THE ASSOCIATION BETWEEN THE COMPONENTS OF METABOLIC SYNDROME AND SENILE CATARACT IN MALANG REGENCY

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ABSTRAK
Katarak merupakan kekeruhan lensa kristalina yang menjadi penyebab utama kebutaan di dunia. Pada individu dengan sindrom metabolik (MetS), katarak dapat terjadi melalui tiga mekanisme utama, yaitu stres oksidatif, ketidakseimbangan osmotik, dan glikasi protein non-enzimatik. Penelitian ini bertujuan untuk menganalisis hubungan antara kejadian katarak dengan komponen MetS pada populasi di Kabupaten Malang. Desain penelitian ini adalah cross-sectional retrospektif berbasis populasi, yang dilaksanakan di tiga desa di Kecamatan Kepanjen, yaitu Mendalanwangi, Sidorahayu, dan Cepokomulyo. Uji korelasi Spearman digunakan untuk menilai hubungan antara variabel ordinal, dan regresi logistik dilakukan untuk menentukan variabel dominan yang berpengaruh terhadap kejadian katarak. Dari total 692 populasi, sebanyak 337 subjek memenuhi kriteria inklusi dan eksklusi. Hasil menunjukkan bahwa indeks massa tubuh (BMI) memiliki nilai p=0,043 (OR=0,827), sedangkan kadar trigliserida memiliki nilai p=0,022 (OR=1,462), yang keduanya menunjukkan hubungan signifikan dengan kejadian katarak. Sementara itu, variabel hipertensi (p=0,766; OR=0,952), glukosa darah puasa (p=0,294; OR=0,798), dan kolesterol HDL (p=0,613; OR=1,092) tidak menunjukkan hubungan yang signifikan. Simpulan penelitian ini adalah bahwa kadar trigliserida merupakan faktor yang paling dominan dalam meningkatkan risiko katarak senilis, diikuti oleh BMI.

Kata kunci **:** glukosa darah puasa, hipertensi, indeks massa tubuh, katarak senilis, kolesterol HDL, sindrom metabolik, trigliserida

ABSTRACT
Cataracts are opacities of the crystalline lens and are a leading cause of blindness worldwide. In individuals with metabolic syndrome (MetS), cataracts can occur through three main mechanisms: oxidative stress, osmotic imbalance, and non-enzymatic protein glycation. This study aimed to analyze the relationship between cataract incidence and MetS components in a population in Malang Regency. This study used a retrospective, cross-sectional, population-based study conducted in three villages in Kepanjen District: Mendalanwangi, Sidorahayu, and Cepokomulyo. The Spearman correlation test was used to assess the relationship between ordinal variables, and logistic regression was performed to determine the dominant variables influencing cataract incidence. Of the total 692 subjects, 337 subjects met the inclusion and exclusion criteria. The results showed that body mass index (BMI) had a p-value of 0.043 (OR=0.827), while triglyceride levels had a p-value of 0.022 (OR=1.462), both of which showed a significant association with cataract incidence. Meanwhile, hypertension (p=0.766; OR=0.952), fasting blood glucose (p=0.294; OR=0.798), and HDL cholesterol (p=0.613; OR=1.092) did not show a significant association. The conclusion of this study is that triglyceride levels are the most dominant factor in increasing the risk of senile cataract, followed by BMI.

Keywords ***:*** *fasting blood glucose, hypertension, body mass index, senile cataract, HDL cholesterol, metabolic syndrome, triglycerides*

INTRODUCTION

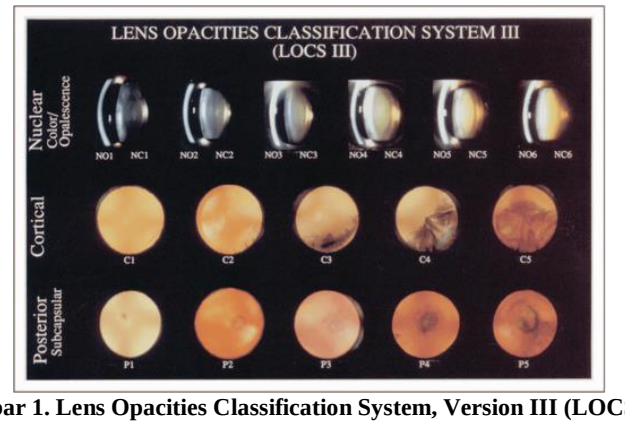
Globally, there are 19 million people who are blind secondary to bilateral cataracts and estimated to reach 40 million by 2020 (Kementerian Kesehatan Republik Indonesia, n.d.). The prevalence of blindness in the population >50 years of Indonesian is 3% with the highest prevalence in West Nusa Tenggara (3.1%) followed by East Java (2.9%) (Riskesdas, 2013).

