8]	1	–	1	–	1	1	–	1	5
Kwon et al[10]	1	1	1	–	1	1	–	1	6
Lee et al[7]	1	1	1	–	1	1	–	1	6

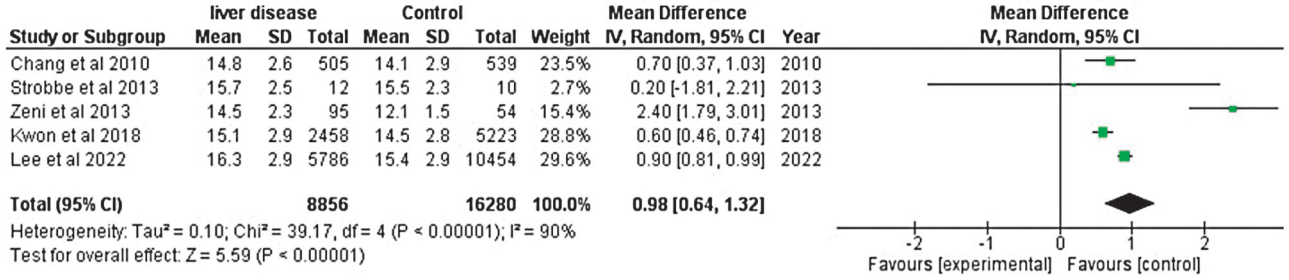

Figure 2. A forest plot of the association between liver disease and intraocular pressure (mean difference [MD]: 0.98; 95% confidence interval [CI]: 0.64, 1.32; p<0.0001; p Heterogeneity <0.0001; I-squared: 90%; p Egger: 0.6214).

publication bias (p: Egger: 0.6214), and we observed a symmetric Funnel Plot (Supp fig 1).[15]

DISCUSSION

Our data indicated that individuals with liver disease exhibited higher IOP levels than healthy individuals. To our knowledge, there was no published meta-analysis exploring the association between liver disease and IOP, therefore preventing us from comparing our findings to similar studies. Existing meta-analyses have focused solely on the effects of alcohol consumption,[16] antihypertensive drugs,[17] and statins[18] on IOP. They revealed that alcohol consumption is positively associated with IOP, and systemic beta-blockers were found to be inversely associated with IOP.[16,17] However, the studies revealed calcium channel blockers were not associated with IOP and the effect of statin use on IOP is uncertain.[17,18] Our current findings may contribute to the body of evidence concerning potential predictors of elevated IOP.

The potential mechanism underlying our findings might not be fully understood. However, some potential mechanisms could be proposed. First, the mechanism bridging liver disease and increased IOP may likely involve metabolic syndrome. In metabolic syndrome, there is a well-known phenomenon where the accumulation of triglycerides in the liver, resulting from an imbalance in the uptake, synthesis, export, and oxidation of fatty acids, can lead to fatty liver.[19,20] This condition may contribute to elevated IOP as metabolic syndrome is strongly associated with it.[5] Higher serum triglycerides decrease aqueous humor outflow by accumulating orbital adipose tissue, increasing orbital and episcleral pressure, thereby elevating IOP.[21] Additionally, lower HDL levels had been shown to induce vascular sclerosing changes, increase serum osmolality, enhance oxidative stress due to adiposity, impair the function of trabecular meshwork and the intracellular system, elevate episcleral pressure, and consequently lead to increased IOP.[4] Furthermore, studies have indicated that fatty liver contributes to elevated IOP by 0.879 mmHg.[7] However, some studies suggested that fatty liver could be an independent risk factor for elevated IOP, possibly linked through the sympathetic nervous system.[22] An activated sympathetic nervous system plays a role in the development of NAFLD and in increasing IOP.[10,23] Moreover, obesity, a predictor of NAFLD, has been shown to increase the outflow resistance of episcleral veins by increasing blood viscosity through an increase in red blood cell count and hematocrit, thereby elevating IOP.[24] Second, another potential mechanism bridging liver disease and increased

IOP might involve hepatitis C infection. Chronic hepatitis C infection is well-known to have ocular manifestations, primarily alterations in the ocular surface.[25] A study demonstrated that inflammation secondary to chronic hepatitis C infection affects the expression of glaucoma biomarker genes related to antioxidant response and inflammation.[26] As a result, this could elevate IOP. The explanations above potentially bridge the mechanism between liver disease and increased IOP, as reported in our study.