Risk factors for cataracts can be divided into metabolic syndrome (MetS), degenerative, genetic factors, trauma, inflammatory diseases, toxic substances, radiation (RAAB, 2016). Metabolic syndrome is an accumulation of several risk factors secondary to insulin resistance and abnormal adipose storage and function (Gupta, et al., 2014). MetS is a cluster of metabolic abnormalities that include hyperlipidemia, hypertension, obesity, and insulin resistance (Wang, 2022). The global prevalence of MetS based on epidemiological data is 20–25%. In Indonesia the prevalence of MetS is to 23% (Riskesdas, 2013).

International Diabetes Federation (IDF) 2006 is the most commonly used criteria due to its convenience. This criteria consists of central obesity added with 2 of the following 4 factors, namely hypertriglyceridemia, low HDL cholesterol, hypertension, and hyperglycemia (Riskesdas, 2013; Grundy et al., 2005; Sabanayagam et al., 2011). The pathophysiology of cataracts in the MetS can be explained by 3 pathomechanisms, including oxidative stress, osmotic imbalance, and non-enzymatic protein glycation. Risk factors of MetS component that are closely related to the occurrence of cataracts are obesity, diabetes mellitus, dyslipidemia and hypertension (Grundy et al., 2005; Park et al., 2013). Several studies have highlighted the increasing burden of cataract among individuals with metabolic disorders. A large-scale cohort by Lin et al. (2016) in Taiwan demonstrated a significant association between metabolic syndrome and increased risk of age-related cataracts, particularly in individuals with high triglyceride levels and central obesity. Similarly, a population-based study by Sabanayagam et al. (2011) in Singapore reported that metabolic syndrome and its components, especially low HDL cholesterol and hypertension, were independently associated with higher cataract prevalence. Despite these findings, the underlying mechanisms and population-specific risk profiles may vary between countries due to differences in lifestyle, genetics, and environmental exposures. Therefore, localized data from specific regions in Indonesia is essential to develop appropriate prevention and intervention strategies.

Mendalanwangi, Sidorahayu, and Cepokomulyo Village are located on the countryside of Malang City, East Java. Additionally, this location is next to cigarette and sugar factories. Until recently, there is no population-based study discussing about the relationship between MetS and the risk of cataract occurrence in the East Java, especially in Malang Regency. Therefore, we decided to choose these 3 villages as the research population. This study aimed to identify and analyze the association between senile cataract incidence and each component of metabolic syndrome in a population in Malang Regency.

METHODS



Gambar 1. Lens Opacities Classification System, Version III (LOCS III)

This study is a population-based retrospective cross-sectional study. The population of this study were participants in the Smarthealth biomarker development research who had initial examinations in 3 villages in Malang Regency, namely Mendalanwangi, Sidorahayu, and

Cepokomuylo Village from 5 month. Inclusion criteria are those who are >50 years, diagnosed with MetS, diagnosed with cataract according to Lens Opacities Classification System (LOCS) III criteria. Subjects who did not complete all required examinations, had a history of eye surgery, and had infection-associated cataracts, traumatic cataracts were excluded from the study. The independent variables are Body Mass Index (BMI), blood pressure, fasting blood glucose (FBG), cholesterol HDL, triglycerides (TG) level. Whereas the dependent variable is senile cataract. Cataract was determined by a slit lamp (Nidek model SL 1800) examination under dilated by the ophthalmologists and diagnosed according to the LOCS III criteria.

Metabolic syndrome defined according to IDF criteria (2006), with the diagnostic criteria of central obesity (abdominal circumference >90 cm for men and >80 cm for women) plus 2 of the following 4 factors: (1) High triglyceride >150 mg/dL or on treatment ; (2) Low HDL–C: HDL-C <40 mg/dL in men and <50 mg/dL in women or on medication; (3) Systolic blood pressure >130 mmHg or diastolic >85 mmHg or current use of antihypertensive medication; (4) FBG >100 mg/dL, or having been diagnosed with type 2 diabetes. BMI was calculated as the weight in kg divided by the square of height in meters, classified the weight groups into normal (18.5-22.9 kg/m^2), underweight (<18.5 kg/m^2), overweight (23-24.9 kg/m^2) and obese (25-29.9 or <30 kg/m^2). Blood pressure is measured with a digital sphygmomanometer. Sample of FBG, HDL, TG were obtained from venous blood in fasting conditions for at least 10-12 hours.