To the best of our knowledge, our current study represents the first meta-analysis examining the association between liver disease and IOP. Our findings underscore the significance of liver disease as a notable predictor of elevated IOP, a crucial indicator of glaucoma. Given that early-stage glaucoma is often asymptomatic and symptoms may only manifest in advanced stages, the recognition of a substantial association between liver disease and elevated IOP prompts the consideration of integrated evaluations.[27] In light of this, patients with liver disease could benefit from routine eye examinations, with a particular focus on IOP measurement, to proactively prevent the development of glaucoma. Furthermore, our present study contributes additional insights into the relationship between liver disease and IOP. Consequently, future studies planning to explore the connection between liver disease and IOP can be developed with a more comprehensive understanding, building upon the knowledge generated by our current investigation.

This study is subject to several potential limitations. First, we did not analyze potential confounding factors, such as corticosteroids use, anticholinergics use, blood pressure, and BMI which could impact the final findings. Second, the inclusion of a limited number of studies might weaken the level of evidence, necessitating further study with a larger sample size for enhanced statistical robustness. Third, variations in the method of measuring IOP across studies might introduce measurement bias. Additionally, the diversity in the types of liver disease in each study might contribute to potential bias. Last, it was imperative to consider publication bias, as this meta-analysis relied on published studies.

In conclusion, our investigation demonstrated a noteworthy association, indicating that individuals afflicted with liver disease exhibit a statistically significant elevation in IOP. The outcome of this study suggests that it might be necessary to examine the IOP of patients with liver disease as a step forward to prevent glaucoma development. This current study offers valuable insights into the relationship between liver disease and ocular conditions.

ΠΕΡΙΛΗΨΗ

Η επίδραση του ήπατος στην όραση: Μια μετα-ανάλυση που αποκαλύπτει τη σχέση μεταξύ της ηπατικής νόσου και της ενδοφθάλμιας πίεσης

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ΣΚΟΠΟΣ Η αξιολόγηση της σχέσης μεταξύ ηπατικής νόσου και ενδοφθάλμιας πίεσης (ΕΟΠ). **ΥΛΙΚΟ-ΜΕΘΟΔΟΣ** Πραγματοποιήσαμε μια μετα-ανάλυση από τον Δεκέμβριο του 2023 έως τον Ιανουάριο του 2024 (PROSPERO: CRD42024505202). Από τις 15 Δεκεμβρίου 2023 διεξήχθη μια ενδελεχής αναζήτηση για την απόκτηση σχετικών μελετών από PubMed, Embase και Scopus. Για την αξιολόγηση της ποιότητας των άρθρων χρησιμοποιήθηκε η κλίμακα Newcastle-Ottawa και η συλλογή δεδομένων έγινε με τη χρήση πιλοτικού εντύπου. Η συσχέτιση μεταξύ της ηπατικής νόσου και της ΕΟΠ προσδιορίστηκε με τη χρήση της δοκιμασίας Z, με τη μέθοδο της αντίστροφης διακύμανσης. **ΑΠΟΤΕΛΕΣΜΑΤΑ** Στην ανάλυσή μας, εξετάσαμε σχολαστικά τα δεδομένα από μια συλλογή 5 μελετών που αφορούσαν σε 8.856 ασθενείς διαγνωσθέντες με ηπατική νόσο και 16.280 άτομα ελέγχου. Διαπιστώσαμε μια αξιοσημείωτη διαφορά στην ΕΟΠ μεταξύ των ασθενών με ηπατική νόσο και της ομάδας ελέγχου, κατά την οποία οι ασθενείς με ηπατική νόσο παρουσίασαν υψηλότερη ΕΟΠ σε σύγκριση με εκείνους χωρίς ηπατική νόσο (μέση απόκλιση: 0,98, 95% διάστημα εμπιστοσύνης: 0,64–1,32, p<0,0001). Ωστόσο, δεν συμπεριλάβαμε πιθανούς συγχυτικούς παράγοντες, όπως η χρήση κορτικοστεροειδών, αντιχολινεργικών, η αρτηριακή πίεση και ο δείκτης μάζας σώματος, που θα μπορούσαν να επηρεάσουν τα αποτελέσματα. **ΣΥΜΠΕΡΑΣΜΑΤΑ** Τα ευρήματα της παρούσας μελέτης καταδεικνύουν ότι η ηπατική νόσος χρησιμεύει ως σημαντικός προγνωστικός παράγοντας για αυξημένη ΕΟΠ. Η εν λόγω μελέτη παρέχει

πρόσθετες πληροφορίες σχετικά με τους παράγοντες που συμβάλλουν στην αύξηση της ΕΟΠ.

Λέξεις ευρετηρίου: Ενδοφθάλμια πίεση, Ηπατική ίνωση, Ηπατική νόσος, Ηπατίτιδα, Μη αλκοολική λιπώδης νόσος του ήπατος

References

1. WEINREB RN, AUNG T, MEDEIROS FA. The pathophysiology and treatment of glaucoma: A review. *JAMA* 2014, 311:1901–1911
2. GBD 2019 BLINDNESS AND VISION IMPAIRMENT COLLABORATORS; VISION LOSS EXPERT GROUP OF THE GLOBAL BURDEN OF DISEASE STUDY. Causes of blindness and vision impairment in 2020 and trends over 30 years, and prevalence of avoidable blindness in relation to VISION 2020: The Right to Sight: An analysis for the Global Burden of Disease Study. *Lancet Glob Health* 2021, 9:e144–e160
3. ACOTT TS, KELLEY MJ, KELLER KE, VRANKA JA, ABU-HASSAN DW, LI X ET AL. Intraocular pressure homeostasis: Maintaining balance in a high-pressure environment. *J Ocul Pharmacol Ther* 2014, 30:94–101
4. CHEN YJ, CHEN JT, TAI MC, LIANG CM, CHEN YY, KAO TW ET AL. Examining the associations among intraocular pressure, hepatic steatosis, and anthropometric parameters. *Medicine (Baltimore)* 2019, 98:e17598
5. YI YH, CHO YH, KIM YJ, LEE SY, LEE JG, KONG EH ET AL. Metabolic syndrome as a risk factor for high intraocular pressure: The Korea National Health and Nutrition Examination Survey 2008–2010. *Diabetes Metab Syndr Obes* 2019, 12:131–137
6. ZARGHAMRAVANBAKHSH P, FRENKEL M, PORETSKY L. Metabolic causes and consequences of nonalcoholic fatty liver disease (NAFLD). *Metabol Open* 2021, 12:100149
7. LEE JH, KWON YJ, LEE HS, HAN JH, JOUNG B, KIM SJ. Fatty liver is an independent risk factor for elevated intraocular pressure. *Nutrients* 2022, 14:4455
8. ZENI LP, VIERA PD, MICHALCZUK MT, BIRKHAN OA, VILELA MAP, ÁLVARES-DA-SILVA MR. Hepatitis C virus induces abnormalities in surface and intraocular pressure: A comparative study. *Eur J Gastroenterol Hepatol* 2013, 25:411–415
9. CHANG YC, LIN JW, WANG LC, CHEN HM, HWANG JJ, CHUANG LM. Association of intraocular pressure with the metabolic syndrome and novel cardiometabolic risk factors. *Eye (Lond)* 2010, 24:1037–1043
10. KWON YJ, KIM JH, JUNG DH. Association between nonalcoholic fatty liver disease and intraocular pressure in Korean adults. *J Glaucoma* 2018, 27:1099–1104
11. STROBBE E, CELLINI M, CAMPOS EC. Aqueous flare and choroidal thickness in patients with chronic hepatitis C virus infection: A pilot study. *Ophthalmology* 2013, 120:2258–2263
12. STEWART LA, CLARKE M, ROVERS M, RILEY RD, SIMMONDS M, STEWART G ET AL. Preferred reporting items for a systematic review and meta-analysis of individual participant data: The PRISMA-IPD Statement. *JAMA* 2015, 313:1657–1665