Data analysis was performed using SPSS program version 26.0. The normality of the data in each group was analyzed using Kolmogorof-Smirnof test. The Spearman correlation test was used to determine the relationship between MetS and the incidence of cataracts (ordinal data), while logistic regression test was used to determine the most dominant effect. A p value less than 0,05 was considered statistically significant.

RESULTS

Of the 692 study populations, 337 people met the inclusion and exclusion criteria and were included as research subjects. The characteristics of the study sample are listed in Table 1. Age >50 years was chosen considering that older age is a risk factor for both cataracts and MetS. This is supported by Park and Lee (2013), who stated that age is related to the incidence of cataracts in the elderly. In our study, prevalence at all ages and genders showed that the prevalence of nuclear cataract was higher than that of cortical cataract and posterior cataract, in line with one study conducted in Taiwan (Ghaem Maralani et al., 2013). On the contrary, there are some disagreement in other studies, where the prevalence of cortical cataracts is higher than nuclear cataracts (Lindblad et al., 2008; Bautista et al., 2005). Based on the degree of clinically significant cataract, our findings are similar from the previous studies (Paunksnis et al., 2007)

Table 1. Characteristic of All Participants (n=692)

Variables		Total	%
Age	50 - 55 years	228	32.94
	56 - 60 years	142	20.18
	61 - 65 years	172	25.52
	> 65 years	146	20.77
Gender	Women	446	64.45
	Men	246	35.54
Body Mass Index	*Underweight*	28	3.56
	Normal	241	37.69
	Overweight	236	36.20
	Obesity	187	22.55

Hypertension	No	252	37.98
	Yes	440	62.02
Hyperglicemia	No	579	84.87
	Yes	113	15.13
HDL ↓	No	446	63.20
	Yes	246	36.80
TG ↑	No	579	84.87
	Yes	113	15.13
Cataract	No	355	51.30
	Yes	337	48.70

The prevalence of senile cataract based on gender according to LOCS III criteria are shown in Table 2. Of the 337 respondents, nuclear cataract mostly occurred at the age of 50-55 years in women and 56-60 years in men. Most patients with cortical cataracts are at the age group of 50-55 years in women and 50-55 years in men. Meanwhile, Posterior cataract are mostly found at the age group of 61-65 years in women and >65 years in men.

Table 2. Prevalence of Cataract Based on Gender and Age According to LOCS III Criteria

Gender	Age	Nuclear	Cortical	Posterior
Women	50 - 55 years	49 (54,44%)	34 (37,78%)	7 (7,78%)
	56 - 60 years	43 (51,19%)	30 (35,71%)	11 (13,10%)
	61 - 65 years	36 (51,43%)	23 (32,86%)	11 (15,71%)
	> 65 years	32 (50,79%)	23 (36,51%)	8 (12,70%)
Men	50 - 55 years	13 (48,15%)	12 (44,44%)	2 (7,41%)
	56 - 60 years	15 (62,50%)	8 (33,33%)	1 (4,17%)
	61 - 65 years	15 (44,12%)	10 (29,41%)	9 (26,47%)
	> 65 years	30 (44,78%)	19 (28,36%)	18 (26,87%)

Table 3. Logistic Regression Test Between The Components Of Metabolic Syndrome And Cataract

Variable		Cataract		*P*	OR	95.0% C.I	
		No	Yes			*Lower*	*Upper*
MetS		335	337	0.012	1.538	1.098	2.152
BMI	*Underweight*	16	12	*0.040*	0.827	0.690	0.991
	Normal	114	127				
	Overweight	114	122				
	Obesitas	111	76				
HT	No	124	128	0.766	0.952	0.689	1.316
	Yes	231	209				
Hyperglicemia	No	293	286	0.294	0.798	0.524	1.216
	Yes	62	51				
Low HDL	No	233	213	0.613	1.092	0.777	1.534
	Yes	122	124				
Hypertriglyceride	No	228	189	*0.022*	1.462	1.057	2.021
	Yes	127	148				