13. STANG A. Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. *Eur J Epidemiol* 2010, 25:603–605
14. BRUSINI P, SALVETAT ML, ZEPPIERI M. How to measure intraocular pressure: An updated review of various tonometers. *J Clin Med* 2021, 10:3860
15. ZAHRA A, FAJAR JK. Supplementary files: Hepatic influence on vision – meta-analysis uncovering the link between liver disease and intraocular pressure. 2024. Available at: https://doi.org/10.6084/m9.figshare.25098818.v1
16. STUART KV, MADJEDI K, LUBEN RN, CHUA SYL, WARWICK AN, CHIA M ET AL. Alcohol, intraocular pressure, and open-angle glaucoma: A systematic review and meta-analysis. *Ophthalmology* 2022, 129:637–652
17. LEUNG G, GRANT A, GARAS AN, LI G, FREEMAN EE. A systematic review and meta-analysis of systemic antihypertensive medications with intraocular pressure and glaucoma. *Am J Ophthalmol* 2023, 255:7–17
18. MCCANN P, HOGG RE, FALLIS R, AZUARA-BLANCO A. The effect of statins on intraocular pressure and on the incidence and progression of glaucoma: A systematic review and meta-analysis. *Invest Opthalmol Vis Sci* 2016, 57:2729–2748
19. ALVES-BEZERRA M, COHEN DE. Triglyceride metabolism in the liver. *Compr Physiol* 2017, 8:1–8
20. GODOY-MATOS AF, SILVA WS Jr, VALERIO CM. NAFLD as a continuum: From obesity to metabolic syndrome and diabetes. *Diabetol Metab Syndr* 2020, 12:60
21. SON J, KOH H, SON J. The association between intraocular pressure and different combination of metabolic syndrome components. *BMC Ophthalmol* 2016, 16:76
22. CANALE MP, MANCA DI VILLAHERMOSA S, MARTINO G, ROVELLA V, NOCE A, DE LORENZO A ET AL. Obesity-related metabolic syndrome: Mechanisms of sympathetic overactivity. *Int J Endocrinol* 2013, 2013:865965
23. ADORI M, BHAT S, GRAMIGNOLI R, VALLADOLID-ACEBES I, BENGTSSON T, UHLÈN M ET AL. Hepatic innervations and nonalcoholic fatty liver disease. *Semin Liver Dis* 2023, 43:149–162
24. JUNG Y, KIM GN, OH EB, OHN K, MOON J II. Metabolic health, obesity, and intraocular pressure. *J Clin Med* 2023, 12:2066
25. BERTRAND RHC, BERTRAND ALX, GOMES TM, FERREIRA A DE SP. An eye on hepatitis C: A review [O olho na hepatite C: Uma revisão]. *Arq Bras Oftalmol* 2019, 82:161–167
26. PLAYER JK, RIORDAN SM, DUNCAN RS, KOULEN P. Analysis of glaucoma associated genes in response to inflammation, an examination of a public data set derived from peripheral blood from patients with hepatitis C. *Clin Ophthalmol* 2022, 16:2093–2103
27. SCHUSTER AK, ERB C, HOFFMANN EM, DIETLEIN T, PFEIFFER N. The diagnosis and treatment of glaucoma. *Dtsch Arztebl Int* 2020, 117:225–234

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