Further analyses was carried out between the independent and the dependent variable of the 337 subjects. The results of logistic regression test results (Table 3) present a relationship between MetS components and cataracts. The OR value for the BMI is 0.827(p value =0.043), indicating that people with obesity have a higher risk of cataracts and there is a significant association between the BMI and the incidence of cataracts. The OR value for the hypertension is 0.952 (p value =0.766), indicating that there is no significant relationship between

hypertension and the incidence of cataracts. The OR value for the hyperglycemia is 0.798 (p value =0.294), indicating that there is no significant relationship between hyperglycemia and the incidence of cataracts. The OR value for the low HDL levels is 1.092 (p value =0.613), indicating no significant relationship between low HDL levels and the incidence of cataracts. The OR value for the triglyceride is 1.462 (p value =0.022), indicating that people with higher triglyceride levels tends to have a higher risk of developing cataracts and there is a significant association between the higher triglyceride and the incidence of cataracts.

DISCUSSION

These findings are consistent with a growing body of evidence linking metabolic syndrome components to the development of senile cataracts. Obesity, especially abdominal obesity, remains a consistent predictor of cortical and posterior subcapsular cataracts. The Blue Mountains Eye Study (Rowe et al., 2000) reported a strong association between increased BMI and incidence of cataracts, particularly PSC. In these cohorts, obesity was associated with higher levels of systemic oxidative stress, chronic inflammation, and insulin resistance, all of which are implicated in the pathophysiology of cataractogenesis. Similarly, Hardy (2012) emphasized that abdominal fat contributes more significantly to cataract development than general obesity due to its stronger link with insulin resistance and systemic inflammation.

Furthermore, leptin dysregulation is proposed to play a role in lens damage among obese individuals. Elevated leptin levels and leptin resistance may impair the antioxidant defense system of the lens, promoting ROS accumulation and oxidative stress (Nankam et al., 2021). A more detailed molecular explanation is provided by Babizhayev (2011), who found that leptin induces mitochondrial dysfunction and oxidative injury in human lens epithelial cells, leading to cataractogenesis. In contrast, the lack of a significant relationship between hypertension and cataracts in this study may reflect complex interactions between blood pressure regulation, medication use, and oxidative stress. While studies such as those by Xu et al. (2014) found positive associations, reported inconsistent results after adjusting for antihypertensive medications. Some antihypertensives, such as ACE inhibitors, may offer protective effects against cataract formation by mitigating oxidative damage (Li et al., 2024).

The inconsistency regarding hyperglycemia and cataract risk may also be explained by the duration and severity of glycemic exposure. While long-term studies, including the Singapore Malay Eye Study (Sabanayagam et al., 2011) and Ghaem Maralani et al. (2013), have demonstrated increased cataract risk among diabetic individuals, cross-sectional designs like this study may underestimate the cumulative effects of hyperglycemia. Moreover, HbA1c, a more stable marker of long-term glucose exposure, is a stronger predictor than fasting glucose in lens opacification (Ghazanfari et al., 2010). Regarding HDL-C, inconsistent findings are frequently reported. While Sabanayagam et al. (2011) found no significant association between low HDL and cataracts, other longitudinal studies, such as those by Tan et al. (2008), showed that lower HDL-C was linked with cortical cataracts, potentially through reduced antioxidant capacity. HDL particles have been shown to possess antioxidant enzymes like paraoxonase, which protect against lipid peroxidation in lens membranes (Ferretti et al., 2009).

Triglycerides, on the other hand, consistently appear as a significant risk factor. The Women's Health Study (Park et al., 2014) observed that hypertriglyceridemia significantly increased the risk for cataract extraction among middle-aged women. Elevated TG levels promote systemic inflammation and oxidative stress and may alter lens membrane lipid composition, accelerating opacity formation (Paunksnis et al., 2007). In experimental settings, excess circulating triglycerides have been shown to impair lens transparency via lipid peroxidation and activation of NF-κB pathways (Jomova, 2023). Overall, the findings of this study support the hypothesis that among components of metabolic syndrome, BMI and

triglycerides are the most influential risk factors for cataract formation. However, the absence of significant findings for other MetS components may be attributed to sample size limitations, confounding medications, or the cross-sectional nature of the study, which may not capture long-term effects. Future studies with prospective cohort design, larger sample sizes, and comprehensive metabolic profiling (e.g., HbA1c, lipid subfractions, leptin levels) are needed to elucidate these associations further.

CONCLUSION

There is a significant association between BMI and triglyceride level with cataract, where triglyceride level has a stronger association compared to BMI in increasing the occurance of cataract. Meanwhile, there is no significant association between blood pressure, fasting blood glucose, and HDL-cholesterol level with cataract.

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